The TRUST Project: Immersive Play for Children in Hospitals and Rehabilitation

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1 Introduction

In recent years, children's hospitals worldwide have investigated using aspects of video games and other media tools available to young patients to address such problems as isolation, stress management, and rehabilitation. Online communities represent a novel solution to the problems of isolation, for example, for children in hospital care. The majority of such network interactions are generally text-based, utilising chat and forum clients such as StarBright Web and the Cystic Fibrosis Teams Initiative. There is a growing body of evidence suggesting that these communities, despite being limited to text interfaces, can improve pain scores and may improve depressive symptoms, reduce anxiety, and raise self-esteem [1][2][3].

While the use of interactive digital entertainment, or video games, in hospital settings is not new, studies performed to test more graphical interfaces show a similar potential for gaming networks. The work of Bers et al. examined the use of a three-dimensional graphical virtual city, Zora, which provided the setting for a pilot group of hemodialysis patients to socialize in the same network space and to interact via their avatars [4]. This and similar work demonstrates the potential of virtual gaming as a means to escape from difficulties afforded by their situation in hospital settings. The work of Hoffman et al. also details the use of virtual environments in reducing pain scores when employed as an adjunct to pharmacotherapy for patients with burn and dental pain [5][6].

2 The TRUST Project

The objectives of the TRUST Project is to develop game-based interactive play in order to aid in children rehabilitation and ease the stresses associated with hospital scenarios. The play environment is designed to be inclusive, i.e. not solely for able-bodied and able-minded people. The virtual environments and game scenarios have been tailored to an audience of 8 to 13 year old children with varying degrees of abilities. TRUST seeks to offer more than distraction, but also a tool for collaboration and connection from the isolating environment of the hospital, and a tool for studying the impact of cooperative game-play on physical, emotional and rehabilitation (http://www.give-trust.org).

To address these objectives, the TRUST framework has integrated several modes of artistic and technological innovation; a game engine and associated software framework and a pneumatically operated, active chair which provides a closed loop haptic interface that is synchronised and congruent with the game play. In addition, an array of joysticks allows users with constrained mobility to interact with the system. The following sections outline the technological innovation that has been developed and is being currently installed in the KK Women & Children's Hospital in Singapore.

2.1 The Game Engine and its Mechanics

The prototype game engine employed and subsequently developed in this work is the "3D Interactive Media Lounge" (3DIML) [7], an open source 3D game software project developed by BBC R&D. It is built upon the reputable "Crystal Space 3D" game SDK (http://www.crystalspace3d.org), which provides all the facilities that one would normally expect from a state-of-the-art computer game. The aim of the 3DIML is to extend these features to provide access for all, to both interactive and linear content. The game engine provides the core software framework for the system and integrates the various interfaces and provides the game functionality, such as 3D visual and sound rendering, physics, and network interface.

2.2 The Artistic content

The project involves the development of bespoke content tailored to the objectives of the game and the target audience.

Figure 3. The TRUST virtual interaction space

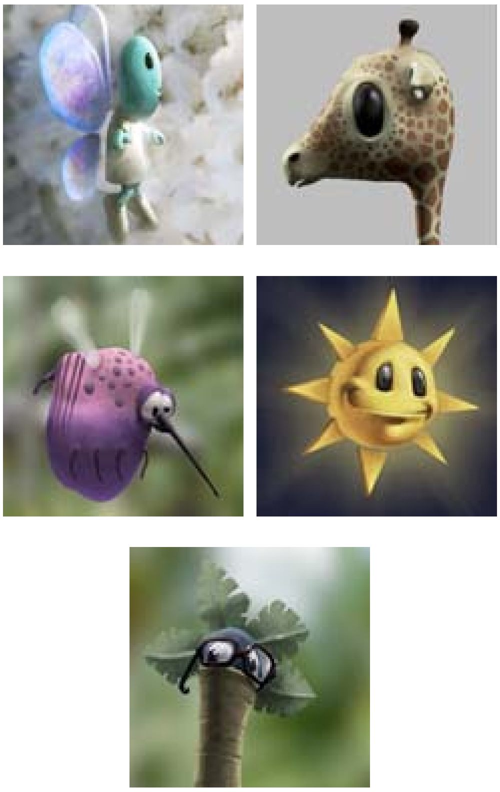

Figure 4. The TRUST virtual characters

The game responds to a child's creative exploration in physical space, and to their empathetic responses to the characters within the world. As new vistas open up, the interactive game take on new depth, colour and rewards with new characters with each level of the game. These characters were first drawn in 2D and then modelled in 3D using such development tools as Maya, 3DStudioMax and Blender.

