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Serious Games for Health – Personalized Exergames

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ABSTRACT
In this paper, we describe a set of personalized exergames which combine methods and concepts of serious games, adaptation and personalization, authoring and sensor technologies. Compared to existing systems, the set of games does not only keep track of the user's vital state, but also directly integrates vital parameters into the gameplay and supports the training and motivation for sustainable physical activity in a playful manner.

Categories and Subject Descriptors
H.5.2 [**Information Systems**]: User Interfaces – *input devices and strategies (bicycle ergometer, accelerometer),* 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 for Health, Exergames, Training, Personalization and Adaptation, Authoring, Multiplayer Games, Sensorics.

1. INTRODUCTION
Serious Games are 'more than fun' [11]: Game-based methods and concepts and game technology are combined with other ICT technologies and research areas and applied to a broad spectrum of application domains ranging from training, simulation and education to sports and health or any other societal relevant topic or business area. In the field of sports and health, commercially successful products such as Sony's *EyeToy Kinetic* or Nintendo's *Wii Fit*, *Wii Sports* or *Your Shape* show the potential of video games concerning motivation and for health entertainment. Solid scientific evaluation studies by Baranowski [1] and Kato [5] have proven positive effects of game-based approaches in the direction on health-related behavior changes, e.g. a more healthy nutrition or a better understanding of cancer and the willingness to fight against it – motivated by the serious game Re-Mission [5]. Comprehensive studies by Papastergiou [10], Kretschmann [8] or Kliem and Wiemeyer [7] also indicate a) positive effects such as an increased energy expenditure while playing the *Wii Sports* boxing game [8] or b) the potential use of *Wii Fit* as medium for training balance in prevention and rehabilitation. Hereby, limitations of video games and exergames are clearly stated as well: Apart from the fact, that they are no adequate substitute for 'real sports', concrete obstacles of existing systems include the lack of concepts for personalization and a strong need for long-term motivation and the sustainable use of serious games in sports and health [14].

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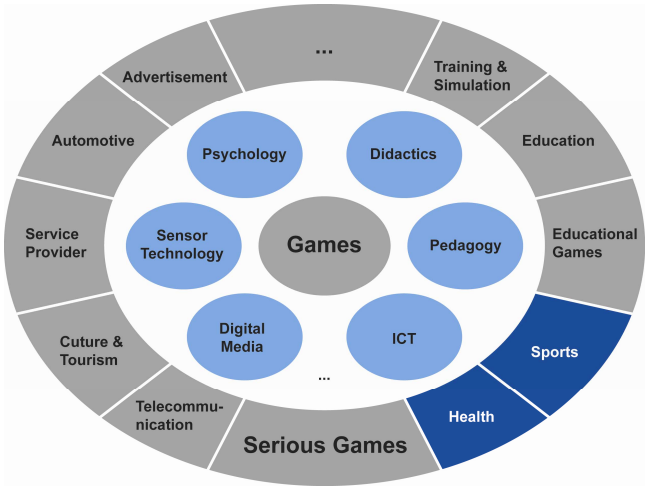

Figure 1. Serious Games for Sports and Health

Based on this observation, the basic idea of this research is to tackle those challenges and to provide a set of exergames combining the positive effects of serious games for sports and health with sensor technology, additional concepts for personalization and adaptation and competitive multiplayer game modes. Furthermore, authoring aspects are considered to support doctors or personal coaches and fitness trainers to create personalized training plans.

