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Review

Customising games for non-formal rehabilitation

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Abstract

The field of rehabilitation has increasingly adopted commercially available games using perceptual interfaces as a means for physically training patients. The adaptability of such systems to match each person's need and rehabilitation goal remains problematic. This paper presents a rapid prototyping approach for customising gaming technology using various affordable commercial devices and open source software. We first demonstrate how a freely available game is adapted for training disabled people through different sensors and control modes. We then show how an open online virtual world such as Second Life® offers sufficient conditions for quickly building custom content for testing with interactive devices. When presented with these prototyping possibilities, people from the target groups (healthcare professionals, patients, people with disabilities, older people, families) related such systems to their needs and further elaborated on the use of such systems. Our research indicates how availability of simple prototyping platforms expands upon the possibilities for developers and practitioners.

Keywords: customised non-formal rehabilitation; interaction devices; serious gaming.

Introduction

An increasing trend in gaming is the use of interfaces that require physical activity for an improved user experience (e.g., the Sony EyeToy™ or the Nintendo Wii™). These and other sensor-based interfaces offer new opportunities for players to interact with a game so as to become more (physically) engaged. Such gesture interaction technologies are not new [e.g., Vivid's Mandala system (1)], but their recent use as a motivating rehabilitation tool reflects a broadening application beyond solely entertainment. These marginal application areas for games challenge the use of such interactive interfaces from various perspectives. Studies involving the Sony EyeToy™ to help in stroke rehabilitation (2) or the Nintendo Wii™ Bowling to keep elderly people fit in retirement homes (3) show that, beyond the proof of concept, commercial games used 'as-is' in a different application context are inadequate for specific needs. Adaptability to each specific user and evaluation of use are two examples of what should be improved.

According to our experience with console games for rehabilitation, a mismatch is clearly palpable between the interface, the participant's limited abilities and the mapped content feedback. This is exemplified in a study where a video game platform was provided in a day-care children ward at hospitals (4): as both interface and content could have been improved to address better the different abilities of the children, some frustration in the primary (participants) and secondary target groups (therapist, facilitator, family) was observed.

This shows the need to design and develop improved sensor-based interactive systems that can address such incompatibilities. Solutions should also be simple enough to be operated by untrained staff, family members or the participants themselves. Game industry would have the expertise and the means to create such a product, but the market is not profitable enough. Companies are also reluctant to invest in marginalised segments of society where they think they might be judged as exploiting inequalities.

For these reasons we focused away from the product design and towards defining means to enable the prototyping of custom devices and software that can be customised for specific users. Prior research (5, 6) has shown how interactive system prototypes are efficient communication supports between experts (patients/families and/or therapists) and technological experts (developers and/or researchers). This is precisely what gaming interfaces and the open source software community can provide: an affordable access to an increasingly large range of devices, and the possibility to freely use and customise software with various levels of technical skills required.

To illustrate this, we built various interactive systems by interfacing open source games with interaction devices – e.g., a standard webcam, a commercial ultrasound sensor called Soundbeam, compass sensors and others such as accelerometers. To show how these technologies can be adapted across disciplines, we made demonstrations to various lab visitors, including medical, academic and pedagogical professionals. What we experienced is that, from their point of view, these systems are perceived as potential applications despite the technological simplicity and the use of pre-existing software.

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This paper illustrates how prototyping of rehabilitation systems can be done in practice, first by comparing different devices and control modes for one game, and second by quickly prototyping a game adapted to one device and a specific control mode. We will then present the feedback we have had when using this approach and discuss the problems yet to be resolved.

Hardware prototyping

The principle of our approach is to take existing games and to swap the usual interaction devices with more physically involving perceptual sensor-based intuitive interfaces. This is done by modifying a game whereby the source code is available, and by integrating the code for reading the input from other devices.

Testing platforms

Planet Penguin Racer (PPRacer) is an open source project that is sufficiently established and advanced to offer good quality graphics, sound and game-play. It is a racing game where the user controls (via traditional keyboard interface) a penguin descending a snow-covered mountain route. The challenge is for the player to maximise his/her score by targeting herrings strategically placed along the way, while avoiding trees and arriving in the shortest time possible. The thrill of playing comes from the feeling of speed, the risk of hitting obstacles and the possibility to jump to save time. The fun of the game also simply comes from the empowered direct control of an artefact and from visual immersion in a three-dimensional virtual environment.

