Immersive Simulations and Engineering Environment (iSEE)

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Updating the Immersive Simulations and Engineering Environment

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In January 2017, the Immersive Simulations and Engineering Environment (iSEE), formally known as the Human Factor Tool (HFT), was brought back online. Since August, the lab had been operating at a nominal status, but with dated hardware. An evaluation was done on the present system so that the improvements and capabilities brought about by the upgrades can be quantified. Immediately following the analysis, evaluations with human factor engineers were performed and some upgrades were implemented. Due to a malfunction with a crucial piece of hardware, the lab was reconfigured temporarily. This allowed easy analysis and integration of various other components which improved the laboratories' overall performance. Soon after, work began on creating a video to showcase the capabilities of the lab. This video not only served to show the actual functions of the lab, but also show the expanded capabilities the new hardware and software made available. Skills were acquired throughout the renovation process in various fields, all of which were crucial to not only implementing the updates to the lab, but understanding how they will improve it.

Nomenclature

iSEE	=	Immersive Simulations and Engineering Environment
HFT	=	Human Factor Tool
Ultranet	=	Ultranet High speed router used to control cameras
Giganet	=	Giganet High speed router used to control cameras
Mocap Orb	=	Silver spherical ball coated with special material designed to be visible by motion capture camera

I. Introduction

A. Introduction

The iSEE is designed to explore the many uses of Virtual Reality and Motion Capture technology for the purpose of advancing our capabilities in Human Factors evaluation and Research and Development (R&D). In particular, the goals of the iSEE are to perform human factor analysis and testing of systems for various projects on site. The advantages this lab has over traditional full scale mockups and live testing lie in the ability to simulate conditions reminiscent of the actual work environment without having the expense of building large scale physical models to test with. The lab is able to go one step further and utilize engineering human analyzation software to determine long term effects of different postures and work routines without actually having to perform such routines.

In order to extend the lifetime of the system and expand the range of utility for the iSEE system, the software, hardware, and documentation needed to be updated. At the onset of the investigation, the system was functional, however, it was in need of maintenance and improvements. Motion capture software, analysis software, and malfunctioned hardware needed to be updated as well as the layout of the lab itself, With the new hardware and software, documentation and workflow needed to be upgraded and upgraded hardware needed to be implemented.

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B. Overview

Along with upgrading the lab, a better understanding of its functions and how it can be optimized was included in the scope of the project. The aim was to create an extended and thorough set of documentation that could be used to understand the lab's functions. Due to all of the unexpected anomalies that occurred since project inception, the documentation would also serve as a troubleshooting guide.

The primary goals included becoming familiar with the maintenance and operation of the iSEE lab, learning how to calibrate and capture objects for continued use, upgrading the system with the required hardware and software, and assisting with troubleshooting situations that arose. Some other tasks included figuring out new ways to expand the capabilities of the lab through writing custom scripts for the previous software or implementing freeware for use in the lab.

In order to move forward with the completion of the objectives, no more than a week was spent on familiarization with the daily setup and basic operation of the iSEE. From that point forward, steps were taken to commence with the renovation. Due to unforeseen anomalies in key pieces of hardware, it was difficult to proceed with the objectives detailed above. These anomalies and how they affected progress will be detailed in the troubleshooting section.

Using the iSEE

C. Layout of the Lab

The Interactive Simulations and Engineering Environment lab is unique in that it uses motion capture to virtualize live capture data for analysis. This is achieved through the use of 32 cameras interspaced throughout the room, mounted atop an aluminum fast track support rail system. These cameras are designed to detect the location in 3 dimensional space of small silver spherical objects known as markers or Mocap Orbs by using rapidly strobing high intensity red light. The cameras themselves use Ethernet cables to connect to 4 high speed router units that package the information into data that can be read by the image capture software. The system's primary strengths are accuracy and the ability to virtualize up to 3 people performing a particular task. This data can be sent to the vendor software for analysis. The setup of the lab is quite old as is a majority of the hardware. Because of this, in order to optimize the performance of the lab, the newer cameras are positioned nearer the top of the capture volume to take advantage of their stronger and more robust view range.

