



COLLEGE OF TECHNOLOGY

Department of Computer Graphics Technology

CGT 411 Final Papers

Fall 2005 Semester

Compiled by Bryce Hyland & Kurt Luther

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* Denotes winner of Phoenix Award.

† Denotes winner of Outstanding Project Award.

Initiative for improving functionality of web-based evaluation in the Department of Computer Graphics Technology (IIT)

CGT 411 Group 1 QED, Fall 2005
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1.0 Abstract

In an effort to improve the evaluation of instructional performance, Purdue Online Evaluation (P.O.L.E.) system was created for the College of Technology at Purdue University. Four years after implementation P.O.L.E. has gone unchanged. With every additional year, the shortcomings of the unfinished project become more apparent and detrimental to its original purpose. With some lost functionality from the original implantation and growing faculty complaint, P.O.L.E. is overdue for an overhaul.

The rejuvenation process for P.O.L.E. is the focus of this semester long endeavor. The first step in the process is by exterminating the original audience and the intended functionality of the system. After the functionality was refined, it was streamlined towards the audience. Then, the advantages of the original proposed solution were utilized. This included taking advantage of the correlations that can be made and the dynamic display of the instructional performance data.

2.0 Introduction

Over the years, Purdue University has been using traditional paper forms to evaluate the professors on their job. The questions ranged from teaching style to the course material and the level it is presented at. In the fall of 2000 and through the spring of 2001, a project was proposed to develop an application that could replace the current paper evaluation method. The project was titled *Initiative for Improving Teaching in the Department of Computer Graphics Technology (IIT)*. Originally, the application, named TestPilot, was developed in Microsoft Office 2000 using a combination of Excel and Access as well as server side Active Server Pages (ASP). The problem with TestPilot was that it was very large and complex. There were 96 separate files to configure. It also had paper based

reports and required the students to use login slips.

In the spring of 2002, a CGT 411 group headed up by Steve Ragan, took charge of this project and worked on the existing application. They adapted the original Access database into an SQL database. From there, everything was streamlined in order to make things run smoother. The overall number of ASP files as well as the number of lines of code was reduced. Features were added to the system to improve usability and the overall evaluation system.

The project was left with bugs to be fixed, security holes that needed to be plugged and features that, for the most part, worked, but not to their full potential. In this third iteration, there are many things to be picked up from the previous group project. The system was operating, but the entire process was

tedious. The student roster had to be loaded and updated manually instead of simply downloading the list from the registrar. This process alone would take days worth of work to do. The professors were given a table filled with numbers that showed the results of the evaluations. Overall, the application did what it was supposed to, but not very effectively. Too much work was needed to use the system as a whole.

Presently, there are several other schools that use a similar method to gathering feedback about their professors and courses. Some of the universities include Northwestern University, IUPUI, the University of Illinois, and the University of Florida. Each university has put in a considerable amount of time and work into their systems to customize them to be at the optimal effectiveness possible.

3.0 Problem Statement

The Computer Graphics Technology department head and faculty can not successfully evaluate the professors' and Technical Assistants' instructional performance within a course using the existing web-based instructional evaluation system.

4.0 Significance

Instructional performance data is required to be gathered by Purdue University. This data is gathered to be utilized by the professor to help improve instructional performance as well as by the department head to see instructors' performance and help decide on the rewarding of tenure. Under the current P.O.L.E. system, instructional performance data was being gathered, but it was available only to the professor to which the data pertained. This instructional performance was

voluntarily given to the department head which goes against university regulation. In addition, the performance of lab instructors was not being collected in a way that a professor could distinguish between multiple technical assistants.

5.0 Solutions

Under the current solution, the department head and faculty can not successfully evaluate the professors' and Technical Assistants' instructional performance. In order for this web based solution to serve its initial purpose, a complete overhaul of the existing P.O.L.E website will be required. The focus of the overhaul is to ensure the department head and faculty can successfully evaluate the professors' and Technical Assistants' instructional performance, in addition to added functionality as specified by the original study.

6.0 Methodology

Upon commencement of the project there was a lack of legacy documentation. Initial brainstorming was conducted to develop solutions for the existing product. Research was conducted on similar online evaluation systems investigate similar products.

The legacy documents were later discovered, *Web Based Instructor Evaluations: An Application Solution for the Initiative for Improving Teaching in the Department of Computer Graphics* and further documentation confirmed our proposed solutions for improvement. Based on those findings, methodologies were developed as follows.

6.1 Department Head Interview

A structured interview (appendix #1) was conducted with the department head in order to further validate the areas

of study. An open ended segment was left at the end in order to help identify potential areas that could have been overlooked.

6.2 System Administrator Interview

A similar structured interview (appendix #1) was done with the system administrator to provide his unique perspective on the current P.O.L.E. system. Similar to the previous interview, an open ended segment was left at the end to help identify potential areas of study.

6.3 Student Survey

Surveys were given to the students in both the CGT 112 and CGT 411 classes in order to confirm group suspicion and a Northwestern University study showing that students fear their anonymity was not preserved (appendix #2). The main purpose of the survey was to compare perceived anonymity in blackboard/WebCT websites and third-party applications such as P.O.L.E.

6.4 Faculty Survey

A survey (appendix #3) was given to faculty members to analyze the following areas:

- Time breakdown of usage.
- Importance of areas within P.O.L.E.
- Validation of the importance of solutions
- Perception of data rating scale

6.5 Department Head Exit Interview

An exit interview was conducted with the department head in order to receive qualitative feedback for the project. The purpose of the evaluation was to see whether the project met its goals to provide the evaluation tools necessary for the department head and

faculty's needs.

6.6 System Administrator Exit Interview

An exit interview was also performed with the system administrator. The intention of the interview was to gather more qualitative feedback for the project. The qualitative evaluation was over the work accomplished during the semester. An open ended segment was left at the end in the hopes of identifying overlooked issues.

7.0 Results

After conducting qualitative research, the proposed solution was developed to the faculty specification and to the specification of the problem statement. The following are the respected areas developed over the projects duration to improve the faculty's' ability to successfully evaluate instructional performance.

7.1 Speed

In response to a common complaint from faculty members an effort was made to increase the speed. Typically the data grid page would take about seven seconds to load depending on server usage. This would be due to the data grid loading the data from a view. The view hits thousands of data points in order to get the information to be placed into the data grid. An obvious drawback to this method was the sheer number of data points that needed to be accounted for every time the data grid was loaded.

A solution to the costly load time is to dump the values from the view into a separate table, and load from the table. Upon the first instance the data grid loads for a semester, the values are loaded from the view. These values are

in turn passed to the separate table. Each time thereafter, the values are loaded from the separate table with significant speed increases. The new method offers a loading time of less than .02 seconds.

During the qualitative review with faculty members, the significant difference in load times was commented upon by most of faculty members interviewed. Unfortunately, not enough faculty members were willing to participate to create a valid statistic of perceived speed increase. In the speed test that was conducted, the new method offers on average over 425 times faster load time when the data has been moved into the new tables. Without the new tables being filled, the new process is on average over 40 times faster.

7.2 Security

Several security issues were discovered and addressed during the project. First, sensitive information was passed through query string as shown below.

 <http://sotdev6.tech.purdue.edu/cgt-eval/choose.asp?userID=>

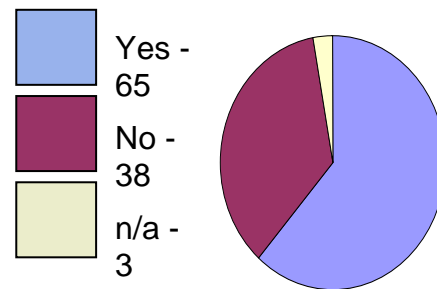
The user could simply edit the query string in order to gain access to information that they didn't have privileges for, or contaminate data. Such a security breach would have serious repercussion, and could compromise the integrity of the database. To correct this problem all sensitive information is not being passed through query strings, instead by form or session variable. This ensures no unauthorized access to data as well as no possible data contamination due to unauthorized access. The other security issue is regarding FERPA and Purdue compliance with no Social Security numbers in the database. Notification regarding these incidents was given to

the P.O.L.E. system administration and the problem has been rectified.

7.3 Perceived Student Anonymity

Going into the project, group members were aware of fellow student scrutiny regarding the anonymity of P.O.L.E. In order to better measure this, a survey was conducted on two convenient samples (Appendix #2).

Do you think doing faculty evaluations on P.O.L.E. is anonymous?



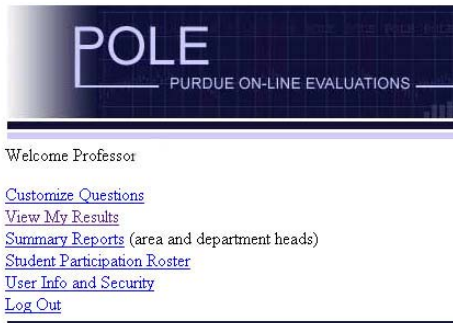
The majority of the student populous sampled believed that their faculty evaluations done through P.O.L.E. were anonymous, however about 40% of students did not think their evaluations were anonymous. These results were similar to a study conducted by *Northwestern University Course and Teacher Evaluation Council (CTEC)* regarding the anonymity of blackboard vs. independent web based solution. In order to improve the perceived anonymity of P.O.L.E., a security policy and trusted social and human interaction expert Dr. Spafford of CERIAS was consulted.

His recommendations consisted of implementing a privacy statement at the bottom of the page and investigate implementing a system of anonymous receipts in a future study. He insisted that privacy statement will help ensure a majority of the concerned users. Additionally, the appearance of the site

matters when it comes to perceived anonymity.

7.4 Faculty Navigation

Under the previous iteration of the site, a common frustration within the faculty was the site's navigation. A trail of broken bread crumbs with no consistent menu across pages was all the navigation available to the faculty and staff (shown below). There was one menu at the beginning, but that disappeared as a person navigates deeper into the site.



This problem was rectified in a two-tier solution. First the bread crumbs were fixed to allow easy navigation between the pages. Second, a menu system was implemented at the top of the site as shown below.



This menu is a more streamlined version of the navigation page. Most importantly, it provides a way for the user to log out at any given time which was another common complaint amongst faculty members.

7.5 Graphs

As suggested by the previous project, the use of graphs and graphics should be used to aid in the display of information. The following are the implemented solutions.

7.5.1 Data grid

The information on the data grid lends itself to be compared to the selected course. The previous method of presentation was a visual overload, with no comparative element to allow easy relationship to the course being viewed. The solution is as follows.

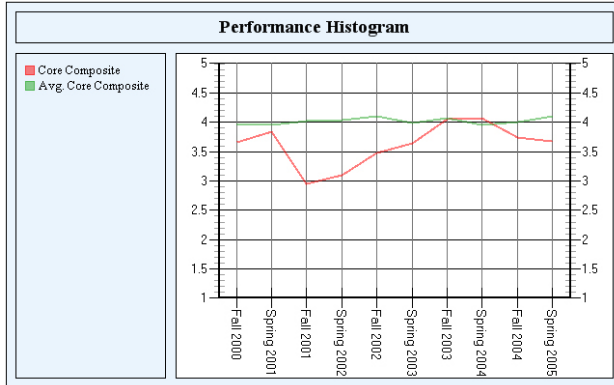
3.49	3.49 ▲
4.53	4.53 ▼

(Appendix #4) (Appendix #5)

The obtrusive cell border was removed to keep the focus on the numbers. Additionally color arrows were associated with the number compared to the current course. If the current course was better than what it was being compared to there would be a green up arrow▲, and likewise worse a red down arrow▼. The color chosen was due to the social implications of green being good and red being bad. The choice of arrows was large in part due to the use of the symbol throughout the stock market. Similarly, on mouse over, the difference of that statistic compared to the selected course is displayed.

7.5.2 Histogram

Following the suggestion for future study from the legacy project, graphs were used as part of the solution of displaying the enormous dataset. One dimension of that dataset that could not be easily seen previously was time. A histogram was used to allow instructors to compare instructional performance in a course against other elements over time.



Above is a sample histogram as it would look in the browser. The uncropped scale of 1-5 is used to provide an undistorted view of the data. The user selects which elements will be displayed on the graph as shown below.

Current Course				
CGT Criteria		Composites		
Instr. Delivery	<input type="checkbox"/> Pick	<input type="checkbox"/> CGT Composite	<input checked="" type="checkbox"/> Pick	<input checked="" type="checkbox"/>
Instr. Design	<input type="checkbox"/> Pick	<input type="checkbox"/> Core Composite	<input type="checkbox"/> Pick	<input type="checkbox"/>
Course Content	<input type="checkbox"/> Pick	<input type="checkbox"/> Core		
Content Expertise	<input type="checkbox"/> Pick	<input type="checkbox"/> Instructor Core	<input type="checkbox"/> Pick	<input type="checkbox"/>
Course Management	<input type="checkbox"/> Pick	<input type="checkbox"/> Course Core	<input type="checkbox"/> Pick	<input type="checkbox"/>

User selection of color is important because it allows the user to change the colors so they are easier to differentiate. It also allows colorblind users to pick colors that they can easily differentiate. A large color box is utilized when picking colors to give the user a large color sample. This supplements the legends limited color sample size.

7.6 Comments

Though not all the faculty members surveyed found the same helpfulness with the comments, all agreed that a tool to help streamline comments would be useful.

7.6.1 Search Engine

The purpose of the search engine is to allow faculty members the ability to scan through comments for key words as shown below.

You last search was: 'good'

Comment Search:

Lab Section: ALL

The users' average response is averaged at the bottom of the page to display an average of the searched comments. In the survey offered to faculty, all faculty members that responded found this tool useful to very useful.






7.6.2 Color Correlation

In an effort to help faculty members scan through comments, color was correlated to the students' average. In a survey offered to faculty members (Appendix #3) the question "Historically it appears that any score in instructional performance data of 4 and above to be good, 3-4 to be acceptable and below 3 to be below average." was asked. Of the responding faculty members, 10/11 faculty members responded with either a four or five, with five strongly agreeing on the scale for comment color as shown below.

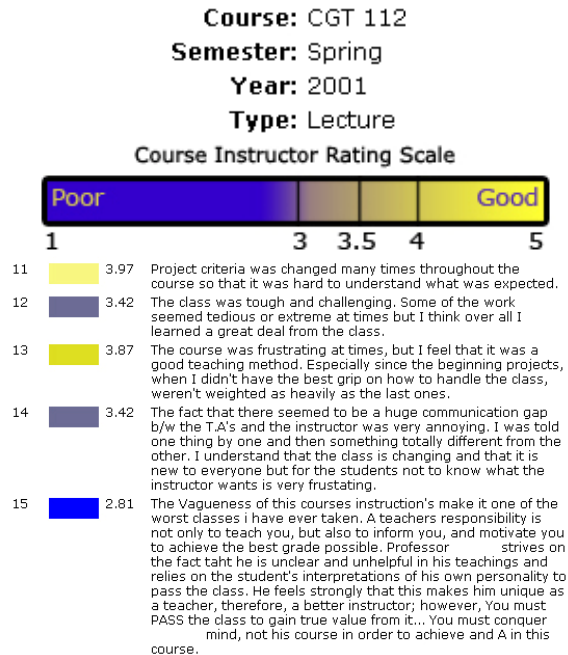
Course: CGT 112
Semester: Fall
Year: 2000
Type: Lab



Above is the color associated with the students' average. A red yellow green stoplight color scale was used with red being less than 3, yellow 3.5 and green with 4 and above. A gradient was used to help differentiate comments in-between. On the next page is the colored comments section.

11		3.97	Project criteria was changed many times throughout the course so that it was hard to understand what was expected.
12		3.42	The class was tough and challenging. Some of the work seemed tedious or extreme at times but I think over all I learned a great deal from the class.
13		3.87	The course was frustrating at times, but I feel that it was a good teaching method. Especially since the beginning projects, when I didn't have the best grip on how to handle the class, weren't weighted as heavily as the last ones.
14		3.42	The fact that there seemed to be a huge communication gap b/w the T.A's and the instructor was very annoying. I was told one thing by one and then something totally different from the other. I understand that the class is changing and that it is new to everyone but for the students not to know what the instructor wants is very frustrating.
15		2.81	The Vagueness of this courses instruction's make it one of the worst classes i have ever taken. A teachers responsibility is not only to teach you, but also to inform you, and motivate you to achieve the best grade possible. Professor _____ strives on the fact taht he is unclear and unhelpful in his teachings and relies on the student's interpretations of his own personality to pass the class. He feels strongly that this makes him unique as a teacher, therefore, a better instructor; however, You must PASS the class to gain true value from it... You must conquer mind, not his course in order to achieve and A in this course.

During the qualitative review, many professors remarked on how quickly they were able to identify the nature of the comment with the colors along side. During the qualitative review colorblindness was brought up. It turns out that about 9% of the population has some sort of colorblindness. In order to accommodate this population, we incorporated a separate colorblind scale as shown below.



The blue yellow color choice is because it best accommodates 99% of colorblind individuals who are some form of red green colorblind. The 1% that is overlooked is blue yellow

colorblind which the original scale accommodates for.

7.7 Custom questions

As modeled from *Web Based Instructor Evaluations: An Application Solution for the Initiative for Improving Teaching in the Department of Computer Graphics*, custom questions were implemented in P.O.L.E. In a survey issued to faculty members (Appendix #3) found all faculty members who responded agreed that custom questions were important. However, about half the faculty members that responded were not aware that the functionality for custom questions existed.

In order for faculty members to utilize custom questions under the previous system, they had to send a request to the system administrator. The system administrator would then update the professors' custom question for the course and notify the professor of the change. There was no documentation that hinted the existence or the process in which to change these questions which would explain why there were not aware of the administrative functionality.

To fix this problem, a custom questions tab was added to the navigation. This streamlines the process in addition to making the professor aware of the functionality. It also gives the professor the ability to view their current questions.

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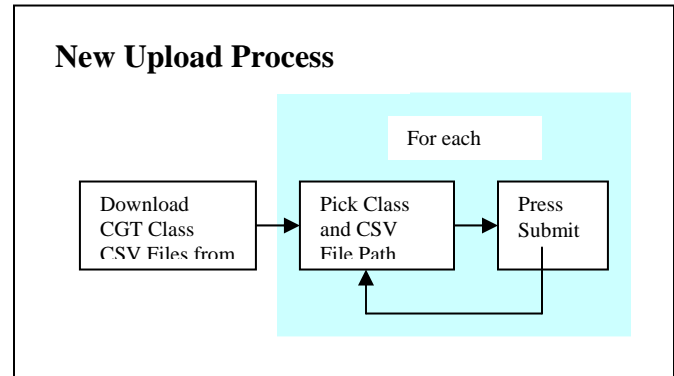
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7.8 Administration functionality

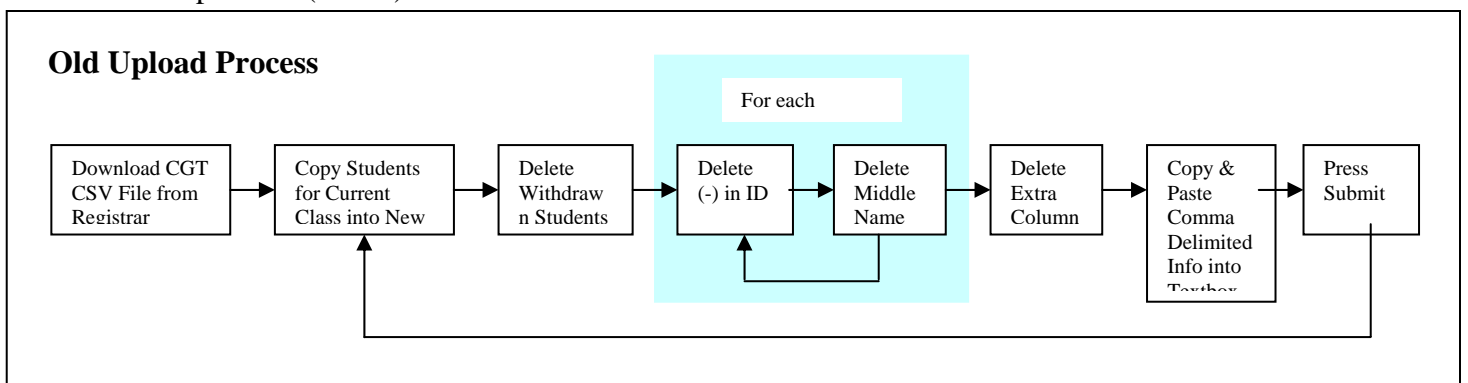
Upon conducting an interview with the system administrator the question was asked "From your current experience, what do you dislike about P.O.L.E.?" Among the list of issues, the one that stuck out the most was the process in which class rosters are uploaded (below).

This monotonous process would take about a week for the system administrator to upload all the rosters. Much of the process was repetitive and seemed intuitively automated. Over the course of the semester, the process automated as much as possible and refined down to a three step process shown in the next column.



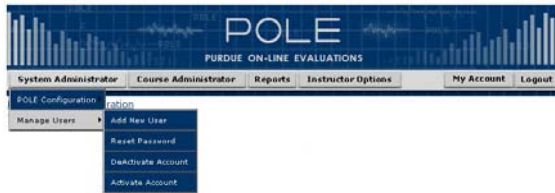
All the steps between selecting a class and submitting were removed and automated. Currently, with the new process, it takes about one to two hours to upload all the class rosters. This is a drastic improvement because it takes less time and removes the chance for human error. The system administrator was overjoyed with the new process over the exit interview.

Another functionality issue was brought up while conducting an interview with the department head. The department head had no access to



login and he didn't know what to do to get access. Likewise, when interviewing the system administrator the question of why the department head didn't have access was asked. The response was startling because the system administrator did not know how to do it and there was no application functionality to do that.

The functionality was added and incorporated into a new administrative navigation as shown below.



7.9 Documentation

While conducting an interview with the system administrator the question of sufficient documentation was asked. The system administrator began to elaborate that there was such a lack of documentation that if he was to leave, there would be no way another system admin could take over. There was no documentation on P.O.L.E. especially regarding the administrator's functionality. In response, documentation was generated on the functionality to make it easier for new faculty members and system administrators to orient themselves to P.O.L.E.

7.10 Individual Teaching Assistant Data Error

This problem with the previous version of P.O.L.E. was being created by databases not being correctly populated. The lab section variable was not correctly populated with the corresponding lab section. In turn, the section variable would default to zero. With all the section variables the same,

all the data collect would be for one lab section instead of the individual sections.

This problem has been fixed in the way class rosters are being populated. Nevertheless, there is no feasible way to separate old data collected under one lab section in to their respected sections. Future teaching assistant data collect will be able to be viewed by lab sections.

7.11 Question Frequency Breakdown

Under the *Web Based Instructor Evaluations: An Application Solution for the Initiative for Improving Teaching in the Department of Computer Graphics*, the questions used were broken down to several categories. Under the previous version, the questions were averaged into their respected areas on the data grid, but there was no grouping mechanism in the question frequency page. This lack of grouping was a common question from faculty members. The solution was to group the corresponding questions into their respected categories as shown below.

#	Question	SA	A	U	D	SD	Mean
1.	The instructor's presentation or explanation of the subject matter is clear.	10	34	22	20	5	3.26
2.	The instructor's lectures help me understand the subject matter.	12	41	20	17	1	3.51
3.	The instructor's use of instructional delivery media (i.e. the chalkboard, overhead projector, computer) is effective	18	44	21	8	1	3.76
4.	The instructor's lectures make a unique and important contribution to the course content.	17	51	12	9	3	3.76
5.	The instructor seems concerned with the students' understanding and progress.	29	45	9	7	2	4.00
6.	The instructor encourages students to think.	58	30	3	0	0	4.60
7.	The instructor motivates me to do my best work.	24	33	22	0	0	4.03
8.	The instructor's attitude towards students is courteous and considerate.	20	48	13	0	0	4.09

Doing so brought to attention that the averages on the question frequency page were not matching the data grid. This was due to a calculation error which occurs when there are no responses for one column. For the remaining questions on that column, the responses all display. This was corrected with the new grouping as shown below.

Instructional Delivery Skills						
Question	SA	A	N	D	SD	Mean
1. The instructor's presentation or explanation of the subject matter is clear.	10	24	22	20	5	3.26
2. The instructor's lectures help me understand the subject matter.	12	41	20	17	1	3.51
3. The instructor's use of instructional delivery media (i.e. the chalkboard, overhead projector, computer) is effective	10	44	21	0	1	3.76
4. The instructor's lectures make a unique and important contribution to the course content.	17	51	12	9	3	3.76
5. The instructor seems concerned with the students' understanding and progress.	29	45	9	7	2	4.00
6. The instructor encourages students to think.	58	30	3	0	0	4.66
7. The instructor motivates me to do my best work.	24	33	22	11	2	3.72
8. The instructor's attitude towards students is courteous and considerate.	20	48	13	9	2	3.88

8.0 Limitations

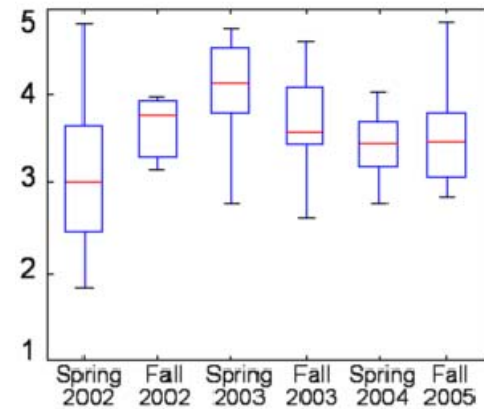
8.0 Recommendations for Future Study

Unfortunately, due to the lack of the target populations' participation in the development and validation of the proposed solution, only a limited qualitative evaluation was possible. In order to develop an application towards such a small population, it is imperative that as much of the population responds and gets involved with development as possible. Quantifiable statistics was the original measure, but in order for them to be valid with such a small population, the entire populations' response is necessary. This limitation forced the measure to be shifted to qualitative. All of the development work described above was completed in less than four weeks. In order to maintain quality and completeness, certain features had to be omitted from this iteration of P.O.L.E. As a byproduct of the omissions, a plan for possibilities for the next iteration of P.O.L.E. is detailed below as follows:

8.1 Multi Variable Graphical Correlations

One of the deciding criteria for the graphical plug-in selected for this iteration of P.O.L.E. was the plug-in's ability to graphically represent more than two variables (<http://www.sasq.co.uk/sasqChart/>). Unfortunately, there was not sufficient time to determine and implement multivariable graphical correlations. Fortunately, the data set lends itself to a number of possible correlations.

Left is an example of a possible graph that could be generated by a future study. It is a box plot over time, and it shows the mean, first quartile, third quartile, maximum and minimum over time. The underlying thought of any future implementation of additional graphs is to display large amounts of information quickly.



8.2 Additional graph functionality

The current functionality of the histogram feature is limited to as described above. With each additional year of data being added on to the data set, the functionality of the histogram will become more and more of a pressing issue. A limiting feature should be implemented to allow the user to limit the number of years being displayed at once. This would be helpful with each year of instructional performance data collected creating a denser graph. Additionally a zoom feature should be added to allow the user to zoom in and be able to distinguish smaller changes.

8.3 Application esthetic redesign

The primary focus of the study was for the functionality of the P.O.L.E. system to be improved. An aesthetic redesign was outside the scope of the project.



A functional redesign of the header was done to allow the implementation of the new navigation and menu system.

Additionally, the new header allowed administrators as well as programmers an easy way to distinguish between the versions of P.O.L.E.

A future study could improve the aesthetic properties of the site. The purpose of the study would be to bring the site up to the current standards of web design. To maximize the user compatibility, W3C XHTML standards or comparable applicable web standards should be utilized in addition to a multi-tier usability study.

8.4 Midterm and final correlation

Although not regulated by university regulation the first iteration of P.O.L.E. could collect midterm data as recommended by the *Web Based Instructor Evaluations: An Application Solution for the Initiative for Improving Teaching in the Department of Computer Graphics*. Due to the very small minority of professors that collect midterm data, it was impractical to incorporate this specific functionality into this iteration of the application. However, as outlined, the correlation between midterm and final instructional performance data would be extremely beneficial in improving instructional performance.

Content Expertise	Course Mgmt.	CGT Composite	Content Expertise	Course Mgmt.	CGT Composite
4.14	3.62	3.84	4.33	3.94	4.07
4.08	3.79	4.03	4.08	3.75	3.98
4.21	4.18	4.14	4.21	4.18	4.23
2.50	1.50	1.95	4.21	3.83	4.03
4.77	4.79	4.79	3.58	3.56	3.67
4.03	3.70	4.03	4.12	3.80	4.06
3.91	3.35	3.62	4.03	3.58	3.87
4.29	4.09	4.20	4.03	3.87	3.95
3.96	3.67	3.82	4.07	3.91	3.96
4.10	3.85	4.05	4.01	3.56	3.84
4.54	4.48	4.52	4.58	4.49	4.59

(midterm) (final)

Currently the only way to compare these two data sets is in two separate browser windows (as shown above). Merely

placing the data-grids next to each other shows an obvious improvement in instructional performance. This functionality should be embedded in the application to allow an easy comparison of both question/question frequency and the data-grid.

8.5 Search engine

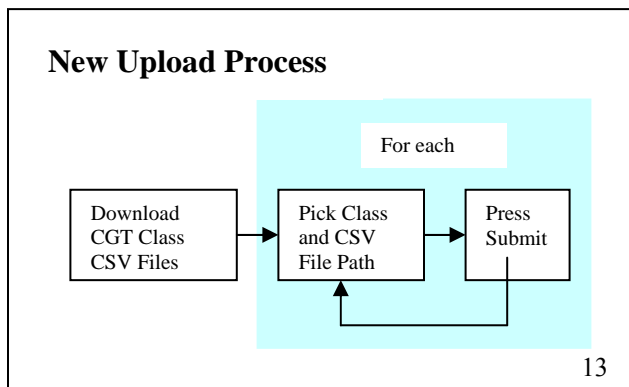
Currently, there is a basic search engine, but it has very limited functionality. Through a future study, information can be gathered to determine if the search engine is meeting the needs of the faculty and staff. Research and exploration will be used to determine existing specialized search engines, and possible solutions to search the comments more effectively. Depending on the information gathered, an existing search engine could be implemented or a specialized search engine could be developed to search the comments.

8.6 Multi-campus support

The existing P.O.L.E. system is being utilized by some statewide campuses, however there is no correlation being made between the campuses. This functional is important to help the department head evaluate performance across the campuses.

8.7 Registrar feed

Pulling class rosters directly from the registrar would remove one additional step to the new upload process



Instead of downloading csv files, the system administrator would have to pick a course and populate it directly from the registrar feed. This would save a few minutes of downloading the class rosters from the registrar, selecting and uploading them. These few minutes add up over courses, and currently would save about an hour of time. This is especially attractive for a larger scale implementation, because the class roster population would not be a timely limitation.

At the time of the paper all the information has been provided by David McClure at ITAP regarding the feeds. It is currently being pursued and will hopefully be implemented shortly after the paper. If the registrar feed does not materialize in this iteration, it would be a valuable area of study for the next iteration of P.O.L.E.

8.8 Anonymity

While consulting Dr. Spafford from CERIAS, the suggestion of implementing a system of *anonymous receipts* could be the best solution to the perceived anonymity issues. The process of *anonymous receipts* works by first giving the user a randomly generated login to fill out an evaluation. Upon the evaluations completion, a randomly drawn pre-generated ticket is given to the user. The user then either prints out the ticket and brings it into class or submits the ticket electronically. Caution about the six months of development needed to implement this system blocked the group from further investigation of this option.

10.0 Conclusion

Thru qualitative validation, the functionality of P.O.L.E. has been improved to allow the Computer Graphics Technology department head and faculty the ability to successfully evaluate the professors' and Technical Assistants' instructional performance within a course. Navigation and graphical representation of the web-based system were improved and validated through professor input. However, due to the nature and sheer size of the web-based application, a one semester development cycle was insufficient to address every aspect that can be improved within this system. Further development is strongly recommended.

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Appendix #1 – Structured Interview

- 1.) What is the purpose of P.O.L.E.?
- 2.) From your current experience, what do you like about P.O.L.E.?
- 3.) From your current experience, what do you dislike about P.O.L.E.?
- 4.) What do you think is most needed to be improved?
- 5.) Any additional improvements or functionality that would be helpful?
- 6.) Is there a lack of documentation?
- 7.) Any additional thoughts?

Appendix #2 – Student Surveys

- Do you know what P.O.L.E. (Purdue Online Evaluation) is? Yes No
- Have you used P.O.L.E.? Yes No
- Do you know what webCT or webCT Vista is? Yes No
- Have you used webCT? Yes No
- Is anonymity important when evaluating instructors performance in a course?
Yes No
- Do you think doing faculty evaluations on P.O.L.E. are anonymous? Yes No N/A
- Do you think doing faculty evaluations on webCT are anonymous? Yes No N/A
- Do you trust the anonymity of P.O.L.E. more than webCT? Yes No N/A
- Are you aware of any breach of your computer? Yes No

Appendix #3 – Faculty Surveys

Name: _____

(This will be used to keep track of the % of the population we sample. This will not be used to pair instructors with data or comments, confidentiality will be maintained)

1. Are you aware of the CGT student online evaluation software Purdue Online Evaluations (P.O.L.E.)? Yes No
 2. Have you used it? Yes No
(if you answered no, skip to # 16)

 3. Do you still use it? Yes No
 4. About how many hours a semester do/did you spend using P.O.L.E. _____
Retrieving data _____
Instructing how to use it in class _____
Reviewing data _____
Massaging data _____
 5. Do you use the P.O.L.E. data to facilitate improving your course(s)?
Yes No
 6. If yes, what is the most important data you use to improve instruction
Comments 1 2 3 4 5 Cafeteria data
 7. Are instructor created custom questions important? Yes No
 8. Are you aware that P.O.L.E. has the capability of creating custom questions?
Yes No
 9. Are the student comments useful?
(Not at all Useful) 1 2 3 4 5(Very Useful)
 10. Would a tool to search student comments be useful?
(Not at all Useful) 1 2 3 4 5(Very Useful)
 11. Is the current method of data presentation easy to understand?
(Not easy to understand) 1 2 3 4 5 (Very easy to understand)
 12. Does it require too much time to comprehend the data presentation?
(Very little time) 1 2 3 4 5(Too much time)
 13. Would graphs of the data help your comprehension?
 14. Would a data history image of performance over time be helpful?
(Not Helpful) 1 2 3 4 5 (Very helpful)
 15. Are there other data relationships that would be helpful?
(No there are not) 1 2 3 4 5 (Yes there are)
- Please list any additional data images that would be helpful
-
-
16. Historically it appears that any score in instructional performance data of 4 and above to be good, 3-4 to be acceptable and below 3 to be below average.
(Strongly disagree) 1 2 3 4 5 (Strongly Agree)
 17. Any additional comments?

Appendix #4 – Old Data Grid



[Menu](#) > [Course](#) > [Report Type](#)

Final Data is shown, click here for [Midterm Data](#)

	Instructional Delivery	Instructional Design	Course Content	Content Expertise	Course Management	CGT Composite	Instructor Core	Course Core	Core Composite
My Course	3.80	3.68	3.90	4.04	3.71	3.85	3.69	3.67	3.68
All Courses	4.11	4.09	4.11	4.17	3.93	4.10	4.17	4.04	4.11

Animation	4.29	4.21	4.26	4.40	4.23	4.29	4.43	4.25	4.34
Construction	4.00	4.00	4.04	4.23	3.98	4.07	4.06	3.92	3.99
Elective	4.42	4.34	4.00	3.47	4.18	4.04	4.00	3.82	3.91
Foundation	4.18	4.19	4.19	4.28	4.02	4.19	4.20	4.13	4.16
Manufacturing	4.11	4.08	4.07	4.04	4.17	4.08	4.31	3.80	4.06
Multimedia	4.38	4.43	4.39	4.42	4.32	4.40	4.50	4.33	4.42
Professional	4.01	3.83	3.94	3.98	3.72	3.92	4.12	3.89	4.00
Service	3.92	3.90	3.96	4.01	3.62	3.92	3.98	3.91	3.94
Not Specified	3.54	3.70	3.68	3.49	3.33	3.57	3.71	3.14	3.42
Graduate	4.62	4.68	4.71	4.53	4.56	4.63	4.83	4.83	4.83

100 Level	4.07	4.08	4.10	4.16	3.83	4.08	4.12	4.06	4.09
200 Level	4.15	4.11	4.14	4.22	4.16	4.16	4.19	3.95	4.07
300 Level	4.18	4.14	4.18	4.28	4.13	4.19	4.27	4.15	4.21
400 Level	4.09	3.98	4.02	4.04	3.83	4.01	4.26	3.94	4.10
500 Level	4.62	4.68	4.71	4.53	4.56	4.63	4.83	4.83	4.83

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Appendix #5 – New Data Grid

POLE
PURDUE ON-LINE EVALUATIONS

View My Results Participation List Custom Questions My Account Logout

Menu > Course > Report Type

Final Data is shown, click here for [Midterm Data](#)

Composite and Core Results CGT 112

Arrows:

	Instr. Delivery	Instr. Design	Course Content	Content Expertise	Course Mgmt.	CGT Composite	Instructor Core	Course Core	Core Composite
My Course	3.80	3.68	3.90	4.04	3.71	3.85	3.69	3.67	3.68
All Courses	4.11 ▼	4.09 ▼	4.11 ▼	4.17 ▼	3.93 ▼	4.10 ▼	4.17 ▼	4.04 ▼	4.11 ▼
Animation	4.29 ▼	4.21 ▼	4.26 ▼	4.40 ▼	4.23 ▼	4.29 ▼	4.43 ▼	4.25 ▼	4.34 ▼
Construction	4.00 ▼	4.00 ▼	4.04 ▼	4.23 ▼	3.98 ▼	4.07 ▼	4.06 ▼	3.92 ▼	3.99 ▼
Elective	4.42 ▼	4.34 ▼	4.00 ▼	3.47 ▲	4.18 ▼	4.04 ▼	4.00 ▼	3.82 ▼	3.91 ▼
Foundation	4.18 ▼	4.19 ▼	4.19 ▼	4.28 ▼	4.02 ▼	4.19 ▼	4.20 ▼	4.13 ▼	4.16 ▼
Manufacturing	4.11 ▼	4.08 ▼	4.07 ▼	4.04 ▲	4.17 ▼	4.08 ▼	4.31 ▼	3.80 ▼	4.06 ▼
Multimedia	4.38 ▼	4.43 ▼	4.39 ▼	4.42 ▼	4.32 ▼	4.40 ▼	4.50 ▼	4.33 ▼	4.42 ▼
Professional	4.01 ▼	3.83 ▼	3.94 ▼	3.98 ▲	3.72 ▼	3.92 ▼	4.12 ▼	3.89 ▼	4.00 ▼
Service	3.92 ▼	3.90 ▼	3.96 ▼	4.01 ▲	3.62 ▲	3.92 ▼	3.98 ▼	3.91 ▼	3.94 ▼
Not Specified	3.54 ▲	3.70 ▼	3.68 ▲	3.49 ▲	3.33 ▲	3.57 ▲	3.71 ▼	3.14 ▲	3.42 ▲
Graduate	4.62 ▼	4.68 ▼	4.71 ▼	4.53 ▼	4.56 ▼	4.63 ▼	4.83 ▼	4.83 ▼	4.83 ▼
100 Level	4.07 ▼	4.08 ▼	4.10 ▼	4.16 ▼	3.83 ▼	4.08 ▼	4.12 ▼	4.06 ▼	4.09 ▼
200 Level	4.15 ▼	4.11 ▼	4.14 ▼	4.22 ▼	4.16 ▼	4.16 ▼	4.19 ▼	3.95 ▼	4.07 ▼
300 Level	4.18 ▼	4.14 ▼	4.18 ▼	4.28 ▼	4.13 ▼	4.19 ▼	4.27 ▼	4.15 ▼	4.21 ▼
400 Level	4.09 ▼	3.98 ▼	4.02 ▼	4.04 ▲	3.83 ▼	4.01 ▼	4.26 ▼	3.94 ▼	4.10 ▼
500 Level	4.62 ▼	4.68 ▼	4.71 ▼	4.53 ▼	4.56 ▼	4.63 ▼	4.83 ▼	4.83 ▼	4.83 ▼

Version 2.0 :: Released 28-Nov-2005

A Comparative Analysis of Keyframing to Motion Capture in American Sign Language Animations.

Matthew Sanders, Tim Dale, Andrew Ryzner, Laurie Ide, Joe Humbert

Abstract

The better method of creating 3D American Sign Language fingerspelling animations was determined through this work. The main objective of this study was to determine the best method of creating these animations. The methods compared were motion capture and keyframe animation. Individual letters were created by both keyframe animation and motion capture animation. Then they were blended together using a blending engine found in the Alias Maya 6.5 software. Ten animations were created using each method, and tests were administered to 72 subjects on how quickly they could recognize the word, how easy it was to read, and how natural and realistic the animation looked. In most all instances, it was found that the keyframe animations were better in all three categories. The results tend to demonstrate how much better the keyframe animations were rated over the motion capture ones. The conclusion of this particular study is that keyframe animations are more suited for presenting when animating fingerspelling in American Sign Language.

Introduction

“¡Hola! ¿Cómo estás?” For those that don’t speak Spanish, that little phrase could be confusing. Just like if someone signed, “Hello. How are you?” in American Sign Language; it would be equally confusing to a person that doesn’t know ASL. If a person wanted to translate Spanish, all he or she needs to do is find a translator online. Unfortunately, this is not possible with ASL because it is not a written language. ASL has its own quirks, body movements, grammatical structure, etc.; just like many other languages, but instead of just learning how to say and write phrases, a person needs to learn how to physically sign the words (“American Sign Language”, 2005). This poses a problem when representing ASL on a computer.

There were apparently no papers available that describe which is more effective for animated ASL, either motion capture, or keyframing. This knowledge was deemed necessary to know so that animators can know how to best represent fingerspelling generated in a computer application.

In this study, different hand shapes that represent different letters in ASL were captured using motion capture equipment. After cleaning up the motion capture data, the different hand shapes were blended in sequence to spell out words. A similar method was repeated when creating the different words in the keyframed animation. The hand shapes were created by an animator instead of motion capture.

Comparing keyframed and motion captured hand shapes will show which animation method is better when making computer generated signing of words in ASL.

