Pro-MOTE: 3D whiteboard for scientific collaboration

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Abstract

In the era of internet, virtual collaboration for presentation, lectures or discussion, through Microsoft Meeting, VNC, or virtual whiteboard are common forms of communication in research and industry. Most of these present technologies focus on 2D virtual environment depicting a chalk-and-board classroom. However with the advent of 3-D visualization techniques, and gesture recognition methods, it's possible to create a 3D virtual environment, which can be used for more intuitive communication. This work proposes to create a 3D whiteboard, where several collaborators can draw and edit 3-D objects using hand-gestures. In this paper, we discuss the system architecture for the development of this 3D whiteboard (Pro-MOTE), integrating Wiimote for motion capture, GlovePIE as a platform for algorithmic computation and interface builder, and Blender to render/recreate the 3D objects intended to be drawn. These virtually created 3D objects can then be viewed by special eyewear and used by any scientific community for discussion, debates, education and collaboration.

1 Introduction

Rapid growth in scientific innovations in last few decades, as compared to the previous ones, has been largely attributed to the better and faster means of communication (Edadi and Utterback, 1984).

Further, in the era of internet, innovators can share knowledge, resources and tools with their peers, faster and more effectively, regardless of physical distances. Means of interaction have been transformed from text, voice and video based communication to virtual platforms, which allow multiple users to manipulate and control a single platform. Most of the present virtual platforms focus on 2-D environments with conventional inputs from devices such as mouse and keyboard (Shrum *et al*, 2007).

Developments in the field of virtual reality (such as, Kavakli, 2008; Gao and Kavakli, 2006), specifically, hand gesture recognition, and 3D rendering and viewing, make it possible to communicate remotely with gestures in a 3D virtual world, making the interaction more intuitive.

In this paper, our aim is to develop a 3D Virtual Whiteboard (Pro-MOTE) as a platform for scientists to interact with each other using a virtual pointer, so that the diagram created in real time can be displayed on a head mounted display worn by each user. Pro-MOTE is intended to improve the quality of collaboration between remotely located professional and research groups.

Rest of the paper is organized as follows. Section 2 outlines the related work in the field of scientific collaboration and hand gesture recognition, and makes a case for the usability of Pro-MOTE system. Section 3 details the approach we use and outlines the system architecture of Pro-MOTE. Section 4 summarizes the implementation, followed by our plans for testing in section 5. We draw conclusions for the development of

3D whiteboards from the implementation of Pro-MOTE in section 6.

2 Related Work

2.1 Systems for scientific collaboration

`"Collaboration among organizations is rapidly becoming common in scientific research as globalization and new communication technologies make it possible for researchers from different locations and institutions to work together on common projects." (Shrum et al, 2007).`

Advances in scientific collaboration have been well documented and researched in the past years (Edadi and Utterback, 1984; Hara *et al*, 2003). Concepts such as "Collaboratories", aptly defined as "centers without walls" (Johnston, 2000), have been proposed on various forums for organized approach towards joint scientific efforts. Social engineering and improved means for distant communication, to exchange ideas and share resources and tools, remain the central theme behind such efforts.

Communication technologies relevant to scientists and collaborators can be broadly categorized as text based, voice based, voice and video based, and shared platform based. While the conventional text/voice/video based technologies form the base of communication, there has been significant development in recent years to create common platforms which can be viewed or edited by several collaborators, either asynchronously or in 'real-time'.

Examples of such asynchronous shared platforms include "Google Docs", an online document sharing engine; Wiki, where multiple users can contribute development of single or multiple web-pages, resulting in truly worthwhile projects such as Wikipedia.

Real-time communication platforms include Group Chat clients, where single window is duplicated by each client, and can be controlled by multiple users; a VNC client-server system, where multiple users can connect and manipulate single X-windows server instance in real time; or more recent electronic whiteboards, connected to internet, such as Dabbleboard (Dabbleboard Corporaton, 2009), which can be drawn upon by multiple users in real time.

