DEVELOPMENT AND EVALUATION OF VIDEO GAME FOR LEARNING CAPABILITIES IMPROVEMENT OF ADHD CHILDREN

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Abstract – Persistent and severe impairment of psychological development resulting from a high level of inattentive, restless and impulsive behavior is classified according to the fourth Diagnostic and Statistical Manual of Mental Disorders (DSM-IV) as attention-deficit/hyperactivity disorder (ADHD) and according to the Tenth International Classification of Diseases (ICD-10) as hyperkinetic disorder (HD). ADHD is associated with poor grades, poor reading and math standardized test scores, and increased grade retention in schoolchildren.

Besides medical treatment of these children, biofeedback is recognized as an internationally recognized alternative therapy for ADHD children nowadays. Moreover, there are many studies regarding the influence of the video games on ADHD children. Although in many cases the opinions and findings are contradictory all of them are concluding that ADHD children could benefit from properly designed video games that are played according to a specific protocol and under supervision of teachers or parents.

This paper presents a developed video game that aims at helping ADHD in improving their learning capacities. It consists of several different modules and levels. The design and development of the game as well as its architecture are presented in this paper. The game has been experimentally evaluated on ADHD children. The results of the evaluation are also presented in the paper and conclusions are drawn.

I. INTRODUCTION

Among all neurobehavioral disorders, Attention Deficit Hyperactivity Disorder (ADHD) is the most frequent one diagnosed in childhood. There is estimation that it is affecting 5.29% of children worldwide [1]. Childhood ADHD has been studied intensively in the last decade. One very comprehensive theory focusing on executive functions (EFs), such as working memory (WM), Visuo-spatial WM, response inhibition, and temporal processing, is developed by Barkley and it assumes that self-regulation deficits are at the core of the ADHD syndrome.

Another theoretical approach to ADHD claims that low level of reinforcement and motivation, have huge impact on performance deficit in ADHD children.

Various studies have shown that computerization of tasks can have positive impact on increasing ADHD children's interest and motivation. This is mainly because computer programs have clearly defined protocols and scenarios, evidenced goals and objectives, and immediate feedback on the performed actions. Moreover, if the computer programs are created in the form of interactive video games could attract the children's attention, concentrate for longer period, and behave less impulsively.

In contrary, the literature evidences cases in which the effect of video games has negative influence on children [2-4]. The main drawback of these studies is that they are not considering the specificity of the video games. Most of them did not even specifically examine the video games and their details, but are classifying them as a subset of television or Internet use. One extensively studied area is the content of video games and their relationship to subsequent aggressive behavior in children [5, 6]. Other case reports have documented correlation between video games with lower academic achievements [7]. However, the latest should be analyzed very carefully, because the main reason for the lower academic performances might not be caused by the video games themselves, but it might be a result of a very long time spent playing video games instead of reading and curriculum-related academic study.

Considering the previous, one may conclude that carefully designed and developed video games that are played according to a specific protocol and under supervision of teachers or parents could be beneficial.

Therefore, ADHD children might benefit from video games designed in such a way that their gameplay gradually stimulates the players to perform more accurate and precise actions to make accurate and more demanding decisions and actions at higher levels of the game i.e. at higher speeds. Consequently, it should increase working memory spans, it can provide pro-social training and can offer positive neurological changes in the brain system.

This paper presents a developed video game that aims at helping ADHD in improving their learning capacities. It consists of several different modules and levels. The design and development of the game as well as its architecture are presented in this paper. The game has been experimentally evaluated on ADHD children. The results of the evaluation are also presented in the paper and conclusions are drawn.

II. RELATED WORK

In general all computer video games related to ADHD children could be classified into two big categories i.e. diagnosis and evaluation games and treatment/therapeutic games. Second group is the main subject of interest in our study. The first therapeutic videogame was developed by Pope and Bogart in 1996, and is a modification of software developed by NASA for the training of pilots, based on the progressive adaptation of a computer programme to user attention levels [8].

Latter on in 2001, Pope and Palsson have developed a methodology, which was combining commercial off-the-shelf videogames with the use of EEG measurements. It was aimed as an intervention tool for the improvement of ADHD children [9].

Commercially available videogame "The Journey to Wild Divine" is a simulation in which virtual characters in the 3D virtual world are controlled through biofeedback. Game control is based on relaxation techniques, which are very useful in the regulation or monitoring of hyperactivity and impulsivity in children and adolescents with ADHD [10].

