Evaluating the impact of a cloud-based serious game on obese people

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A B S T R A C T

This paper describes the process of monitoring obese people through a cloud-based serious game that promotes them to engage in physical exercises in a playful manner. The monitoring process focuses on obtaining various health and exercise-related parameters of obese during game-play, such as heart rate, weight, step count and calorie burn, which contributes to their weight loss. While the obese are engaged in the game session, therapists/caregivers can access their health data anytime, anywhere and from any device to change the game complexity level and accordingly provide on the spot recommendation. In our study, we evaluate how the different physical activities performed through this game impact their cognitive behavior in terms of attention, relevance, confidence and satisfaction. The evaluation was based on the participation of 150 undergraduate obese and overweight students who were asked to play the game and fill a questionnaire after game-play. The data analysis conducted on their feedback showed that they were self-aware and motivated to play the game for weight loss.

1. Introduction

In recent years, obesity has become a major health problem all over the world affecting people of all ages (NHLBI, 2000; Puska et al., 2003). This is no different in the Kingdom of Saudi Arabia where more than 65% of people are overweight and becoming obese (Al-Hazza, 2007). Obesity leads to many serious health problems such as diabetes, heart diseases, hypertension and cancer. The World Health Organization (WHO) defines obesity by a Body Mass Index (BMI) of an individual higher than 30 kg/m^2 (Puska et al., 2003). To combat obesity, different approaches such as regular physical exercise, self-control and monitoring, consuming healthy food and decreasing the amount of daily food intake are prescribed (Villalobos et al., 2012; Görgü et al., 2010; NHLBI, 2000; Puska et al., 2003). Among these, physical exercise is considered as one of the most effective approaches that helps burning extra calories to prevent obesity (Jang et al., 2011).

However, in most cases it is not easy to monitor the health conditions of obese people during exercise and prescribe suitable exercise levels for them. More specifically, it is difficult to measure and record long term monitoring data of consumed calories during exercise and analyze them to get meaningful information which can help obese people to be self-aware and be motivated for weight loss. Therefore, an intuitive health monitoring system is needed for obese and overweight people to better prevent and manage obesity.

In order to motivate obese people to do physical exercise, one possible approach suggested in recent years is to utilize serious gaming concept (Alt, 2012; Zyda, 2005; Vandewater et al., 2004; Jackson et al., 2011; Arteaga et al., 2012) which includes indoor or outdoor exerting activity in the game play and teaches people regarding health issues. It can implicitly encourage people to increase physical activity levels while playing but without inducing boredom. Most popular indoor exergames are Dance Dance Revolution (Konami, 2012), Wii Fit (Wii, 2012) and Gitter Hero (Activision, 2012). Other outdoor exergames include AR Quake (Piekarski and Thomas, 2002), Pirates (Bjrk et al., 2001), Neat-0-Game (Fujiki et al., 2007), etc.

While the existence of the above works, which are very recent and shows varying level of success on weight loss and management, they are clearly not enough since obesity is still rising (Görgü et al., 2010). All of these works, at a general level, encourage increased physical activity to help prevent or treat obesity. However, more work is needed to get the full potential of pervasive serious gaming that supports real-time physical activity monitoring and on the spot recommendation and evaluation regarding exercise intensity or changing game levels.

In our preliminary work (Hassan et al., 2012; Hassan et al., 2013; Alamri et al., 2013), we introduced a cloud computing-based serious game framework considering the above issues. The framework acts as an enabler to develop different pervasive serious game applications suitable for the obese people. In contrast, in this paper, we describe the process of monitoring the heath conditions

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of obese people in real-time by integrating different kinds of sensors with our cloud-based serious game framework. Using a Treasure Hunting game scenario, we show how the physical activities performed through this game effects the body parameters of obese and overweight people. In addition, we explore the impact of game-based exercises on their cognitive behavior in terms of attention, relevance, confidence and satisfaction. Our study showed promising results in motivating the obese people to become self-aware and motivated in losing weight.

The remainder of the article is organized as follows. Section 2 describes the related work regarding serious game, its definition and application to obesity treatment as well as behavior monitoring through game. Section 3 presents the detailed methodology used for monitoring obese people. Section 4 shows the results of the study and a discussion follows detailing the implications of the findings. Finally, Section 5 concludes the paper with future research directions.

2. Related work

The work presented in this paper are related on a broad sense to the work of serious game applications to support obesity treatment as well as the works that studied the impact of game on the players' cognitive behavior. In the following, we briefly comment on some of these work.

