Application of invisible playground theory to assistive technology design for motivating exercise within activities of daily living

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ABSTRACT

Regular exercise promotes safe mobility for people affected by stroke, multiple sclerosis, and other disability related health conditions. It is also important for the prevention of falls among older people. Recent research investigates the use of indoor technology such as virtual reality (VR) and games to support and motivate regular exercise. Other research considers the use of mobile and wearable technology to track and promote exercise within the home and outdoors. In this paper we propose an approach that uses ideas from both contexts to develop a more persistent connected health system for encouraging more enduring exercise associated behaviour change. We utilise gameful design principles and play research to blend home-based VR and Serious Games with wearable, mobile tracking and reminder system approaches that are integrated into activities of daily living. In particular, we utilise ideas about the Invisible Playground from play theory to frame our interactive multi-modal exercise system. Our hypothesis is that by establishing a gamified, information rich feedback loop between structured system based exercise indoors and tracked activities of daily living outdoors, that motivation to exercise regularly may be improved. In this paper we summarise key relevant literature, discuss the Invisible Playground, and present the system architecture, APPRAISER, which will be used for the system development.

1. INTRODUCTION AND RELATED WORK

Promotion of exercise is important for maintaining and enhancing health after injuries or disabilities (Chao et al. 2013) and for older people to help prevent falls. Many people find motivation to sustain exercise and physical rehabilitation difficult (Uzor & Baillie, 2014) as it is often tough and not enjoyable. Games and virtual reality (VR) may be used to develop exergames or active games that help rehabilitation be more engaging and fun (Burke et al., 2009) and can be effective in the absence of physiotherapist supervision (Bateni, 2012). Traditional physiotherapist supervised rehabilitation continues to be the most effective way to administer high quality, directed physical therapy. However, it is important that people can be self-sufficient and self-manage their rehabilitation and so there has been increased focus on smart homes and on home automation (Chan et al, 2009). Creating adaptive rehabilitation systems to encourage positive user behaviour at home is one approach (Leonardi et al., 2009). Smartphones have been recently been widely used in experiments focused on people's activities of daily living (ADLs) outside the home (Brunnberg et al, 2009) due to their inherent tracking capability using built-in GPS, accelerometer or gyroscope capabilities. In commercial applications, there are a range of social games that have been designed to encourage people to be collectively active. GeoCaching apps encourage people to go to real location in the real world to attain objective or collect "treasure" and games such as Ingress (Niantic, 2014) overlay an actual videogame. Active tracking apps such as Runtastic (Runtastic, 2016) or Strava (Strava, 2014) blend sociability with game design features to build active communities. Thus technology has great potential to bring people together to engage in a physical activity. In this paper we outline an approach to motivating exercise, influenced by the Invisible Playground (Salen & Zimmerman, 2005) from digital game theory, which seeks to bridge the gap between indoor situated exercise and ADLs. A serious game underlies the approach which be more persistent and be less bounded than existing approaches.

2. MOTIVATING EXERCISE IN THE INVISIBLE PLAYGROUND

Serious games for rehabilitation are typically based indoors and often do not integrate social factors that provide crucial communal enjoyment. Games can be designed to include social communication features and for example may provide competitive and cooperative gameplay offline or across the internet. Though social interaction online can improve enjoyment within interactive software it is generally more satisfying for people to engage with other people in the real world outside the home. The system that we propose uses games and VR technology in the home to improve fitness and confidence to exercise outdoors, while also gamifying ADLs. We consider ideas from digital games research on the Invisible Playground, previously applied to commercial game design and educational games (Charles & McAlister, 2004) and relate the theory to the design of serious games in an assistive health technology context. The fundamental idea of the Invisible Playground is that modern games are not bounded by the "Magic Circle", (Huizinga, 1971) but rather overflow from the virtual out into everyday life and embedded into culture (Figure 1). In simple terms we consider the application of the Invisible Playground to a health context by creating a game which is persistent, with gameplay mechanics fitted to location, technology and circumstance.

