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FITTER - A Framework for Integrating Activity Tracking Technologies into Electric Recreation for Children and Adolescents

R. Altamimi, G. Skinner, and K. Nesbitt

***Abstract*—**Encouraging physical activity amongst children and adolescents is becoming an increasingly relevant issue in modern society. Studies have shown that involving children and adolescents in physical activity is essential for their physical, mental and social development. However, with technology playing an increasingly important role in reducing physical work it is becoming more critical to incorporate adequate physical activities into our lives. One way to overcome this problem is to harness technology so that it promotes physical activities, for example, by motivating children and adolescents to exercise more. This paper describes a promising solution to the question of how to increase levels of physical activity in children and adolescents by combining gaming technologies with exercise tracking goals. This research describes a framework called FITTER (Framework for Integrating activity Tracking Technologies for Electronic Recreation) that combines video game play with more traditional, non-computer physical activities.

***Keywords*—**Exergames, Home-based eHealth, Human-computer Interaction, Natural User Interfaces, Wearable Health Informatics.

I. INTRODUCTION

CHILDHOOD obesity is a major health issue and unfortunately it is also one that has been increasing globally prevalence over the past few decades [1], [2]. Furthermore current predictions are that this problematic health trend is likely to continue. With obesity becoming a major health concern it is not surprising that it has attracted the attention of a number of scientists and researchers [3], [4]. Obesity presents a number of negative consequences for both children's physical and psychological well-being. Obese children are at greater risk of developing conditions such as cardiovascular disease, diabetes, sleep-breathing disorders and some forms of cancer [5], [6]. Obesity has also been associated with negative psychological outcomes such as depression, poor body image and low self-esteem [7].

Several studies have explored the reasons behind the increasing number of overweight children and adolescents and uncovered a strong relationship between obesity and physical inactivity [8]. The combination of lower levels of physical activity and higher levels of sedentary activity is a simple mechanism that underpins the increasing number of overweight and obese children and adolescents [9]. While it is recognized that more effort needs to be made in ensuring younger people engage in greater levels of physical activity it is also recognized that this is difficult in a society where many engaging but sedentary entertainment technologies are available. For example, video games, which are a popular leisure activity amongst children and adolescents [10], are considered to be one of the sedentary, screen-based activities that contributes to the increased levels of obesity amongst children and adolescents [11].

It is recommended that children and adolescents participate in at least 60 minutes of moderate to vigorous physical activity daily [12]. Apart from improving general fitness, physical activity provides a number of benefits to the overall healthy development of children. Despite the social acceptance of the key role exercise plays in young people's lifestyles, it is also true that a number of barriers can exist that discouraged children and adolescents participating in physical outdoor activities. Examples of these barriers include unsafe conditions when playing outside [13] or poor weather conditions such as rain, cold temperatures and snow [14]. More complex social barriers include lack of time and energy for children to play outside or indeed the lack of parental time and energy for facilitating of childhood exercise [15].

Active video games are a new generation of video games that integrate physical exertion into the mechanics of the game play. Players have to physically interact in the real world with a motion sensor in order to control their actions in the virtual world. This form of game has the potential to exchange sedentary behavior in children and adolescents with active behavior. Because they are played indoors, such games obviously overcome these barriers of outdoor play.

Thus integrating exercise into purpose built video games may provide one way to combat childhood obesity. These games might offer an entertaining atmosphere while encouraging players to partake in increased levels of physical activity. However the efficacy of such games is not clear. Whilst some researchers have found that active video games are effective in increasing the level of physical activity in children [16]-[18], others have reported that such games have no effect on improving rates of physical activity [14]. There is still no compelling evidence that active video games are effective enough to replace real life sports which, compared to video games promote higher rates of energy expenditure and greater ranges of movement [17], [19], [20].

R. I. Altamimi is a research student with The University of Newcastle, NSW, Australia (e-mail: Reem.Altamimi@uon.edu.au).

G. D. Skinner is with the Faculty of Science and Information Technology, The University of Newcastle, NSW, Australia (phone: +61 2 4985 4512; mobile: +61 (0) 401 434 112; e-mail: Geoff.Skinner@newcastle.edu.au).

K. Nesbitt is with the Faculty of Science and Information Technology, The University of Newcastle, NSW, Australia (e-mail: Keith.Nesbitt@ newcastle.edu.au).

