Research in Developmental Disabilities 37 (2015) 1–8

Contents lists available at ScienceDirect

Research in Developmental Disabilities

Interactive augmented reality using Scratch 2.0 to improve physical activities for children with developmental disabilities

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ARTICLE INFO

Article history:
Received 9 October 2014
Accepted 10 October 2014
Available online 14 November 2014

Keywords:
Disabilities
Scratch 2.0
Augmented-reality
Webcam

ABSTRACT

This study uses a body motion interactive game developed in Scratch 2.0 to enhance the body strength of children with disabilities. Scratch 2.0, using an augmented-reality function on a program platform, creates real world and virtual reality displays at the same time. This study uses a webcam integration that tracks movements and allows participants to interact physically with the project, to enhance the motivation of children with developmental disabilities to perform physical activities. This study follows a single-case research using an ABAB structure, in which A is the baseline and B is the intervention. The experimental period was 2 months. The experimental results demonstrated that the scores for 3 children with developmental disabilities increased considerably during the intervention phrases. The developmental applications of these results are also discussed.

1. Introduction

These recent changes in Information and Communication Technologies (ICTs) have changed society, influencing the method people relate, communicate, work and learn (Simões, Redondo, & Vilas, 2013), real-time interactive multimedia is more popular and affordable (Hwang, 2012), thus, allowing for the use of technology for special needs (Kagohara, Sigafoos, Achmadi, O'Reilly, & Lancioni, 2012). However, one of the challenges in human–computer interactions is to design systems that are not only usable but also appealing to users (Bonnardel, Piolat, & Bigot, 2011). Augmented reality (AR), as an emerging interactive technology, has increasingly attracted public interest during the last few years (Olsson, Kärkkäinen, Lagerstam, & Ventä-Olkkonen, 2012) (Radu & MacIntyre, 2009). AR technology enables the merging of virtual objects with real objects, resulting in augmented reality environments (Trojan et al., 2013), and can be used for a live direct or indirect view of a physical real-world environment, the elements of which are augmented by computer-generated sensory inputs, such as sound or graphics (Chang, Kang, & Huang, 2013). Because in augmented reality environments both virtual and real objects can co-exist and interact in real time, the augmented reality applications are broad and the number of applications is increasing rapidly (Solari, Chessa, Garibotti, & Sabatini, 2012). The main advantages of AR applications used across different fields have been widely discussed in the literature, such as in education (Wojciechowski & Cellary, 2013), textiles (Harris,

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http://dx.doi.org/10.1016/j.ridd.2014.10.016
0891-4222/

2013) surgical interventions (Volonté et al., 2011), games, home-training system, online teaching (Andujar, Mejías, & Marquez, 2011),and learning disabilities(Chang et al., 2013). Augmented reality can lower the barrier to entry for students engaging in virtual content. The ease of interaction within AR-based experiences has already been shown by the use of virtual experiences in early school years (Bujak et al., 2013).

People with developmental disabilities experience limitations in fine motor control, strength, and range of motion, which can reduce their participation in community and leisure activities (Chang, Chen, & Huang, 2011). Custom made alternative devices for those with special needs are expensive and the low unit turnover makes the prospect unattractive to potential manufacturers (Standen, Camm, Battersby, Brown, & Harrison, 2011). Most leisure pastimes available for people with severe physical limitations are often extremely limited (Lotan, Yalon-Chamovitz, & Weiss, 2009), so are not useful for people with developmental disabilities.

Art games on console systems such as the Microsoft Xbox, Nintendo Wii or Sony PlayStation are not only for fun, but have also been applied in rehabilitation treatments, and therapeutic systems (Ding et al., 2013). Recently, many open source activities have become available, which share their programs, so users can design their own custom interfaces. This study uses Scratch 2.0, which is a visual programming environment designed at the MIT Media Lab (Resnick, 2012; Resnick & Rosenbaum, 2013) and which includes costumes and scripts. Scratch Web site (http://scratch.mit.edu) create a free online interactive community, with people sharing, discussing their programs, most important that could be designing, creating, and remixing one another's projects (Resnick et al., 2009a,b). Programming is done by inserting command blocks which form scripts that control the interactive interface. Various researchers and designers have imagined that Augmented Reality technology could be well suited for children (Radu & MacIntyre, 2009). In Scratch 2.0, video sensing has been added, and there are new camera programing blocks that allow users to create projects that react to movements in the physical world through the use of a webcam (Carini, 2012). In other words, augmented reality could be applied to this interface (Massachusetts Institute of Technology, 2013). Using the webcam effect design in Scratch 2.0 (Radu & MacIntyre, 2009), the virtual objects and related sounds appear when the webcam detects movement, thus allowing for augmented reality. Users are able to now use their webcam to interact with projects and can also create their own programming blocks in Scratch 2.0.

The advantage of this study is that is it low-cost, as only a webcam is needed for children with different needs to extend their activities.

2. Materials and methods

2.1. Participants

There were 3 participants in this study, all of them children with different developmental difficulties. Prior to the study, we obtained formal consent from their parents. This study designed individual physical activities for the different needs of the participants to enhance their body motion motivation.

Cindy, a 4-year 1-month-old female has developmental disabilities. She is able to walk by herself, but she walks slowly and unevenly. She is mildly intellectually retarded and seldom talks, she could understands basic oral instructions, the oral ability belongs to basic expression with tardy. In this case, we wanted to train Cindy's body movement abilities by stimulating her feet using an AR interactive game, which was similar to step training.

Kitty, the second participant, is a 6-year-old girl, who has severe cerebral palsy. She belongs to no oral expression. Because of her condition she is unable to stand by herself and all her limbs involuntarily twitch, so she has to sit on a customized Kinder chair and be strapped into her H-harness to remain stable. As she has weak leg movements, she is always sitting and lacks the motivation to lift her legs. In this case, we wanted to train her leg muscles and give her the motivation to move her legs and feet.

John, our third participant, is a 3-year 11-month-old boy, who has moderate multiple disabilities, weak legs and low vision. He is able to climb but is not able to stand or walk by himself, so he is always sitting, he could understands basic oral instructions and he could express what he want to do. He is able to lift his legs and feet, but lacks the initiative to strengthen them.

2.2. Apparatus, material and setting

The interactive feedback was designed using Scratch 2.0 software. The original design was a video pop balloon game, from an original program by Christine Garrity. With the Scratch 2.0 added webcam support, she designed an intuitive interactive game. Using a webcam, users are able to see themselves and the balloons on the screen. As the balloon changes position, the user uses their hands (or any part of their body) to move in the air. When the body movement is in the sensor area (in the original design it is in balloon area), the screen shows a punctured balloon. The game's design is similar to the Xbox, and is fit for normal children. However, in this study pretest, as the participants all had developmental disabilities, the knowledge required exceeded their cognitive load, so at the beginning, the participants always approached the screen with the intention of touching the balloon. Therefore, this study revised and remix the program, that make the virtual stimulus object always appear in the same position, which overlap the real object on the screen, when the participant touch the real object, it's means also touch the virtual stimulus object, and then the participant could got the feedback, so it could be used for special needs participants. To do this, we put a real brick on the floor, and focused the external webcam toward the real brick, making