just Physio kidding - NUI and Gamification based Therapeutic Intervention for Children with Special Needs

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Abstract. This paper presents the "just Physio kidding" approach, which intends to improve the engaging qualities of therapy programmes towards children with special needs, mainly with cerebral palsy, spinal muscular atrophy, or developmental delay. Therefore, "just Physio kidding" intends to address both physiotherapy and cognitive stimulation therapy. The system is functioning as a complement to the work of therapists, with and without their live supervision. It is part of a project with the aim of developing software based on the concept of personalized serious games for rehabilitation. The paper presents the concept and the prototype behind "just Physio kidding".

Keywords: Natural User Interface · NUI · Physiotherapy · Serious games
Children with special needs · Cognitive stimulation · Cerebral palsy
Gamification

1 Introduction and Background

Recent years have seen a healthcare community demonstrating much interest in therapy approaches based on serious games (theragames) to improve the engaging qualities of its programmes [1]. Gamification [2] can provide rehabilitation environments that can increase the motivation of patients to achieve successful completion of rehabilitation programs that can be dreary or very demanding [3]. Several projects based on theragames have appeared, which shows a wide general interest in sustaining and improving this technology towards a more versatile and wide-range therapy. The utility of this technology is demonstrated by projects in diverse areas, which for instance can work as means of increasing compliance or help patients follow through with otherwise often-repetitive therapy tasks [4, 5]. Among the theragames, exergames are a form of physical activity that requires the user to move at least a part of the body in order to interact and best experience the game. These exergames are considered active games with the goal of creating stimulating methods to maintain an active lifestyle tailored to the specific physiological and psychological conditions of patients, thus being designed

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explicitly to help them improve their physical health [6]. Exergames have been successfully applied to the rehabilitation of people with motor impairments [6].

Moreover, in the last decade, the use of Virtual Reality (VR) technologies has expanded rapidly for creating innovative tools for rehabilitation. VR-based rehabilitation uses sensing devices to capture and quantitatively assess the movements of patients that are under treatment to track their progress more accurately [7]. A 3D camera is one of those sensing devices, which combined with serious games turns out to be a perspective tool in advanced rehabilitation sessions. The development of more cost-effective devices, such as Microsoft Kinect, means that the development of Natural User Interfaces (NUI) is gaining a wider space and great importance across all fields. NUI can be seen as the ability to interact with a machine using nothing but the human body, avoiding the use of visible control elements to the greatest possible extent to ensure a more natural control. Thus, the use of Microsoft Kinect to control the games, provide feedback to patients, and even as a measuring tool, is a valuable asset to the rehabilitation process among different projects [7, 8]. The integration of VR and NUI technologies with exergames can provide more motivation and engagement to patients while they are in rehabilitation activities [7].

We conducted a previous study [9] to assess the importance of using gamification and NUI-based devices, such as Kinect, in physiotherapy. A survey was directed exclusively to physiotherapists that work mainly with victims of stroke, older adults, and children with special needs that present reduced mobility. The large majority of participants stated patients were highly motivated to use these solutions. Motivation was, indeed, the argument most frequently mentioned, but others arguments were that they could be a valuable complement to physiotherapy and they could be strongly directed to the younger patients. In order to better complement classic physiotherapy, participants also expected monitoring and feedback capabilities from these solutions.

Therefore, we are creating an interactive and smart rehabilitation exergaming system by exploiting the concepts of gamification and NUI. This paper presents "just Physio kidding" (jPk), which applies the findings from our previous work, aiming to encourage physical exercise in order to combat physical deterioration while working on the cognitive stimulation component. It should be a complement to the therapists that work with children with special needs, especially with cerebral palsy (CP).

2 The "just Physio kidding" Prototype

2.1 Principles

The main idea behind "just Physio kidding" is the implementation of a richly interactive and smart rehabilitation exergaming system towards each one of its users (patients and therapists). Moreover, we are exploiting the use of NUI devices and, in a first phase, we started by using Microsoft Kinect to infer mechanical motion of patients since it is a relatively low-cost consumer game interface device and easy to set up. The project was then designed having in mind the therapy work in a clinic that deals with children with special needs, such as the cases of children with spinal muscular atrophy or developmental delay, besides the ones with CP.

For instance, CP is a group of disorders that affects the development of movement and posture, causing activity limitations [10]. Children with CP have muscle weakness, reduced range of motion, and poor control over their movements, which pose additional difficulties and challenges with the finely controlled movement required by Kinect [6]. This way, it is required to provide a high motivation to these children to comply with crucial treatments and therapies. The gamification of these therapies' exercises and their deployment in ubiquitous and NUI based devices may provide a more engaging and compelling rehabilitation [11], even at patients' homes with the supervision of the parents. However, the implementation of jPk needs to take into account both the specific context being gamified and the qualities of the end-users [11], the children with special needs, in order to obtain the desired outcomes.

Therefore, jPk relies on the Gamification and NUI concepts in order to encourage physical exercise to combat both physical and cognitive deterioration, and it should function as a complement to the work of therapists, with and without their real-time supervision. The therapist plays an important role in this system since s/he is the user responsible for (1) configuring the jPk's components according to each patient's needs; (2) supervising patients' performance and progress. Besides the patients (children) and the therapists, jPk also presents the role of administrator as a third user. This user is the responsible for the whole system, issuing general reports and supervising the jPk installations in clinics and others spaces. Figure 1 shows the different components and their connections. It should be noted that the patient has access to the NUI-based gaming component (JPK), and the therapist has access to the JPKT component that presents two interfaces: a NUI-based interface that allows the therapist to configure and supervise her/his patients' sessions in loco, in the therapy clinic's scenario, and a Web interface which is focused on providing remote access to a wider range of configurations and more detailed dashboards about patients' results and progress.

