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Augmenting the Task of Exercise Gamification: An Expert View on the Adoption of a New Technology for Deploying Existing Virtual Environments in Virtual Urban Exergames

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Abstract

Exergames commonly denote serious games and gamified systems that were developed for the sake of improving health and exercise adherence. One of the recent trends in exergaming are urban games. They are defined as "highly interdisciplinary digital games which root in such diverse fields as architecture and urban planning, healthcare sciences, and serious games research" (Knoell et al., 2014). *Besides having various 'physical benefits', such as promoting movement patterns, urban exergames have the core task of psychologically motivating players to exercise more and inspire them to be physically active. While offering an innovative and an immersive way to exercise, urban games come also with the typical drawbacks which outdoor exercising generally has (e.g. being dependent on good weather and intimidation problems for obese people). A possible solution would be simulating urban games for indoor exercise. On top of augmenting the sedentary game input to a motion-based one, designing and developing 3D environments for virtual urban games is not an obvious task and it takes a vast amount of knowledge, time and budget to create a realistic world with a "tremendous appeal and a powerful attraction". To bypass this challenge, we introduce in this work a new technology for accessing and gamifying existing game environments. Furthermore, we validate our approach by presenting the results of a qualitative research that we have conducted with the help of gamification experts and exergame designers.*

***Keywords**: Exergames, Gamification, Serious Games, Health, Virtual Words, Immersion*

Introduction

Background

In the recent years, many studies have been conducted on technological solutions aiming at enhancing the experience of exercising and physical activity (Singh et al., 2011; Finkelstein & Suma, 2011; Hossain et al., 2013). Exergaming, commonly defined as the use of video games in physical exercise, has gained in attention and acceptance and, with the release of various motion tracking-based technologies (e.g. Wii Mote, Microsoft Kinect, fitness trackers), an important number of exergames has been published (Wii Fit, Kinect Sports). These games are characterized by having body motion as input and game mechanic. Hence, they help decrease sedentariness, and enjoy physical activity.

While studies on exergaming have been carried out in the past years, a large number of them opted for the use of existing commercial consoles such as Nintendo Wii and Microsoft Xbox with the corresponding motion-based video games such as Wii Fit and Kinect Sports. Further works tried to convert existing sedentary games (e.g. games played using a normal gamepad or keyboard) into active ones by altering the input form static (e.g. button-based) to a motion-based one. The rest chose to exclusively develop an entire system for the study's purpose. (See ***Exergame Development Methods*** for references and further details)

While augmenting game input by introducing body motion capture is an essential research field, we also believe that the task of designing and developing an immersive game experience is very crucial. Taking serious charge of this task would enrich the creation of challenging activities that trigger the users' skills and satisfy their common desires such as achievement and self-competition.

A fundamental challenge, however, in achieving the pursued immersive exergaming experience is the disposition of appealingly designed virtual worlds. The development of such environments is however quite difficult and delicate. Due to this time-consuming and costly design task, different studies on exergaming were bound to the deployment of existing open source worlds for their systems. These worlds though, were generally poorly designed and did not always satisfy the users' needs of enjoyment. One better alternative would be the use of high quality virtual worlds available in the majority commercial games. These are however typically not accessible and thus cannot be used.

Motivation

One of the recent trends in exergaming are urban games. They are defined as a "highly interdisciplinary digital games which root in such diverse fields as architecture and urban planning, healthcare sciences, and serious games research" (Knoell et al., 2014)

Besides having various 'physical benefits', such as promoting movement patterns by dint of, amongst others, stairs and slopes, urban exergames have the core task of psychologically motivating players to exercise more and inspire them to be physically active. That is to say, urban exercise environments have emotional effects on players and are rather engaging and stimulating.

Although offering an innovative and an immersive way to exercise, urban games come also with the different drawbacks which outdoor exercising generally has (e.g. being dependent on good weather and intimidation problems for obese people, who do not necessarily feel well when they exercise outdoors (Guixeres et al., 2012))

To bypass the above stated limitations, we introduce in this work a new technology for accessing and gamifying 3D game environments. We thereby start by presenting the state of the art, then we state the different challenges and motivations behind our work. Further, we introduce an architectural concept of our technology, which we validate at last by presenting the results of a qualitative research that we have carried out with exergame designers.

