Available Online at www.ijcsmc.com

International Journal of Computer Science and Mobile Computing

A Monthly Journal of Computer Science and Information Technology

ISSN 2320–088X

IJCSMC, Vol. 3, Issue. 4, April 2014, pg.156 – 165

RESEARCH ARTICLE

HAPTIC SCIENCE AND TECHNOLOGY IN SURGICAL SIMULATION, MEDICAL TRAINING AND MILITARY APPLICATION

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ABSTRACT

Engineering as it finds its wide range of application in every field not an exception even the medical and military field. One of the technologies which aid the surgeons to perform even the most complicated surgeries successfully is Virtual Reality. And In this paper I have a look at different military fields and applications. I present example applications, which are being used in those fields. The applications are discussed and conclusions are made. Haptics, despite of being a relatively new topic in military field, has a small but certain ground already and will be more important in the future. Even though virtual reality is employed to carry out operations the surgeon's attention is one of the most important parameter. If he commits any mistakes it may lead to a dangerous end. So, one may think of a technology that reduces the burdens of a surgeon by providing an efficient interaction to the surgeon than VR. Now our dream came to reality by means of a technology called "HAPTIC TECHNOLOGY".

Keywords: Military; communication; haptic cue; tactile signal; tactile display; vibrotactile; tactors; virtual reality; surgery simulate

I. INTRODUCTION

Haptic, is the term derived from the Greek word**, haptesthai**, which means **'to touch'**. Haptic is defined as the **"science of applying tactile sensation to human interaction with computers".** It enables a manual interaction with real, virtual and remote environment. Haptic permits users to sense and manipulate three-dimensional virtual objects with respect to such features as shape, weight, surface textures, and temperature.

In our paper we explain the basic concepts of **'Haptic Technology and its Application in Surgical Simulation, Medical Training'. and Military operations .** Military operations and actions include often many different areas; in one large scale military operation involved could be strategic, logistical, medical, communication, combat and maintenance areas. Traditionally training in military has been training in theory and then practicing the learned theories in real life environments or in environments, which imitate real environments, such as obstacle courses. As technical and electronic products and applications are developing, there is a need also in military field to research and introduce new technologies, which could help in training and operating in different military areas. The using of new technologies can bring along advantages that can lead to improved performance and reduced risks. Haptic is the **"science of applying tactile sensation to human interaction with computers".** In our paper we have discussed the basic concepts behind haptic along with the haptic devices and how these devices are interacted to produce sense of touch and force feedback mechanisms. Also the implementation of this mechanism by means of haptic rendering and contact detection were discussed. The use of haptics has potential to enhance the feeling of immersion in training whether the training is performed in virtual reality simulators or real life training situations.

'**Application of Haptic Technology in Surgical Simulation and Medical Training'.** We explained the storage and retrieval of haptic data working with haptic devices. Also the necessity of haptic data compression is illustrated.

II. HAPTIC DEVICES

The Haptics are classified into two devices as :-

2.1 Virtual reality devices

In virtual devices there are also four sub devices which are as fallows

2.1.1 Exoskeletons and Stationary device

2.1.2 Gloves and wearable devices

2.1.3 Point-source and Specific task devices

2.1.4 Locomotion Interfaces

2.1 Virtual Reality systems present a computer-generated visual and auditory experience that allows a user to be immersed within a computer generated "world" for various purposes. This is used in conjunction with traditional computer input systems. Following figure show the powerful design tool which allowing a user to see objects that he or she is designing.

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Fig1 Virtual environment

The application to training simulation systems is equally useful for the creation of an infinite number of immersive environments. The haptic systems to virtual reality will greatly increase its effectiveness at simulating real-world situations. One example can potentially include a medical training system using a simulator and virtual reality where a haptic system provides doctors with the “feel” of virtual patients. Following Figure shows the schematic of such a medical simulation system, the visual display and the haptic gloves are combined to simulate.