In the lab there are three computers where most of the data processing and analysis are done. The primary computer, 03, is the one with the blade installation and is where most of the data composition takes place. The second computer, 02, is where the simulation software is and where data from 03 is streamed directly to perform real time live analysis of a particular activity.

D. Calibration and Setup

On the onset of this project, the first thing I learned was the calibration of the lab. While currently the lab can function acceptably without daily calibrations, the previous installation was rather buggy, and required calibrations be done daily to ensure integrity of the lab. It is important to note, part of the flaws had to do with the limited number of operating cameras. Over time some of the old hardware died resulting in small holes within the capture volume.

The Calibration process as detailed in the documentation version 1 consisted of an auto threshold which applied masks to the cameras to compensate for objects in the room that may appear identical to but in fact are not Mocap Orbs. After the auto thresholding is done, the most rigorous part of the calibration, the wand wave is completed. This task is extremely important in that it, through advanced calculations built into the blade software, is designed to determine the relation of each camera relative to itself. This is accomplished by waving a wand in such a manner that it covers the capture volume of the room. After the wand wave is done, a metal calibration object is placed in the center of the room such that 3 of the 4 markers interspaced atop it in an L formation are lined up with the x axis of the capture volume. This positions the volume in the correct orientation, rather it be Y up or not depending on the user. The last calibration step involves the placement of 8 Mocap orbs in a grid patter around the floor to mark the floor plane. After all of these steps are complete, the lab is ready to use.

While not always required, the room calibration is a crucial step for ensuring integrity of the system as its key strong point is accuracy. The subject will be explored more in the troubleshooting section as a possible cause for one of many of the problems encountered. A good calibration keeps the room in a ready fully functional format.

E. Daily use

The primary goals of the lab are for human analysis of particular tasks. Data is captured through the workflow mentioned previously, and the results are gathered through the analyzation software. The week of October 19th the lab saw the visitation of one of its regular clients, Ian, who was in the process of creating a report on the subject of Human Factors analysis pertaining primarily to a Vertical Stabilizer post. The iSEE team was proud to assist in providing the data that Ian needed. iSEE provided Ian with the required data on both short term and long term stresses on a human form while performing a task. This data is important for many reasons, both for determination of safety standards, and the determination of what constitutes a practical workflow. This tool can evaluate how the human form can perform in multiple situations, both over longer periods of time and under certain physical stresses without the high cost of building expensive mock-ups. It is believed that with the iSEE made available a more detailed look into the study of human factors and how specific designs can be improved ergonomically before production is much more within reach.

Troubleshooting

F. Failure of MX Giganet

Progress towards renovating the lab began smoothly, however some setbacks, both major and minor were encountered. Many involved the malfunctioning of the iSEE primary system as it is a relatively innovative system with old hardware. The primary problem came as a result of a malfunction of the Giganet switch taking with it the functional ability of half the lab. Ten of the T-series cameras which contained the most updated hardware no longer worked since the Giganet was the bridge between the raw sensor data and the computer. Since this was a crucial component, steps were taken to troubleshoot this mishap with mentor and advisor Mr. A. Pego.

At first the problem was thought to be caused by an accidental key press so the camera vendor was contacted. From there the information detailing how to reset the program interface was obtained. Unfortunately, this did not work, so to make absolutely sure the problem could not be attributed to any software malfunction, the camera software was installed on a different PC within the lab. This, however like the first, yielded no real results.

By this time there was enough evidence to attribute this to a hardware error, so steps were taken to troubleshoot and examine the hardware. The Giganet was examined next, making sure that all of the test points on the circuit board were coming up with their required voltage levels as the boards themselves had no signs of visible distortion. Each of the capacitors were examined for damage, and like before, no points of fault were discovered.

There was one notable peculiarity in that when the device is started up two indicator LED's would light up inconsistently. However this did not seem to provide any more information on what the problem could be directly attributed to.

