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4302 University Drive, Room 316

Houston, TX 77204 -2015

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a. REPORT	b. ABSTRACT	c. THIS PAGE			Guoning Chen
UU	UU	UU	UU		19b. TELEPHONE NUMBER 713-743-3350

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INVESTIGATOR(S):

Name: Guoning Chen
Email: chengu@cs.uh.edu
Phone Number: 7137433350
Principal: Y

Name: Zhigang Deng
Email: zdeng@cs.uh.edu
Phone Number: 7137431018
Principal: N

Organization: **University of Houston**
Address: 4302 University Drive, Room 316, Houston, TX 772042015
Country: USA
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Final Report for Period Beginning 18-Apr-2016 and Ending 17-Apr-2018
Title: Scalable Interactive Visual Computing Infrastructure for Modeling, Training and Planning
Begin Performance Period: 18-Apr-2016 **End Performance Period:** 17-Apr-2018
Report Term: 0-Other

Submitted By: Guoning Chen Email: chengu@cs.uh.edu
Phone: (713) 743-3350

STEM Degrees: 0 **STEM Participants:** 0

Major Goals: This project aims to acquire the hardware equipment necessary to construct the visual computing system to support the key research relevant to a number of DoD challenges, including (1) scalable 3D modeling and user-steerable simulations; (2) large scale and heterogeneous data analysis and visualization; (3) virtual human modeling and animation.

The visual computing system will consist of three main components in order to provide support to the aforementioned key research areas: (1) the high performance computing (HPC) component offers the computation power and storage space needed for the development of the scalable modeling techniques; (2) the high de♀finite display with larger display area and wider viewing range supports the multi-modal and multi-view visualization that is needed for fusing and making sense of multifaceted data; (3) the virtual reality and user interaction component facilitates the investigation of novel human computer interaction paradigm for high dimensional modeling tasks and the study and data collection of human factor related problems.

Accomplishments: The following hardware equipment were acquired for the set up of the proposed visual computing system during the period of the project (details are provided in the uploaded document).

1. A video wall system installed by Mechdyne including a 3x3 tiled display (with 9 1080P 46" panel displays), a rendering PC, an audio system, and a control system with touch panel with the corresponding software.

2. One computing cluster with 1 head node and 8 sub nodes mounted in a rack, installed by Mechdyne. The computing cluster is equipped with 64GB RAM per node (i.e., 576GB in total) and offers 48TB storage space.

3. A walk-through virtual reality (VR) system acquired from WorldViz, with the VR headset, head and body sensing system, a PC and the corresponding software.

4. An eye-tracking system acquired from Egoneer.

In summary, this project successfully set up a visual computing environment with the three components as listed in

the major goals. The system is currently located at Philip Guthrie Hoffman Hall (PGH), Room 220, at the University of Houston.

Training Opportunities: Nothing to Report

Results Dissemination: Nothing to Report

Honors and Awards: Nothing to Report

Protocol Activity Status:

Technology Transfer: Nothing to Report

PARTICIPANTS:

Participant Type: PD/PI
Participant: Guoning Chen
Person Months Worked: 4.00 **Funding Support:**
Project Contribution:
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Participant Type: Co PD/PI
Participant: Zhigang Deng
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Other Collaborators:

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PI: Guoning Chen; Co-PI: Zhigang Deng

The main goal of this project is to acquire equipment to set up an integrated visual computing environment to enable a number key research that is relevant to a variety of DoD challenges, including (1) the modeling and computation of higher fidelity simulations; (2) faithful analysis of incomplete and heterogeneous data; (3) effective quantification and modeling of human factors. This integrated visual computing environment consists of three key components: (1) a compute cluster for data-centric computing, (2) a large-scale display for data analytic and modeling, and (3) a walk-through VR system for the study of human factors. In the following, we provide some detailed report on the acquired hardware equipment for these three parts, including their specifications, brands, and costs.

1. An Integrated Videowall System and a Computing Cluster

We combined the acquisition of two components as listed in the proposal because of two reasons. First, we wished to have an integrated system comprised of both rendering and computing components so that the results of data analysis and simulations, performed on the computing cluster, can be visualized on the large-scale display with minimum data movement. Second, we wished to cut the installation fee and the possible heavy communication between two vendors should the two components had been acquired from two different vendors.