2. CONCEPT AND RELATED WORK
Figure 2 provides a schematic overview of the proposed technical framework for serious games for sports and health: Within the authoring environment *StoryTec* [2] medical doctors, fitness coaches or members of other user groups (e.g. private individuals or group leaders) can either define fitness programs and game-based applications for sports and health from scratch or retrieve preconfigured programs and templates from the database (repository) and customize those to the needs and characteristics of individuals and groups. The personalized programs and games are saved within the repository and loaded into an adaptive (game) engine – based on the Story Engine elaborated by the Serious Gaming team of the Multimedia Communication faculty at TU Darmstadt in the EU funded project 80Days for the control of Story-

based digital educational games [3]. The adaptive engine serves as control unit for the overall framework, being responsible for processing sensor data (vital parameters) retrieved by different devices and controlling the different player components as game interfaces to the users as well. Additional components of the framework include a portal being implemented as an information and communication platform, both for individuals and groups.

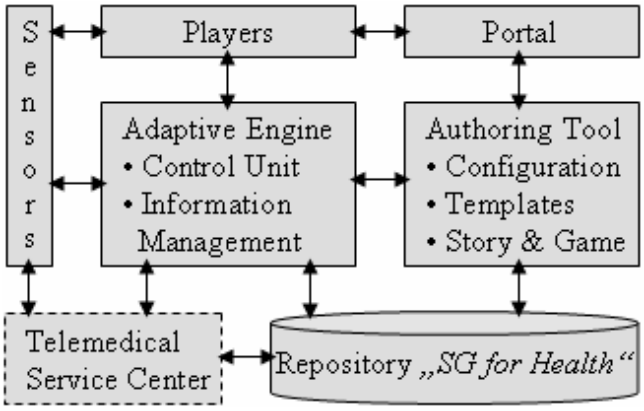

Figure 2. Serious Games for Sports and Health – Framework

2.1 Input Devices and Sensors

Recently, exergames have become very popular. However, the idea of combining physical movement (and its recognition via computer vision or other sensor technology) is not entirely new: In 1982, the *Atari Puffer*[1] was developed – but not launched – as the first exergame using an ergometer to control games on Atari's 2600 console. Nowadays, the trend of commercial exergaming systems [12] is not only to use game consoles as motivational instrument to enforce workout, but also to combine it with vital parameters. A current prominent example for that represents *EA Sports Active* which aims not only to recognize activities via accelerometers and to measure the heart rate and pulse for health-care purposes (tele-monitoring, documentation and analysis of workout data), but also to improve the training and results of exergaming in general. A major drawback is that the personalized workout data and the vital parameters are not considered within the gameplay of the exergaming applications. For this purpose, the adaptive engine retrieves and processes the vital parameters of the users and directly influences the gameplay. As devices for the first set of exergame applications, we are using Daum's ergometer *8008 TRS 3* plus further equipment (e.g. an ear clip) to measure the speed, RPM, pedal resistance, watt and heart rate of a user as well as Sun's *Java SunSpots* to recognize activities and movements. We have selected those products since both offer open programming interfaces and the ergometer supports bi-directional connection between the bike and the computer.

2.2 Personalization and Adaptation

The overall aim of our approach is to provide a personalized and adaptive environment which considers both static information – e.g. training plans, application logic or other content such as user/player models (authored by doctors, fitness coaches etc.) – and dynamically created information during play such as vital parameters and potentially changing player behavior. The data is brought together within the adaptive engine as control unit of the overall framework which decides how a (Story based) exergame continues at a specific moment during play. For that, the different training and exercise modules are structured into game levels and situations within the authoring environment *StoryTec* (see below) and are annotated according to the appropriateness of individual player types (and corresponding characteristics, e.g. the vital status). Then, during play, the player behavior and the vital status are measured via sensor technology and compared to the authored training plans. At this stage the major difference compared to other existing solutions is that the vital parameters etc. are not only documented, but directly influence the gameplay. Further, we make use of the backchannel to the ergometer and – for instance in the distinct case that a user/player is stressed too much or the pulse is too high for a longer time – change (decrease) the pedal resistance of the ergometer.