American Sign Language (ASL)

American Sign Language, known as “ASL”, has widely been used by deaf people in the United States, Canada and Mexico. For an estimated 500,000 to 2 million deaf people in the United States, ASL is the primary means of communication (“American Sign Language”, 2005). ASL uses the hands, arms, and facial expressions to convey words through body language. There are many different hand-shapes and facial expressions used. One significant part of ASL is

fingerspelling. Fingerspelling is the forming of hands and fingers in different shapes to create letters of the alphabet. There are several different techniques for fingerspelling words, such as “short cut” transitions between letters, or skipping letters because the recipient is still able to get the idea of the word as a whole (“American Sign Language”, 2005). This is somewhat similar to the study done at Cambridge University where they had a paragraph in which the words’ letters were mixed up, but the first and last letters were still the same. People were still able to read the paragraph without any trouble, because the human brain is used to viewing the words as a whole, and it is not necessary for the letters in the middle to be in the correct order (Davis, 2003). The process of fingerspelling words is similar to this in a way; because when a signer is spelling a word, s/he tends to skip letters or take quick shortcuts and the recipient still understands (“American Sign Language”, 2005).

The words that this project used were chosen because they almost all of the letters from the alphabet. Also, “apple”, “Nicoletta”, and “queen” have double letters, so this project tested which animation method showed the double letters fingerspelled more clearly. With the exclusion of the letter “x”, all letters of the alphabet were used to make these words. It is best to use as many letters from the alphabet as possible, and in different fingerspelling combinations, because every two letters have their own special kind of transition from one to the other. This way, the testing was able to get more accurate results when it tested different subjects. Since most of these words are basic words, they were chosen to remove the confusion of what words are being spelled.

Previous Research

Research was conducted on what had been done in the past to make the different hand shapes. It was found that some methods were better than others, having evolved more.

There have been studies on whether finger spelling would be recognized in a computer environment. At DePaul University, researchers created still images of finger spelled words and created animated images. This was then tested at a conference for signers, and concluded that the animations were better recognized than the still images (Sedgwick, 2001). After that study, the researchers at DePaul created an animation generator so that signers can create the different hand positions and gestures to create the different words and letters, and make them as realistic as possible (Tomuro, 2000). These studies showed the potential of recognizing ASL in a computer.

There have been studies as to how to create animations so that they can be transported with inexpensive equipment. At the University of California, the researchers used a motion capture system to create animations of different words. They put the words into a game engine that blended the different hand shapes to create the different words that were needed and played the animations on an inexpensive laptop (Steinback, 1997). This process was successful therefore it shows that animators can create fingerspelling animations and place them on an inexpensive computer in a gaming engine to create the words needed.

In all of the research performed, no study confirmed whether animated finger spelling was better recognized when created through motion captured hand shapes or keyframed hand shapes. This indicates the potential importance of this research in the creation of sign language using a computer.

Animaiton Methods Used

It was compared whether keyframed letters or motion-captured letters were better recognized. The two methods that were used only captured the different hand shapes that formed the letters. Then the hand shapes were blended together using the Trax Editor in Maya.

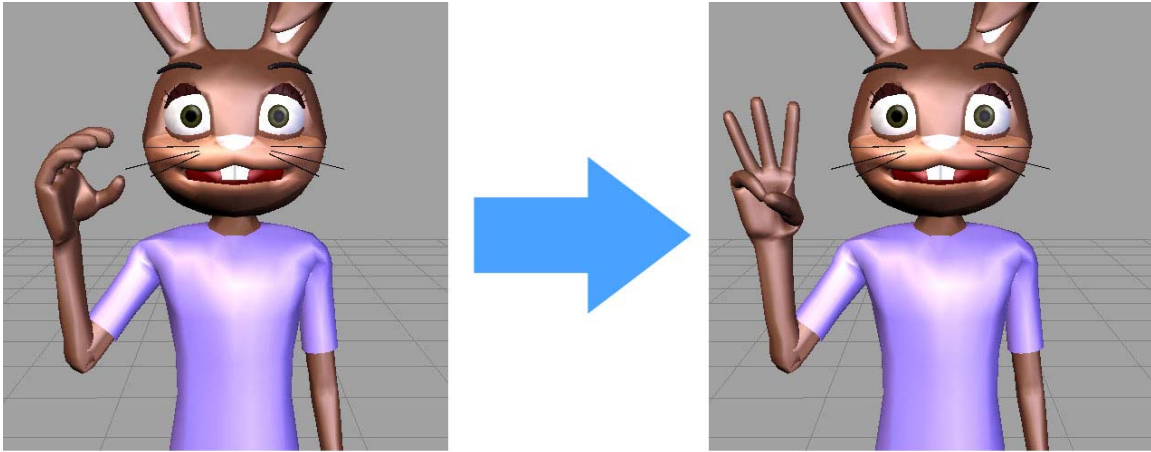


Figure 1- Keyframing from C to W

Keyframed Hand Shapes

The different letters of the alphabet were created using keyframing in Alias Maya 6.5. Each keyframe was a different letter of the alphabet (figure 1). After creating the different letters in Maya, the Trax Editor was used in Maya to blend the different hand shapes to create whole words.

Motion Captured Hand Shapes

The Purdue Envision Center for Data Perceptualization’s Motion Capture (MoCap) system was used in this study. This system consists of 6 Infrared (IR) cameras setup in a hexagonal pattern on tripods, 3 computers, and Motion Captor Software by STT (figure 2). One computer is used for the capturing of the data. Another computer is used for the processing of the captured information. The final computer is used for running the MoCap program, which controls the capture and how it is used.

Since the project deals with intricate hand motions, Immersion Software’s CyberGlove. (figure 3) was used as well. These gloves, which work with STT’s software, have 18 sensors each to capture most of the hand movements needed for American Sign Language (Immersion Corp. 2005). Using a combination of gloves and cameras allowed almost every aspect of what the signer’s body was doing to be captured. This should lead to



Figure 2- Motion Capture System



Figure 3 – CyberGlove by Immersion
 lifelike animations of each fingerspelled letter. Each set of captured data was saved in FBX format. This is the standard format for this motion capture system. It was then imported into Alias MotionBuilder for clean up.

Ideally, all the data captured would be without error or occlusion. In reality, the cameras miss data or the system cannot capture certain motions. In the study, the glove captured the data, but still required cleanup. Data cleanup was performed in Alias MotionBuilder 6.0.1.

MotionBuilder allows one to take the data that was captured, clean up any errors, then attach the motion to a character and export it to most 3D animation programs. To clean up the motion capture data, an animation layer was added which used a few key frames to correct the hand and finger positions. Finally, after everything was finished, the animation was “baked” to the character and exported into Alias Maya to be made into movies for the program created for the experiment.

Experiment

To test which method (keyframing or motion capture) was the best, a testing program was created using Macromedia Flash MX 2004. This software package was used to allow online testing, which enabled test subjects to evaluate the animations at leisure.

Within the program, test subjects were requested to fill out a pre-test questionnaire (appendix A). The purpose of the questionnaire was to determine if the subjects were qualified to take the test. As the subjects filled out the questionnaire, the program loaded the fingerspelling animations. This was done to help minimize the amount of time that the test subjects must wait before viewing any animations.

Once the users completed the questionnaire, instructions were given on how to complete the first part of evaluating each animation. This part of the testing program is known as the “Recognition” part of the testing (appendix B). It was titled this because the test subjects were asked to press a “Play” button to view the fingerspelling animation. When the user pressed this button, a hidden timer would begin.

Upon viewing the animation, the user was required to determine whether he or she could identify the word fingerspelled by pressing a “Recognized” or “Not Recognized” button. If the user recognized the word, he or she was asked to type in the word that was fingerspelled in the animation. Regardless of whether the subject recognized the fingerspelling, he or she is asked to rate the readability of the animation and its closeness to actual fingerspelling. The test featured twenty fingerspelled animations; ten created using keyframing and ten using motion capture. There were ten different words in the evaluation program. Each word was animated twice: once using keyframe animation and once using motion capture.

Analysis

One thousand four hundred forty (1440) pieces of data were collected for each speed of recognition, readability, and closeness to actual ASL (72 subjects, 20 animations). In addition, test subjects left many helpful comments.

The first data analyzed was the amount of time it took to recognize the word (figure 4). The natural log was taken of the speed of recognition for comparative purposes.

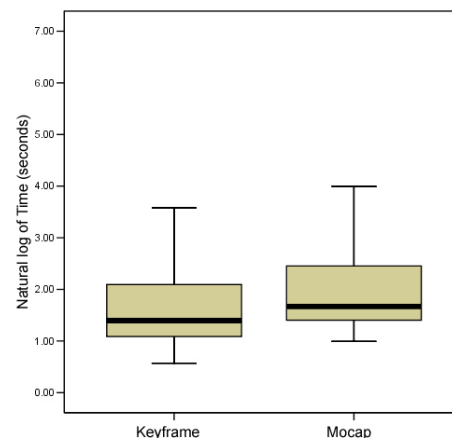


Figure 4-Time Needed to Recognize

The test results indicated that the median speed of recognition of the keyframed animations was lower than that of the motion captured animations. In addition, the first and third quartiles were lower for the keyframed animations as well as the upper and lower limits. This means that the speed of recognition of the keyframed fingerspelling animations was faster than the speed of recognition of motion captured fingerspelling animations.

The definition of readability was given to the test subjects as “how easily one can understand what is being fingerspelled.” Using that definition as a guideline, the subjects rated each animation’s readability on a scale of 1 to 10, where 1 through 5 was bad and 6 through 10 was good (higher is better).

The mean keyframe readability rating was 8.289, and the median was 9. This was higher than motion capture’s 7.470 and 8, respectively. As shown in figure 5, the majority of the ratings for keyframe were higher (better) than the majority of the ratings for motion capture.

The definition of closeness to ASL fingerspelling was given to test subjects as “how visually similar the animated fingerspelling is to human fingerspelling.” The subjects then rated each animation’s closeness to ASL on a scale of 1 to 10, where 1 through 5 was labeled as bad and 6 through 10 was labeled as good (higher is better).

The keyframe portion of the closeness to ASL yielded high ratings (figure 6). The median value is 9, and the first and third quartiles are both in the “good” section. At the same time, some keyframed animations had low scores, pulling the average value down to 7.963, over one point lower than its median value. The median value of the motion capture closeness to ASL was 7, two points lower than keyframe’s closeness to ASL median score of 9. The first and third quartiles of motion capture closeness were not far from keyframe closeness to ASL, but the majority of the data was still lower than the majority of the keyframed animation. The average motion capture closeness to ASL was

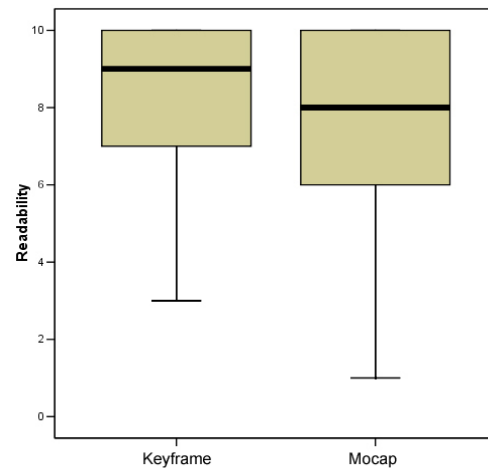


Figure 5 – Readability of Methods

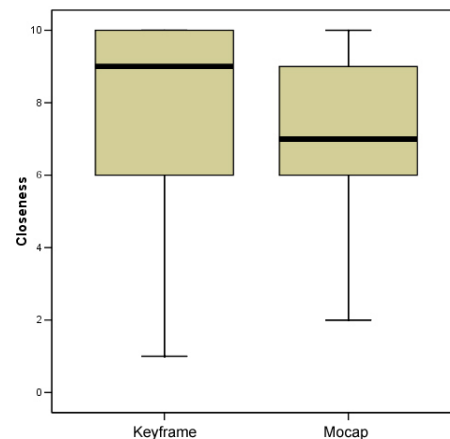


Figure 6 – Closeness to Actual ASL

7.083, almost one point lower than the closeness to ASL of keyframe animation.

Conclusion

Keyframe animations of ASL fingerspelling consistently scored better than those created using motion capture: speed of recognition, readability, and closeness to ASL. This appears important because it indicates that motion capture animation may not be better than keyframe animation in fingerspelling animations, and that it may be better to use keyframe animation for fingerspelling purposes. While this research does not prove that keyframe animation is better than motion capture, it certainly raises questions whether keyframe animation ought to be used in favor of motion capture, in certain circumstances, for example in ASL animations.

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Appendices

Appendix A

How much experience do you have with fingerspelling?

Please rate your experience in recognizing fingerspelled words:

Bad | Good

How proficient are you at recognizing fingerspelled words at a natural speed?

Bad | Good

Submit

Appendix B

Instructions:

Please press the "Play" button to view the animation. If you recognize the word, please press the "Recognized" button.

If you did not recognize it, press the "Not Recognized" button. After pressing either button, you will be asked about the animation. You may view it as many times as you wish.



Movie Controls

Creating a Presentation for Integral Forming Technology

By
Building Blocks Visual Design Studio®

Chris Davis
Luke Donkle
Jessica Lyttle
Josh Satterlee
Cody Wells

CGT 411
December 2005

Building Blocks

Creating a Presentation for Integral Forming Technology

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ABSTRACT

A quality presentation can drastically improve communication of a new idea. Meaningful visuals greatly improve the perceptions of the speaker, audience attention, audience retention, idea comprehension, and agreement between the audience and the presenter. (Vogel, 1986) This is why Milton Reynolds was so desperate for powerful visuals for his new idea. The idea, Integral Forming Technology (IFT), is a new way to construct buildings. The idea involves prefabricating concrete forms, constructing them on the job site, and finally leaving the forms in place to remain an integral part of the final structure, adding much strength to the building. Having most of the details of his new idea figured out, Reynolds needed a high quality presentation to show investors so he could sell his idea. To solve this problem, Building Blocks Visual Design Studio created animations, a high-quality PowerPoint presentation, and detailed graphics for a brochure. After testing to see if the new presentation was effective on “investors”, the deliverables were given to Reynolds.

INTRODUCTION

“Comprehension of another’s idea is vital to the realization of that idea,” Milton Reynolds believes. Reynolds, retired contractor, had an idea called Integral Forming Technology.

Integral Forming Technology (IFT) is a potentially new way to construct concrete buildings. It may be an effective way of prefabricating concrete wall forms that add to the wall’s strength.

IFT, though a simple process, is difficult to describe. Knowing visual aids would greatly improve the comprehension of IFT. Reynolds came to Building Blocks Visual Design Studio seeking visual aids that he could show to investors to help sell IFT.

To solve the problem, Building Blocks researched IFT and other construction practices. After comprehending the idea of IFT, Building Blocks planned, created, and proceeded to validate three short animations, explanatory still graphics, and a presentation suitable for investors.

PROBLEM STATEMENT

There are no visual aids describing the construction process of Integral Forming Technology being assembled to show investors.

RESEARCH QUESTION

Could Building Blocks visually explain the construction process of Integral Form Technology to investors?

INITIAL RESEARCH I: CURRENT CONSTRUCTION PRACTICES

The first step in solving the question was to develop a complete understanding of Reynolds’ idea. To complete this task, other current concrete construction methods were researched. It was of utmost concern to know all similar construction practices to see how IFT compared. The other methods are pre-cast concrete, temporary prefabricated forms, permanent prefabricated forms, and smartblocks.

Pre-cast Concrete



Figure 1: Pre-cast concrete wall section. Image from <http://www.thermomass.com/construction/tilt.htm>

It is not uncommon for companies to prefabricate walls in a factory and ship the concrete walls to the building site. The heavy pre-cast walls are then erected with a crane while a crew connects the walls to the structure. Successful companies that use a variation of this common method include Royall Wall Systems and Superior Walls of America (Vanderwerf, 1995).

Temporary Prefabricated Forms



Figure 2: Temporary prefabricated form. Image from <http://www.efco-usa.com/EngVer/home.html>

Another common concrete construction method is to prefabricate cast-in-place concrete forms in a factory, ship the forms to the job-site, and erect the forms with a crane (Elliot, 2002). This is unlike the previously mentioned pre-cast concrete, because it is only the form that is prefabricated and not the entire wall.

This method may sound similar to IFT, but these forms are later destroyed or removed after the concrete has cured. This method of construction does not use forms as a structural member, nor are the walls pre-finished immediately after erection.

Permanent Prefabricated Forms

This method uses a prefabricated concrete form that stays in place after construction is completed. However, the form is not used as an integral load-bearing wall member. An example of this construction method is Autoclaved Aerated Concrete, which boasts its speed of prefabrication, large-scale uses, and high insulation values (Vanderwerf, 1995). Reynolds believes that IFT has all of these benefits as well as it uses the forms as structural members, and is totally pre-finished once erected.

Smartblock



Figure 3. Smartblocks. Image from www.smartblock.com

This unique form of construction uses the concrete form as an integral part of the construction, but it lacks the broad range of uses as IFT. Smartblock uses small, stackable, concrete form-blocks as a part of the structural system (ConForm, 2004). The Smartblocks are made of polystyrene, a plastic, and lacks the strength to be used in the large commercial projects IFT hopes to achieve.

INITIAL RESEARCH II: INTEGRAL FORMING TECHNOLOGY

After understanding concrete construction practices, Building Blocks made learning all of Reynolds' written material the top priority. Reynolds was also an available resource to answer any questions about the workings of IFT. Reynolds' patent and rough draft of a brochure on IFT were the only written documents, obtained concerning the IFT process.

IFT uses a factory fabricated and pre-finished cast-in-place form. It is designed for on-site placement of steel rebar and concrete (Figure 4). Once the concrete is poured, the form is left to add to the stability of the structure.

IFT was first conceived as a design to limit the effects of damaging hurricane-force winds and terrorist activity by increasing the exterior strength of each concrete wall (Reynolds, 2005). Currently, IFT's objective is to find the best possible design for both structural sustainability and lessening any external form of damage.

IFT Off-Site Construction

Research has proven steel reinforced concrete to be the most efficient concrete structural system available. Unfortunately, the added cost of on-site rebar placement and formwork has prohibited the use of steel reinforced concrete to only the most expensive of structures (WikiPedia, 2005).

Once implemented, Reynolds believes that IFT would be the most cost-effective way to deliver a steel reinforced concrete structure. IFT could achieve this by constructing its complicated integral forms off-site, in an industrialized atmosphere. Since all forms that leave the factory are completely pre-finished, the cost of on-site work is significantly reduced (Reynolds, 2005). The only on-site work required will include:

1. Connecting the IFT form to the structure.
2. Placing the steel rebar.
3. Placing any wires or plumbing within the wall.
4. Pouring the concrete.

IFT Wall Section

Each side of an IFT wall is made up of a composite product (Figure 4). The wall panel consists of rigid foam insulation, a metal rib lathe, and cement/plaster (Reynolds, 2005).

Directly containing the concrete is rigid

foam insulation. This insulation can be modified to different sizes, depending on the application (Reynolds, 2005).

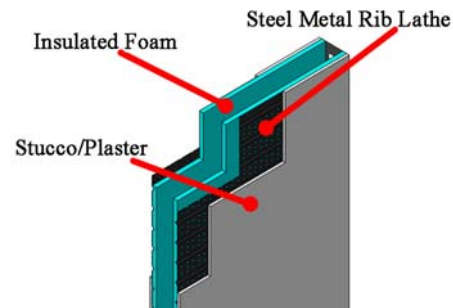


Figure 4. An IFT wall section.

Outside the foam is a metal rib lathe. Once applied, the metal lathe is totally encased in a cement plaster which bonds to the rigid insulation. The lathe/plaster combination forms the strong exterior layer to the wall.

These wall panels are bracketed on both sides by modified steel studs. These steel studs are also placed every 24 inches on center.



Figure 5. Modified steel stud.

The modified steel stud units (Figure 5) are very thin for maximum cost efficiency (24 AWG in some cases), as their only purpose is to temporarily hold the form together. The modified studs have predrilled holes for on-site rebar and wiring placement.

IFT Module

Once the factory has created a complete form, an IFT module is created (Figure 6). This is considered a "5-walled box" with a ceiling form attached.

Four integral form units are attached to form the walls of the box. They are attached using angle clips (*Figure 7*). The clips were designed for simplicity and cost-effectiveness alone (Reynolds, 2005). Reynolds states that future research could uncover a more effective form-attachment method.



Figure 6. IFT modules are created by joining four wall panels and one ceiling form.

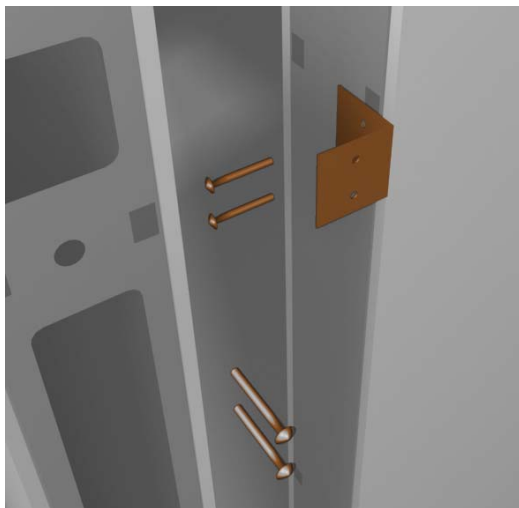


Figure 7. Angle clips are used to join IFT wall sections.

IFT Ceiling Unit

Once the sides are assembled, a ceiling unit is placed on top. The ceiling unit consists of plaster, steel metal rib lathe, and rigid insulation.

For every metal stud, a joist is placed to support the floor/ceiling unit. The gull wing joist was made for this purpose (*Figure 8*).

The gull wing joist was designed to keep a void open for field placement of steel and

concrete (Reynolds, 2005). The void within the joist lines up with the void within the wall section and every other adjacent wall section.



Figure 8. Gull wing joist.

Each wall section will be structurally integrated with each ceiling section where they meet. Steel dowels will be installed at every junction and the concrete will be continuous. These connections are made to be monolithic, so any external force applied to one section will be evenly distributed to every adjacent section (Reynolds, 2005). The performance of this concept is of particular importance during periods of storm like stresses. The gull wing joist allows for this homogeneous interaction (Reynolds, 2005).

To be the most cost effective, IFT requires an easy method of stacking IFT modules. For this reason, the alignment device was designed.

The alignment device has been designed to provide the element of precision necessary to facilitate the ease of stacking (Reynolds, 2005). At higher elevations it is more important to minimize the communication between the crane operator and the flagman. This self-alignment device is to increase the speed and accuracy of erection. Once completed in the factory, these modules are shipped to the job-site for erection.

IFT On-site Installation

Reynolds' imagines IFT Modules being transported on a modified flatbed (*Figure 9*).

The modules would then be lifted off the

flatbed and placed in their proper location on the jobsite using a crane.



Figure 9. Modified flatbed.

Once the module has been set in place, steel rebar is fed through predrilled holes in the “modified steel stud” units.

Hollow metal window casings and door jambs eliminate the need for any additional concrete form work (Figure 3). Forms and gull wing joists are then ready to be filled with concrete.

Building Blocks IFT Paper

Once the concept of Integral Forming Technology was fully understood, a paper was prepared that described the creation, application, and benefits of IFT. The paper was designed with the hope that it could be published in a scholarly journal in the future. The paper was denied by one journal because a working model of IFT does not exist (Bob Mendel, personal e-mail, October 12, 2005).

CREATING AN EFFECTIVE PRESENTATION

Building Blocks needed a way to convey the idea of IFT to investors. The next question was obvious: how should Building Blocks do this? To answer this, research was done.

Visuals in Presentations

To create an effective presentation, the use of good visuals is crucial. There are three areas in particular where visuals can improve presentations (Vogel, 1986). Those three areas are communication effectiveness, audience perceptions of presenter, and speaker’s confidence.

Visuals improve communication effectiveness in numerous ways. By using

visuals, the presentation is able to add another sensory channel to the oral communication process. It is well documented that understanding auditory cues is done in the left hemisphere of the brain, while spatial processing is done on the right side. By using both hemispheres of the brain, the receiver gets a better “whole picture” of what is being communicated (PLU, why use visuals, 1998).

By using visuals, various aspects of communication are improved. It was noted in a University of Minnesota/3M Study that decisions were 12% faster when visuals were used, and the average time of a meeting was 18 minutes with visuals, compared to 26 minutes without visuals (Vogel, 1986).

Characteristic	% Change
Action	43.0
Perceptions of presenter	11.0
Retention	10.1
Comprehension	8.5
Attention	7.5
Agreement	5.5

Table 1. Source: University of Minnesota/3M Study, 1986

Visuals also improve the audience’s perception of the presenter. Presenters that use visuals are considered to be more professional, persuasive, credible, interesting, and prepared (PLU, why use visuals, 1998).

Confidence of the presenter is also improved through the use of visuals. The University of Minnesota/3M study states, “A typical presenter using presentation support has nothing to lose and can be as effective as a better presenter with no visuals. The better a presenter is, however, the more one needs to use high quality visual support.” (PLU, why use visuals, 1998)

Creating Effective Presentations

After multiple studies, the 3M Meeting Network created tips on how to create an effective visual presentation.

- Each visual should be made to make one major point. The theme or idea of

the visual should be clear to the audience (Anthony, 1995).

- The visual should be simple and clean. Make text easy to read and spaced out for quick, easy viewing. Text should be kept to a minimum. Use only one font with upper and lower case letters. Sans Serif fonts are much easier to read than serif fonts when projected (Anthony, 1995).
- Highlight key words and graphics. This brings special attention to the main points of the presentation (Anthony, 1995).
- Use color sparingly. Never use more than three colors on one visual. Colors should be used to contrast, highlight, and differentiate categories. They are also used to call attention to a key idea. It has been found that light-colored text against a dark background is easier to read from a distance than dark text on a light background (Anthony, 1995).

Creating Effective Animations

Video footage in a presentation is an effective form of communication. When creating a video, the footage should be shorter than 60 seconds. Cut down all videos into small clips (Presentation Helper, 2005).

DELIVERABLES

Having established the importance of visuals and using well researched tips on how to create such visuals, Building Blocks was ready to create their product.

Animations

Three animations were created to describe IFT. These animations are to be shown to investors and anyone interested in IFT to get a better understanding of the entire process.

All of the animations were under 60 seconds in length to comply with the research findings on making an effective animation. All three animations were created in 3D Studio Max. The models for the animations were created in both 3D Studio Max and CATIA. Each animation was rendered in both textured and non-textured formats. Originally, a realistically textured format was planned, but research indicated that simpler, non-textured animations may be easier to comprehend, so the second set of non-textured animations was created (Santella 2004). Later, this research was found to be true through the validation stage of the project, and the non-textured animations were chosen for the final deliverable, as described in the validation section.

The picture below (*Figure 10*) shows a screenshot of the first animation, which illustrates an exploded view of a form. This animation is meant to visually describe the materials and construction of an IFT mold.

The second animation is the construction of an IFT module (*Figure 11*). Four walls are put together using angle clips and bolts. Once the 4 walls are joined, a ceiling unit is placed on top.

The final picture shows a screenshot of the third animation, where modules are taken off the module carrier and placed on the jobsite (*Figure 12*). The animation then goes on to show how a one-corridor building can be created with Integral Forming Technology.

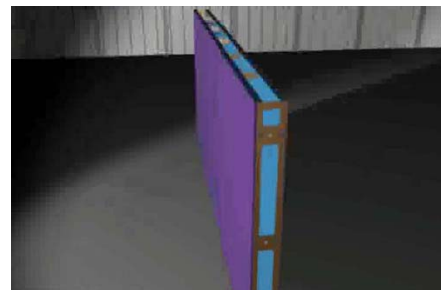


Figure 10. Screenshot from animation 1.



Figure 11. Screenshot from animation 2.

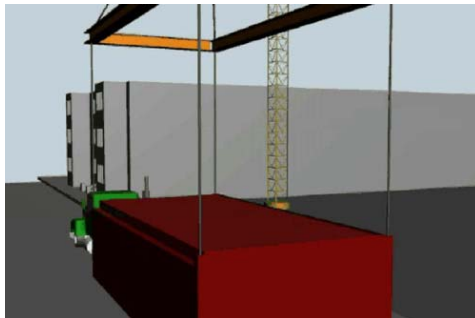


Figure 12. Screenshot from animation 3.

Presentation

These three animations were designed to show each element in the construction of IFT as simply as possible. To present these three animations, the same principle was used.

Building Blocks designed a Macromedia Flash application that contained three buttons, representing the three steps to create an IFT building (Figure 13).

Macromedia Flash was chosen due to its large popularity, as it is enabled on 97.3% of all PCs (Adobe, 2005).

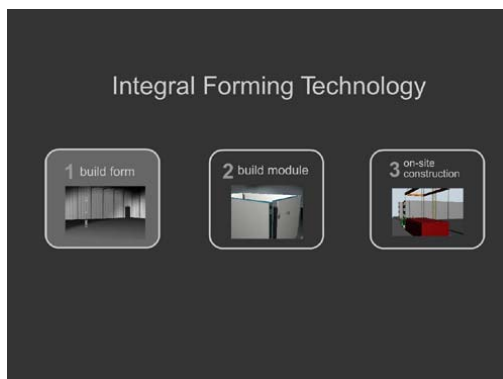


Figure 13. Main menu of Flash application created by Building Blocks.

VALIDATION

With the deliverables completed, Building Blocks was faced with the task of validating their work.

Method

The presentation was designed to be seen by investors. Ideally, to validate the presentation it would be shown to investors, measuring their response. Lacking the time and the means of obtaining real investors for an experimental population, investors needed to be simulated. The best resources available to simulate this group were the management majors at Purdue University. MGMT 411, a management class focusing on “Investment Management” was called upon to test the presentation. This class was composed of undergraduate junior and senior level Purdue University Management students, many seeking a minor in finance.

Three separate MGMT 411 classes were given a 14 question survey that asked questions regarding if they would invest in IFT. (See Appendix A) The questions were multiple choice - with “yes”, “no”, and “I don’t know” as options. A “yes” response was the only answer accepted as effective. Both “no” and “I don’t know” were considered ineffective.

Three separate presentations were to be scored. The first presentation was without the animations. This presentation was created strictly with material from Milton Reynolds and was meant to simulate a presentation Reynolds would have given prior to coming to Purdue. This presentation was our baseline.

The second presentation contained Building Blocks’ deliverable, using *textured* animations.

The third presentation contained Building Blocks’ deliverable, using *non-textured* animations.

To show these three presentations to three separate experimental groups, a “loop design”

method was used to perform the study, shown in Table 2. Each of the three classes was shown two of the three presentations, and each presentation was shown two times.

Class	First presentation shown	Second presentation shown
1	Old	Textured
2	Textured	Non-Textured
3	Non-Textured	Old

Table 2. "Loop" design method.

The benefit of this loop design is that it allows for control of class, presentation, and order. If only one presentation was shown to a single class, the data would be generated by only one class which could have a particular unaccounted for bias and thus not give a quality sample. By giving each presentation twice, where each presentation is given before another presentation and once after a presentation, it rules out the chance that any presentation had an advantage (Tyner, 2005).

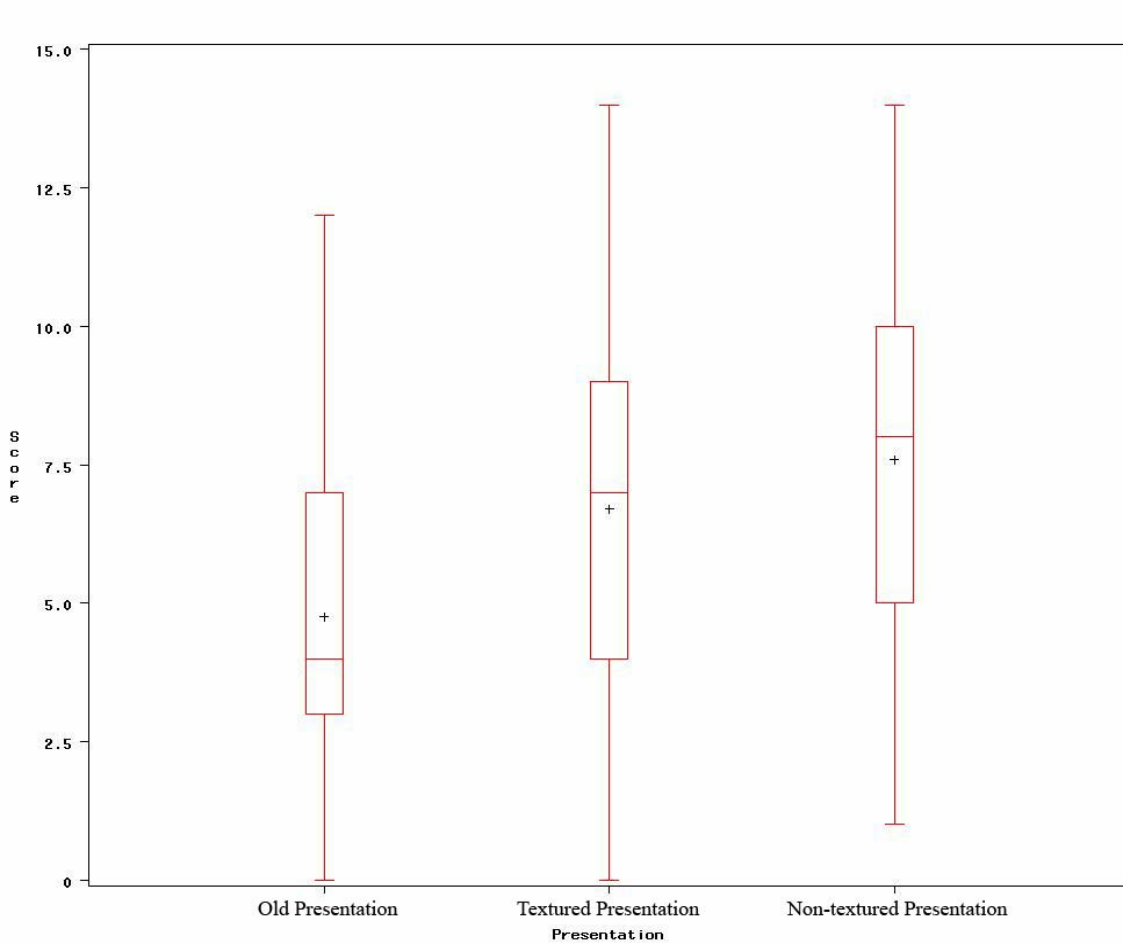


Figure 14. Box plot of average "Yes" responses per presentation.

Results

Compilation of the survey results concluded that the new presentations were

much more effective than that of the baseline presentation. The sample size consisted of 132 students. Of the two

animation-oriented presentations, the presentation with non-textured animations scored better. This result supported the previous research that stated non-textured animations were better communicators.

The original presentation averaged about 5 yes responses. The non-textured presentation received about 7.5 yes responses. This results in approximately a 17% increase in yes responses compared to the old presentation.

Presentation	Average "yes" responses
Old	5.28
Textured	6.71
Non-Textured	7.65

Table 3. Average "Yes" responses per presentation.

The presentation averages were statistically significant according to Type III

sum of squares (Table 4). The P-value for the presentations was .0123, well under the often suggested .05. The order the presentations were given was not statistically significant. The P-value for order was at .2672. The classes were also not statistically significant with a .4062 P-value.

Variable	Type III SS	P-Value
Class	.4062	
Order	.2672	
Presentation	.0123	

Table 4. P-value chart.

These P-values claim that the amount of "yes" responses is not dependent on what order the presentation was given and was not affected by which class the presentation was shown in.

Means 95% Confidence Intervals

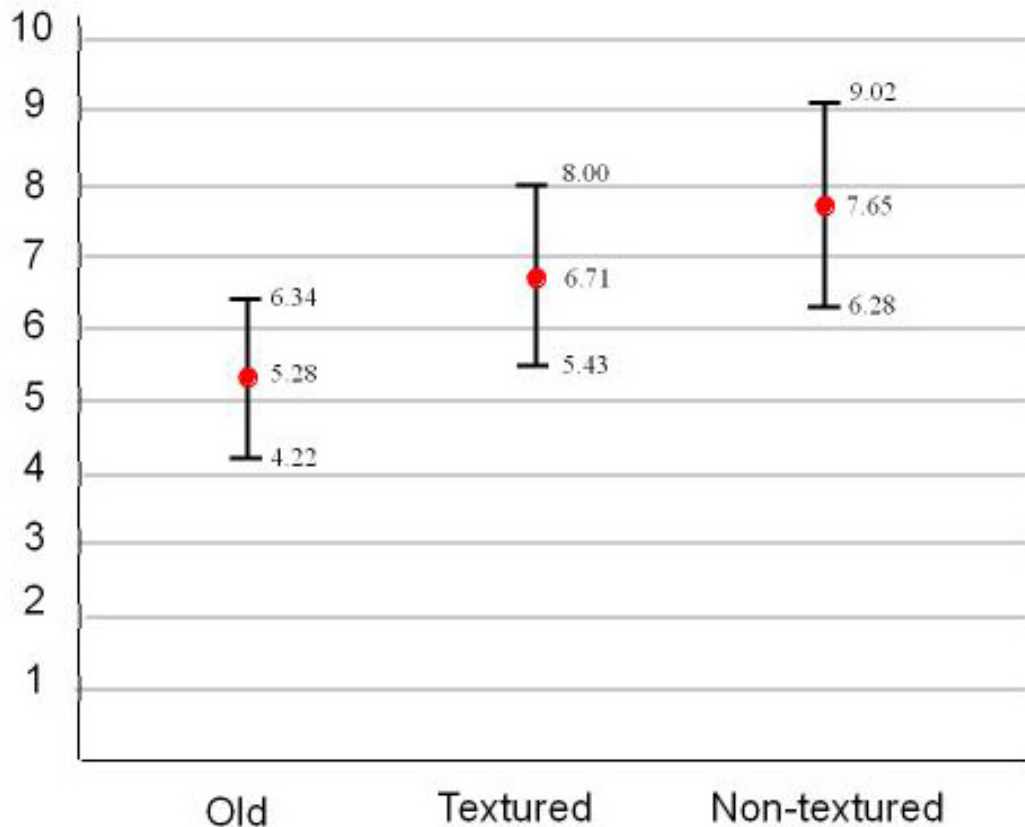


Figure 15. Mean 95% confidence intervals.

The 95% confidence intervals show very little overlap between the old presentation and the non-textured presentation. This is more proof that the non-textured animation presentation was significantly more efficient than that of the old presentation.

CONCLUSION

As expected, a presentation created with helpful visuals proved to be more effective than without.

It has been found in previous research, such as the University of Minnesota/3M study in 1986 that graphics drastically improve various aspects of sending a clear message to an audience. Attention, comprehension, and perception of the suggests that yes, Building Blocks was indeed successful in effectively communicating IFT to a simulated group of

speaker are just a few characteristics that improve by inserting graphics into a presentation.

Non-textured animations were the most effective in getting positive responses on IFT. This supports previous research done in the field of communicative visualizations.

It is strongly advised that future tests be done with actual investors. It would be interesting to see if the results were duplicated.

So, did Building Blocks visually explain the construction process of Integral Form Technology to investors effectively? The data collected through the validation

investors. Because after viewing the animations more people said they would in fact invest in IFT.

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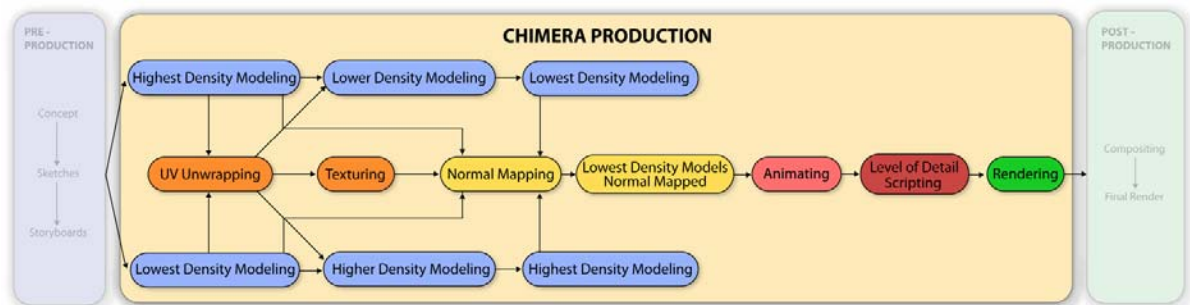
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Appendix A – MGMT 411 Survey

Circle the best answers:

1. Does Integral Form Technology solve a problem?
Yes No I don't know
2. Is Integral Form Technology better than alternative construction methods?
Yes No I don't know
3. Could Integral Form Technology change the world?
Yes No I don't know
4. Could Integral Form Technology be used to form a \$100-million-size company?
Yes No I don't know
5. Is Integral Form Technology worth investing in?
Yes No I don't know
6. Are you compelled you to invest in Integral Form Technology?
Yes No I don't know
7. Are you compelled to tell others about Integral Form Technology?
Yes No I don't know
8. Did the entrepreneur (who spoke in the video) demonstrate a contagious excitement about his vision for Integral Form Technology?
Yes No I don't know
9. Did the entrepreneur prove he has the stamina and willpower to stay with his vision through thick and thin?
Yes No I don't know
10. Do you think the entrepreneur is willing to reevaluate and refocus his plans when things don't work out as anticipated?
Yes No I don't know
11. Do you think the entrepreneur is willing to invest enough of his own money into this project to convince investors he's serious?
Yes No I don't know
12. Do you think the entrepreneur has a background that is rich and impressive in the construction industry?
Yes No I don't know
13. Does the entrepreneur seem coachable, or does he seem to know everything he needs to know to succeed?
a.) He seems coachable
b.) He seems to know everything he needs to know to succeed
c.) I don't know
14. How long will it be until the market will recognize and embrace Integral Form Technology?
a.) Less than 5 years
b.) More than 5 years
c.) Never
d.) I don't know

Chimera: A Hybrid Pipeline for Film and Broadcast Animation Production



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Abstract

Small production houses in the film and broadcast animation industry lack the resources to render complex 3D scenes which require massive data sets. Consequently, time and money is wasted on hodgepodge techniques that look less convincing. Chimera, a hybrid animation production pipeline, combines normal mapping and level of detail to drastically improve run-time rendering performance while maintaining perceived visual quality. As a result, small production houses can render animations that look more detailed using software and hardware they already own.