According to the above logic, we packaged the above two components as a single unit for a bidding, which took place from March 2017 to April 2017. 6 bidders participated the bidding. Among these bidders, three provided the detailed specifications of their proposed systems. We considered both the specifications of their proposed systems against the minimum requirements listed in the bid and their proposed costs against the available budget, and selected Mechdyne to implement our system.

The following lists the detailed specifications and costs of the two components of the system.

Video Wall Display:

• Nine (9) Professional LCD Displays - 46" 1920x1080 minimum resolution - Planar Matrix LX46HDU model prefered
• 3 tall x 3 wide Arrangement
• Wall Mounting System (Wall Must be Structurally Capable of Supporting the Display System)
• Approximately 3.7 mm bezels Image to Image Between Panels
• 500 nits brightness per panel
• Off-board Power and video electronics

Laptop Wireless Connection System:

• One (1) Barco CSC-1 wireless presentation system with Four (4) USB Powered Buttons with Storage Basket

Audio System:

• Professional Audio Receiver and Amplifier - Integra DTR-20.4
- Rack mount kit for Integra DTR-20.4
• Two (2) Full Range Audio Speakers - JBL AV25
- all Cabling and connectors and wall mounts for connecting and mounting speakers

Control Station:

• One (1) 24" LED Monitor wth minimum 1920x1080 resolution
- One set of Extron DTP 4K 330 HDMI extender TX/RX pair for placing monitor and keyboard in the back of the room to run the system.

- *Logitech Wireless Keyboard and Mouse*
- *Extron USB extender plus extension system*
- *Logitech F710 wireless Gamepad for controlling OFE software*

Control System:

- *Crestron CP3N controller*
- *Crestron 7" Wired Touch Panel with Table Docking Station*
  -16 port gigabit network switch

Rendering Workstation:

- *Quantum TXR430-0512R - Tower / 4U ConvertableChassis, Supports 2x E5-2600 v3/v4 Processors, DDR4 Memory, Supports Up To 3x 5.25IN Bays, 8x 3.5IN Hot-Swap HDD Bays, Up To 4x Double-Width GPU, Up To 1TB DDR4 Memory, 2000W Redundant Power Supplies*
- *2 Intel® Xeon® processor E5-2637 v4, 4C, 3.5 GHz 15M, 135W*
- *8 16GB DDR4-2133MHz ECC Registered 1.2V Memory Module*
- *2 512GB 2.5 SATA III Internal Solid State Drive (SSD) *1x for Windows, 1x for Linux)*
- *2 2.5" to 3.5" SATA 6Gb SSD Hard Drive Converter / Adapter / Bracket*
- *3.5" 6TB SATA 6Gb/s 7.2K RPM 128M 4Kn*
- *Intel X540T2 Ethernet Converged Network Adapter 100Mbps/1Gbps/10Gbps PCI Express*
- *Microsoft Windows 7 Professional 64-Bit*
- *CentOS 7 Installation*
- *4U / Tower Conversion Kit / Rail Kit*
- *4 NVIDIA VCQM4000-PB QUADRO M4000 8GB GDDR5 GPU MEMORY DP 1.2 (4) + ST (1)*
- *K/M-Series Quadro Sync Kit*

Compute Cluster:

Computer Server

- *2 - 2U Quad Node Server, 2x-Intel Xeon E5-2600v3 Haswell processors*
- *16 Intel® Xeon® processor E5-2640 v4, 10C, 2.4 GHz 25M, 90W*
- *64 8GB DDR4-2400MHz ECC Registered Memory Module*
- *8 240GB 2.5 SATA III Internal Solid State Drive (SSD)*
- *8 480GB 2.5 SATA III Internal Solid State Drive (SSD)*
- *16 2.5" to 3.5" SATA 6Gb SSD Hard Drive Converter / Adapter / Bracket*

