This is a pre-print version of an article. The actual version will be published in ACM DL at http://dl.acm.org/event.cfm?id=RE248 by late 2015. Please use the official version of the paper and publication reference when citing: *Petri Ryhänen, Jouni Ikonen, Antti Knutas, Janne Parkkila. Linking physical activities and video games. CompSysTech 2015.*

International Conference on Computer Systems and Technologies - *CompSysTech'15*

Linking physical activities and video games

Petri Ryhänen, Jouni Ikonen, Antti Knutas, Janne Parkkila

Abstract: This study presents a concept for linking individual physical activities and video games together to build an ecosystem to motivate players to exercise. We used a systematic mapping study to establish current state of art and an user questionnaire to understand how players feel about digital rewards from physical exercises. In addition we implemented a prototype to demonstrate the applicability. The results suggest that combining games and physical activity trackers together is technologically feasible, and there is an audience who would be willing to exercise in order to receive rewards in games.

Keywords: video games, exercise motivation, physical activity tracking, player questionnaire, application federation, sports monitoring

INTRODUCTION

Tracking physical activities has become widely popular, partly because of the quantified self movement. Devices such as Fitbit, Nike+ Fuelband and mobile applications like Sports Tracker and Endomondo are quite well known. The tracking applications often reward their users by using gamification techniques, such as giving digital badges for completing different tasks. In addition, video games have become a widely accepted form of entertainment. Usually both of these are separate, independent applications. What if they could be connected together, to encourage video game players to perform physical activities by rewarding them with digital bonuses for their favourite games?

Previously, in a project called Game Cloud [4], we have studied the possibility of connecting multiple games together in order to form larger game universes and continuity between separate games. The research has focused on enabling connections between games, but interest from industrial partners suggests that bringing physical world interactions to games and vice versa could be worthwhile. Thus, we present a study on feasibility of combining physical exercising with video games.

In order to study the feasibility of connecting video games and physical activity tracking, we present the following research questions:

- Research Question 1: How video games and physical exercising could be combined together?
- Research Question 2 : What research has been done on linking separate games and exercise applications?
- Research Question 3: What do active video game players think of connecting physical activity with video games?

In this paper we follow the principles of design science [6] to evaluate the feasibility of connecting physical activities with video games. Before going into the implementation of our vision, it is important to properly study what research has previously been done in the academia. Thus, we carried out a systematic mapping study on two academic databases to find the current state of the art. In addition, to gain a better understanding of player opinions on connecting physical activities with video games, we conducted a short survey on possible end-users. We also implemented a prototype to demonstrate the possibility of connecting multiple physical activity trackers and video games together.

The rest of the paper continues as follows; second chapter describes the protocol and results of the systematic mapping study. Paper continues by presenting the design and results of the player survey on player perceptions of connecting video games and physical activities together. After this, we elaborate the implementation of connecting multiple physical activity trackers to video games. Finally, conclusion discusses the results of the complete research and draws everything together with concluding remarks.

RELATED WORK

We wanted to use a formal method to establish the current state of the art in academic research on connecting independent video games to physical exercising. For carrying out a scientifically valid background research, we decided to use systematic mapping study [8]. The systematic mapping study helped us to eliminate possible biases in our review and ensures repeatability as it forced us to act in a systematical manner.

For the systematic mapping study we used ACM digital library and SpringerLink publication databases to extract the research data. We conducted initial searches on both databases and got results shown in Table 1. The search terms were created from our research questions and were shaped more accurate based on the search results.

After our first search the results were rather varied, thus we wanted to limit our search by adding logical search operators between search terms and adding quotation marks around words. This caused ACM hits to become too few in numbers so we decided to remove some quotation marks for the next search. SpringerLink on the other hand was at manageable size for our next phase so we decided that no more searches were needed. After third search ACM hits were also at appropriate amount so we decided to stop here.

From this search we found total of 185 research articles from ACM and SpringerLink that were included or excluded according to our study selection criteria. Our inclusion criteria (as required to be defined by [8]) were

- topics closely related to our research questions
- papers related to linking of games together
- exercise tracking related research
- research including mobile game implementation

and our exclusion criteria were

- mobile learning related research
- non-human related research e.g. animals
- meta-research
- health or medical care related research.