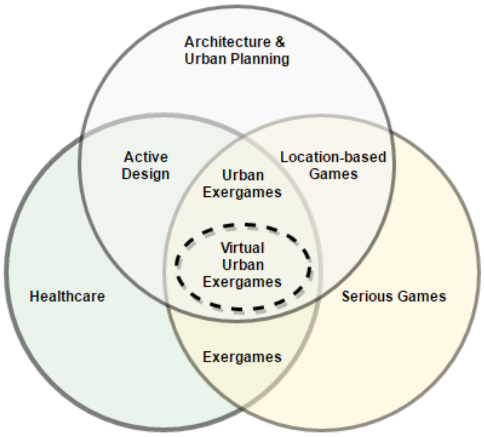

Figure 1. Relevant influences to the field of "Virtual Urban Exergames" - Adapted from (Knoell et al., 2014)

We would like at this point to emphasize again on the objectives of this work, which are on one hand presenting a new tool that would help gamification designers benefit from existing game worlds and use them in the intended serious contexts such as education and health promotion; one the other hand we give an evaluation of this tool with the help of a qualitative study conducted with gamification experts.

Related Works

Different studies have tried augmenting the sedentary games to active ones. To the authors' knowledge, the only approach that the developers have come up with to gamify existing game environments (i.e. game scenes), was through modifying the corresponding source code. Since, however, the source code of commercial games is typically not accessible, developers were left with open-source games. Converting these latter to motion-based ones was exclusively done through deploying the needed mechanics and behavior into the disposed source code.

In (Nguyen et al., 2012) the authors have introduced a system which enables the users to explore virtual environments using a DDR Pad (a floor-based dance pad called so after Dance Dance Revolution). This system helps enhancing physical activity and reducing sedentariness through replacing the usual game controller by motion-based one. Exclusively for this purpose and the corresponding conducted study the authors have developed an exergame in which the player controls a character's movement and behavior by performing on the DDR.

In (Chowdhury et al., 2014) an implementation of a stimulating system for muscle conditioning activities has been presented. Using Game Maker Studio, a game engine, the authors have developed three games from scratch to be used in the given study. The common characteristic among these games is the fact that they are all played using only two buttons, namely the left and the right arrow buttons. To deploy these games in autism treatment, the authors have augmented the input method (button pressing) to a motion-based input using hand grippers.

In (Matallaoui et al., 2015) the authors have introduced a model-driven serious game (and hence exergame) development. To validate the proposed approach, the authors have presented a use case in which they can be perceived to gamify an existing application. They therefore have integrated an achievement system on the top of the application main purpose. While the achievements' unlocking logics are defined outside the considered application, the achievement system's graphical representation is done through extending the available code with the corresponding plugin that was developed and provided by the authors.

To decrease sedentary playing and to drive forward active one, the authors in (Berkovsky et al., 2010) have integrated new game mechanics into an open source game. In this game, players have to move a ball through a given course to a target point. The time parameter was the central game mechanic and had to be allocated to accomplish the game levels. To do so, an accelerometer was used to capture the physical activity of the players. This activity is then mapped into time that players could use to continue playing. While motion-based input was implemented, the source code of the game had to be modified in order to visualize the acquired amount of time.

In (Guo & Quarles, 2013) the authors presented an approach for deploying any genres of games, even those negligibly used as exergames, to enhance motivations and engagement for physical activity and exercise. They, therefore, presented a car racing game controlled by motion-based input. Thereby, an open source Unity3D game was modified in a way that the game car is steered using Kinect captured motions.