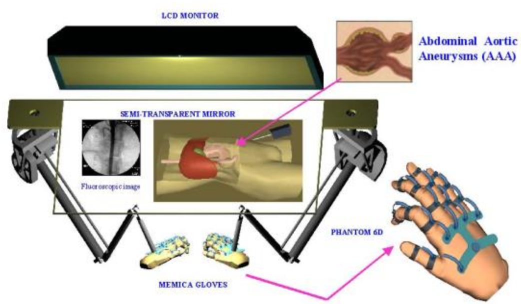

Fig 2 Virtual Reality for Surgical Training

2.2Feedback devices:-

The feedback devices also divided into two sub devices are as

2.2.1 Force feedback devices

2.2.2 Tactile displays

Force feedback is the area of haptics that deals with devices that interact with the muscles and Tendons that give the human a sensation of a force being applied with hardware and software that stimulates humans’ sense of touch and feel through tactile vibrations or force feedback the following figure show the haptic feedback block diagram

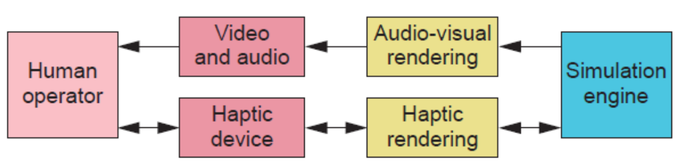

Fig 3 Haptic Feedback Block Diagram

In computer system force feedback input devices are usually, but not exclusively, connected, and designed to apply forces to simulate the sensation of weight or resistance in order to provide information to the user. As such, the feedback hardware represents a more sophisticated form of input/output device, complementing others such as keyboards, mice, or trackers. Input from the user is in the form of hand, or other body segment, position or exerted force, whereas feedback from the computer or other device is in the form of force or position. These devices are translating digital information into physical sensations. The Force feedback joysticks, mice, driving wheels, and other devices, some of which are shown in Figure 2.2(b), have been developed. This method of conveying force information allows programmers and designers an additional way to interact with and send information to a user. These devices mainly consist of robotic manipulators that push back against a user with the forces that correspond to the environment that the virtual effector's is in.

Fig4 Sidewinder Force feedback Joystick, Microsoft Corp

2.2.2 Tactile Displays:

Simulation tasks involving active exploration or delicate manipulation of a virtual environment require the addition of feedback data that presents an object's surface geometry or texture. Such feedback is provided by tactile feedback systems or *tactile displays*. Tactile systems differ from haptic systems in the scale of the forces being generated. While Haptic interfaces will present the shape, weight or compliance of an object, tactile interfaces present the surface properties of an object such as the object's surface texture.

III. COMMONLY USED HAPTIC INTERFACING DEVICES

Two devices are used in haptic interfacing are as:-

3.1 PHANTOM:

It is a haptic interfacing device developed by a company named Sensible technologies. It is primarily used for providing a 3D touch to the virtual objects. This is a very high resolution 6 DOF device in which the user holds the end of a motor controlled jointed arm. It provides a programmable sense of touch that allows the user to feel the texture and shape of the virtual object with a very high degree of realism. One of its key features is that it can model free floating 3 dimensional objects.

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Fig 5 PHANTOM

3.2 CYBER GLOVE:

Cyber glove consists of opposing the movement of the hand in the same way that an object squeezed between the fingers resists the movement of the latter. The glove must therefore be capable, in the absence of a real object, of recreating the forces applied by the object on the human hand. The two conditions can be simplified by requiring the glove to apply a torque equal to the interphalangian joint.

(1) The same intensity and

(2) The same direction.

Following figure shows how cyber glove used

Fig 6 Cyber glove

IV. APPLICTIONS

There are various application used in haptic technology

- Surgical simulation & Medical training.
- Physical rehabilitation.

- Training and education.
- Museum display.
- Painting, sculpting and CAD
- Scientific Visualization.
- Military application.
- Entertainment.

4.1 SURGICAL SIMULATION, MEDICAL TRAINING AND MILITARY APPLICTION

1. Long, thin, straight probes for palpating or puncturing the tissue and for injection (puncture and injection needles and palpation probes)

2. Articulated tools for pulling, clamping, gripping, and cutting soft tissues (such as biopsy and punch forceps, hook scissors, and grasping forceps). Haptic Science operational structure is shown in following fig.

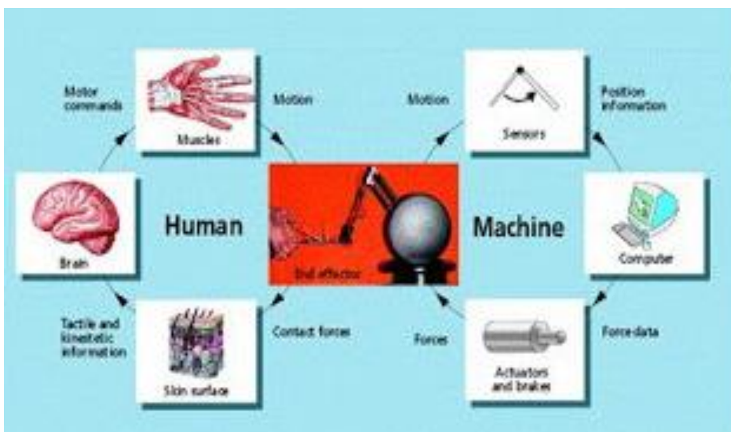

Fig7 Haptic Science operational structure

Grouping of surgical instruments is used for simulating tool tissue interactions. Group A includes long, thin, straight probes. Group B includes tools for pulling, clamping, and cutting soft tissue [7] which is shown in