Table 1: Search terms for systematic mapping study

Search round		**ACM digital library**	**SpringerLink**
Round 1	Search terms	mobile games sports physical activity tracking monitoring	mobile games sports physical activity tracking monitoring
	Found articles	130	376
Round 2	Search terms	"mobile games" sports OR "physical activity" tracking OR monitoring	"mobile games" sports OR "physical activity" tracking OR monitoring
	Found articles	8	121
Round 3	Search terms	mobile games sports OR "physical activity" tracking OR monitoring	
	Found articles	64	
End Result	**Found Articles**	**64**	**121**

For this selection we studied topics and abstracts of the researches and after this selection we included 45 articles. As the final phase we did data extraction by reading the full articles and removing unrelated work. This left us with 43 articles. Based on the data extraction we chose to focus on the articles with application implementation to make it match better our work. Our review showed us that 14 research articles were related to how games motivate people to exercise and 15 research articles on implementations of exercise tracking software. Of all the included articles, four studied combining video games and physical exercising together.

One of the articles, by Berkovsky et al. [1], discussed adding exercise properties to already existing games with PLAY, MATE! design. This included in-game tracking of users

activity and adding awards for them. The work demonstrated that games can motivate users to exercise and adding exercises to a game didn't reduce its appeal. The research of Chenin & Pun [2] demonstrated that users exercise more if they do it together rather than competing against each other. For this research they implemented HealthyTogether mobile application and integrated Fitbit device support to the application in order to track user activity.

In a Gemini [9] game users can gain rewards that can be gained by doing physical activities. This is categorised into indoors, outdoors and near other players activities. The user is allowed to examine his exercise history through some in-game ability parameters. In Treasure Hunting [5] user does physical activities involving quests. The game uses cloud service and it has separate exercise tracking which allows user to exam his exercise history through his profile.

From the literature references we came across with NEAT-o-GAMES [7] which is a group of mobile games where user can earn points in the racing game NEAT-o-Race and use those points in NEAT-o-Sudoku. These games were not truly independent and were built under main application which at the same time provided access to user's exercise data. This does not suit our concept of independent applications but offers different kind of model where an exercise tracker and a collection of games which utilised the tracker were provided.

Actual federation of applications utilising research which would implement independent application for a game and an exercise tracking application was not found. We see some similarities in design principle of gemini which says that user should be able to choose what kind of exercise he wants to do. NEAT-o-GAMES presented some relatively independent game entities. It would be feasible to implement more games to this collection, but they would be bound to the same exercise tracking application. This way user would not have the freedom able to choose his preferred type of exercises.

SURVEY ON PLAYER OPINIONS OF USING PHYSICAL EXERCISE AS TOOL TO EARN IN-GAME REWARDS

In order to have a better grasp on how players perceive the possibility of combining their favorite video games to physical activity tracking, we carried out a short survey. The survey was aimed at Counter Strike players as we saw that targeting a specific group would ease attracting gaming communities to reply. The survey was advertised in a gaming event, Twitter, Facebook group and via personal player contacts in Steam. The questionnaire consisted of 17 questions out of which 8 were for asking personal information and their playing habits, 1 question was for our chocolate bar raffle and 8 questions were focusing on our subject including an open comment field.

The questionnaire received 47 answers from 44 males and 3 females. Majority (60%) of respondents were between 19-30 years old, 31% were between 10-18 and 9% were 31-50 years old. Respondents were asked to estimate how many hours they play per week and at same time reminded that they can use statistical information, e.g. from Steam

to check their actual use. 17 of the respondents identified that they checked their data from these services. Most users (42%) told that they play more than 3 hours/day, 30% identified that they play 2-3 hours/day and 27 % said that they play less than 2 hours per day. When asking about purchasing behavior, 87% of the respondents replied that they have bought in-app purchases in some game.

Respondents were asked few questions on a 5-step Likert scale if they would be more likely to do something or not. When asking "Would you do some task to unlock special weapon and skin in the game?", 53% of the respondents replied that they would do a tasks to gain a reward in a game and 28% that they would not. For the next question, we changed the question to specify that earning a reward requires physical exercising: "Would you do physical exercise (e.g. run for an hour) to unlock exclusive skin or special weapon in the game?". 47% of the respondents replied that they would do tasks and 35% that they would not, so interest to do tasks goes down a bit if the task requires physical effort. For the third variant, we wanted to find out whether having a reward only for a limited time would change the opinion of the users: "If the skin acquired by doing physical exercise is only available for two days, would this make item more or less appealing in the game?". Most of the respondents selected the middle category and seemed to be unsure of their opinion.

Correlation analysis was also performed on questionnaire variables. The correlation analysis was done using Pearson's product-moment correlation coefficient with Dancey and Reidy's [3] scale for the strength of correlation (r-value). A weak inverse correlation was found between people interested doing a physical task to unlock a weapon and the amount of exercise the respondent was doing ($R=-0.31$; $p=0.04$). This means that the respondents who exercise a lot are not willing to do extra task for in-game rewards, but conversely respondents who exercise little could be motivated to exercise more with in-game rewards. People who currently exercise 1 to 7 hours per week would be most motivated by in-game rewards and people who exercise 8 to 14 hours per week least.