1. Introduction

There is a tremendous need for the development of a production process to manage and render extremely large data sets (Cohen, 2005). While research-oriented visualization science has produced techniques and procedures for manipulating and rendering huge quantities of data, the migration of this technology to practitioners' tool sets has been slow or nonexistent. For example, radiosity was invented in 1984 at Cornell University (Coral, Torrance, & Greenberg, 1984) and saw widespread use in the scientific visualization field by the late 1980s, but did not appear in commercial animation packages until a decade later. The same pattern can be repeatedly observed with computer graphics techniques such as subdivision surfaces, UV mapping, and so on. With respect to the development of novel rendering techniques, this lag time between research in academia and implementation in industry represents a discrepancy with potentially significant economic consequences.

An important example of this discrepancy exists between the data management and rendering techniques used for film and broadcast animation, and real-time interactive 3D techniques used to render massive data sets. When producing animations for film and broadcast, it is common practice to render animations in layers (such as background and foreground elements, specular and diffuse maps, etc.) and composite them to create the final frames; all of

the elements seen on a final frame are not rendered simultaneously. One purpose of this technique is to reduce the computational expense of rendering the massive amounts of data required to produce a completed image. People working in the field of 3D interactive graphics have taken a very different approach. By using techniques such as normal mapping and level of detail, they have been able to manage and render large data sets in an efficient manner for real-time rendering (Shaffer & Garland 2005).

Surprisingly, there has been little or no cross-pollination between these groups. This paper proposes a software- and hardware-agnostic production pipeline called Chimera which enables production houses in the film and broadcast animation industry to manage and render massive data sets using a single off-the-shelf computer.

Chimera applies contemporary real-time rendering techniques to traditional film and broadcast animation production. It can be implemented on setups as small as one off-the-shelf computer, though it is flexible enough to easily be expanded to larger production environments. The techniques combined to form this pipeline, along with the rationales for doing so, are described in Section 4.

A metric for comparing rendering techniques was devised and used to measure the visual quality and performance of Chimera. The experimental design and analysis of this metric is described in Section 5.

Discussion of the benefits of Chimera versus other rendering techniques can be found in Section 6.

2. Key Terms

A **massive data set** is one that is so large and complex that existing methodologies, tools, and technologies can't cope with it readily (Kettinger, 1998). A **manageable data set** is one just beneath the threshold of the massive data set. If a 3,500,000 polygon count is determined to be massive, then 3,499,999 is its manageable equivalent.

Off-the-shelf, for the purposes of this paper, refers to software and hardware that can be purchased or acquired freely without extensive customization. Proprietary software or hardware is not included.

A **production pipeline** can either refer to the software and hardware processes and techniques used to render computer graphics or the various theories of professional role delegation when creating computer graphics in a team environment. This paper refers to the former definition.

Real-time rendering refers to interactive computer graphics outputted immediately to a viewing device, while **run-time rendering** refers to the process of computing a 3D scene in animation software and storing the results on hardware or media for later processing or viewing.

3. Problems

Compared to large visual effects companies, small- to mid-sized production houses in the film and broadcast animation industry face very different kinds of problems. Specifically, smaller production houses must get by with substantially fewer computing resources and manpower than their larger, better-equipped competitors. With respect to production pipelines, small production houses deal with at least three kinds of issues: hardware costs, model complexity, and pipeline secrecy.

3.1 Hardware Costs

By definition, massive data sets require immense computing power to be adequately managed. Large production houses address

this problem with server farms or hundreds of networked workstations. For example, Weta Digital, Ltd., a Wellington, New Zealand-based production house, built a server farm of 3,200 processors to produce the visual effects seen in the *Lord of the Rings* films (Mitchell, 2004). Industrial Light & Magic's new facility in San Francisco, CA boasts over 3,000 networked processors (Scanlon, 2005). The cost of this equipment, not including setup, maintenance, and customization, numbers in the millions of dollars. Smaller production houses lack this budget, and must rely on other strategies to render their animations. To cut costs, some small companies have outsourced their rendering needs to brokers like Hewlett-Packard's utility rendering service ("HP and Alias," 2004) and IBM, through RenderRocket. The cost of these services is typically calculated per CPU-hour. When individual frames of an animation can require 90 CPU-hours or more to render, the 50- to 60-cent cost per CPU-hour quickly adds up (Borland, 2005).

Alternately, small production houses may heavily rely on compositing to work around massive data sets. One type of compositing involves the process of rendering multiple elements of a sequence separately as layers and combining the layers into a finished frame. The contents of these layers may range from digital background plates to filmed miniatures. Compositors may also create the illusion of continuity by "stitching" together many short clips into one long sequence. Because each clip is rendered separately, a kind of digital "sleight-of-hand" must be employed to disguise the transitions between short clips and make the long sequence look uninterrupted. For example, a Powers of Ten animation which begins in outer space and zooms into a building on Earth's surface may use clouds and other distractions to hide the changes from shot to shot. If not executed properly, this process may lack the elegance and natural appearance of a truly continuous animation. Moreover, these compositing tricks force small companies, already heavily restricted by their budgets, to add compositors, compositing tools, and additional steps to an already complex pipeline. With the cost of real-time compositing solutions beginning at \$100,000 per unit ("Discreet Delivers," 2003), it

is in small production houses' best interest to reduce compositing needs whenever possible.

3.2 Model Complexity

The off-the-shelf software and hardware used by small production houses typically cannot handle massive data sets with many complex models. Preliminary tests for this paper revealed that an off-the-shelf computer running Alias Maya 7 can load about three million polygons into a scene before the program crashes. For modelers or animators to effectively manipulate the data for any task besides rendering requires even less complex scenes than this. Thus, artists are limited by their software and hardware in the amount of detail they can add to models and textures. Yet, expectations of quality remain high, as small production houses often produce special effects for such widely-seen venues as television commercials and films (Dolbier & Megler, 2005). "Audiences who have seen Pixar's best work, many of whom have logged hundreds of hours inside beautifully rendered video game worlds, are brutally critical of shortcuts" (Borland, 2005). To meet the demand for realism and detail, these companies must settle for lower resolution textures and models that don't look as good, or more often, compositing tricks which increase pipeline complexity at the expense of visual continuity.

3.3 Pipeline Secrecy

Reliable, publicly-available information on animation production pipelines is extremely limited. The dearth can be attributed to intellectual property claims within the animation industry. With several large companies releasing animated features each year and countless smaller production houses competing for contracts, all specific processes and techniques are considered competitive advantages. No books have been written about animation production pipelines, though snippets of specific processes can be garnered from "making of" featurettes found on some DVDs. In addition, there seems to be no "industry standard" or generic production pipeline; experts familiar with the industry claim that every company does things their own way (Bettis, 2005). As a result, information on production pipelines can typically be gleaned

only from non-academic sources such as company press releases, news articles, and trade magazines.

4. Chimera

Chimera is a publicly-available hybrid production pipeline designed to primarily benefit smaller animation houses which lack super-computers or render farms and extensively customized proprietary software. To address these specific needs, Chimera is software- and hardware-agnostic, though for the purposes of this research it has been implemented on an off-the-shelf desktop computer running Alias Maya 7. It consists of two main components working in concert: normal mapping and level of detail. By marrying techniques typically associated with real-time rendering with traditional techniques for animation production, Chimera enables smaller production houses to produce animations using massive data sets.

Chimera allows for two possible production workflows, depending on the needs of its user (see Appendix A). One option is to work from high polygon models, such as laser-scanned models, and simplify the models incrementally using a progressive mesh or CLOD algorithm. The other option is to work from a simple base mesh and continually add detail to the model until a sufficient level of complexity is reached. Once the models are created, UV unwrapping must occur to ensure that the models' textures are comparable. Normal maps can then be created from the high polygon models and mapped onto the low polygon models. Once the low polygon models are mapped they can be placed in the scene. The user can now animate and prepare the scene for rendering. The last step before render is to set up the level of detail script. The user can then render the scene.

The benefits of normal mapping and level of detail are briefly explained in Sections 4.1 and 4.2, respectively. Section 4.3 describes the reasons for combining the two techniques, and Section 4.4 outlines the development process for Chimera.

4.1 Normal Mapping

Normal mapping is a type of bump mapping first introduced at SIGGRAPH 1996 (Krishnamurthy & Levoy, 1996). One application of

normal mapping permits 3D models with low polygon counts to appear more detailed and complex by instructing the renderer to replace the model's surface normals, resulting in more detailed shading (Cignoni, Montani, Rocchini, & Scopigno, 1998). The normal map itself is a 2-dimensional texture with normal information encoded in the red, green, and blue (RGB) color channels of the image. Animators can generate a normal map from a high polygon model and apply it like any other texture to a low polygon model. The calculations required for producing the normal information are "baked" into the normal map so the renderer needs not calculate them again at render time. A normal-mapped low polygon model can appear highly detailed but the actual polygon count and rendering time can actually be decreased. Dan Prochazka, Product Manager for 3D Animation Software at Discreet, echoes these advantages:

The primary benefits of normal maps are time-savings in rendering and the ability to fit more objects into a scene because everything can be at a much lower resolution. So, you don't have to worry if your pipeline can't deal with massive data sets — with normal maps the eventual output is the same as it would be if everything in-scene was at an incredibly high resolution.

(Moldstad, 2004, para. 3)

Normal mapping has been embraced for interactive and real-time computer graphics applications, particularly gaming and virtual reality, because normal mapping permits highly detailed images to be generated from very low polygon models. In real-time rendering, visual quality often comes second to frame rate and performance; 15 to 30 frames per second are required for acceptable interactive navigation (Constantinescu, 2000). However, normal mapping has not received equivalent attention from the film and broadcast animation industry because off-the-shelf animation packages did not come equipped with tools to easily generate normal maps until very recently. The newest versions of industry-standard animation packages such as Discreet 3D Studio Max, Alias Maya, and SoftImage XSI have been furnished with normal mapping capabilities in response to, and resulting in, increased interest in the

benefits of normal mapping technology. Pixologic zBrush, a 3D modeling package, has popularized normal mapping by generating normal maps from extremely complex models created in the software and exporting lower polygon models that look comparable.

4.2 Level of Detail

Level of detail (LOD), another concept borrowed from real-time and interactive computer graphics, has been employed since the 1970s (Heok & Daman, 2004). LOD refers to the process of swapping among several versions of the same base model depending on predetermined importance criteria. One application of LOD relates to a model's distance from the virtual camera in a 3D scene. For example, a low resolution version of the model is displayed when the model and camera are far away from each other, and higher-resolution versions of the model are displayed as the distance between the model and the camera decreases. Other techniques for LOD selection include size, eccentricity, depth of field, velocity, fixed frame rate, and culling (Constantinescu, 2000). Computing performance can be improved by using low detail models in a scene when their details are unlikely or impossible to be perceived by the human viewer.

Two level of detail frameworks include continuous level of detail (CLOD) and view-dependent level of detail (Heok & Daman, 2004). CLOD employs an algorithm to automatically reduce polygons via a multiresolution or "progressive" mesh (Hoppe, 1996). In some user-controlled manifestations, this process benefits from being extremely easy to use; an animator need only specify the starting and ending polygon resolutions and the CLOD algorithm takes care of the rest. The result boasts superior fidelity; however, the computation required to interpolate polygon resolution at each frame is expensive.

While a variety of CLOD algorithms have been written, few have been ported from an academic context to work with off-the-shelf animation packages. In addition, industry professionals have been hesitant to adopt academic LOD algorithms. At the 2003 Game Developers Conference in San Jose, CA, Robert Huebner of Nihilistic Software described some of the big-

gest problems of integrating academic LOD algorithms into his company's pipeline. Most studies pay little attention to the effects of vertex shading, texture, and UV coordinates, which are priorities for game developers. He also found that most algorithms could not maintain data in a format that computer hardware could process directly, for maximum performance gains (Huebner, 2003).

An alternative to CLOD, view-dependent level of detail, works by swapping different versions of a model based on the virtual camera's "view." Human perception generally can not discern between a low detail and high detail model at a certain distance, though this threshold is dependent on many factors including model shape (geometric, organic, animal, man-made, etc.), model complexity (Watson, Friedman, & McGaffey, 2001), and the actual distance from the camera. The term "popping" is used to describe the undesirable situation where a model swap is noticed by the viewer, but with care popping can be minimized or altogether avoided.

In real-time applications that use view-dependent level of detail, the rendering engine must "guess" when to swap models. This decision is usually based on a formula that considers model importance, proximity to the active camera in the scene, and other factors. The lack of human input in this process means that popping frequently occurs; thus, this kind of LOD by itself is unsuitable for most run-time rendering applications, such as film and broadcast animation production, where popping is not acceptable.

Fortunately, run-time applications, by definition, need not be rendered immediately and adjustments can be made by animators. Human-calibrated LOD is more time-consuming but can be fine-tuned to eliminate popping. Animators can choose how many levels of detail they wish to use as well as when each model can be swapped out. This is typically done by importing several versions of a model into a scene and keying the visibility of each version to allow each to appear and disappear at various points throughout the animation. The process is tedious, requiring substantial trial-and-error on the part of the animator, and the presence of several versions of each model in a scene exponen-

tially complicates the process. Without scripting to aid the process, even human-calibrated LOD is impractical for run-time rendering scenes with advanced camera movement and more than a few different models.

4.3 Combining Normal Mapping and Level of Detail

While both normal mapping and LOD have been extensively proven to improve performance for real-time rendering, their adoption for run-time rendering for film and broadcast animation has been hindered by technological barriers. Until recently, normal mapping was difficult or impossible to implement at run-time using off-the-shelf animation packages. LOD, while adequate for interactive 3D animations where popping is acceptable, is too slow and clumsy to implement in run-time animations where human calibration is the only feasible option for achieving continuous sequences.

Normal mapping and LOD have been successfully married for interactive 3D applications. Hoppe produced one such interactive demo using progressive meshes based on his SIGGRAPH 2001 paper (Sander, Snyder, Gortler & Hoppe, 2001). Chimera transfers these ideas to the realm of run-time rendering for the purposes of managing massive data sets.

4.4 Development Process

The first step in developing Chimera was the acquisition of a sample massive data set. Stanford University's collection of 3D-scanned models proved to be an invaluable source of complex models appropriate for academic research. These models feature extremely high detail—many with hundreds of thousands of polygons—and a variety of intricate surfaces. They are free for academic use, enjoy a long history of use in computer graphics research, and quickly provided this research with a variety of model types.

After examining many professional animation packages, Alias Maya 7 was selected as the off-the-shelf animation package to be used for this paper primarily because of its ubiquity in industry, especially at smaller companies that can't afford to write their own animation software (Goldman, 2001). "Maya is the absolute, undisputed industry-standard in 3D animation

software,” said Adam Yaniv of Rhythm & Hues, a Los Angeles, CA-based production house (“Vancouver,” 2005, para. 7). Maya enjoys a large user community with plenty of support and interest. More practically, researchers in this study were most familiar with Maya as compared to other packages and could develop in the software most easily.

A workstation in Purdue University’s Department of Computer Graphics Technology served as an off-the-shelf computer for this paper. The workstation, a Dell Optiplex GX280, includes a 3.2 GHz Pentium 4 processor, 1 GB of RAM, dual 160 GB SATA hard drives, and an nVidia Quatro 7800 video card.

Erik Pojar’s Progressive Mesh plug-in was initially selected for Chimera’s LOD computation (Pojar, n.d.). One of the only open-source, freely available CLOD plug-ins for Maya, the Progressive Mesh plug-in is derived from the QSlim algorithm (Garland & Heckbert, 1997), whose quadric error metric (QEM) is one of the best available for baseline simplification (Heok & Daman, 2004). It features a straightforward GUI and allows animators to “paint” on each progressive mesh which areas should be priorities for retaining detail and complexity. While the Progressive Mesh plug-in performed well on individual frames, it was soon discovered that an off-the-shelf computer could not render animated sequences of frames with this algorithm without crashing. The calculations required for polygon reduction from frame to frame was simply too processor-intensive.

The Progressive Mesh plug-in was not completely abandoned for this paper; surprisingly, it provided functionality that greatly assisted the efficiency of normal mapping portion of the Chimera pipeline. Chimera permits modelers to adopt one of two possible modeling techniques. A modeler may begin with a low polygon model, preserve this version, and add details until a high polygon model is created. Alternately, a modeler may begin with a high polygon model and use a CLOD algorithm to produce a low polygon model. In this case, the Progressive Mesh plug-in allowed modelers to start with a high polygon model and easily create additional versions of that model at any specified level of detail, simply by adjusting a “resolution” slider in the plug-in. Since all mod-

els are derived from the same base model using this technique, their UV coordinates remain aligned. Modelers can then use these models to create normal maps. This process is a substantial time-saver over manually reducing polygons, or creating a new low polygon version from scratch and attempting to align UV coordinates by hand.

Since the Progressive Mesh plug-in was too computationally taxing for the LOD portion of the Chimera pipeline, a more efficient method was necessary. View-dependent LOD frameworks change model complexity less often and are therefore less processor-intensive. No user-controllable view-dependent LOD plug-ins for Maya could be found, so one was developed from scratch in the form of a MEL script (see Figure 1).

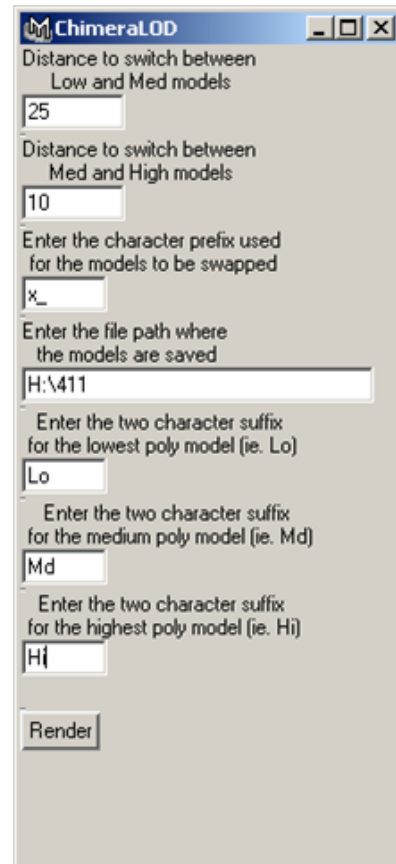


Figure 1. MEL script GUI.

The MEL script dynamically swaps models and textures at run-time at user-specified distances. To address the issue of multiple versions of each model in the scene consuming

excessive resources, versions that are replaced are unloaded from memory. While this implementation is coarser than a CLOD algorithm, it adequately reduces the massive data set by only loading complex models into memory when viewers will appreciate the detail. A GUI within Maya allows the user to input camera distances for each level of detail transition, as well as prefixes and suffixes to associate different versions of each model.

The script must be fine-tuned or “calibrated” by the user to ensure models switch at the proper threshold; that is, soon enough that there is no popping, but late enough that computer performance is improved by rendering low-detail models whenever feasible. Human calibration is an unfortunate necessity until research reveals a perfect formula or ideal threshold for calculating level of detail transitions (Pajarola & Rossignac, 2000).

5. Metrics

Changes in rendering techniques can dramatically affect the visual quality and performance of an animation, so both variables must be measured to draw meaningful conclusions. Two visual tests and a performance test were designed to measure how Chimera compares to other rendering techniques.

Many possibilities exist for measuring visual quality. The visual tests in this paper measure similarity, which is “imperative” for applications like movie special effects (Lindstrom, 2000, p. 103), in terms of perceived detail. Because film and broadcast animations are produced primarily for aesthetic reasons, human visual perception of similarity is a more appropriate metric than computed comparisons with tools like Metro and MeshDev, even though perceived similarity is more difficult to accurately measure (Luebke, 2001; Watson, Friedman, & McGaffey, 2000). For the purposes of this paper, what people perceive as looking similar is more important than what is geometrically similar.

5.1 Visual Test 1 (Ranking)

Purpose. The purpose of the ranking test was to compare animations rendered with Chimera, normal mapping, LOD, or traditional high polygon models in terms of similarity. The hy-

pothesis was held that participants would find normal mapping and Chimera to look the same, while LOD would look less detailed. The results of this paper would then permit a comparison of normal mapping and Chimera’s performance. The experiment design is based on visual fidelity preference measurements for LOD still images (Watson, Friedman, & McGaffey, 2001), but the addition of a time variable dramatically altered the requirements of the instrument design. Greg Francis of Purdue University’s Department of Psychology was consulted to validate the changes with respect to the experiment’s goals.

Method. Twenty three undergraduate students, mostly freshmen, participated in the proctored experiment. All of the students had some familiarity with computer graphics and basic knowledge of 3D animation practices. An unproctored, identical version of the experiment was made available on the Web to collect the maximum number of responses, which were categorized separately. In total, 778 proctored and 1,615 unproctored data points were recorded.

Participants were shown two still images juxtaposed on a computer screen in a forced dichotomy scenario. They were asked to use the mouse to click on the image which seemed to have more detail. The computer recorded which image was chosen (the “winner”) and which was not chosen in a database. The participant would then be shown another comparison and asked to perform the same task again. Proctored participants were asked to make at least twenty comparisons; unproctored participants could make as many or as few as they liked. To avoid prejudicing the results, participants were not told what the test measured or what each image represented.

The images shown to the participants were highly varied to acquire a breadth of data points. Three 10-second animations were used, featuring three different models—the bunny, Buddha, and dragon from Stanford University’s repository. Each of the three animations was rendered using Chimera, normal mapping, LOD, and high polygon models for a total of twelve animations. For this test, Chimera and LOD swapped models twice: from 0.5% to 2% polygon resolution at frame 75, and 2% to 5%

polygon resolution midway at frame 150. The normal mapped models maintained 5% polygon resolution throughout the animations. A standard template was used for all the animations: the virtual camera in the scene would be positioned far away from a single model so that it could barely be seen; the camera would then zoom in towards the model until it nearly filled the entire frame; the camera would then rotate 360° around the model to capture a variety of angles. To avoid confounding variables, the models were untextured except for normal maps (where applicable) and the scenes were solid black with default lighting. Participants were shown a randomized frame (1 through 300) of one of the models rendered with two randomized techniques which were always different from each other. The model type was also randomized for each comparison.

Results. Figure 2 depicts the results of the ranking test. Each rendering technique’s comparative win percentage (i.e., wins vs. total comparisons) is displayed on the y-axis. Proctored and unproctored results were calculated separately and averaged.

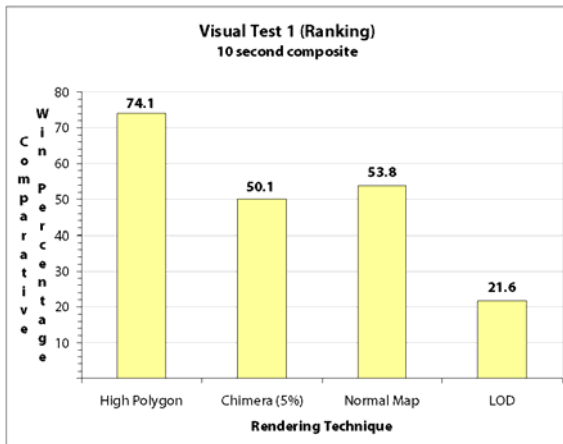


Figure 2. Ranking test results.

Statistical analysis showed that no significant difference exists between the animations rendered with Chimera and normal mapping, regardless of camera position. In addition, animations rendered with LOD lost comparisons to the other techniques almost all of the time. These results confirm the stated hypothesis that normal mapping and Chimera look the same, but it remained unclear how these techniques compared to high polygon models. In

this test, high polygon models won comparisons to the other techniques at close frames (greater than 150) almost three-fourths of the time. However, the high polygon models were composed of 95% more polygons than the other techniques. Before performance data would be relevant, another test was necessary to determine if Chimera (and its statistically similar partner, normal mapping) could be made visually comparable to high polygon models.

5.2 Visual Test 2 (Preference)

Purpose. The purpose of the preference test was to compare animations rendered with Chimera at different levels of detail to traditional high polygon models. The ranking test revealed that high polygon models looked more detailed than Chimera models at close frames when Chimera’s polygon resolution was 5% of the high polygon models. However, it was possible that the two techniques would be visually comparable when Chimera’s polygon resolution was higher than 5%. The hypothesis was held that at some polygon resolution greater than 5%, Chimera would be visually comparable to high polygon models.

Method. This experiment was conducted via the Web to collect the maximum number of responses, with participants solicited from Purdue University’s Computer Graphics Technology listserv. Most subscribers to this listserv are faculty, alumni and current students of Purdue University’s Department of Computer Graphics Technology, so it can be assumed that many of the participants were familiar with computer graphics and had basic knowledge of 3D animation practices. In total, 645 data points were collected.

The testing procedure of the preference test was identical to that of the ranking test, with a few important exceptions. In this experiment, Chimera was visually compared to high polygon without level of detail transitions. This setup permitted an analysis of Chimera at a constant level of detail throughout each animation, thereby identifying a time threshold for when (if ever) Chimera surpassed high polygon models. Chimera animations were rendered at polygon resolutions of 5%, 10%, 25%, and 50% of the high polygon models. The 5% polygon resolution animations served as the control in this

experiment; the ranking test revealed that participants would choose high polygon models over Chimera at 5% polygon resolution almost all the time. Animations rendered with normal mapping or LOD were not included in the preference test.

Results. Figure 3 illustrates the detailed results of the preference test. Each point represents a “win” for that particular polygon resolution compared to one of the others (the comparison always pits a high polygon “control” against a version of Chimera). Thus, more points at a given polygon resolution over a par-

ticular time frame indicate the participants’ preferred polygon resolution for that time frame. The graph is divided into three regions representing three level-of-detail changes (5%, 10%, and 25%). Relationships between polygon resolution (on the y-axis) and time (on the x-axis) indicate how camera distance affects a participant’s ability to discern one technique from another. The results reflect a composite of wins for all three model types. Figure 4 presents the same results with the time variable omitted.

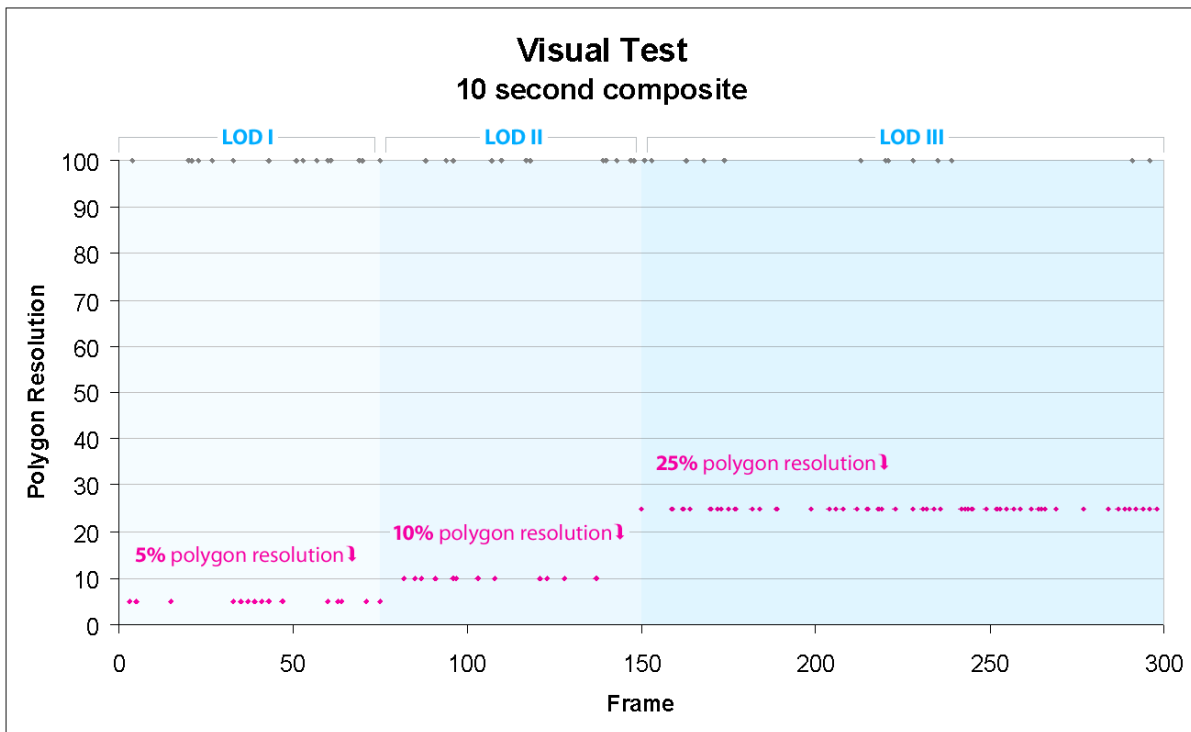


Figure 3. Detailed preference test results.

Results of the preference test revealed that at no point in the animations did participants consistently prefer high polygon models over Chimera. At times when the virtual camera in the 3D scene was far away from the model, participants chose either technique about half the time. As the camera moved closer to the model and participants could perceive more details, Chimera was preferred more often and high polygon models were preferred less often. At very close frames (greater than 250), Chimera won comparisons to high polygon models almost all the time. The difference in preference

was most drastic when Chimera’s polygon resolution doubled from 5% to 10% of the high polygon models, and in fact was not much different from the results at resolutions of 25% and 50% of the high polygon models. Resolution, rather than camera distance, played a greater role in changing preferences from high polygon models to Chimera. With Chimera established as equivalent or superior to high polygon models in terms of perceived detail, a performance test comparing the two techniques in terms of rendering time could be conducted.

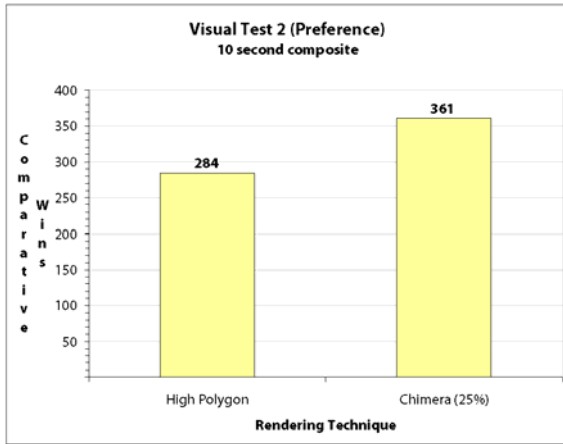


Figure 4. Preference test results sans time.

5.3 Performance Test

Purpose. The purpose of the performance test was to compare each of the four rendering techniques—Chimera, normal mapping, LOD, and high polygon models—in terms of their rendering time, or how much computational processing was required to produce a sequence of frames for a given animation. The starting point for the animation in the performance test is a massive data set in the form of a highly complex scene with multiple models and extensive camera work. The hypothesis was held that Chimera would require the least rendering time, with LOD, normal mapping, and high polygon models requiring incrementally more rendering time.

Method. A 3D scene consisting of a massive data set was constructed in Maya to be used in the performance test. To create a massive data set, high polygon models were imported into the scene until Maya crashed. Then the scene was recreated with one less model than the number which caused Maya to crash. In Maya using an off-the-shelf computer, a massive data set which crashed the program was determined to be about 3.25 million polygons, while a manageable data set, meaning the maximum number of polygons Maya could handle without crashing, was defined as one less model than the massive data set, approximately 3 million polygons. A virtual camera was set up in the scene similar to that of the visual tests. Models in the scene were dispersed so that some would be directly in the line of sight of the camera while others would be located peripherally, behind, or in front of the camera's

focus. The goal of this setup was to simulate a practical situation in broadcast or film animation where a massive data set would be used; for example, a camera zooming into a group of figures or vehicles moving across a landscape.

The scene was rendered using each of the four rendering techniques, with maximum polygon resolution capped at 25% of the high polygon models, as with the preference test. For consistency, the animation was limited to 10 seconds (300 frames) in length. For this test, Chimera and LOD again swapped models twice: from 5 to 10% polygon resolution at frame 75, and 10% to 25% polygon resolution midway at frame 150. Performance was measured in terms of rendering time; i.e., how much time it took to completely render all 300 frames of the animation from start to finish.

Results. Results of the performance test are displayed in Figure 5. Normal mapping required the least amount of rendering time, while high polygon models required the most. The hypothesis that Chimera would perform the best was rejected. Some useful generalizations of these results can be made. In terms of rendering time in highly complex scenes with multiple models and extensive camera movement, Chimera, normal mapping and LOD dramatically outperform high polygon models. Furthermore, the performance of Chimera, normal mapping, LOD performance is clustered at around 6 minutes, whereas, high polygon performance is much worse at over 50 minutes. In summary, the high polygon models rendered much slower than any of the other techniques.

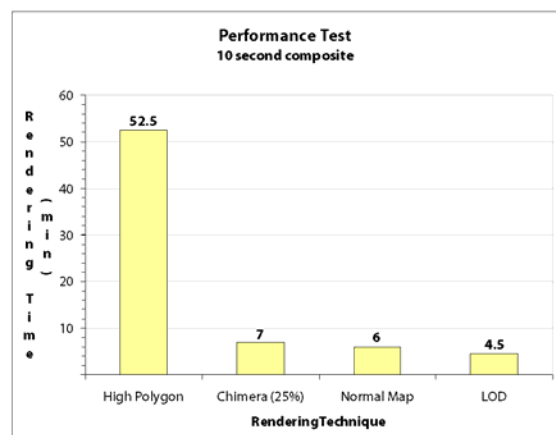


Figure 5. Performance test results.

6. Discussion

6.1 Surprises

The results of both the visual tests and the performance test were surprising. The ranking test set the stage for the hypothesis that high polygon models would always look more detailed than other techniques, yet the preference test revealed that this is not always the case. The preference test showed that when the distance between the virtual camera in a 3D scene and the model is large, participants can not discern between high polygon models and Chimera at any level of detail. This is expected; when models look very small, it is difficult for the human eye to detect minute differences. However, as the distance between the camera and the model decreased, Chimera not only caught up to high polygon models in terms of comparative wins, it actually surpassed it by a significant margin. Equivalent preference between Chimera and high polygon models would seem to make sense because the Chimera model has much less actual detail and complexity than high polygon models; at close frames, Chimera had 75% fewer polygons. It seems that normal mapping more than compensated for the decreased resolution. While human perception is the metric for measuring similarity in this paper, it is probable that Chimera seemed more detailed at close frames because normal maps can exaggerate minor topographical variations. Further exploration into this area may uncover additional explanations.

The rendering times of each technique in the performance test were also unexpected. It was hoped that Chimera would outperform the other techniques in rendering time because it rendered fewer polygons than high polygon models or normal mapping when the distance between the virtual camera in the 3D scene and the model was large. However, an unexpected complication arose in the design of the MEL script responsible for swapping the models in animations rendered with Chimera and LOD. When models are swapped at each level of detail, the computer must load the new model into memory, and this may require additional time, depending on the complexity of the model and the number of swaps occurring at a given frame. For this reason, the MEL script allows more models to be initially loaded into a scene,

but at the expense of some rendering time. For the performance test in this paper, the increase of rendering time was just 37%, as compared with 1,084% for high polygon models. However, it is not known at this time how rendering time may be affected by longer animations, more complex scenes, or different kinds of camera movement. More performance tests must be conducted to understand the implications of these differences.

6.2 Recommendations

In certain situations, Chimera is the only viable technique for rendering a 3D scene, while in others, several may work equally well or better. A number of factors must be considered when evaluating which technique to use. This section provides guidelines for when normal mapping, Chimera, LOD, and high polygon models are appropriate choices.

Normal mapping

- Normal mapping presents the best combination of visual quality and performance.
- Normal mapping alone won't work for massive data sets; however, it is a good baseline technique to use when Chimera is not necessary.
- Avoid normal mapping when the camera moves very close to models and low polygon counts may be noticed.
- Use normal mapping for scenes which require high detail and a moderate number of models, or moderate detail and a large number of models.
- Use normal mapping for scenes which require minimal camera movement.

Chimera

- Chimera takes slightly longer to render, but allows more models to be initially loaded into the scene.
- Use Chimera for scenes which require high detail and a large number of models.
- Use Chimera for scenes which require extensive camera movement, particularly camera zooms that take advantage of LOD.

Level of detail

- LOD offers the worst visual quality but the second-best performance.
- Use LOD for scenes which require low detail and a large number of models.
- Low detail scenes are seldom desired for broadcast animation, so LOD by itself is unlikely to be a best choice for most run-time rendering scenarios.

High polygon models

- While the visual quality of high polygon models is comparable to Chimera and normal mapping, it performs much worse than the other methods.
- Use high polygon models for scenes which require high detail and a very small number of models.
- Use high polygon models for scenes which require minimal camera movement.

Since Chimera and normal mapping look and perform so similarly, it's important to know when to choose one technique over the other. Ultimately, no technique seems to be universally appropriate. The decision of which rendering technique to use depends on the individual requirements of each scene; specifically, the number of models, the detail of those models, and the nature of the camera movement in the scene (see Figure 6). The best pipeline may make use of all of these techniques for different parts of an animation.

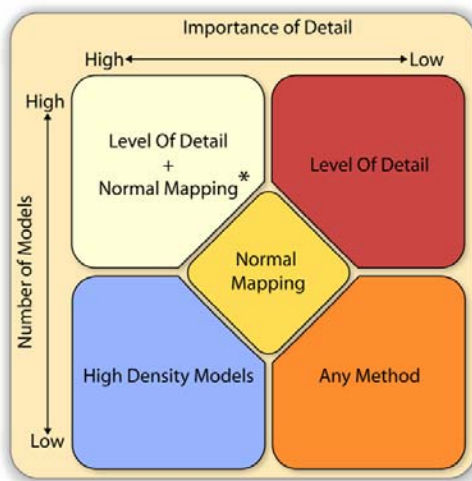


Figure 6. Pipeline usage guidelines.

It is also important to point out that pipeline managers will ideally know early on approximately how many models and how much camera movement a scene requires, in order to inform modelers if they need to create multiple versions of a model at different resolutions. However, changes to this pipeline can be made relatively cheaply and quickly during production. Since normal mapping and Chimera renders so much faster than high polygon models, the time spent creating these multiple versions will still likely be much faster than rendering only high polygon models from start to finish, because re-renders do not take nearly as long. As a result, this pipeline could result in a lower cost to produce an animation or it could create extra time to be used for revisions or improvements to an animation.

7. Conclusions

Managing and rendering massive data sets presents considerable challenges to small- and mid-sized production houses in the film and broadcast animation industry. Barriers such as hardware cost, model complexity, and pipeline secrecy pose special problems for these smaller companies to produce high quality work without proprietary software or expensive hardware solutions.

Chimera, a hybrid production pipeline which applies interactive 3D techniques to traditional animation production, enables smaller production houses to manage massive data sets using off-the-shelf software and hardware of their choice. Normal mapping and LOD, two techniques borrowed from gaming and real-time visualization, offer time-saving benefits to film and broadcast animation and run-time rendering as well. When combined, they permit animators to fit more highly detailed models into a scene than other rendering techniques.

Experimental data shows that Chimera and normal mapped animations can look as detailed as high polygon models. In addition, Chimera and normal mapped animations perform better than high polygon models in terms of rendering time. Chimera offers a unique solution to specific problems in film and broadcast animation; however, its advantages and disadvantages must be compared to normal mapping and

other rendering techniques. The best pipeline depends on the individual requirements of a scene and combines different techniques to achieve the best results.

8. Further Work

The development of a novel production pipeline sets the stage for a great deal of future research. The effect of textured versus untextured normal-mapped models on detail perception would answer important questions about why people find normal mapped models more detailed than high polygon models. An effective solution for rendering scenes with primarily geometric, rather than organic, models would neatly supplement this paper. Additionally, it is currently unknown how the pipeline described in this paper would perform with manually-created models, as only laser-scanned models have been tested thus far. Implementation of mipmapping, external memory management and out-of-core simplification may improve the pipeline's performance. Finally, this paper used detail as an indicator of similarity for comparing models rendered with different techniques. Other metrics for similarity exist,

and the value of this pipeline as measured by other metrics may answer important questions about what truly matters with respect to human visual perception.

Acknowledgements

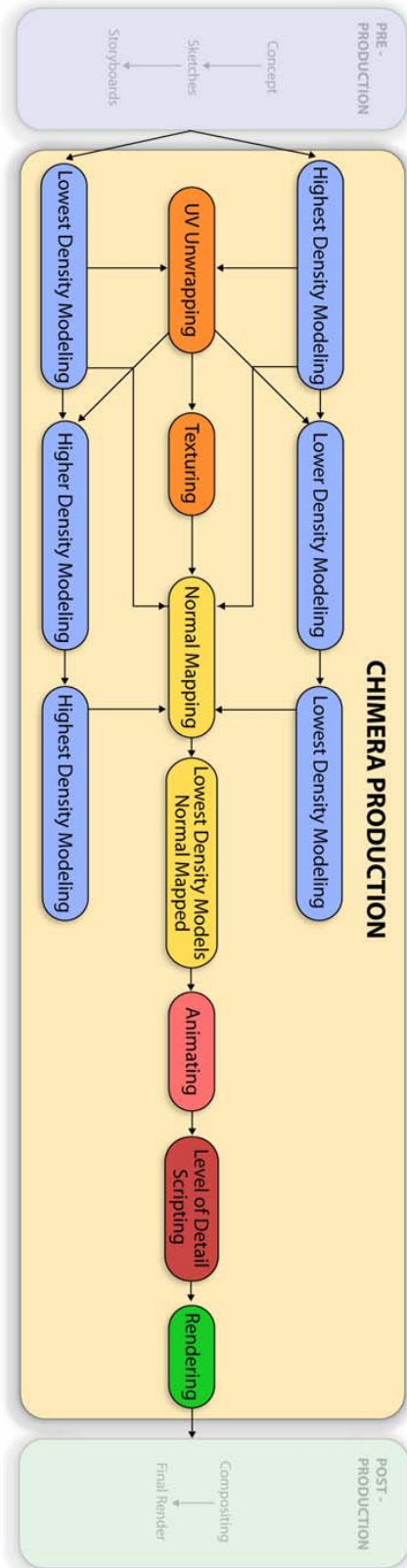
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Appendix A: Chimera Pipeline



Analyzing the E-Factory Tools Suite for Rolls-Royce: A Case Study

February 25, 2006

CGT 411 – Group 22

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Abstract

A trend has developed over the last few years in the fields of Computer Aided Design (CAD), Computer Aided Manufacturing (CAM), and Computer Aided Engineering (CAE). This trend is Product Lifecycle Management (PLM). Software companies have begun to increase the versatility of their packages until they intend to be involved with every aspect of a product, from its inception until its demise. With the added capabilities in software, many companies have implemented PLM systems into their framework. Companies that were around before these systems, however, have a difficult time integrating this software (Pilkington, *Turbine Wheel Cell Simulation*). This is the current situation at Rolls-Royce. The corporation has recently purchased a software suite from UGS with many of the capabilities of a PLM system. Understandably, they would like help to build a knowledge base about the products they own in order to get past the sometimes steep learning curve involved with the implementation of new software. The aim of this project was to provide Rolls-Royce with information about the E-Factory suite of tools that allowed them immediate efficiency. This knowledge transfer included simulation data and a visualization of the turbine wheel creation process at Rolls-Royce.

