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Keep on Moving: Designing a Physiotherapeutic Exergame for Different Devices and Exercises

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INTRODUCTION

Exergames, as one might infer from the name, are a combination of exertion (physical movement) and games (Adams et al., 2009; Oh & Yang, 2010). As such, they stimulate players to perform certain behaviours by providing them with engaging game mechanics (Whitehead, Johnston, Nixon, & Welch, 2010). While they can be used during physiotherapeutic rehabilitation sessions, they are particularly useful to increase therapy adherence at home (Song, Peng, & Lee, 2011).

For such a system to work, one needs to be able to somehow measure the bodily movements of players, and use them as input for the game. With the emergence of low-cost input devices, such as the Nintendo Wii-Mote, Microsoft Kinect and Leap Motion, a wide range of movements and therapeutic exercises can be measured accurately (Burdea, 2003).

However, most exergames target a specific set of behaviours. As such, the game only works with a specific input device, e.g. Nintendo Wii-Mote for arm rehabilitation (Vanacken et al., 2010) or a custom VR-system for full body exercises (Finkelstein & Suma, 2011). This approach limits the potential of exergames in at least two ways. First, the availability of hardware may vary per therapist, client, and therapy. Second, the games may become boring after repeated use, undermining long term-term use (Macvean & Robertson, 2013).

In this extended abstract, we explore an approach that addresses the first problem: how can we design a game that can be used for a wide range of therapeutic exercises?

METHOD

Instead of creating a single game for a specific set of physical behaviours using a particular interaction modality, we approached the problem by designing a game that can be configured to work for different devices and exercises.

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To expand the range of therapeutic exercises that can be practised with a particular exergame, we propose a mapping scheme that consists of three combinations: (1) the specific movements of the user, (2) the types of movements that can be measured by a particular device, and (3) the game mechanics that are triggered by particular movements. The conceptual mapping is shown in Figure 1.

The mapping of input device onto movements specifies which body movements can be measured through which devices. This requires a way of defining particular movements (see for example Maung et al., 2013), as well as a way of defining input device capabilities (see for example Buxton, 1983, 1990). For example, the Leap Motion device may capture wrist, hand, and finger movements in detail, while the Microsoft Kinect may capture all body movements but with less spatial resolution. The mapping of movements onto exercises specifies which body movements are required to perform particular exercises.

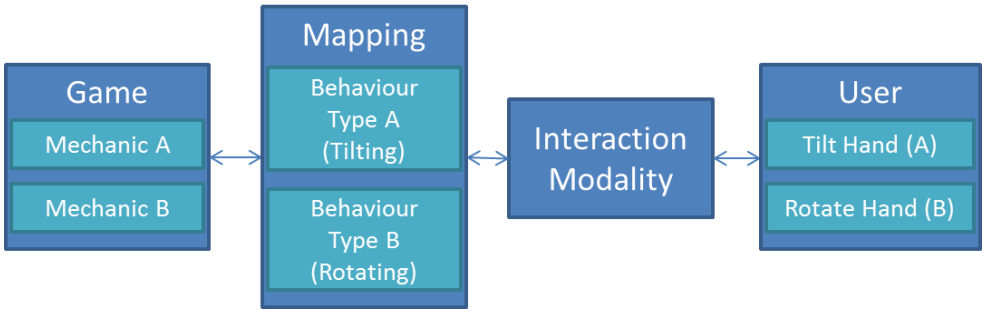

Figure 1: The relation between input devices, physical movements, and exercises and game mechanics.

The mapping of movements onto game mechanics specifies which types of movements are required to control particular game mechanics. For example, steering a character through a maze may be done by balance board movements as well as by tilting an accelerometer. Combining the three mappings allows for the construction of a game that suits the available input device and required exercises for a particular therapy, and subsequently selects relevant game mechanics.

CASE STUDY

In the game 'Creatures of the Forest', we used the Leap Motion as an input device to captures wrist, hand, and finger movements, and designed a game to motivate clients to perform gesture-based exercises. Importantly, we specifically designed the visual elements of the game and the game mechanics to be able to accommodate different types of input.

In Creatures of the Forest, the player needs to navigate through a set of connected rooms to find the exit to the level. To progress through the game, players have to solve a set of puzzles. For example, they may be required to find parts of a broken mirror that are distributed across various rooms, or select the correct combination of spells to open a door. As the puzzle mechanics, the rooms, and their connections can be arbitrarily combined, new levels can be automatically generated (an approach used in Dormans & Leijnen, 2013). A screenshot from the game is shown in **Figure 2**.

Figure 2: Screenshot from 'Creatures of the Forest', showing a puzzle room created by combining individual game elements.

The player can solve the puzzles by casting certain ‘spells’. Each spell can be cast by performing a certain type of movement that is registered by the Leap Motion device. The mapping of gestures onto spells can be configured to suit particular therapeutic rehabilitation exercises. Moreover, this setup allows the introduction of other input devices to use the game with different exercises.

DISCUSSION

In this abstract, we presented the first steps of a generalised design approach for exergames. This tool can be used with different interaction modalities and similar types of behaviours, and can be used, when finalized, for different types of physical exercises. While promising, there are some concerns that need to be dealt with before continuing with this work.

‘Creatures of the Forest’ currently features consistent and engaging gameplay. However, is this still the case when it is used for different movements (standing or sitting might influence the level of engagement)?

When employing exergames in the context of physical rehabilitation, we need to determine how effective the game is as a rehabilitation tool. Validating individual exergames is already a complicated and time-consuming effort. However, validating a setup such as the one we have proposed would be even more complicated.

In conclusion, we think that the approach we outlined in this abstract presents a novel approach to serious game design, raising challenging design questions for future research. We think the key question is how to design and evaluate serious games when the outcomes as well as the game mechanics vary between different uses of the game.

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