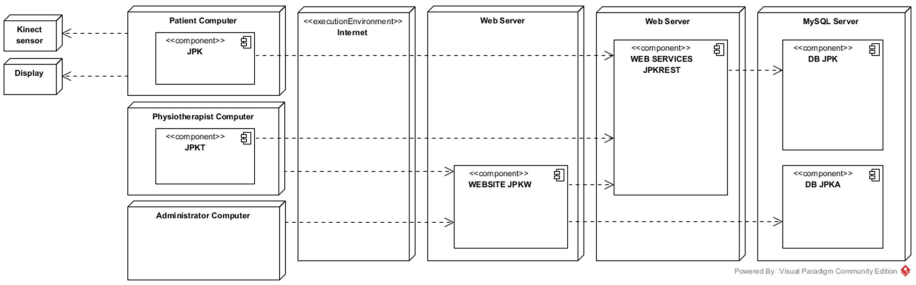

Fig. 1. The physical architecture of "just Physio kidding".

Based on previous findings [9], the jPk team's therapists have selected an initial set of essential basic movements (Table 1) of the upper-body, more specifically of the upper-limb, for balance training and motor coordination. The basis of the core game mechanics of jPk is based on these movements since they are crucial for the rehabilitation process of the patients targeted by jPk.

Table 1. The set of essential basic movements.

Movement	Description
Weight transfer	Transferring the weight of the body from one hip to another
Side reach	Inclination of the trunk - for both sides
Anterior reach	Take torso forward
Rotation of the trunk	For both sides
Later reach	Bring torso back

In a first therapy scenario of jPk, we have one display and a Kinect device for each user, all of them connected to the same computer (middle server). Each display will show its application running. In a second scenario, there is only one Kinect and one display connected to the home computer, for instance. In both scenarios, data will be sent to the jPk's server in order to be processed and integrated into a global view. This allows having appropriate supervision, even when we have a patient that is in her/his home or doing rehabilitation exercises more independently in the clinic.

2.2 Gaming and User Interfaces

Since the jPk system is based on PhysioMate [9], it is composed of two different sets of NUI-based serious games: routines and challenges. Regarding the routines set, the patient plays games that are routines of movements created by the physiotherapist. The main aspects of this game are the following: directed only for physiotherapy, there can be scheduled routines that integrate a global plan of rehabilitation exercises created by the therapist, who can, for instance, create and add routines to the system, supervise what her/his patients are doing, and analyse patients' progression in a particular routine.

About the challenge games, these also address cognitive stimulation. We are integrating several games in this set since we want to address different everyday life scenarios in order to engage children that have different interests and preferences. We started by implementing "Eco" (Fig. 2), which refers to the recycling theme since it was easy to set up providing scenarios that could easily include the movements previously defined. "Noir" (Fig. 2) is another game that focuses on private detectives, in night environments, that collect objects from clues and store them in a safe.

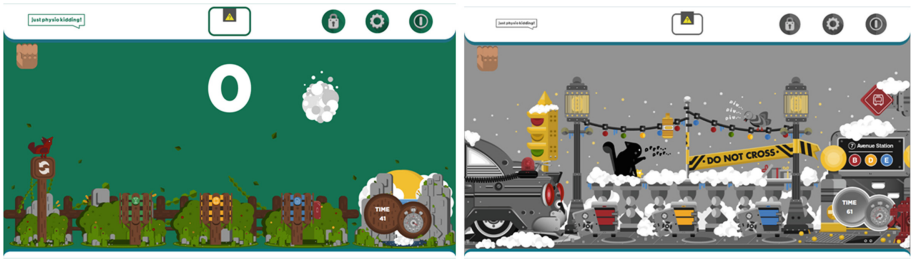

Fig. 2. Challenge games interfaces: "Eco, The Last Boy Scout" and "Noir, Cats Have 7 Lives".

In all games, the objects that must be caught appear only at points that will require the patient to perform the movements trained in the routines game. The games present several levels to the patient, based on different features, such as: with/without time limit; more or fewer objects to caught; objects can appear on predefined zones; only touch the objects, caught them or bring them to the bins/safes; among others. The patient can earn points and have a classification in a global ranking, among other functionalities related to each game. Therapists can configure the games towards each one of her/his patients, defining profiles that take into account that each child presents very particular characteristics. The way engagement with the games works with one child may differ greatly from another child.

Initially, a calibration process must be done taking into account the arms of the user. The objects will appear in points according to the calibration obtained in order to make the user perform the movements predefined by the therapist.

3 Conclusions and Future Work

This paper presented "just Physio kidding", which is focused on interactive and smart rehabilitation towards children with special needs, exploiting the Gamification and NUI concepts. The project aims to encourage physical exercise in order to stimulate cognition and combat physical deterioration, functioning as a complement to the work of therapists, with and without their live supervision. User tests with children and an acceptance evaluation with a physiotherapist were conducted in a clinic in order to align the development with the needs of the health professionals that lead with these "special patients". The results were very positive, and children were selected to integrate a participatory design process for the rest of the development. This process will be important to gather insights on how the games should be personalised towards the potential end-users of jPk.

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