Towards an Adaptive Behavior Change Game Based on User-tailored and Context-aware Interventions

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Abstract

Persuasive technologies represent a great opportunity to provide interventions capable of leading people to behavior change in the health and wellness domain. However, changing behavior is a difficult process and these technologies often adopt a one-size-fits-all approach, also scarcely considering the meanings that users may attribute to the process of change. In this sense, behavior change requires more personalized and meaningful interventions to bring more effective outcomes. This goal may be achieved with the combination of adaptive systems, which can adapt on the basis of a user model and some contextual data, and video games, which can make the process of change more enjoyable and meaningful. To this aim, we propose a mobile-based adaptive Behavior Change Game that promotes positive habits by personalizing its gameplay on the basis of a comprehensive user model, containing information about her habits, behavior and context collected through smart devices. We believe that adapting the game on the basis of the real-world user's behaviors may give the feeling that the behavior change in the real world is a game itself, intertwining the real and the virtual worlds and increasing the motivation to change.

Keywords

Persuasive technologies, persuasive games, Behavior Change Game, behavior change system, personalization, wellbeing

1. Introduction

Changing human behavior is essential to address many personal and societal issues. Persuasive technologies represent a great opportunity to this aim, providing interventions capable of leading people to behavior change. Especially in the health and wellness domain, a variety of applications and devices are currently spreading among general population, promising to help people increase physical activity, lose weight, reduce stress, and, more in general, improve their well-being.

However, changing behavior is a difficult process and technologies have been proven to be only partially effective to this aim [1]. In fact, they often focus only on the single target behavior to be modified, whereby behavior change intertwines with habits, everyday practices, constraints, and life circumstances, and the person's perceptions, motivations and meanings. Moreover, behavior change technologies often adopt a static view of the person, without

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accounting for the changes in her internal states, promoting a one-size-fits-all approach, in contrast with the dynamic and idiosyncratic nature of change [2].

In this sense, behavior change requires more personalized interventions [2, 3, 1], which have been proven to bring more effective outcomes [1, 4]: these could be achieved by integrating behavioral change strategies with *adaptive systems*. Adaptive systems [5] are able to perform adaptation on the basis of a user model with knowledge and information inferred from the user's data and contextual features.

In this sense, the growing number of smartphones and wearable devices, together with the massive use of social networks, have recently increased the availability and amount of data about the person, potentially allowing adaptive systems to create a comprehensive view of the users and their life [6] and to tailor the most appropriate intervention to them [7].

Moreover, the spreading of video game practices among the general population is becoming an opportunity to design interventions that leverage "the persuasive power of games" to induce people change their behavior. In fact, they may make behavioral interventions, as well as the behavioral data collected by the user, more meaningful, also making the process of change more enjoyable and motivating [8, 9]. By using game-based designs, people could be less inclined to disengage from the behavioral program and abandon the technology. Beyond serious games and gamification, recent years brought out a new kind of game for this specific purpose: Behaviour Change Games, which are capable of providing interventions through game elements, apparently producing effective outcomes [8, 10]. However, even in this case, personalized designs are still very limited: personalization of content, based on the player's in-game and "real-world" behavior, may represent a strong factor for the engagement of the user and for creating tailored interventions.

Our purpose is to design and implement a persuasive technology that combines both adaptive systems and games to exploit their advantages, going beyond traditional persuasive approaches' limitations. We thus propose a mobile-based adaptive Behavior Change Game that promotes positive habits (e.g., doing physical activity and dieting), able to personalize its gameplay on the basis of a "holistic user model", that is a user model containing information about habits, behavior and context collected through smart devices [6]. Adapting in-game elements based on *real-world user's behaviors* may give her the feeling that the behavior change in the real world is a game itself, exploring a completely new approach that intertwines the real and the virtual worlds leading to novel insights and research questions.