This paper aims to bridge search gap in this area by proposing a blended solution that integrates traditional sporting activities with video game technologies. We will propose an approach that integrates electronic recreational game play with non-screen based physical activities such as sports, outside play and exercise in a manner that encourages children to be more physically active both in front of the game screen and in the real world. To achieve this goal we present a conceptual architecture called FITTER. The FITTER framework will be described in Section IV. However, first we present a detailed review of related work, including previous active video games, game technologies such as Kinect, and current tracking technologies used in measuring exercise activity.

II. Background and Related Works

A. Active Video Games for Exercise Motivation

Active video games are seen as an effective way to motivate people to start exercising as well as a way of encouraging their adherence to an ongoing exercise program [21], [22]. This idea has been frequently discussed in the literature, leading to the concept being identified with the term *exergame* [16], [18], [23], [24]. Exergames have the primary aim of motivating people to exercise by providing a safe, entertaining and engaging fitness experience [24]. Another term that is in use in relation to exergamesis the idea of a flow state where the player/exerciser becomes fully immersed and focused in the game activity. In order to investigate the correlation between the exergame experience, player's flow state, enjoyment and physical fitness, one study developed a number of questionnaires to analyze these factors in exergames [25]. One hundred and thirty participants with previous experience using active gaming technologies were enrolled in the study. The study reported that two factors, the frequency of play and the duration of playtime correlated to an increase in both the player's flow state and their enjoyment. Furthermore, a relationship between the frequency of play and the player's sense of health and physical fitness was measured [25].

Exergames then have the potential to encourage children to exercise and promote a more active lifestyle, helping to alleviate the widespread problem of obesity in children [24]. However, whether or not active video games actually promote physical activity among children and adolescents is still controversial. While some literature reports that active video games are indeed effective in increasing the level of physical activity in younger people [16]-[18] other studies report the contrasting view that active video games actually have no effect on improving rates of physical activity [14], [26].

One study that found a positive effect from exergames examined players' physical activity over time as well as the players' motivation and normal behaviors [27] using a mobile-based game called "iFitQuest". This exergame consisted of eight mini games which all incorporated the players physical movement into the games mechanics[27]. The exergame was tested in a school environment and involved 12 students aged between 11 and 12 years old. According to the authors observations, the game successfully motivated participants to engage in light intensity exercise throughout the duration of the seven week study [27]. This study has some limitation sin terms of the number of the population size and subjective assessment used.

By contrast another study concluded that playing active video games under naturalistic circumstances did not lead to increased daily physical activity in children [26]. The study revealed that the difference between active video game play and traditional light to moderate physical activity, in terms of energy expenditure, heart rate and oxygen consumption was statistically insignificant. This was especially true for children and adolescents, who expend more energy than adults whilst playing active video games [28]. However, this study also had some limitations, using only one game console and providing no instructions on how to be physically active as well as testing a small sample of children of a limited age range [26].

As a result of the conflicting reports about the efficacy of exergames a number of suggestions have been made to try improving the testing of active video games. In particular evaluations need to be made over longer periods of time in order to gauge how sustainable exergames are as a long term approach to engaging youth in physical activity [16], [29], [17]. Furthermore, different active video game technology need to be compared under different play conditions [26]. One key to successful exergames is improving player motivation. Therefore, in conjunction with better testing of active video games further effort needs to be dedicated designing game elements that specifically enhance player motivation [26].

B. Technology's Influence on Physical Activity

As in other areas, technology has the potential to play a significant role in contributing to physical activity and influencing exercise behaviors. Indeed there is a notable trend for using technology to help promote physical health [30], [31]-[33]. A number of new technologies have been employed within this context, including desktop computer systems, mobile applications, monitoring devices, computer games and more specific exergame technologies [31]-[33]. Indeed many health clubs and fitness industries have employed technology as a tool for physical education and training. For example, low-end web-based applications have been used by the fitness industry and health clubs to try and achieve a high uptake of exercise by the general of population [30]. At the other end of the spectrum, researchers have designed higher end technology solutions in an attempt to create 'persuasive technologies' that might attract users to adopt healthier behaviors and manage weight loss [34].

When developing applications to encourage people to exercise there are a number of design concerns that should be met. Firstly, users need a technology that effectively tracks their physical activity and registers their overall level of activity. In should be kept in mind that some exercise tracking devices may be effective in one application but not others. For example, a pedometer device used to track and record step counts is not appropriate for physical activities such as swimming and cycling [31].

