ALBERTA INFORMATICS CIRCLE OF RESEARCH EXCELLENCE

2005 Research Report

PIERRE BOULANGER

APRIL 2004 - MARCH 2005

This document is an excerpt from the 2005 iCORE Annual Research Report. For information or copies, please contact iCORE.

iCORE
3608 33 Street NW
Calgary, Alberta, Cananda T2L 2A6
Tel: (403) 210-5335
Fax: (403) 210-5337
Email: info@icore.ca
www.icore.ca

COLLABORATIVE VIRTUAL ENVIRONMENTS

Collaborative Virtual Environments (CVE) are truly the next generation of human- computer interface. In CVE systems, large and small computer resources are connected via the Grid allowing virtual groups of scientists to interact and collaborate in real time with simulations, instruments, and large datasets as if they were in the same meeting room.

PIERRE BOULANGER

iCORE Industrial Research Chair
Computing Science, University of Alberta
http://www.cs.ualberta.ca/~pierreb/

The iCORE chair on Collaborative Virtual Environments was awarded on January 1rst, 2005. It was officially launched on March 15th 2005. The launch received significant interest from local and national media; the announcement made the front page of the Edmonton Journal.

EXECUTIVE SUMMARY

During the first five months, our team was busy establishing the Chair. Besides solving the numerous administrative problems that come with setting-up research accounts, most of the time was spent on making sure the hardware and software infrastructures were ready for the bulk research work that started in April. On the communication infrastructure side, an Access Grid (AG) room, similar to a design office, was built at TRLabs and is now operational. We also upgraded the VizRoom at the Department of Computing Science to be AG compatible. This is in addition to the AG room at the University of Alberta Computer Network Services (CNS); making three AG rooms available for testing various configurations of collaborative environments. This will allow us to rapidly experiment with various collaborative configurations and will also become a showcase of collaborative technologies.

We also reconfigured the network in the laboratory to be fully accessible with the WESTGRID 1Gb/s backbone, the CANARIE CA*net4 User Controlled Light Paths (UCLP) as well as the TRNet 10Gb/s experimental network. We also acquired multiple cameras, haptic interfaces, and display devices to be integrated in the lab environment. In particular, we were able to build a low cost stereo display using a similar design to the one built at The Banff Center ART lab last year.

On the software side, multiple copies of CATIA, an advanced CAD software used by industry, was acquired and configured to be integrated with the AG environment at the various nodes.

On the scientific side, at Super Computing 2005 in Pittsburg, we demonstrated an example of collaborative computational steering of an earth magneto simulation. This demonstration included the UofA simulation server/client technology, the AG, and SGI Vizserver software. The simulation ran on multiple WESTGRID computers and successfully demonstrated the power of collaborative visual steering for simulation to the grid computing community. In many ways, this was a first for the grid community and the presentation created a lot of interest in the US and in Europe. As a consequence of this demonstration, we were asked to make a similar demonstration in September of this technology at the prestigious iGrid 2005 conference in San Diego. Apart from technical demonstrations, we also started to work on computational steering of Computational Fluid Dynamic (CFD) using the recent release of OpenFOAM. This open source code is truly a parallel CFD code that will allow us to rapidly demonstrate the power of visual steering for a wind tunnel application. Results so far show that this code scales very well with the number of CPUs and is capable of producing results in the time and with the precision necessary for the real-time constraints of a virtual wind tunnel. One of our goals for next year is to integrate this CFD real-time simulation server/client technology as part of a collaborative design review environment using CATIA V5 and AG.

These technology demonstrations have received significant interest from various industrial partners such as HP Research in Palo Alto, IBM Canada, and SGI Canada. So far SGI Canada and HP Research have made commitments to invest in the chair. In addition to these large corporations contributions, two small Canadian CAD companies (InnovMetric and Creaform

3D) are investing over $60K in the Chair to create a demonstration of collaborative CAD review for some of their high-end customers such as Airbus and Boeing. As the Chair progresses, we are expecting further involvement of large and small corporations.