Exergame Development

Exergame Development Methods

The development as well as the deployment of exergames and gamified systems can be categorized into three forms according to (Matallaoui et al., 2017):

1. The disposition of already available (commercial) consoles (e.g. Nintendo Wii, Xbox Kinect) with their corresponding physical activity-engaging games (e.g. Wii Fit, Kinect Sports); (e.g. (Guixeres et al., 2012; Hanneton & Hanneton, 2009; Monteiro et al., 2014))

2. Augmenting sedentary systems to active ones by means of 'meta-games' (e.g. badges, ranking) to achieve and enhance a targeted physical behavior; (e.g. (Berkovsky et al., 2010; Guo & Quarles, 2013; Warburton et al., 2007))

3. Exclusively developing exergames from scratch. (e.g. (Finkelstein & Suma, 2011; Mazzone et al., 2013; Snyder et al., 2012))

Challenges While Developing Exergames

Figure 2 shows an abstraction of the common modules of exergames. These consist of 1) mainly, the game, on top of which the exercise is built, 2) an extended input, using motion and physical activity and lastly 3) the output, being extended to haptic (e.g. vibration), audio (e.g. applause) and visual feedback (e.g. badges)

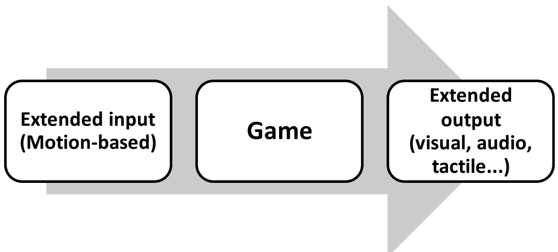

Figure 2. Exergame components

As noticeable in the afore listed related works and based on the depicted exergame components in Figure 3, it is clear that designing exergames is a concurrence of multiple tasks, namely:

1. the use of motion and health-related tracking devices and technologies, in order to collect the users' exercise-associated data,

2. the deployment of the gathered physical activity data as game input,

3. and the design of an immersive exergaming experience, typically following the different game design principles and behavior models (Flow theory (Csikszentmihalyi, 1988), Motivation theory (Maslow, 1943; Nevid, 2013)).

Challenges Simulating Urban Environments for Indoor Exercise

Virtual urban games, being also an instance of serious games, inherit all the design and development challenges and hurdles these latter have. Besides augmenting the game input to a motion-based one, designing and developing 3D environments for virtual urban games is not an obvious task and it takes a vast amount of knowledge, time and budget to create a realistic world with a "tremendous appeal and a powerful attraction" (Weber, 2015).Hence, gamification designers/developers who are intending to build their own 3D environment would face high risk and get distracted from their main task, which consists primarily in deploying gamification mechanics (e.g. levels, badges, and ranking) with the goal of enhancing exergame motivation and engagement.

In this work, we only focus on the exergame visual output (Figure 2 – extended output). The extension of the game input (Figure 2 – extended input) to meet exercising requirements will be treated separately in further works. In the next section, we present a conceptual depiction of the proposed technology and the underlying approach.

Technology Concept

To overcome the afore mentioned limitations concerning the affordability of such 3D environments, we present in this section a technology (Figure 3), by which exergame developers can take advantage of the commercial virtual worlds when designing and developing exergames.