2. State of the Art

Persuasive technologies are designed to change attitudes or behaviors by making desired behavioral outcomes easier to achieve [11]. They address different domains (e.g. work, safety, health and well-being) and may be based on behavior change theories to provide specific and appropriate intervention strategies [1]. However, traditional persuasive technologies encounter some limitations. Rapp et al. [2] and Nosakhare and Picard [7] observed that they are often addressed to a single target behavior, not considering the user's contextual factors, as well as other behaviors and habits and her internal processes, which may influence the process of change. Riley et al. [3] also asserted that most of behavior change theories, on which technologies are

based, have a static, linear nature, and consider change as a linear process consisting of a series of discrete events, which unfolds in a fixed and standardized sequence of phases, as it happens in the Transtheoretical model of behavior change [12]. This does not fit with the dynamic and idiosyncratic nature of behavior change, which may differ across individuals [2]. In fact, current persuasive technologies mostly adopt a one-size-fits-all approach, but interventions need to be adaptive and tailored to the individual to match such dynamic and idiosyncratic nature.

To overcome these limitations, persuasive technologies may be integrated with adaptive systems leveraging their personalization capability [5].

In this sense, the rise of new technologies such as smartphones, wearable and sensor-enriched devices has increased the amount of data that is possible to collect implicitly about the user, in addition to his/her preferences and goals, opening new opportunities for personalizing the behavioral intervention. Cena et al. [13] and Musto et al. [14] introduced the concept of holistic and real-world user model, which encodes heterogeneous user features (e.g. personal interests, psychological traits, health data, social connections) from multiple data sources, as a basis for providing personalized technologies. Indeed, Torkamaan and Ziegler [1] demonstrated that a complete view of the user to personalize and adapt interventions to her habits and context, is needed as it increases persuasive technologies' relevance and effectiveness in assisting people to achieve their goals.

For instance, contextual data are significantly relevant to design better interventions, as users are highly influenced by their context and relationships when they are trying to change their own behavior, as literature exploring behavior change in clinical practices has already suggested [15, 16]. In this line, Afzal et al. [17] and Lin et al. [18] provided personalized well-being suggestions exploiting contextual factors such as location, agenda, weather and time from lifelog data and open data. Gyrard and Sheth [19] created an IoT-based well-being recommendation system with a web-based knowledge base to infer meaningful information from data produced by devices, through diverse common sense knowledge catalogs.

However, persuasive technologies that leverage together a variety of contextual data as well as user data, like those referring to her internal states, like preferences, emotions, and meanings, which all may heavily affect the process of change [2, 20], are still limited. For instance, Bentley et al. [21] built a Health Mashup system that identifies connections between users' contextual and wellbeing data and displays observations through texts in a mobile application, increasing people's understanding and leading to quite positive changes in their behavior. Anyway, it does not consider that each individual gives different meanings to these correlations and internal aspects can highly influence the person's behavior.

In this sense, behavior change applications commonly suffer from another issue: persuasive interventions and personal behavioral data visualization (e.g. numbers, graphs) often lack meaning, as they may not consider the user's sense-making process [2, 20], which is essential for a long-lasting change, or provide information that are too abstract and difficult to interpret by the users [22]. This can lead to disengagement and abandonment of the behavioral program.

It is thus necessary to identify technologies capable of making the behavioral change strategies more meaningful for the user, creating a valuable experience that can motivate and engage her to achieve his/her aim: this is the case of video games [2].

In particular, people may be motivated to do something by two kinds of "stimuli": extrinsic rewards, e.g. money or material goods, or intrinsic rewards such as inherent satisfaction, positive

emotions, interest or enjoyment [23]. Intrinsic motivation or self-motivation is considered the key of success to change behavior in coaching practices [15], as it increases the quality of effort that people put into a given task [24]. McGonigal [25] states that games provide players with a variety of intrinsic rewards, first of all meaning, that is the feeling to be part of something bigger beyond their own individual lives. In fact, the game activity itself is meaningful per se, as highlighted by literature on meaningful play [26, 9].

Iacovides and Mekler [27], for instance, investigate the role of games in times of personal difficulty, showing that people playing video games, may use playing for personal growth and change: by playing, players feel involved and focused on improving something that gives them meaning through achievable goals, rewards and clear connections between their actions and performance, and the competence and motivation that they develop in game can influence their out-of-the-game life.