A second design criterion is that any device should allow users able to constantly check their level of activity including the history of their recent behavior, their current status and how their performance levels in compare to their goals. This is known to help users stay motivated.

Thirdly, users have indicated that their motivations are influenced by social support. For example, sharing daily activity levels with friends can motivate users to become more competitive in their exercise goals [31], [35]. Moreover, messages of support from friends can encourage a person to keep active and further achieve their exercise goals [31]. However, some possible negative impacts of social connectivity also need to be kept in mind. For example, if social support leads a person to set goals that are unsustainable then they may experience a decrease in motivation [27]. The situations in which this negative motivation might arise include low player performance and low self-efficacy [27].

Fourthly, designers should be aware that there is variation in the self-efficacy profiles of individuals and account for this when designing technology targeted at exercise. A users' self-efficacy can be defined as their judgment of their capability to perform certain tasks adequately [27]. Not all users will have the same expectations about their ability to obtain perform physical activities.

Finally, exercise technology designers need to consider the practical constraints of users' lifestyles which include the portability and usability of the technology [31]. These criteria, along with the other four design factors should be considered together when employing technologies designed to motivate exercise.

C. Similar Works

In this section we consider a study that is directly relevant to our own approaches for designing exercise related games.

"Fish'n'Steps" is a social computer game that links the players' physical activity directly with the game play [32]. It uses a pedometer device to count the players' daily steps. This in turn influences the growth of their virtual character in the game; the more steps they take the bugger their character grows. Developers conducted a 14 weeks study involving 19 participants aged between 23 and 63 years in order to assess the potential of this system for encouraging exercise. The experiment consisted of three phases: pre-intervention, intervention and post-intervention. In the pre-intervention phase (4 weeks), participants only used the pedometer in their everyday activities in order to count their average daily total steps. This pre-intervention phase helped the researchers to establish individual baselines and set individual goals in terms of how many steps they show take each day. During the intervention phase (6 weeks), the subjects used the pedometer device as well as the game application. They were encouraged to achieve the goal that had been set in the pre-intervention phase in order to make their virtual characters grow. This was achieved by connecting the pedometers to the game and mapping the daily steps participants had accumulated in real life to the growth of their game character. In the post-intervention phase (4 weeks), the participants again used only the pedometers to assess their physical activity levels. These post-intervention physical activity levels were compared with both the pre-intervention and intervention activity levels. The researchers concluded that that their system was effective in creating initial excitement as well as motivating players to increase their levels of physical activity in entertaining way. A further benefit was that participants become more aware of their daily physical activity levels [32].

III. Modern Exercise Tracking Technologies

Various types of technologies have already been adopted that help people monitor their physical activities. Examples of this include online tracking systems, mobile applications and even wearable activity trackers such as pedometers and Health Life wristbands that allow individuals to track their levels of exercise and everyday physical activity. The motivation behind using these tracking systems is to record activity and calories burned. There is some evidence that when individuals receive feedback about their negative health behaviors such as lack of exercise or eating too much, they are more likely to try and change these unhealthy habits [36]. Current tracking technologies not only allow users to become aware of their activity level but also to compare their amount of physical activity with friends. This in turn can motivate them to become even more physically active [36].

In the following sections we describe some currently available tracking technologies as well as their reported impacts on physical activity levels. We also look at recent gaming technology that has been adapted to this purpose.

A. Health Tracking Wristband Technologies

Health Life wristband is one example of a popular type of wearable, activity tracker that has been recommended by various training and fitness groups. Most of these wristbands have a flexible design which makes them ideal for everyday use and there are a number of popular bracelets available on the internet. The most common wearable activity trackers are reportedly, Jawbone UP, Nike+Fuelband and Larklife [37]. While Fitbit Flex band and Amiigo band are brands of fitness bracelets that have been recently released [38], [39].

Users can wear these bands in most of their daily activities including swimming and sleeping. They also come with corresponding mobile applications where users can synchronize data in order to check their physical activity progress. The fitness band called Nike FuelBand has a built-in screen, so users can monitor their physical activity level at any time by pressing a button on the band. Users can also set a goal and track their progress towards this goal. Some bands even allow their users to track their sleep mode (hours' slept and light sleep versus deep sleep) as well as food intake. Users can also keep a record of their daily physical activities including exercise intensity, distance covered, steps taken and calories burned. This data can then be evaluated in terms of how well their current physical activity supports their intended goals.