In addition to industrial funding, the Chair was also awarded $139K by NSERC for an equipment grant to acquire various video and networking equipment. The Chair, in partnership with the University of Ottawa and the University of Calgary, was also awarded two $1.5M CANARIE Advanced Research Project (ARP) grants. The grants will be used for the applications of CA*net4 user controlled light paths (UCLP) for remote medical training of ophthalmology residents between Ottawa and Edmonton, as well as the use of Visual Area Networking for collaborative simulation steering between Montreal, Toronto, Edmonton, Calgary, and Vancouver. These projects are an excellent complement to the activities of the Chair, allowing further leverage of the money invested by iCORE.

RESEARCH PROGRAM OVERVIEW

The advent of high-capacity storage devices, powerful computer workstations, and high-speed networks is enabling (both technically and economically) a variety of multimedia communications services. Applications in training, medicine, education, concurrent-engineering design, remote monitoring, travel, real estate, entertainment, banking, insurance, administration, and publishing/advertising have quickly emerged. These applications are characterized by large multimedia documents that have to be communicated with very short delays. Computer-controlled co-operative projects, whereby a group of users can jointly create, edit, view, and produce collaborative work with multimedia documents, characterize many current and future research activities.

Professor Pierre Boulanger at the 2005 Intelligent Software Systems Chair iCORE Launch

In many new multimedia technology systems, Virtual Reality is now being used to display a multitude of information in a form that can be easily interpreted, shared, and manipulated.

One of the hottest topics in Virtual Reality research is in the field of Collaborative Virtual Environments (CVE). The idea behind CVE is very simple; a simulated world runs on several computer systems, each running a compatible CVE application. The computers are connected over a network and people using those computers are able to interact and collaborate in real-time, sharing the same virtual world. Some tele-immersive CVE systems recognize the presence and movements of individuals and objects, process those images, and then project them in realistic, multiple, geographically-distributed virtual environments where individuals can interact with each other and with computer-generated models.

CVE systems raise a number of resource allocation problems, including high-speed networks, clusters of large computers, data storage distributed over a grid, and advanced visualization tools such as the University of Alberta VizRoom. The advent of grid computing/visualization facilities such as WestGrid provides fresh challenges and opportunities for collaborative visualization, including the close coupling of simulation, visualization, and Internet communication tools in a steering environment capable of creating the equivalent of a real-time physics experiment.

In some systems, CVE aims to enhance a video conferencing environment with access to visualization facilities. At the most basic level, pre-generated visualization may be shared through a shared whiteboard tool. In these systems, interactive change and exploration of the influence of simulation parameters is time-consuming and not very intuitive. Richer approaches enable users to share control of the visualization/simulation process allowing for true exploration of the simulation space. The main goal of this Chair is to conduct research and development on the various issues relating to implementation of CVE systems. The key scientific and technical challenges that have to be solved will require an expansion of the boundaries of computer vision, low latency networking, real-time tracking, stereo display, haptics, and real-time rendering technologies.

RESEARCH PROJECTS

On the research side the following projects will be the main focus of our activities for this year:

CVE for the Collaborative Visual Steering of Large Simulations using the WestGrid Infrastructure

The goal of this project is to explore how advanced technologies will allow scientists to collaborate with each other easily, efficiently, and effectively in the context of a computational physics simulation. More specifically, we will explore how to maximize the Quality of Experience (QoE) for the end user over a wide range of technology platforms. Critical to this work is the fact that QoE is a human-centered measure and not a technology-centered measure. Thus, we want to maximize the human perception based on a rich and diverse set of factors. These factors include, but are not limited to: networking (broadband, wired, and wireless), interaction (3D tracking, touch sensitive devices, voice recognition, mouse, keyboard), and display (immersive displays, wall, table top, desktop, laptop, tablet, PDA). Fundamental to this project is the creation of an architecture to support advanced collaborative environments. This architecture is an open one, allowing for the extensible creation of collaboration services and the ability to deploy those services on a wide range of heterogeneous technology platforms.