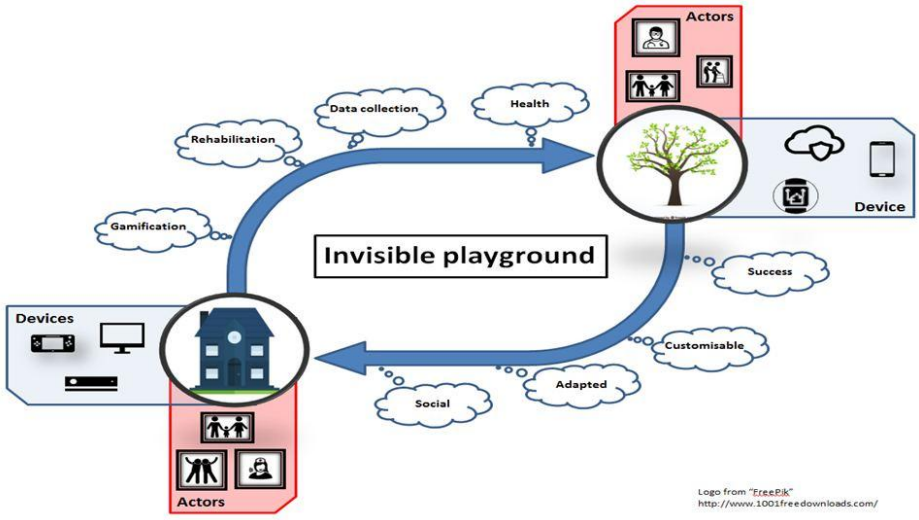

Figure 1. *Illustration of the Invisible Playground showing the closed loop between indoors and outside.*

In home games VR hardware systems (e.g. Omni Treadmill, HTC Vive, Kinect, and Leap Motion) may be used to tailor specific and safe exercise programmes while wearable trackers (e.g. Moov, Withings, or Fitbit) may be used paired with Smartphone technology to continue the game in ADLs. The main idea is that indoor game based health technology activities can motivate and encourage transfer of exercise to everyday activities and vice versa. Indoor games and VR provide supportive and directed programmes of activity with built-in challenge-reward schemes, adaptive difficulty, and personalised activities schemes. Tracker systems based around wearable, smartphone technology, and gamification design can enable the "game" to continue around the house and within the community; providing additional challenge-reward scenarios based on location and motion tracking. On return to the home, logging back into the home based system allows the user to collect rewards and view fitness and achievement profiles – so establishing a feedback loop between virtual and real world exercise, between the home and outdoors. It is this closed loop system at the heart of our proposed approach that we believe can be more effective in providing sustained engagement with exercise and potentially more enduring behaviour change than with other approaches. The approach requires thoughtful gameful design across modalities.

To facilitate development of a rehabilitation system based on the Invisible Playground principles we created the APPRAISER component architecture (Figure 2). In essence APPRAISER is a connected health architecture and contains what we consider to be all of the required components for effective Invisible Playground system design and development: models of person's physical ***A**bility*, ***P**ersonality* type, personal ***P**references*, and embedding of specific rehabilitation ***R**equirements*, so the system can be effective in ***A**dapting* to individuals. Internet-based services via computers (indoors) and smart devices (outdoors) facilitate enriched social ***I**nvolvement* and access to clinical Support to improve ***E**ngagement* with exercise and ***R**ealise* goals through forming positive habits. State-of-the-art technology monitors, records and facilitates dynamic interaction with users based on personalised models and network connectivity supports clinical and social interaction. APPRAISER uses our rehabilitation game model (RGM) (Holmes, Charles, Morrow, McClean, & McDonough,

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2015). The RGM was developed to guide the design of rehabilitation games on the basis of an extensive catalogue of game design patterns, gamification principles, and core behaviour change techniques.