Statements et al. [11] have conducted a comprehensive study in which ADHD children were involved in a virtual helicopter game. In this game, the children were given different tasks to control the helicopter using MRI images which were used to measure the activity on certain areas of the brain.

3D video game Self City [12] was oriented towards the improvement of social skills in adolescents diagnosed with ADHD and/or Pervasive Developmental Disorder. In this game, the players were faced and challenged to cope with several different situations.

Personal Investigator (PI) is a 3D game specially designed to help adolescents with disorders with Focused Solution Therapies—SFT and therapy games. It was initially tested with 4 adolescents with positive results [15].

Play Mancer is another serious videogame developed for therapy of various disorders but also including ADHD [13,14].

Besides these, various other commercial videogames were adapted to ADHD therapy program such as Robomemo (CogMed, Stockholm, Sweden) [16], the Supermarket Game and CyberCruiser which have been tested with over 50 users.

De La Guia et al. [17] present collaborative games developed in a novel multi-device environment applying the distributed user interface paradigm together with tangible user interfaces (TUIs). The aim of this game is to improve memory and attention in children with ADHD.

Pier et al. [18] developed computerized executive functioning training with game elements aimed at enhancing self-control. They have experimented and evaluated the transfer of training effects to daily life, and enhancing motivation through more gaming elements. The presented results in their study are promising.

Finke et al. [19] have investigated the attitudes and opinions of parents having children with ADHD and ASD disorders, which are playing various video games. They concluded that parents indicate that video game play was positive for their children with ASD, particularly if they believed the games were having a positive impact on their child's development.

Brezinka [20] has investigated the influence of the game Treasure Hunt that was developed to support cognitive behavior therapy with children who come into treatment for various mental health problems. She is mentioning the how important is to know the opinion of therapists on the impact of the game on treatment success. The 42 therapists treating the 218 children reported that the game was helpful and it was also used as reinforcement, enhanced child motivation, structured therapy

sessions and strengthened the therapeutic relationship with the child.

Ferguson et al. [21] in their study are examining the possibilities of applying the video games (Wii Sports) to develop social skills i.e. "good sportsmanship" in children diagnosed with ADHD. They are concluding that video-game technology could be part of social skills intervention programs.

III. VIDEO GAME DESCRIPTION

In this study, an interactive closed loop game was created. The game was based on Microsoft Kinect (Figure 1) sensor, which is providing the input to the game. The main components are the RGB camera, depth sensor and microphone array. The depth sensor combines an IR laser projector with a monochrome CMOS sensor to get 3D video data. Besides these, there is a motor to tilt the sensor array up and down for the best view of the scene, and an accelerometer to sense position.

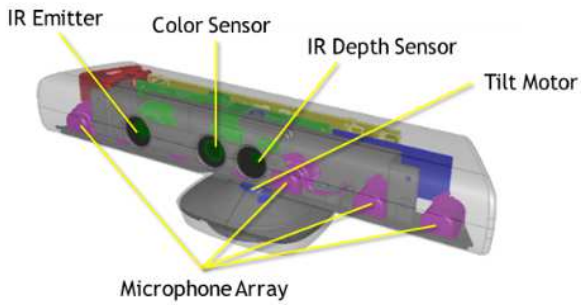

Fig.1. Microsoft Kinect Structure

The architecture of the game developed is presented in Figure 2.

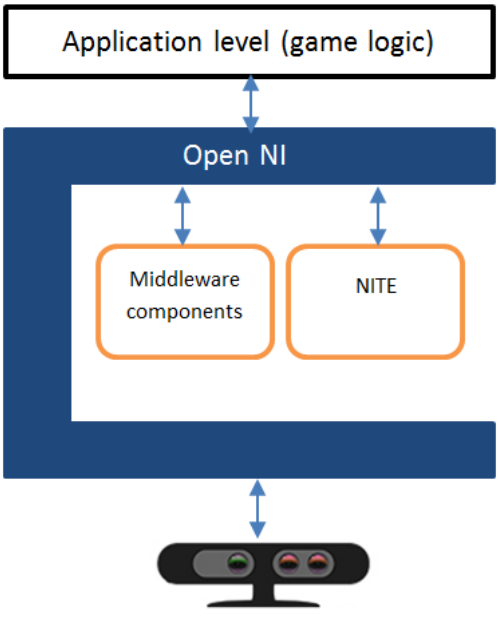

Fig.2. Application Architecture

The game is played in a way that the child is placed in front of a big screen (can be TV set or projector) and in front of the Kinect device. Typical game set is depicted in Fig. 3. The application using the device input is capable to detect the child's body and characteristic points. All the characteristic points that could be detected are presented in Fig. 4.

