Towards a Framework for Gamification-Based Intervention Mapping in mHealth

Helf Christopher, Patrick Zwickl, Helmut Hlavacs, Peter Reichl

Towards A Framework for Gamification-based Intervention Mapping in mHealth

Helf Christopher, Patrick Zwickl, Helmut Hlavacs, and Peter Reichl

University of Vienna,
Währingerstraße 29, 1090 Vienna, Austria
http://cs.univie.ac.at/

Abstract. Given increasing obesity rates, reduced physical activity and other unhealthy practices, mobile gamification-based health applications have gained momentum in motivating individuals towards behavioral change. The lack of corresponding frameworks enabling the efficient cooperation between health professionals and independent game developers has resulted in a clutter of mHealth apps, which uncoordinately make use of large numbers of motivational techniques, gamification metrics and health data. In this paper, a unified user-centered framework is proposed, running health applications crafted by external developers within a sandbox, and thus mitigating the most concerning privacy and safety issues. It is capable of differentiating between apps on intervention-level granularity and tailoring suggested treatments based on users and their current environment, and aims at maximizing motivational impact in order to sustain and facilitate healthy lifestyles in the long run.

Keywords: mHealth, eHealth, Gamification, Individualisation, Health Intervention, Framework

1 Introduction

Overweight, obesity and lack of physical activity are considered a major public health concern worldwide. Studies indicate that by 2030, up to almost 58% of the world's adult population could be either overweight or obese [9]. A sedentary lifestyle on the other hand can be directly linked to serious health consequences in forms of chronic diseases, such as diabetes, hypertension or heart problems [8, 9]. This alarming development has encouraged developers to utilize new technologies to create mobile health (mHealth) applications [15] and has also given rise to novel gamification approaches that aim at increasing the individual's engagement with systems by providing elements such as play, fun, reward, challenge, social context, visually appearing aesthetics or creative interaction types. Nevertheless, applications in the health domain targeting behavior change are often developed without or little involvement of health professionals [4] and thus subsequently have been found to be only weakly backed by scientific evidence or validation [1, 3]. Furthermore, most gamified applications nowadays individually collect, process and analyze health data and thus try to motivate users in form

of island solutions. The high fragmentation of these applications leads to the conclusion that users need a large number of apps in order to achieve the often desired lifestyle change [5]. Gamification metrics among these apps are additionally often not comparable and designed incoherently due to the high competition among developers in this field. Consequently, it is imperative to create a holistic framework in which both serious game and gamification developers as well as health professionals can operate independently for the benefit and motivation of the user. In this context, the main contribution of this paper is the definition of a holistic mHealth framework of a highly-modularized system for gamified applications. The framework and subsequent implementations are developed within the EU project PRECIOUS[1].

2 Related Work

Few approaches have been made hitherto with respect to combining mHealth interventions with motivational aspects, such as gamification elements. A recent and promising eHealth framework named the Behavioural Intervention Technology Model (BIT) [10] depicts a high-level model following three existing and comparable design models and includes design intentions from different stakeholders. Another model being complementary to the BIT approach [7] is Intervention Mapping (IMA) [2]. Instead of describing a technical framework, it is a protocol on how to create health-related interventions. Both models address limitations of existing models [7] and thus underline the lack of frameworks in this field in addition to highlighting the importance of key stakeholder inclusion in app-development, such as health professionals [6]. Another important point with regards to motivational aspects are a framework's capability to adapt to user needs and circumstances. A study by Orji, Mandryk et al. showed for instance that different gamer types based on the BrainHex classification [11] responded differently to game mechanics in the context of health behavior change, thus emphasizing the need to tailor health determinants to various gamer types for example. Implemented Behaviour Change Techniques (BCT) for instance are often not considered along with the individual's personality and characteristics [10], which generally leads to the conclusion that people may need multiple apps to initiate and maintain behavior change [5].Even though gamification has been suggested as a design pattern [13], dynamic interventions based on gamification elements represent an entirely new concept to the field of health applications, which are often of rather static nature with regards to user characteristics and environments. They often lack understanding of behavioral interventions, where feedback loops and responsive or reactive systems are crucial for the success of health interventions [12]. In general it can be said that there exists a large gap between current clinical interventions based on scientific methods and iterative gaming and app technology design [14]. Most designers and human-computer-interaction professionals place an emphasis on usability, aesthetics and engagement, whereas health researchers focus on efficacy and often personal treatment.

[1] http://www.thepreciousproject.eu

Current suggestions for eHealth models have already tried to bridge this gap, but have placed an emphasis on specific intervention problems rather than creating a framework where apps can deliver arbitrary interventions within a single framework.

