Improving the Learning of Child Movements Through Games

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Abstract. A Developmental Coordination Disorder can be identified when children show motor skills either below the expected levels considered adequate to their physical age or the opportunities provided for their learning. This problem affects four to six percent of school-age children, meaning that, from a very early stage of their life, they have several difficulties to adapt to the daily needs. In order to reduce the impact caused by this disorder, a team of therapists from "*Centro DIFERENÇAS – Centro de Desenvolvimento Infantil*" collected a wide range of exercises that allow the stimulus of several motor areas, including both the Gross and Fine Motor Skills. However, the application of this therapeutics is restricted to regular appointments. Since the motor stimulus, in order to be effective, need continuous application, it was found to be necessary to have a tool that in a practical and affordable way, fulfill this need. Therefore, the proposal presented in this article describes the creation of a systematic collection of such exercises in a friendly user manner for the children to be able to exercise elsewhere.

Keywords: Developmental Coordination Disorder · Serious games · Kinect Sensor · Natural user interface

1 Introduction

A Developmental Coordination Disorder can be identified when children show motor skills either below the expected levels considered adequate to their physical age or the opportunities provided for their learning. It is estimated that the number of children affected by this disorder ranges from four to six percent of the children at school age. This disorder is one of the many areas that therapists of "*Centro DIFERENÇAS – Centro de Desenvolvimento Infantil*" focus on. The DCD requires regular stimulus, meaning the children must do regular exercises, despite many of these exercises are restricted to books that the children's parents do not have neither the access nor the time to search for them. In order to provide both the correct exercises and to continue

the work done on the regular appointments, the therapists of *Centro DIFERENÇAS* collected a wide range of exercises from the books [1, 2], dividing them by area, category and age. This information was transferred to an application so it can be available to anyone in a practical and affordable way.

1.1 Developmental Coordination Disorder

The Developmental Coordination Disorder is a neurological disorder defined in the Diagnostic and Statistical Manual of Mental Disorder, Fifth Edition (DSM-5) [3]. Here were defined a set of parameters that have to be found in children in order to diagnose them with DCD. These parameters are:

- The learning and execution of coordinated motor skills show to be below the expected level for age, given opportunity for skill learning;
- Motor skill difficulties significantly interfere with activities of daily living and impact academic or school productivity and vocational activities, leisure and play;
- Onset is in the early developmental period;
- Motor skill difficulties cannot be better explained by intellectual delay, visual impairments or other neurological conditions that affect movement.

In the past 40 years, many treatments were developed, roughly divided into two categories: process-oriented and task-oriented treatments. The process-oriented treatments that focus on reducing the deficit of the body structure responsible for the motor skill problems still, this approach is not the recommended by the European Academy of Childhood Disabilities (EACD). The recommended approach is the task-oriented treatments that by defining a set of tasks that one child has difficulties with, divide them into a set of objectives that have to be accomplished and, according to the child's progress, adapt the difficulty of the exercises have better results [4].

1.2 Serious Games

Serious games are a set of software or hardware solutions that are designed to, with the use of games, teach their players. Two of serious games' areas are games for health and exergaming, being the first one related to the improvement of the health of a child and the second one related to games where the exercise is required to play them. Being the solution developed both a tool for the parents to guide them when doing the exercises with their sons and one game that needs movement to be played, these two categories are the ones that this solution can be put on. The application of serious games was studied in [4] with some promising results. Despite the effectiveness of serious games, the traditional approach of task-oriented process is more effective. Because these games cannot replace the physical or occupational therapy, the solution developed was divided in two to provide both the traditional task-oriented exercises and the practice of a game to improve the motor skills. Some serious games were previously developed by students of Faculdade de Ciências e Tecnologias with promising results, examples of them are: [5] where is described the implementation of a serious game to teach medical students to carry out neurological examinations and [6] where was constructed a tool to teach non-deaf people sign language.

2   State of the Art

Some games have been developed to provide solutions in this area. Examples of them are the "Uni_Paca_Girl" using the Kinems approach (the use of Kinect Sensors to empower children to reach their full potential) [7] and Kinect-o-Therapy [8].