2.3 The Active Chair

In order to develop a strong sense of immersion within a virtual space, a haptic chair was designed and developed to reinforce visual stimuli experienced during a game [8]. The geometry of the Active Chair and consequently the positioning of the body in the chair have been designed to facilitate relaxation and immersion in the virtual environment and draws from the neutral body posture which involves the midpoint between the position of greatest extension and greatest contraction of the joints in the body. The chair is driven by three pneumatic cylinders with variable air speed and pressure controllers. The design allows for a simple and effective range of motion of the chair. A USB hardware interface allows a PC control the position of each of the pneumatic cylinders and provides a simple and flexible control solution. This is achieved through a custom circuit using a PIC controller (PIC16F87x) with a serial communications interface in full duplex mode (asynchronous) through a USB interface board. In order to provide an equal footing for all participants, whether able- or disable-bodied, a modular framework for input controller positioning is incorporated, which accommodates the individual needs of the participants.

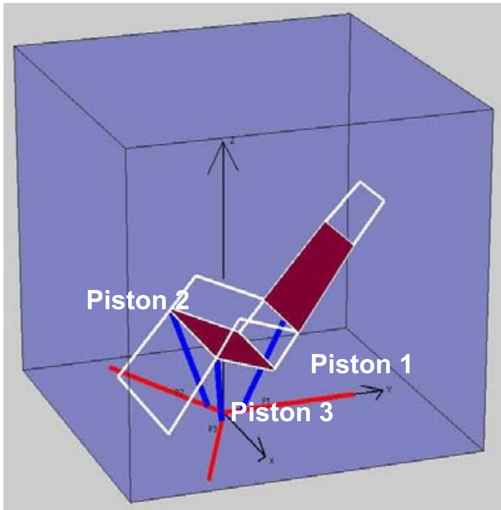

Fig 5. A schematic of the Active Chair showing the orientation of pistons 1,2, and 3

The intended degree of tilt of the participant was used as a basis to move pistons 2 and 3. When the avatar perspective of the participant tilts to the left during turning in the virtual world with an angle α, piston 3 is lowered and the piston 2 is raised by an angle β. The relation between a tilt of angle α and the tilt of angle β of the active chair is shown in equation 1.

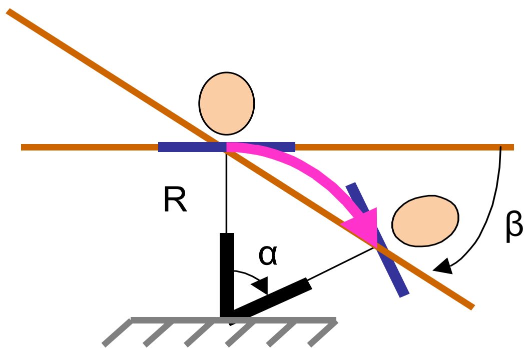

Fig 6. Correlation between the angle α and the angle β

$$tan(\beta) = \frac{1 - \cos(\alpha)}{sin(\alpha)} \quad (1)$$

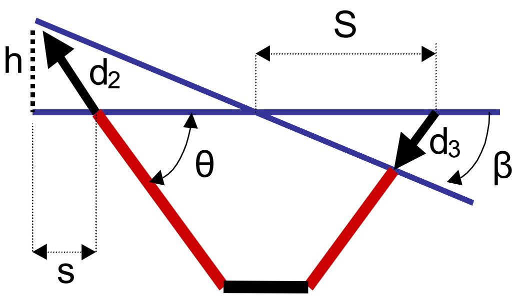

Fig 7. Correlation between the pistons 2 and 3 displacement (d2 and d3) and the tilt of angle β

The equations between the pistons 2 and 3 displacement (d2 and d3) with the tilt of angle β is:

$$d_2 = \frac{-S \times \tan(\beta)}{\cos(\theta) \times \tan(\beta) - \sin(\theta)} \quad (2)$$

$$d_3 = \frac{S \times \tan(\beta)}{\cos(\theta) \times \tan(\beta) + \sin(\theta)} \quad (3)$$

Using these equations with the tilt signal we have the piston 2 displacement signal and the piston 3 displacement signal as shown in the following figure.