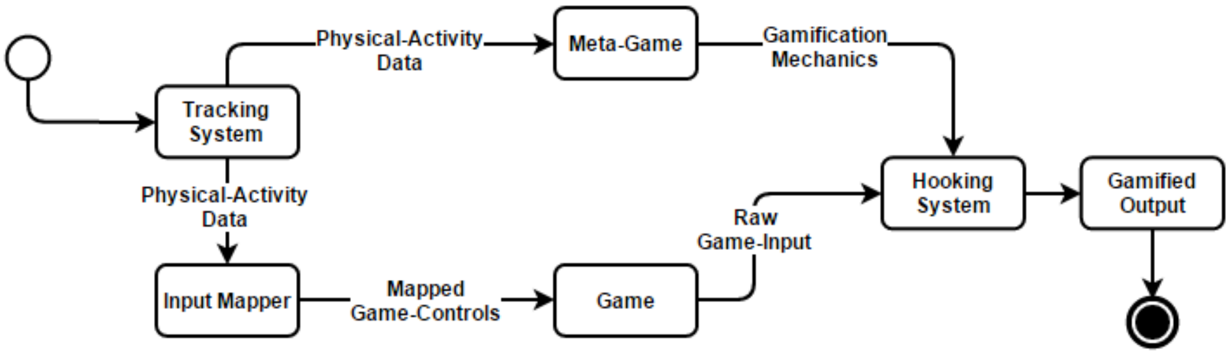

Figure 3. Data-Flow Concept

The ***Tracking System*** is responsible for gathering the physical activity data. Different devices (e.g. Kinect, tracking band, smart phones) and technologies (e.g. IR sensing, ANT+, Smart Bluetooth) have recently been deployed for this purpose. In exergames, tracking the users' motion and health-related data (e.g. speed, heart rate, steps count, and temperature) is cruical, since this data represents the base of the exergame input.

The task of the ***Input mapper*** is to transform the received physical activity data into game compatible inputs. For instance, a measured positive speed of a jogger is transformed by the input mapper to the Up-Arrow command, which represents the actual game control for moving forward.

The ***Game*** component responds to the simulated input and updates the game scene. It contains the virtual environment on which the gamification takes place.

The ***Meta-Game,*** i.e. a game over the actual game, encloses the gamification design. This latter is responsible for the exergame flow.

The ***Hooking System*** is responsible for integrating the generated gamification mechanics into the raw game output in order to produce the final exergame scene (visual output). This technique takes control over a specified code chunk and manipulates with, amongst others, the purpose to extend its original behavior.

Technology Review

Case Study

To validate our approach, we have developed a use case scenario, in which we have used the introduced technology to add badges and real-time feedback on top of Grand Theft Auto 5 (GTA5), "an open world, action-adventure video game developed and published by Rockstar" (Wikipedia). We have picked GTA5 for our case study, as it disposes of an attractively designed open world. GTA5 offers a discovery mode, in which the game environment can be freely explored.

The use case goes as follows: after starting the meta-game application, the user cycles in front of a display connected to a PC on which the GTA5 game is running. The cycling characteristics are sensed using an ANT+ cadence sensor mounted on the bike. The sensor transmits the data to the exergame interface, which to its turn forwards it to the input mapper as well as the meta-game.

Figure 4. **(a) Raw-game output** **(b) Extended output.**

Figure 4 shows how the actual game (a) was extended (b) to visualize the tracked physical activity data (heart rate = 108bpm on the bottom right corner) and the gamification mechanics ("Cycling Pro!" badge unlocked for cycling 10Km on the top right).

Research Methodology

In addition to having dominated acceptance research in information system technology (Choudrie & Dwivedi, 2005; Lee & Baskerville, 2003), quantitative research methods are very appropriate for evaluations focusing on impacts such as user satisfaction, system usage rates and effectiveness (Corbin & Strauss, 1998). Since, in this work, our study issues cannot be simply subdivided into discrete ones and we are not examining the static characteristics of the presented technology, we have opted for a qualitative study. The followed qualitative approach was adopted from (Vogelsang et al., 2003) and has been partially custom-tailored to meet some impediments (e.g. availability of gamification experts).

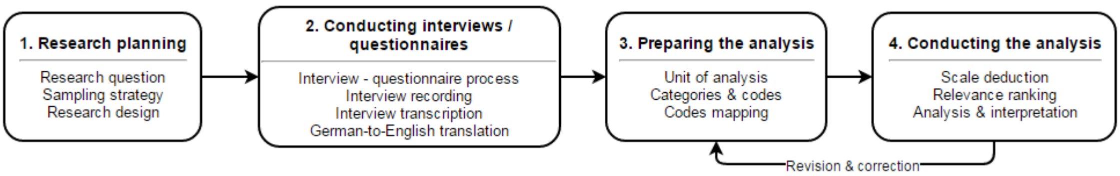

Figure 5. Applied research methodology adopted from (Vogelsang et al., 2003)

Research Planning

At the planning stage, according to the diagram in Figure 5, we agreed to conduct interviews with gamification experts and exergame designers. Contact acquisition was mainly initiated in-person at the

HICSS (Hawaiian International Conference on System Sciences) and mutual projects with the departments of Agent Technologies and Human-Machine Systems of the Technical University of Berlin Germany through the presentation of the project intentions. Additional gamification experts and exergame designers were suggested by the already contacted ones. We further decided to also use a questionnaire for this qualitative research due to the fact that many experts, which we planned to interview, did not have the time for it and preferred the written form.