The "Uni_Paca_Girl", later renamed to "Walks", was developed in 2013 and is similar to the "Pacman" game, requiring the movement of the users arm to move the character along the track avoiding both the margins and other obstacles.

The "Kinect-o-Therapy" was also developed in 2013 including four games: Shoulder Exercise, Balloon Pop, Path Follower and Play Along, aiming to develop four different areas of motor skills. The movements of the hand also control the navigation in this software.

Despite the most common hardware found at educational centers be the Wii console, the Kinect Sensor is easier to play with, this is due to the requirements of Wii (the need to use in one hand one controller with buttons and, at the same time, practice body movements). As many of DCD's children have hyperactivity disorder or attention deficit, they tend to cheat when using this type of hardware. As the Kinect Sensor is based only on body movements, solutions that use this sensor are expected to be better.

3   "Aprender os Movimentos" (Learning to Move)

The application developed was named "*Aprender os Movimentos*" (Learning to Move), divided into two complementary parts: one search motor that allows the access to the information gathered by the *Centro DIFERENÇAS* therapists and one game that aims to develop the eye-hand coordination, weight transfer, reflexes and locomotion, achieved with a game of catching multiple balls in different positions.

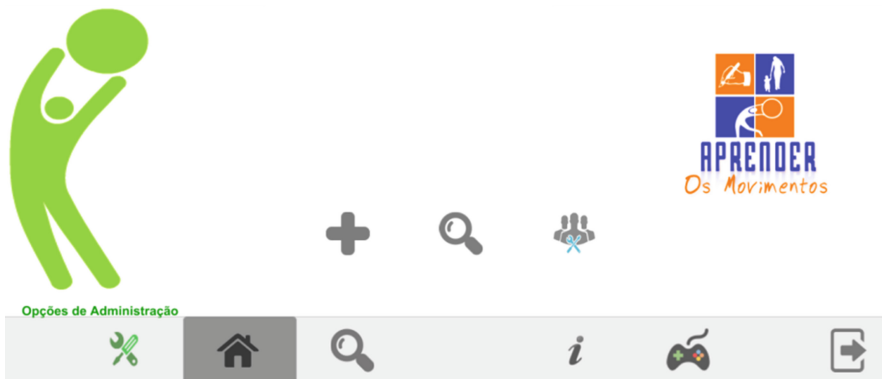The main screen of *Aprender os Movimentos* application is shown in Fig. 1.

Fig. 1.   Application main screen

As can be seen in the figure shown below, there are multiple options available to the user. The grey bar at the bottom displays all the options available to common users but the options at the middle of the screen are only for administrators. When the application is opened, it reads a unique number of the machine who runs it, consulting the file with all the user's data, the application automatically distinguishes from a common user and from an administrator. However, if the unique number wasn't found in the file, it is necessary to fill a new user page information.

As the first part of the application is an information database, it was required to develop a method to transfer the information in papers to a digital support. Analyzing the documents the therapists gathered it was possible to identify a set of fields that were common to all exercises. These fields were:

- **Area** – Identifying the area that the exercise will stimulate, it can be either Gross Motor Skills or Fine Motor Skills;
- **Category** – Divided in a set of sub-categories according to Gross Motor Skills and Fine Motor Skills. For Gross Motor Skills, the categories are: Reflexes, Weight Transfer, Locomotion and Reception and Propulsion of Objects; for Fine Motor Skills, the categories are: Grasp, Manipulate, Coordination Eye-Hand and Dexterity;
- **Age** – As not all exercises are adequate to any age, it was required to specify the age, in moths, that should be appropriate to each exercise;
- **Materials** – Identifying the material needed to do the exercise;
- **Description** – Presents generically what will the exercise be about;
- **Objective** – Specifies what are the objectives to be achieved by the exercise;
- **Image** – In some exercises, shows how some objects are supposed to be placed;
- **Strategies** – From one to eight, indicates step by step how the exercise is supposed to be done. As some strategies may require different images or videos, it is also allowed the association of one image and/or video to each strategy.

After filling all the required fields, they will be converted to an eXtensible Markup Language (XML) file.