Some bands are quite flexible in terms of everyday use, having been designed with features such as water resistance, water-proofing and even buzz reminders for extended periods of inactivity [36]-[42]. However, there have been drawbacks identified with these bands including aesthetic complaints that their designs lack femininity and elegance. On the question of usability, users also identified the need to physically connect the device to a mobile for synchronizing data as annoying [37].

B. Pedometers

A pedometer is a portable electronic device that a person can wear in order to record the number of steps he/she takes [43]-[46]. Some models also estimate the distance that the person has travelled [47] and the amount of calories they have burned [43], [46]. A pedometer, also referred to as a 'step counter' or a 'movement detector' [46] is usually clipped to a person's waistband. The correct placement of a pedometer is on either the left or right lateral side of a person's body at the level of the hip, in line with the knee. Additionally, the pedometer should be worn in the upright position [48]. Pedometers are available in different models and brands that may differ in cost, internal mechanism and sensitivity [43].

Previous studies have examined the accuracy of pedometers in counting steps [43], [44], [47] as well as their ability to consistently measure vertical movement of the legs [49]. A further study tested the accuracy of pedometers for both counting steps and recording the distance walked at different speeds [47]. Pedometers have been shown to be more accurate at higher walking speeds as footsteps may not be captured when the insufficient forces generated by foot strikes in slow walking fail to register on the pedometer [44], [47].

It can be concluded that pedometers are a useful tool for estimating walking distance and number of steps taken at different speeds. While pedometers are reasonably accurate at calculating the distanced walked [47] the accuracy of pedometers also varies depending on the sensitivity of the model and brand [43], [47]. One study examined 10 different pedometer models [43] and found that pedometer models vary in their accuracy and reliability due to variations in their internal mechanisms and sensitivity. The Yamax, NL and KZ pedometers were reported to have the highest accuracy and reliability in counting steps (with acceptable rates of error) [47], [49], [43].

While the Yamax brand pedometer has been validated for accuracy and reliability in estimating walking distance and walking steps [43], [47], [49]. Moreover, one treadmill-based study demonstrated the high accuracy of the Yamax pedometer at slow-to-moderate walking speeds [47]. Based on these results, different researchers have used the Yamax brand pedometer in their studies [44], [50]-[53].

However, while pedometers have been validated for accuracy while performing light to moderate physical activity they are less accurate at lower levels of energy expenditure, particularly during activities that require little or no vertical movements for example household or yard-work [59]. It was proposed that the reason for this may relate to inability of the pedometer to detect the movements of the arms and upper body parts.

Pedometers are simple to use, and appropriate models can also provide measurements in diverse situations. For these reasons, researchers have frequently employed pedometers to assess levels of physical activity [50]. It has been suggested that pedometers are particularly useful for assessing physical activity in children [53]. However, there are some considerations that need to be made by researchers and practitioners when using pedometers to measure physical activity. These include the choice of metric, the monitoring time frame and the data recording and collection procedures [46]. An additional factor that may need to be considered is cost [43], [46], [54].

One study used the pedometer to examine the impact of natural variables such as the season, the month and the type of day (weekday versus weekend) on levels of physical activity over a one year period [50]. The pedometer was deemed to be an appropriate tool for self-monitoring of physical activity over the 12 month time frame due to its simplicity and accuracy [50]. Pedometers are cost-effective tool that is applicable within wide and large communities [54]. Furthermore, due to its simple operation and long term effectiveness the pedometer has been recommended used for the purpose of measuring physical activity in large studies [53].

Age is an important factor when considering physical activity levels and pedometers have been used to measure physical activity across a range of age groups [52], [49], [53]. In terms of appropriate levels of physical activity one study recommends that adults take 10, 000 steps per day in order to keep adequately active [55]. It has been suggested that this is equivalent to the recommended public health activity guideline [56]. Of course, this recommendation may not suit some population groups such as older adults or those who live with chronic diseases [56]. Furthermore, this recommendation may be too low for children and adolescents.