3 Towards a Framework for Gamification-based Intervention Mapping

While today isolated applications are hardly aligned to each other, future health frameworks have to provide the required umbrella for synchronizing individual efforts to optimally target common goals, i.e., the improvement of the user's health. As a consequence, the goal of the presented framework is threefold: Firstly, it needs to provide a structured and consistent translation of interventions, medical treatments or other user-specified aims into an actual implementation delivered through apps developed by externals. Secondly, it needs to facilitate the actual development of serious games or gamification-based health apps by providing both straightforward but privacy-aware access to relevant data as well as a standardized motivational system, i.e., system-wide rewarding schemes. Thirdly, the framework needs to initiate interventions based on psychological user characteristics such as gamer types or preferred BCTs, as well as availability of requirements of a desired intervention, such as time, location or weather conditions for instance. Similar to [10], the term "intervention" (IV) will be referred to as a single interaction with a single element of the system, whereas we refer to a set of of IVs delivered by apps as treatments (TMs). In the context, an app is considered to be potentially developed by externals with limited control by the platform, and is run within the framework itself. Figure 1 shows the big picture of the framework's components.

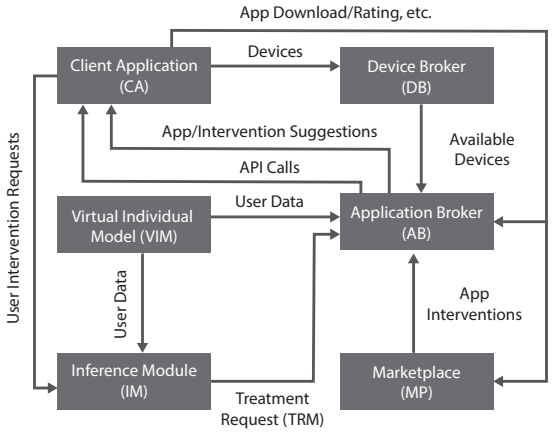

Fig. 1. Overview of the presented framework.

The overall architecture of the framework consists of several components which are described in brief in the following.

The **Client Application (CA)** serves as the main application for the user with execution of potential apps developed by externals. It is the single trusted point of interaction of the user with the system and moderates access to the back-end functionalities. Mainly, it implements a sandbox for running externally developed apps, e.g., a food intake diary realized with HTML5 and JavaScript (JS), as well as central, sandbox-independent functionality for personalization of the system. With this design, we can guarantee data protection as well as straightforward developer access to commonly used functionalities. Furthermore, developers have easy access to all the health data, analysis and gamification metrics offered by the platform e.g. through a JS API, which is bundled with the CA, and which also offers native resources and functionalities like available sensors (geolocation, heartrate, camera, etc.) or algorithms (step counters, etc.). Users can overview, like, filter, browse, hide and launch applications according to their needs, while suggestions are made by the framework itself dynamically according to preferences and set goals. The **Virtual Individual Model (VIM)** is a collection of historic user states which are collected and aggregated over time. Each state then contains several parameters and variables capturing both the user and their environments, as well as health-related micro and macro goals of the user following continuous needs assessment. The **Inference Module (IM)** represents the "clinical" part of the framework and is designed to create treatments based on user-specific parameters and different sets of rules. Starting from parameters from the VIM such as health indicators or treatment preferences, recipes represented as "if-this-then-that"-like rules trigger so-called "Treatment Requests" (TMR) based on health parameter thresholds and user contexts (e.g., location) and are targeted at improving health conditions or to implement change objectives. Main recipes could be based on general health guidelines issued for instance by public institutions, whereas both developers and users can adjust and create their own rules, i.e. users may specify to be notified when sitting for more than two hours. The **Application & Device Brokers (AB, DB)** are generally responsible for selecting potential ways to operationalize the suggested treatment by the IM. First, the DB module is contacted to gather available actuators and devices for the TMR. Once one of the CAs has been opened by the user, the best fitting app (i.e. matching TRM requirements, whether the user has enough time for necessary tasks, etc.) is triggered. The selection algorithm should also consider the popularity and ranking of apps within the marketplace, not only on a global level, but also with respect to users and user type specifics, i.e. which apps have worked best for which gamer type in which context. A **Gamification Interface** is provided additionally to facilitate and standardize the gamification aspects of the framework, such as specifically designed metrics forming a global inter-app reward system which are required to reflect healthy activities. In general, the aim is to achieve a systemic integration of gamification aspects, such that the relative achievement, progress and motivational status of the users are *a*) (quantitatively) comparable within a social group; both users and apps can

access the user's current status measured in system-wide understandable metrics, e.g., coins, levels, leaderboard positions, and *b*) can be attributed to apps, i.e., reflecting the status within the app and the contribution to the health goals. A Gamification API, e.g., available via the JS API in the CA, will be the central entrance point for applications to access features with regard to gamification and associated health metrics, individualization and motivation. Besides the aim of a homogeneous interface, comparable metrics and the collaborative support for the user, the multifacetedness and creativity of individual apps are an asset, which need to be supported by limiting restrictions. Thus, the framework will provide means to access and set gamification metrics on the one hand, but also to create own metrics, badges or leaderboards on app-level on the other hand.