It was also developed a search engine/browser that uses the area, the category and the age to search through the XML file. As the videos were recorded using either blue or orange shirts and background, it was essential to change the search bar to match this colors, as can be seen in Figs. 2 and 3.

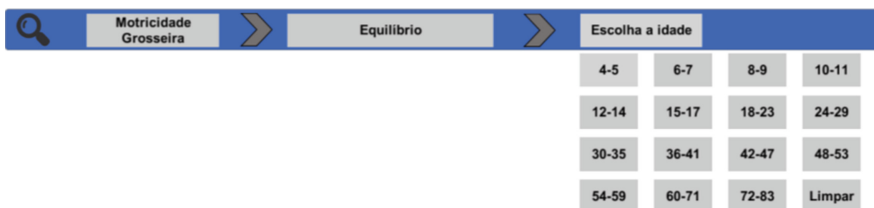As soon as all search fields are selected, the results are shown as seen in Fig. 4, including:

**Fig. 2.** Gross motor skills (Color figure online)

Fig. 3. Fine motor skills (Color figure online)

- The main objective to be achieved;
- The materials needed to practice the exercise;
- A set of sub-objectives to be fulfilled;
- Images or videos explaining the exercise steps.

To prevent the need of filling all the fields if some information changes, it was developed a screen, similar to the Fig. 4, that allows changing the field's information individually, saving automatically on the XML file.

The second part of "*Aprender os Movimentos*" (Learning to Move) application is the game "*Apanha-me se puderes*" (Catch me if you can). This game, as the presented in the state of the art chapter, uses one Kinect Sensor to track the user's body. Using a Software Development Kit (SDK), the user's joints are converted into 26 spherical objects. Being the objects the main resource of Unity3D, it is important to do this conversion otherwise, it would not be possible to attach colliders for collision detections, retrieving its special coordinates or change its graphical properties (colors, materials and so on).

"Apanha-me se puderes" is then a game that, with the use of two colored targets (green and blue) stimulates the shoulder abduction, lateral walking, jumps and cross-arm movements. This variety of movements goes further than the ones found in the state of the art applications however, follows the same thoughts. The spherical
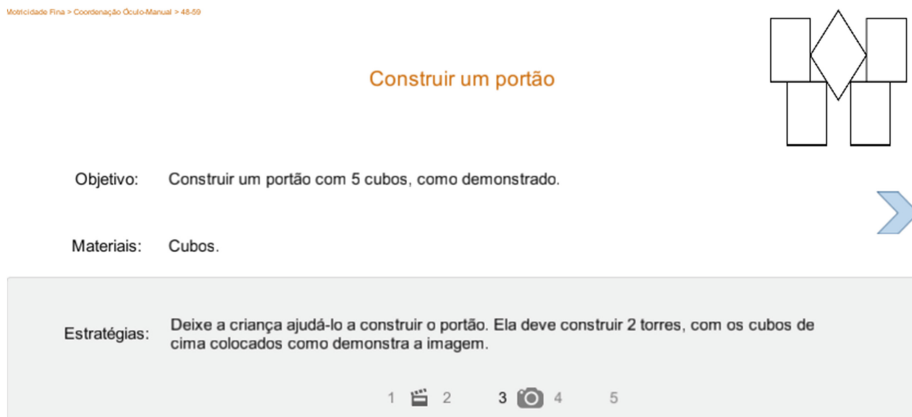
Fig. 4. Results of searching

objects of the hands (in the user skeleton) have the same two colors (green for the left-hand and blue for the right-hand). If the left-hand (blue) touches a green target, one life is lost, on the contrary, if the left hand touches a blue target, points are added. The objective of the game is to gather the most points possible in 3 min without losing all the three lives.

