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# Glove Based Virtual Reality (VR) Interaction for the Purpose of Rehabilitation

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**ABSTRACT**

This paper describes the study for interfacing of dataglove with the virtual reality (VR) system for the purpose of the rehabilitation.Dataglove is a device capable of recording hand movements, both the position of the hand and its orientation as well as finger movements.*GloveMAP* with a flex sensor is a low cost solution for hand rehabilitation and is adapted in the VR environment. In this project, the system for hand rehabilitation using data glove, virtual reality and head mounted display is proposed. The proposed system will be the best solution toward the low costfor improving the efficiency of rehabilitation activityin the future.



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## INTRODUCTION

As technology improves, innovative modifications took place in rehabilitation's techniques and equipment. It is engineered from the beginning of basic hardware apparatus of assisting or even swapping human body parts to the intelligence system of the effective training, rehabilitation and assessment (Rose FD *et al*., 1996). This includes the use of interactive virtual reality environments to the advance movement rehabilitation. Modern medicine is a four-in-one system which includes clinical treatment, disease prevention, healthcare and rehabilitation. With the enhancement of postoperative living rate, the number of patients who require rehabilitation also increases and rehabilitation treatments is developed (Chen Hao *et al*., 2010). A cost-effective glove has been demonstrated to be effective in evaluating hand movements and helping in grasping. Even though a finger-assistive glove could effectively offers assisted motor exercise in virtual environment, it still has disadvantages in remote accessibility and mobility. In addition, rehabilitation with guide of VR technological innovation has improved the restorative potential of stroke patient.

This paper surveys studies on the hand rehabilitation based on dataglove interfaced with the VR environment. The organization of this paper is as follows; Section 2and Section 3 explain about dataglove and virtual reality while Section 4 and Section 5explain about the arm rehabilitation and stroke patient respectively. Arm rehabilitation by using dataglove with VR interaction for stroke patient is reviewed in Section 6. Section 7 states the conclusion.

### *2. Dataglove:*

Dataglove is the first wired glove devices used for touch less manipulation of graphical objects on the computer.It has an ability to cooperate with computer through Human-Computer Interaction (HCI). Dataglove as shown fig. 1 is designed to archive requirement of modern technology of motion capture and artificial interaction with animated object through high data quality. It is very ideal for realistic real-time animation because of low cross-correlation and high data rate. Dataglove otherwise called parts of "Haptic Science" PC, haptic engineering is a mechanical stimulation to client which by applying compels, vibration or movements to the clients and the business provisions incorporates film amusements, virtual actuality, portable gadgets and PCs (S.Jezernik *et al*., 2003).

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**Fig. 1:** X-IST CyberGlove made by Immersion Corp.

Additionally, dataglove is likewise utilized within the study of hand rehabilitation by combining together with a VRsystem (Wang Junhua, 2010 ) and head mounted display (HMD).It has various sensors which accurately give the orientation of bending fingers and the whole hand as well as position of the fingers. Magnetic resonance sensors are placed at the fingertips of the gloves for the positioning purpose. Software on the computer takes the relative orientation of the fingers in space given by the sensor and maps it on to a simulated hand. The rotation and orientation of the hand is captured by other sensors like accelerometers and gyroscopes and integrated with other positional information. The bending ofthe fingers is sensed by a technique by using optical sensors which can tell how much a fingeris bent by the amount of light reaching it through an optical fiber. The more the fingeris bent, the more the light through the fiber is restricted and hence gives an indication of the amount of bend.

**Fig. 2:** Cyber Glove II (Immersion Inc.)

Fig.2 shows a dataglove that has been widely used as an input interface to control several graphical objects and game over the years. It is used in motion pictures to create animated objects in a process called the 'Hand over'. These devices give very accurate positioning, depending on the number of sensors in the glove. The fact is this device has to be worn at all times and the only problem remaining is the wired aspect.

***3. Virtual Reality (VR):***

The application of VR in physical therapy has concentrated mainly on the post-stroke patients. Fewer effort has focused patients with musculo-skeletal deficits, depending on whether from surgery, fractures or arthritis(Sveistrup H *et al*., 2003). VR handles the requirements of sub-acute musculo-skeletal training by offering virtual activities intended to motivate and employ the patients in a time of intensive physical activity (Forducey et. al., 2005) as illustrated in fig. 3.