The last attempt at troubleshooting the Giganet was examining the operating system to determine if the computer itself would detect the existence of the switch. This was done using the windows XP command line interface. Multiple tests were ran to verify if the system could communicate with the device, however none of them succeeded.
Due to these setbacks, the lab for the remainder of the week and until this problem could be resolved, was forced to operate in an off-nominal state.

After it was confirmed the Giganet was problematic, steps were taken to contact the vendor and upper management to procure a contract to acquire another Giganet router. After a number of phone calls and filling out of the necessary paperwork, the order was put in for a replacement. In light of this setback, it was determined that a more detailed look be taken at the current state of all the hardware in the lab, and it be temporarily reconfigured to operate without the T series cameras.

G. Reconfiguration of Capture Volume

The lab in its native configuration would not be able to operate with good results with the absence of the T series units. As a result, a restructuring of the capture volume was necessary to proceed with continued operation. Many cameras had been taken offline prior to this due to small malfunctions, or them being broken. To ensure the temporary capture volume was achieved, cameras were put back online for diagnostics. At the time of the Giganet's failure, there were 14 cameras in operation. During the analysis of all the older camera units, 2 were put back in service for a total of 16 working cameras to reconstruct the new capture volume. The cameras that were not deemed fit for service were disconnected completely from the system and put onto a cart to be disassembled and troubleshooted at the component level. With the new cameras, the volume had to be reduced, however steps were planned to get the most coverage with the limited hardware. The final temporary capture volume was reduced from 6x6 meters, to 6x5 meters. With these modifications, a sufficient accuracy was achieved allowing the lab to be fully operational until the arrival of the new Giganet, and second reconfiguration of the room.

H. Local network restructuring due to upgrade to windows 7

During the restructuring of the capture volume, the lab received a new license for the camera software which allowed the software to be upgraded to a newer version. Updates to the software in the lab began immediately but additional problems were encountered. At the time, all of the computers in the lab with the exception of computer 01, were running Windows XP. The upgraded camera software was incompatible with this version of the operating system. As a result, the operating system needed to be upgraded. Unfortunately it was determined there was no way to directly upgrade the computer to Windows 7 from XP and as a result the data had to backed up before installation. During this time a network card for computer 01 had to be obtained so that it could be used to run the system while the necessary changes were made to the primary computer. After the network card was installed, and Windows 7 was installed on the primary computer, the original documentation for the lab was referenced in an effort to figure out what the structure of the network was so communication could be reestablished with the machines.

After the installation of the new software on the main computers, there was one issue with the hardware brought to life by Windows 7 that needed to be addressed immediately as it could potentially affect the workflow in the lab. After running a certain amount of time, the operating system would crash. This led to the computer being temporarily out of order. After troubleshooting this problem and using the installation disk to repair the boot manager, the original issue was linked to a bad driver issue, which was promptly resolved.

I. Other troubleshooting problems

There were more issues, however these were primarily rooted in having an understanding of how the different software and hardware work together to create the data stream necessary for the analyzation software to interpret. In any case, all of these issues were documented in the lab's various sets of documentation and if anything helped contribute to an understanding of how the system works and how it can be improved.

Renovations

J. Previous Hardware Conditions

The lab was unfortunately not functioning at full potential during the beginning of this investigation. Due to the aging equipment, many cameras were offline, causing the system to have to be calibrated more often. This problem with the cameras was intended to be rectified with the addition of 3 of the vendor's latest cameras that would be installed at a later time. The improvement is believed to increase the accuracy of capture volume significantly. Some of the other updates to the hardware included addressing the overall untidiness of the lab itself. In its previous state the lab control area was plagued by a jumbled mess of wires. Plans were designed to rectify this by utilizing a rack server cabinet to store all the routers, and two computers for extra storage of archives. Along with the general hardware updates, there were plans put in place to improve the function of the lab with the updating of the computers to more modern hardware.

