IMPLIMENTATION OF VIRTUAL REALITY IN REHABILITATION

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Abstract: In the field of rehabilitation providing training motivation (enjoyment) is very important. This paper outlines the employment of VR (Virtual Reality) to increase rehabilitation training motivation. A large scale yet portable semi-immersive 3 dimensional display is placed in front of existing rehabilitation training equipment. The patient wears a pair of polarized glasses (active polarization) and thus interacts with the dynamic scenery (hills and valleys) in a 3 dimensional virtual world. Feedback is provided through a 3D spatial sensor mounted on one of the pedals (in the case of lower limb exercises). By monitoring the patient's speed of operation any variation in speed, particularly slowing down, typically indicating physical fatigue, a form of visual virtual loading is applied by changing the ascent rate on the pathway from ascent (slow progression per cycle - psychologically difficult) to a descent (rapid progression per cycle of patient operation - psychologically easy).

Keywords: Virtual Reality, rehabilitation, portable large scale semi-immersive 3 dimensional display

1 INTRODUCTION

Through the employment of Virtual Reality (VR) a new form of rehabilitation training assistance system has been developed. The purpose being to increase training motivation (enjoyment), or to express it in reverse terms, to take a leisurely stroll or ride through some beautiful scenery and at the same time carry out rehabilitative training exercises. Correct training techniques can also be encouraged and all patient activities are monitored and can be easily recorded. As rehabilitative training is conducted in a wide variety of places ranging from hospitals to specialized rehabilitation centers, important aspects of rehabilitation assistive devices are portability and being multipurpose.

Figure 1. Concept of using an exercise bicycle in front of the display

The VR system outlined in this paper presents a newly developed portable (collapsible) large scale sloped semi-immersive display. The display is designed to be used with any existing rehabilitation equipment. The purpose of using existing training equipment is understood to be important for reasons of the high cost of training equipment and from the perspective of patient's familiarity with existing

equipment. This research focuses on the implementation of VR assisted rehabilitative training using the newly developed display. The previous work of T.Takeda et.al. has to date used a simple CRT monitor [1,2,3] and more recently a fully immersive display system [4,5,6] representing the two extremes of cost and effectiveness in terms of providing a virtual world.

2 SYSTEM OUTLINE

Figure 1 shows a concept view of a patient using an exercise bicycle in front of the display. Respective plan and side views of the screen and projector arrangements are shown in figure 2. The screen size measures 2.4 meters wide by 1.8 meters high, it is inclined at between 55 to 60 degrees (viewing angle). The patient thus faces slightly downwards minimizing viewing fatigue. Despite standing directly in front of the screen a sense of distance is imparted, further having the screen extend down to the floor further enhances the sense of realism, hence the terms “semi immersive” is used. The computer graphics are projected from the rear of the screen as shown in figure 2.