In this vein, serious games and gamification are applied in many persuasive contexts (e.g. health, education, environmental sustainability), allegedly promoting the behavior change of individuals leveraging specific game design elements or creating full-fledged games [10, 8]. Nonetheless, both the approaches suffer from key limitations. On the one hand, gamification design often insert stand-alone game elements into existing applications without adopting a more systematic design, elicit mechanical behaviors without creating a truly engaging and meaningful experience, and limit the game design elements used to points, badges and leaderboards, which are meant to stimulate merely the user's extrinsic motivation [20]. On the other hand, serious game design tends to give less importance to the "fun factor", possibly resulting in games that are less enjoyable and engaging if compared with commercial video games: this may negatively impact on the user's motivation in adhering to the intervention [28]. Moreover, both the approaches commonly adopt a one-size-fits-all approach, which does not consider the individuals' idiosyncrasies in undergoing the behavior change process.

Recent applications have led to the definition of Persuasive or Behavior Change Games (BCGs), that is, games created for the major purpose of promoting behavior change on the basis of specific behavior change theories, resulting more effective than traditional persuasive technologies as they aim to provide enjoyable and meaningful experiences through game-based metaphors [8].

For example, Ndulue and Orji [29] developed a persuasive game for health aimed at promoting risky sexual behavior change by sharing knowledge about sexual diseases, then Ndulue and Orji [30] evaluated the game, which resulted effective in motivating change and led to a significant increase in the knowledge about sexual diseases and their preventive measures.

Also in this case, the tailoring of the game content and interface to the user's needs, preferences and behaviors, could increase involvement and player identification [31]. Indeed, Orji [32], Bakkes et al. [33] and McCallum [34] stated that tailored persuasive games are more effective in motivating the desired change than non-tailored systems. Orji et al. [35] and Orji et al. [36] conducted large-scale studies and observed that people's personality traits and gamer types play a significant role in persuasion, as specific kinds of people are more motivated by certain game-based persuasive strategies, highlighting the importance of tailoring persuasive games. However, they do not implement an actual game to evaluate the effectiveness of such strategies.

By and large, personalization is rarely implemented in even game-based systems for behavior change. In any case, even when it is present, it is only based on what the user performs within

the game: there is no game that provides adaptive gameplay based on what the user performs in the real life to improve user's engagement and enjoyment in a behavior change therapy. The main novelty of our proposal lies in the adaptation of the game to the user's behavior in the real world.

3. Scenario

In this section we will provide a very simple descriptive scenario, which, nonetheless, may help to envision the aim of our solutions.

Mark leads a sedentary lifestyle and even if he knows that it is important to exercise, he is not motivated enough to do so.

Recently he downloaded a new adaptive game for behavior change and connected it to his smartwatch. Since he does not perform physical activity, his avatar in the game walks slowly and is only able to perform some basic actions (like punching the enemies). Anyway, the game has an evolving gameplay and Mark likes its challenging setup. One day, Mark walks more than he usually does, because his car broke down the day before. His smartwatch captures this behavior and updates his game's user model. At the end of the day, when Mark comes home and lies down on the sofa to play the game, he observes that his avatar walks faster, has increased its experience level, and can now can unlock new features like new powers.

He is informed through a text message that this is the consequence of his real-life behavior, as he walked more than usual and the gameplay has been adapted to his real-life behavior. Now, the whole game experience changes: he can beat more enemies, perform new actions and level up, unlocking new elements. The fact that what Mark performs in real life influences the game gives him the feeling that behavior change in the real world is a game itself: walking more than usual had no meaning to him before, but now that it has an impact on his in-game performance, he feels like his daily actions can be connected with heroic endeavors in the game, giving meaning to the process of change, and involving him in something that he can actively improve [25, 27]. Walking starts becoming something with an intrinsic value for him, motivating him to keep exercising.

4. Our proposed adaptive Behavior Change Game

We aim to combine all the advantages and computational strategies of adaptive systems and games together with models and theories of behavior change, to implement a Behavior Change Game able to adapt game elements on the basis of the user's behavior in real life. The game will be connected to different smart devices that implicitly collect data about the user, then a Machine Learning model will infer new knowledge about his/her habits, context and behaviors.