Introduction

According to *Modeling and Simulation Magazine* there are currently 71 different modeling and simulation software packages on the market today (Modeling and Simulation Software Guide, 2004). The preponderance of new software solution is related to the recent emergence of this technology into new aspects of manufacturing, such as factory layout optimization and production cycle simulation. In order to determine how successful a specific software solution can be at its intended purpose, there must be accurate records left by those who are the pioneers in this specific field (Hamel 1993).

Each pioneering venture includes a specialized array of supplies, strategies, maps, re-

sources, and, of course, the pioneers themselves. This is why the current project was aligned within the framework of the case study. It provides an accurate way of using very limited knowledge about a narrow scope of an even narrower field to hint at general applications that could be of use for a much broader audience. While on the surface, using this method as a replacement for a statistical analysis might seem to be the easy way out, that is a long way from the truth. In the past, the case study was looked upon by the scientific community to be lacking rigor. It was considered too narrow to generate accurate generalizations. Over time, however, it has become apparent that case studies can not only be used to draw theoretical generalizations, but also can apply to many different fields of inquiry. The

use of the case study has slowly spread to new areas until it is now internationally recognized and, when used appropriately, can be a very scientifically rigorous form of inquiry (Yin, 1994). The difficulty in this research framework is that it is sometimes more time consuming to establish the validity of the case being studied, as well as implementing the study itself. There have been different approaches used to document a case study. Some of these have been defined and named within this case study framework. As none of the sources consulted use the same naming and description of the different approaches, no label was given to the style taken with this study. This was to avoid ambiguity and promote the unique handling of this one case (Tellis, 3).

As any journey is recorded regarding both expected needs and adaptive measures, this project was no different; it verified the path taken along with the final goal. Specifically, this project dealt with a particular manufacturing cell that produces turbine wheels for Rolls-Royce North America (see figure 1).



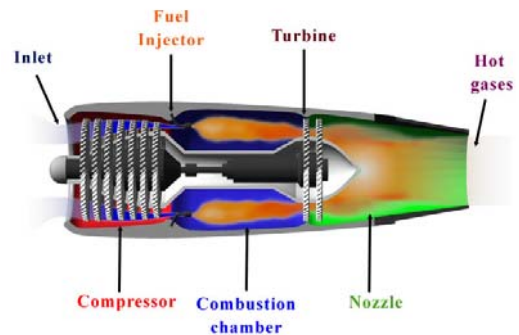
Turbine Wheel Graphic Provided by Rolls-Royce

Figure 1

The particular problem that this project attempted to solve was that Rolls-Royce needs knowledge of E-Factory tools and the resulting data in an effort to gain approval for funding a Makino machining center. It also answered the question: Can this project provide Rolls-Royce

with the information required to finalize a decision to purchase a Makino machining center (Pilkington, *Turbine Wheel Cell Simulation*)?

Turbine wheels are one of the components used in jet engines. Each wheel has a similar use, and is used after the gas has combusted. The turbine wheel also has a series of turbine blades that attached around the edge of the wheel and either has pressurized air around them to cause spinning, or is spun at high rates to aid in the process of pressurizing the incoming air (see figure 2). This information came from the Fact Monster website (*Jet Propulsion Engines*, 2005), and if a deeper understanding of jet propulsion is desired, there is an accurate description on this site.



Jet Engine Graphic Provided by Cislunar Aerospace Inc.

Figure 2

A current manufacturing cell at the Rolls-Royce factory produces turbine wheels, and has been doing so for over forty years. According to Rolls-Royce, these wheels operate under extreme conditions. These conditions include rotation of the wheel at speeds in excess of 17,000 revolutions per minute and temperatures higher than the melting point of the wheel's material. These conditions make the creation of turbine wheels a very expensive process. The estimate presented by Rolls-Royce indicated the cost to be greater than \$15,000 to manufacture a single wheel. Part of this cost is due to the time it takes to manufacture turbine wheels. Rolls-Royce currently takes over 36 hours on the machining processes used to produce one wheel (see figure 3) (Pilkington, *FASTWheels Capability Acquisition*).

Current Cycle Times

Op 10 - Turn Rim & Bore	69 mins
Op 20a - Rough Turn Side A	110 mins
Op 20b - Rough Turn Side B	110 mins
Op 60 - Mill Balance Tabs	206 mins
Op 80 - Rough Broach	148 mins
Op 100 - Grind OD & Rim	34 mins
Op 130a - Finish Turn Side A	112 mins
Op 130b - Finish Turn Side B	111 mins
Op 150 - Grind Bore	82 mins
Op 160 - Grind Rim Face	35 mins
Op 165 - Grind Rim Face	34 mins
Op 170 - Broach	338 mins
Op 190 - Shape I.Spline	79 mins
Op 200 - Shape I.Spline tooth	14 mins
Op 205 - Shape E.Spline	129 mins
Op 210 - Grind Thread	86 mins
Op 260 - Mill Loading slots	34 mins
Op 265 - Drill Holes	24 mins
Op 290 - Grind ID Datum B	41 mins
Op 300 - Grind Bore	50 mins
Op 310 - Grind OD/Face	69 mins
Op 312 - Turn Rim ID Pilot	40 mins
Op 314 - Almco Slurry	138 mins
Op 315 - Dynaflo	41 mins
Op 316 - Turn seals	46 mins
Op 320+ - Deburr, Spin Pit, etc.	

Cycle Time = 36hrs 20mins
Cycle Times Provided by Rolls-Royce

Figure 3

Until recently, the technology and machines needed to improve this process were unavailable or unreliable. The advances in technology have recently allowed the creation of machines that perform many of the operations without human intervention. This makes it possible to eliminate up to two-thirds of the time necessary to manufacture a turbine wheel (see figure 4).

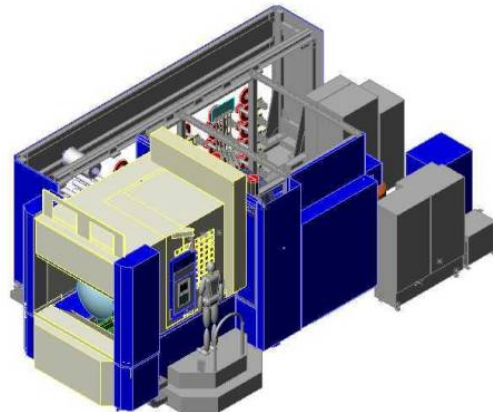
Makino Cycle Times

Op 10 - Rough Grind Long Side & Slots	80 mins
Op 20 - Finish Short Side	240 mins
Op 30 - Finish Long Side	120 mins
Op 40 - Finish Broach Slots	120 mins
Op 100 - Shape I.Spline	80 mins
Op 314 - Almco Slurry	138 mins
Op 315 - Dynaflo	41 mins
Ops 320+ - Deburr, Spin Pit, Insp	

Cycle time = 13hrs 39mins
Cycle Times Provided by Rolls-Royce

Figure 4

There have also been advances in computer software that make it possible to visualize a proposed plant layout, to more easily achieve process optimization. The Rolls-Royce Company is considering the purchase of two Makino 5 axis grinding machines (Figure 5) to replace many of the machines currently used to produce turbine wheels. They have also purchased a Unigraphics suite of software which allows visualization of the machining processes. According to the Rolls-Royce project manager Jason Wood, they currently lack any clear understanding of the capabilities of this software. In order for them to fully utilize their new software to digitally layout their manufacturing cell, Rolls-Royce must gain this understanding.



Graphic Provided by Rolls-Royce

Figure 5

While this situation is unique, the current industry trend lies along the same path as Rolls-Royce (Rohrer, 2000). This area of inquiry is still expanding, and so is the body of literature surrounding it. This case study, along with the increased amount of literature will help to advance the larger body of knowledge concerning digital manufacturing.

This being said, it should be noted that the resources used in this case comprise a very small amount of the choices available. There is a vast array of different options that provide different functionality as well as a myriad of options. All of the specific processes documented here can be taken into a more broad setting, and can be used to understand what all of these similar packages allow the user to per-

form. The specific use of the software in question has been documented. This usage is in no way the full extent of the capabilities of these packages, and further exploration into their functionality is encouraged. The specific nature of this project provides many limitations on the depth that can be reached by its undertaking. This depth can be achieved, however, if more exploration is conducted. In this context, the goals of the project take precedence, and should be fully understood.

In order to better facilitate understanding of the purpose of this project its main goals must be stated in clear, unambiguous terms. Specifically, Rolls-Royce needs knowledge of E-Factory tools and the resulting data in an effort to gain approval for funding a Makino machining center. This project also attempted to answer whether or not it will provide Rolls-Royce with the knowledge and data required to finalize a decision to purchase a Makino machining center.

Method

The case study method of scholarly review was selected for this endeavor for several reasons. The most important is that this undertaking is only taking place with Rolls-Royce, meaning that its specific nature and narrow goals make it impractical and almost impossible to verify statistically. Secondly, the results format of a case study better suits the needs of Rolls-Royce by presenting the information they want in the format they require. Finally, the case study is a predominant form of research and scientific inquiry that seemed well suited to manufacturing. There are already many case studies of a similar nature in scholarly journals all over the world. Some examples of these can be found in the references section of this paper (Part Manufacturing, 2005). The case study needs to have quantifiable goals. These goals allow a measure of success to be used to help validate its findings (Hamel, 1993). The main goals for this project were found to be as follows:

- Demonstrate visually what the Makino machining center would do
- Simulate what goes on in a Makino cell using more than one machine
- Allow further work to be done by documenting the knowledge base acquired while completing the first two goals

In order to reach these goals, three different areas of inquiry were identified. These areas were each found to be critical if the goals were to be reached. After conducting extensive research in the areas of visualization, animation, and simulation, short descriptions were written to describe each with an emphasis placed on each goal they accomplish. Animation was found to be a specific type of visualization. In the context of manufacturing it is only used to demonstrate the concept of how something works. It is not used to draw conclusions since it does not emulate real world activities with the accuracy necessary to do so. The knowledge that an animation conveys is strictly to help the observer understand what is going on, it will not answer any other questions regarding what has been animated. The *visualization*, a more generalized term, includes any graphic that conveys knowledge about a certain process (Rohrer). Simulation, conversely, is the emulation of some real world activity that is used to study that activity. What this means in the context of manufacturing is that simulation uses real world parameters such as machine times and work cycles to help with optimizing the time needed to complete a specific process (Pritsker, 1999). These definitions provided a clear picture of the form that reaching the goals would take. The animation gave a sense of the overall process, but in doing so simplifies a complex activity. The simulation attempted to emulate what would really happen at Rolls-Royce if they had the Makino cell. In order for the visualization and simulation to achieve their goals, though, the tools used to create them should be thoroughly understood.

Some of the E-Factory software tools were used in this project. To provide a full understanding of what the E-Factory suite of tools is capable of doing, knowledge must be trans-

ferred accordingly by describing each tool to the extent possible within the scope of the project.



Figure 6

E-Factory

In order to provide information regarding the E-Factory suite of tools, it is important to understand what E-Factory is specifically. E-Factory (see figure 6) refers to a suite of tools that are owned by the company, UGS. Much like Microsoft Office refers to software titles such as Word, PowerPoint, and Excel, E-Factory refers to many different software titles such as FactoryCAD, FactoryFLOW, FactoryPLAN, eM-Plant, and Jack. There are many other software packages included in E-Factory, all of which aid in the design and simulation of a factory. There are tools in E-Factory that aid in the sequencing of batches, material-handling, and part-flow, and many other areas of manufacturing. The scope of this project required personal use of only two packages in the E-Factory suite, FactoryCAD and Jack, and the indirect use of eM-Plant. This was on account of Rolls-Royce not owning a license to use eM-Plant. Because of this, FactoryCAD and Jack were discussed from usage standpoints while eM-Plant was discussed from a strictly observational and research driven standpoint.

E-Factory is very advantageous for companies who need to change the way that they do business. Because of the large number of tools in E-Factory, almost anything related to manufacturing can be digitized and analyzed with relatively little cost. Depending on the application, the software can be customized to a company's needs. E-Factory can save companies time and money especially since everything is done on the computer and is not physically set up, tested, then changed to accommodate a new scenario (Mixing it up for multi-plant flexibility, 2005). It allows much of the physical work of manufacturing to be done without as high of an initial investment.

Because E-Factory refers to such a large number of software tools, it is somewhat difficult to pin-point a specific tool for a particular application. Some tools overlap in some areas but excel in others. Therefore, it is challenging to find out which tool is needed based on a specific application. A visit to the UGS product website can prove this scenario. A consultant from UGS would aid in this specific matter (Part Manufacturing, 2005). Additionally, there is not a single interface in which to access all of these tools. Each tool in the suite is basically a stand-alone software package. These separate packages do not fully interact since many of them have proprietary roots elsewhere. Since each tool is a separate piece of software, the learning curves vary from package to package. Some E-Factory tools may be very easy to use and operate while others may be very complicated and cumbersome to use. Also, a special license is required for each E-Factory tool that is desired. An understanding of E-Factory is beneficial when using the tools that it provides. One of these tools, called FactoryCAD will be explained next. This tool was used because of its capability of easily creating a factory layout. The layout of the factory is one of the main requirements of this project.

FactoryCAD

FactoryCAD, as part of the E-Factory suite of tools, is a plug-in for AutoCAD that allows a user to create a 3-dimensional factory layout with relative ease. Its library of generic factory items is broad enough to accommodate several different industries but can be tailored to suit an individual company's needs (Optimizing workspace and reducing cycle times, 2005). Factory items such as support columns, walls, floors, safety fencing, conveyors, overhead cranes, and robotic arms can simply be dropped into a FactoryCAD drawing with the click of a button. Once the items are in the drawing, their parameters can be updated and changed as the application requires. Also included are OSHA standards for factory layout that are pre-programmed into the FactoryCAD tools. Examples of the implementation of these standards include automatically surrounding a platform with a railing if it exceeds a certain height, adding a gate to a stairway, and forcing

a landing on a stairway if the stairway is more than 7 feet high. These standards can be overridden; however, they serve as reminders when developing a layout of a factory.

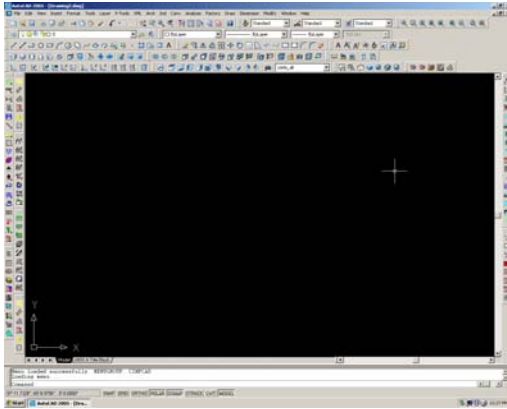


Figure 7

Because it interfaces with AutoCAD (see figure 7), one of the most popular design packages in the world (Modeling and Simulation Organization Guide, 2004), many potential users will already have some familiarity with the way the interface looks and interacts with the user. All of AutoCAD's tools such as copy, move, and solid modeling, are accessible with the FactoryCAD plug-in loaded. The FactoryCAD tools are used just like current AutoCAD tools are used. All of the functions available in FactoryCAD are accessible through icons that can be displayed in the toolbars or through the "Factory" menu that the plug-in installs. The most difficult aspect of learning this software is discovering which icons are connected to a specific function. The models created in FactoryCAD also contain data that add depth to the factory layout. This data can be manipulated to alter the model to adapt to a specific application. Examples of this data include, for example, the length of a straight section of a conveyor or the height of a support column. Also, data such as material handling times, operations times, and cycle times can be applied to a model. This data can then be used to run simple simulations inside the FactoryCAD interface.

When E-Factory is loaded, AutoCAD will have a new menu item labeled "Factory". To load FactoryCAD, select "FactoryCAD" from

the "Factory" menu (see figure 8). This will load the FactoryCAD plug-in and start a new FactoryCAD drawing. A factory floor can be added and the depth can be adjusted. Walls can be added to surround the floor and a grid of columns can be placed to support the roof of the factory. Mezzanines can be added into the drawing as well as stairs to access them. Railings can be added or taken away as necessary. Conveyors and other types of part handling methods can be added to the drawing. Overhead cranes can be dropped into the drawing as well as robotic arms for process automation which are included in the model library. Some other models that can be quickly added include picnic tables for break areas, work benches, cabinets, safety fence, pallets, types of guide track, and even models of human operators. For many items, once the tool is activated, a dialogue box will appear in which you can add or change settings to accommodate the current factory layout. These dialogue boxes are generally self-explanatory and can be navigated and used with little effort.

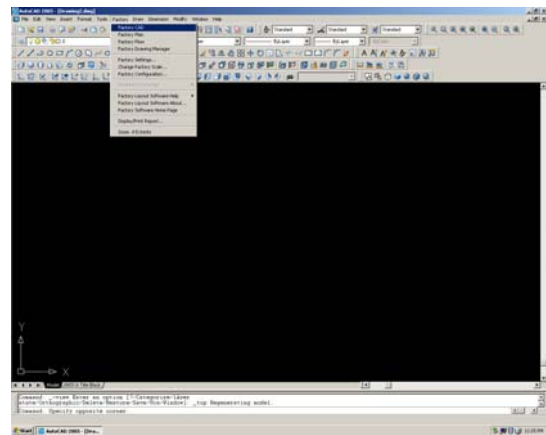


Figure 8

If the FactoryCAD library does not contain a necessary model, such as a model of a milling machine, models can be imported from other CAD packages through the direct model file format, otherwise known as .JT files. This file format is a neutral format that contains the solid model data as well as other parameters that drive the model. 3D models can also be created in AutoCAD and be brought into the FactoryCAD drawing. FactoryCAD does come with a model creator that uses XML to create FactoryCAD models, but is archaic and some-

what complicated to work with according to Andy Lane (personal interview, 10 November, 2005). This feature allows the user to create simple 3-dimensional primitives, and place them in the model, relative to each other. For example, one rectangle that is 4 feet long by 4 feet wide and 1 inch thick can be placed on 4 cylinders that are 1 inch in diameter and 3 feet long. This will represent a table and the model can then be placed within the FactoryCAD drawing. This alternative to importing models can be a little time consuming but it has advantages over importing models. Since the models are made native to the FactoryCAD software, the models can be easily manipulated and changed. Because models imported into FactoryCAD use the neutral file format .JT, they can not be changed within the FactoryCAD software. This can cost the user a lot of time and effort.

Although FactoryCAD is very well suited for creating factory layouts, it does not include a library of common machine tools. The libraries contained in the software are specifically for generic factory items. This can be troubling especially when specific models are needed but not contained within the given libraries. The XML model creator, used to create FactoryCAD models, is cumbersome; however, models can be created with a little patience and practice. The additional icons and functions can also be overwhelming to a new user. Often, useful functions are not used because the user may not be aware of their existence as the tools are often lost within each other. As the user gets better acquainted with the software and its capabilities, it is our observation that this issue resolves itself. An issue that does not resolve itself is that of file corruption. Through the course of the project with Rolls Royce, it was discovered that FactoryCAD files often become corrupt for no apparent reason. Several backups were kept at several locations in an effort to relieve this problem. It was not uncommon to go through 2 or 3 backups before a specific file would open. The most difficulty in this area was with files that were created from another file. For example, a file was saved as another file and the new file was altered. This new file would be the file that was often found

to be easily corrupted. Although corrupted files do destroy work and waste time, if precaution is taken, they can be reduced to an inconvenience. This issue was investigated with a UGS representative, but the issue had not been brought up to UGS before according to Andy Lane (personal interview, 10 November, 2005). This leads us to believe that there may be an error with our specific license for the software.

Overall, FactoryCAD provides many useful features that allow a factory to be modeled easily. Once the factory floor has been laid out, E-Factory contains another tool that allows the human interaction with a factory to be demonstrated. This tool is called Jack. Jack is a tool that has a focus on the human interaction with the components of a factory. It was used to assist with the visualization of the proposed Makino cell.

Since the version of Jack that was used during this project was outdated, many of the capabilities and recommendations could not be included. The tools and procedures found in the older version of Jack that remain applicable to newer versions of the software have been included.

Jack

As a standalone title within the E-Factory suite of tools, Jack helps visualize and animate the factory layout designed in FactoryCAD. For the purpose of this project the models created in FactoryCAD were saved as a .STL file. From the File menu select Import and within the dialog box select the appropriate files and click Translate. Due to time constraints, all of the options were left at their default setting. All of these options were contained within one of the following five tabs: Input, Optimization 1, Optimization 2, Optimization 3, and Output. Once the models are translated into Jack, many different properties of the objects can be set by right clicking on the object and selecting Properties. The details within the properties dialog box are separated by tabs near the top of the dialog box. Details include density, color, material, texture, opacity, shading mode, and display options. After all models and objects have

been imported and translated, mannequins can be inserted by selecting the Create item under the Human menu. Choosing the Custom option allows the user to select and change parameters such as size, weight and gender. Once all parameters are set, name the new manikin and press 'Create new' (see figure 9).

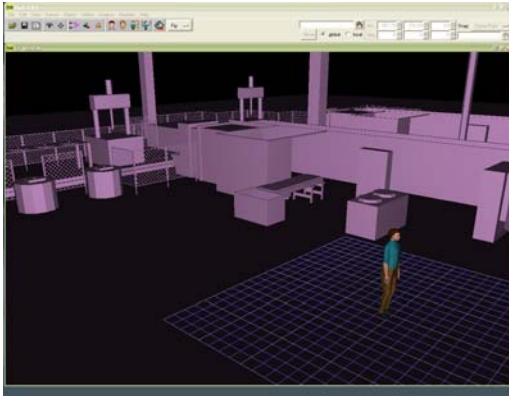


Figure 9

Manipulation of objects and manikins within Jack is all performed in the same way. They can be scaled, moved, or rotated. Scaling in Jack is done using the Scale tool under the Edit menu. Selecting Segment allows the user to scale in one, or all directions, individually or proportionally. Moving objects is done by selecting the object and holding the ALT key. Dragging with the left mouse button moves the object from side to side. Dragging with the right mouse button moves the object forward and back and dragging with the middle button moves the object up and down. Rotating objects is similar to scaling only by holding the SHIFT key and dragging with a mouse button. To rotate along the x-axis, hold SHIFT and drag with the left mouse button. Rotating along the y-axis and z-axis is done by holding SHIFT and dragging with the middle and right mouse buttons respectively. Rotating the view can be done by holding the CTRL key and dragging with the left mouse button. Panning and zooming can also be accomplished by holding the CTRL key and dragging the middle and left mouse buttons respectively.

Path creation is done with the Paths option under the Object menu. Selecting Create Path will cause a small coordinate axis to appear. This is to be used to locate the beginning of the

path using the same mouse buttons described earlier for moving objects. Once the beginning of the path has been located press the 'Add After' button and continue to create and locate points needed to finish the path as necessary and click the 'Create' button to save the path. The newly created path can be assigned to a mannequin by using the Animation tool under the Modules menu which will open the animation timeline dialog box. Selecting the Path Walk tool under the Human menu in the animation dialog box will allow the user to select a path for a mannequin to follow. Options to set a time for walking the path or setting a constant speed can be selected. Also there is an option to have the mannequin to swing his or her arms. Once all parameters are set, press the 'Create' button. To view the walking motion, under the 'Control' menu select 'Generate' or click the stopwatch icon.

There were also some issues involved with the use of this software. On several occasions, the scaled up models did not save their size upon exiting the program. When re-opened, the models were original size when imported and needed to be scaled back to the correct size. This happened occasionally, but not every time; no explanation could be found for this occurrence. Also care needs to be taken to ensure Jack uses the same JT file version as FactoryCAD. This will allow the user to import smart models from FactoryCAD and makes for easier visualization since parameters can be saved with the model out of FactoryCAD such as color, density, etc.

This was a brief description of what was discovered in Jack. Since access to any new version of the software was not possible, there is a chance that some of these features will not be used in this exact way. The version of Jack used for this project also does not recognize the file formats that are necessary to create animations. More recent versions of the software, however, do have this option. The animation was still a vital part of the project, though, since a visualization of the proposed process was a requirement. In order to get around the fact that no animation could be produced using the version of Jack available, another anima-

tion program was used to complete the animation. This software was 3D Studio Max. Since this piece of software does not fit into the scope of the project, the capabilities and methods used to create the animation were not included. However, the creation of the animation has been documented and included in appendix A along with the rest of the software knowledge transfer. Another piece of software that was not available for this project is eM-Plant. The results of simulations run in this software package were obtained, however, and a general conception of the capabilities and intended purpose was inferred.

eM-Plant

eM-Plant, as a tool in E-Factory, is responsible for simulating processes. The graphical interface and drag-and-drop abilities seem to streamline the process layout (see figure 10). After the parameters are assigned to the simulation models, the simulation can be compiled and run. After the simulation is finished running, a report of the simulation is displayed that relays certain information to the user such as overall equipment usage, buffer utilization, overall wait times, as well as lead times.

The user interface of eM-Plant is somewhat reminiscent of Microsoft's Visual Basic. A workspace is surrounded by a number of menus and tools. Items are dragged and dropped on the workspace and arranged as necessary. Parameters are assigned to the item based on what type of item it is. Station items act differently and require different parameters than a buffer item for example. Although it seems pretty easy to use on the surface, a more realistic simulation requires a more complex setup. To accommodate for this, events and scripts can be written and called upon at certain points in the simulation. For example, if you want to set the simulation to call an operator to a specific station to handle a part as it leaves a station, an event could be set up to call a script that incorporates additional time into the process as a part leaves a station. The ability to add realism into the simulation adds capability to the software. It also automatically displays the simulation report after the simulation finishes running. The HTML document that is generated can be saved for later viewing and it can also be published on the internet or sent via email for sharing the data.

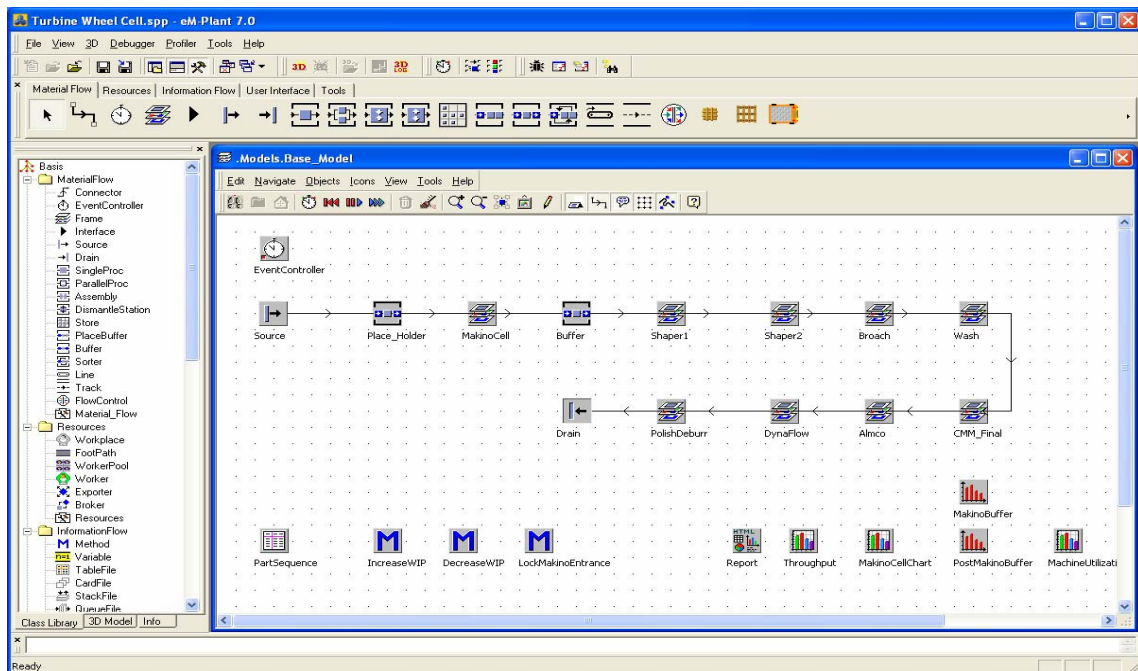


Image provided by UGS
Figure 10

Despite its intuitive interface, eM-Plant can be very complicated especially when adding

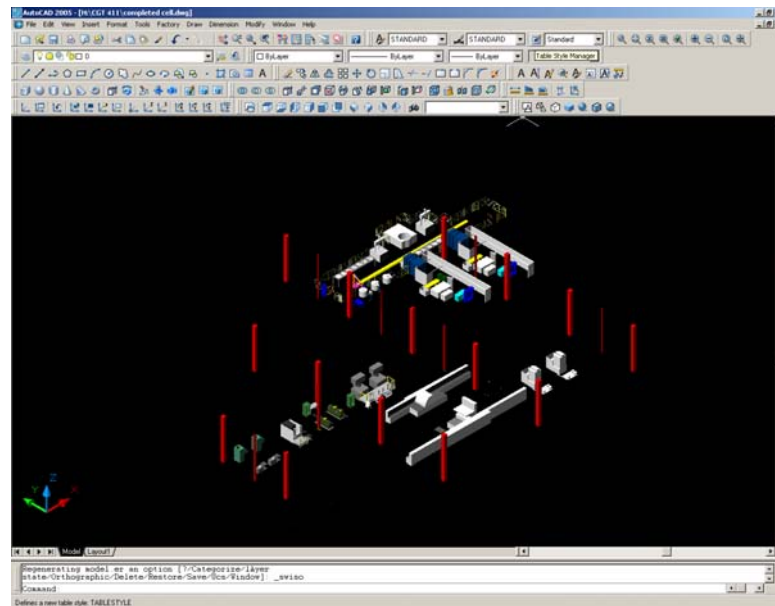
more realism to the simulation. It has a very steep learning curve as you delve deeper into the potential of the software. To create a simulation with a reliable accuracy, one must not only know the software, but also the process in which he or she is simulating. An intimate knowledge of the process is crucial to the reliability of the simulation. eM-Plant also has difficulty incorporating information that does not strictly deal with cycle times of the process. Examples of this would be showcased when trying to implement operators, material handling, and work schedules. To incorporate this type of information into a simulation, it would require the coding of scripts as well as setting up the events to call the scripts. To do this effectively, it is pertinent that the user have some previous computer programming skills as this process requires many types of loops, if/else statements, among other commonly practiced programming skills. While these skills are difficult to grasp, they are much more intuitive, and therefore, more simple to pick up, if a general knowledge of programming is already obtained. The use of all of these software tools have not only given a much greater understanding of their capabilities, but has also allowed the creation of deliverables for Rolls-Royce.

Results

The results obtained from this project were divided into three distinct sections. The first of these includes screenshots generated from the software that provide general information about the deliverables as well as brief descriptions of each part of the deliverables. This section simply provides an overview of what was

accomplished. It does not represent the entire body of work. The second section includes verification of the deliverables success. The third part is the electronic files that have been delivered to Rolls-Royce. These deliverables include the knowledge transfer, visualization, animation, and simulation. The first two have been included in this case study. The first to be addressed is the plant layout created in FactoryCAD.

The plant layout consisted of specific requirements being met that were provided by Rolls-Royce. The main consideration was given to the footprint created by the Makino cell. Once this had been finalized, the next consideration was leaving as many supporting columns as possible intact and unmoved (see figure 11). These supporting columns are



placed at regular intervals throughout the plant and can not be moved because they bear heavy loads. These considerations were then abandoned in favor of creating different possible plant layouts that might be possible in the context of the factory space

at Rolls-Royce (see figure 12). More information about these other possible configurations can be found in appendix B. The layout of the Makino machining center has also been created using FactoryCAD (see figure 13). This layout involves two identical Makino machines along with a robotic loading arm and two Coordinate Measuring Machines (CMMs). A CMM is an automated inspection station that would be used to keep the parts produced by the Makino machines within a specified tolerance. The FactoryCAD models generated by this portion

of the project were then imported into the Jack program.

**Other possible plant layouts
(not fully explored)**

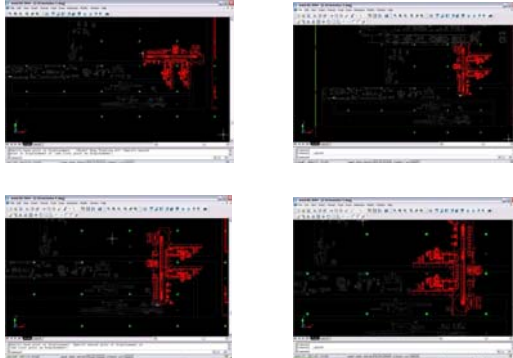


Figure 12

Makino cell layout

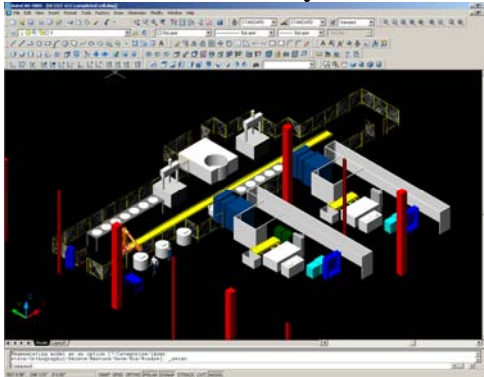


Figure 13

Once the Makino cell was imported into Jack, a manikin was added to demonstrate what actions would be required of the cell operator (see figure 14). More views of this manikin at the Makino cell are available in Appendix B. Once the relevant capabilities of Jack version 3.0.1 were explored, the animation was created to demonstrate fully what the automated Makino cell would be capable of doing. The method used to complete this animation is contained within Appendix A. The animation is also located in Appendix B.

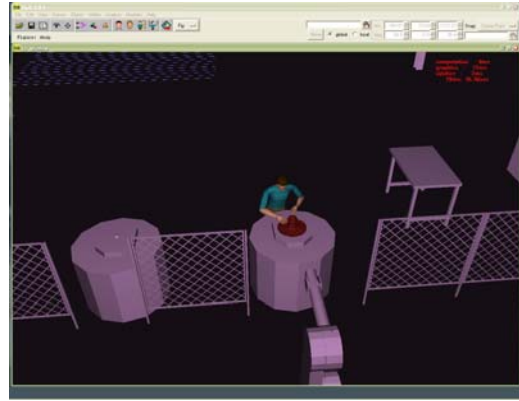


Figure 14

At the same time as the visualization aspect of the project was being completed, all of the information about the proposed Makino cell was given to a UGS representative who used this information to run a simulation using eM-Plant. The software generated a report with all of the information that was outputted placed into a series of graphs and charts (see figure 15). The report in its entirety is located in Appendix A. Now that the deliverables have been described in some detail, the validation procedures used to determine if the project has met the goals set for it is included.

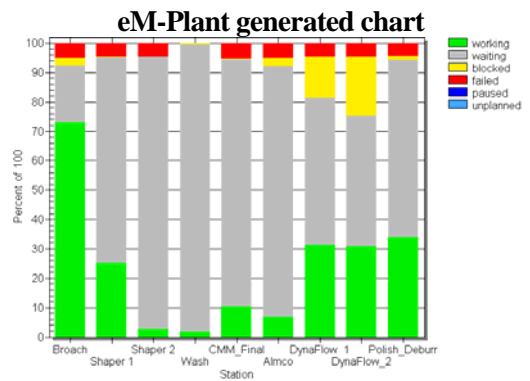


Figure 15

Verification

In order to verify any endeavor, some measure of success must be defined (Kantowitz, 2005). In this context, the measure of success rests solely in the hands of our employers. This means that their evaluation was the only thing necessary to ensure that the goals of this project were achieved. In order to have documented evidence of the reaction to the deliverables generated during the project a short an-

swer survey was generated. The questions contained in this survey were posed to each attendee of our final presentation to Rolls-Royce that demonstrated the progression of the project. The questions in their entirety were as follows:

- How are you connected to this project?
- Are you satisfied with the level of completeness of this project?
- Does our presentation suit your professional needs? Why or why not.
- What would you suggest for future projects of this type?

The answers to these questions can be found in appendix C. For the purpose of discussion, only selected responses were mentioned.

The question that appeared to provide the most insight into how each team member assessed the project dealt with the level of completeness. All but one of the responses confirmed that the project met its goals. The sole response that did not, "I think the team completed what they could in the timeframe but were ambitious in their goals," could have been in reference to the original list of deliverables produced by Rolls-Royce. Some of these deliverables were impossible to complete from the onset because of time and resource constraints, and in subsequent meetings with Rolls-Royce were identified as such.

The question that dealt with each member's connection to the project was simply to ensure the validity of the responses. There were no instances in which the qualifications given were not applicable to the project. There was a response, however, that qualified the affiliation as purely software related. "Manager of group responsible for new tools and systems for manufacturing. Interested in the tools used, interfaces of tools, results, etc." Even though this was the case, all responses were still believed to be valid. The question posed regarding future undertakings was primarily used for making recommendations and has been addressed further later.

Discussion

When an undertaking, such as the one presented in this paper, is initially conceived, it is universally agreed upon by the academic community that the limitations and delimitations of the project be identified (Kantowitz, 2005). A limitation is an existing constraint that must be followed in order to successfully complete the project (Princeton Wordnet, 2005). It cannot be avoided and will warrant no further rationale. A delimitation, on the other hand, is some constraint that could conceivably be remedied, but not within the scope of the current project. These will be discussed in more detail as they could be avoided in the future.

During the initial review of the project, the limitations that were found are as follows: The software package used and the amount of time in which it could be utilized were predetermined by Rolls-Royce. The machines being visualized and simulated were again already selected by Rolls-Royce prior to any outside involvement. Another limitation is the amount of proprietary information that Rolls-Royce was able to divulge. Much of this came from the fact that they currently are working on projects with the Department of Defense. The time limits within the project could not be changed, in addition to the monetary contributions of the involved parties. Finally, a separate authority that evaluated the project was mandatory for its completion.

The delimitations, while less numerous, require more explanation. All of them, in fact, had to do with the previous knowledge of the different aspects of the project. First, the software package had previously not been available to anyone associated with the project, so the user interface was far from familiar. Next, the 5-axis machines involved are not easily accessible, and therefore information to help become better acquainted with them was hard to come by. Third, the intimate knowledge of industrial engineering principles required for the optimization for the cell layout was not involved. The only way this knowledge could be gleaned would be to consult an expert, or to conduct in-depth research on the subject. Fi-

nally, the understanding of industrial simulation itself was delimiting in the fact that it is still in its infancy, and there is not as much literature on the subject as there will be available in the near future. All of these factors played a role in what this project has accomplished. While all of the goals for the project were met to varying degrees, there were things that would be changed if the project was to start over.

The initial assessment of the tools available would be much more rigorous in order to ensure that all aspects are indeed what they appear to be. Mainly this would include the assurance that every piece of software be compatible with each other, and that each item be available to Rolls-Royce. A much larger amount of research would also be conducted in the field of Industrial Engineering. This would allow at least some form of process optimiza-

tion. Optimization was one of the initial requirements set by Rolls-Royce. The optimization would have also been much more easily accomplished with a larger time frame. This longer period would also allow other important aspects of the project to be addressed.

Using the newest version of Jack, a new animation could be completed and exported for all of the different design options. FactoryCAD can be used to further explore different layouts and possible footprints for the Makino cell. eMPlant can be scripted to account for all of the different aspects involved with the entire turbine wheel creation process, and once this has been completed, many different iterations can be simulated to help find process optimization. Completing all of these procedures would undoubtedly give a more complete understanding of what the Makino machining center and the UGS suite of software is capable of doing.

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Appendix A

Software Summaries

E-Factory

E-Factory is a suite of software tools that aids in digital manufacturing by utilizing factory layout plug-in for AutoCAD™, material handling, part flow, ergonomics, and process sequencing and simulation. The specific tools used within E-Factory include FactoryCAD, Jack and eM-Plant.

Advantages to using this suite of tools includes the user can create almost any aspect of a factory digitally, it saves time and money by allowing many iterations of a layout to be tested and retested digitally without invading the actual floor of the factory.

Disadvantages include the usage of different software titles across different aspects of digital manufacturing which leads to no uniform interface. Also the large number of tools within the suite causes varying learning curves.

FactoryCAD

The AutoCAD plug-in, FactoryCAD, allows the user to create 3D factory layouts utilizing a library of generic factory items that can be selected from drag and drop menus. All of AutoCAD's tools and features can still be used to aid in creation and placement of factory model items.

FactoryCAD is mainly used for simple visualizations, so accuracy is not required. It's easy to use and has a low initial learning curve once basic AutoCAD functions have been learned. FactoryCAD can be used to create new layouts or alter previously created layouts. Models from other packages can be imported using the .JT file format. It also allows the user to create "smart" models that can be assigned simulation parameters that can be transferred into simulation software.

However, there is no specific machine tool library and the XML tool editor is archaic and complicated. The addition of many icons and toolbars can be a bit overwhelming and the files can often become corrupted.

Jack

Jack is the ergonomics and animation software of the E-Factory suite. It is used to visualize the handling and animation of a part and the person interacting with that part. It can also be used to analyze the ergonomics and tasks of the humans interacting with the process.

The ease of importing files and mannequin posturing make Jack easy to start using. The use of the .JT file format makes Jack compatible with many modeling software titles. Also with many preset mannequin poses, the user can easily view many possible human interaction scenarios and also the limitations of certain scenarios.

Menu navigation can be a bit tiresome with the lack of customizable menu bars and the low number of icons. Actual navigation within the environment can be cramping with the numerous different key/mouse button combinations utilized.

eM-Plant

The simulation software, eM-Plant, is a process simulator that can be used to find overall equipment usage, buffer utilization, and overall part wait times, and process lead times.

Advantages of using eM-Plant include, it is a very powerful piece of software with a simple interface. It also has the ability to add more realism through events and scripts, and it can export the simulation data into an HTML file for easy viewing.