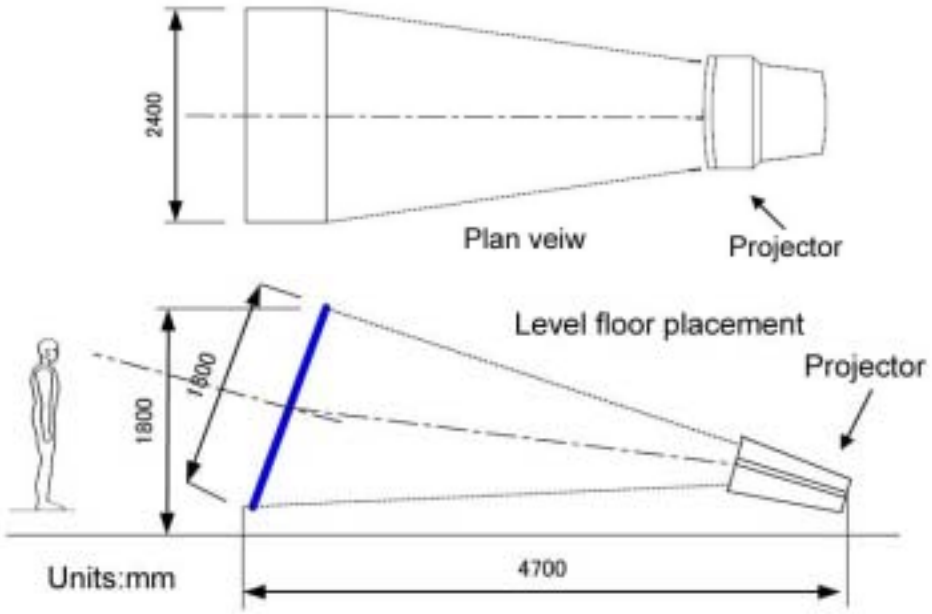

Figure 2. Large scale sloped display outline

Assembly detail of the screen is shown in figure 3. Firstly the pole frame is assembled and then the screen stretched out and connected as shown. For the purpose of maximizing versatility a windows computer has been used.

