Physical and Cognitive Training of Children with Down Syndrome Using Video Games

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Abstract. In this study, a video-games based training platform that aims to provide user-specific physical and cognitive tasks is developed so that children with Down Syndrome can continue their training autonomously at home. For this purpose, a set of video games which addresses physical activities (balance and feet coordination) and cognitive tasks (abstraction, memory and word-forming) are being designed and implemented. During the gameplays, center of pressure, brain activity and electrodermal activity measurements are done to identify the specific needs of the child and to tailor a training programme that addresses these difficulties.

Keywords: Down Syndrome · Serious games · Video games

1 Introduction

Down Syndrome (DS) is a genetic disorder usually stemming from an extra chromosome 21 [1]. Children with DS in general has physical (posture, balance, motor skills) and cognitive (language, arithmetic, short term memory) impairments and to overcome these impairments and to make them become autonomous adults, special education and exercise programmes exist [2–5]. However, these programmes are being held with therapists during the day and there lacks a training program that is tailored for the necessities of the kid which he/she can continue to perform at home, autonomously. The purpose of this study is to provide kids with DS a specialized physical and cognitive training platform which is composed of video games. This platform is customized with sensors and measures the requirements of the child and creates a training program to handle those requirements. Besides, given that video games create a sensation of flow [6], the training programs aim to motivate the child to follow the training program for a longer period of time and with enthusiasm. In this ongoing study, physical and cognitive video games are being developed. The following sections describe the methodology (game descriptions and instrumentation), data acquisition, evaluation and future work of the study.

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2 Methodology

In this section, proposed video games for physical training, for cognitive training and the instrumentation used, are presented in detail. The games are developed with Unity3D game engine given that it provides multi-platform support and a powerful layer to handle multiple devices.

2.1 Video Games for Physical Training

Hopscotch Game (Feet Coordination): Hopscotch is a game which is played with Wii Fit. The user is guided with the numbers in order to understand on which square to put the foot on. While one foot is put on the correct square, the other foot has to be removed from the platform, which requires the user to be in balance with only one foot. The purpose of the game is to enable feet coordination, to pay attention to the correct foot and to be fast while doing the exercise. As the difficulty of the game increases, the directions of the movements are not only limited to the right or left side, but to forward and backward as well. Besides, the frequency of the numbers, the duration of staying on one foot increases as the difficulty of the game progresses (Fig. 1).

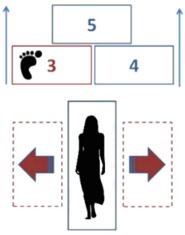

Fig. 1. Gameplay representation of the Hopscotch game.

Kite Game (Balance): In this game, the user sees her silhouette as a kite. The purpose of the game is to stabilize the kite in a given area and stay still during the task. The game is played with Wii Fit and the direction of the kite changes due to the center of pressure. When the user is in balance, the kite remains still, but when the center of pressure is moved to right or left, wind appears on the direction of the center of pressure and the kite moves to that direction as well. As long as the kite is not met to the center, the user loses points. To ensure safety, the screen is divided into three different areas and when the user starts to enter the risky areas, the game stops. When the difficulty of the game increases, the width of the areas diminishes and extra factors such as birds and clouds enter the screen and try to distract the user.

2.2 Video Games for Cognitive Training

Word Tetris (Attention): As in the traditional game of Tetris, there are different types of blocks that move on the screen. The main difference is that, each block has letters on

them and the main purpose is to form a meaningful word fitting the blocks to the correct place. Depending on the level difficulty, the complexity of the words increases and the blocks move faster. On the right side of the screen, there is a hint of the word to be formed. The main purpose of this game is to make the child perform attention tasks and to increase the word memory [7] (Fig. 2).

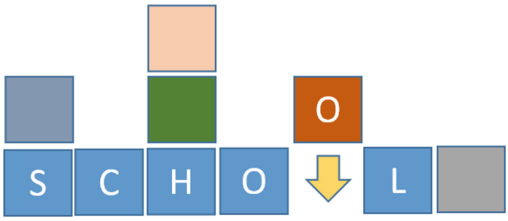

Fig. 2. Gameplay representation of the Word Tetris game.

Lego Game (Attention, Memory and Abstraction): At the beginning of the game, the user chooses a picture of which a lego-like structure is to be built. The chosen image is mapped to a 3D empty lego-like structure and the user is expected to put the correct colored pieces in order to complete the structure. During the game, the picture disappears to challenge the user to remember the colors and the picture reappears randomly again to remind the user of the chosen image. Depending on the difficulty level, the complexity of the proposed images changes and the 3D structure is seen from a different depth. While in the first levels, the camera angle is the same as the picture's angle, when the difficulty increases, the camera viewpoint also changes. This challenges the user to map the 2D image to a 3D structure and to envision the image in 3D. When the colors of lego blocks do not match the given part of the image, the user loses points [6].

2.3 Instrumentation

- **Microsoft Kinect:** In the games targeting physical training, Microsoft Kinect is used. Users interact with the game via their avatar and their movements are reflected on the game in real-time. The ideal range of motion data is set due to the therapists' suggestions and when the children are about to overdo that range, the game is stopped in order to prevent injuries. Feedback regarding the risky movements is displayed on the screen.
- **Wii Fit:** For the balance-oriented games, users use Wii Fit and right and left foot movements are recorded accordingly. The gameplay depends on the correct selection of the foot for a given amount of time.
- **BioSignalsPlux EDA Sensors:** During the gameplay of cognitive games, electrodermal skin activity (EDA) of the user is recorded so that the tasks which overwhelm the user most are recognized. These data are used to create a tailored training program for the specific necessities of the user.

- **BioSignalsPlux EEG Sensors:** During the gameplay of cognitive games, neuroactivities of the user are also recorded to understand which brain waves are activated and which cognitive tasks require more time to be completed. Combined with the data of EDA sensors, these data provide a clearer picture to design a specific training program for the user.

3 Data Acquisitions, Evaluation and Future Work

The proposed work is still in progress and the video game set will be enlarged so that the physical training set will include three games and the cognitive part will include four games in total. So far, usability tests with healthy users have been started for the games presented in this work and the same procedure will be applied to the new games as well. Then, the games will be tested with children with DS and the outcomes of the training will be monitored using biofeedback sensors and questionnaires. At least 10 autonomous DS children (7–17 ages) will be recruited and the ethical permission procedure has already been completed.

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