One comprehensive American study used the pedometer to measure the levels of physical activity among elementary school children based on age and sex [49]. This study involved a total of 711 children and measured their activity levels over a period of 4 weekdays. The study found that there was no significant decrease in daily step counts between 6 year old and 12 year olds. The author reports that this result is not consistent with other studies that indicate step counts decrease incrementally with advancing age. It has also been reported that there is a significant difference in step counts between boys and girls with boys being more active than girls [49]. The authors of this research suggested that the daily activity should fall within the range of 11, 000 steps per day for girls and 13, 000 steps per day for boys [49].

A further study conducted in the United Kingdom used the pedometer to measure the steps children took at school and in their leisure time [60]. A sample of 104 participants aged between 7 and 11 years took part in the study. The results showed that step counts were significantly higher during leisure time on weekdays. The authors postulated that this was due to there being fewer restrictions on play-time outside of school hours. The mean daily step counts on weekdays were

13091 (±3535) for girls and 17055 (±4165) for boys. This gender difference in daily step counts corresponded with the American study [49]. With regard to weekend step counts, this study reported no significant difference between the steps taken by boys on weekdays and weekends and while girls accumulated fewer steps on weekends compared to weekdays [52].

A third study also reported that step counts were higher for boys than for girls [53]. Again a pedometer was used to measure the physical activity in a sample of 34 children aged between 8 and 10 over a period of 4 weekdays and 2 weekend days. It was reported that, on average, boys took 16, 035 (± 5, 998) steps per day and girls took 12, 728 (± 4, 026) steps per day.

A systematic review examined the results of 32 studies within this context and produced step count ranges for different population groups [46]. The ranges reported by this systematic review were: 12, 000-16, 000 steps/day for 8 to 10 years old children; 7, 000-13, 000 steps/day for healthy younger adults; 6, 000-8, 500 steps/day for healthy older adults; and 3, 500-5, 500 steps/day for individuals with disabilities and chronic diseases [46].

In summary, the pedometer is a simple and inexpensive device that may be useful as part of a motivational tool to promote physical activity. The use of pedometers to monitor activity have been associated with significant increases in levels of physical activity and significant decreases in weight and blood pressure [45]. Two key motivators should be taken into account when attempting to increase physical activity levels using a pedometer. These are step goal setting and self-monitoring techniques such as using a step diary in combination with the pedometer [45], [46]. Having a daily step target for children to achieve both in school and in leisure time seems to provides a promising strategy for promoting increased physical activity in younger populations [52].

C. Mobile Technologies

Increasing physical activity and fitness awareness using tracking technologies has positive impacts amongst both active and inactive individuals [35]. However, there are draw-backs to the use of currently available activity measuring technologies such as pedometers and fitness bracelets [35]. These draw-backs include both aesthetic and practical considerations. For the fashion conscious, this externally visible technology does not currently come in styles that suit all individuals normal clothing [65]. The technology can also be uncomfortable as it may requires users to wear a belt or a structure to attach the technology to [57]. There is certainly scope for the development of technology in this area that is more suitable for everyday use [35]. Furthermore is has been suggested that alternative ubiquitous computing technologies could be developed or that existing and social media technology could be used to motivate people to exercise.

Mobile phones are one example of an existing technology that has already been used to track individual levels of physical activity. Mobile phones devices are ideal for this purpose as individuals have already been conditioned to carry them at all times [57]. Mobile phones can be used without any additional sensing devices to detect high-level user mobility as well as daily step counts [57]. For example, the Nokia 5500 mobile phone includes a sport mode that is able to detect some physical activities such as running and walking when users clip it on their wrist [58].

Researchers have also developed mobile applications that are able to track a user’s level of physical activity and increase their awareness of their activity levels. One study developed a mobile-based prototype called “Shakra” that was able to track the daily physical activity of its users [33] with the aim of increasing people’s awareness of their physical activity using activity tracking and sharing features. Through the experiment phase of this study, the researchers demonstrated that the system was; cost effective as a monitoring tool, easy to use, easy for the public to access, that it raised users’ awareness of their current level of physical activity, and that it created an enjoyable competitive atmosphere with a fun game-like characteristic [33], [59].

Another mobile system developed in the same style was named ‘UbiFit Garden’ [58]. This system used a sensing activity detector and a mobile display and once again the aim was to encourage physical activity. Twelve participants were used to test the effectiveness of the system on participants’ daily activity over a three-week period. Participants’ reactions to the system were positive and it was determined that the system encouraged participants to exercise, and in some cases helped them plan and arrange time for physical activity. The effectiveness of this system for monitoring is apparent in its ability to allow users to add, edit and delete data relating to physical activity in order to keep an accurate record of their overall physical activity [58].