2.3 Multiplayer Games – Competition

With respect to long-term motivation, apart from methods and concepts for personalization and adaptation, multiplayer games can provide additional stimulation compared to single player games. It is important not only to provide an innovative, playful and challenging sports application which arouses the players' interest, but to provide a sustained motivation to keep them playing. Whereas single player games might loose their attraction after being played several times, the competitive aspects in multiplayer games can provide an ongoing and recurrent motivation for the users. For instance, it is not only possible to monitor the own fitness status and progress, but also to compete with others in a racing game or sport tournaments. Leaderboards and leagues represent another way for motivation through competition, as information about one's performance inside a group/league and a comparison to friends or colleagues is an important motivational factor. Nevertheless, the motivational aspect that comes with a human opponent resp. teammate is considered only in a few exergames like *PingPongPlus* [4]. The desire to be the best and to win is a key element of every sports game, be it 1 on 1 (e.g. tennis) or a team game (e.g. soccer). Hereby, competition is 'a major factor in the explanation of video game enjoyment' as shown by Vorderer et al. [13]. Furthermore, as a game against a human opponent always plays out differently, the replayability is enhanced, which supports sustainability in terms of motivation, too.

2.4 Authoring

In the field of serious games such as educational adventure games, the use of authoring tools allows the creation of games on higher levels of abstraction than working directly with low-level libraries and source code. An approach developed by the authors in this field is the authoring system *StoryTec* [2], which integrates the concept of Narrative Game-Based Learning Objects [3] in the course of the EU funded project 80Days for configuring a game which can be adapted based on a user's input at runtime along the axes of storytelling, gaming (using player modeling) and learning. The structure of a game is determined in the authoring tool using the *Story Editor*, in which the authors create the entire (story, game) structure by splitting up the game into scenes which are connected by (adaptable) transitions.

In the context of games for health such as those presented in this paper, the authoring tool can be repurposed for the configuration of such games. Scenes in the Story Editor correspond to stages in a session of playing the game. Such stages could be identified as stages similar to regular training stages, including warm-up, actual

[1] gadgets.boingboing.net/2008/05/15/from-atari-joyboard.html

exercising, and cool-down. Adaptation during gameplay could either be provided based directly on user input (by querying the user, for example whether he/she wants a low or high intensity workout) or automatically by adapting the game at runtime. As an example, based on values determined during the warm up, the system could automatically choose between a low-intensity version of the core exercise and a high-intensity version. An input parameter might be the user's heart rate combined with the intensity of the warm-up (e.g. the power setting of the ergometer). Figure 3 shows the StoryTec authoring environment with a configuration for the *Pigeon Hunt* game. The Story Editor in the lower left shows the structure of the game as described in the last paragraph – the dashed lines going out of the initial scene indicate a choice made by the game at run-time. Using the Property Editor in the lower right, users can configure properties of the selected training stage, for example the duration or the target heart rate.

Figure 3. StoryTec Authoring Environment for SG for Health

3. DESCRIPTION OF THE EXERGAMES

In the following a first of set exergames is described: *ErgoActive* is a set of mini games situated in the field of serious games for sports and health using an ergometer and directly integrating vital parameters of a player into gameplay, *SunSportsGo* uses accelerometers to recognize movement categories and intensity, *Y-Move* uses video recognition to recognize movements which are directly injected into the game to control the direction of a car.

3.1 ErgoActive

The simplest example is using the physical activity of the user to control a film. This way, for instance the user can ride a leg on the Alps of the Tour de France on the Ergometer. Hereby, duration, intensity, and stress are kept track of and used for evaluation and adaptation of individual, playful training programs. In *Pidgeon Hunt*, the speed is used to control the flight level of a pigeon to collect letters. Here, the player gets a feel for speed. Of course - as with all games of ErgoActive - the stress level (speed, gear) can be configured according to the player's individual needs and vital condition. *Balance* is a mixture of a 'Shoot-Em-Up' game and a sport game, facilitating both endurance and coordination of the player. A clown is balanced on a balloon by keeping the stress level (measured by the player's heart frequency) in a pre-defined range. Additionally, falling balloons have to be hit either with a mouse or with the Wii Mote.