Conducting Interviews & Questionnaires

At the second stage, we conducted various interviews and questionnaires with 10 experts (Table 1).

	Companies / Institutions		Interviewees / Participants (position)
	Industry / Field	**Size (# of employees)**	
P1	Internet of Things (IoT)	> 100	UX designer
P2	Psychology & Ergonomics	> 200	Gamification designer
P3	Fitness & E-health	> 10	Serious game designer
P4	Travel & Leisure	> 100	Head of marketing
P5	Information Technology	> 10	Software development
P6	Health	> 100	Serious game designer
P7	Mobility & Transport	> 10	Gamification designer
P8	Food Delivery	> 100	Head of marketing
P9	Consulting (IoT)	> 1k	Gamification consultant
P10	Serious Games	> 10	Game Developer

Table 1. Overview of conducted interviews and answers to the questionnaire

The interviews took place in-person and lasted 30-45 minutes. All experts had middle to senior executive positions and several years in the field of exergames and exercise gamification.

Thematic aspects	Guiding questions
Interview context	Could you, please, detail on your expertise and knowledge in the field of gamification?
	What is your current occupation, with regards to gamification?
Thematic view	What is your understanding of "exergaming"?
	What type(s) of game environments do you think would fit with exercising (sports)?
	In your opinion, which characteristics should be available in a game environment in order to be suitable for exergaming?
	What do you think is the appropriate way to give feedback about the reached progress?
Technology adoption	How would the availability of such a technology affect the process of exergame design?
	What effects do you expect the presented technology to have on exergame designers?
	How do you evaluate the proposed technology? Innovation? Efficacy?
	What does such a technology mean for future projects in exergaming?
Further aspects	What do you think this study should further focus on (within "visual output")?

Table 2. Questionnaire / Basic interview guideline

The questionnaire (Table 2) was sent as a google form to the corresponding interviewees and was answered per email. The interviews, after agreement with the experts, were audio-recorded for later transcription.

Preparing the Analysis

Third, the transcripts that we generated from the recorded interviews and the additional questionnaires received per email formed the units of analysis for our study. Core statements as well as complementary ones were extracted, segmented into discrete elements and sorted into different categories in order to enable insight, review and further development according to (Corbin & Strauss, 1998). The different steps of extracting, segmenting and sorting were reviewed by different persons to ensure objectivity and understandability. Data extraction and breakdown was supported by ATLAS.ti, a computer program used mostly in qualitative content analysis when dealing with unstructured data.

Conducting the Analysis

At the final stage, we weighed the significance of each category based on the following two criteria, namely frequency (1) and relevance (2):

1. We counted the interviews and the questionnaires in which the category was mentioned or implicitly pointed to.
2. We assessed the relevance of the categories as follows: a) the category's corresponding feature is highlighted in the gathered data in particular (+2); b) the given feature is considered important but complementary (+1); c) the concept is principally considered not relevant (-1)

Hence, the conducted analysis gives a thorough portrait of the discussed categories as well as a classification of these categories based on the outcome of the weighed frequency and relevance all over the questionnaires and interviews.

Analysis Outcome

We identified 12 features, which we have conceptually categorized under 1) Gamification technology characteristics, 2) Exergame environment characteristics and 3) Progress feedback.