Hapto-Audio-Visual Environments for Collaborative Tele-Surgery Training over Photonic Networking (HAVE Project)

The goal of this project is to develop shared Hapto-Audio-Visual Environments (HAVE) with advanced multi-point 3D video conferencing, new display and interface technologies, and solution servers technologies that will be used for collaborative medical research and training. The expected result is the demonstration and evaluation of a realistic HAVE immersive collaborative virtual environment application for the training of ophthalmic residents in cataract surgery, linking the Virtual Reality CAVE systems at the University of Ottawa and University of Alberta through regional high-speed networks and CA*net4. This innovative project will create collaborative training environments in which residents can perform virtual cataract operations on real and virtual eyes using real/virtual surgical instruments, while receiving immediate sensory feedback from a haptic system that simulates real tissue resistance and facilitates the learning of proper hand-to-eye coordination. HAVE tele-surgery applications will enable junior residents to be trained by remote experts and deliver improved patient care and reductions in training costs and risks. The benefits to the community are to raise the profile of the bandwidth and networking capabilities of CA*net4 and the use of end-to-end User Controlled Light Paths necessary to meet the quality-of-service requirement of this demanding application.

Professor Pierre Boulanger and part of his research team at the 2005 Banff Informatics Summit

At this point, we are in the design phase of the project. We have had numerous meetings with our partners at the University of Ottawa, with doctors at the Ottawa Eye Institute, and with Dr Matt Tennant at the Department of Ophthalmology at the University of Alberta. Our aim is to capture current surgical practices and how cataract surgery is taught at various medical schools. Following best practice captures, a more precise technical specification of the project will be performed and various equipment and software will be acquired. This year, we were very fortunate to get a NSERC Equipment grant ($139K) to cover most of these hardware expenses.

Multi-Modal Interface for CVE Systems

In this project, we will investigate enriched interactive environments where multiple types of devices and technologies can be combined in novel ways for single and collaborative work and to explore simulation data in new ways. Several technologies are being combined and evaluated, from the leading edge to consumer products including PC-based passive stereo wall and table-mounted large touch-screen displays, high-resolution desktop systems, laptops, haptics interface, handheld trackers for sonification, pen-based computing tablets and even paper. The research goals for this project centre around the study of how heterogeneous devices may be combined into device suites for particular complex information tasks, and what tasks these suites and enriched environments may aid or impede. For the first phase of this project, we are planning to use 3D haptic devices to sonify and feel flow field resulting from simulations from the virtual wind tunnel simulations.

This year, a basic prototype of the haptic/sonification system for the real-time wind tunnel is under development. In this prototype, an interface between OpenFOAM and the UofA visualization client was created to display (in real-time) flow field transmitted by the simulation server. In addition, an interface between MAX/MP, sound synthesis software, and the visualization client is under development using a local area network based on Virtual Reality Peripheral Network (VRPN).

OBJECTIVES FOR NEXT YEAR

CVE for the Collaborative Visual Steering of Large Simulations using the WestGrid Infrastructure

This year we demonstrated that the current simulation server/client technology for the CFD simulation as well as for the earth magneto simulation is working well but suffers from numerous design problems. It is planned next year to redesign the simulation server using MPI instead of threads, and to optimize openFOAM to work in real-time. We are also planning to develop specialized functions in the client to deal with CFD results. We also aim to add more steering functionality such as the ability to change advanced boundary conditions (in real-time) and then integrate the CFD real-time simulation server/client technology as part of a collaborative design review using CATIA V5 and the Access Grid. We are also planning to demonstrate this technology at iGRID2006 and HPC 2006.

Hapto-Audio-Visual Environments for Collaborative Tele-Surgery Training over Photonic Networking (HAVE Project)

This year we captured the preliminary design specifications for the requirements of a cataract surgery trainer. We also produced a preliminary HAVE application design including a refined HAVE architecture for both graphics and haptics communications with a specific 3D teleconferencing system in mind. Next year, we aim at deploying a network infrastructure using CA*Net4 User Controlled Light Path. We are also planning to build a first prototype of the HAVE eye tele-surgery trainer, and test the system with ophthalmologists located in Ottawa and Edmonton. We are also planning to demonstrate this system to the annual CANARIE meetings and to publish the results in various peered reviewed journals.

Multi-Modal Interface for CVE Systems

Over the next year we aim to integrate haptic interface to a visual system. We will also aim to develop haptic and sound-rendering algorithms specialized for CFD data and then integrate sound and haptic together. We will study usability for various haptic, visual and auditory strategies in the context of CFD data analysis, and will endeavor to publish our results.