Apart from the simple interface, eM-Plant has a steep learning curve that requires an intimate understanding of the process required to create highly realistic, more complex scenarios. Finding specific information often requires coding of complex scripts and equally complex events.

Knowledge Transfer

E-Factory

In order to transfer knowledge of the E-Factory suite of tools, it is important to understand what E-Factory is specifically. E-Factory refers to a suite of tools that are owned by the company, UGS. Much like Microsoft Office refers to software titles such as Word, PowerPoint, and Excel, E-Factory refers to many different software titles such as FactoryCAD, FactoryFLOW, FactoryPLAN, eM-Plant, and Jack. There are many other software packages included in E-Factory, all of which aid in the design and simulation of a factory. There are tools in E-Factory that aid in sequencing of batches, material handling, and part flow, among many other areas of manufacturing. The scope of the Purdue project required personal use of only two packages in the E-Factory suite, FactoryCAD and Jack, and the indirect use of eM-Plant. Because of this, FactoryCAD and Jack will be discussed from usage standpoints while eM-Plant will be discussed from a strictly observational and research driven standpoint.

E-Factory is very advantageous for companies who need to change the way that they do business. Because of the vast number of tools in E-Factory, almost anything related to manufacturing can be digitized and analyzed with relatively little cost. Depending on the application, the software can be fine-tuned to a specific company. E-Factory can save companies time and money especially since everything is done on the computer and not is physically set up, tested, then changed to accommodate a new scenario. It allows a lot of the brunt work of manufacturing to be done without a huge initial investment.

Because E-Factory refers to such a large number of software tools, it can be somewhat difficult to pinpoint a specific tool for a particular application. Some tools overlap in some areas but excel in others. It is challenging to find out which tool you will need based on a specific application. A consultant from UGS would be able to aid in this specific matter. Another shortcoming of E-Factory is the fact that there is not a single interface in which to access all of these tools. Each tool in the suite is basically a stand-alone software package. This is due to UGS buying the software companies that originally created the software. Since not all of the tools were originally designed and created by UGS, it is difficult to implement a bridge between the software. Since each tool is a separate piece of software, the learning curves vary from package to package. Some E-Factory tools may be very easy to use and operate while others may be very complicated and cumbersome to use. Also, a special license is required for each E-Factory tool that is desired.

FactoryCAD

FactoryCAD, as part of the E-Factory suite of tools, is a plug-in for AutoCAD that allows a user to create a 3-dimensional factory layout with relative ease. Its library of generic factory items is broad enough to accommodate several different industries but can be tailored to suit an individual company's needs. Factory items such as support columns, walls, floors, safety fencing, conveyors, overhead cranes, and robotic arms can simply be dropped into a FactoryCAD drawing with the click of a button. Once the items are in the drawing, their parameters can be updated and changed as the application requires. Also included are OSHA standards for factory layout that are pre-programmed into the FactoryCAD tools. Examples of the implementation of these standards include automatically surrounding a platform with a railing if it exceeds a certain height, adding a gate to a stairway, and forcing a landing on a stairway if the stairway is more than 7 feet high. These standards can be overridden; however, they serve as reminders when developing a layout of a factory.

Because it interfaces with AutoCAD, the learning curve for FactoryCAD can easily be overcome. All of AutoCAD's tools such as copy, move, and solid modeling, are accessible with the FactoryCAD plug-in loaded. The FactoryCAD tools are used just like current AutoCAD tools are used. All of the functions available in FactoryCAD are accessible through icons that can be displayed in the toolbars or through the "Factory" menu that the plug-in installs. The most difficult aspect of learning this software is discovering which icons are connected to a specific function. Once this issue is conquered, the potential of the software can start to be unlocked. The models created in FactoryCAD also contain data that add depth

to the factory layout. This data can be manipulated to alter the model to adapt to a specific application. Examples of this data include, for example, the length of a straight section of a conveyor or the height of a support column. Also, data such as material handling times, operations times, and cycle times can be applied to a model. This data can then be used to run simple simulations inside the FactoryCAD interface.

When E-Factory is loaded, AutoCAD will have a new menu item labeled "Factory". To load FactoryCAD, select "FactoryCAD" from the "Factory" menu. This will load the FactoryCAD plug-in and start a new FactoryCAD drawing. A factory floor can be added and the depth can be adjusted. Walls can be added to surround the floor and a grid of columns can be placed to support the roof of the factory. Mezzanines can be added into the drawing as well as stairs to access them. Railings can be added or taken away as necessary. Conveyors and other types of part handling methods can be added to the drawing. Overhead cranes can be dropped into the drawing as well as robotic arms for process automation are included in the model library. Some other models that can be quickly added include picnic tables for break areas, work benches, cabinets, safety fence, pallets, types of guide track, and even models of human operators. For many items, once the tool is activated, a dialogue box will appear in which you can add or change settings to accommodate the current factory layout. These dialogue boxes are generally self-explanatory and can be navigated and used with little effort.

If the FactoryCAD library does not contain a necessary model, such as a model of a milling machine, models can be imported from other CAD packages through the direct model file format, otherwise known as .JT files. This file format is a neutral format that contains the solid model data as well as other parameters that drive the model. 3D models can also be created in AutoCAD and be brought into the FactoryCAD drawing. FactoryCAD does come with a model creator that uses XML to create FactoryCAD models. This feature allows the user to create simple 3-dimensional primitives, and place them in the model, relative to each other. For example, one rectangle that is 4 feet long by 4 feet wide and 1 inch thick can be placed on 4 cylinders that are 1 inch in diameter and 3 feet long. This will represent a table and the model can then be placed within the FactoryCAD drawing. This alternative to importing models can be a little time consuming but it has advantages over importing models. Since the models are made native to the FactoryCAD software, the models can be easily manipulated and changed. Models that are imported into FactoryCAD from outside sources can not be changed within the software. This can cost the user a lot of time and effort.

FactoryCAD has many strong credits to its name. However, it does have some points that should be considered when diving deeper into it. Although this software is very well suited for creating factory layouts, it does not include a library of common machine tools. The libraries contained in the software are specifically for generic factory items. This can be troubling especially when specific models are needed but not contained within the given libraries. The XML model creator, used to create FactoryCAD models, is archaic and somewhat complicated to work with. Models can be created, however, with a little patience and a little practice. The additional icons and functions can also be overwhelming to a new user. Often, useful functions are never used because the user may not be aware of the existence as the tools are often lost within each other. As the user gets better acquainted with the software and its capabilities, this issue should resolve itself. An issue that does not resolve itself is that of file corruption. Through the course of the project with Rolls Royce, it was discovered that FactoryCAD files often become corrupt for no apparent reason. Several backups were kept at several locations in an effort to relieve this problem. It was not uncommon to go through 2 or 3 backups before a specific file would open. The most difficulty in this specific area was with files that were created from another file. For example, a file was saved as another file and the new file was altered. This new file would be the file that was often found to be easily corrupted. Although corrupted files seem like a large issue, if precaution is taken, this issue mostly eliminates itself as well.

Jack

As a standalone title within the E-Factory suite of tools, Jack helps visualize and animate the factory layout designed in FactoryCAD. For our purposes we used the models created in FactoryCAD saved as a .STL file. From the File menu select Import and within the dialog box select the appropriate files

and click Translate. Due to time constraints we left all options at their default setting. Once the models are translated into Jack, many different properties of the objects can be set by right clicking on the object and selecting Properties. The details within the properties dialog box are separated by tabs near the top of the dialog box. Details include density, color, material, texture, opacity, shading mode, and display options. After all models and objects have been imported and translated, mannequins can be inserted by selecting the Create item under the Human menu. Choosing the Custom option allows the user to select and change parameters such as size, weight and gender. Once all parameters are set, name the new manikin and press 'Create new'.

Scaling in Jack is done using the Scale tool under the Edit menu. Selecting Segment allows the user to scale in one, or all directions, individually or proportionally. Moving objects is done by selecting the object and holding the ALT key. Dragging with the left mouse button moves the object from side to side. Dragging with the right mouse button moves the object forward and back and dragging with the middle button moves the object up and down. Rotating objects is similar to scaling only by holding the SHIFT key and dragging with a mouse button. To rotate along the x-axis, hold SHIFT and drag with the left mouse button. Rotating along the y-axis and z-axis is done by holding SHIFT and dragging with the middle and right mouse buttons respectively. Rotating the view can be done by holding the CTRL key and dragging with the left mouse button. Panning and zooming can also be accomplished by holding the CTRL key and dragging the middle and left mouse buttons respectively.

Path creation is done with the Paths option under the Object menu. Selecting Create Path will cause a small coordinate axis to appear. This is to be used to locate the beginning of the path using the same mouse buttons described earlier for moving objects. Once the beginning of the path has been located press the 'Add After' button and continue to create and locate points needed to finish the path as necessary and click the 'Create' button to save the path. The newly created path can be assigned to a mannequin by using the Animation tool under the Modules menu which will open the animation timeline dialog box. Selecting the Path Walk tool under the Human menu in the animation dialog box will allow the user to select a path for a mannequin to follow. Options to set a time for walking the path or setting a constant speed can be selected. Also there is an option to have the mannequin to swing his or her arms. Once all parameters are set, press the 'Create' button. To view the walking motion, under the 'Control' menu select 'Generate' or click the stopwatch icon.

On several occasions, the scaled up models did not save their size upon exiting the program. When reopened, the models were original size when imported and needed to be scaled back up to correct size. This happened occasionally, but not every time; we could not figure out why this would happen. Also care needs to be taken to ensure Jack uses the same JT file version as FactoryCAD. This will allow the user to import smart models from FactoryCAD and makes for easier visualization since parameters can be saved with the model out of FactoryCAD such as color, density, etc.

eM-Plant

eM-Plant, as a tool in E-Factory, is responsible for simulating processes. It's graphical interface and drag-and-drop abilities seem to streamline the process layout. After the parameters are assigned to the simulation models, the simulation can be compiled and run. After the simulation is finished running, a report of the simulation is displayed that relays certain information to the user such as overall equipment usage, buffer utilization, overall wait times, as well as lead times.

The user interface of eM-Plant is somewhat reminiscent of Microsoft's Visual Basic. A workspace is surrounded by a number of menus and tools. Items are dragged and dropped on the workspace and arranged as necessary. Parameters are assigned to the item based on what type of item it is. Station items act differently and require different parameters than a buffer item for example. Although it seems pretty easy to use on the surface, a more realistic simulation requires a more complex setup. To accommodate for this, events and scripts can be written and called upon at certain points in the simulation. For example, if you want to set the simulation to call an operator to a specific station to handle a part as it leaves a station, an event could be set up to call a script that incorporates additional time into the process as a part leaves a station. The ability to add realism into the simulation is a very good

benefit of the software. The software also automatically displays the simulation report after the simulation finishes running. The HTML document that is generated can be saved for later viewing and it can also be published on the internet or sent via email for sharing the data.

Despite its intuitive interface, eM-Plant can be very complicated especially when adding more realism to the simulation. It has a very steep learning curve as you delve deeper into the potential of the software. To create a simulation with a reliable accuracy, one must not only know the software, but also the process in which he or she is simulating. An intimate knowledge of the process is crucial to the reliability of the simulation. eM-Plant also has difficulty incorporating information that does not strictly deal with cycle times of the process. Examples of this would be showcased when trying to implement operators, material handling, and work schedules. To incorporate this type of information into a simulation, it would require the coding of scripts as well as setting up the events to call the scripts. To do this effectively, it is pertinent that the user have some previous computer programming skills as this process requires many types of loops, if/else statements, among other commonly practiced programming skills.

Simulation Data

Simulation Duration

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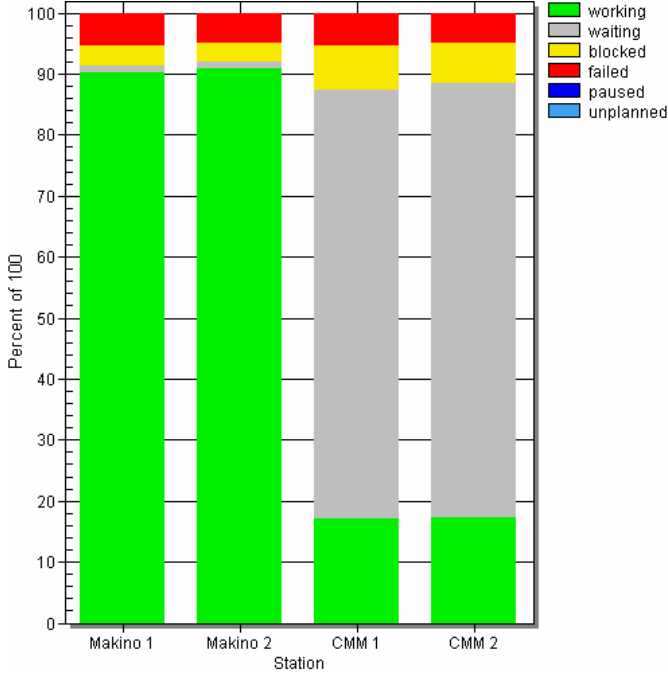
Days: Hours: Minutes: Seconds

Task Time

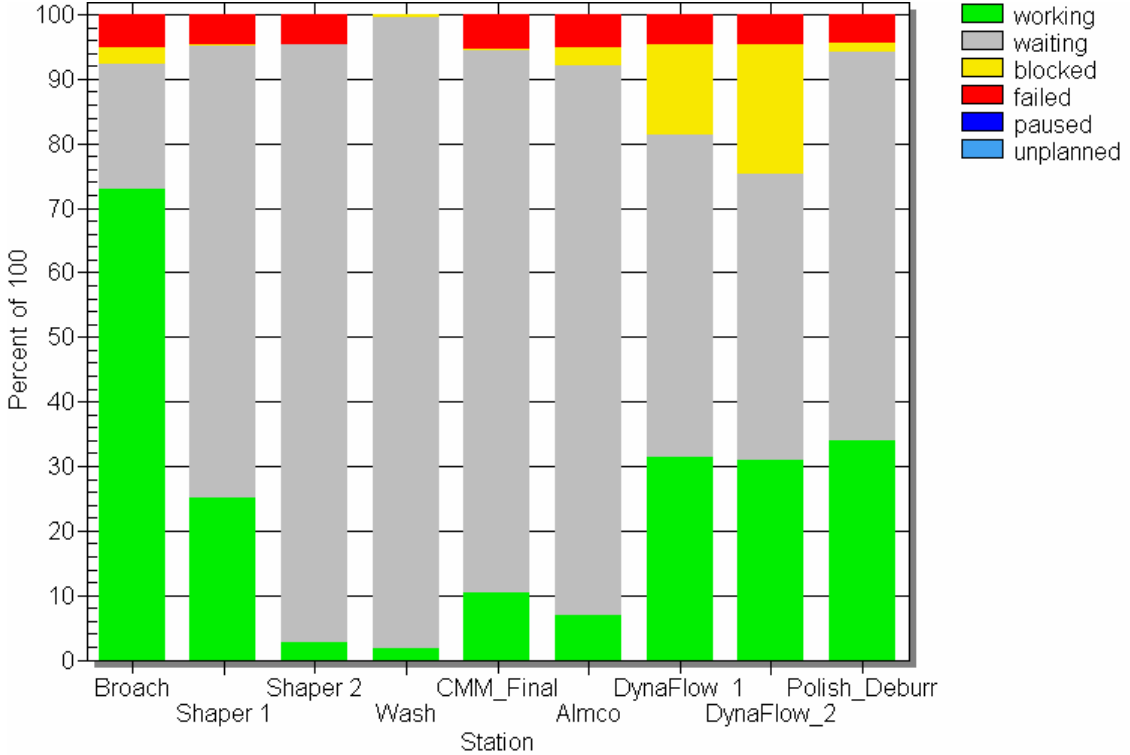
1:00.0000

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.MUs.HP_2	2	HP_2	Table : instantiated
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.MUs.HP_2	2	HP_2	Table : instantiated
.MUs.HP_1	2	HP_1	Table : instantiated
.MUs.HP_2	2	HP_2	Table : instantiated
.MUs.HP_1	2	HP_1	Table : instantiated
.MUs.HP_2	2	HP_2	Table : instantiated
.MUs.HP_3	2	HP_3	Table : instantiated
.MUs.HP_4	2	HP_4	Table : instantiated
.MUs.HP_3	2	HP_3	Table : instantiated
.MUs.HP_4	2	HP_4	Table : instantiated
.MUs.HP_1	2	HP_1	Table : instantiated
.MUs.HP_2	2	HP_2	Table : instantiated
.MUs.HP_1	2	HP_1	Table : instantiated
.MUs.HP_2	2	HP_2	Table : instantiated
.MUs.HP_1	2	HP_1	Table : instantiated
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.MUs.HP_2	2	HP_2	Table : instantiated

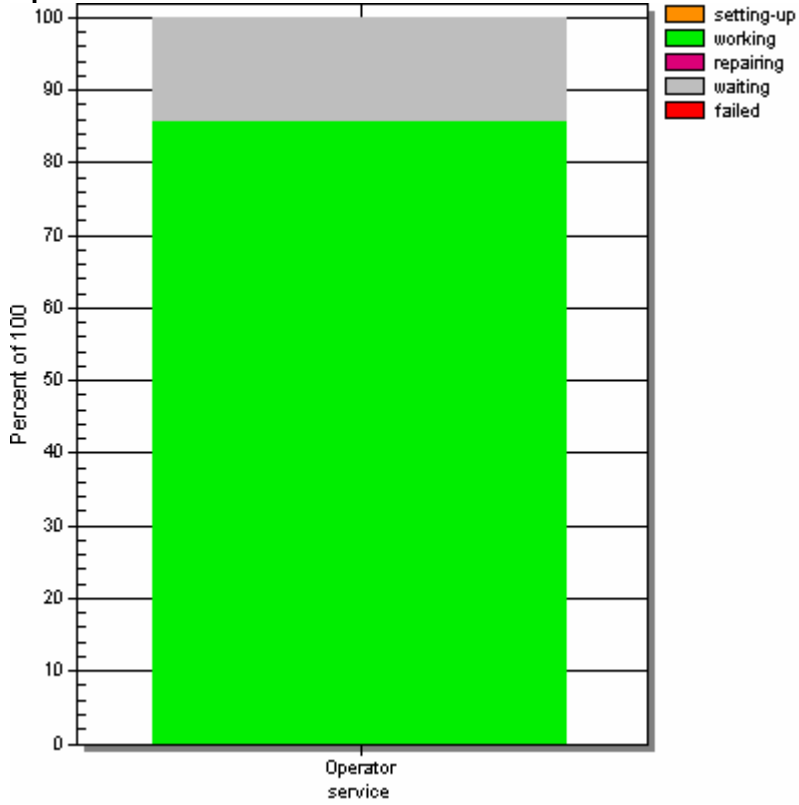
Makino Cell Utilization



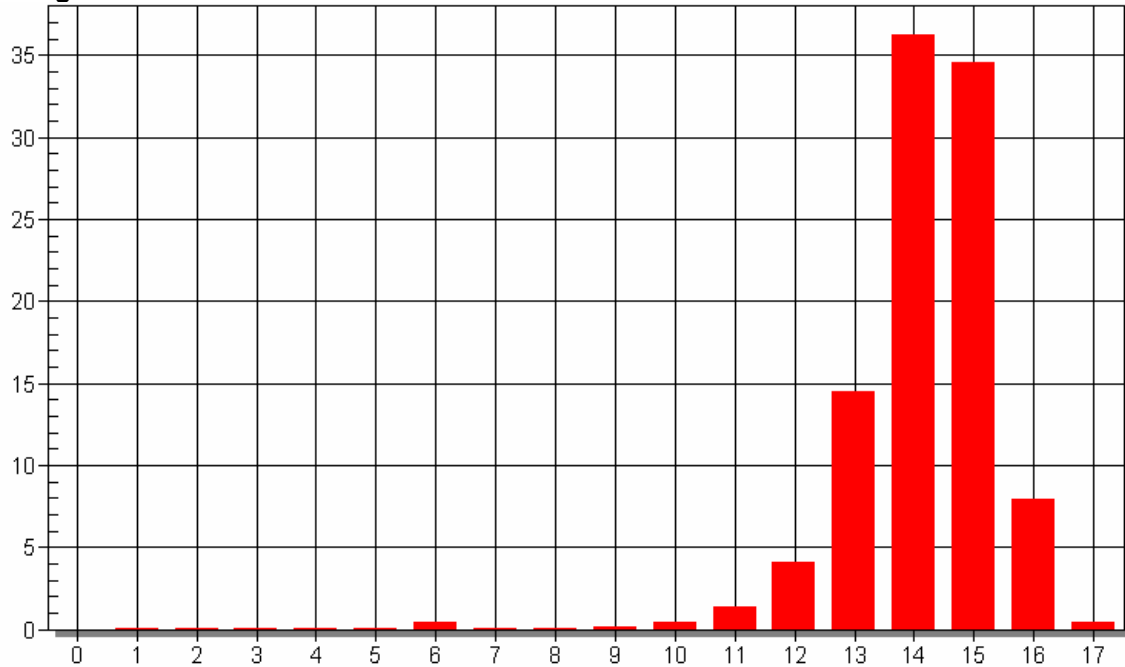
Traditional Line Utilization



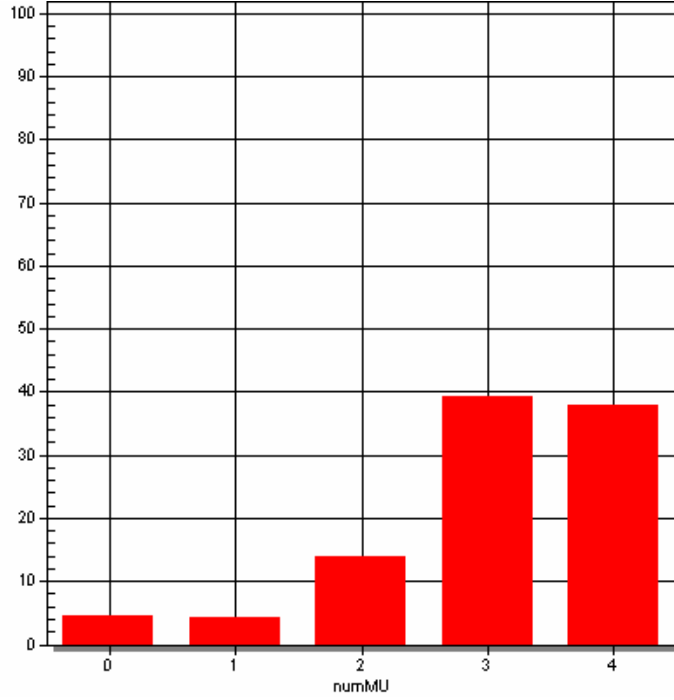
Operator Utilization



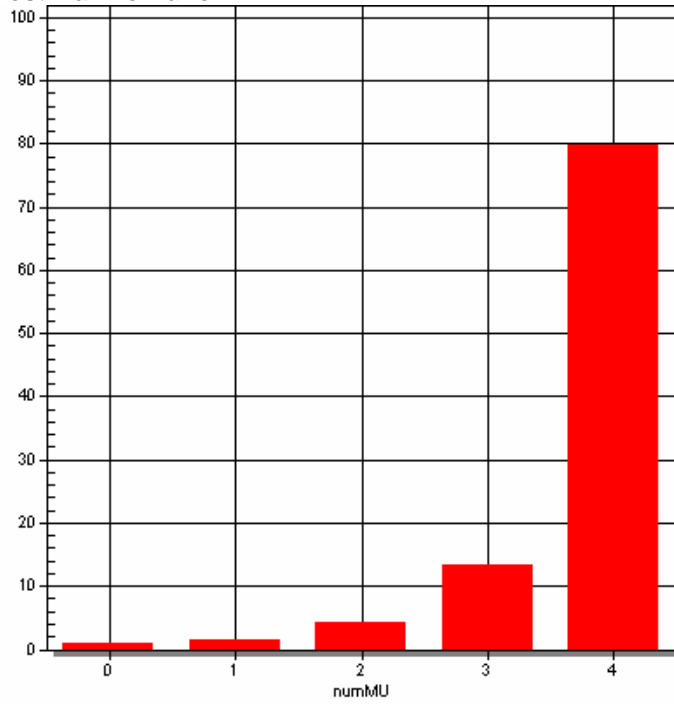
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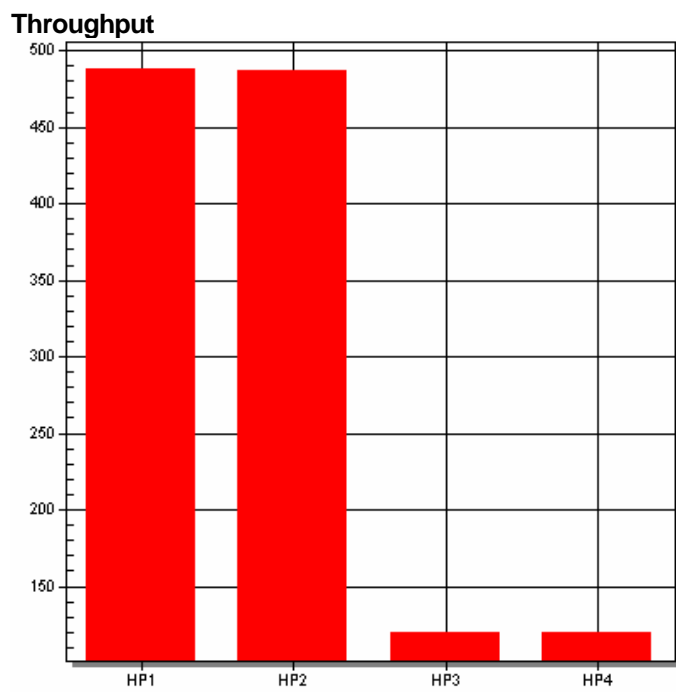


Internal Makino Buffer



Post Makino Buffer





Model Statistics

Type	Time	Total Throughput	%Parts	LT_Mean
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HP_2	245:00:00:00.0000	487	40.082304526749	3:02:55:05.0414
HP_3	245:00:00:00.0000	120	9.87654320987654	2:21:24:07.6100
HP_4	245:00:00:00.0000	120	9.87654320987654	2:20:35:35.1150

Type	LT_StdDev	LT_Min	LT_Max	TPh_Mean
HP_1	5:57:06.7257	1:14:32:04.3270	3:12:38:53.6050	1
HP_2	5:14:45.3024	2:05:39:22.0102	3:15:31:39.9936	1
HP_3	4:53:11.5625	2:06:41:22.0102	3:09:05:25.9781	1
HP_4	5:21:33.1290	2:03:56:22.0102	3:08:46:56.3680	1

Type	TPh_StdDev	TPh_Min	TPh_Max	TPd_Mean
HP_1	0	0	1	2.3047619047619
HP_2	0	0	1	2.30622009569378
HP_3	0	0	1	2.03508771929825
HP_4	0	0	1	2.05357142857143

Type	TPd_StdDev	TPd_Min	TPd_Max	CT_Mean
HP_1	0.700291252106051	0	4	11:59:02.0915
HP_2	0.629414845295881	0	4	11:59:15.4491
HP_3	0.731068500813847	0	4	1:22:59:40.8668
HP_4	0.77270817394274	0	4	1:22:58:16.0254

Type	CT_StdDev	CT_Min	CTS_Max	W_Mean
HP_1	10:56:27.5501	3:35:00.0000	2:10:45:08.8427	1:02:13:12.7090
HP_2	10:54:34.9911	3:50:00.0000	2:10:35:38.3868	23:57:17.6683
HP_3	2:22:22:35.1964	2:55:00.0000	7:14:12:21.1693	1:01:18:53.7474
HP_4	2:22:02:33.4583	2:55:00.0000	7:13:02:36.8192	1:02:30:16.9059

Type	W_StdDev	W_Min	W_Max	S_Mean	S_StdDev
HP_1	5:52:04.2810	1:45:10.1490	1:16:48:40.1707	5:26.8033	22:05.3725
HP_2	5:02:51.2951	8:27:18.2788	1:21:17:08.9429	17:20.0821	56:36.5478
HP_3	5:17:26.0037	13:20:57.4918	1:14:19:41.3605	5:33.0000	22:19.8323
HP_4	5:48:40.5053	15:06:09.0355	1:14:37:25.8118	13:21.0000	48:48.1753

Type	S_Min	S_Max	IP_Mean	IP_StdDev	IP_Min
HP_1	0.0000	4:06:00.0000	1:21:32:02.7149	4:52:17.6163	10:35:44.5921
HP_2	0.0000	4:06:00.0000	2:01:27:15.1713	4:24:22.9453	20:00:44.5921
HP_3	0.0000	4:06:00.0000	1:18:53:16.7868	3:27:59.5930	1:10:48:47.7895
HP_4	0.0000	4:06:00.0000	1:17:08:09.8997	3:40:37.3276	1:04:49:27.8192

Type	IP_Max	P_Mean	P_StdDev	P_Min	P_Max
HP_1	2:09:27:39.5466	0.0000	0.0000	0.0000	0.0000
HP_2	2:12:01:24.2406	0.0000	0.0000	0.0000	0.0000
HP_3	2:01:29:45.7962	0.0000	0.0000	0.0000	0.0000
HP_4	2:02:11:48.5781	0.0000	0.0000	0.0000	0.0000

Type	F_Mean	F_StdDev	F_Min	F_Max	W_P_Mean
HP_1	1:15:36.0734	1:18:25.4561	0.0000	6:58:23.3915	16:29:59.9792
HP_2	1:21:17.8333	1:25:38.0298	0.0000	6:56:01.9797	14:15:58.4009

HP_3	1:11:57.0758	1:19:34.1754	0.0000	7:10:02.2602	16:20:08.5591
HP_4	57:08.3094	1:09:05.3664	0.0000	7:09:06.1782	17:15:05.0462

Type	W_P_StdDev	W_P_Min	W_P_Max	S_P_Mean	S_P_StdDev
HP_1	5:26:30.4035	1:45:10.1490	1:09:51:49.9374	5:26.8033	22:05.3725
HP_2	4:52:22.4209	2:30:32.0304	1:12:40:07.1026	17:20.0821	56:36.5478
HP_3	4:45:38.7495	6:50:59.5090	1:02:17:09.7229	5:33.0000	22:19.8323
HP_4	5:39:43.9775	6:03:40.1411	1:07:19:23.0609	13:21.0000	48:48.1753

Type	S_P_Min	S_P_Max	IP_P_Mean	IP_P_StdDev	IP_P_Min
HP_1	0.0000	4:06:00.0000	22:22:27.7237	51:11.8352	10:35:44.5921
HP_2	0.0000	4:06:00.0000	1:02:40:56.0889	32:18.9457	17:36:15.3071
HP_3	0.0000	4:06:00.0000	20:21:00.0000	0.0000	20:21:00.0000
HP_4	0.0000	4:06:00.0000	18:43:00.0000	0.0000	18:43:00.0000

Type	IP_P_Max	P_P_Mean	P_P_StdDev	P_P_Min	P_P_Max
HP_1	22:27:00.0000	0.0000	0.0000	0.0000	0.0000
HP_2	1:02:43:00.0000	0.0000	0.0000	0.0000	0.0000
HP_3	20:21:00.0000	0.0000	0.0000	0.0000	0.0000
HP_4	18:43:00.0000	0.0000	0.0000	0.0000	0.0000

Type	F_P_Mean	F_P_StdDev	F_P_Min	F_P_Max	W_T_Mean
HP_1	1:15:36.0734	1:18:25.4561	0.0000	6:58:23.3915	0.0000
HP_2	1:21:17.8333	1:25:38.0298	0.0000	6:56:01.9797	0.0000
HP_3	1:11:57.0758	1:19:34.1754	0.0000	7:10:02.2602	0.0000
HP_4	57:08.3094	1:09:05.3664	0.0000	7:09:06.1782	0.0000

Type	W_T_StdDev	W_T_Min	W_T_Max	S_T_Mean	S_T_StdDev
HP_1	0.0000	0.0000	0.0000	0.0000	0.0000
HP_2	0.0000	0.0000	0.0000	0.0000	0.0000
HP_3	0.0000	0.0000	0.0000	0.0000	0.0000
HP_4	0.0000	0.0000	0.0000	0.0000	0.0000

Type	S_T_Min	S_T_Max	IP_T_Mean	IP_T_StdDev	IP_T_Min
HP_1	0.0000	0.0000	0.0000	0.0000	0.0000
HP_2	0.0000	0.0000	0.0000	0.0000	0.0000
HP_3	0.0000	0.0000	0.0000	0.0000	0.0000
HP_4	0.0000	0.0000	0.0000	0.0000	0.0000

Type	IP_T_Max	P_T_Mean	P_T_StdDev	P_T_Min	P_T_Max
HP_1	0.0000	0.0000	0.0000	0.0000	0.0000
HP_2	0.0000	0.0000	0.0000	0.0000	0.0000
HP_3	0.0000	0.0000	0.0000	0.0000	0.0000
HP_4	0.0000	0.0000	0.0000	0.0000	0.0000

Type	F_T_Mean	F_T_StdDev	F_T_Min	F_T_Max	W_S_Mean
HP_1	0.0000	0.0000	0.0000	0.0000	9:43:12.7298
HP_2	0.0000	0.0000	0.0000	0.0000	9:41:19.2674
HP_3	0.0000	0.0000	0.0000	0.0000	8:58:45.1883
HP_4	0.0000	0.0000	0.0000	0.0000	9:15:11.8598

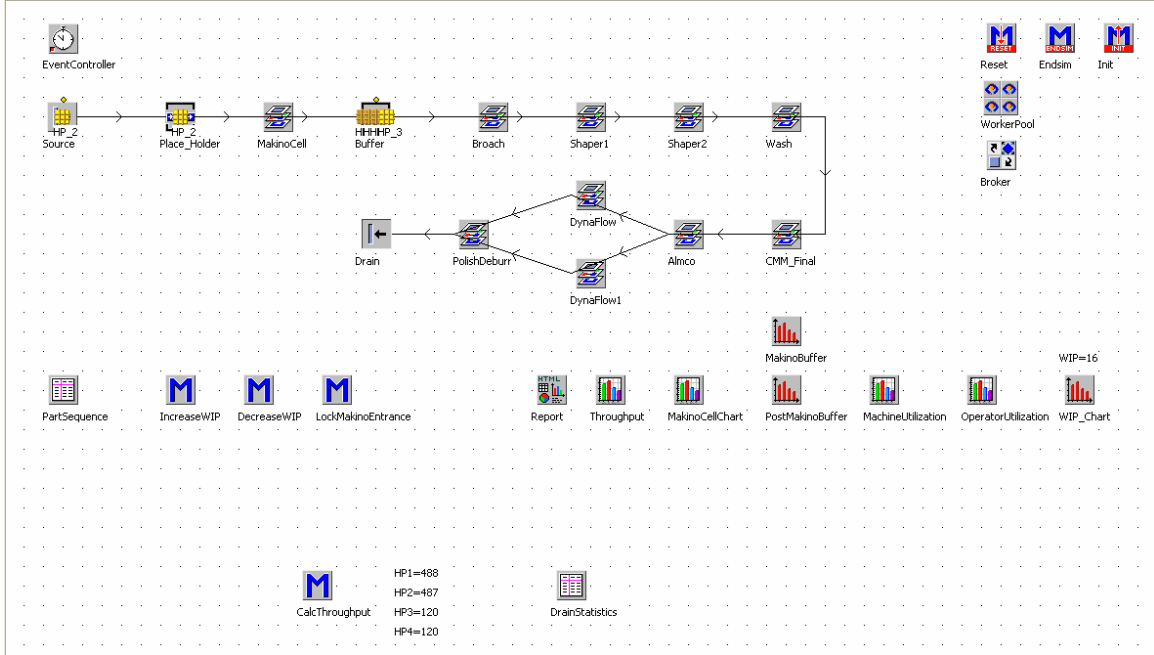
Type	W_S_StdDev	W_S_Min	W_S_Max	S_S_Mean	S_S_StdDev
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HP_2	2:11:10.2504	2:19:22.3198	17:22:29.3021	0.0000	0.0000
HP_3	1:58:42.0668	4:54:40.5828	15:20:47.5551	0.0000	0.0000
HP_4	1:55:11.6375	5:25:25.9915	16:51:35.3766	0.0000	0.0000

Type	S_S_Min	S_S_Max	IP_S_Mean	IP_S_StdDev	IP_S_Min
HP_1	0.0000	0.0000	23:09:34.9912	4:26:54.6616	0.0000
HP_2	0.0000	0.0000	22:46:19.0824	4:13:19.1747	2:24:29.2850
HP_3	0.0000	0.0000	22:32:16.7868	3:27:59.5930	14:27:47.7895
HP_4	0.0000	0.0000	22:25:09.8997	3:40:37.3276	10:06:27.8192

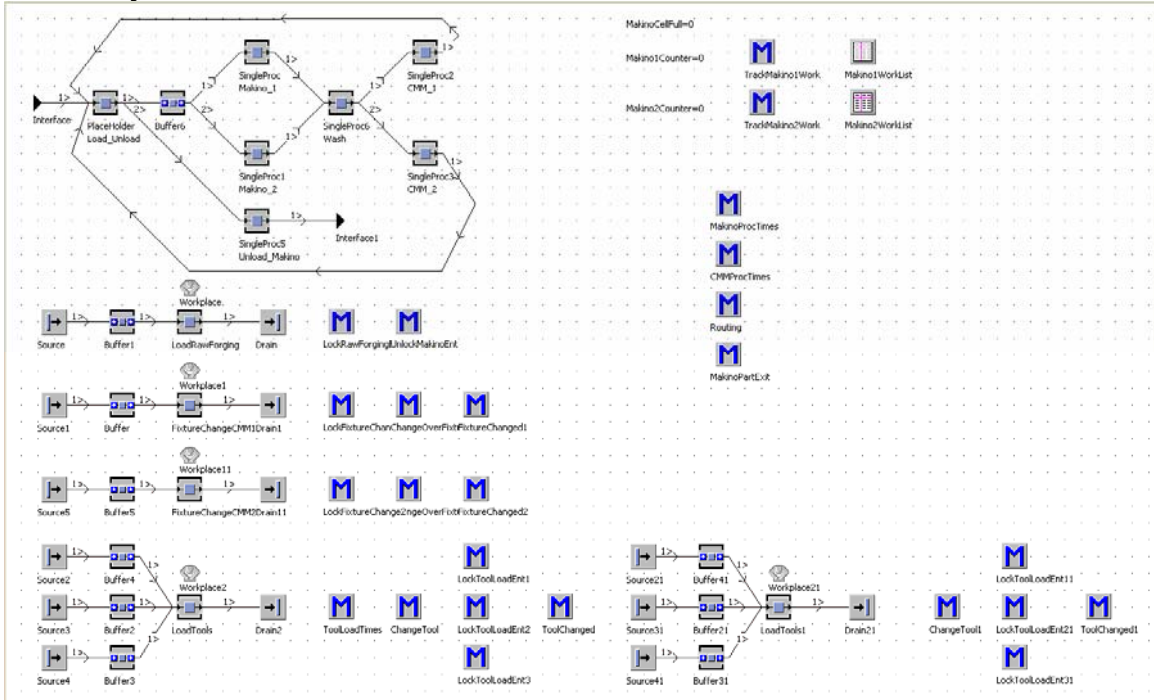
Type	IP_S_Max	P_S_Mean	P_S_StdDev	P_S_Min	P_S_Max
HP_1	1:11:00:39.5466	0.0000	0.0000	0.0000	0.0000
HP_2	1:09:18:24.2406	0.0000	0.0000	0.0000	0.0000
HP_3	1:05:08:45.7962	0.0000	0.0000	0.0000	0.0000
HP_4	1:07:28:48.5781	0.0000	0.0000	0.0000	0.0000

Type	F_S_Mean	F_S_StdDev	F_S_Min	F_S_Max
HP_1	0.0000	0.0000	0.0000	0.0000
HP_2	0.0000	0.0000	0.0000	0.0000
HP_3	0.0000	0.0000	0.0000	0.0000
HP_4	0.0000	0.0000	0.0000	0.0000

Process Layout



Makino Layout



Data Definitions

Item	Shows the
Type	Name of the MU.
Time	Last arrival of part of this type.
Total throughput	Number of parts of this type.
%Parts	Percentage of parts of this type.
LT_Mean	Mean life time (throughput time) of all investigated parts.
LT_StdDev	Standard deviation of the life times of all investigated parts.
LT_Min	Minimum life time of the investigated parts.
LT_Max	Maximum life time of the investigated parts.
TPh_Mean	Mean throughput per hour. Statistics only collects values for full hours and only for hours during which parts arrived.
TPh_StdDev	Standard deviation of the throughput per hour.
TPh_Min	Minimum throughput per hour.
TPh_Max	Maximum throughput per hour.
TPd_Mean	Mean throughput per day. Statistics only collects values for full days and only for days during which parts arrived.
TPd_StdDev	Standard deviation from the throughput per day.
TPd_Min	Minimum throughput per day.
TPd_Max	Maximum throughput per day.
CT_Mean	Mean cycle time of two parts that arrive back-to-back.
CT_StdDev	Standard deviation of the cycle time difference.
CT_Min	Minimum cycle time difference of two parts that arrive back-to-back.
CT_Max	Maximum cycle time difference of two parts that arrive back-to-back.
W_Mean	Mean waiting time of the investigated.
W_StdDev	Standard deviation of the waiting times of the investigated parts.
W_Min	Minimum waiting time of the investigated parts.
W_Max	Maximum waiting time of the investigated parts.
S_Mean	Mean set-up time of the investigated parts.
S_StdDev	Standard deviation of the set-up times of the investigated parts.
S_Min	Minimum set-up times of the investigated parts.
S_Max	Maximum set-up times of the investigated parts.