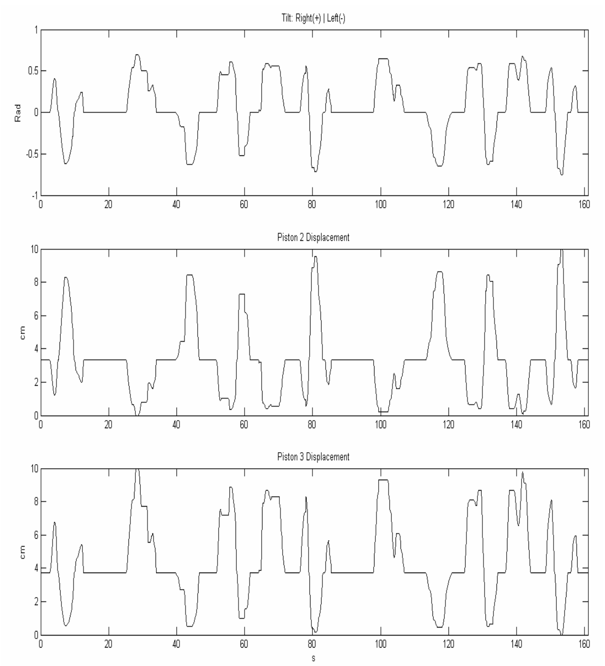

Figure 8. Example piston 2 and 3 displacement signals

2.4 Control Algorithm

Each piston i (i = 1,2,3) has a displacement signal S^i and comfort speed v_c. A piston i at the instant t_k will have a position d^i_k. At a time $\Delta t = t_{k+1} - t_k$ later, a piston i will have a displacement $d^i_k + D$ if the movement is up, $d^i_k - D$ if the movement is down, and d^i_k if the position doesn't change ($D \cong v_c \Delta t$) (see figure 9).

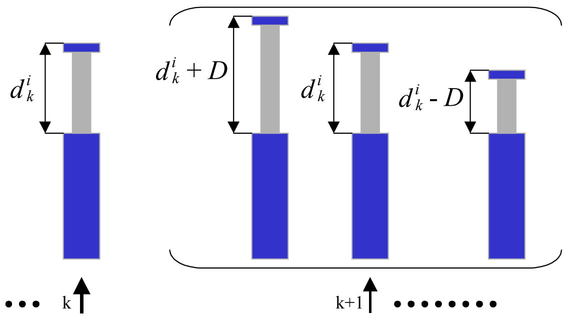

Figure 9. Piston displacement

The control algorithm compares the value of displacement signal S^i_{k+1} at the time t_{k+1} with three positions of the piston: the position of piston d^i_k at the time t_k, d^i_k +D and d^i_k -D. Subsequently, it chooses the min {abs {Equal=$S^i_{k+1} - d^i_k$, Up=$S^i_{k+1} - (d^i_k+D)$, Down=$S^i_{k+1} - (d^i_k-D)$ }} where S^i_k, d^i_k and D are ≥ 0. The piston displacements have been adapted for the displacement range of the pneumatic cylinders (100mm) with a speed less than the maximum comfort speed value selected (v_c). The PIC controller driving the pneumatics of the active chair performs the order Equal, Up or Down for a time Δt through the use of either a "0", "1", or "2" signal values from the games engine.

The result is a flexible active chair control system that is integrated with a full games engine. It is possible to integrate new worlds, characters and functionality and provides a basis for a range of haptic gaming scenarios.

3 Conclusions

The TRUST Game has aimed to put the child in rehabilitation or person with disabilities at the centre of an empowering game world with a sense of movement achieved through the progression of an avatar of his or her own making through the virtual world. This is undertaken in tandem with other avatars cooperating in a humorous competition-based gaming environment.

Figure 10. The TRUST game world

Figure 11. The Active Chair in use by children from the Women and Children's KK Hospital in Singapore

The project has aimed to aid in community building and cooperation between children (in contrary to approaches explicitly designed to foster competitive environments) as young people play the game from hospital and rehabilitation settings. This integrated immersive experience is currently undergoing testing and evaluation in the Women and Children's KK Hospital in Singapore (in collaboration with the gameLab at Nanyang Technical University).

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