Features	Freq.*	Rel.*	Proven?*
Gamification Technology Characteristics			
Guidance & assistance	4	7	-
Set of gamification components	5	8	-
Simplicity	6	9	+
Generic	4	8	+
Exergame Environment Characteristics			
Exercise-dependent	5	8	-
Immersive	8	14	+
Variable	4	6	+
Realistic	6	11	+
Progress Feedback			
Real-time feedback	9	15	+
Dashboard	5	7	-
Long-term goal tracking	5	8	-
Short-term goal tracking	7	11	+

*Rel: Relevance score - Freq: Frequency - Proven?: Is feature available in the presented technology.

Table 3. Feature frequency & relevance as identified in the expert interviews

Gamification Technology

Gamification technologies (aka. software or platforms) are tools that enable the implementation of game mechanics into non-game contexts with the goal of boosting the motivation and enhancing the engagement with the given task. Whereas the focus in this work was on introducing a solution for exploiting available digital urban environments and not on offering a suitable user experience with the platform, the results of the study still show that interviewees found the presented technology *simple* and *generic*. These two characteristics had in fact relevance scores of (Rel.=9 & Rel.=8) and were respectively quite often mentioned (Freq.=6 & Freq.=9). Nevertheless, in order to improve the developer's experience with this technology, the implementation as well as the improvement of various features such as *design guidance* and providing ready-to-use customizable *gamification components* are essential and must-have features according to the experts. These factors were mentioned 4 and 5 times and had relevance scores of (Rel.=7 & Rel.=8) respectively.

Exergame Environment

3D game environment present a stimuli for the players who can thus “experience a degree of presence” (Singhal & Zyda, 1999). One of the important features that game environment should have is being immersive. This latter was mentioned quite many times in the interviews (Freq.=8) and has a relevance score of (Rel.=14). Besides providing a solution for deploying immersive game environments, the interviews outcomes show that the introduced technology also help using realistic worlds (Freq.=6 Rel.=11).

Progress Feedback Notification

According to (Nakamura & Csikszentmihalyi, 2002; Schaffer & Fang, 2015), “clear proximal goals, immediate progress feedback, and challenges that stretch skills” form three crucial conditions to reach a state of flow. We, in this work, have presented a gamification technology, which helps exergame designers integrate badges and game-related progress on top of an existing game.

Real-time progress feedback continuously informs the players about their evolvement in the certain activity, if any given adjustments are needed and how these latter could be carried out. (Csikszentmihalyi et al., 2005). With relevance scores of 15 and 11 based on statements found in 9 and 7 interviews respectively, it is reliable to state that real-time feedback and short-term goal tracking are fundamental as far as progress feedback is concerned. In addition to these both important features, which are supported by the proposed gamification technology, the interviewed experts also mentioned that having a dashboard, in which long-term goals get tracked is also important for durable engagement. (relevance scores of 7 & 8)

Discussion & Limitations

The analysis of the results show that the proposed technology proposes a solid solution for deploying existing game worlds in exergames. Despite its simplicity and support of real-time feedback, the technology however, lacks different crucial features such as designer guidance, long-term goal tracking and a set of predefined gamification components. Moreover, certain interviewees mentioned diverse issues that need to be further discussed and investigated regarding the intellectual property of the used worlds. Certain interviewees (P5, P6 & P8) suggested conducting further research on the design and the placement of graphics (e.g. badges) on top of the game screen. “This study should also focus on how and where the feedback should be placed on the screen” (P5). “The design of the badges should adapt the game content” (P6).

Conclusion

Serious game development in general, as well as exergame development in specific, steadily face major barriers. These include amongst others: 1) high development costs, which are in the case of serious games expanded due to the need of domain-experts (e.g. doctors, trainers, and psychologists), 2) the combination of both words “serious” and “games”, which stimulates “the psychological barrier towards the use of entertainment technologies and methodologies for serious purposes” and finally 3) the fact that, nowadays, players have very high expectation with regards to the audio and visual quality of the game. (Wortley, 2014) To bypass this last challenge, we have, in this work, introduced a new technology for accessing and gamifying existing game environments. We, moreover, have validated our approach by presenting the results of a qualitative research that we have conducted with the help of gamification experts and exergame designers. The relatively positive results of the study show that the presented technology, although lacking some important features, offers an adequate solution for deploying existing immersive game environments.

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