2.1. Serious game and its application to obesity treatment

The recent advancements of computer graphics and computer hardware gave a large support to the development of computer games which have emerged as a powerful new economic, cultural, and educational force. Their ubiquity with increasingly diverse groups of people such as children, adults, and elderly people, suggests that their utility may extend beyond entertainment purposes. Clark Abt first introduced the term *Serious Game*) into the entertainment arena (Alt, 2012). He defined a serious game as an activity among two or more independent decision-makers seeking to achieve their objectives in some limiting context. In Game Developers Conference (GDC) 2004 (Anonyms, 2004), Sawyer introduced serious games concept as solutions to solve problems. According to him, serious games' primary goal is not entertainment, or they can be entertainment games applied in a different manner. In 2005, Zyda in (Zyda, 2005) updated some serious games concepts. He defined serious games as "mental entertaining context played in accordance to specific rules to serve certain objectives including training, education, public policy, and health". Thus, serious games engage users in a purpose and help to achieve a determined goal that extends beyond pure entertainment El Saddik et al. (2008),Wendel et al. (2013), Bououd and Boughzala (2013).

An emerging line of research on serious game focuses on health issues such as prevention of disease, healthy lifestyles, and physical exercise. In order to support obese and overweight patients, some exergaming applications have been developed using serious games concept. Göbel et al. (2010) developed three serious games – ErgoActive, SunSports Go and Y-Move for health purposes. The same authors also propose a context-aware serious game framework for sports and health to select appropriate exergaming based on users' current context (Hardy et al., 2011).

The Wit Fit from Nintendo (Wii, 2012) is probably the most well known commercial example of exergaming platform providing a series of games, such as golf, dance and football. Dance Dance Revolution (Konami, 2012), Guitar Hero (Activision, 2012), Feeding Yoshi (Bell et al., 2006) and RTChess (Stanley et al., 2008) are other examples of exergames. Selmanovic et al. in (Elmedin et al., 2010) produces a serious game for children that uses Wii Controller and

Wii Balancing Board. Play Mate! (Berkovsky et al., 2009) is a game which motivates users to perform physical activities that lead to changing the game difficulty level depending on users performance in the game. Exertion interfaces (Mueller et al., 2003) aims at increasing the physical activity of computer users stating that persuasive physical activity intervention will contribute to overall well being. NEAT-o-Game (Fujiki et al., 2007) collects user activity data from a wearable accelerometer which controls the animation of an avatar that represents the user in a virtual race game running on cell phone and playing with other players over the network. Similarly, MacLellan et al. (2009) perform measurements of physical activity and the location of users to promote the utilization of walking as a form of transportation as a primary mechanism to encourage people to become more active. Botella et al. (O'Donovan and Hussey, 2012) examined the energy expenditure and heart rate response while playing Wii based active video games, and the effect of gaming experience on energy expenditure.

While the existence of the above works, which are very recent, none of the above work would be used clinically by an obesity expert. They generally fail to provide activity recommendation, evaluation and in many cases even a suitable activity tracking mechanism. On the other hand, commercial systems such as RunKeeper and Endomondo often provide activity evaluation and activity tracking. However, they target already physically active people, who often do not require recommendation or evaluation of their activity, nor any special motivation, as they can handle all these factors on their own.

Thus, in our preliminary work (Hassan et al., 2012), we introduced a cloud computing-based serious game framework considering the above issues. The framework acts as an enabler to develop different pervasive serious game applications suitable for the obese people. However, we did not explore how the game activities effect various physical as well as cognitive behavior parameters of obese people during the game playing sessions. This study is very important to find out their motivational stimuli to play the game over a long period.

2.2. Behavior monitoring through a game

There are few works which focus on monitoring human cognitive behavior through a game. In (Orun and Seker, 2012), the authors introduced a method of collecting cognitive behavioral data via computer/console games. In the experiment, a commercial console game was utilized by different users to complete the tasks in which each game player followed his/her own optional scenarios of the game for a certain period of time. The attributes were then extracted from the behavioral video data sequence by visual inspection where each one corresponds to users behavioral characteristics spotted throughout the game and then analyses by the Bayesian network utility. In Botella et al. (2011), the authors developed a serious game for the treatment of cockroach phobia that uses a mobile phone as the application device. They monitored various cognitive load of a participant like anxiety levels, fear and avoidance from cockroaches while game-play. Their preliminary results showed positive impact on reducing cockroach phobia. The authors in Luse et al. (2012) studied the attitude of business professionals to accept the premise that virtual worlds could be useful for business applications. In Huang (2011), the authors presented the process and results of an evaluation on an online game-based learning environment (GBLE) by focusing on learners motivational processing and cognitive processing. They primarily investigated the correlation between learners motivational and cognitive processing capacity. In contrast to all these works, we focus on how a cloud-based game activities effect various physical as well as cognitive behavior parameters of obese people and help them to lose weight loss.