We also asked if physical exercise could be used as ingame currency by: "Do you think that physical exercise (like running) could be used as currency in some other games which you play?" To this, 60% answered that they believe so. Next question asked: "If doing physical exercise would give you in-game currency for one of your favorite games, how likely would you be to use this feature? Example of this could be that you go outside running for an hour to earn some game currency". 26% of the respondents replied that they would definitely use this option and 30 % that they are likely to do so, summing up to 56% of potential users. Some people also answered that they would buy a tracking device to collect exercise data to receive in-game rewards.

Results indicate that there are people who would like to receive in-game rewards from doing physical activity and there are people who clearly do not want to physical activity to earn in-game rewards. Results could be different if the survey had been made for casual gamers or different age demographic. We recognise the issue that most of the people who answered our questionnaire were young adults. This means that they have

greater financial power compared to younger gamers. For example, younger gamers might have been more willing to try things out and do things that do not require monetary investments. In addition, the survey did not target casual gamers, which are more used to free-to-play games, where using money is more common than for example in Counter Strike. The casual gamers might have also interest to gain rewards or advancement in other ways than just money.

BUILDING A PROTOTYPE FOR FEDERATING PHYSICAL ACTIVITIES AND VIDEO GAMES

To demonstrate the possibility of connecting multiple physical exercise applications together to reward players in a video game, we developed a prototype mobile game called Bugbear Wars. The goal of the game is to raise a bugbear to fight against other bugbears controlled by computer and other players. The gameplay consists of user choosing different attacks for his bugbear and executing simple touchscreen gestures on a smart phone. The player whose bugbear's health drops below his minimum health (defined by his max health and morale) first, loses. The winning bugbear gains experience points that contribute towards gaining new levels for the bugbear. The amount of nearby users has an effect on the bugbear. The more users there are in the near vicinity of the player the greater the benefits are. Nearby users thus contribute indirectly to the development of the bugbear. In addition, the bugbear regains health only once per day. If all the energy has been depleted, the player has to wait until bugbear has recovered enough energy to continue fighting.

The game is connected to a platform called Game Cloud, which is a result of our previous research. The platform enables information exchange between different games in a standardized manner that is machine readable. This platform also allows gathering information of player's physical exercises done with an activity tracker, enabling communicating this knowledge of performed exercises to video games. The game of Bugbear Wars utilizes this connection by rewarding players after physical exercises. Each exercise tracked and recorded to the Game Cloud platform grant a single, one-time healing point in Bugbear Wars. As seen in figure 1 these points can be used to heal the player's bugbear instantly, without waiting for a certain time to pass by.