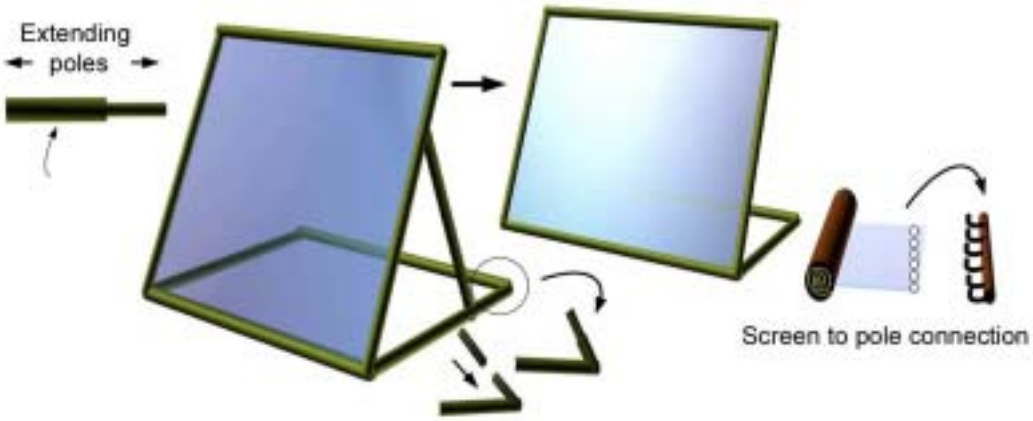

Figure 3. Screen assembly

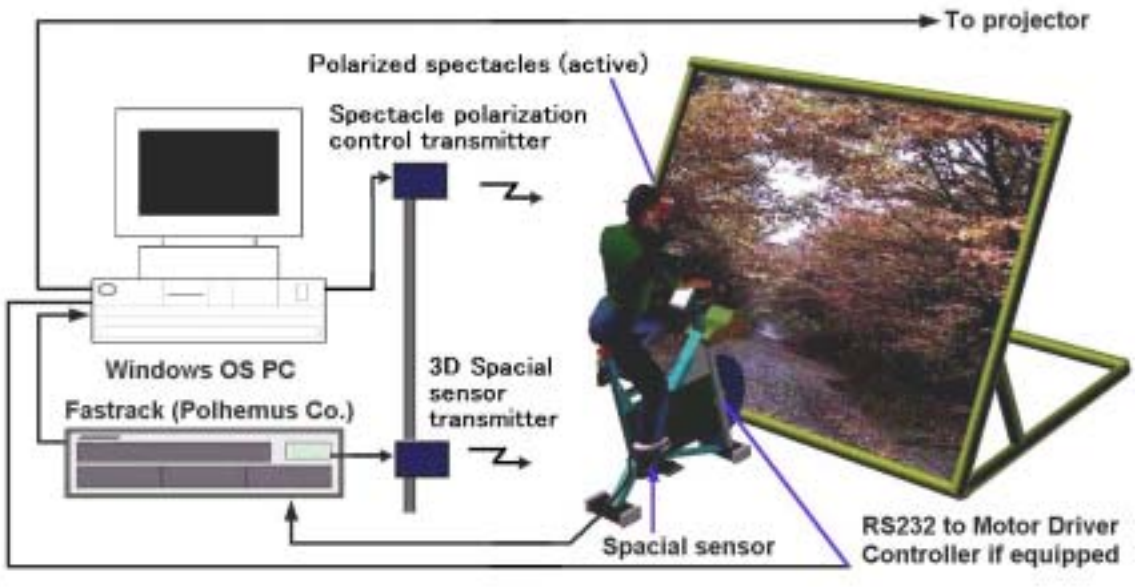

Figure 4. VR rehabilitation system schematic

Figure 4 illustrates the overall VR system developed for rehabilitation. The exercise bicycle is representative of rehabilitation equipment often used in hospitals and rehabilitation centers for lower limb training. As the exercise bicycle is pedaled the 3D projected image (scenery) progresses based on the pedaling speed. A 3D spacial sensor (Polhemus) is attached to one pedal, to provide feedback to the VR system regarding the patient's speed of operation. The purpose of using the sensor being to ensure compatibility with every possible form of (lower limb) rehabilitation equipment.

3D operation was achieved by using a pair of actively polarized spectacles (Crystal eyes), the spectacles are controlled via an infra red link configured as shown in figure 4. The projector is sent alternating frames which are synchronized with the spectacle polarization. An alternative approach would be to use fixed polarized spectacles and use two projectors arranged also with fixed polarization matching the spectacles, this approach would also require the use of a dual head display output card.

To use the VR system an initial scale setting is required, this defines progression speed per cycle. Foot movement is calculated from the 6 parameters provided by the Fastrack receiver. The parameters are distance (transmitter to sensor) x, y and z axes, and from angular movement x, y, and z (roll, pitch and yaw).

3 Application

The VR operation for with an exercise bicycle is illustrated in both figures 1 and 4, Figure 5 illustrates usage with a mini-stepper standing (5a) and operated from such as a wheelchair semi-standing (5b).

Figure 5. Mini-stepper (a.) standing (b.) semi-standing

The computer monitors the patients pace at all times, the aspect of physical fatigue, is typically detected by the gradual reduction in speed. As this occurs ideally the exercise equipment's loading torque should be reduced, this is possible on some very expensive rehabilitation equipment where computer control of the torque is possible via an RS232 connection to a computer (shown as an option in figure 4). However as most exercise devices are not equipped as such a form of "visual virtual load control" is employed. This is implemented by changing the inclination of the pathway towards a descent and increasing the rate of progress per cycle correspondingly. This results in a psychological or "virtual" reduction in load torque. In the same way overexertion could be discouraged by the reverse, that is going into a climb and corresponding reduction of progress per cycle of operation.

4 CONCLUSION

A large scale and yet portable sloped display has been developed and used to provide a semi-immersive 3 dimensional virtual world in which rehabilitative training can be enjoyed. The display has been used in conjunction with a 3D spacial sensor to provide information regarding the patient's progress. The use of VR has been used to increase training motivation levels.

Future work includes the need to provide a simple and inexpensive general purpose means of controlling the torque on the rehabilitation equipment.

REFERENCES

[1] M. Lawn, T.Takeda, T. Yamada, "Development of a 5 axis upper limb force display operating in a VR environment for training," presented at 7th International Conference on Artificial reality and Tele-existence, Tokyo University, 1997.

[2] M. Lawn, T.Takeda, "A 5DOF force feedback arm interface for rehabilitation operated in a virtual environment," presented at 8th International Symposium on Measurement and Control in Robotics, Prague, Czech Republic, 1998.

[3] M. Lawn, T.Takeda, "Design of an action interface with networking ability for rehabilitation," presented at 20th International Conference of the IEEE Engineering in Medicine and Biology Society, Hong Kong, 1998.

[4] T.Takeda, Y.Kanou, I.Itoh, "A prototype three-dimensional Virtual Aquarium," Journal of the Society of Instrument and Control Engineers, News and Report, vol. 13, pp. 451-454, 1988.

[5] C.Nakagawa, M.Ohsuga, T.Takeda, "Toward designing sickness-free VE systems --A basic study using a cube type 4-Screen 3D display and a 6-DOF motion base--," Human Interface Society, Correspondence on Human Interfaces, vol. 1, pp. 21-24, 1999.

[6] R.Noto, N.Kumimoto, Y.Ichinose, T.Takeda, "Experiment of running on a treadmill 3D images," presented at Virtual Reality Society of Japan, 1999.

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