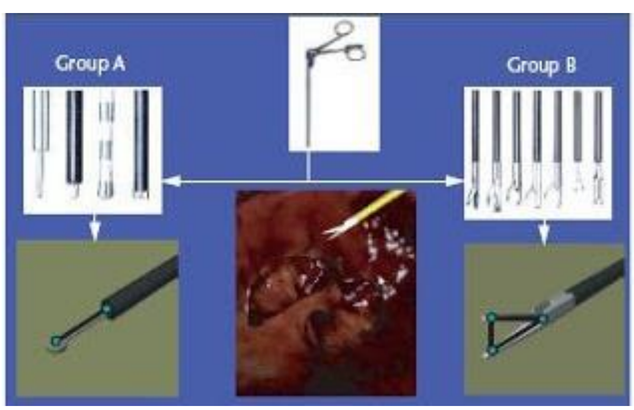

Fig 8 Haptic device Interaction

3. Users feel torques if a proper haptic device is used. For example, the user can feel the coupling moments generated by the contact forces at the instrument tip and forces at the trocar pivot point. Fig2.5.1: Haptic device Interaction

4. Users can detect side collisions between the simulated tool and 3D models of organs.

5. Users can feel multiple layers of tissue if the ray representing the simulated surgical probe is virtually extended to detect collisions with an organ's internal layers.

6. Users can touch and feel multiple objects simultaneously. Because laparoscopic instruments are typically long slender structures and interact with multiple objects (organs, blood vessels, surrounding tissue, and so on) during a MIS (Minimally Invasive Surgery), ray-based rendering provides a more natural way than a purely point-based rendering of tool-tissue interactions. To simulate haptic interactions between surgical materials held by a laparoscopic tool (for example, a catheter, needle, or suture) and a deformable body (such as an organ or vessel).

7. Communication field: Comparison of Army Hand and Arm Signals to a Covert Tactile Communication System in a Dynamic Environment

Pettitt et al. conducted a study [2006], in which soldiers' abilities to interpret and respond to tactile commands was evaluated. The study was conducted with infantry soldiers while they were carrying out a combat patrol simulation on an obstacle course. Tactile signals and visual hand signals were sent to the soldiers, and their response times and accuracy of signal interpretation was documented. According to the authors, with proper implementation the using of tactile displays could reduce interference with the soldiers' visual and auditory channels and improve their overall performance. The objective of the study was to find out, if soldiers are able to interpret and response mto tactile commands as efficiently as they can to hand signals in a dynamic environment. They also wanted to find out, if the use of a tactile system hinders the ability of soldiers to complete an obstacle course. The soldiers were given commands while completing an obstacle course. The commands were tactile signals, hand and arm signals from a leader in front of the soldier and hand and arm signals from a leader behind the soldier. The soldiers were voluntary participants from the Infantry Training Brigade, Fort Benning, Georgia. All tasks in the study were a normal part of a soldier's life. They were wearing their normal combat uniform and a device to simulate an M4 assault rifle. The tactile systems in this study consist of tactile displays and receiver units. The display consists of eight tactile actuators, which are attached to a belt that is worn around the waist of a soldier. The tactors can be activated individually, sequentially or in groups to create sensations to replace standard army hand and arm signals. The four signals that were used are shown in Table 1 and the tactile display is shown in Figure.

Fig 9 Tactile display. [Pettitt et al., 2005]

The obstacle course simulated the following actions: patrolling, crawling, climbing and firing. Once the obstacle course was started, the soldiers would follow their team leader from a distance of around ten meters until the end of the course. A squad leader would follow behind the soldier. Before entering the obstacle course, the soldiers were trained to recognize the tactile signals with 100% accuracy. The soldiers on the course could receive signals at any point from the team or squad leader or from the tactile display. When receiving a tactile signal, the soldiers told the meaning of the signal to a data collector, who was nearby. The study was conducted during daytime at an obstacle course, which made it much easier to notice and interpret given hand signals correctly. In a realistic environment there would have been lots of vegetation and landscape obstacles.