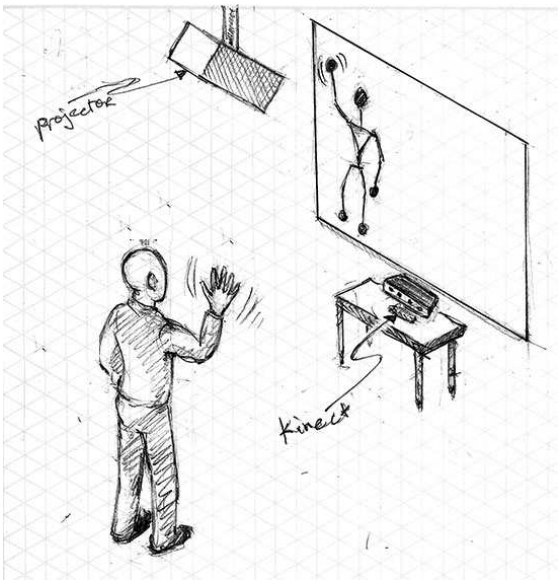

Fig.3. Typical game set

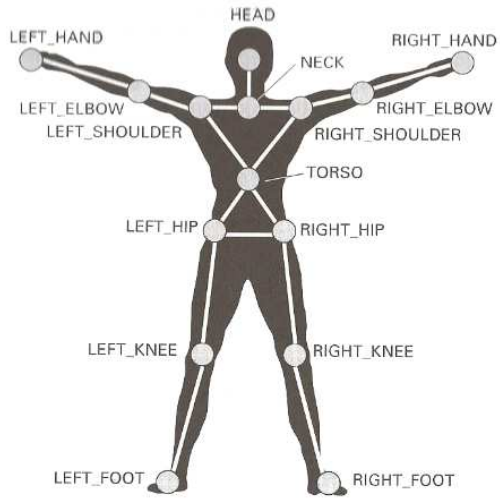

Fig.4. Key points on human body that could be detected and used at application level

By detecting the body's key points the application is capable to detect the actions the player performs and track them. Moreover, some of those points i.e. their position could be used as an input to the game (i.e. use them as a mouse pointer).

This way the child through its movements can command the game and interact with the virtual 3D world that is displayed on the screen in front of him.

In our study, the game is composed of two different modules. One of them was aimed at stimulating the child to perform more accurate and precise actions at higher at higher speeds of the game. The second module aims at helping the child to train his working memory spans and spatial orientation.

In the first module the child is controlling (using his hands) one fish which is swimming in a water tunnel. The aim is to reach the end of the tunnel. The problems the child is facing on its way along the tunnel are obstacles showing randomly that should be avoided. When the obstacle appeared on the screen, an audio stimulus is also presented to the child as an additional input. Moreover, the swimming speed is increasing as the game proceeds i.e. the fish is going towards the end of the tunnel, and the tunnel is getting narrower.

The second module is presenting matrix of various number of boxes hiding pairs of different images. Some of the images are very similar to each other. The player in each move is opening two of them and tries to pair the exact images. As the game progresses, the number of boxes is augmented.

Upon each well-completed move in both modules, the player is awarded by collecting golden coins, which at the end are compensated with real fruits.

IV. EVALUATION AND RESULTS

Ten children between 6 and 12 years (6 male and 6 female) diagnosed with ADHD, three teachers from different primary schools attended by these children and four therapists were involved in the evaluation study.

The evaluation was performed in three phases. The first one is regarding explanation of the user interface to the children and calibration of the system. In the second phase the children were given a practicing session. The third phase is regarding the evaluation itself. The evaluation phase was lasting for four weeks. During this period, each of the children was playing the game for 35 minutes three times a week under supervision of the therapist. For each gameplay, therapists were annotating the impressions of the children collected by an interviewing methodology. During the evaluation period, also the teachers were conducting a special diary regarding the children's achievements at school and their behavior.

At the end of the evaluation period, both teachers and therapists' opinions were collected. All of them have reported important progress. Namely, working memory has been significantly increased, number of forgotten tasks at school has been significantly diminished, and time for which the children stayed calm and focused on their tasks has been almost doubled after the evaluation period.

V. CONCLUSION

This paper presents a developed video game that aims at helping ADHD in improving their learning capacities. It consists of several different modules and levels. The design and development of the game as well as its architecture are presented in this paper. The game has been experimentally evaluated on ADHD children. The results of the evaluation are promising and are showing improvements of the children performances.

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