4 Discussion & Conclusion

The presented framework defines an approach of translating isolated app-based interventions into a holistic user-centered treatment implementation that not only tailors to the users themselves, their context and environment, but also eliminates common barriers between apps, which is to our knowledge a novelty in the eHealth domain. With this approach, we can aggregate efforts and creativity of individual apps to jointly address the goals of individual beings with their personality, needs, desires and background, while at the same time creating a platform that is able tackle privacy issues and reduce the cost of change for the entire spectrum of eHealth. Whereas the framework can help developers to formalize game ideas in terms of health-related IVs by adhering to it's structure and conventions, a multitude of different stakeholders can interact with the framework through our recipe-based intervention selection approach, hence providing transparent means for integrating the expertise of health professionals with limited technical backgrounds. The increasing smartphone adoption rates we see today on a global scale paired health interventions delivered through mobile technologies point to the conclusion that health apps will be deeply integrated into medical practices of the future. Holistic frameworks are thus promising for facilitating the cooperation of different stakeholders in the area of eHealth. The approach of fully utilizing the strength of modular apps in a coordinated way seems to be a promising balancing act towards targeting a very heterogeneous and unhealthy society. Our model is intended to be at a sufficiently high level to be generalizable for different eHealth problems, however, details such as the actual structure or categories of IVs or IVRs need to be specified upon implementation of the framework. Furthermore, the efficacy of dynamic app-selection for certain users needs to be evaluated and tested in long-term studies. Future work has to shed light on algorithms that align the current context and status of the user, required and available interventions, as well as health goals. Moreover, we will focus on the operationalization and implementation of the proposed framework.

Acknowledgements This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no 611366.

References

1. Azar, K.M., Lesser, L.I., Laing, B.Y., Stephens, J., Aurora, M.S., Burke, L.E., Palaniappan, L.P.: Mobile applications for weight management: theory-based content analysis. American journal of preventive medicine 45(5), 583–589 (2013)
2. Bartholomew, L.K., Parcel, G.S., Kok, G., Gottlieb, N.H., Fernandez, M.E.: Planning health promotion programs: an intervention mapping approach. John Wiley & Sons (2011)
3. Boulos, M.N.K., Brewer, A.C., Karimkhani, C., Buller, D.B., Dellavalle, R.P.: Mobile medical and health apps: state of the art, concerns, regulatory control and certification. Online journal of public health informatics 5(3), 229 (2014)
4. Buijink, A.W.G., Visser, B.J., Marshall, L.: Medical apps for smartphones: lack of evidence undermines quality and safety. Evidence Based Medicine pp. ebmed–2012 (2012)
5. Conroy, D.E., Yang, C.H., Maher, J.P.: Behavior change techniques in top-ranked mobile apps for physical activity. American journal of preventive medicine 46(6), 649–652 (2014)
6. Craven, M.P., Lang, A.R., Martin, J.L.: Developing mhealth apps with researchers: multi-stakeholder design considerations. In: Design, User Experience, and Usability. User Experience Design for Everyday Life Applications and Services, pp. 15–24. Springer (2014)
7. Crutzen, R.: The behavioral intervention technology model and intervention mapping: The best of both worlds. Journal of medical Internet research 16(8) (2014)
8. Haslam, D., Sattar, N., Lean, M.: Obesitytime to wake up. Bmj 333(7569), 640–642 (2006)
9. Kelly, T., Yang, W., Chen, C., Reynolds, K., He, J.: Global burden of obesity in 2005 and projections to 2030. International journal of obesity 32(9), 1431–1437 (2008)
10. Mohr, D.C., Schueller, S.M., Montague, E., Burns, M.N., Rashidi, P.: The behavioral intervention technology model: An integrated conceptual and technological framework for ehealth and mhealth interventions. Journal of Medical Internet Research 16(6), e146 (2014)
11. Nacke, L.E., Bateman, C., Mandryk, R.L.: Brainhex: preliminary results from a neurobiological gamer typology survey. In: Entertainment Computing–ICEC 2011, pp. 288–293. Springer (2011)
12. Navarro-Barrientos, J.E., Rivera, D.E., Collins, L.M.: A dynamical model for describing behavioural interventions for weight loss and body composition change. Mathematical and computer modelling of dynamical systems 17(2), 183–203 (2011)
13. Oduor, M., Alahäivälä, T., Oinas-Kukkonen, H.: Persuasive software design patterns for social influence. Personal and Ubiquitous Computing 18(7), 1689–1704 (2014)
14. Paredes, P.: Design principles for the conceptualization of games for health behaviour change. CHI 2013 (2013)
15. Riley, W.T., Rivera, D.E., Atienza, A.A., Nilsen, W., Allison, S.M., Mermelstein, R.: Health behavior models in the age of mobile interventions: are our theories up to the task? Translational behavioral medicine 1(1), 53–71 (2011)