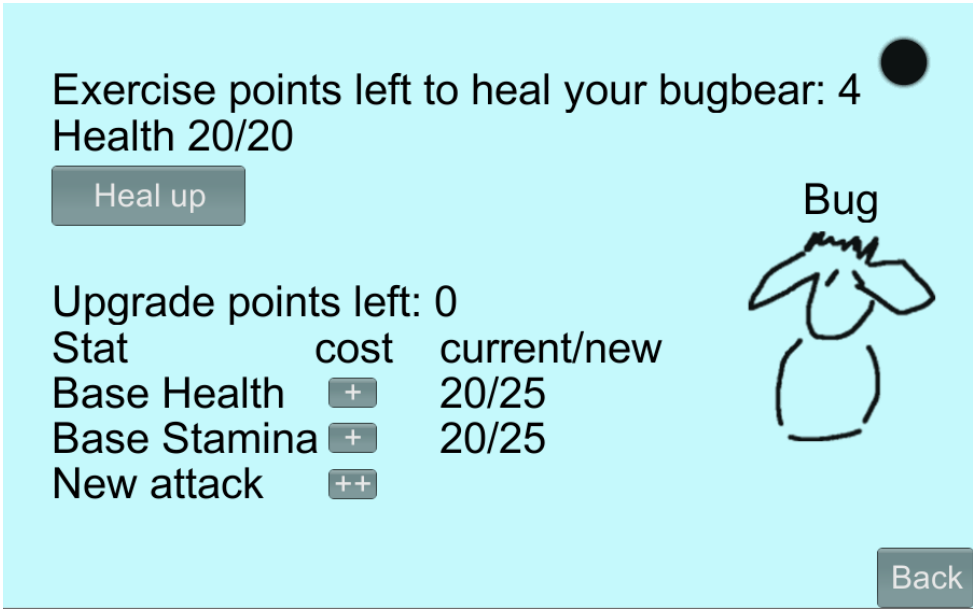

Figure 1: ***Bugbear Wars level up menu***

The implementation of Bugbear Wars demonstrates that connecting games and activity tracking is feasible. Instead of having one big application for connecting exercising and games, we assume that the user would like to choose his exercise tracking application for the sport type he likes and benefit from using that in his favourite game. We see an opportunity in using such a federated approach, where different applications can be connected to each other, without the need for one party to implement everything. In our vision, multiple applications can produce data that multiple applications can consume. This many-to-many approach gives freedom of choice for the end-users. In addition, it creates new business opportunities to developers as their applications can be cross-promoted by others via the connections between their products. Instead of competing with each other the developers could all benefit by rewarding the user for using multiple products.

CONCLUSION

In this work we introduced ideas of using user's physical exercise as a currency in games and that we can building larger federations from individual games and exercise applications, so they can collect and distribute exercise data between them. We used systematic mapping study to establish the current state of the art in research. The literature review revealed a research gap in connecting physical activity tracking and video games together. To gain an understanding on how players would feel about connecting physical activities with video games, we carried out a questionnaire to possible end users. The questionnaire was targeted to Counter Strike players and the responses showed that there is an audience for using in-game rewards to motivate users to exercise, especially among the segment that does not currently exercise a lot.

We also implemented a prototype to demonstrate the technical possibility of connecting activity trackers to video games. The prototype enabled players to gain a one time instant healing boost to the game by doing physical exercises. As we have demonstrated the possibility of combining physical exercising with games via the prototype and the interest of end users for the concept, the next logical step to continue the work is to carry out field studies with different applications to study the real effects on people.

The goal of the presented work was to demonstrate that connecting video games and physical activity tracking is a feasible vision. We wanted to present our idea combined with some proof that it could be viable. We know that there is still lot to be done, and we could devote one paper only to present and discuss about the results our systematic mapping study. The presented questionnaire gives an idea of opinions from a group of gamers, but should be extended later to other game and audience types. Also the presented proof of concept application could be replaced by doing trial e.g. by building application federation with Google Fit to collect data from different exercises and making that available for other games. In addition, the concept could be expanded for example to include language learning applications.

REFERENCES

[1] Berkovsky, S., Freyne, J., and Coombe, M. *Physical activity motivating games: Be active and get your own reward*. ACM Trans. Comput.-Hum. Interact. vol. 19, no. 4, Article 32, 2012.

[2] Chen, Y. & Pu, P. *HealthyTogether: exploring social incentives for mobile fitness applications*. Chinese CHI '14: Proceedings of the Second International Symposium of Chinese CHI, April 26 - 27, Toronto, ON, Canada, 2014.

[3] Dancey, C.P. and Reidy, J. *Statistics without maths for psychology.* Pearson Education, 2007.

[4] Game Cloud project - Project description http://www2.it.lut.fi/GRIP/about Innovation and software laboratory, Lappeenranta University of Technology. (Visited 23.3.2015)

[5] Hassan, M. M., Hossain, M. S., Alamri, A., Hossain, M. A., Al-Qurishi, M., Aldukhayyil, Y., Ahmed, D. T. *A Cloud-Based Serious Games Framework for Obesity*. CMBAS-EH '12: Proceedings of the 1st ACM multimedia international workshop on Cloud-based multimedia applications and services for e-health, November 2, Nara, Japan. 2012.

[6] Hevner, A.R., March, S.T., Park, J., and Ram, S. *Design Science in Information Systems Research*. MIS Quarterly 28, 1, pp. 75-105, 2004.

[7] Kazakos, K., Bourlai, T., Fujiki, Y., Levine, J., Pavlidis, I. *NEAT-o-Games: Novel. Mobile Gaming Versus Modern Sedentary Lifestyle*. 10th Intl. Conference on Human. Computer Interaction with Mobile Devices and Services, pp. 515–518, ACM, New York, 2008.

[8] Petersen, K., Feldt, R., Mujtaba, S. and Mattsson, M. *Systematic mapping studies in software engineering*. Proceedings of the 12th international conference on Evaluation and Assessment in Software Engineering, p.68-77, June 26-27, Italy, 2008.

[9] Stanley, K. G., Livingston, I. J., Bandurka, A., Hashemian, M., Mandryk, R. L. *Gemini: A Pervasive Accumulated Context Exergame*. ICEC'11: Proceedings of the 10th international conference on Entertainment Computing, October 5-8, Vancouver, Canada, 2011.