Three motion sensing input devices were tested for controlling the penguin: a camera, an ultrasound sensor and a set of three axis accelerometers.

Camera interface

Our camera interface detects motion by frame subtraction using the Open Computer Vision Library (7). Steering direction and intensity are computed according to the amount of movement detected to the left and right sides, the central area being neutral. Acceleration and braking can be computed similarly from activity detected at the top and bottom of the image, respectively.

The user is positioned in front of the camera that, in our case, was positioned under the high definition 5×2 m rear projected screen of the lab. A minimal level of light on the player is required for the camera to detect motion. Players can control via body and arm gesture. A repositioning of the camera can enable a level of head-only control.

Ultrasonic sensor interface: Soundbeam

Used primarily as a sound controller, we adapted the Soundbeam as a game interface. The sensor measures the distance between the ultrasonic emitter-receiver and an obstacle reflecting the narrow beam. In this case, the distance measured by the device is used to steer left and right.

Considering a calibrated measurement range, e.g., of 0.50 cm, the centre corresponds to the neutral position, a shorter distance steers it in one direction (e.g., to the left if the device is on the left) and a longer distance steers to the opposite. The best way to use this interface is to sit in a chair and to turn and lean the head to the side.

Acceleration sensors interface

Accelerometer sensors are affordable and easily interfaced with electronic controllers so as to communicate with a PC via USB. As these sensors provide a measure of their orientation relative to gravity, we attached two of them on the wrists of the player to detect the orientation of the arms.

Mapping of the sensor data enabled the following steering gestures: a neutral posture (penguin glides straight ahead) is with the forearms, lowering a single arm means touching the ground and therefore initiates braking on the side of 'contact' (similar to rowing a boat). Lowering both arms acts as a brake, and raising both arms accelerates the penguin's descent. A brief user calibration also allows customising the neutral posture.

Software prototyping

Whilst developing interactive systems and devices for use in rehabilitation, we have encountered several major issues. Firstly, each and every case is different: as every patient has different needs and capabilities, the software and content need to be extensively customised every time. In addition, such adaptation has to be done quickly, ideally on the spot in response to the actions of the user or to therapeutic needs. This is important especially when trying to find out what type of activity is appealing and effective to the user, because it is difficult for these people to attend and/or endure multiple trial sessions. Ideally, the content customisation should be achievable by a person without specialised skills, perhaps after short initial training. Most software used in this context is either not customisable at all or requires specialised skills and software (8, 9). Also, communication between the users (both therapists and their patients) and the engineers providing support is difficult; it is often easier to show how the idea should work than to describe it.

These issues indicate the need for a simple and readily available software prototyping and testing platform. To satisfy this need and to demonstrate the possibilities available in the off-the-shelf free software, we propose a rapid prototyping approach using the Second Life® virtual world.

Testing platforms

Second Life® virtual environment is an online persistent world, with the users connecting to it using specialised software (free and open source client). The major feature that enables us to use Second Life® as a testing platform is the fact

that the entire virtual world is user-built with simple tools provided directly to the client. Clicking and dragging the mouse can build non-interactive content. Interactive content can be obtained using the built-in scripting language. Furthermore, a lot of premade material can be obtained easily either for free or for modest payment.

By contrast, Second Life® has also significant technical shortcomings, limiting its usefulness mostly to prototyping and situations where a tightly controlled environment is not absolutely necessary, and occasional technical glitches are tolerable. Most of the problems stem from the fact that the system is a massively multi-user application, with tens of thousands of people being simultaneously online at any given moment (10). Other users can teleport from place to place, engage a user's avatar in conversation or even attack it at any time, potentially disturbing the session. The system also suffers from chronic performance problems, especially during peak usage times, resulting in frequent outages.

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Avatar navigation and vehicle driving in Second Life®

We explored the possibilities of Second Life® to experiment with the design of an application for a child with severe motor impairment. He used two large push buttons positioned on each side of his head (JoyBox3) to play a motorcycle simulation game. Observations indicated a mismatch between the required game input control movements and his motor skills (mainly reaction time problems) that meant he hit obstacles. The free open spaces of Second Life® do not have these problems, and it was easy to find an island with a lot of interesting things for a child to explore.