There are other technology-based tools that align to developments in ubiquitous and wearable computing and have been developed to support physical activity tracking. Nike has developed a range of tools such as Nike+ iPod sensor, Nike+ shoes and nikeplus.com. Users can insert a wireless sensor inside a built-in pocket in the Nike+ shoes beneath the insole of the shoe and then use their iPhones, iPads or iPods to monitor and track their physical workout. The sensor is able to track walking or running time, distance travelled, pace of exercise and the calories burned. The user can also synchronize the data back to nikeplus.com where they can view their physical activity record, set goals and share motivations with other runners across the globe [60], [61].

D. The Kinect

Microsoft’s Kinect is an image-based, motion-sensing peripheral that allows users to physically interact with games and applications. As of 2013, the Microsoft Kinect, along with the Nintendo Wiiare two of the more popular hardware devices that have been used for creating active game play. The Kinect sensor for example, is well-suited to detecting player’s gestures and body movements and can also detect players voice commands in noisy environments. This provides a developer with the ability to provide a natural user interface to applications. Importantly for exergame applications the Kinect can be used to map the players physical interaction within a game [62], both to measure player responses and to control the game play itself.

Kinect is available for two development platforms, one being used with the Microsoft Xbox 360 (Kinect for XBOX) and one designed for use with Windows based computers (Kinect for Windows). Inour previous investigations in this area, we have looked closely at the Kinect for Windows platform for developing exercise-based games. We found that the Kinect device was able to accurately detect players' interaction and track their movements and was most suitable for developing active video games that involved whole body movements [63]. The Kinect provides a versatile, hands-free controller that requires no additional hardware to be purchased or integrated. It also provides a multi-player option which is can be a significant advantage when the Kinect is compared to other active video games peripherals [64].

As well as providing an effective platform, the Kinect for Windows is cost-effective and accessible with the Software Development Kit (SDK) for the Kinect for Windows platform being freely available to download [63].

Due to the low cost and accessibility it is not surprising that the Kinect sensor device has already been adopted for use within a number of different application domains. One relevant area that has been quick to apply this game technology for more serious uses is the medical domain [65]. For example, the technology has been used to estimate a patient's body volume by utilizing the depth data provided by Kinect to create a 3D model of the patient [65]. Other studies also used the Kinect device as part of a scanning system to capture visual images of human bodies and to produce full 3D human models [66], [67]. Kinect is an affordable and easy to use device that still provides an effective solution. Traditionally more expensive 3D scanning solutions requiring expert knowledge were required deployed in these types of applications [67]. Furthermore, these more expensive technologies have larger space requirements [66], whereas the Kinect can be set up to operate in a standard size room.

Another typical use of the Kinect has been developing hand gesture recognition systems for controlling applications [68]. A more exotic application involves the integration of the Kinect to provide hand tracking for a wearable computer [69]. The low-cost and widespread use of gaming technology such as the Kinect also suggests that it might be incorporated into physical exercise programs. Indeed similar active video game technologies, such as Wii Fit, have previously met with some commercial success.

IV. Conceptual Framework

This study proposes to integrate contemporary exercise tracking technology, such as pedometers with active video game technology, such as the Kinect into a single framework. Simply setting positive health goals for younger people may not provide sufficient motivation as they may not relate to or comprehend the health benefits of exercise. As such, traditional exercise programs may not work efficiently with children and adolescents. However, there is scope to encourage greater physical activity in children and adolescents by incorporating entertainment into physical activity in a way that suits their understanding and thought processes. The use of active video games for this purpose has been suggested repeatedly in the literature. Tracking technologies have also been proposed as a method of motivating individuals to exercise. Each of these tools has the potential to promote increased levels of physical activity in children and adolescents. However, we propose that integrating these two technologies will have a better outcome in terms of increasing physical activity in children and adolescents than either technology in isolation.

This section presents the conceptual design of the proposed FITTER framework. Fig. 1 illustrates the architecture of this design. Using the FITTER framework, children and adolescents can perform two types of exercise: screen time exercise and non-screen time exercise. In both modes, children can collect exercise points as a reward.