In the Fig. 5 it is possible to find both the avatar that the user controls (represented by the 26 spherical objects forming a skeleton) and one target (inside the number 1 area). The possible locations where the targets can be spawn are represented by the areas 1, 2, 3 and 4. These areas were found to be the ones that require some movement by the user to reach the targets, however these movements do not need to be highly difficult.
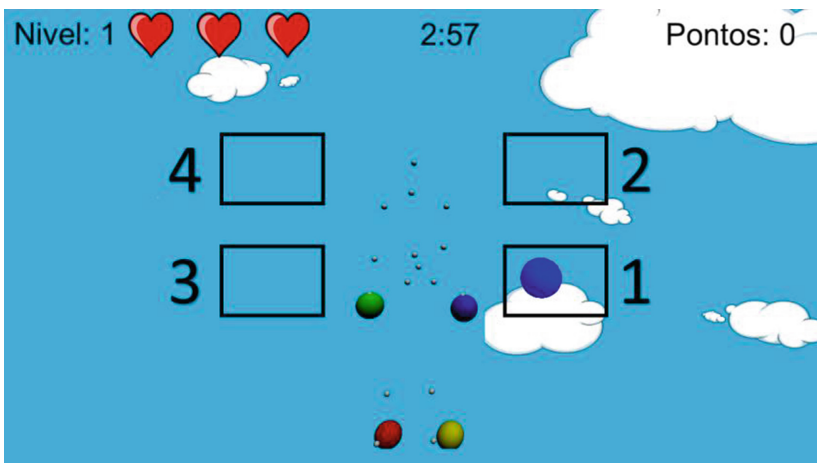

Fig. 5. Game environment (Color figure online)

The game is divided into five levels, each one more difficult than the previous. At Table 1 it is intended to demonstrate the behavior of the game. The "Blue target" and "Green target" fields represent the areas where the corresponding targets can spawn, the "Sequence" represents the sequence in which the targets will spawn if correctly hit, and the "Position" identifies if the target will spawn always at the same spot (Fixed) or if it can be random within the defined areas (Variable).

A user's page was also developed, here each user of *Aprender os Movimentos* can see what exercises are supposed to be done according to the time planned. Each time the player plays the game, the application will save the data retrieved from the try allowing the track of user's progress.

Table 1. Game behavior

Level	Blue target	Green target	Sequence	Position
1	1, 2	3, 4	1->2->3->4	Fixed
2	1, 2	3, 4	1->2->3->4	Variable
3[a]	1, 2	3, 4	1+3->2+4	Variable
4	1, 2, 3,4	1, 2, 3, 4	Random	Variable
5[b]	1, 2, 3, 4	1, 2, 3, 4	Random	Variable

[a]The + (plus) signal represents the targets spawn simultaneously.
[b]In this level, opposing to the 4th level, it is possible to spawn two targets at the same time.

4 Results

This research initiative took place within the Social Tech Booster (http://stb.uninova.pt) branch from the Robotics and Industrial Complex Systems (RICS) research group, trying to solve a concrete problem and pursuing the real deployment of the result, as illustrated in [9].

This application currently sums 284 different exercises saved in the XML file. The filling of this data file was divided by five assistants resulting in five separated files. After all files were completed, the information was grouped in a single file. During the implementation of the application, the structure of the file changed several times, however none of the information already saved was lost. This adaptability shows the possible scale-up of this application to whatever number of exercises needed to be included in it.

DCD's players due the time they need to be familiarized with the software and hardware did not yet test the game, however, it was presented to 20 non-DCD player's requesting critic opinions. The majority of these players confirm the utility of this game in the stimulation on motor skills. In addition, they suggest the implementation of rewards purchases with the points gathered and the implementation of new levels with higher difficulty objectives to stimulate other motor areas.

During the playtime of non-DCD player's it was possible to observe that they require a lot of movements to hit the targets but at the same time they really seem to enjoy the game proving the concept of serious gaming.

5 Conclusions

Serious games are a powerful tool that provides a fun way to learn new skills. The Developmental Coordination Disorder was proved an area where these games can be helpful despite the reduced existing solutions. Studies suggest that the best way of acquiring motor skills is to conciliate the traditional therapy with fun games however, the solutions that were found in the research done only focus in the game's area. This

way, this article proposes one application that combines both the information available in the therapy centers and one fun game that stimulates several motor skills.

Despite the lack of results with DCD users, the non-DCD player's results proved to be promising.

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