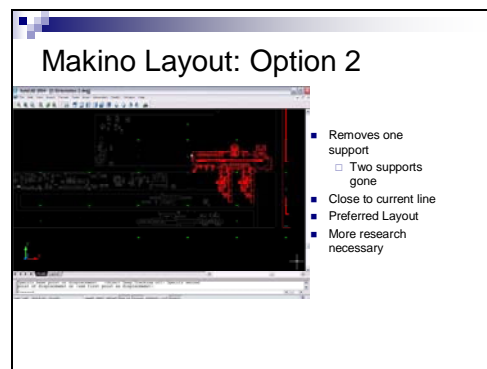
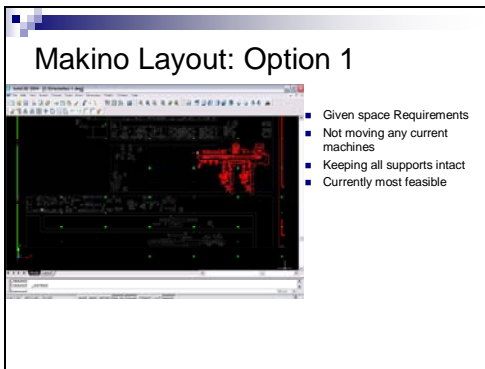
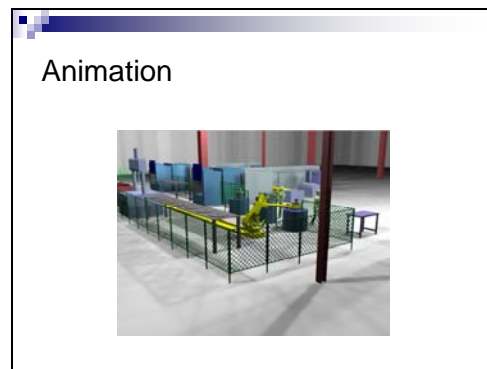
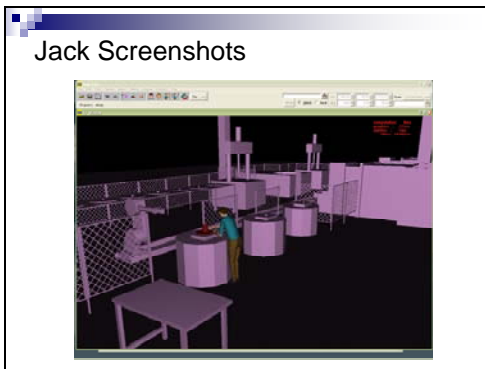
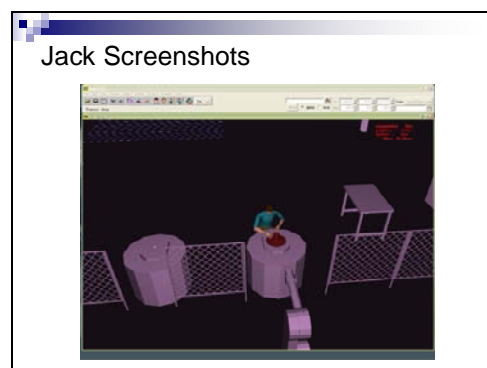
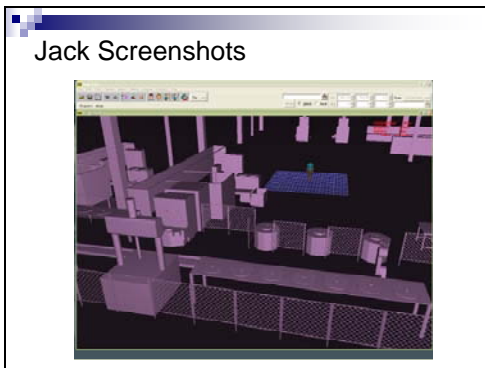
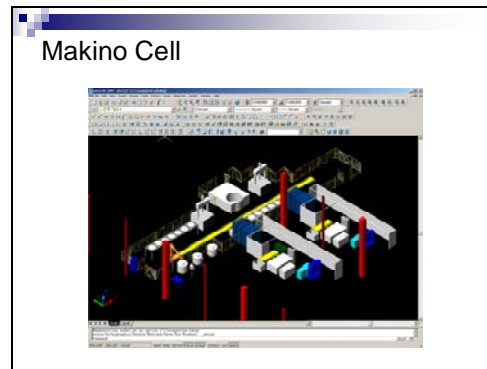
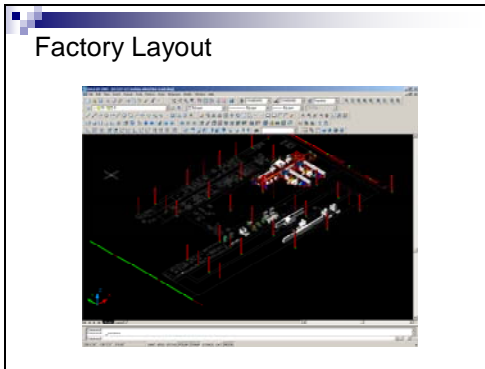
IP_Mean	Mean processing time of the investigated parts.
IP_StdDev	Standard deviation of the processing times of the investigated parts.
IP_Min	Minimum processing times of the investigated parts.
IP_Max	Maximum processing times of the investigated parts.
P_Mean	Mean time that the investigated parts were located on a paused resource.
P_StdDev	Standard deviation of the times that the investigated parts were located on a paused resource.
P_Min	Minimum time that a part was located on a paused resource.
P_Max	Maximum time that a part was located on a paused resource.
F_Mean	Mean time, that the investigated parts were located on a failed resource.
F_StdDev	Standard deviation of the times that the investigated parts were located on a failed resource.
F_Min	Minimum time that a part was located on a failed resource.
F_Max	Maximum time that a part was located on a failed resource.
W_P_Mean	Mean waiting times of the investigated parts on a resource of type Production .
W_P_StdDev	Standard deviation of the waiting times of the investigated parts on a resource of type Production .
W_P_Min	Minimum waiting time of the investigated parts on a resource of type Production .
W_P_Max	Maximum waiting time of the investigated parts on a resource of type Production .
S_P_Mean	Mean set-up times of the investigated parts on a resource of type Production .
S_P_StdDev	Standard deviation of the set-up times of the investigated parts on a resource of type Production .
S_P_Min	Minimum set-up time of the investigated parts on a resource of type Production .
S_P_Max	Maximum set-up time of the investigated parts on a resource of type Production .
IP_P_Mean	Mean processing times of the investigated parts on a resource of type Production .
IP_P_StdDev	Standard deviation of the processing times of the investigated parts on a resource of type Production .
IP_P_Min	Minimum processing time of the investigated parts on a resource of type Production .
IP_P_Max	Maximum processing time of the investigated parts on a resource of type Production .
P_P_Mean	Mean times of the investigated parts on a paused resource of type Production .
P_P_StdDev	Standard deviation of the times that the investigated parts were located on a paused resource of type Production .
P_P_Min	Minimum time of the investigated parts on a paused resource of type Production .

P_P_Max	Maximum time of the investigated parts on a paused resource of type Production .
F_P_Mean	Mean times of the investigated parts on a failed resource of type Production .
F_P_StdDev	Standard deviation of the times that the investigated parts were located on a failed resource of type Production .
F_P_Min	Minimum time of the investigated parts on a failed resource of type Production .
F_P_Max	Maximum time of the investigated parts on a failed resource of type Production .
W_T_Mean	Mean waiting times of the investigated parts on a resource of type Transport .
W_T_StdDev	Standard deviation of the waiting times that the investigated parts were located on a resource of type Transport .
W_T_Min	Minimum waiting time of the investigated parts on a resource of type Transport .
W_T_Max	Maximum waiting time of the investigated parts on a resource of type Transport .
S_T_Mean	Mean set-up times of the investigated parts on a resource of type Transport .
S_T_StdDev	Standard deviation of the set-up times that the investigated parts were located on a resource of type Transport .
S_T_Min	Minimum set-up time of the investigated parts on a resource of type Transport .
S_T_Max	Maximum set-up time of the investigated parts on a resource of type Transport .
IP_T_Mean	Mean processing times of the investigated parts on a resource of type Transport .
IP_T_StdDev	Standard deviation of the processing times of the investigated parts on a resource of type Transport .
IP_T_Min	Minimum processing time of the investigated parts on a resource of type Transport .
IP_T_Max	Maximum processing time of the investigated parts on a resource of type Transport .
P_T_Mean	Mean times of the investigated parts on a paused resource of type Transport .
P_T_StdDev	Standard deviation of the times that the investigated parts were located on a paused resource of type Transport .
P_T_Min	Minimum time of the investigated parts on a paused resource of type Transport .
P_T_Max	Maximum time of the investigated parts on a paused resource of type Transport .
F_T_Mean	Mean times of the investigated parts on a failed resource of type Transport .
F_T_StdDev	Standard deviation of the times that the investigated parts were located on a failed resource of type Transport .
F_T_Min	Minimum time of the investigated parts on a failed resource of type Transport .
F_T_Max	Maximum time of the investigated parts on a failed resource of type Transport .
W_S_Mean	Mean waiting times of the investigated parts on a resource of type Storage .
W_S_StdDev	Standard deviation of the waiting times that the investigated parts were located on a resource of type Storage .

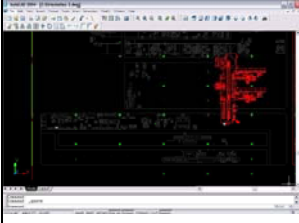
W_S_Min	Minimum waiting time of the investigated parts on a resource of type Storage .
W_S_Max	Maximum waiting time of the investigated parts on a resource of type Storage .
S_S_Mean	Mean set-up times of the investigated parts on a resource of type Storage .
S_S_StdDev	Standard deviation of the set-up times that the investigated parts were located on a resource of type Storage .
S_S_Min	Minimum set-up time of the investigated parts on a resource of type Storage .
S_S_Max	Maximum set-up time of the investigated parts on a resource of type Storage .
IP_S_Mean	Mean processing times of the investigated parts on a resource of type Storage .
IP_S_StdDev	standard deviation of the processing times that the investigated parts were located on a resource of type Storage .
IP_S_Min	Minimum processing time of the investigated parts on a resource of type Storage .
IP_S_Max	Maximum processing time of the investigated parts on a resource of type Storage .
P_S_Mean	Mean times of the investigated parts on a paused resource of type Storage .
P_S_StdDev	Standard deviation of the times that the investigated parts were located on a paused resource of type Storage .
P_S_Min	Minimum time of the investigated parts on a paused resource of type Storage .
P_S_Max	Maximum time of the investigated parts on a paused resource of type Storage .
F_S_Mean	Mean times of the investigated parts on a failed resource of type Storage .
F_S_StdDev	Standard deviation of the times that the investigated parts were located on a failed resource of type Storage .
F_S_Min	Minimum time of the investigated parts on a failed resource of type Storage .
F_S_Max	Maximum time of the investigated parts on a failed resource of type Storage .

Appendix B

Final Presentation

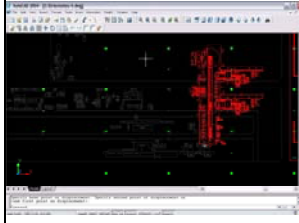


Makino Layout: Option 3



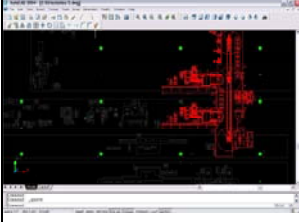
- Interferes with other lines
- Not advised

Makino Layout: Option 4



- Interferes with current line
- Not advised

Makino Layout: Option 5



- Removes 2 supports
- Interferes with current line
- Moves part input away from line
- Not advised

Using Radio Frequency Identification (RFID) to bring up user preferences and decrease login time across networked computers

CGT 411 Group 25 Vidation, Fall 2005
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College of Technology, Department of CGT
Purdue University

Abstract

The speed and convenience of radio frequency identification (RFID) appears ideal for the transfer of information in fields where time matters. The military and the health care industry both have needs for said technology. The need or implementation of the technology within the Computer Graphics Technology Department at Purdue University still needs to be explored. This pilot study and accompanying research explores the need and possible use for RFID technology within the Department as well as on the general campus. The prototype developed using RFID technology will be tested and the results of this study will facilitate a better understanding of whether or not the technology has a place within the department or within the university in general. Due to the successful completion of the prototype, this could be applied to the aforementioned areas where speed and versatility will be most needed. The goal of this study was to determine the effectiveness of using RFID technology over a traditional computer login technique.

Introduction

Radio frequency identification (RFID) is becoming more and more mainstream and according to Jonathan Collins' article in the March 2005 edition of *RFID Journal*, RFID spending in Western Europe will be up from \$464 million in 2004 to \$1.9 billion by 2009 (Collins, 2005). Here in the United States, 82% of companies are planning on implementing the tracking technology, with 69% of companies looking to implement it this calendar year (Best, 2005). With this in mind, it is only natural that the Computer Graphics Department at Purdue University explore the technology and its potential benefits.

At present, the Computer Graphics Department is not using any version of RFID technology or software to login to their computers. Computer logins are done manually using built in Windows server software. The current method fulfills its purpose, but when outside the College of Technology, simply logging in does not grant access to many of the programs that Computer Graphics students need to complete their coursework.

The process is also time-consuming because of all the settings that need to be loaded. This is one area that warrants an exploration of the possible benefits RFID technology can bring to the department.

To solve this problem, a prototype system involving the use of RFID tags and readers, has been developed to expedite the login process. This system also allows students access to the software they need anywhere on campus via a "preference" embedded in their student identification card with their college designation (*See Figure 1*). Since software needs vary from students to student, identification cards need to be equipped with a means of distinguishing a liberal arts student from an engineering student. The implementation of this system would allow individuals to access and view information from computers in a manner that suits their personal needs.



Figure 1 – Example Student Identification Card

The research being conducted is an effort to prove that RFID technology, coupled with proprietary software, could possibly decrease down time and increase user productivity in a university environment.

Utilization of RFID technology within the university system could then lead to the technology being adapted to be used in military and health care environments. The time saved over traditional login techniques could save lives in environments where time is of the essence.

Establishing a Need for Our Product

Research was conducted during the previous semester regarding learning preferences and the project’s intended implementation into the military. After meeting with the members of the previous semester’s team, the next step in the project was to develop a working prototype and answer the question of how RFID technology could be used within the Computer Graphics Department at Purdue University (see figure 2 for how an RFID system works).

Group 25, also known as the Vidation Team, began weekly meetings with course director Terry Burton so as to keep the lines of communication open during the semester. On campus resources were utilized; including Professor Eugene Spafford (executive director of C.E.R.I.A.S), Assistant Professor Steven Elliot, and several professors in the ECE department. To gain a practical perspective, a meeting was set up with Mr. Keith Mulford, Dr. Nitya Narasimhan, Mrs. Julie Leverenz, and Mr. Raja Natarajan, from The Emerging Technologies Group from Motorola. From these discovery meetings it was evident that there could be use

for technology that would allow an individual, in high or low-stress environments, the ability to gain access to their computer configuration in a decreased amount of time, compared to traditional methods.

Such a technology could have the ability to be widely applicable. In high-stress situations, present in both the military and health care industries, the time saved could mean the difference in the number of lives saved. In low-stress environments, like those found in academic settings, students are often going from one computer lab to another and the time saved could enable students to be more productive in a shorter amount of time.

This technology has the potential to increase productivity by reducing the amount of time spent getting at an individuals’ information. RFID technology can play an important role in areas where efficiency is more than a mere convenience. In academic settings, the technology could allow students to access software required for their course work from anywhere on campus rather than in designated computer labs. Keeping these factors in mind, development began on an RFID-based prototype that will reduce the amount of time wasted each day.



Figure 2- How the proposed RFID Login System Works

Target Audience

One of the first issues considered when developing the prototype was the basic characteristics of the people that make up the product's target audience. It was decided they wanted to make the product simple enough to for the everyday user.

Since the RFID prototype opened a Microsoft Office program, target audience needed to be familiar with the programs. It was decided that users must be 18 or older. According to prior research, Microsoft Office programs are currently being used by the military and so Microsoft Office was used in this study. (Personal Communication, February 23, 2005).

Security Issues

The next step in the development process was to determine the civil liberty and security issues surrounding the use of RFID tags. During the discovery phase of the project, it was found that RFID tags can be monitored, with very sensitive devices, up to a couple hundred feet away (personal communication, October, 19, 2005). This begged the question of whether or not students that carry this technology within their student identification cards would be "tracked" as they moved from location to location on campus. If they can be tracked in an academic setting, then military personnel could also be tracked as they move from one hostile environment to another. Both situations cause high security risks as well as possible infringements on a person's civil liberties.

In an attempt to answer questions regarding these security and civil liberty issues, a meeting

was arranged with Professor Eugene Spafford, executive director of C.E.R.I.A.S (Center for Education and Research in Information Assurance and Security) program at Purdue University. During the hour-long question and answer session, Professor Spafford (personal communication, October 19, 2005) confirmed that RFID tags could indeed be "tracked" if the tag continued to pass by RFID readers in different areas of campus. It was also confirmed that there was technology available to read information from RFID tags from several hundred yards away. However Professor Spafford also posed the question, "If you know where someone is, does that necessarily invade their privacy?"

While the answer to this question was still not clear, it was found that SmartCards have the ability to store security certificates. However upon further research it was discovered that these SmartCards were expensive to manufacture in bulk, most often required physical contact with the reader, and often had more technical issues during use than simple RFID tags (personal communication, October 22, 2005).

Professor Spafford highlighted the protocol that goes along with the technology. He said technology that involves the transfer of personal information is more dependent upon questions of protocol than upon the security of the technology being used. It is protocol that would have to answer questions regarding three crucial areas: denial, duplication, and loss (personal communication, October 19, 2005).

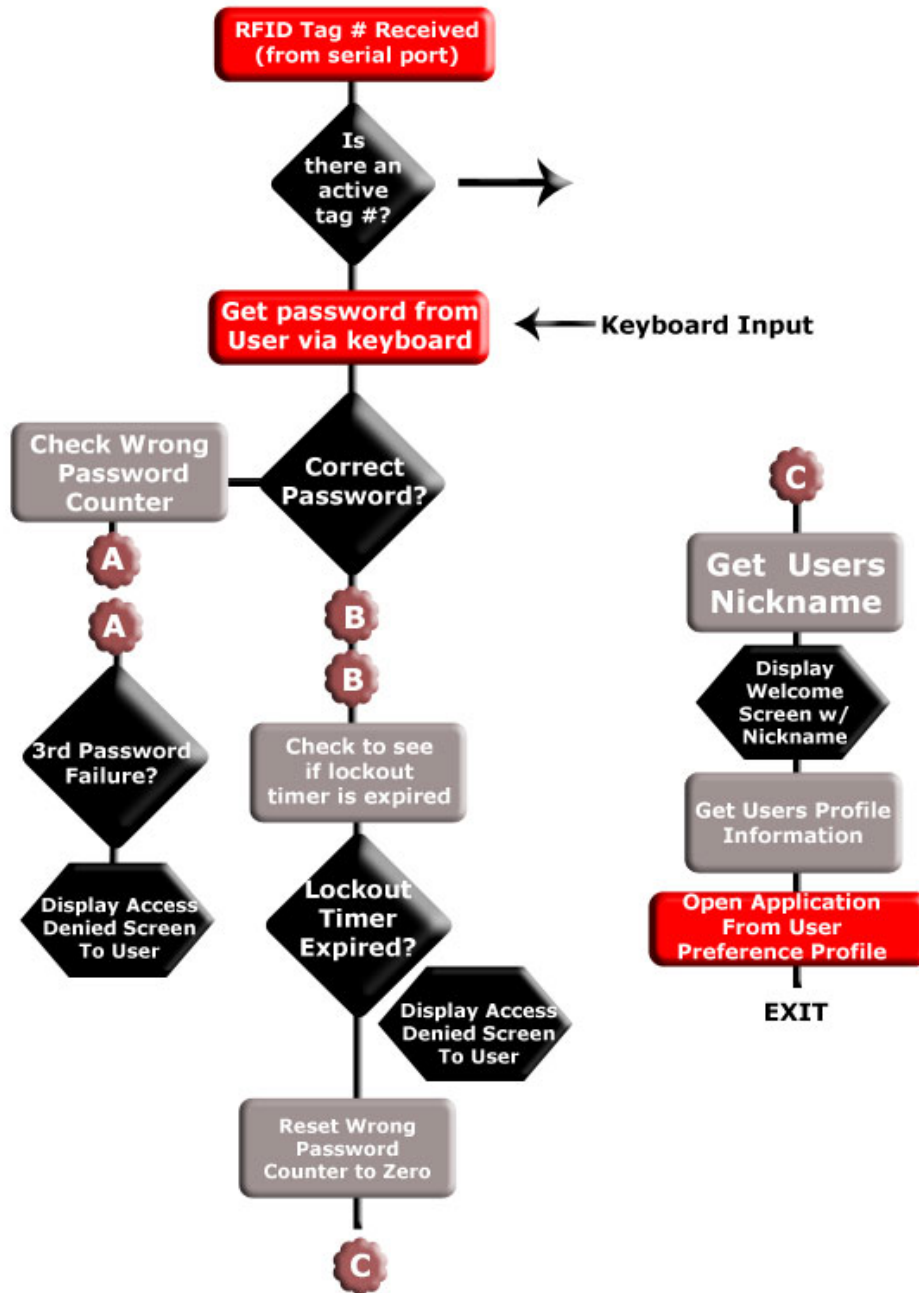


Figure 3- Flowchart of RFID Login System

It was decided to answer the protocol concern of duplication, in that the card would simply store an alphanumeric code that would serve as the user's login. The code would then be combined with a manually entered password from the user as a means to ensure only the proprietor of the card could gain access to information associated

with that account (See figure 3). This decision was validated by acknowledging that the current system in place at Purdue University used a similar method of requiring a password to gain account access. The alphanumeric number would also be tied to a database storing the accounts with their passwords. If an account

card is lost or stolen, information stored within the account is protected, due to the password, and upon notification of a lost or stolen card, the password would automatically be reset and the user informed of the change via email.

Hardware/Software Used

RFID is not the only technology currently available that can complete our task.

As mentioned earlier, SmartCard technology represents another viable solution. SmartCards and RFID use very similar technology. In fact, the key difference between the two technologies is the sophistication of the semiconductor that makes up the tag or card (personal communication, November 22, 2005). However, like RFID, SmartCards has its own set of advantages and disadvantages. Its advantages include: substantially improved security, by means of security certificates, and the ability to run multiple applications on the card (separate purses). Some of the Java-based SmartCards can even “push” new applications to the card without having to reissue it, which allows the card’s capabilities to grow over time. Not having to reissue the card also saves both the issuer and the user money (personal communication, November 22, 2005).

Due to the fact that the technologies are so similar, there are some things to consider when deciding between the two solutions. According to Bruce Heyman (personal communication, November 22, 2005), MCEI VP in the Asset Visibility Solutions Group at Motorola, INC., “The smartest (‘most capable’) RFID tag can be smarter than the dumbest SmartCard.” Since the cost of implementing and using SmartCards is higher than using RFID tags, it is important to match the cost of the solution to the customer’s needs. It is important to consider whether or not the lack of security on RFID tags truly warrants the added cost associated with SmartCards.

Another available software product on the market is called the Automatic Personal Identification System and is made by a company called AXCESS. Some of the products’ features could possibly be incorporated into further development of the RFID prototype such as its

security system and its flexible read range (Axxess, 1999). A product called iButtons (*see figure 4*) was also investigated and while they could serve as a technically more secure method of information transfer, they are contact based (“iButton”, 2005). One of the goals of the prototype was to be proximity based as opposed to contact-based.



Figure 4 – An iButton

After an investigation, it was decided to proceed with the development a solely RFID prototype using Texas Instruments’ (TI) Standard Development Kit. The kit came with a reader and three passive RFID tags contained within three different objects: a credit-card sized tag, a tube, and a key chain tag. Each tag is read-only and has a unique alphanumeric identifier stored within it.

Production Schedule

Production officially began on Monday, October 17, 2005. The completion date set for the prototype was week 11 (Monday, October 13, 2005). Initial programming was done in Basic and the accompanying graphical user interface was written in Visual Basic. The prototype itself was completed on time and testing began on Thursday, November 10, 2005.

Testing

Testing began on Thursday, November 10, 2005. Twenty students, a convenient sample, was chosen from within the Computer Graphics Department at Purdue University’s West Lafayette campus to participate in the pilot study. The aim of testing was to prove that using an RFID based login system was more efficient than using traditional login techniques. Efficiency, for the purposes of this paper is the production of the desired effects or results with minimum waste of time, effort, or skill. The testing itself was comparable to that of the previous semester, meaning both are testing for efficiency and both made use of a crossover testing methodology. By keeping the tests

similar, it enabled effectual comparisons and also serves to further validate the previous study's hypothesis. Since this is a pilot study, efficiency will be studied only in terms of time. Testing was a two part study: pretest survey and a task oriented test.

Pre-conditioning Survey

The pretest was the initial phase of the testing process. Participants were asked to complete a pretest survey asking, among other things, their familiarity with RFID, hours per day spent on a computer, and how many times per day they log into a computer. The pretest survey consisted of two Lickert scales, one multiple choice, and two short answer questions. For the purposes of this paper, short answer questions are defined as a question where there are no predefined answers available for the participant to choose, they must enter their own answer on the provided answer space.

Task-oriented Test

Once the pretest was completed, participants were brought into the testing room where two computers were set up in the following configurations: one computer displaying login screen, one computer displaying the text-based RFID prototype interface. Each participant was given the same set of instructions by the same moderator. The variable being tested was the time it took for a user to login, open the predefined Microsoft Office program, either Excel or PowerPoint, close said program, and then logout. The same procedure was conducted on both machines, alternating between using the RFID-based system and the traditional system first (See *Figure 5*).

Audience

The pilot study included men and women ages 18 and older.

Choosing Software

Microsoft Office was chosen based upon the previous research and its prevalence in a college setting. (CITE)

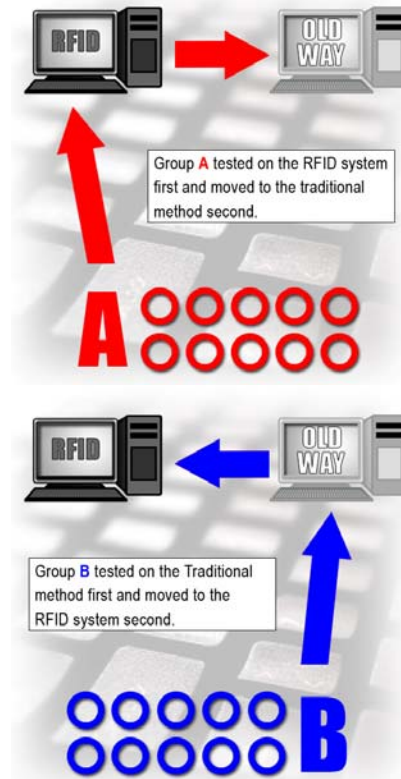


Figure 5 – Illustration of Testing Methodology

Sampling limitations

Ideally, the sample for this study would include military or health care employees due to the potential benefits of RFID technology in these fields. Unfortunately accessibility to military personnel was limited. For purposes of convenience and lack of time, a random sample was instead taken from the CGT list serve. The first twenty respondents were selected to participate. The sample included these students because they are all relatively familiar with basic computer tasks. None of the participants had any prior knowledge of the study. Participants tested one at a time in a room with the door closed so as to prevent future participants from becoming familiar with the testing procedure.

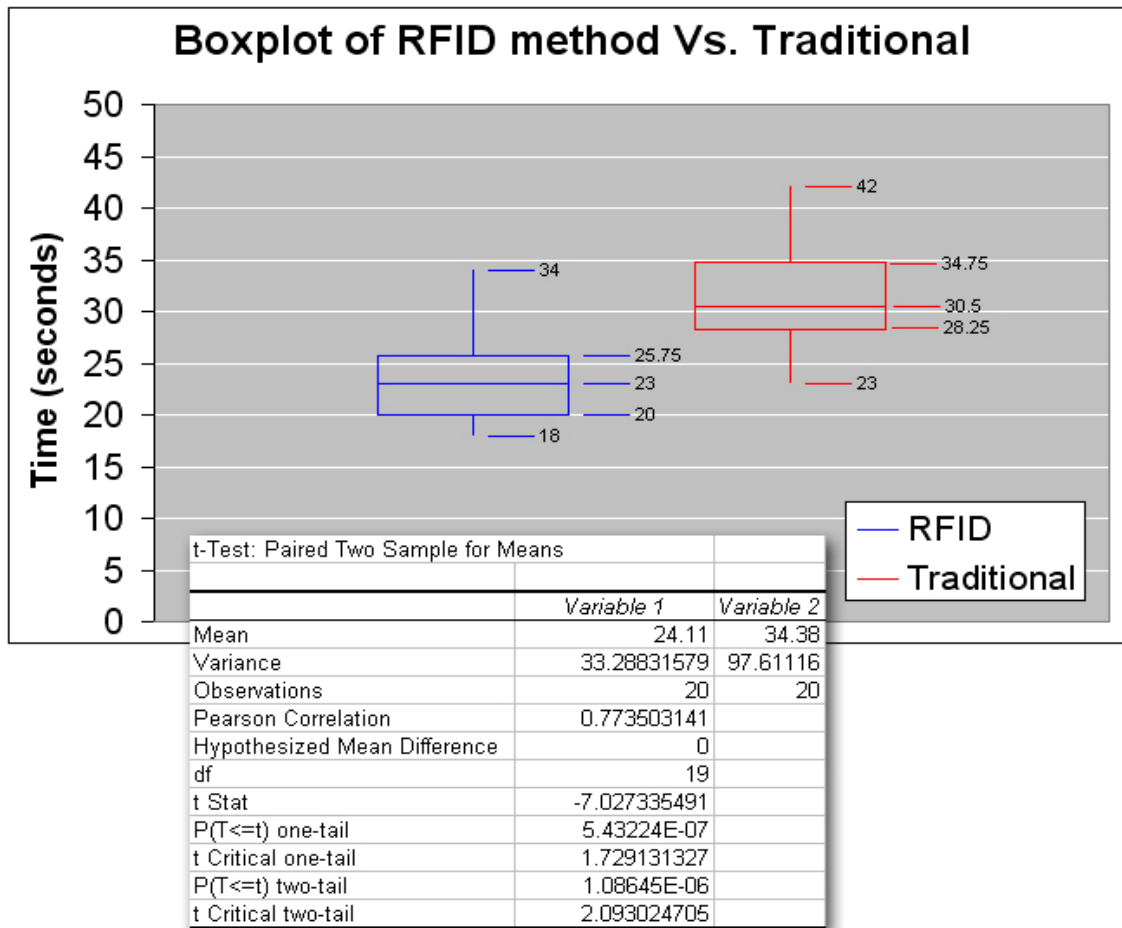


Figure 6 – Boxplot of Testing Results

Testing Limitations

There were two obvious problems with data collection. The first issue was with the technical nature of the computers themselves. Unfortunately, two completely identical computers could not be acquired in time for testing. The computer used for timing the traditional login method was a slightly older computer than the computer used to time the RFID login method. To counter the possible effects this may have had in our data collection, the desktop only had the operating system and the Microsoft Office suite of products stored on its hard drive, it was free of any “extraneous” software.

The second problem with data collection was the order of the trials. Once the participant entered the testing room, they were given a set

of instructions by the testing moderator, with the same set of instructions given to each participant. The testing moderator alternated the login system that was used first. Therefore in the trials in which the RFID based login tested second, it is possible that participants could have forgotten the instructions given by the testing moderator at the beginning of the test.

Results

The null hypothesis for this study stated a significant time difference would not be found using the RFID login system versus the traditional login method by indication of a comparable or slower time to completion. The hypothesis stated that there would be a significant time difference using the RFID login system versus the traditional login method by indication of a faster time of completion.

The data was gathered and compiled (See *figure 6*). Each participant has a time for the RFID portion of the test, a time for the Traditional method portion of the test; also there is a numerical value for the difference between the two.

A two-tail t-test analysis was done on the figures received from testing (See *figure 6*). In addition, the correlation between participants' time in the RFID portion of the test and the time in the non-RFID enabled portion of the test are displayed (See *figure 6*).

It is worth noting that with a p-value less than an alpha level of $\alpha=.05$, combined with the fact that most users were able to complete the tasks using our RFID method more efficiently than without it, it is evident that the null hypothesis should be rejected. The results from the RFID part of the test are not equal to or greater than the results from non-RFID part of the test. Then, by the t-stat being negative (the result of taking the mean of the RFID section of the test minus mean of the traditional method portion of the test) it can be suggest that the hypothesis be accepted. This pilot study tends to suggest that the time for the RFID portion of the test is less than non-RFID portion of the test, which validates our aim of a more efficient login system.

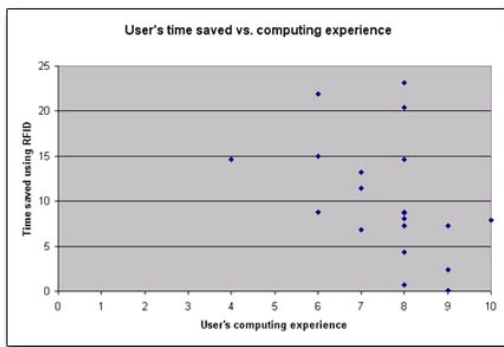


Figure 7 – Graph of Time Saved vs. Computing Experience

The data was analyzed for any correlation between a user's prior computing experience versus the time they saved. This was done to see if the participant's computing experience

influenced the amount of time saved (See *figure 7*). The data suggests there is no apparent correlation between the two, which then infers that a user's experience has no bearing on whether or not they would be able to save time using our solution.

Future of the Project

Phase III

Group 25 has already taken the steps toward Phase III with the development of the graphical user interface (See *Figure 8 & Figure 9*). Further development and customization of the interface is needed; this phase should research what the needs of both military and health care professionals are. Since both fields have different needs, they naturally would require slightly different functionality from their systems. Once the needs are established, testing in military and health care settings by military and health care professionals is needed for continued validation.

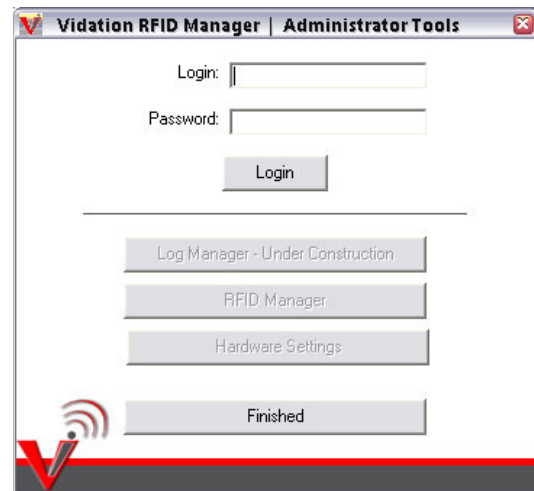


Figure 8 – Administration Login Page on Graphical Prototype

Phase IV

Phase IV will consist of the implementation/commercialization of the product. A strategic plan for the commercialization of this product will be developed to promote the functionality of the technology for the United States military, and health care settings.



Figure 9 – User Login Page on Graphical Prototype

Conclusions

Participants that took part in the pilot study saved an average of ten seconds using their RFID-based login system over the traditional login system. While this may seem insignificant, consider these results in a medical context. If a nurse pulls information on twenty different patients, they have saved in excess of three minutes. Now apply that to all the nurses on duty during a day and the mere ten seconds saved, may create a significant difference.

Although the test subjects were not military or health care personnel, the data collected from the study confirms that there is a significant amount of time saved per login and, when applied in military or hospital environments, could prove to be advantageous. Further testing is needed in these areas to validate this belief. Further development of the graphically-based prototype is also needed.

At the time this paper was written, milestones reached included the development of a proof of concept using TI's RFID kit, accompanying testing data proving its efficiency, and preliminary development of a graphically-based interface using the TI RFID kit.

The initial purpose of this venture was to create a working proof of concept which validated the findings of the previous semester's pilot study. Upon completion of the graphical interface, the project can undergo real-world testing in military and health care environments. As the project progresses further, it can be commercially implemented in those desired settings and become a viable product.

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RSS: Creating effectiveness of exposure in corporate communication.

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In Fulfillment for
Computer Graphics Technology 411
Contemporary Problems in Applied Computer Graphics

RSS: Creating effectiveness of exposure in corporate communication.

- Group XI HEAVYfeather -

Abstract

The mass amounts of messages sent across a corporate platform make it difficult to hold employees accountable to vital company information seen on a computer. Through recorded, quantified exposure of a message via a system process using RSS (Really Simple Syndication) technology, it becomes possible to measure exposure across a digital platform. Using a technological approach, the following question was asked: How can an RSS computer process create quantifiable exposure of information in a team environment as compared to e-mail? An application has been developed to create a clear channel of communication to measure the exposure time of an employee to vital company information.

Introduction

In the workplace today, many organizations have used email as the primary means of communication (Fallows, 2002). Email has still served as an acceptable means of communication when it has not been imperative to know if a message has been read or when a message has been exchanged privately rather than within a group. For vital company information, however, the email communication channel has become too cluttered for clear communication. Through spam, personal messages, newsletter subscriptions, and other interfering elements, email in the workplace has rapidly become obsolete in its effectiveness (Hurst, 2004).

Whittaker has claimed that employees receive too much email, making the retrieval of old messages difficult therefore hindering individual employee performance. Without an established way of quantifying email penetration, providing measurement to company information has become necessary in ensuring the success of relaying messages to employees. Since there is no easy way to do this, collecting information regarding organizational communication effectiveness becomes complicated (Whittaker, 2005).

In order to ensure the success of organizational communication, companies must be able to create a way to ensure that employees have both received and have had exposure to important messages. Employees have claimed to not have enough time to go and “seek information out” when retrieving organizational data (Stenmark, 1998).

The purpose of this investigation was to develop an alternative tool to create a means of measuring an employee’s exposure to vital company information. Through utilization of “push” technologies, the employee was more obliged to read messages sent from the top down, creating instant exposure without having to rely on “pulling” the information. Push technology is defined as technology that does not require the user to retrieve data voluntarily. Instead, it is presented in a means that alerts the user, bringing the information directly to them (Franklin and Tiwary, 1998).

A formidable deployment method of this information involves Really Simple Syndication (RSS). RSS uses standards within the Extensible Markup Language (XML) to create a universal means of syndicating to certain websites (Magid, 2005). Due to its focus on portability and embracing universal standards, RSS feeds can be accessed globally at any location that has an Internet connection. By subscribing to an RSS feed, a user has instant access to any updates in that feed (Miller, 2004).

The importance of RSS to this project was the potential for it to serve as a largely distributable and highly accessible communication platform for organizational information. By developing an application that pushed company information via an RSS feed, it could be shown which employees have been exposed to that data. The information gathered through this process can be displayed to an administrator providing the ability to compare unique datasets of exposure time. Using this information, as-

assessments could be made about a group or individual based on the results of these comparisons. RSS could assist in providing a globally accessible solution for the circulation of essential information.

Problems with Email

Overload. There were several signs that email was becoming an overloaded communication medium in the workplace. One of the main problems with email had been discussed by Fallows who stated only 52 percent of email messages received in the workplace were important and related to an employee's job (Fallows, 2002). Within a test group, amount of messages received on a daily basis varied, but was recorded as being over 100 messages a day for some employees.

While possible alternatives were being developed, there had been no clear solution to ways of alleviating the cluttered email medium. In a 2004 article for the ACM Press, Hurst discussed the move from email to clear a new channel for communication. Microsoft had begun implementing a supplement to email utilizing RSS (Really Simple Syndication) to keep employees up to date (Hurst, 2004). RSS, a lightweight and accessible communication delivery tool, will be discussed in detail later in this paper.

Accessibility. When an email server went down, or an email client was not directly accessible to an employee, there was no way to keep up with company information (Whittaker, 2005). As seen with almost any form of technology, accessibility quickly had become a significant factor in organizational communication. Companies had been forced to look at how users would be affected by service interruptions or the halting of email services altogether (Krupa, 2002).

Exposure. At the time, there had been no prevalent method of quantifying exposure to vital company information. An administrator or supervisor within a major organization had a difficult time knowing if an employee had read or been exposed to the

message sent. Thumma explained that while there was a strong need for a solution like email in the workplace, there was a major overflow of messages received within the corporate setting (Thumma, 1997). It was possible that employees may not have had enough time during the day to sift through personal messages, spam messages, and other email to read important information related to their job.

Without a sufficient way to validate readership and inevitably accountability through the current use of email, alternative methods should be considered. Although Read-Receipts were one option, a Read-Receipt was not required to be sent back for a message acknowledging that an email had been opened. The use of a Read-Receipt was also a voluntary action or "pulled", something that the user must decide to do in order for it to take place. By quantifying exposure to a message, comprehension rates could be determined due to calculations based on exposure time (Bogner, 2005).

Using filters. Email could be filtered based on certain email addresses, text content of the email, and any number of other variables to determine validity of a message (Foltz, 1992). Spam filters could sift through an employee's email to better return valid messages for an employee. As the channel for email was used more frequently for messages, the responsibility of the spam filter invariably increased. As volume increased, it became more difficult for a filter differentiate between valid work messages and personal messages that lead to confusion and extra time spent reading email.

Time management. Without a successful filter to sift through personal messages and work messages alike, an employee tended to spend too much time reading email on a daily basis, eventually reducing productivity. Searching through emails, filtering unwanted messages, and retrieving archived content took excess time that detracted from the normal workday for an employee. This extra time inevitably decreased productivity levels within an organization. It

had grown to the point where some employees reported fearing the reception of email (Sipior & Ward, 2005).

Importance of Really Simple Syndication

Globally accessible. RSS was a universal standard in XML used to give access to information from any location using any number of applications (Miller, 2004). To successfully implement RSS, a user would use an RSS aggregator or web browser that was RSS capable and subscribe to a RSS feed—an auto-populated document containing information input from the main website. RSS was a free tool and could be implemented into almost any form of textual content. Once a feed had been established, it was accessible from any internet connection or website that used the technology. Like most accessible web technologies, RSS was developed to display content within the feed through whatever means a user may require (Miller, 2004).

Dickerson experimented with RSS as a means of communication within the workplace using internal web logs. The web logs monitored employee productivity using checklists and updates to keep everyone on the respective project up to date (2004, May 24). Employees had shown preference to intranets within the workplace as opposed to being responsible for retrieving information for themselves through an email client (Stenmark, 1998). This was a valuable statement considering the foothold that email had developed as being the primary means of asynchronous communication over a digital medium. It also hinted at the fact that employees would prefer to have information presented to them rather than having to retrieve it themselves.

RSS was also cross-platform compatible. Opposed to applications restricted based on an operating system, a user on any Internet connection using any operating system, including Windows and Mac OS X, could have access to an RSS-capable page. As mentioned earlier, in order to subscribe to an RSS feed or syndication, a user could download an RSS aggregator to retrieve all

updated content or use any RSS-capable web browser (e.g. Firefox).