Although it was appealing at first to let him fly freely (as avatars often do to travel faster), the full control of the flying avatar requires at least three degrees of freedom (forward, side and vertical), thus necessitating six buttons or a regular game-pad. To constrain the number of degrees of freedom, we looked for a vehicle steered only laterally. Second Life® allows building all types of vehicles and driving them is a popular activity; modifying the script of a jet ski to match with the binary input of the head buttons was an easy task, and the large ocean surrounding the islands made an easy playground.

Content customisation

The scenario described above allows a variety of options for adaptation, depending on the needs, skills and interest of the user. For example, the driving can be made more or less difficult by swapping the vehicle for another one, with different characteristics (such as a scooter or a sports car). Obstacles, such as traffic cones or boxes can be easily added or removed or the track redesigned. Competitive racing with family, friends or other users in the same virtual environment is possible without any extra effort. A non-technical user can do all this after a short demonstration.

Despite the built-in tools being somewhat primitive, a lot can be built in a short time with little effort – a valuable feature for building quick prototypes for testing various approaches or to adapt the environment on-the-fly, depending on the immediate needs.

Discussion

We have been intensively presenting our interactive perceptual control of games to a broad public. Demos were at the laboratory, major events and exhibition places. Disabled persons were involved several times to obtain a better knowledge on the adaptability of our approach and to learn what should be the next development step. What follows is a synthesis of observations and feedback we obtained.

Tests and limitations with our prototypes

The examples presented for hardware prototyping required minimal programming. The level required of a programmer is equivalent to a Bachelor student in computer science. Regarding electronics, only our homemade solution for the accelerometers required minimal engineering, but those can easily be replaced with, e.g., Wii controllers. The software prototyping presented is, as stated, approachable to any computer users, but more can be done with computer science experts.

Compared to the camera interface, the accelerometer based system offers an increased intuitiveness in control owing to a decreased latency and the ability to brake (and thus make sharper turns). In addition, lighting is not a prerequisite for this interface. By contrast, the camera does not require a player to wear anything and avoids the encumbering cables. A wireless version of the accelerometer device or the use of Wii controllers would offer a good compromise.

The learning curve to play the penguin game was negligible with any of the interfaces and often people would ask to play another level more challenging. In a further experiment, we tested the ultrasonic Soundbeam device with a profoundly disabled young adult controlling via head movement. Although she was unable to speak, her two helpers interpreted that her communication was of being very excited and happy at having fun. She continued playing until exhausted.

Feedback from the Scandinavian Health and Rehabilitation exhibition 2007–2008

To obtain initial feedback on our approach from rehabilitation professionals, we presented the concept at the "HEALTH and REHAB Scandinavia" exhibition in 2007 and 2008. This annual international Congress is organised in Denmark by leading Scandinavian organisations for disability, healthcare and rehabilitation. Attendees include healthcare professionals, institute leaders, as well as students and teachers from related fields. End-users and families also attend. Our stand was set up for live demonstrations of our rehabilitation games. To demonstrate the flexibility of the camera interface, we also borrowed an exercise ball commonly used in physiotherapy; subjects sitting on the ball could then play while training

strengthening of the lower back, waist and hip regions – as confirmed by visiting therapists.

Unanimous positive feedback was received and the long line of people waiting to try the system was an indication of the interest raised. The fact that people asked to purchase it shows that our prototypes looked effective enough to be usable. It was also observed that therapists would often test the game and communicate to their colleagues on how it would be suitable for use by a certain person in their care. This selective referencing to people with impairments at their institute was interesting as they visualised that person in the game scenario and placed themselves into that role.

Many of the physiotherapists excitedly speculated to us the possible benefits such as eye-to-hand coordination, concentration, balance training, proprioception training, general lower-upper limb coordination, and more. This was rewarding as insight from such professionals inspires improved designs addressing issues that non-healthcare professionals such as ourselves can only speculate upon.

Conclusions

The examples presented in this paper typify our approach towards targeting optimising of player experience through adapting interfaces or content to match needs, preferences and abilities. It also illustrates how we have attempted to approach one of the current problems that we see between the commercial gaming solutions and the specific needs for rehabilitation training or people with disabilities.