With the evolution of 3D technologies, cultivating in animation movies of present generation, latest being "Monsters Vs Aliens", the viewing experience is decidedly moving into 3D. Edusim (Edusim Corporaton, 2007) illustrates the idea of "3D multi-user virtual world platform", which can be used as a classroom interactive whiteboard.

Extending the ideas of shared platforms, and 3D virtual systems, purpose of this exercise is to demonstrate the prototype for a 3D whiteboard, pro-MOTE, which can be remotely operated by multiple users to share ideas, diagrams, pictures, flow-charts, or actions resulting in real world visual interactive experience.

2.2 Systems for Hand Gesture Recognition

Gesture Recognition is a topic in computer science and language technology with the goal of interpreting human gestures via mathematical algorithms. Gestures can originate from any bodily motion or state but commonly originate from the face or hand Gesture Recognition enables humans to interface with the machine (HMI) and interact naturally without any mechanical devices. Using the concept of Gesture Recognition, it is possible to point a finger at the computer screen so that the cursor will move accordingly (Kavakli, 2008). Systems used for gesture recognition broadly require three components, sensors for motion capture, algorithms for the interpretation of gestures, and finally the interface which uses these gestures to control other devices to provide a communication channel.

In the development of Pro-MOTE, we focus on hand gesture recognition. Existing sensing techniques for hand gesture recognition can be broadly categorized into three main groups: vision-based, EMG-based, and movement-based techniques.

2.2.1 Vision Based

Vision-based motion capture approach comprises of one or more cameras which collect images of the user's hands. The cameras grab an arbitrary number of images per second and send them to image processing routines to perform posture and gesture recognition as well as 3D triangulation to find the hands' position in space (Mitra and Acharya, 2007). Vision based systems are sensitive to user's circumstances such as background texture, color, and lighting. This limits their applicability.

2.2.2 EMG Based

EMG measures electrical currents that are generated in a muscle during its contraction and represent neuromuscular activities (Mitra and Acharya, 2007). EMG can also be used to sense isometric muscular activity which does not translate into movement. This makes it possible to classify subtle motionless gestures and to control interfaces without being noticed and without disrupting the surrounding environment. On the other hand, one of the main difficulties in analyzing the EMG signal is due to its noisy characteristics.

2.2.3 Movement Based

Movement-based approach utilizes different sensors to measure movement. Most popular approaches are data gloves and accelerometers.

2.2.3.1 Glove Based

Glove-based gesture interaction is a typical movement-based technique and it achieves good performance especially in sign language recognition. In this approach, user is required to wear a data glove to capture hand and finger movement. Instrumented gloves measure finger movement through various kinds of sensor technology. These sensors are embedded in a glove or placed on it (Sturman and Zeltzer, 1994).

Since Gloves allow movement tracking of each finger independently including the bending of fingers, large number of gestures can be represented and captured by the same (e.g., 2^5 for 5DT DataGloves). However primary disadvantage of such systems is the difficulties of defining the thresholds for the person wearing the glove.

2.2.3.2 Accelerometer Based

An accelerometer measures the acceleration and gravity it experiences. Basically an accelerometer behaves as a damped mass on a spring. When it experiences an external force such as gravity, the mass is displaced until the external force is balanced by the spring force (Mitra and Acharya, 2007). The displacement is translated into acceleration.

Modern accelerometer (Analog Devices, 2009) consists of a cantilever beam with seismic mass, damped against residual gas. Under the influence of external accelerations the proof mass deflects from its neutral position. This deflection is measured in an analog or digital manner. Most commonly, the capacitance between a set of fixed beams and a set of beams attached to the proof mass is measured. This method is simple, reliable, and inexpensive. Optical measurement of such systems has been demonstrated on laboratory scale.

Accelerometers can be made easy to wear and can detect hand movements in 3-D with precision. Pro-MOTE architecture is based on this technology.

3 Pro-MOTE system architecture

An interactive whiteboard is primarily a virtual environment to draw 3D objects, which then can be viewed or edited by several users.

Pro-MOTE consists of three components: A 3D motion-capture device, software tool to identify the 3D objects from the raw motion data, and a system or tools to render/recreate the 3D objects.