In fact, all the collected and inferred information will be integrated in a holistic user model, that will be used to adapt the gameplay, giving the player the feeling that what she performs out of the game, as well as the meaning that she develops, have consequences in the game and influence the game flow.

The main purpose is to give meaning to the behavior change intervention, leading the user to maintain positive habits motivated by in-game changes. This will overcome the limitations

of traditional persuasive technologies and allow the rise of new research directions.

Differently from traditional serious game approaches, the game will give great emphasis to the ”fun factor” to make the gameplay enjoyable and engaging. Moreover, differently from gamification design, the game will be based on a systemic design, and not on stand-alone, limited game design elements, exploiting the entire repertoire or game design dynamics and mechanics that game designers have at their disposal.

4.1. User modelling

In order to understand the users' habits and behavior, it will be necessary to connect the BCG to multiple smart devices, such as smartphones and wearable devices. They implicitly collect a significant amount of raw data about the user (e.g., heartbeat, movements, locations, time, etc.) that will be used by a machine learning model to find hidden patterns that represent behaviors and habits of the user (e.g. running, smoking, etc). To increase the accuracy of the inferences, the learning process will include the employment of rules of common sense knowledge to improve user and context data interpretation.

All the inferred information will be collected in a holistic user model, able to give a comprehensive view of what the user performs in real life.

4.2. Adaptive gameplay

The design will follow an incremental and integrated approach. The game will be created by designing different ”modules”, one for each adaptive game aspect of the intervention (e.g., data visualization, reward system, etc.). Each module will include different game dynamics and mechanics tied together, able to be adapted to the user on the basis of one or more features of the user model. The adaptation will be performed for both the game content and interface, mainly changing, hiding or showing specific elements.

Each ”module” will be integrated into the game and tested with users before adding new ones, in order to evaluate its meaningfulness and effectiveness. For instance, how the behavioral data will be represented in the game (e.g., in the form of virtual objects, or missions) will be designed and immediately integrated into the whole game and then tested . In parallel, the game will be also holistically evaluated to understand how the new insertions impact the whole gameplay.

The game will be implemented with Unity[1] as it includes different tools, libraries and plugins for mobile-based game development.

The final goal is to define a framework implementing this new approach to persuasive technologies, giving evidence of the elements to be considered when designing a behavior change game and to be adapted to different domains and scenarios.

5. Discussions and conclusions

Current persuasive technologies can be more effective by integrating them with adaptive systems and games, providing tailored and meaningful interventions. Our Behavior Change

[1]https://unity.com

Game aims to lead the user to a change in an enjoyable way, adapting the gameplay to her user model based on real-life behaviors and habits. To evaluate this new approach it will be necessary to consider both user's behavior change and subjective internal processes that the user experiences through it. To do so, quantitative evaluation methods will be combined with qualitative techniques, exploring externalistic and internalistic states to have a comprehensive view of user's perception of change and how the game is able to affect it [2, 8]. Beyond users' tests of the game, also the user modeling process will be evaluated to determine the accuracy of the user model's features and the Machine Learning model predictions [6], exploiting both mixed methods and precision-oriented metrics.

However, this work shows several challenges and open issues. First of all, the holistic nature of the user model brings privacy issues: the collection of different data about the user, many of which are sensitive, can reveal private habits and lifestyle choices [13]. That is why it would be important to provide a clear privacy notice, clarifying that all data will be used only to provide better adaptation and user experience, but at the same time, she will be always free to modify the access to each kind of data.
Moreover, the adaptation choices performed should be explainable, giving the possibility to understand how the system makes its inferences. The idea is to make the user model scrutable [37], allowing the user to visualize it in a comprehensive but feasible way. The main problem is its complexity and the amount of data collected, however, it would be interesting to adapt the data visualization to the nature of the system, using game elements also to explain the user modelling process. It would make it more enjoyable and meaningful, so that the user will be able to effectively understand how her data are used and which inferences are done.

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