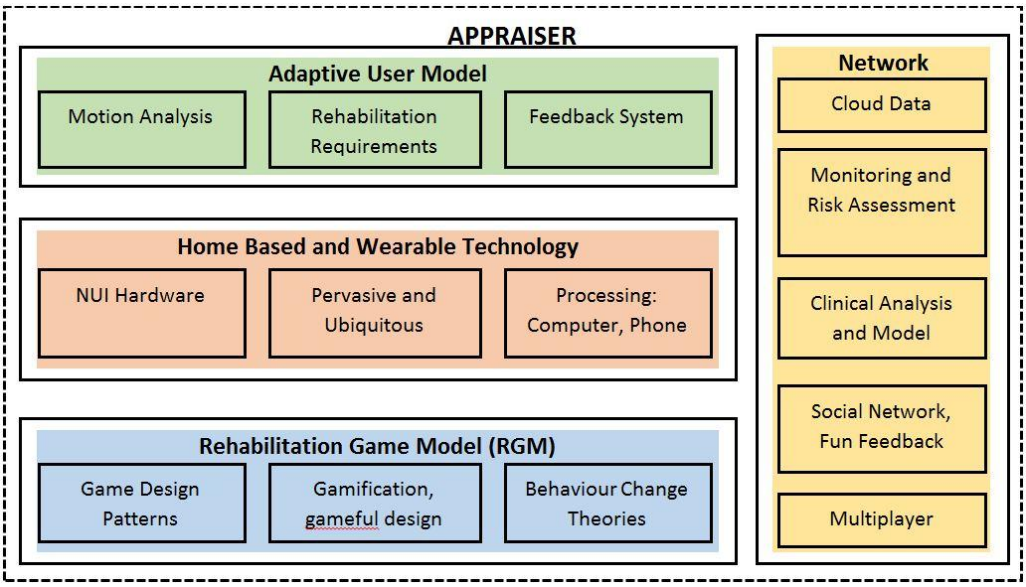

Figure 2. *The APPRAISER architecture comprises four core components*

Our initial experimental focus, currently ongoing, is focused on rehabilitation methods for fall prevention and gait improvement and considers the application of OTAGO and FaME for fall prevention (Gawler & Hanna, 2011), multiple sclerosis and stroke rehabilitation (Batchelor et al, 2012). Figure 3 provides an illustration of our first game design to implement the Invisible Playground, blending fixed location game based exercise and gamified daily life. Ideally, the "game" will be as non-intrusive as possible but will enable people to integrate exercise related fun activities into ADLs. The game illustrated in Figure 3 is a version of the classic "capture the flag" game, where locations surrounding a person's home are partitioned into areas that may be captured by physically visiting them. There will also be other classic gameplay elements outdoors such as treasure hunts and puzzle solving – tied to tracking and reminder systems which offer tailored exercise opportunities (such as structured arm or leg movement). In this game instance the person's home acts as a kind of "base" to which items are brought back for selling or bartering at a store. In the base people can view player statistics, tailor their inventory for outdoor quests and conquests and can improve their (player character's) attributes by performing actual physical exercise. There are many other potential gameplay elements but these examples serve to illustrate how the gameplay is designed to maintain a closed loop gaming system between indoor and outdoor activity.