Head Node

- *Fulcrum IXR230-1000R - 2U Storage System, Supports 2x E5-2600 v3, 2x 10GBASE-T NIC Ports, Up To 1TB ECC DDR4 2133MHz, 12x 3.5" Slots, 920w Redundant Power*
- *2 Intel® Xeon® processor E5-2620 v4, 8C, 2.1 GHz 20M, 85W*
- *8 - 8GB DDR4-2400MHz ECC Registered Memory Module*
- *2 - 240GB 2.5 SATA III Internal Solid State Drive (SSD)*
- *2 - 2.5" to 3.5" SATA 6Gb SSD Hard Drive Converter / Adapter / Bracket*
- *5 - 3.5" 8TB SATA 6Gb/s 7.2K RPM 128M 4Kn *RAID6**
- *LSI 8 Port SATA/SAS Controller, Supports RAIDS0,1,5,10,JBOD 0.6MSATA Forward Breakout Cable*
- *CentOS 7 Based Cluster Provisioning, PXE Boot, Etc*
- *Modules System, Compilers, Libraries, Etc Included*
- *Multiple message passing (MPI) libraries supporting both Ethernet and Infiniband*
- *Job queuing / scheduler system*
- *Benchmarking/Diagnostic tools 9*
- *Bright, Advanced, Educational, 1Yr Maintenance 9*
- *Intel Parallel Studio XE Cluster Edition for Linux OS - Single Academic for 1 year*
- *TGX remote graphics software license*

Switches and Cables

- *1U 24-port 10GBASE-T Including 4 shared SFP fiber port Rackmount Switch (Unmanaged)*
- *1U 48 Port 10/100/1000 Rackmount switch*

Equipment Rack:

- *Middle Atlantic 44RU Equipment Rack with Caster Base*
- *Side Panels and Locking Front Door and Locking back Door and 4QFT fans in rack top, Qfp-2 fan assembly,*
- *2 Advanced power conditioning units with 9 outlets eac*

The total cost of this integrated system is *$199,353.00*, including a one-year part and service package, and shipping and installation costs.

This videowall system has been installed and setup in the room 220 of the Philip Guthrie Hoffman Hall (PGH), and undergone a number of tests and tuning. Currently, the system, including both its 3x3 tiled display and its computing cluster, has been actively applied in various research projects conducted in the Data Visualization and Modeling (DaViM) Lab at the University of Houston.

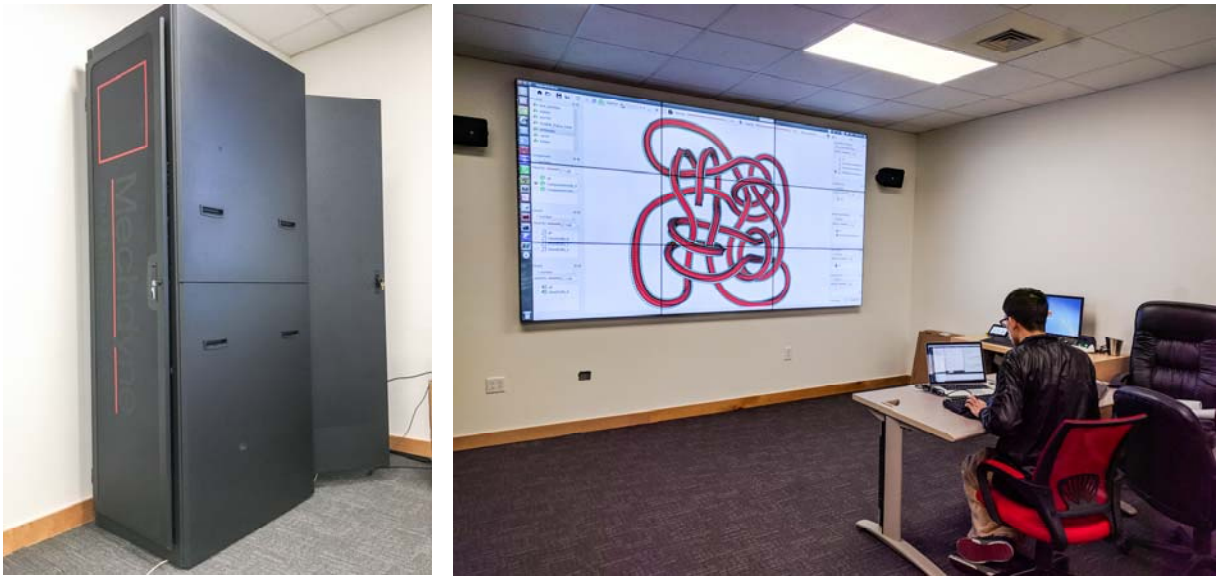


Figure 1. The photos of the computing cluster (left) and the videowall (right) in PGH 220

2. A Walk-through VR System

We were looking for a hardware and software integrated system that can collect and process various human user data during the interaction with VR environment for the study of virtual human modeling. By researching around the market, we concluded that WorldViz provided the solution that best matched our requirement under the given budget constraint. A sole source purchase was made to WorldViz to acquire the system with the specifications detailed below.