We can conclude that existing software and hardware technologies can provide professionals and educators with new opportunities for a cross-disciplinary user-centred design of rehabilitation applications. Software and hardware prototyping can be greatly reduced by adapting off-the-shelf open source solutions. The integration of devices from the virtual reality technology is another direction of development that can be supported by open projects such as VRPN (11).

Our approach has exhibited opportunities to improve the dialogue between the various associated disciplines. The confrontation to various interaction devices and paradigms should develop therapists' awareness to the possibilities of new technologies, and raise new ideas for psychotherapeutic training. The creation of libraries of adaptable input devices alongside adaptable content would be optimal to suit preferences, desires as well as the physiological or psychological profiles. If realised, such an open platform could become an evolving vehicle for openly sharing interdisciplinary and multidisciplinary knowledge alongside user/expert experiences with easy (authorised) access for use.

Finally, it is obvious to us how this work illustrates potentials from increased interdisciplinary collaborations to motivate *non-formal rehabilitation* from achieving a participant flow state as defined by Csíkszentmihályi (12). We envisage a future situation where representatives from the computer art disciplines increasingly cooperate with peers from the more human/naturalistic disciplines. Thus, computer game programmers, digital artists, engineers, animators, interactive designers, audio designers, musicians, etc. should collaborate with psychologists, therapists, doctors, neurologists, as well as social educators, carers and eventually families, to address future service industry needs for disabled and older people with an aim of enhancement of well-being.

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Conflict of interest statement

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References

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1. Vincent VJ. The Mandala virtual reality system: the vivid group. In: Proceedings of VR Becomes A Business, San Jose, CA, USA. 1993:167–70.
2. Rand D, Kizony R, Weiss PL. Virtual reality rehabilitation for all: vivid GX versus Sony PlayStation II EyeToy. In: Proceedings of Disabil, Virtual Reality and Ass Tech, Oxford, UK. 2004:87–94.
3. Ijsselsteijn W, Nap HH, de Kort Y, Poels K. Digital game design for elderly users. In: Proceedings of ACM Future Play, Toronto, Canada. 2007:17–22.
4. Brooks AL, Petersson E. Play therapy utilizing the Sony EyeToy. In: Proceedings of Presence. 2005:303–14.
5. Brooks AL. Virtual interactive space (V.I.S.) as a movement capture interface tool giving multimedia feedback for treatment and analysis. In: Proceedings of World Congr Phys Ther (WCPT), Yokohama 1999. URL: http://sciencelinks.jp/j-east/article/200110/000020011001A0418015.php. Accessed June 5, 2006.
6. Brooks AL, Sorensen, C. Communication method and apparatus. Patent US6893407 Iss 17/05/2005: App 05/05/2000.
7. Bradski G, Kaehler A. Learning OpenCV: computer vision with the OpenCV library. Sebastopol, CA: O'Reilly Press, 2008.
8. Robillard G, Bouchard S, Fournier T, Renaud P. Anxiety and presence during VR immersion: a comparative study of the reactions of phobic and non-phobic participants in therapeutic virtual environments derived from computer games. J Cyberpsychol Behav 2003;6:467–76.
9. Rizzo AA, Graap K, Pair J, Reger G, Treskunov A, Parsons T. User-centered design driven development of a virtual reality

therapy application for Iraq war combat-related post traumatic stress disorder. In: Proceedings of the Int Conf Disabil Virtual Reality and Ass Tech, Esbjerg, Denmark. 2006:113–23.
10. Gaggioli A, Gorini A, Riva G. Prospects for the use of multiplayer online games in psychological rehabilitation. In: Proceedings of Virtual Rehabilitation, Venice, Italy. 2007:131–7.
11. Taylor RM, Hudson TC, Seeger A, Weber H, Juliano J, Elser AT. VRPN: a device-independent, network-transparent VR peripheral system. In: Proceedings of ACM Symposium on Virtual Reality Software and Technology. New York: ACM Press, 2001:55–61.
12. Csíkszentmihályi M. Flow: the psychology of optimal experience. New York: Harper Row, 1990.