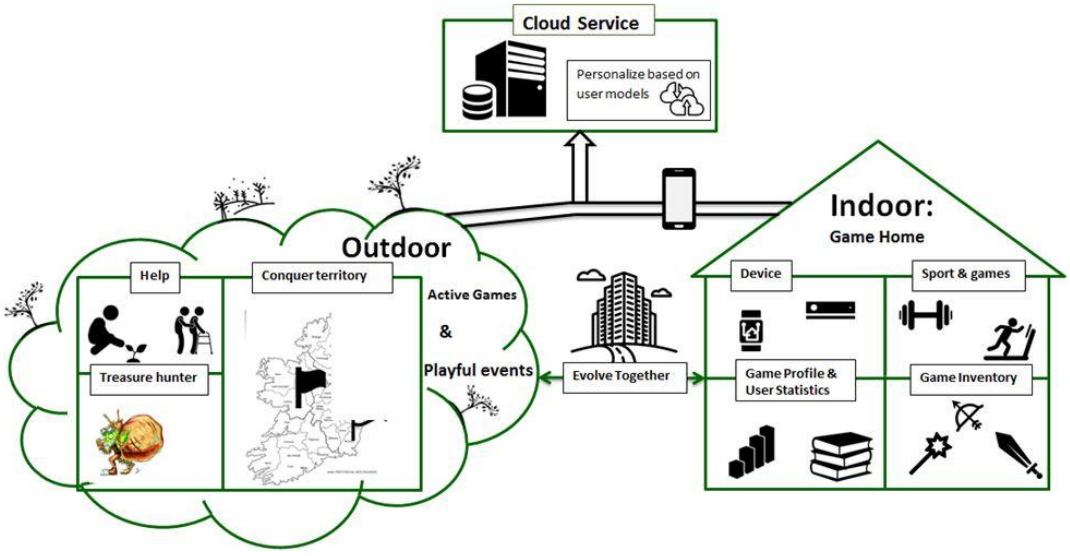

Figure 3. *Real life implementation of Invisible Playground theory.*

3. CONCLUSION

We have proposed using an Invisible Playground design principle to integrate rehabilitation exercises into activities of daily living and discussed implementation in practice. The main benefit of the proposed approach over existing methods is that we explicitly link fixed location exercise or rehabilitation to activities of daily life. Date from physical activity monitoring using smart technology will facilitate modelling and the categorisation of user motion, which will form the basis of reminder, feedback and reward systems. Our hypothesis is that we could improve transference and potentially improve function. We have currently created a Kinect based exercise system for indoors which integrates the Otago fall's prevention programme, and we will move on to build the tracking and reminder game systems for outdoors, then the underlying game and gamification systems. It is our intention to conduct a trial to investigate the acceptance of technology and the effectiveness of gamification in the invisible playground context. We are interested in find out whether the invisible playground improves health conditions and behavioural attitudes to sustainable regular exercise.

4. REFERENCES

Batchelor, F. A., Hill, K. D., MacKintosh, S. F., Said, C. M., & Whitehead, C. H. (2012). Effects of a multifactorial falls prevention program for people with stroke returning home after rehabilitation: A randomized controlled trial. *Archives of Physical Medicine and Rehabilitation*, *93*(9), 1648–1655.

Bateni, H. (2012). Changes in balance in older adults based on use of physical therapy vs the Wii Fit gaming system: A preliminary study. *Physiotherapy (United Kingdom)*, *98*(3), 211–216.

Brunnberg, L., Juhlin, O., & Gustafsson, A. (2009). Games for passengers: accounting for motion in location-based applications. *Proceedings of the 4th International Conference on Foundations of Digital Games*, *12*, 26–33. http://doi.org/10.1145/1536513.1536528

Burke, J. W., McNeill, M. D. J., Charles, D. K., Morrow, P. J., Crosbie, J. H., & McDonough, S. M. (2009). Optimising engagement for stroke rehabilitation using serious games. *The Visual Computer*, *25*(12), 1085–1099. http://doi.org/10.1007/s00371-009-0387-4

Chan, M., Campo, E., Estève, D., & Fourniols, J. Y. (2009). Smart homes – current features and future perspectives. *Maturitas*, *64*(2), 90–97. http://doi.org/10.1016/j.maturitas.2009.07.014

Chao, Y. Y., Scherer, Y. K., Wu, Y. W., Lucke, K. T., & Montgomery, C. A. (2013). The feasibility of an intervention combining self-efficacy theory and Wii Fit exergames in assisted living residents: A pilot study. *Geriatric Nursing*, *34*(5), 377–382. http://doi.org/10.1016/j.gerinurse.2013.05.006

Charles, D., & McAlister, M. (2004). Entertainment Computing -- ICEC 2004: Third International Conference, Eindhoven, The Netherlands, September 1-3, 2004. Proceedings. In M. Rauterberg (Ed.), (pp. 598–601). Berlin, Heidelberg: Springer Berlin Heidelberg. http://doi.org/10.1007/978-3-540-28643-1_79

Gawler, S., & Hanna, S. (2011). Otago Strength & Balance - Home Exercise Programme. *Later Life Training*, *Later Life*, 46.

Holmes, D., Charles, D., Morrow, P., McClean, S., & McDonough, S. (2015). Rehabilitation Game Model for Personalised Exercise. In *2015 International Conference on Interactive Technologies and Games* (pp. 41–48). IEEE. http://doi.org/10.1109/iTAG.2015.11

Huizinga, J. (1971). *Homo Ludens: A Study of the Play-Element in Culture*. *European Early Childhood Education Research Journal* (1st Editio, Vol. 19). Beacon Press; 1st edition (June 1, 1971).

Leonardi, C., Mennecozzi, C., Not, E., Pianesi, F., Zancanaro, M., Gennai, F., & Cristoforetti, A. (2009). Knocking on Elders' Door: Investigating the Functional and Emotional Geography of Their Domestic Space. In *Proceedings of the …* (pp. 1703–1712). ACM. http://doi.org/10.1145/1518701.1518963

Salen, K., & Zimmerman, E. (2005). *The Game Design Reader: A Rules of Play Anthology*. *Review Literature And Arts Of The Americas*. http://www.amazon.com/dp/0262195364

Uzor, S., & Baillie, L. (2014). Investigating the long-term use of exergames in the home with elderly fallers. In *Proceedings of the 32nd annual ACM conference on Human factors in computing systems - CHI '14* (pp. 2813–2822). New York, New York, USA: ACM Press. http://doi.org/10.1145/2556288.2557160