RESEARCH TEAM MEMBERS AND CONTRIBUTIONS

TEAM LEADER	ROLE/TOPIC	AWARDS/SPECIAL INFO
Pierre Boulanger	System Architect	Financed by iCORE, NSERC, Canarie, ASRA

Project #1

FACULTY TEAM MEMBERS	ROLE/TOPIC	AWARDS/SPECIAL INFO
Manuel Garcia	CFD specialist/ Visiting Professor	ASRA
PHD CANDIDATES		
Irene Cheng	Geometric Compression	Paid by NSERC Operating
MSC CANDIDATES		
Maryia Kasakevich	Multi-Modal Interface	
OTHER TEAM MEMBERS		
Curtis Badke	Programmer	Programmers paid 50-50 by iCORE and CANARIE ARP program
Jeff Ryan	Programmer	
Brian Corrie	Interface with Westgrid	
Pablo Figueroa	Retargeting of VR Systems	
Dan St Germain	SGI Canada Associate	
Tom Malzbender	Tele-Immersion	
Maria Lantin	VR System Design	
Charles Mony	CAD Modeling	
Marc Soucy	CAD Modeling	

Project #2

FACULTY TEAM MEMBERS	ROLE/TOPIC	AWARDS/SPECIAL INFO
Janelle Harms	Networking	
Richard Levy	CANARIE Project Manager	
PHD CANDIDATES		
Baochun Bai	Multi-Video Server	NSERC, ASRA
MSC CANDIDATES		
Chris Ozeroff	System Integration	
Hector Padilla	Vision Algorithms	RA paid by CANARIE and iCORE
OTHER TEAM MEMBERS		FINANCED BY CANARIE
Trevor Hall	Canarie Project Manager	
Nicholas Geoganas	System Architect	
Matt Tennant	Ophthalmology consulting	
Tom Malzbender	HP Research Associate	
Brian Moore	BigBangWidth/Associate	

Project #3

FACULTY TEAM MEMBERS		
Walter Bischof	Usability Studies	
MSC CANDIDATES		
Maryia Kasakevich	Sonification + Haptic Implementation	iCORE Chair Funded
OTHER TEAM MEMBERS		
M. Lantin	VR Systems	
P. Bourdot	Multi-Model Systems	
P. Figueroa	Re-targeting of VR systems	

COLLABORATIONS

PARTICIPANTS	NATURE OF COLLABORATION
PROVINCIAL	
Maria Lantin/ Banff Centre	VR Display Specialist
Walter Bischof/Department of Computing Science	Usability Studies Consulting
Matt Tennant/ Faculty of Medicine	Ophthalmology Consulting
Carlos Lange/ Department of Mechanical Engineering	CFD Specialist
Janelle Harms	Network Specialist
Richard Levy/ University of Calgary	User Interface Specialist
NATIONAL	
Trevor Hall/ University of Ottawa	HAVE Project Manager
Nicholas Geoganas/ University of Ottawa	HAVE Project Main Achitect
Brian Corrie/ SFU+WESTGRID	Visualization Specialist
INTERNATIONAL	
Patrick Bourdot / CNRS France	Multimodal Interface Specialist
Pablo Figeuroa/ University of Los Andes, Colombia	Retargeting and Multimodal Interface Specialist
Manuel Garcia/ University of EAFIT, Colombia	CFD Specialist
INDUSTRIAL	
Dan StGermain/ SGI Canada	SGI Consulting
Tom Malzbender/HP Associates	Immersive Video Conferencing Specialist
Charles Mony/ Creaform3D	CAD Consulting
Marc Soucy/ Innovmetric	CAD Consulting

FUNDING

Pierre Boulanger is a new iCORE Industry Chair. iCORE contributes $50K per year and Professor Boulanger recieved a matching $50K contribution from TRLabs. In the next fiscal year the chair will also receive an extra $100K per year from SGI Canada and a one year investment of $50K from InnovMetric.

PUBLICATIONS

PEER REVIEWED JOURNAL

P. Figueroa, W.F.Bischof, P. Boulanger, J.Hoover, "Efficient Comparison of Platform Alternatives in Interactive Virtual Reality Applications", *Int. J. Human-Computer Studies 62*, 2005, pp. 73–103.

I. Cheng and P. Boulanger, "Feature Extraction on 3D TexMesh Using Scale-space Analysis and Perceptual Evaluation," *IEEE Transactions on Circuits and Systems for Video Technology, Special Issue October 2005*, vol. 15, no. 10, pp. 1234-1244.