VizMove Walking VR:

- *Turnkey System Includes:*
    - *WorldViz Vizard Development software*
    - *WorldViz PPT 4-sensor wide area motion tracking system with PPT Studio software, calibration rig, sensor mounting brackets, network switch and cables*
    - *WorldViz Wireless Navigation and Interaction Wand Controller*
    - *WorldViz Wireless Tracking Devices for head and body-motion (8)*
    - *Oculus Rift VR Headset and extension cable*
    - *High-performance PC featuring Intel i7 technology and state of the art NVIDIA GeForce GPU*
    - *5 Port USB charging station*

- 4 Tripod Set

- 5DT Data Glove Ultra 5 sensor (right hand). A separate MotionBuilder license is required for 5DT+MotionBuilder Compatibility
- InterSense Inertia Cube 4/5DT Glove Integration Right Hand

The total cost of this hardware and software system is *$42,985.00*, including the fees for one-year warranty and shipping.

This walk-through VR system is portable and currently located at PHG 220 for the study of human behaviors under various VR environments.

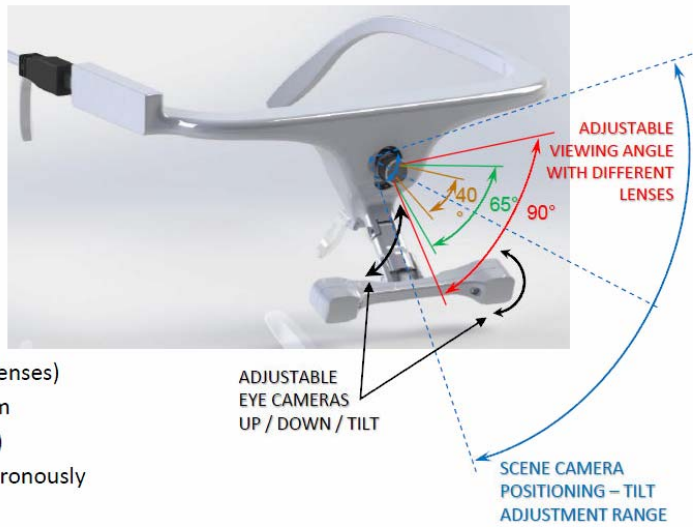
Figure 2. This figure demonstrates the usage of the above walk-through VR system

3. An Eye-tracking System

With the remaining budget after acquiring the three key components above we purchased an eye-tracking system, which is a valuable addition to our visual computing environment. In particular, we will utilize the eye-tracking system to measure and collect the eye motion data as the additional information for the modeling of human behaviors under various (VR or no-VR) tasks.

By researching the market, we concluded that Ergoneers provided the solution that best matches our need under the given budget. Thus, a sole source purchase was made to Ergoneers to acquire the *Dikablis Glasses 3 & D-Lab Eye Tracking Essential* system with the specifications detailed below.

- Automatic analysis of glances towards Areas of Interest
- Compliant with eye tracking standards EN ISO 15007-1 and ISO/TS 15007-2
- Form factor:
  - Designed to work over eye glasses
  - No sight obstruction in the peripheral view
- Eye cameras adjustable
- Scene camera vertically adjustable
  - Important for interior research due to different seating positions
  - Mobile device research since devices are held downwards close to the body
- Scene camera viewing angle adjustable (different lenses)
- Integrated head tracking with 6 degrees of freedom
- Interfaces with the ICA (Index of Cognitive Activity)
- Allows to record and analyze additional data synchronously (via other D-Lab modules)



The total cost of this eye-tracking system is *$7,494.30*, including shipment fee. This eye-tracking system is portable and currently located at PGH 220.