**Fig. 3:** Virtual reality hand for virtual activities

Deutsch utilized the Rutgers Ankle robot together with VR to instruct about three patients with musculo-skeletal impairments to their ankle (S.Jezernik *et al*., 2003). Patients sat in front of a computer and were requested to lead a virtual aircraft with their ankle, passing through hoops against the robot resistance. All three patients enhanced in numerous computerized measures such as ankle range of motion, ankle control or ankle torque (Forducey *et al.,* 2005). Sveistrup revealed on the application the Interactive Rehabilitation Exercise System (IREX, Ottawa, Canada) for the coaching of patients with chronic frozen shoulder(Deutsch J *et al*., 2001).VR-based rehabilitation was offered through soccer games aimed toward rotation, abduction andeliciting shoulder flexion. A couple of case studies exposed that around 20% improvement after a following six weeks of training (Forducey *et al.,* 2005).

***4. Arm Rehabilitation:***

In recent times, specialist manufactures in oversea have previously offered a line of multi-functional rehabilitation devices (Chen Hao *et al*., 2010). For instance, the Proxomed Corporation in Germany has designed a Compass for medical related application in neuro-rehabilitation and orthopedic as well as in sports medicine and geriatric. Hocoma a Switzerland Manufacturers has offered a computerized robotic gait evaluation and training system which can be used for robotic treadmill training of patients with movement troubles (Chen Hao *et al*., 2010). The solution of Biodex USA is a Multi-joint System 4 as shown in Fig. 4, an adaptable ergometer that suits the requirements of wellness, sports medicine, cardiac, orthopedic rehabilitation, or general conditioning program. Each one of these devices focuses the complete process from training the patientsand assessment. Furthermore, many highly developed technologies in other areas can be applied for rehabilitation training such as 3D motion image capture system and VR technology. It is actually designed for special effects of entertainment or film and motion analysis, but additionally can be used in the gait analysis (Wang Junhua, 2010).

**Fig. 4:** Biodex System 4 Pro

The rehabilitation of hand disorders in China typically involves occupational therapy and various traditional techniques of physical treatment (Chen Hao *et al*., 2010). There is little difference from the global therapy concept (R.Boian *et al*., 2002), but is backward in terms of assessmentand therapy equipments. Nearly all medical organizations still implement the methods of using visual to examine, simply because the execution of rehabilitation methods may not be manageable. Additionally, because of the insufficient automated devices, physicians can only keep an eye on the patients for each individual in the therapies (Chen Hao *et al*., 2010). Every time the number of patients increases, the physiciansor therapists always get tired easily, along with the work efficiency is decreased.

Overseas research studies for hand rehabilitation have started to create high-tech signifies including intelligent measurement and sensing technology for objective rehabilitation and functional assessment (Chen Hao *et al*., 2010). Rutgers University, NJ, USA have designed a VR-based device using a CyberGlove along with a MPII haptic glove to rehabilitate post-stroke patients in the chronic stage. Both sensing gloves were integrated with VR enviroment operating on the computer workstation. The post-stroke patients interact with the platform via the sensing gloves and nformation was given on screen of the PC. Final results displayed all patients experienced major improvement on their fingers' functions[9].

***5. Stroke Patient:***

In Malaysia, stroke is the number three most significant factors that cause death and said to be the single most typical reason behind severe impairment. Annually, approximately 40,000 Malaysian citizens experience stroke. Anybody can have a stroke which include children, however the large number of the cases affect adults. The objectives of rehabilitation are to assist patients for achieving the best possible quality of lifespan, attain the most effective long-term result and turn out to be as independent as possible. Rehabilitation facilitates stroke

patients relearn skills which are lost when part of the brain is damaged. To illustrate, these types of skills range from performing the steps involved in every complex activity such as dress using only one hand or coordinating leg movements in order to walk as shown in Fig. 5. Rehabilitation specialists said that the key element in any rehabilitation program is repetitive practice, well-focused and carefully directed. The similar type of training utilized by everybody when they learn a new skill for example pitching a baseball or playing the piano.

**Fig. 5:** A stroke patient at Rehabilitation Hospital

***6. Arm Rehabilitation by Using Dataglove with VR Interaction for Stroke Patient:***

After a careful reasearchin general procedure of handrehabilitation, another sort of system is proposed.

***GloveMAP:***

Researches have been conduct to build other version of "wired glove" that share similar purpose known as *GloveMAP*. *GloveMAP*is a low cost "wired glove" that are design to capture all the data when the fingers are bending and the data will transmit to Quest3D software. The physical data such as force generate when finger in contact with various kind of objects will be collected to analyze and synthesis.The positioning sensor on the dataglove will track the actual hand position in real environment so that the virtual hand will move accordingly with the actual hand.An essential element will be used to ensure a perfect reading of hand position.Suitable sensor is needed to detect any smallest changes in any portion of fingers. This sensor also requires withstanding high force once glove bend completely 90 degree and should be able to use in long period of time.