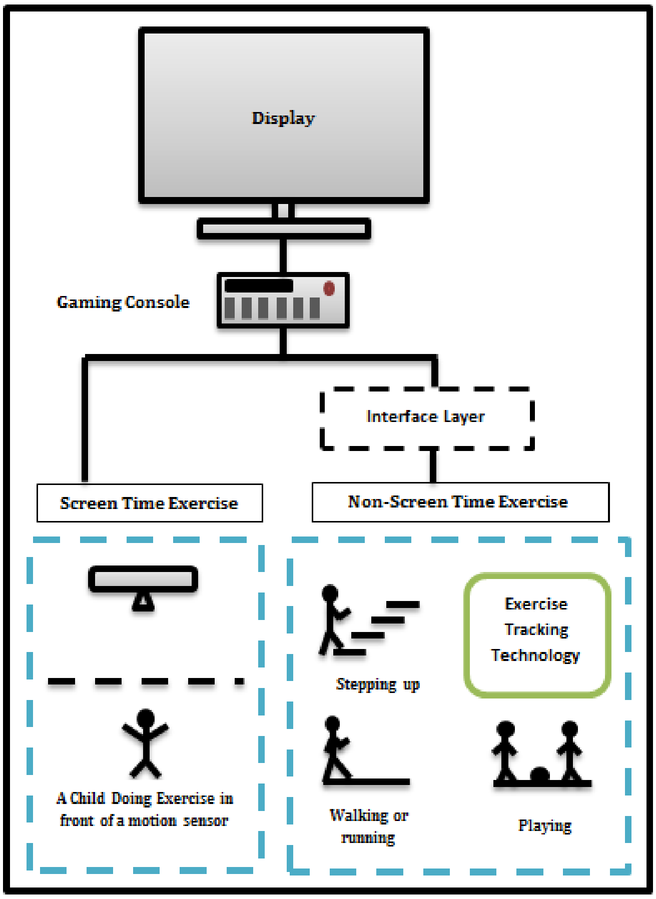

Fig. 1 Conceptual Framework

In screen time exercise, players are involved in physical activity through playing video games that use active gaming technologies. Exercise points are collected by meeting set challenges in the game. In this framework, for the active gaming technology we propose the use of Microsoft's XBOX 360 with the Kinect sensor as this technology has previously demonstrated its ability to accurately detect and track player's physical interactions [63]. The framework developed in this study suggests active video games should satisfy four key design criteria. These criteria are: entertaining and engaging game elements, balanced game play challenges with physical challenges, age-appropriate levels of exercise and, activities that require whole body movements [63].

In non-screen time exercise physical activities performed in normal daily indoor and outdoor activities such as running, sport and general motion are tracking. As mentioned previously, there are many tracking technologies, such as pedometers that currently exist to monitor these physical activities.

In our proposed framework, children and adolescents can accumulate exercise points when using these tracking technologies in addition to the points accumulated during screen time exercise. For example, if a child walks for thirty minutes, he/she will receive a set number of points. Physical activity of greater intensity will be awarded with more points. For example, an intensive game of soccer will allow the individual to accumulate more points than a short walk.

In the FITTER Framework exercise points that children and adolescents accumulate from day-to-day activities can be transferred into games. Thus physical activities in the real world provide incentives that can be used to enhance the players experience in screen screen-time exercise games. Examples of rewards for points achieved include extra lives for the game avatar, extra game money to buy utilities in the game world, and points-based level advancement. Translating physical activity to rewards in the game setting has the potential to encourage children to become more physically active in a way that education and explanation of the benefits of physical activity alone could not.

Exercise points accumulated by children and adolescents during real world physical activity (non-screen time exercise) will be transferred to gaming consoles via the interface layer. Fig. 2 presents the components of the interface layer. The interface layer consists of a Data Access and Application Layer and a Communications Layer. The Communications Layer shows the different means whereby activity-tracking technologies can be connected to gaming consoles. For example, some physical activity trackers may connect via Bluetooth while others require a USB connection. Exercise points will be transferred to either local storage or cloud storage depending on the gaming technology that is used. These exercise points will then be correlated with rewards in the game setting.