Figure 4. *ErgoActive* Exergames – *Film* and *Pidgeon Hunt*

3.2 SunSports Go

SunSportGo is a multiplayer game combining sports and gaming technology. Similar to biathlon, the player alternately runs or shoots at targets. The player can play either alone or against other players via split screen. Sun SPOT sensor nodes, which are fixed at the player's legs, are used to determine the player's movement (categories) such as standing, lying on the floor or stretching as well as the running speed. Depending on the speed, a video (route or lap of a racing game) is played faster or slower. Via the Sun SPOTs attached to each leg, the player data is transferred to the computer using the open IEEE802.15.4 standard. In order to win the game, the player has to both run and shoot at targets. For that, he/she aims at another Sun SPOT near the screen. Just like playing biathlon, the goal is to concentrate and keep the hand still for a few seconds despite the physical exertion. In order to increase the motivation, it is possible to compete with another player in a multiplayer game mode. For that, two additional Sensor Nodes are necessary for the second player. Then, the game runs in a split screen mode presenting the performance of both players.

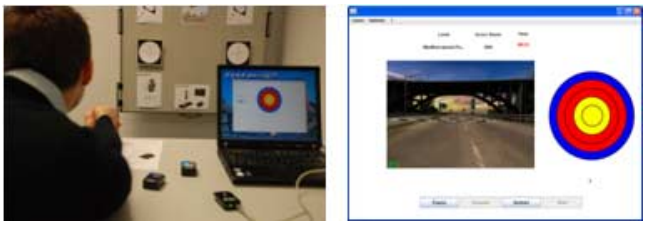

Figure 5. *SunSportsGo* – Workout and Concentration

Figure 6. *Y-Move* (left) and *SunSportsGo* – Multiplayer (right)

3.3 Y-Move

Y-Move is a multiplayer racing game which uses head-tracking technology as input. Similar to *EyeToy Kinetics*, the player can control a car by moving the head to the desired direction. The game

provides different modes: A single, multiplayer and a ghost mode – competing to former own races or those of anyone else.

4. CONCLUSION

This paper introduces a set of exergames aiming to improve the (long-term, sustainable) motivation of users to workout by the use of a combination of game technology and game-based methods and concepts (e.g. competitive multiplayer features), mechanisms for personalization and adaptation and sensor technology. The latter is used to recognize physical player activities, movements and the vital status of players. That sensor information is passed to an adaptive engine and directly influences the gameplay of the exergames.

First technical feasibility studies and focus group tests with a limited number of elected persons (26 in total) have generally shown the benefit of the approach: End users (independent of the age – ranging from 18 to 75, gender – 21 male and 5 female and profession – students in computer science (12) and the humanities (4), scientific (2) and administrative staff (3), 2 silver gamers, 1 medical doctor and 2 fitness coaches) were motivated to work out in a playful manner, additionally the doctor and the two fitness coaches see a good and valid chance to support prevention and rehabilitation programs in the medical domain or fitness activities in leisure. Compared to other well-known existing systems such as Nintendo's *Wii Fit* and *Wii Sports* or *EA Sports Active*, the concepts of personalization and adaptation – enabled by the bi-directional communication between the ergometer and the computer – and the direct influence of player behavior and vital parameters on the gameplay have been received very well.

In the next steps, comprehensive evaluation studies will be initiated a) in order to determine which competencies (e.g. strength, endurance or speed in the field of sports or common skills such as concentration or social interaction) are supported by the exergames, and b) to measure user experience aspects of the systems (e.g. motivation, fun or suspense) [6,9,10]. Further, it is planned to connect the exergames to existing fitness portals such as Vitaphone's *Motivation Platform* or OK-Vital's *myVITness – my Personal Coach* portal and to create business models with providers of healthcare services, gym chains or health insurances.

5. ACKNOWLEDGMENTS

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