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Standard Mobile Phones Plus a Balance Board Are Sufficient: Designing a Serious Game for Better Knee Rehabilitation

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Abstract. The rehabilitation process after knee injuries is often challenging for patients and requires a high level of resilience, as it involves the frequent repetition of mostly monotonous exercises. Based on recent research, serious games can significantly improve motivation by merging exercising with entertainment aspects and even combining it with hardware to apply external tasks and track the progress. The aim of this research is to propose and evaluate a new serious game pattern. The development is performed using systematic feedback from domain experts. The test setup involves analysis of patients' feedback. The final game comprises an interaction with a balance board and an attached smartphone. Evaluation showed two main results. From a technical point of view: sensors of a standard smartphone (and it's sensitivity) paired with a PC and its screen are usable in a rehabilitation setting. From a psychological point of view: the motivation to perform the knee rehabilitation process can be enhanced with a serious game delivering entertaining aspects to it.

Keywords. Serious Game, Knee, Rehabilitation

1. Introduction

Diseases and injuries of the knee joint are among the most common associated problems of the human postural and locomotor system, accounting for around thirteen percent of all complaints of the human postural and musculoskeletal system. [2] In terms of rehabilitation the knee-joint is in Austria the leader requiring therapy and long-term damage possibilities. [1] Due to the repetitive and monotonous nature of rehabilitation exercises motivation often decreases over time, which can be avoided by using serious games. [3]

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2. Methods

In a first step, a comprehensive literature research was conducted, followed by a brainstorming session with a therapist. A feasibility analysis was built on game ideas. Wireframes were then designed, and 7 therapists interviewed. On this basis, the requirements were defined. The hardware chosen was a smartphone to capture the movements (sensors) and a classic balance board to control the serious game. The game was then developed and evaluated by two therapists and a patient.

3. Results

To capture the movements of a classic balance board, the sensors of an Android smartphone (gravity, gyroscope, and accelerometer) are used. A mobile phone case is attached to a classic balance board with adhesive tape so that the smartphone itself can be easily removed. This construction also ensures sufficient robustness against unwanted movements.

A game idea was chosen where the player can move an avatar (frog) using the balance board. Various randomly appearing objects (e.g. a cherry) have to be caught by shifting weight around the avatar while standing on the balance board. Various obstacles (e.g. traps in the shape of a saw blade) placed in the game area must be avoided when catching these objects. Different rewards can be collected during the game.

For evaluation, the prototype was shown to two therapists and one patient. The therapists argued that random appearing objects are beneficial because different types of muscle fibre activations are needed for the movements performed to balance with different tilt angles, which supports the healing process. It was also convincing that the game makes it possible to intensify the training by bending the knee joints, which strengthens the muscles better. Regarding the control, therapists and a patient agreed that it was intuitive and sensitive enough for effective knee rehabilitation training. Therapists also said that the use of this system is suitable for home exercises, but the patient needs to be instructed in the use of the balance board beforehand and instructions are currently lacking. All three people involved in the evaluation said that they enjoyed the game.

It was shown that the serious game and the game mechanics it contains support the correct execution of the exercises and are also useful for knee rehabilitation. The use of a smartphone and the sensors it contains is also practical - the movements can be recorded precisely enough. Improvements could be made further in the future, for example the attached phone cover could be damaged. In the beginning, the exercises with the game can also be (too) demanding. Gameplay can also be enriched by adding things like bosses or power-ups.

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