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Adaptable and Personalized Game-based Training System for Fall Prevention

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ABSTRACT
Digital Games which incorporate movements of the player`s body in their gameplay are becoming more and more popular. An increasing number of doctors and physical therapists use such games for training exercises, although these games are not designed to achieve predefined training goals. Various studies show that the training effects of these games are small in comparison with classic exercises. Therapists request more accessible and more flexible games. In this paper we present an adaptive game for fall prevention based on the adaptation and exergame analysis framework StoryTecRT which allows the adaptation of parameters which impact accessibility, acceptance and training load of a game. This paper includes an insight into the framework and the implementation as well as first evaluation results.

Categories and Subject Descriptors
H.5.2 [**Information Systems**]: User Interfaces – *input devices and strategies;* J.3 [**Computer Applications**]: Life and Medical Sciences – *health;* K.8 [**Personal Computing**]: General – *Games.*

General Terms
Algorithms, Measurement, Documentation, Human Factors.

Keywords
Serious Games, Health, Exergames, Training, Personalization, Adaptation, Sensors.

1. INTRODUCTION
Lack of exercise is a world-wide and well-known problem which leads to an amount of severe diseases. This problem is increased by the demographic change. Especially elderly people suffer from diseases caused by inactivity, since their decreasing mobility lowers the amount of possibilities for being active. This leads to insufficient muscular training which increases the risk of falls.

Solving this problem requires to focus on two aspects: A) Increase the accessibility of training exercises or activities of daily life (ADL) which stabilize or improve the physical health of elderly people. B) These exercises and ADLs must be attractive and motivating in order to be accepted and performed with intrinsic motivation by elderly people. Physical exercises are addressed in physical education and sports science, while the attractiveness and user experience of activities is a research topic in psychology. The adaptation framework StoryTecRT allows to measure the impact of parameters which influence acceptance of an exertion games and the training effects. After giving as small overview in section 2 about the background we present a prototype, the conceptual approach, and a prototype in section 3 as well as first qualitative evaluation results in Section 4.

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2. RELATED WORK
The approach of using interactive multimedia technologies for motivational training touches related approaches from three different research fields: user game experience, physical training and technology (multimedia and medical measurement). Sport science researches the effectiveness of exercises and defines metrics for the evaluation of training effects. For the measurement of gait stability and balance, beyond physical assessments such as the Tinetti-test digital measurements can be used as indicator for the risk of falls. Measurable indicators are i.e. the center of pressure (COP), stability, range of movement, reaction time or movement speed. All these tests and measurements are performed apart from training exercises and with the help of professionals. The tests follow explicit rules and provide only limited room for adaptation to a user's skills. Furthermore they allow no interaction or reaction to the user's behavior (feedback) and are not intended to engage users. The acceptance and therefore the training frequency and duration, which are both important for the training load, correlate with the motivation and engagement of the user. The question what motivates users/players is focused in different approaches. Beginning with psychological concepts such as Flow, which includes challenge in the threshold between boredom and anxiety, different authors propose specialized concepts and design guidelines for successful games. The constructs include but are not the limited to challenge, curiosity, feedback, control, empowerment and social interaction [1]. Other work shows the feasibility of digital virtual training and the configuration of exergames [3]. Since each of these constructs is operationalized in different ways, the impact (difference between two versions) can't be measured. A challenging question is how to measure the impact of different constructs and the interdependencies between them which would pave the ground for "engineering games".

3. ADAPTIVE EXERGAMES

3.1 Basic Approach

Since the training effects depend on physical and psychological aspects (the training load and motivation of the user), we suggested a theoretical model for the analysis of exergames [2] and an adaptation concept which allows the adaptation of single parameters in order to precisely measure the impact of these parameters [4].