3.1 Wiimote

One of the most popular and readily available gesture sensing devices today is the remote used by Wii gaming consoles, popularly known as Wiimote. A Wiimote has primarily two communication channels. IR based control, where buttons on the Wiimote transmit IR signals, and a 3D accelerometer which detects movement of Wiimote in 3D, and transmits the relevant data depicting movement via Bluetooth. As discussed in the previous section, advantage of an accelerometer-based motion sensing technology, over vision, or EMG based techniques is ease of operation with reasonable degree of accuracy. Therefore, we propose to use the Wiimote as a gesture sensing tool for Pro-MOTE. Figure 1, demonstrates 3D motion capture device Wiimote.

Figure 1 Wiimote

3.2 Gesture recognition

Once the hand movement is captured, intended gestures must be translated. One of the software platforms that can be used to process Wiimote [or data gloves], is GlovePIE (GlovePIE Software, 2007). Glove Programmable Input Emulator (GlovePIE) was created by Carl Kenner, originally for Glove based input devices Joystick and Keyboard in Microsoft Windows. Now it has been extended to support emulating all kinds of input and also Wii Remote. GlovePIE interface, that is similar to text editor, can be used to write an application which will be able to recognize certain gestures as objects, intended to be drawn. For example, circular movement of hand with Wiimote could be translated into a sphere object. A hand gesture of stroke could be translated as an erase operation.

3.3 Object Recreation

Once the object has been identified it will be displayed on the 3D whiteboard, Pro-MOTE. Currently, several interfaces such as, Blender, Nvidia 3D vision (Nvidia 3D Vision, 2009), and Vizard are used for 3D rendering of objects. For Pro-MOTE, we use Blender for 3D modeling, due to its simplicity, and open-sources, free universal acceptance.

Blender (Hara *et al*, 2003) has two primary modes of work, Object Mode and Edit Mode, which are toggled with the Tab key. Object mode is used to manipulate individual objects as a unit, while Edit mode is used to manipulate the actual object data. For example, Object Mode can be used to move, scale, and rotate entire polygon meshes, and Edit Mode can be used to manipulate the individual vertices of a single mesh. There are also several other modes, such as Vertex Paint, Weight Paint, and Sculpt Mode.

Figure 2, demonstrates Pro-Mote System components and its usage model.