8. Communication, navigation and combat fields: Tactile Displays and Detectability of Vibrotactile Patterns as Combat Assault Maneuvers are Being Performed

Another study about tactile displays is presented by Krausman and White [2006], in which they examine the detectability of vibrotactile patterns as combat assault manoeuvres were performed. They say that one issue, which has not yet been looked at thoroughly, is how different types of tactile displays affect to recognition on tactile messages especially considering the tasks that soldiers perform during combat operations. They wanted to find out those things in their study. The other objectives of Krausman and White's study were to find out how wearing protective body armour affects the recognition of tactile messages and if different tactile patterns have the same recognition rates. The participants of the study were ten officers from Fort Stewart, Georgia. Like in the study from Pettitt et al. there was an obstacle course, which the participants carried out. The manoeuvres were similar; they included running, jumping, balancing, windows climbing and crawling.

Fig 10 Different manoeuvres at the obstacle course. [Krausman and White, 2006]

The system consisted from a tactile display and a receiver unit. There were two different tactile displays; one like in Pettitt et al. used in their study, and a display that consisted of an 4x4 array of tactors. The belt display was worn around the participants' lower abdomen and the array display on the lower back.

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Fig11 Array and belt displays. [Krausman and White, 2006]

V. CONCLUSION

We finally conclude that Haptic Technology is the only solution, which provides high range of interaction that cannot be provided by BMI or virtual reality. Whatever the technology we can employ, touch access is important till now. But, haptic technology has totally changed this trend. We are sure that this technology will make the future world as a sensible one. Haptic signals can be used to communicate and navigate. This field requires research about how to deliver signals as reliably as possible. It should be looked in if is it possible at all to give orders by haptic signals. Perhaps haptic signals should be used as cues about other information, as kind of attention grabbers, or haptic signals are good for certain kind of messages. Be that as it may, the use of haptics in military applications is looking promising as long as more thorough research will be done.

REFERENCES

[1] OpenHaptics Toolkit version 3.0,Programmer's Guide, Sensable Technologies, Inc., 1999-2008.
[2] Mobile Guerilla, "Samsung Touch Screen Phone Launched" [Online].Available: http://www.mobileguerilla.com/articles/2008/ 03/25/samsung-haptictouchscreen.php, 25th March 2008.
[3] "Haptic Technology", Wikipedia [Online]. Available: http://en.wikipedia.org/wiki/Haptic.
[4] J.J.Barkley, "Haptic Devices", MimicTechnologies. 2003.
[5] Guido B¨ottcher, Dennis Allerkamp and Franz- Erich Wolter, "Virtual reality systems modeling haptic two-finger contact with deformable physical surfaces", IEEE Trans.On Cyberworld, 2007.
[6] Volkov, S. and J. Vance, Effectiveness of Haptic Sensation for the Evaluation of Virtual Prototypes. Journal of Computing and Information Science in Engineering, 2001.
[7] Lien L.L, Chen Y.H. "Haptic Surgical Simulation: An Application to Virtual Suture", Computer-Aided Design & Applications, Vol. 3, Nos. 1-4, IEEE 2006, pp 203-210.
[8] Liu, Bhasin and Bower: A Haptic-Enabled Simulator for Cricothyroidotomy. Studies in Health Technology and Informatics, vol. 111, pp. 308-313. IOS Press, 2005. http://simcen.org/pdf/liu%20mmvr%202005%20paper.pdf
[9] Krausman and White: Tactile Displays and Detectability of Vibrotactile Patterns as Combat Assault Maneuvers are Being Performed. U.S Army Research Laboratory, Technical Reports. 2006.
http://www.arl.army.mil/arlreports/2006/ARL-TR-3998.pdf
[10] Pettitt, Redden and Carstens: Comparison of Army Hand and Arm Signals to a Covert Tactile Communication System in a Dynamic Environment. U.S Army Research Laboratory, Technical Reports. 2006.
http://www.arl.army.mil/arlreports/2006/ARL-TR-3838.pdf

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[11] Jiang, Girotra, Cutkosky and Ullrich: Reducing Error Rates with Low-Cost Haptic Feedback in Virtual Reality-Based Training Applications. Eurohaptics Conference, 2005 and Symposium on Haptic Interfaces for Virtual Environment and Teleoperator Systems, 2005. World Haptics 2005.
http://bdml.stanford.edu/twiki/pub/Haptics/ImmersionProject/STTR_paperV7.doc
[12] Fowlkes, Durlach, Drexler, Daly, Alberdeston and Metevier: Optimizing Haptics Perceptions for Advanced Army Training Systems: Impacts on Performance.
http://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.14.1953

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