3.2 Framework

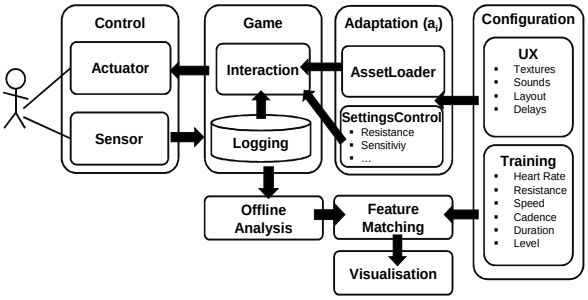

Figure 1: Realtime Adaptation and Analysis Framework StoryTecRT

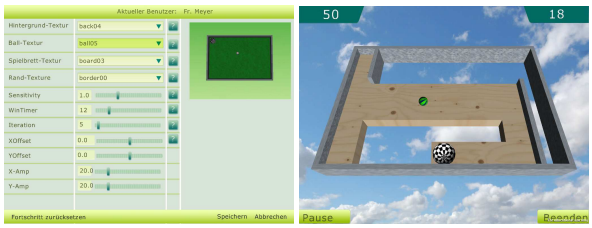

Figure 2: Settings screen with configuration preview (left) and level with advanced difficulty (right)

StoryTecRT allows the adjustment of single game attributes a_i (Figure 1) in order to change the operationalization of psychological constructs and approaches from physical science while all other attributes keep the same characteristic. For example the framework allows to create two configurations A and B of the same game which differ only in visual style or responsiveness. The framework provides different loggers which record the raw input data of the sensor (i.e. Balance Board, Ergometer, 3D-Tracker) as well as game-specific events and physiological data. Based on this data the influence (the difference between the versions A and B during the time of a specific interaction i) can be extracted and compared according to the training rules.

3.3 Prototype BalanceFit

Based on this conceptual framework we developed an exergame (BalanceFit) which focuses on the overall aim fall prevention for elderly people. The hardware consists of a standing frame (Figure 3) to provide stability and safety for gait impaired seniors. As input control we use a Nintendo Wii Balance Board which has four pressure sensors to measure the weight distribution of the player standing on the Balance Board. Out of the weight distribution we calculate the center of pressure (COP) which is used as input to control the game. The goal of the game is to change the declination of a virtual plate by moving the body in order to navigate a ball through a labyrinth into a target (Figure 2). If the player moves in a direction, the COP also moves in this direction and the virtual ball follows immediately. StoryTecRT allows the adaptation of the visual style, the layout of the labyrinth and the sensitivity of the controller.

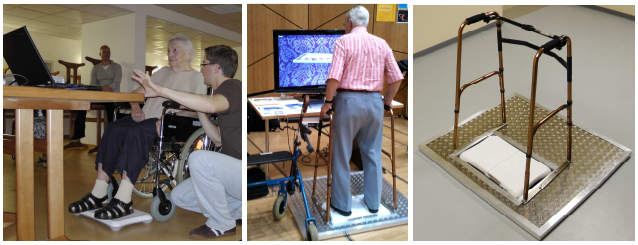

Figure 3: Wheelchair driver (left) and walking frame user (center) while playing BalanceFit, stability frame (right)

3.4 Evaluation Results & Conclusion

We evaluated the acceptance of the prototype balance fit with seniors in a senior's home for a time period for more than one year. Qualitative analyses (interviews and observations) with more than 30 people show that the visual style and the sensitivity play an important role for the accessibility of the overall system. By changing the visual style and increasing the contrast BalanceFit can be adapted for people with visual impairments. Adjusting the sensitivity of the control allows the game to be played by seniors with heterogeneous skills. This way the game is successfully playable by young and fit people as well as by people with small and bigger gait impairments. Even wheelchair drivers (Figure 3) are able to play BalanceFit as long as they theirs legs are not completely paralyzed. The results show the acceptance of the multimedia training system by elderly people. The adaption concept improves the accessibility of the system. The next step is the investigation of the effects of single parameters.

4. ACKNOWLEDGEMENTS

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5. REFERENCES

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