I. Cheng and P. Boulanger, "Adaptive Online Transmission of 3D TexMesh Using Scale-space and Visual Perception analysis," *IEEE Transactions on Multimedia, 2005* (in press) Accepted May 11, 29 Pages.

PEER REVIEWED CONFERENCES

I. Cheng and P. Boulanger, "A 3D Perceptual Metric using Just-Noticeable-Difference," *EUROGRAPHICS 2005 Dublin*, Short Paper, pp. 97-100. Acceptance rate 30 percent.

I. Cheng and P. Boulanger, "A Visual Quality Prediction Model for 3D Texture," EUROGRAPHICS 2005 Dublin, Short Paper, pp. 101-104.

I. Cheng and P. Boulanger, "Automatic Selection of Level-of-Detail based on Just-Noticeable-Difference," *SIGGRAPH 2005 Poster Session*, Los Angeles, California, USA, July 31, 2005, Poster 0104.

I. Cheng and P. Boulanger, "Adaptive Online Transmission of 3D TexMesh Using Scale-Space Analysis", *The second International Symposium on 3D Data Processing, Visualization, and Transmission* (3DPVT), Held in the city of Thessaloniki, Greece, September 6 to 9, 2004, pp. 688-695.

G. Osorio, P. Boulanger, and F. Prieto, "An Experimental Comparison of a Hierarchical Range Image Segmentation Algorithm", *18th Canadian Conference on Artificial Intelligence Graphics Interface 2005 2nd Canadian Conference on Computer and Robot Vision* in Victoria BC, May 8-11, 2005, pp. 571-578.

P. Boulanger, "From High Precision Color 3D Scanning of Cultural Artifacts to its Secure Delivery Over the WEB: A Continuum of Technologies", *Workshop on "Recording, Modeling and Visualization of Cultural Heritage* in Ascona Switzerland May 22-26, 2005. On invitation only, electronic publication will be published in a book in 2005-2006.

M. Garcia, O. Ruiz, M. Gomez, and P. Boulanger. ''Spring Particle Model for Hyper-elastic Cloth''. *Canadian Congress on Applied Mechanics*, McGill University, Montreal, 29 May to 2 June 2005, pp. 141-142.

R. Taylor, D. Torres, and P. Boulanger, "Using Music to Interact With a Virtual Character", *5th International Conference on New Interface for Musical Expression*, Vancouver, Canada, May 26-28, 2005, pp. 220-223.

R. Taylor, P. Boulanger, and D. Torres, "Visualizing Emotion in Musical Performance Using a Virtual Character", *5th International Symposium on Smart Graphics*, Munich, Germany, August 22-25 2005, pp. 13-24.

P. Boulanger, G. Osorio, F. Prieto, "Hierarchical Segmentation of Range Images With Contour Constraints", The 5th International Conference on 3-D Digital Imaging and Modeling, Ottawa, Ontario Canada, June 13-16, 2005, pp. 278 - 284.

B. Bai, P. Boulanger and J. Harms, "An Efficient Multiview Video Compression Scheme", ICME 2005, *IEEE International Conference on Multimedia & Expo*, Amsterdam, The Netherlands, July 6-8, 2005. pp. 562-566.

PRESENTATION BASED ON ABSTRACT

Pierre Boulanger. *Manufacturing and Collaborative Environments, Symposium on Virtual Reality and Visualization In Human Performance and Wellness*, March 22, 2005, University of Calgary, Calgary Alberta.

Pierre Boulanger, *From Computational Biomolecular Design to the Virtual Exploration of the Genome: A State- of-the-Art of the link between Visualization and Simulation for Bioinformatics*. WestGrid Summit, Monday April 18 – Wednesday, April 20, 2005, Banff, Alberta.

Pierre Boulanger. *Collaborative Virtual Manufacturing from the Ground Up*, BCNet 2005 Conference, April 25-27 2005, Vancouver, BC.

Pierre Boulanger. The HAVE Project: *Remote Surgical Training Over Advanced High-Speed Networks*, BCNet 2005 Conference, April 25-27 2005, Vancouver, BC.

Pierre Boulanger (Invited Speaker). *Virtual Reality: A New Tool for Rehabilitation, First Conference on Virtual Rehabilitation: Visioning the Art of the Possible*, May 27th 2005, At the University of Alberta, Edmonton Alberta.