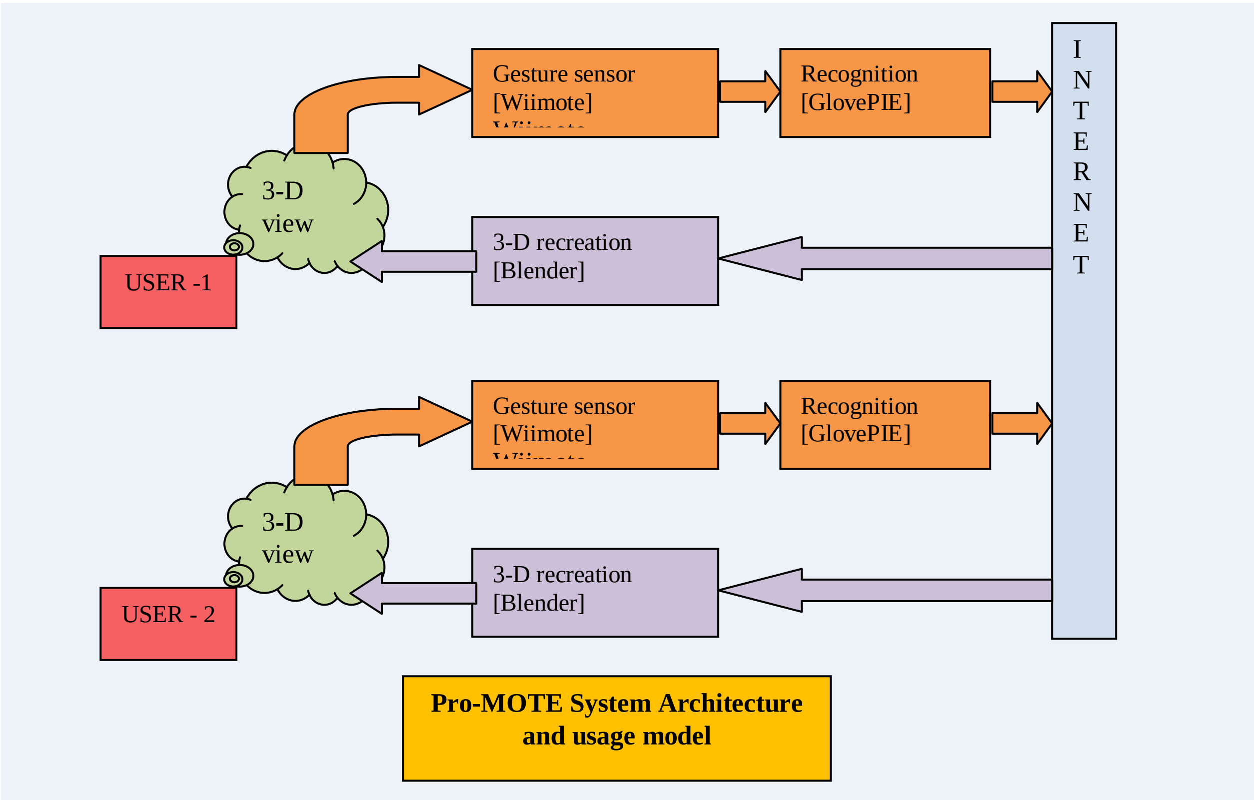

Figure 2 Pro-MOTE System Architecture

Users far away can manipulate or edit in 3-D environment with gestures. Users can draw arbitrary 3-D objects, which can then be viewed by a virtual reality system using special Eyewear which supports 3-D viewing.

4 Implementation

Scope of the Pro-MOTE project is to setup Wiimote communication channel between user and a virtual object rendering software, so that the rendered images then can be displayed and viewed in a virtual 3D environment.

4.1 Wiimote communication setup

First step for Promote implementation is to setup Bluetooth communication channel with a system running windows XP. Once the channel is set, Wiimote accelerometer starts sending data through Bluetooth which can be captured by suitable software running on the test-system.

4.2 Command and Gesture recognition

We used GlovePIE as a platform to capture Wiimote data and to build interface with the object rendering tool Blender. The interface was defined in two parts. Figure 3, demonstrates the script written in GlovePIE for capturing data from Wiimote.

4.2.1 Key Mapping

In this implementation, button-A of Wiimote corresponds to the pop-up menu in Blender, and then the arrow keys can be used to browse various operations from the tool-menu. Further button-S in Wiimote is set a shortcut to “scale”, R for “rotate” and G for “Grab” in Blender.

4.2.2 Gesture recognition

Second part of the Pro-MOTE interface is to use hand gestures to draw arbitrary image in 3D space. When in the free draw mode, pressing “R” button makes the Pro-MOTE go in free-draw mode. Any arbitrary movement is registered in Blender as a 3D movement.

Combination of freehand drawing and Blender menu based operations can then be used to create arbitrary objects in a virtual 3D space.