The increase in functionality that came with the restored cameras and the new Giganet router have since improved the integrity of the final capture volume. With the new hardware implemented, many of the tasks in the lab have now been optimized in such a way that they no longer are complicated and require a tremendous amount of documentation to explain their use.

K. Previous Software Conditions

Due to the way the software was written, the lab was forced to rely on presets when working with the motion capture software. The program frequently crashed, not necessarily due to bad programming, but more so due to the fact that motion capture was relatively new at the time of the program's creation. At the time the operating system being used was outdated and as a result hindered the workflow due to the cryptic and rather unorganized file structure that the lab had been forced to develop around.

As soon as the motion capture software upgrade was acquired, both the demonstration and the primary computers were updated with the software. This served two purposes, first, to gain an understanding of how the software worked so documentation could be updated, and finally, to provide experience in the steps necessary to install the software on the new computers once they were obtained. The results of both of the software updates came immediately. The motion software programing allowed for a more accurate calibration such that the program is able to determine the positions of each camera relative to one another after only one wand wave, whereas in previous versions this step had to be performed a number of times. This is evidenced by the calibration status indicators the program returns during the position calculation, which return ‘Awesome’, ‘Excellent’, ‘Good’, ‘Bad’, or ‘Unknown’. Many other improvements came as a result of the motion capture software upgrade including but not limited to: better performance even with dated hardware, and a more streamlined workflow that allows for the completion of tasks that were originally 6 or 7 steps with the push of a button. The program interface is also much more user friendly with the inclusion of a multifunction manipulator that allows more organic movement of the bones as opposed to typing in values and seeing what happens.

The file structure that the upgraded operating system provided proved to be much cleaner and organized and allowed for easier access to core files for backup and editing. Overall the improvements that came with the software updates were numerous and assisted in improving the productivity of the lab by a large margin. There were plans in place to update the human simulation software which is our current analysis suite, however, it is unknown exactly what the status is of this at the time of this report. If the upgrade to the current version does go through however, it is anticipated that this would significantly increase the productivity and ease of use in the lab much in the same way the upgrade to the operating system and motion capture software did before.

Conclusion

L. New Documentation

Throughout the semester many changes have taken place within the iSEE, from reconfigurations, to renovations, troubleshooting to software updates. All of these are to be recorded in a set of new documentation that details how to use the lab as well as the new skills, resources and experiences gathered along the way. Many of these modifications were made to the current manual along the way. With the image capture software, a new way to capture both objects and characters was documented, as well as calibration tips and tricks. One of the key additions to the manual is the model creation section, designed to provide useful tips on how to create models in house for use in the lab environment. Another new addition will include the troubleshooting guide designed specifically for when things go wrong.

M. Creation of Demo Video to showcase lab capabilities

One of the hallmarks of the renovation is the creation of a demonstration video that showcases the many different capabilities of what can be done with the lab. This video is designed to stretch the bounds of what the lab can do, in an effort to showcase the many applications the system has and it’s availability for center wide use. The video also serves as a test for the lab to see what works, what can be done, and what cannot. The video itself explores a mission essential task and how different environments can affect the conditions at which this task is performed and potentially the ability to get the task completed. The completion of this video has already seen the employment of a number of new resources that when combined with the current setup enhance the capabilities of the lab by a large margin.

N. Goals of iSEE

The primary goal of the immersive simulations and engineering environment is to assist in the study of the field of Human Factors. This lab is designed to provide an insightful and deeper understanding of people. In particular, how people will work around, work with, and utilize the equipment that will soon become part of the workplace. As humanity ventures farther out into space, more attention needs to be paid to Human Factor and the ergonomics of how well people work with the equipment responsible for keeping them alive. As society moves further towards deep space exploration and industrialization, as we grant complex systems more control over aspects of our wellbeing, the relationship between these very systems and people become ever more important. The renovation of the iSEE marks a step towards easy access to a field that’s becoming increasingly important in today’s society. With the new documentation, new software and hardware, the lab will be ready once more to provide cost effective solutions to Human Factors analysis center wide.

iSEE the future, and the future is great.

Acknowledgments

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