***Software:***

Since this project needs to do the virtual rehabilitation, software that is suits is Quest3D software which is a platform for VR system for virtual hand. Quest3D is software for developing real-time 3D Microsoft Windows applications. It's consists of only a few high level software tools and almost all tasks are performed identical to the hardware. By using the software development kit, users can build their own components for Quest3D and build support for specific hardware such as dataglove. The Virtual Reality Peripheral Network (VRPN) will be used to interfaced the dataglove with VR enviroment and HMD. VRPN is a zero cost, open source tool that can handles many VR devices.

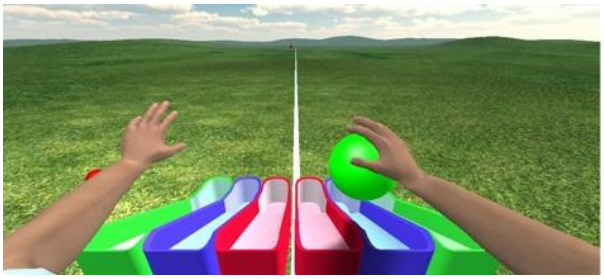

**Fig. 5:** Placing Game. Rehabilitation training task combining reaching and grasping exercises

The VRrehabilitation environment may contained a simple placing game designed by using Quest3D as illustrated in fig. 6. Patient needs to grap a ball and place inside a specific box according to its colour. This game also combine reaching and grasping exercise.

***Hardware:***

The device elements of rehabilitation system consist of a personal computer (PC) together with the dataglove interfaced with VR systems. The systems operate under control of specially made software package which includes a virtual hand enviroment.Other optional accessoriesinclude HMD to replaced ordinary LCD monitor. Theoverall structure of the system components are illustrated in fig. 7.

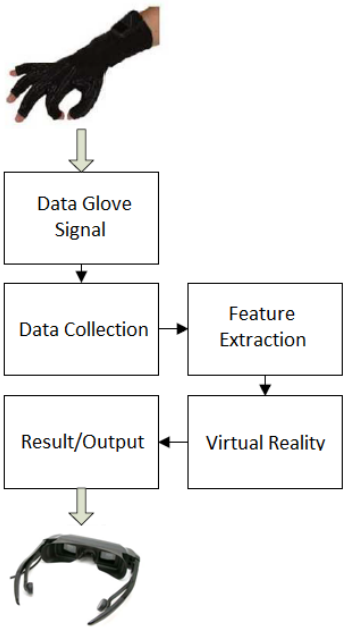


**Fig. 6:** Overall structure of the system

The specification of the PC must be powerful since it must have capability on real time data processing. The specs of recommended PC can be as follows:

CPU : Intel Xeon E5-1620 3.6Ghz
RAM : 4GB DDR3
Hard Disk : 1TB HDD
CD Drive : 16X SuperMulti DVD-RW
Displayer : 20 inch LCD monitor or HMD
Graphic Card: NVIDIA Quadro K600 1GB
Operating System: Windows 7 Professional 64-bit

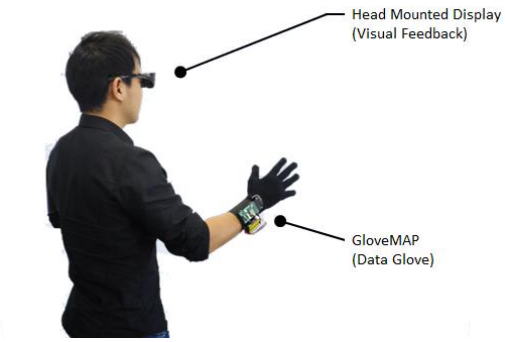


**Fig. 7:** Propose system of hand rehabilitation

Fig. 8 show the propose system of hand rehabilitation. A *GloveMAP* with a single bend sensors on each finger is chosen. There are more than two various sensors implemented on it, and the amount of sensors is flexible. *GloveMAP* is equipped with microcontroller box with USB connector for power source and also data transfer.

***Conclusion:***

In the process to developingnew system of hand rehabilitation, dataglove with comfortable and stretchable material plays an important role. All users willfeel comfortable and the glove fit ontheir hands. The dataglove will measure the impact of human hand movements rapidly and precisely, evaluate and train muscle strength. Moreover, the proposed system will help physicians to assess the disability levels objectively and determine personalized treatment approach for hand rehabilitation. The combination of dataglove and VR will make the therapy accessible to multiple patients by means of expanding the number of equipments. Meanwhile, collected results may be assessed and perhaps managed to generate the medical analysis of various rehabilitation levels in order to create a clinical database as well as further scientific studies. It will respectively enhance the efficiency of rehabilitation later on.

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