Portability. Compatibility expanded beyond just the operating system. Within a corporation, an RSS feed could be accessible from home as well as at work. Telecommuting for employees was becoming more common within organizations, and RSS could potentially feed vital company information out to telecommuters based on the portability of the web-based technology. As wireless technology grew, so did the potential for RSS-enabled applications. This allowed for accessibility from almost any location with cell phones, PDAs, and laptops gaining popularity (Claburn, 2005).

KnowNow. KnowNow was a company developing a common application for RSS aggregation. Their application allowed users on the web to subscribe to any available RSS feed with the click of a button. Once subscribed, the user was then notified of new updates to any of the subscribed RSS feeds. The KnowNow application was developed to show how the publication of content through RSS had become seamless for all users regardless of their technology experience (KnowNow.com).

Purpose of Measurable Exposure

At the time, there had been no standard developed to hold an employee directly accountable for any message sent in the workplace over a digital platform (Whittaker, 2005). Verbal accountability (e.g. asking an employee if a message was read) or Read-Receipts had been the most prevalent way to hold employees accountable within a test group. Both of these methods, as mentioned earlier, require a “pull” to take place. There was a voluntary and often subjective measure to gathering necessary information.

The purpose of measurable exposure, inevitably, was to create a quantifiable means of holding employees accountable for important company information—this idea included meeting times, meeting content, project updates, etc. Based on prior research,

it had been deduced that greater exposure increased comprehension (Krupa, 2001). Comparing exposure against average reading rates also helped measure comparison against a set value.

RSS Application

Concept. To determine the success of an alternative to email within the workplace, an application was created to measure exposure of information. The purpose of the application was to subscribe to a global RSS feed within the test group, to grab the latest information from the feed, and to “push” the information directly onto the desktop of the user. By using this method of delivery, it eliminated any voluntary actions that would need to be taken on the part of the participant. All notifications and messages were delivered directly to their desktop for access to organizational information.

Once new information was received, the application would notify the employee in an obvious manner that new information was available. Upon clicking this notification, the message would be displayed. A timer would then track the amount of time a user spent on a respective message which would be entered into a database for comparison among previous times, development of data graphs, and observation by the administrator of the group.

Prior Attempts. It should be noted that the initiative to develop an application utilizing RSS for organizational communication had been conceptualized in the past within ITaP. Under the direction of Jamie Mohler, former Director of the Informatics group, previous research and development were conducted to develop a process that could create an alternative channel of communication that would be practical for organizational communication. After several months of experimentation, the project was eventually abandoned on the premise that the application simply became a “glorified RSS reader” and offered no advantage over email other than accessibility.

Keeping conclusions of the previous experiment in mind, careful attention was

paid to the way in which the application would be presented to users.

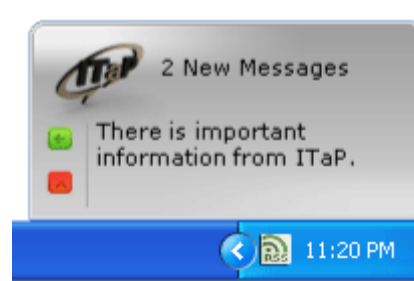


FIGURE 1. The notification system showing a new message.

Implementation. The design of the application was carried out according to the concept envisioned by the project sponsor, Kyle Bowen. The notification was displayed with an animation in the bottom right corner of the screen (Figure 1). The purpose of the animation, in addition to sponsor specifications, was to draw the attention of the employee away from current work to reveal new information without taking screen focus away from current work. An employee was still allowed to continue working within the computer screen and was not forced to click anything relating to the application. The placement of the notification in the bottom right corner was part of a project specification laid out by ITaP as the area of the monitor that would best be suited for their needs. After the notification appeared, the user then had the option to view the message or to ‘X’ out for viewing at a later time.

The application itself was designed with respect to Microsoft Outlook and Outlook Express to create a familiar user interface for the employee who had previous experience with either of those software packages. All participants identified with Outlook as their primary email client. Text was bolded to represent new messages. All recent messages were displayed within the application for later access. Figure 1 shows the notification of the desktop application. As seen in Figure 2, all titles and dates were kept for both new and archived messages in the top pane. The bottom pane was devel-

oped explicitly for viewing current messages. The bottom pane was also developed using a viewing screen with similar capabilities of a web browser so that web pages, images, and web links could be displayed seamlessly within the application.

nymity would be kept for employees using the application. Each time the user clicked away from a message onto anything else on the computer monitor, timing would stop until focus was brought back to the original message.

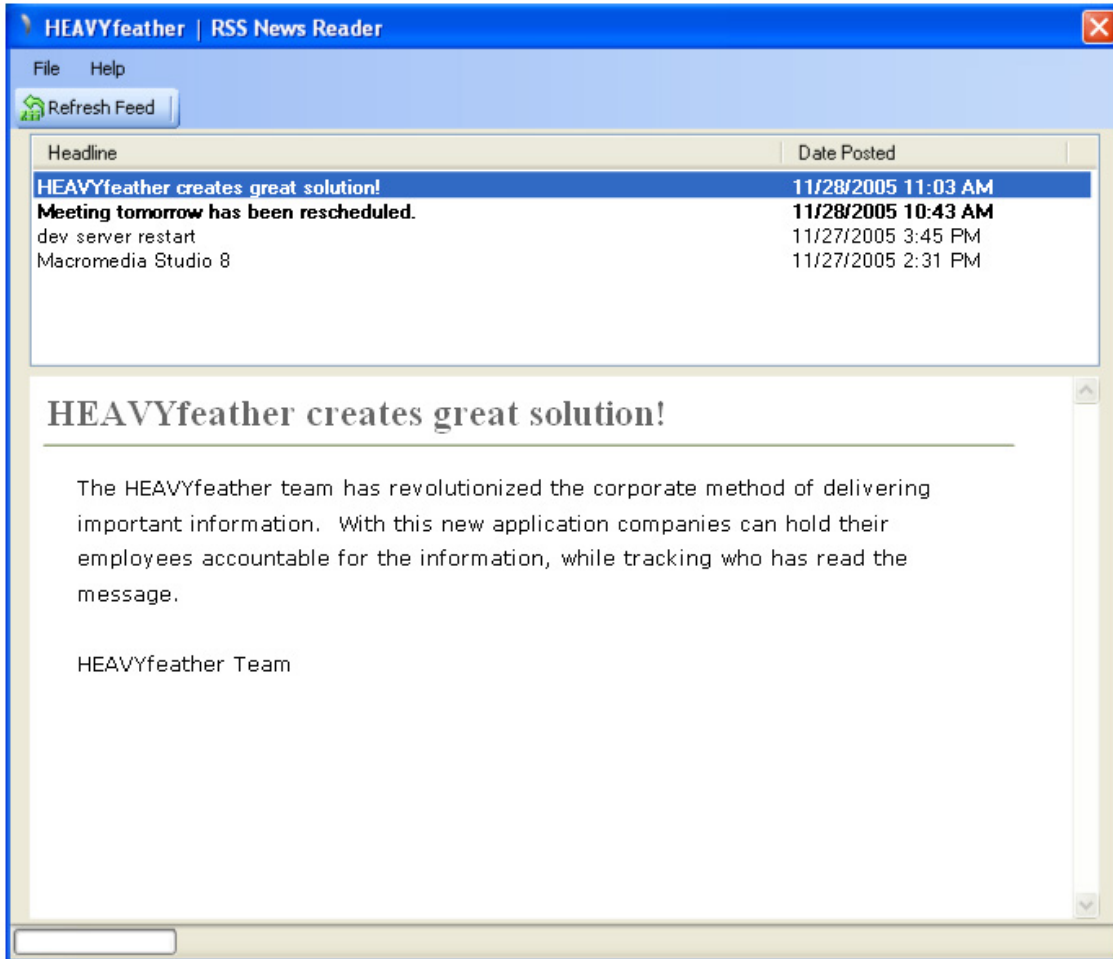


FIGURE 2. A screen capture of the desktop application showing new and old messages in the top pane with the current message displayed in the bottom pane.

In order to record information within the test group, once a user clicked the notification icon, the recording of exposure began. For the test group, anonymity was required in order to protect the reputations of each employee by not revealing who reads or does not read the information. For future applications, it would be up to the group administrator to decide whether ano-

Study

The next phase of development was to implement the application in a real-time environment. To test the capabilities of measuring exposure, datasets were created unique to each individual. This led to the eventual establishment of accountability based on perceived readership. The experi-

ment was designed to generate results that would determine the success of the hypothesis of the study.

The study was conducted in order to test whether quantified exposure of information was indeed related to accountability and its corroboration between readership and comprehension. By having a measured amount of feedback given, the application would be filling a void in the communication method of email and its lack of readership notification (Figure 3).

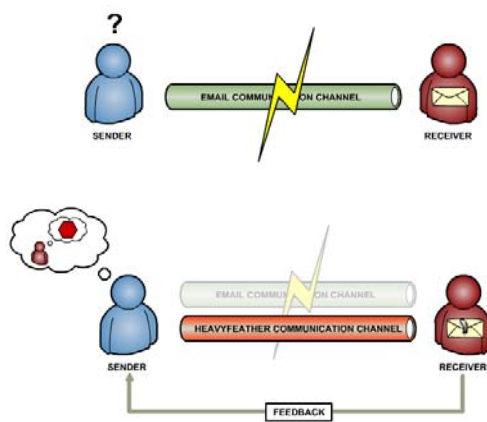


FIGURE 3. A visual comparison of feedback received via email (top) compared to the HEAVYfeather solution (bottom).

Test Method

Test Group. The test group was not randomly selected, but was put together in advance by project sponsor and test group supervisor, Kyle Bowen, for participation in the desktop application. The group consisted of the Informatics team within Information Technology at Purdue University (ITaP). All members of the group capable of accessing the application were asked to participate in the week-long study.

Experimental design. The purpose of the experiment was to gather data to compare to a previous click-thru evaluation

completed within ITaP. The previous evaluation consisted of an email sent within ITaP employees containing a link to click-thru within the body for viewing of the message. Those who clicked the email link were taken to a page which recorded that the respective employee viewed the page. Click-thru rate on this email was 22 percent, a number that the team was determined to improve upon.

The new experiment was to begin with a pre-test survey completed by the test group in order to obtain attitudinal opinions towards email. By doing so, a better understanding of their feelings towards the communication method could be established. The main purpose of the test was to generate an idea of whether any bias or misjudgment of the treatment would take place during the study. In addition to attitudinal values, quantifiable datasets such as email volume were gathered. After this time, a working version of the application was installed on all employees' computers to evaluate exposure to information sent by the test group's supervisor, Kyle Bowen.

During the testing, exposure time of an employee to a message alone did not determine readership. Using a calculation of unique user words per minute compared to an average established reading rate of 240 words per minute, an educated guess was made of which employees read the message (Gallo 1972).

The hypothesis of the experiment was to answer the question of whether or not an alternative to email could successfully measure exposure to valuable company information. Utilizing a push technology, such as RSS, quantifiable exposure of information was created in a team environment as compared to email.

Pre-test survey. As part of the experiment, the Informatics team participating in the evaluation took part in a pre-test survey asking questions related to the amount of email they received in the workplace as well as opinions pertaining to using an alternative application. Most employees were

generally satisfied with email, but almost all were strongly in favor of an alternative.

Experiment. The experiment was designed to take place over the course of a week within the Informatics team. For one week, Kyle Bowen used the application as a supplement to sending out mass email to his team to evaluate the effectiveness of the application in measuring exposure to valuable company information. Messages were sent out in mass to the employees on the Informatics team, the notification application was displayed, and the employees would successively click on the notification to be exposed to the message from the supervisor. Messages were also designed to vary in length so that exposure times of large bodies of text could be compared against smaller amounts.

The amount of time the user was exposed to the message was counted and sent back to a database which stored all of the information relative to the employee's access of the message. For each message, a respective numeric value representing the number of seconds the employee spent on the message with the window open was calculated. Using this data, live data graphs and mean words per minute calculations were made. After an extended period of time, each user eventually developed a unique words per minute rate at which message exposure times were compared against for more accurate accountability assessments.

Results

Reading rates. Reading rates (R.R.) were determined comparing actual time spent with the message open on the user's desktop against the number of words in the message:

$$R.R. = \frac{\text{Message Length}}{\text{Exposure Time}} \times 60 \text{ sec / min}$$

Analysis. Upon analysis of the weeklong study performed on the test group, reading rates were calculated and compared. For each user, average reading rates were formulated. A line was drawn across a bar graph, as shown in Figure 4, to compare the

average reading rate of the group with that of the individual.

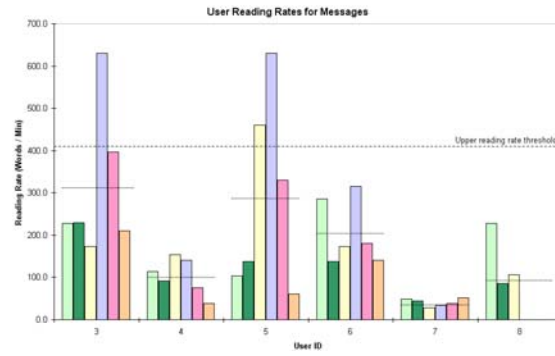


FIGURE 4. Calculated reading rates for messages among users in the test group.

An upper threshold was determined within one standard deviation (as calculated with this study) of the average reading rate of 240 words per minute. Users with reading rates for a respective message above the upper threshold were discarded as unread.

Calculating the upper threshold would include, within one standard deviation of the average reading rate, over sixty-eight percent success rate of the users' reading rates. Only 3 of the 36 total messages sent over the course of the weeklong study were actually unopened.

After calculating the data present, over eighty percent of the messages were determined to be read. This return presented a significant improvement over the click through study previously performed by ITaP, which returned only 22 percent of employees clicking through.

Testing Conclusions

The application proved to be successful within the ITaP Informatics work environment due to the significant difference in exposure returns in the weeklong study. Over eighty percent of the messages were exposed to the employees long enough to have been read, according to this study. In addition, employees did not open only three messages.

It could be stated that the Hawthorne effect contributed to the test results. However, the exposure time measurements were not mentioned to the test group. They were informed that the application would act as an alternative channel for viewing company information. The data gathering process was integrated into the application so that it would be seamless on the end of the user. Since it utilized a push technology and a familiar user interface (Outlook), the application was used in a way that caused little behavioral change to take place on the part of the user.

The specifications of the project were fulfilled to the sponsor's satisfaction. The sponsor agreed that the application created a level of accountability for the employee. The amount of time an employee was exposed to a message was tracked and recorded, displaying this data to the supervisor of the group. This provided the feedback the sponsor of the project desired. By having the ability to go back and compare datasets between different messages, the administrator was given the tools necessary to assess the effectiveness of communication in the organizational environment of the Informatics group of ITaP (Figure 5). Having the ability to make these comparisons allowed for conclusions to be made that would have been very difficult to replicate with e-mail alone.

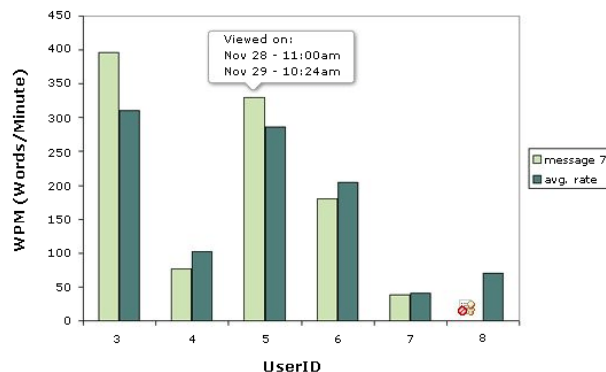


FIGURE 5. A dynamically generated graph showing specific values compared with user averages over a web presence.

Creating a digital means of accountability for messages sent to employees in the workplace would be very difficult to accomplish using email (Whittaker, 2005). This application provided a plausible means, as proved by the data, for creating a way to successfully measure the exposure time of a user to a specific message. This inevitably could hold that employee accountable for the information sent.

This application provided instant feedback to the supervisor. Instant feedback and live tracking of message exposure time helped the supervisor determine the penetration a message had reached.

Points of Further Study

Commenting. To further add to the feedback provided by this application, a commenting system could be added to allow for direct contact to be seen by all of the users. This could prove useful for employees to make remarks about a message without cluttering the communication channel.

The display of comments could be shown in a way that they would not hinder upon actual messages submitted by the administrator. By showing them in a subgroup below messages, a hierarchy could be established among messages, something that is difficult to accomplish through communication means such as email.

File sharing. The ability to share files through this application could have added benefits for group collaboration. By introducing a feature such as file sharing, projects could be versioned and revised for greater awareness among team members. It would essentially eliminate the need to re-send vital documents to team members in hopes that someone else hasn't already done something similar.

Using this application for project assistance within a team environment should be considered as a possibility. Allowing employees to circulate files within a team could increase their ability to share documents and ideas not easily expressed by text alone.

Search Engine. Having all messages stored in a database and published over a scalable RSS feed allows for an easy transition into advanced search functionality among all information. This could allow for easier access of information allowing for greater comprehension among users.

Archiving. As mentioned above, messages stored on a database allows for increased functionality on several fronts. Another area of expansion lies in archiving and the ability for users to recall old messages long after they've finished reading them. Rather than users deleting messages at their own convenience, the group administrator can have the final say in what messages are both sent and removed from the RSS feed eliminating excuses that a message no longer exists on a user's machine.

Email Plug-in. While the primary purpose of this application was to create an alternative to email for important company information, it was never intended to replace that communication channel. With this in

mind, considering the possibility of a plug-in to work in accordance with existing email applications could provide the benefits of measuring exposure time with increased familiarity of existing application interfaces.

Project Summary

Over the course of a semester, a project originally envisioned as a proof of concept turned into something much more. An entirely testable application was developed with the capability of establishing exposure time of important organizational information among a team environment.

Further development could bring the project closer towards a marketable organizational tool. By utilizing user commenting, file sharing, searching, archiving, and increased administrative functionality, this application could improve its functional value as an organizational communication tool. The ability to measure exposure time of important company information was shown to be a valuable asset to the ITaP Informatics group.

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Flash RPG Creator

Can an RPG Maker be created in Flash that is Simple, Quick, and Easy Enough to Use that it Gains a Significant Fan Base Using the Newgrounds Community?

Michael Moreth, Rowland Rose, Craig Tinsley, Courtney Hannibal
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CGT 411 Fall 2005
Group X4
December 12, 2005

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By Michael Moreth, Rowland Rose, Craig Tinsley, and Courtney Hannibal
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Abstract

The purpose of this project was to determine how to successfully create an application that allowed users to create their own Flash video game, in turn giving the developers of said application experience and exposure in the video game industry. The nature of the application was similar to that of known software currently on the PC and console video game market, but it was believed that there had not been an application of this type made in Macromedia Flash. The Flash application was promoted towards users in an easily accessible online Flash community – the Newgrounds.com population – and feedback from the users would help to gauge the application’s effectiveness and level of difficulty. The goal of making the application in Flash was to simplify the archetype of a game-maker enough to allow a casual gamer to enjoy it without becoming disinterested in a short period of time or dissatisfied with the fun factor of the application. The measure of success in this project was taken from the feedback of the users. As aspiring video game developers, the members of this team chose this project as a means of finding a way to implement current technologies in a way never before utilized. Given the Computer Graphics Technology curriculum at Purdue University, the team wanted to use the senior project as an opportunity to explore entrepreneurship and game development dynamics within the video game industry.

Introduction

Online game play has been gradually increasing in popularity as the internet continued to become more of a household commodity (Tinney, 2005). Greg Mills, the Director of Premium Games at America Online, reported in the IGDA Casual Games White Paper (2005) that the online gaming industry is a \$600M industry as of 2004. More people were playing online games than ever before, such as those offered by MSN and AOL gaming communities. The majority of the online games played in these communities were comprised of ‘casual games,’ which were defined as “games that a casual consumer can pick up and learn to play quickly” (Mills, 2005). Although a game may have been classified as casual, many games of this type had the potential to be as engaging or addictive as a game requiring more dedication to comprehend. Because web-based casual games were often less expensive and more readily accessible than stand-alone PC or console games, casual users were more apt to play casual games in the flow of their daily life (Mills, 2005).

Major video game companies have created games that were within what Mills called the “hardcore” category. As stated in Mills, the hardcore game industry included Halo, published by Microsoft, and Half-life, published by Sierra. These were distributed in hard copies to retail stores across the world, and usually sold for as much as \$60 per copy. Therefore, more commitment was required of gamers that prefer console games, as users had to purchase the software along with a console on which the game operates. These users were generally considered to be more ‘hardcore’, given their larger amount of dedication. However, these ‘hardcore’ gamers rarely depended on web-based communities for their gaming enjoyment (Mills, 2005).

Conversely, many of the online gaming communities were free and asked nothing more of users than an e-mail address and username registration. One community that appeared to be bridging the gap between casual game play and more serious, dedicated gaming was a web site called Newgrounds.com. They were combining these types of gaming by allowing users to

submit their own games and videos which were all created using Macromedia Flash. The team observed that these users took on more of an active role within the community by being allowed to play and rate other users' submissions. A more dedicated following appeared to be correlated with a web-based gaming community of this nature.

The research that was done consisted of finding a way to create a Flash application that would be submitted to the Newgrounds community in order to attract a dynamic and supportive fan base for an RPG Creator. A fan base was defined by Webster's Dictionary (2005) as, "the regular supporters and enthusiasts of a team, musician or musical group, entertainer, or other celebrity." Sore Thumb Studios gained a fan base of users that tested the application.

Data was collected from the community by our own methods (the survey) and the methods built into Newgrounds.com (rating and review system). Our method was to retrieve polling and usage statistics gathered from a separate website that was solely dedicated to the Flash application in question was used to gather feedback. The Newgrounds.com method collected data from every user that visited our section of the site. The data it gathered included a rating of 1 to 5, the amount of hits our project received, and reviews written by users. The final product attempted to offer a happy medium between the 'hardcore' PC gamer, who would spend extensive amounts of time using the application for primarily personal enjoyment, and the casual gamer, who may have been less meticulous in using such an application but would still share his or her created content with the web community for others to play.

Flash vs. Traditional PC Games

RPG creators have been made for the traditional PC market, such as Enterbrain's RPG Maker™ series, which offers detailed customizability and back-end functionality. The Flash RPG Creator is attempting to offer

a similar experience with a shallower learning curve and a redirected presentation style for casual gamers. Figure 1 shows the character parameters for RPG Maker XP™.



Figure 1

Flash RPG Creator Demographic

RPG Maker™ and similar game-making applications have built a fan base of users that are willing to take time using that application to share their ideas with others across the numerous internet communities. The ways in which the team measured their potential fan base are as follows: the amount of hits on Newgrounds, the score on Newgrounds, the amount of people who took the survey, and the types of comments left by the users. Websites that contain these communities include GamingWorld, with over 27,000 (Gaming World, 2005) members, RMXNet, with over 10,000 members (RMXNet, 2005) and RPGamer, with over 6,000 members (RPGamer, 2005), among many others. The fact that these sites had thousands of members may have indicated that a fan base existed all over the internet.

Comparatively, the Newgrounds audience was a virtual breeding ground for Flash game developers, which have the potential to rack up several thousand plays of their game in a few weeks. Newgrounds' Portal was the submission forum to which an independent Flash developer could display his or her work to over 800,000 registered users who may potentially play and review it. Given the nature of the project, the team believed that the Newgrounds Portal was the best

community to which the team could submit the Flash RPG Creator.

Emerging Technology

The emerging technology in the project was that a user was allowed to create an RPG with the program that was designed in Macromedia Flash 8. There were previous RPG makers and game creators available; however, Sore Thumb Studios was believed to be the first to develop an RPG creator in Flash.

The Product

The purpose of the project was to create an RPG creator in Flash that was fast, easy, and simple to use. Many aspects of previous RPG creators, mainly RPG Maker XP™ were left out of Flash RPG Creator or changed to simplify the program so as to allow for a broader range of users.

One area the team focused on to reduce the time required in creating a game was to create pre-built houses, as well as pre-built trees. The team wanted to reduce the time required in the creation of games in the program to best meet the needs of the program's target audience, which were people who did not have the patience or time of the traditional RPG Maker enthusiast. In other tile based RPG creators, specifically the RPG Maker series, buildings are tile based as well to allow for more customization. However, the team decided to create buildings as an object that takes up more than one tile, to reduce the time required in the design process. An example of this would be that a building would take up 9 tiles, but the user would only have to place one object, instead of placing each of the 9 tiles separately to make one building. This process was also done for any object that exceeded a 1 by 1 tile ratio. Another attempt to reduce time required in the tile building process was the use of auto generating walls. The program took care of all of the different wall sections, to allow the walls to bend around corners. This means that the user could make a wall, without worrying about changing toolsets to make the wall

change appearances depending on what direction the wall should be facing. This same technique will be used in future versions to let the user generate transitions between tiles types. An example would be a tile going from grass to desert. To keep graphics looking smooth, there are 15 tiles for each tile type, but the program handles which tile will be placed, instead of the user selecting them. The program would decide what transitioning tile needs to be placed depending on the tiles that were surrounding it. Figure 2 shows the tiles as they were created. Figure 3 shows how the program places the tiles based on its surrounding tiles.

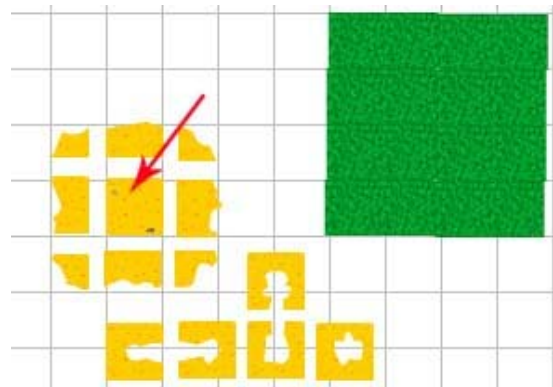


Figure 2

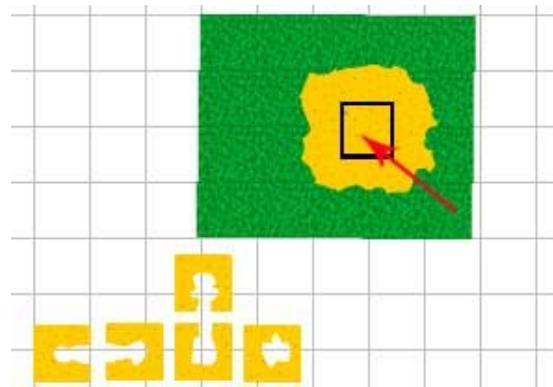


Figure 3

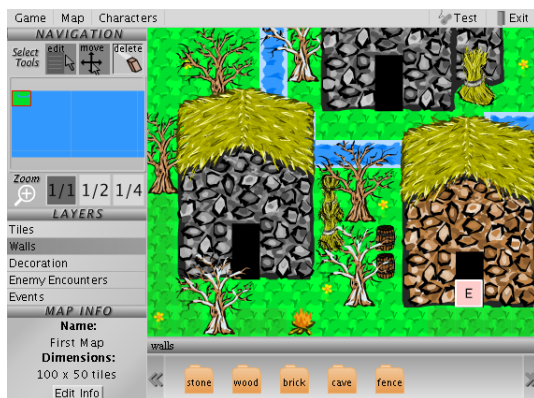
Another simplification of the RPG creator was that the program took care of what layer certain objects could be placed on. In other RPG creators, such as Enterbrain's RPG Maker™, the user keeps track of what layers certain objects need to be placed on. There were five layers for the Flash RPG Creator. These layers contained certain objects so that

the program knew which set of objects has priority over others. This enabled the house to look like it is above the grass, instead of the grass covering the house. The Flash RPG Creator that the team used kept track of the layers for the user. This was one less process for the user to be concerned with.

Interface

The program's interface was designed for a 570 pixels wide by 420 pixels tall window. This size was chosen because it would allow the user to be able to fully view it in an 800 x 600 screen resolution using the Newgrounds interface (the html page the flash is embedded in on Newgrounds contains advertisements and links, reducing the possible screen area). It also allowed a larger amount of tiles, while still being able to fully view the program in the Newgrounds browser window. Grey was chosen as the interface color so that it would not attract attention away from what was necessary. Color Wheel Pro states,

“When designing for a gallery of art or photography, you can use a black or gray background to make the other colors stand out.” This allows the user to more easily navigate our RPG creator, since the interface doesn't distract the user (“Color Wheel Pro,” 2005). Figure 4 shows the user



interface in Flash RPG Creator.

Figure 4

Research Question

Through the survey the team wished to discover the answers to the question, “Can an

RPG maker be created in Flash that is simple, quick, and easy enough to use that it gains significant fan base using the Newgrounds community?”

Testing

For the project, the team used an online poll to gather data on the RPG creator. Since the users were anonymous, and gathered from Newgrounds.com, the team placed a link from the program to an online poll created using www.freeonlinesurveys.com. This enabled the team to test only those users that tried the program, since the actual program was the only place that listed the location of the online survey. The reason the team used this service was because it kept track of percentage data as well as supplied the team with a *Microsoft Excel* spreadsheet that allowed them to analyze their own data. This spreadsheet had a list of how each individual user responded. This allowed them to gather information about how each user responded.

The team used a short fifteen question survey as well as a comment box where the user was allowed to enter anything they wanted to say about the product. They asked a variety of questions, including multiple choices, true and false, and text boxes (see appendix A for more information). The team gathered through conversations with Dr. Nathan Hartman of Purdue University, that it was more advantageous for the team to gather numerical data for certain aspects of questioning so they could have a continuous value of scales from zero to the maximum. This allowed the team to artificially categorize the information later. This method also eliminated subjectivity on the users' parts, since the numerical values of minutes or hours was an accepted unit of measurement.

For the multiple choice questions, many proposed surveys were made. Through conversations with Dr. Hartman, as well as through contacts with Ben Tyner of the Statistical Department at Purdue, the team's proposed questions and responses were

decided upon. It was discovered that it was better to leave out any neutral multiple choice selections, and instead force the user to make either a positive or a negative answer. Just by having a neutral item, it caused more people to select an item. Also, excerpts from *Survival Statistics* stated that it was found that just by including the “don’t know” option, data could be skewed. The “don’t know” option should only be used in a factual statement, where there was a good chance of the user not being able to answer correctly (Walonick, 2004).

Gathering Statistics

Through the online poll, 985 responses were recorded before the polls were closed for data collection. Through this data, some background demographics, such as age and gender, were taken to acquire more information about the audience of users. However, what was really sought after through the survey was to gather information about how quick and easy it was to learn to use the program. It was also intended to discover if a fan base had formed.

Through the survey of the alpha version it was found that 72.98 percent of the users were satisfied with learning to use the program. It was also discovered that the average time that a user needed to learn to use the program was 12.63 minutes. In an online review from Cheatcc.com, it was stated, “The first problem with ‘RPG Maker 3’ is the learning curve. It’s steep. Like mountain steep, or even walking-off-a-building steep. The first time you play you’ll spend hours just learning how the game actually works, then days trying to learn all of the various tricks; which immediately deters most potential players” (Erik, 2005). The hours needed to learn RPG Maker 3, could be compared to the Flash RPG Creator’s average time of learning of 12.63 minutes. Also, according to the team’s data, the majority of the RPG Creator’s users required less than 40 minutes. The bar graph in Figure 5 shows that users having previous experience with other RPG makers rated their experience with

learning to use the program better than those that have not had any prior experience. Figures 5 through 7 go into more detail of the time spent learning to use the program.

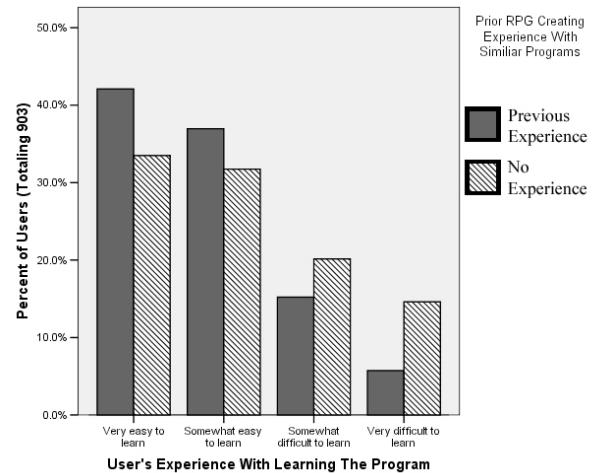


Figure 5

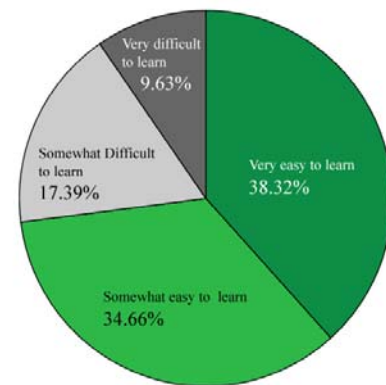


Figure 6

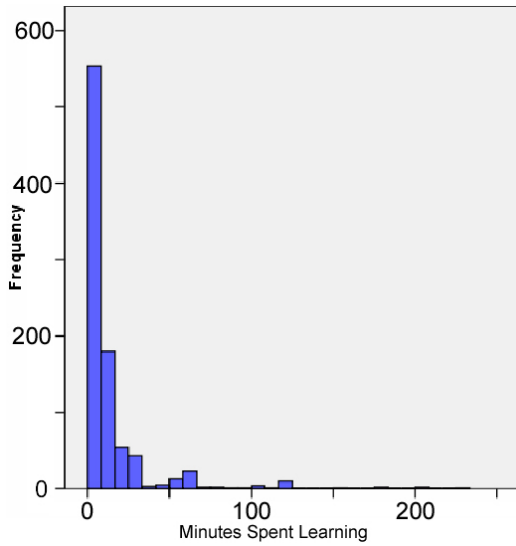


Figure 7

Figure 7 displays the amount of time spent (in minutes) learning to use the program. It shows that a majority of users spent less than 40 minutes learning to use the program. Another question to support the research statement was directed towards the time required to create a scene with the program. It was discovered that 72.98 percent of users were satisfied with the time required to create a scene (Figures 8 and 9 display more information on how satisfied or dissatisfied users were with the RPG Creator).

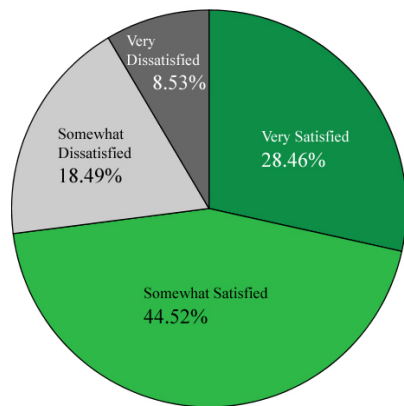


Figure 8

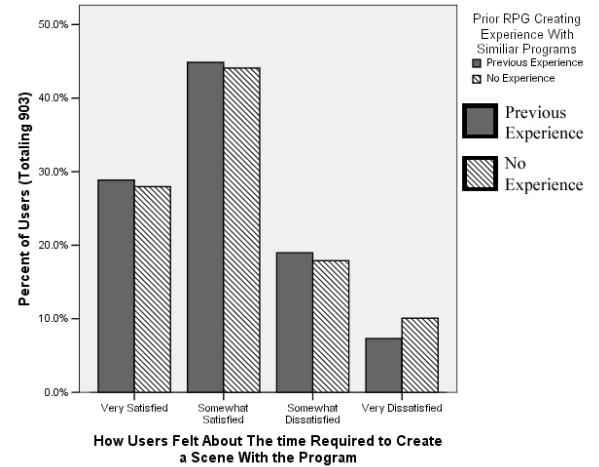


Figure 9

The team also gathered statistics based on how users felt about the customization of the Flash RPG Creator. The team wanted to create a balance between the time it took to create a scene and the customizability. The results of the data showed that users with previous experience with other RPG makers were less likely to be “very satisfied” with the customization of the Flash RPG Creator. However, there wasn’t a great deal of difference between the percentage of previous users and new users that chose “very dissatisfied” (Figure 10 goes into more detail comparing previous users’ feelings versus those of new users).

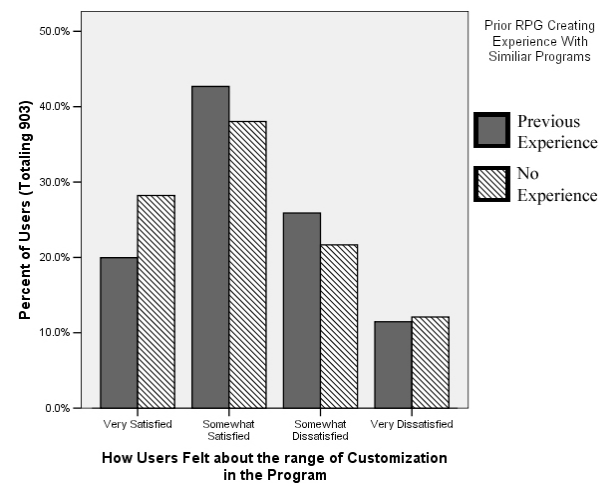


Figure 10

The last question the team wanted to fulfill was whether or not they had attracted a fan base. When looking at the data collected from Newgrounds.com, the program received over 113,000 views. This status also earned the team an “award” for having over 100k views. They also earned the label of “awesome score.” This title is given by Newgrounds to any submission that earns a 3.5 or greater score. The Flash RPG Creator earned 3.64 out of 5.00. Another factor considered when observing this score was that the all-time top ranked Flash submission on Newgrounds was ranked 4.47/5.00 at the time of the team’s submission. The team also gathered 985 users to partake in their online survey within one week. To discover how the users that took the survey felt about the project, the team reviewed every comment that was entered into the “textbox field” of the survey. A large number of users entered comments which were neither positive nor negative, so the team had to create a neutral section for comments as well (Figure 11 shows how users’ comments were perceived).

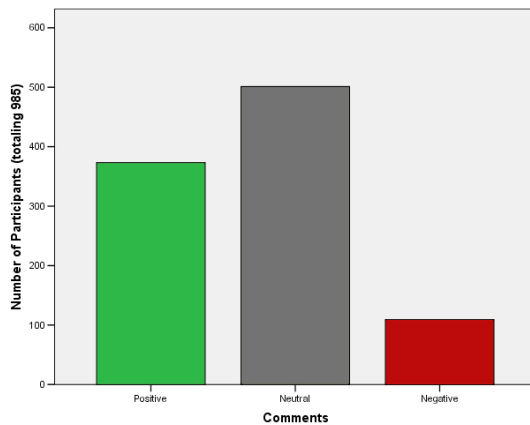


Figure 11

Discussion

Even though the product was still in its alpha phase, the data collected from the survey and the Newgrounds community has shown that Flash RPG Creator appeared to have been simple, quick, and easy for users, and has gathered a fan base.

Many comments from the Newgrounds community have talked about its simple, easy to use interface. The data gathered in the survey also pointed at its simplicity and ease of use. This was exactly what the team wanted to achieve, targeting an audience who preferred ease of use to extreme customization. There were still issues and complaints in the area, such as the drawing tools and the graphics. Improving the usability and simplicity of the program is a future focus of the team.

A fan base has accumulated around the product since its submission to Newgrounds. The team measured this by looking at the score received from Newgrounds (3.64), the number of visits (113,000+), the amount of people who took the survey (985), and the type of comments received by the community [Figure 11].

There is potential for Flash RPG Creator to become a finished product. Members of the team are considering continuing work on the product over winter and into the next semester. The team estimates a final release date during the spring of 2006.

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Appendix A

By taking our survey, you agree that you are at least 18 years of age.

RPG = Role Playing Game.

You may use decimals for any numerical value.

1) What is your age? You must be 18 or older to take this survey.

2) What is your gender?

Male

Female

I Do not wish to disclose that information

3) How many Flash games have you created? Enter the number **0** if you haven't created one.

4) How did you hear about our FLASH RPG CREATOR?

Newgrounds.com

A friend

Search Engine(s)

Advertising

Other (Please Specify):

5) How often do you play Flash games?

Daily

Weekly

Monthly

Yearly

Other (Please Specify):

6) How many RPG makers have you used before using our FLASH RPG CREATOR?

7) How many **hours** combined have you spent using any RPG makers **other than** our FLASH RPG CREATOR? You may use decimals for this number.

8) How much time in **hours** did you spend with our FLASH RPG CREATOR? You may use decimals for this number.

9) Have you ever completed an RPG with a program other than our FLASH RPG CREATOR?

Yes/No

10) How many **minutes** did it take you to learn to use our FLASH RPG CREATOR? You may use decimals for this number.

11) Rate your experience with learning to use our FLASH RPG CREATOR.

Very easy to learn

- Somewhat easy to learn
- Somewhat difficult to learn
- Very difficult to learn

12) How do you feel about the time required to create a scene with our FLASH RPG CREATOR?

- Very Satisfied
- Somewhat Satisfied
- Somewhat Dissatisfied
- Very Dissatisfied

13) How do you feel about the range of customization with our FLASH RPG CREATOR?

- Very Satisfied
- Somewhat Satisfied
- Somewhat Dissatisfied
- Very Dissatisfied

14) How do you feel about the Graphics in our FLASH RPG CREATOR?

- Very Satisfied
- Somewhat Satisfied
- Somewhat Dissatisfied
- Very Dissatisfied

15) Post any Comments or Statements in the box below.

Animating a Near Ideal Sprint Cycle

Mike Nelson, Taz Kang, Bobby Andreae, Jeremy White

Abstract

Do Acceleration Indiana Trainers prefer the addition of multimedia aids in the teaching of Acceleration Indiana material when compared to Acceleration Indiana's traditional non-media aided teaching approach? To answer this, an electronic visual-media representation of a near-ideal sprint cycle was developed in the form of animated clips, which were then incorporated into the teaching lessons for the Acceleration Indiana Trainers. To help determine if the visual media would be beneficial to the Acceleration Trainers, they were given a questionnaire to determine which learning style they preferred. Then, the Acceleration Indiana Trainers were given a qualitative survey to determine if they preferred the original non-media aided method of teaching or if they preferred the inclusion of the new visual-media aided method of teaching.