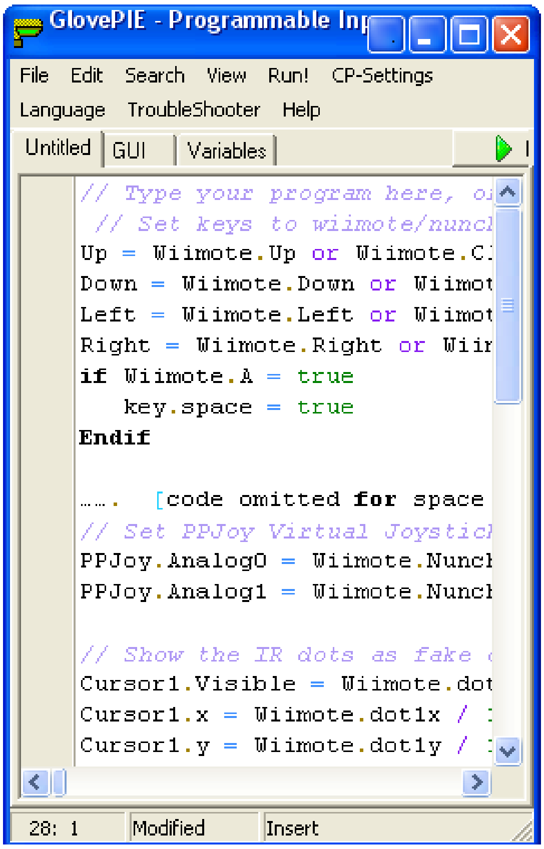

Figure 3 GlovePIE script

5 Experimentation

Basic lab-experimental setup for Pro-MOTE include:

1. Bluetooth interface between Wiimote and GlovePIE is demonstrated by a sample script to control the LEDs of GlovePIE.
2. Using Wiimote Buttons, control of blender functions is demonstrated, which was then used to create arbitrary 3D objects.
3. Using Wiimote gesture data, a virtual whiteboard is calibrated, and a freehand drawing of arbitrary shapes is demonstrated on the virtual whiteboard.

Further, we have already acquired the Ethics approval to conduct experiments. The real world experiments will be conducted using a video conferencing platform (Access GRID) between geographically separated teams of scientists. Participants will be given a questionnaire to assess the quality of the 3D whiteboard system in comparison to the traditional methods.

6 Conclusion and Future work

Pro-MOTE 3D whiteboard system is a multi-user editable platform, which is intended to be used for scientific collaborations. System can interface with Blender to model and render sample 3D objects, based on hand gestures. Primary goal of the system was achieved by demonstrating the proof of concept, which can further be extended.

Using this system as a precursor, we plan to support more shapes and objects to be defined on this platform for more enhanced collaboration between users. We also consider the addition of newly developed technologies such as Nvidia 3-D-vision (Nvidia 3D Vision, 2009) to allow rendered images to be viewed in the 3D whiteboard system.

Acknowledgments

Thanks to Manolya Kavakli for advice and support, and Robert Dale for useful feedback on this work.

References

Edadi, Y. M., & Utterback, J. M. 1984. The Effects of Communication on Technological Innovation. *Management Science,* 30, pp.572-585.

Shrum, W., Genuth, J., & Chompalov, I. 2007. *Structures of scientific collaboration*. MIT Press.

Kavakli, M. 2008. Gesture recognition in virtual reality. *Int. J. Arts and Technology,* 1, pp.215-229.

Mitra S. and Acharya T., 2007. Gesture Recognition: A Survey. *IEEE Transactions on Systems, Man, and Cybernetics*, Vol. 37(3), pp. 311-324.

Hara, H. Solomon, P. Kim, S. and Sonnenwald, D. 2003. An Emerging View of Scientific Collaboration. *Journal American Society for Information and Technology*, 54(10), pp.952-965.

A new world on your SMARTBoard: Edusim 3D in your class., 2007. [Video] US: Open Cobalt Edusim edition.

Dabbleboard Corporation. 2009. Retrieved from Dabbleboard Corporation. Web site: www.dabbleboard.com.

Johnston, W., 2000. *Vision for Collaboratories and the DOE Science Grid*. [Online]. Argonne. Available at: http://acs.lbl.gov/~johnston/Grids/DOE_Science_ Grid+Collab_Grids.4up.pdf

Gao, Y., and Kavakli, M. 2006. VS: Facial Sculpting in the Virtual World. *Computational Intelligence for Modeling, Control and Automation.* Sydney, NSW. 28 Nov 2006.

Sturman, D. J., and Zeltzer, D. 1994. A Survey of Glove-based Input. *IEEE Computer Graphics and Applications*, 14(1), pp 30-39.

Analog Devices. 2009. *Accelerometer Design and Applications*.

Nvidia 3D Vision. 2009. Available at: http://www.nvidia.com/object/GeForce_3D_Vision_main.html [accessed 12 May, 2009]

GlovePIE Software. 2007. *Control Games with Gestures, Speech, and Other Input Devices*. [Online]

Available at: http://carl.kenner.googlepages.com/glovepie [accessed 1 May 2009]