Introduction

The primary goal of this project was to create an electronic visual-media representation of a near-ideal sprint cycle for use as a teaching supplement using current and emerging technology. The final product was created for Acceleration Indiana, an athletic training facility located in Indianapolis, Indiana. The secondary goal was to determine if they preferred the visual-media teaching tool over Acceleration's original teaching supplement, which was hand drawn stick figures. The electronic visual-media teaching tool should allow for clearer comprehension of proper sprinting mechanics by Acceleration Indiana Trainers.

The multimedia aids consisted of a 3D scene of virtual humans animated to display near-ideal sprint cycles. There is no set ideal sprint cycle for all athletes because each athlete has an ideal-sprint cycle that is unique to his/her body. The animations serve the task of conveying the general characteristics necessary for good sprinting mechanics according to Acceleration Indiana.

Initial research led to the decision to make simplified human models, rather than highly detailed and realistic models. In an attempt to increase the credibility and accuracy of the sprinting animation, motion capture data, provided by Steve Swanson, M.S., Director of Research and Development for Frappier Acceleration Sports Training (FAST), was

in used to animate the models. Having applied the data to the models, the environments for the scenes were then designed to appropriately display the animations.

From the 3D scene, multiple camera angles of the animation were rendered to create video clips. These video clips were distributed to Acceleration Indiana via Dartfish Mediabook software.

In order to validate the use of 3D animations as a training tool for Acceleration Trainers, a survey was sent to Acceleration Trainers in an attempt to determine their preferred learning style. To test the final product, a qualitative approach was pursued.

Technologies

A number of emerging technologies were used to pull the final product together. Alias Maya 6.5, a 3D computer modeling and animation software program, was used for the creation of the 3D scene. A state-of-the-art optical motion capture system was used to capture data of athletes running on a Super Treadmill™. Figure 1 shows the runner on the Super Treadmill. Motion Capture is the process of tracking real life movement in 3D space, and recording that movement as a series of XYZ coordinates. This data was then imported into Alias MotionBuilder 6.0, where it was used to animate the models (see **Figure 2**). The animated models were then imported back into Maya for final ad-

justments and for the rendering of each frame of the animation. Adobe After Effects was used to compile the renderings into video clips. Finally, Dartfish TeamPro 4.0 was then used to assemble all of the animations into an interactive deliverable. Dartfish software had already been in use in Acceleration facilities for purposes other than displaying animations, ensuring that Acceleration teachers would be familiar with the software.

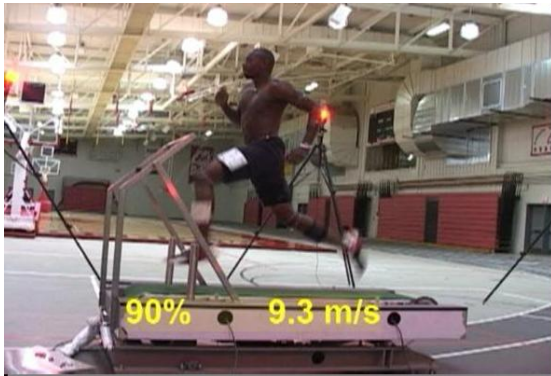


Figure. 1 The runner's motion being captured by an optical motion capture system while he runs on a Super Treadmill.

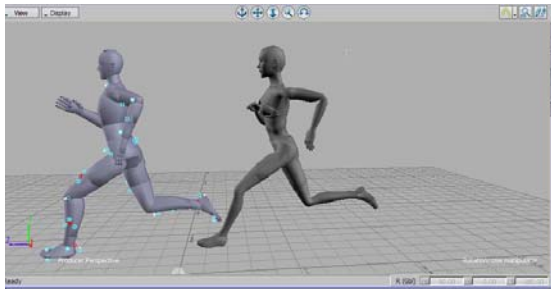


Figure. 2 The runner's motion capture data applied to the model in Motion Builder 6.0

Target Audience

The target audience members for the animations are the Acceleration Trainers. New Acceleration Trainers go through a training process that involves detailed instruction on proper sprinting technique according to the FAST program. This training consists of online reading material, lectures, and hands-on experience in the form of the trainee shadowing a trainer.

A significant learning style for the Acceleration Trainers is visual; the major learning style conveyed by the final product. This was discovered by giving the VARK© Learning Styles Questionnaire to a random sampling of Acceleration Trainers and analyzing the results. The VARK Questionnaire measures four learning styles: Visual, Aural, Read/Write, and Kinesthetic. Upon analysis of the data, gathered from 16 respondents, three important points emerged. First, no dominating preference for one was determined learning style was determined, although kinesthetic was the most preferred, the other three were well represented. Secondly, there was no correlation between any two learning styles (see **Figure 3**). Third, it concluded that the Acceleration Trainers do learn from visuals, which infers that the animations do have merit as a teaching tool.

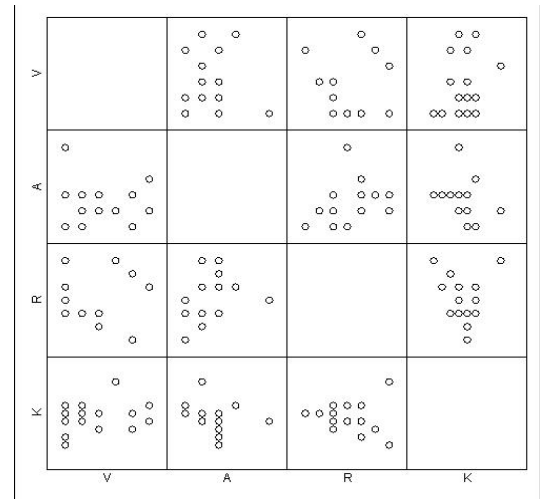


Figure. 3 Each box in the grid displays the correlation between two of the four learning styles.

Two of the four learning styles, visual and read/write, were incorporated in the final product, while also being integrated with a third, aural, provided by the lector. The fourth and most preferred style, kinesthetic, is already an essential part of the trainers' training.

Project Development

The need for the animations became apparent upon seeing an oral presentation used

in teaching the trainers. The lector drew a stick figure on a whiteboard to represent a sprinter in various positions. Arrows and lines soon followed, quickly resulting in a cluttered and confusing diagram that attempted to illustrate key concepts. By being able to select an animation of a near-ideal sprint cycle from various pre-determined angles, the lector would be able to have an accurate representation of the sprint cycle to talk about, versus a messy stick figure diagram.

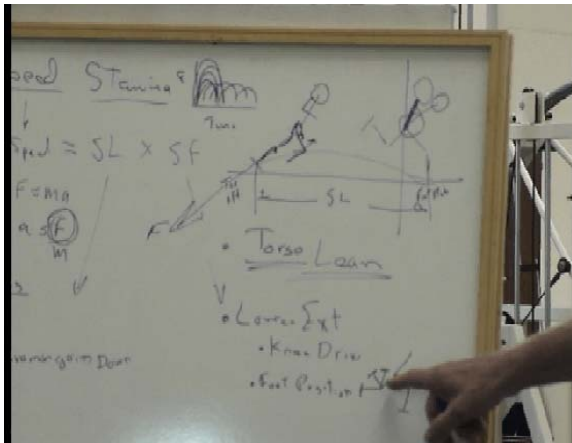


Figure 4 Stick figure drawings

Dartfish was selected as the method for final distribution for two main reasons. First, Acceleration Indiana, along with numerous other Acceleration sites, owns a license for Dartfish. Having previously licensed software gets around any potential licensing issues that might have been encountered if a custom program or distribution method had been created instead. Secondly, Dartfish, having been developed for video analysis, provided a good way to distribute multiple video files with numerous features in a neat, clean method. The next decision was determining the content of the product.

The content of the product was dictated largely by the results of research into the most effective way to present visual teaching aids. It was determined early on that both a male and female model should be created for the animation. Next, the male model was animated using motion capture data of an elite male athlete running 22mph

at 0% grade and the female model was animated using data from an elite female athlete running 20mph at 0% grade. Camera angles were decided from received feedback of an early alpha version from the Frappier Acceleration Advisory Council in Chicago. Five view points were determined: side, front, rear, rear three quarter, and trainer view. The trainer view, as the name implies, is the view that the trainer would see of the sprinter while standing on the treadmill and spotting the athlete. These five camera angles applied to each of the two models resulted in 10 animations. An eleventh animation was later added at the request of the sponsor. This final animation was to be an eye-catching, attention getter, showing both athletes. A fly-around of both athletes running on separate treadmills in the same room was made to answer the request. The fly-around incorporated fast motion, which is a strong way to capture an audiences attention (Franconeri, 2003).

The eleven animations were incorporated into the final deliverable, a standalone application known as a Dartfish Mediabook, which was produced by the Dartfish Team-Pro software. Dartfish allows the developer to select important frames from the video and add text descriptions of the significance of the frame. This text feature was utilized to include an additional learning style used by Acceleration Trainers (see **Figure 5**).

Development Methodology

As with the development of any product, there is a process of determining what is necessary and why it is necessary. For the development of this product, much research was done to determine and validate the very particular things needed for a life-like animation. The choice was made to use both a male and female sprinter with very little detail to accentuate the sprint cycle and allow viewers to closely relate themselves to the models. Research concerning simplified versus detailed imaging shows that a person obtains much more from a visual stimulus if they can closely relate themselves to the



Figure 5 Dartfish Mediabook.

situation and/or the character (McCloud, 1994). Therefore, this concept allows for better attainment of knowledge in a personal, more efficient manner.

Research

Use of Computers in Education

Research results portrayed an aspect of computer use for instruction called novelty effects. A novelty effect is when something new, original, and different is found to be interesting or exciting (Clark, 2001). Novelty effects ensure the student will pay attention to the visual media.

Comparing computer and programmed instruction (PI) to the use of other unaided visuals, the PI and computer studies tend to show about a 30% greater effect in comprehension. However, an even larger effect size is shown for the personalized system of instruction (PSI) approach. PSI was originally designed as a classroom-based method of instruction with the intention of improving student achievement. This approach tends to

focus on its essential methods rather than on a medium. The results of this method are great, especially when combined with the PI method, which would indicate that when method and medium are separated there begins to be more significant amounts of learning variance (Clark, 2001). In light of this, the program and product developed take both of these aspects into consideration and combine them for maximum benefit. Changing the method from drawn stick figures and excessive discussion to defined animations and, hopefully, less discussion, due to clearer visuals, along with changing the medium from a whiteboard to a computer combines those aspects and allows for the increase in effect size of the instruction on the students. In conjunction with this effect, research has shown that the use of computers shows a 30-50% reduction in time to complete instructed lessons versus conventional methods of instruction (Clark, 2001).

Delivery Medium

The human mind learns through three different domains: affective, cognitive, and psycho-motor (Knirk, 1986). The affective

domain is of special interests to the validity of the product. The affective domain includes the attitude, emotions, and appreciation the student has towards the material. Studies of the affective domain of learning have shown that students appreciate and are more interested in motion graphics than static images (Knirk, 1986), implying that animation is an improvement over the stick figure drawings. Additionally, on the Allen Media-Selection Model (see **Figure 6**), the instructional media type of “motion pictures” scored a medium effectiveness for the learning objective of performing skilled perceptual-motor acts and scored a high for the learning objective of learning visual identifications (both of which are learning objectives for Acceleration Trainers). It should be noted that every other instructional media type scored low for performing skilled perceptual-motor acts besides demonstration, which also scored medium. The learning style of 3-D objects and still pictures also scored high on learning visual identification. The final product is a mixture of motion picture and still pictures using 3D objects.

Visual Design

The effectiveness of realism is directly proportional to the time and effort put into studying the images; students who put extra time and effort into studying realistic images will have a greater benefit. However, if the student's time is limited or under someone else's control, then more simplified representations are more effective (Youngs, 2005). Additionally, complicated, realistic images may distract the student, thus impeding their learning. On the other hand, more realistic imagery, especially animated images, can help students understand concepts that cannot be easily explained verbally. This would apply to sprinting mechanics. The amount of physical details of the geometries of the character models and environments were chosen in an attempt to balance these two psychological effects. They were created with enough detail to be engaging human representations, but not so much detail that it would distract from the motion (Montgomery, 2004).

Another effect of leaving the models with less than human geometries was that the models lacked identifying physical features, allowing the character models to be more identifiable to a larger audience (McCloud, 2003). In line with this, the characters were textured a neutral gray. This color helped ensure the models would be racially unidentifiable.

Contrast in color was also used to focus the audience on the models. Color is immediate and draws a person's attention. A sharp contrast in color draws a person's attention even more (McCain, 1992). Contrast in color depends on the three factors of color: hue, which is color; value, which is the lightness or darkness of a color; and saturation, which is the intensity or purity of a color.

Color is important for emphasizing the most important parts within a medium. Ideally viewers should be able to take a quick glance and have their eyes focus on the most important object. In this case, the most important objects were the humanoid models, which is where the focus needed to be. To accomplish this task, colors of contrast were chosen to exaggerate differences in value between the foreground colors and the background colors. Therefore, light gray was used for the models' skin color with a black background. Black is at one extreme end of the scale of grays, opposite to white (McCain, 1992).

In 3D environments, virtual lighting setups need to be established in order to have a source of light with which to illuminate the models. The lighting setups for the product were designed to focus the attention of the viewer towards specific areas of the final product. A 3-point lighting setup, which includes one main light and two supporting lights, was used in the front, side, and rear views to illuminate the scenes in a manner that helped to define the characters' geometries against the backgrounds (Birn, 2000). This helped focus the audience's attention to the character models. Another lighting setup

Instructional Media Type	Learning Objectives					Developing Desirable Attitudes, Opinions, and Motivations
	Learning Factual Information	Learning Visual Identifications	Learning Principles, Concepts, and Rules	Learning Procedures	Performing Skilled Perceptual-Motor Acts	
Still pictures	Medium	HIGH	Medium	Medium	low	low
Motion pictures	Medium	HIGH	HIGH	HIGH	Medium	Medium
Television	Medium	Medium	HIGH	Medium	low	Medium
3-D objects	low	HIGH	low	low	low	low
Audio recordings	Medium	low	low	Medium	low	Medium
Programmed instruction	Medium	Medium	Medium	HIGH	low	Medium
Demonstration	low	Medium	low	HIGH	Medium	Medium
Printed textbooks	Medium	low	Medium	Medium	low	Medium
Oral presentation	Medium	low	Medium	Medium	low	Medium

Source: "Media Stimuli and Types of Learning." *Audiovisual Instruction*. Reprinted by permission of Association for Educational Communications and Technology. Copyright 1967.

Figure. 6 Allen Media-Selection Model (Knirk, 1986)

was used for each characters rear three quarter view, trainer point-of-view, and the animated fly-around. This lighting setup included one light placed behind the scene and one kicker light placed in front of the models, used in conjunction with Maya's advanced rendering settings. This setup resulted in simple yet attractive renderings. This method of lighting allowed for the illumination of the entire room. This was important because these shots were intended not to focus the audience on the character motion, but in the case of the rear three quarter and trainer view, to reproduce the views a trainer would see in the Acceleration training environment. In the case of the fly around, the purpose of the lighting was to provide a flashy and "novel" look to the animation, which creates interest and gains attention, as the previously mentioned "novelty effect" indicates.

Testing Data

After consultation with Ben Tyner, a statistics consultant from Purdue's Statistic Department, it was determined that the most useful form of validation for the project would be to survey the Acceleration Trainers as to which method of teaching they preferred, media aided or non-media aided, and

how helpful the animations were in understanding the major mechanics of sprinting. Prior to giving the survey to Acceleration Trainers, Mr. Gary Nelson, Owner and President of Acceleration Indiana, gave his presentation on sprinting mechanics the original way with stick figure drawings. He then covered the same material using a beta version of the animation product. With the Acceleration Trainers exposed to both methods, back to back, the qualitative survey was given to them. The sample size was four out of a potential population of six Acceleration Indiana Trainers. As you can see in Figure 7, the average response to the question (#1), which asked whether Acceleration Indiana trainers preferred the new material over the old, was 4.75 out of 5, showing strong preference for the new material. Furthermore, no response averaged below a three, showing the Trainers heavily favored this new method.

At the conclusion of the testing, feedback was sought from both the trainers and Mr. Nelson on what they would like to see changed or modified for the final version. The main suggestion was to clean up the animations of the female to show better sprinting mechanics. Another big change from the beta version to the final version

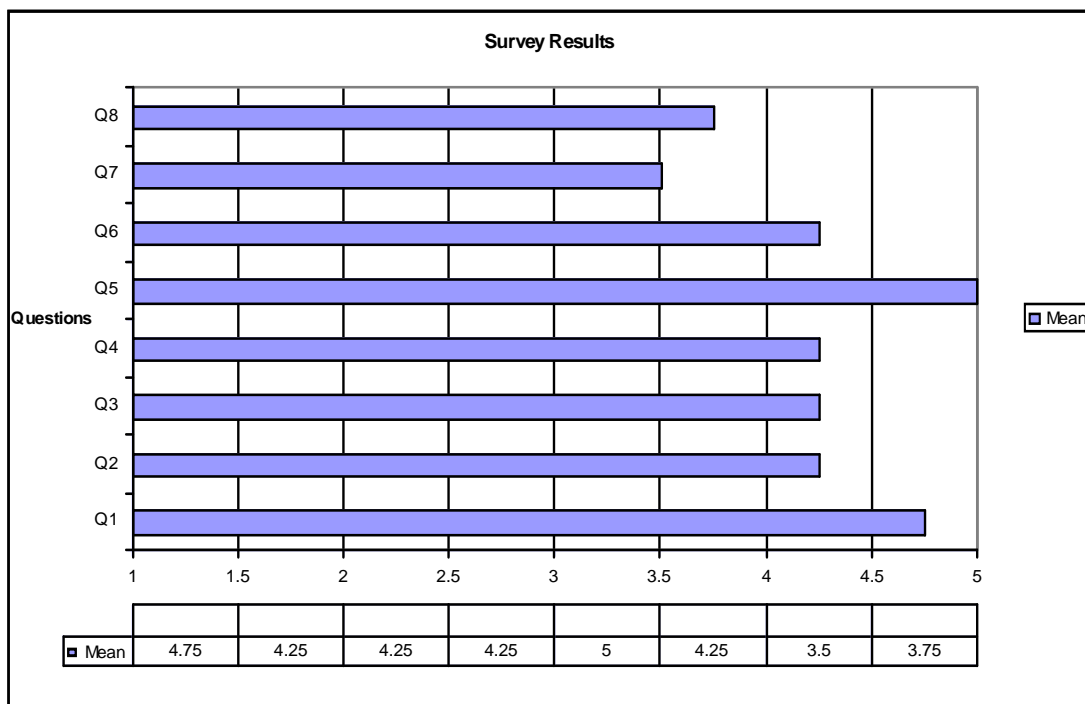


Figure 7. Qualitative survey results.

was the deletion of the background in the side, front, and rear views. This was done to place the focus of the viewer strictly on the athlete, as those views are the views primarily used for educating. The other two views, the trainer view and rear three-quarter view, would retain the background/scene imagery for the purpose of creating a realistic scene that a trainer would actually see.

Deliverables

The final product was delivered on a CD as a Mediabook produced by Dartfish. The Mediabook contains eleven individually selectable scenes; a front, side, and rear view with no background, and a rear three-quarter view and a trainer view, all for both the male and female. The eleventh scene is a fly-around in the room with both the male and female sprinting. There are two video formats for each scene: a high quality Flash version that plays within the Mediabook itself, while a high quality Windows Media Video is accessible from the Mediabook and plays full screen. The animations are selected from a drop down menu above the video screen. To the right of the video screen is a text box, which contains text pertaining to what is showing in the video screen; either the video or a key position. Along the bottom lies an area for key posi-

tion images. Key positions were used for the side view of the runner to show the four different phases of the sprint cycle: toe off, flight, foot strike, and stance.

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ARTISTORM

FORMIDABLE ARTWORK

USING MULTIPLE-LEVEL VISUAL AND TEXTUAL
ANNOTATIONS IN AN ONLINE ART GALLERY

By Group x-6: Artistorm

Greg Bosma, Naveen Nattam,
Laura Rodrian, Adam Tornes, & Reid Young

In partial fulfillment of the requirements for CGT 411
December 14, 2005

Using Multiple-Level Visual and Textual Annotations in an Online Art Gallery

Group X6: Artistorm

Greg Bosma, Naveen Nattam, Laura Rodrian, Adam Tornes, & Reid Young

Abstract

Artistorm is an interactive online art gallery where artists can upload high resolution images of their art and provide annotations and background information for potential buyers. Market research comparing the amount of information provided about an item and the amount of interest shown in that item indicate a positive correlation between the two. Based on these results, Artistorm developed an application which allows artists to provide a wealth of information about their art, and which allows viewers to peruse the artist's work in detail. Usability testing conducted on Artistorm's website indicates that it is an effective implementation of theory presented in this paper.

Introduction

The mission of Artistorm is to provide a profitable way for independent artists to sell their work - high quality, inexpensive prints as well as original pieces - online. Currently, opportunities to sell artwork online are limited to high traffic e-commerce outlet type stores. Websites like Art.com and PaintingsDirect.com use storefronts similar to those of Amazon (<http://amazon.com>) and eBay (<http://ebay.com>) to display their collections. These interfaces allow the potential buyer little opportunity to experience the art before purchasing it.

To purchase art in a physical facility, a person does not typically go to a department or outlet store. Instead, the buyer visits an art gallery where they get quite a different shopping experience. When purchasing art online, consumers should be able to expect this distinction.

Artistorm intends to address issues concerning potential buyers and artists through the development and implementation of a multiple-level visual and textual annotation system. This system allows artists to add comments to specific sections of a piece of artwork for sale. The user can zoom into these sections of the image and learn more about how the art was created and what meaning it holds for its creator. This interaction with the art provides the buyer with more of a gallery-like experience, allowing him or her to invest more interest in a specific piece of art and its artist.

Existing Art E-Commerce

In the paper *Affective Design of E-Commerce User Interfaces: How to Maximize Perceived Trustworthiness*, Egger writes that "as increasingly more products and services are sold over the Internet, it becomes all the more important to build up knowledge in e-commerce-specific user interface and user experience design." (Egger, 2001). This demonstrates the need to be aware of existing online art marketplaces and their methods and standards. Initial observation of several types of e-commerce websites helps to identify some of these standards.

Two examples of large, successful e-commerce sites are Art.com and eBay. Some smaller sites which specialize in selling original art include PaintingsDirect.com and Artistrunway.com. Both of these websites specialize in the selling of art in an online marketplace, but they accomplish this feat using completely different methods. Like Artistorm, both of these smaller sites attempt to build a relationship between the buying party and the artist's intentions in creating the piece (ArtistRunway.com, 2005; PaintingsDirect.com, 2005).

In his book *Make Your Website Work for You*, Jeff Cannon has a case study on an art e-commerce site very similar to Artistorm. This company is called PaintingsDirect.com. The lesson he wishes to convey to the reader is that relationships are required to sell art. PaintingsDirect.com

employs a method of relationship building that involves taking the art, a few facts about the art, and a quote from the artist to make the user feel that they have a better understanding of the artist's ideas. They also have a low-resolution view of the image that has a PaintingsDirect.com watermark placed over the image. Another interesting niche the website tries to fill is the e-card business: the user can create an e-card from any of the paintings on their database. According to them, this is the only such combination of e-cards and paintings on the market (PaintingsDirect.com, 2005).

ArtistRunway.com is the official name of an art agency based in Indianapolis that recently won the Purdue University Lilly Endowment Business Plan Competition. The company's focus in selling art is to build a relationship with and provide a history for each artist. Each artist has an in-depth biography on the website, including awards the artist has won, places he or she has presented art, and the artist's education. ArtistRunway.com also has a large list of services that are either existing or nearing completion. One service is called the Artist Liaison. An artist liaison is a trained individual who works with the buying party so that they find a piece of art that will fulfill their needs and suit their desires as closely as possible. Another service supplied is a seminar in art collection and the importance of art in our culture. It also explains the rationale behind how artwork can be an investment rather than just merely a conversation piece or a static piece of property (ArtistRunway.com, 2005).

The online auction giant eBay has a section of its website dedicated to art. The section's main page has keywords that are most often searched as well as other sections that those searching found interesting. Along with the capability to sell the art on the website, eBay also provides a small explanation about how to best sell art on their website. They include tips on placement, pricing, and other important steps (eBay.com, 2005).

Need For Online Alternatives

In an e-commerce site like Artistorm, two audiences must be taken into consideration: the buyer and the seller. To assess the art buyers' and

sellers' current options and needs, Artistorm conducted two brief online surveys.

A customer survey was made available online for any interested customers to participate in. The survey was advertised by word of mouth and on the Starmen.Net "Fan Forum". The message forum was chosen due to its large assortment of artists and art critics – the forum claimed over 4,100 users at the time of testing (Starmen.Net Fan Forum, 2005).

Artistorm found that of the 119 people surveyed, the average rank given to previous online art shopping experiences was 2.75 out of 5 (1 being low). Only 47.17% of those surveyed said that they were satisfied by the amount of information provided about the art in previous experiences. 52.83% said that they did not have enough information.

A similar survey was set up for artists to respond. It was also advertised on Starmen.Net in addition to solicitations sent to many artists who currently sell work online. 45 participants responded, and when they were asked to rank their online selling experience, the average rank given was 2.57 out of 5 (1 being low).

From this brief evaluation of online art selling and buying experiences, it became evident that there may be room for improvement within the online art marketplace. Artistorm noted the large number of customers (over 50%) that said there was not enough information provided about the art. Secondly, it was evident from the artists' ranking (2.75/5) that the artist experience could be improved.

The Artistorm Solution

Taking into account the previous findings, Artistorm focused on two needs: providing more information about the art to the customer, and flexibility and ease of use for the artist. To create a prototype addressing these needs, several different Internet technologies were integrated, including PHP, XML, JavaScript, and Flash 8.

A user interface was created that displays information about the art: title, artist, medium, size,

price, brief description, and extended description. Rather than providing a traditional static thumbnail image of the art, Artistorm chose to take the visual representation one step further by using an interactive image viewer. This viewer would allow customers to zoom into the art and be able to see details that would otherwise be overlooked. Existing technologies like Zoomify were investigated, but none had the amount of functionality needed for Artistorm. The development team chose to create a new viewer instead, using Macromedia Flash technology. The new viewer developed by Artistorm allows customers to zoom in and out of a high resolution image and to view annotations submitted by the artist (see figure 1). These annotations are textual descriptions about a specific section of the artwork. When a customer rolls over the zoomed out image, areas linked to an annotation are highlighted. The customer can click the numbered annotations to zoom into the specified area and view its text.

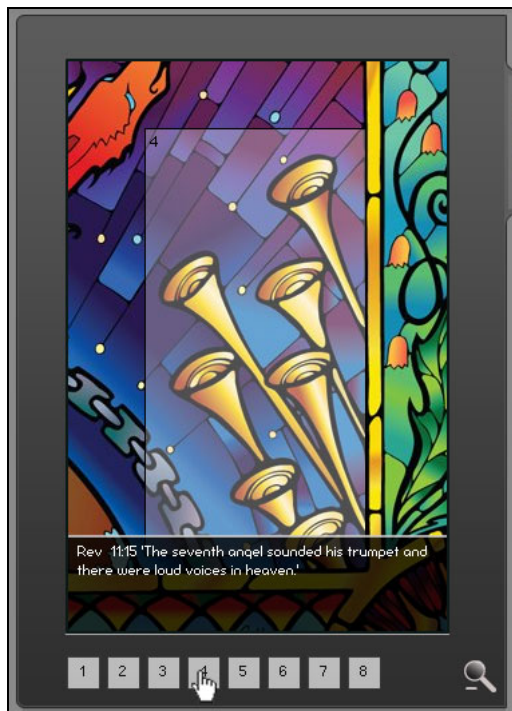


Figure 1: An example of the Flash viewer in use, showing an annotation.

An effective implementation of this kind of content rich environment implies the need for an efficient management system. It is important to allow artists to be able to manage their artwork while keeping the process very simple. To move

the art from the studio to the web, Artistorm created an automated uploading process.

First, artists log into their Artistorm account. They can then upload a new piece of art by filling out basic form fields with information about the piece. Next they upload one high resolution image of the art. A PHP program written using the imageGD library resizes the image for thumbnail use on the site. The user is taken to the “thumbnailer,” a JavaScript application which allows the artist to interactively specify several cropped areas of the image to be converted to thumbnail images. Next, the artist is taken to the “annotator,” an application very similar to the “thumbnailer,” which allows them to select areas of the image to link annotations to. The artist enters text which will be linked to the image areas. All of this information is then stored in an XML file specific to that piece of art. When the customer views the art in the gallery, all of the necessary data is drawn from the XML file.

Research Question

To validate the hypothesis that the unique Artistorm features would attract customers interested in purchasing art, the Artistorm team asked the question “Will potential buyers find value in multiple-level visual and textual annotation of art at artistorm.com?” For the purpose of this study, *multiple-level* refers to the presentation of increasingly detailed annotations as the user targets a diminishingly smaller section of a piece of artwork. A *visual annotation* is a selection of an image that can be enlarged, and a *textual annotation* is a description of image selections defined by the artist who may include explanation of technique, process, symbolism or significance.

In this case, value could be interpreted in several ways. For Artistorm’s purposes, the indicator of value is whether or not a customer makes a purchase. At the time that this study was conducted, the scope of the project was limited: the business portion of Artistorm and its shopping cart were still under development. As such, customers were unable to make purchases. To establish initial predictors of the value of the previously mentioned features, several different means were used: an eBay case study and an observational study of two different Artistorm websites.

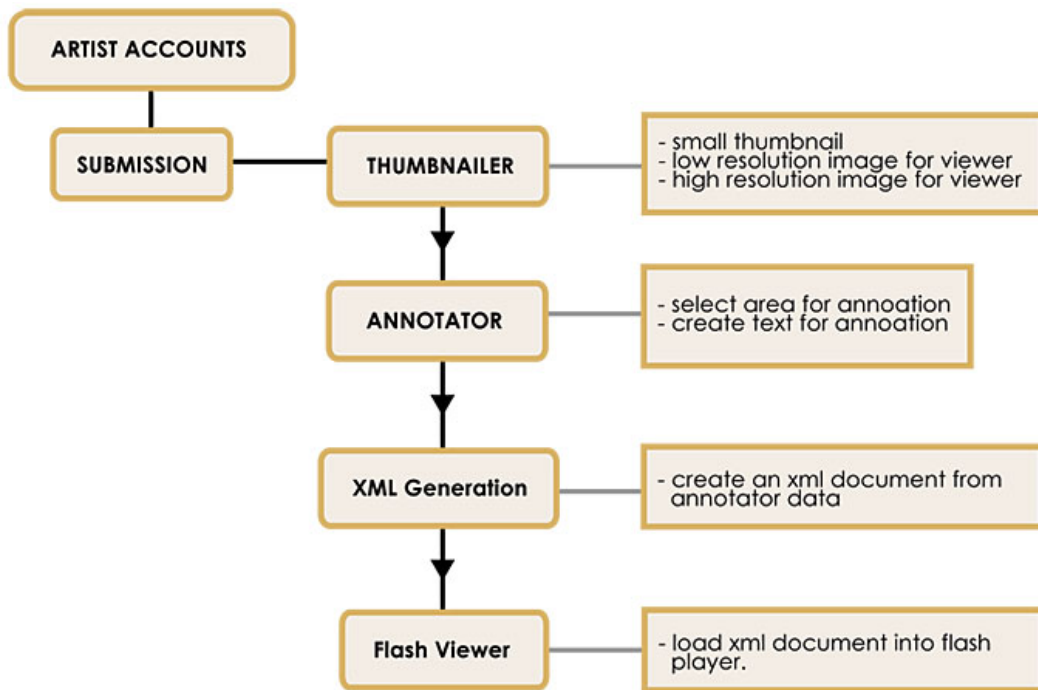


Figure 2: The process of the automated image viewer generation.

eBay Case Example

Methodology. “The more detail you include, the better. People like to know the histories of what you’re selling and who you are,” advises Lynne Dralle, an eBay Power seller who has sold more than 20,000 items at online auctions over the past six years. “Always describe exactly what the buyer is getting. Be honest,” she says. This quote from *Seven Strategies to Boost Your Online Sales* by J.L. Krotz served as the basis for our eBay case study (Krotz, 2005).

Following the realization that more information and content helps people to sell things on eBay, it was concluded that Artistorm.com would pursue a similar business plan: to provide more information about the artists and the art being sold. The hypothesis was that providing more details and information about a product will generate more interest from consumers and improve its potential to sell.

Ten products offered for sale on eBay were selected for the study. Studied products included: a Canon digital camera, a Motorola cell phone, a

Playstation 2 video game, a Sony CD clock radio, BOSE speakers, an iPod, a vintage turntable, an ONKYO stereo receiver, a Beatles album, and an autographed John Elway jersey. Two auctions of the same length, selling nearly identical items, were identified for each product. At the end of each auction data was collected including: item title, seller, number of bids, final price, auction length, a word count of the item description, and the number of images depicting the item.

Results. The data of the two like items was compared to see whether it supported the hypothesis. Every item supported the hypothesis to some degree, as shown by the bid count or the ending price. The auction with a higher word count sold for a higher price 80% of the time. The sale price of the higher word count auction was an average of \$20.12 more for identical items. The item with a higher word count had a higher bid count 100% of the time. The items with higher word count descriptions averaged 13.6 more bids. Following the study, it was concluded that in accordance with the hypothesis, providing more information about a product appears to generate more consumer interest and improve its potential to sell. This conclusion was applied to Artistorm.com in two

ways: users were provided with lots of product information, and non-technical artists were given tools to easily manage that information within the site.

Artistorm Observation

Methodology. Once the preliminary design of the Artistorm website was complete, a two part comparative study was done to assess the preferences of potential customers. Two versions of the gallery at Artistorm were set up: version A, which provided basic minimal information including title, artist name, size, price, and a static image, and version B which included the full functionality of Artistorm.

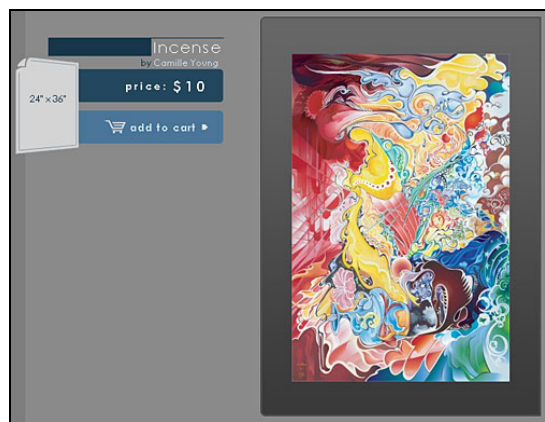


Figure 3: Version A used for testing. This interface provided no interactivity with the art.

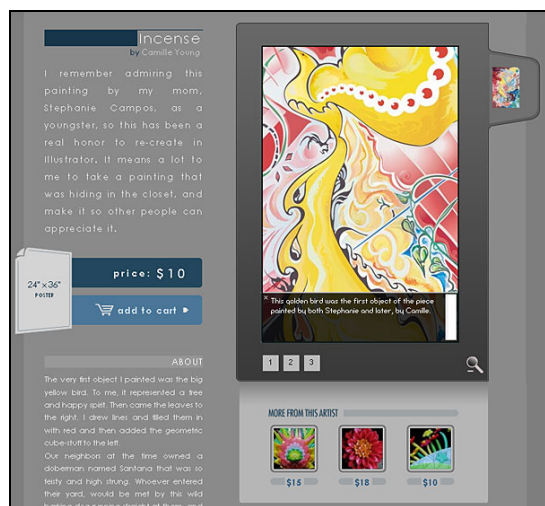


Figure 4: Version B which has all of the Artistorm functionality. This image shows the Flash viewer in use.

In the test, a group of fourteen potential customers were given surveys to complete while

viewing version A of the site. The survey [appendix A] included multiple choice questions about what art the participant liked, whether or not they had enough information to make a purchasing decision, and what, if any, art they would buy.

During the second part of the test, participants were asked to fill out another survey [appendix B] while viewing version B of the site. The same art was displayed in both versions A & B so that the participants wouldn't judge the two versions based on their personal interest in the available art. In the second survey, participants were asked to re-assess the art, making note of any differences from previous interest. If they noted a change in art preference, they were asked to explain why. Participants also were asked what features they liked and did not like, whether they had enough information to make a purchasing decision, and to make comments. There was no reverse sequence or crossover testing conducted, based on the guidance provided by professionals in the Purdue Department of Statistics – this depth of research was reserved for future experimentation based on time and facility constraints.

Results. When asked what pieces of art the potential customer was interested in, 64.29% took notice of more artwork in version B, which provided more information about the art, than in version A. Of that percentage, the majority attributed it to the ability to see more detail of the art (88.89%) and the description of the art (66.67%). Participants also noted other features that affected their interest: learning about the symbolism within the art (44.44%); learning about the history of the art (33.33%); and noticing new aspects of the art due to the use of annotations (33.33%). These findings are consistent with the features the participants liked the most: the zoom feature (liked by 85.71% of participants) and the artist's description of the piece (liked by 78.57%). 42.86% of participants liked the annotations within the image and only 35.71% liked the artist's biography feature.

Few participants disliked some of the features in version B: 2 (14.29%) disliked the zoom feature; 1 (7.14%) disliked the annotation feature; 1 (7.14%) disliked the artist's description; and 1 (7.14%) disliked the artist's biography.

Participants were asked if they felt they had enough information about the art to make a purchasing decision. When presented with version A, only 71% had enough information. However, in the fully functional version B, 100% had enough information (see figure 5). When asked which version the participant would rather shop at, 85.71% chose version B (see figure 6).

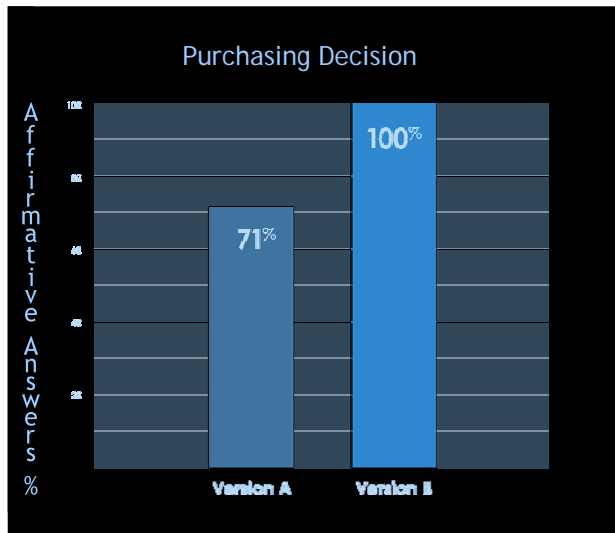


Figure 5 : Participants who positively answered “Do you have enough information to make a purchasing decision?”

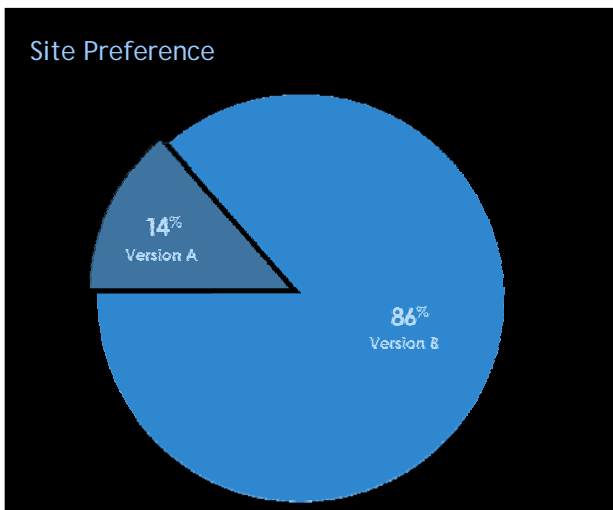


Figure 6: Responses to the question “Which version of the site would you rather shop at?”

Conclusion

Currently, many websites exist to bring the art purchasing experience online. However, neither art buyers nor artists are completely satisfied with these existing options. Potential customers want more information about an item before making a purchase. Artistorm’s case study on eBay demonstrates the positive correlation between the amount of information consumers are provided and their interest in purchasing it.

When asked if current online art marketplaces provide enough information about the product, a significant number (over half) of respondents said no. However, when presented with the Artistorm interface, 100% of participants said that they had sufficient information to make a purchase. Not only did customers like the Artistorm method, but 86% preferred it to traditional online display of art. The reliability of this data, which is based on a survey of 15 users, is undetermined, but the data will act as a basis for potential future experimentation.

This evidence serves as an indicator that Artistorm’s multiple-level visual and textual annotations are an effective implementation of theory - that providing more information to a user will result in more interest in an item.

Appendix A

Pre-Survey **Participant #** _____

1. Have you ever made a purchase online? Yes No

 If no, would you consider making a purchase online? Yes No

 Why or why not?

2. Have you ever purchased art or posters online? Yes No

 If yes, where?

Take some time to browse through the art, and then answer the following questions:

1. Which, if any, of these pieces interest you?

2. Based on what you know about the art, would you make a purchase of any of these?

 Yes No

 Which ones?

3. Do you feel you have enough information to make an informed purchasing decision?

 Yes No

 Why or why not?

Now ask the tester to direct you to the 2nd part of the study.

Appendix B

Post-Survey Participant # _____

Take some time to browse through the art, and then answer the following questions:

4. Which, if any, of these pieces interest you (may be the same or different from the first part)?

If you answered differently than during the first part, why (circle any that apply)?

- a. I was able to see more detail of the art.
 - b. I learned about the technique/medium used to create the art.
 - c. The description of the art made me more interested.
 - d. I learned about the symbolism found within the art.
 - e. I learned about the history of the art.
 - f. The annotations helped me to notice aspects of the art that I previously had not noticed.
 - g. Other: (please explain)
5. When browsing through the art, I liked the following features: (circle all that apply)
- a. The zoom feature
 - b. The annotations within the image
 - c. The artist's description of the piece
 - d. The artist's biography
6. When browsing through the art, I DID NOT like the following features: (circle all that apply)
- a. The zoom feature
 - b. The annotations within the image
 - c. The artist's description of the piece
 - d. The artist's biography
7. If I were to purchase art online, I would rather:
- a. Shop at a site with the first interface.
 - b. Shop at a site with the second interface.
8. Based on what you know about the art, would you make a purchase of any of these?
Yes No

Which ones?

9. Do you feel you have enough information to make an informed purchasing decision?
Yes No

Why or why not?

Appendix C: LITERATURE REVIEW

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