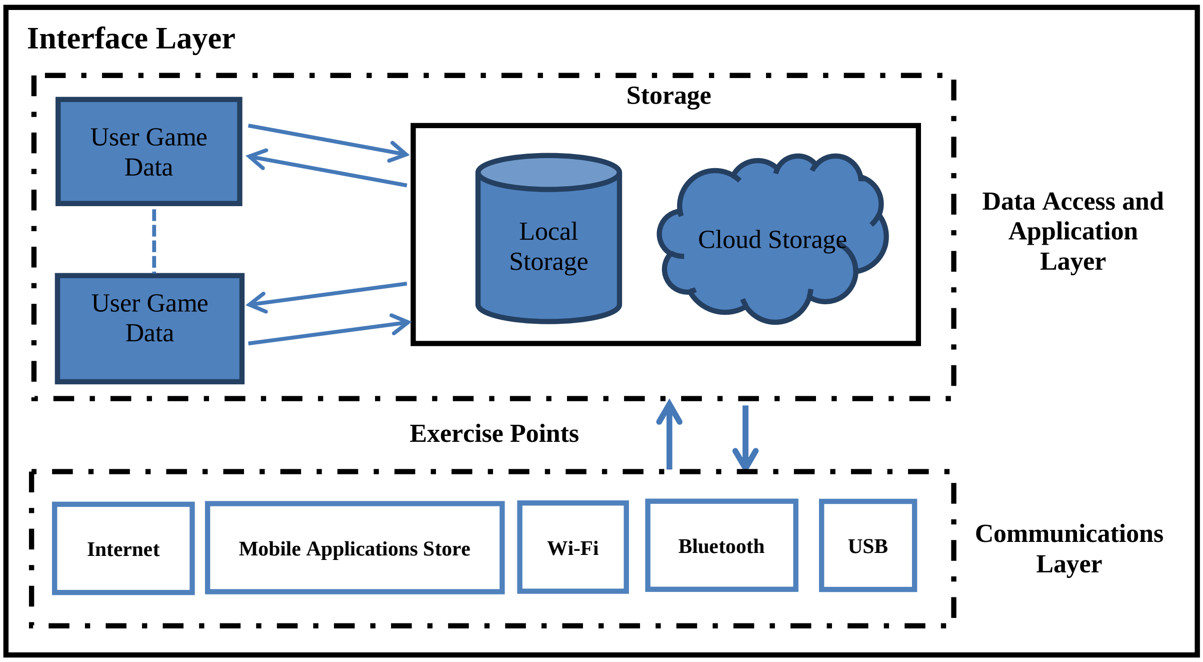

Fig. 2 The Interface Layer

V. The Proposed Solution

The functionality of FITTER, with some real-world examples of different technologies is shown in Fig. 3. There are currently a large number of video games available that have gained popularity and favorability with the public. In Fig. 3, we have listed an example of active video games including Kinect PlayFit. These types of exergames products try to combine fun and fitness. Players can exercise, track their progress and check the calories they have burned. Furthermore, in Kinect PlayFit, players can access the Leader board and view their rankings against their friends and other players across the globe [64]. At the same time, players can earn rewards such as bonus avatars [70]. This kind of exergame allows players to achieve virtual progress in the game while also achieving their fitness goals.

There are also plenty of non-active video games that players find engaging. Examples listed in Fig. 3 include Skylanders and Black Ops. Whilst these types of games provide players with virtual rewards throughout play they do not encourage improvements in fitness and physical activity levels.

With our proposed solution, players can gain both physical and virtual improvements with active and non-active video games. Players' physical activity outside of game play can be recorded using different physical activity tracking technologies. The exercise points that players accumulate from these off screen physical activities will be transferred to the player's game data. In the case of active video games player's physical fitness can at least in part be reflected by improvements in the virtual fitness of their game avatars. In non-active video games player's involvement in physical activity outside of game will be reflected in virtual rewards.

For example, if an individual playing Skylanders was to exercise for 30 minutes outside of game play she could use points from this physical activity to advance a level or perhaps to open a new gate. As these exercise points measure physical activity, parents and carers could also use them as a basis for providing desirable physical rewards such as increased screen time with TVs, computers, video games, tablets or Mobile Phones.

If the FITTER solution was to be properly implemented, the traditionally passive nature of non-active video games could be converted to a positive and productive method of bringing about greater levels of physical activity in children and adolescents. With rewards for real world physical activity as well as physical activity that directly relates to active video game play, children and adolescents are likely to develop a more positive opinion of the value of physical activity in their life.

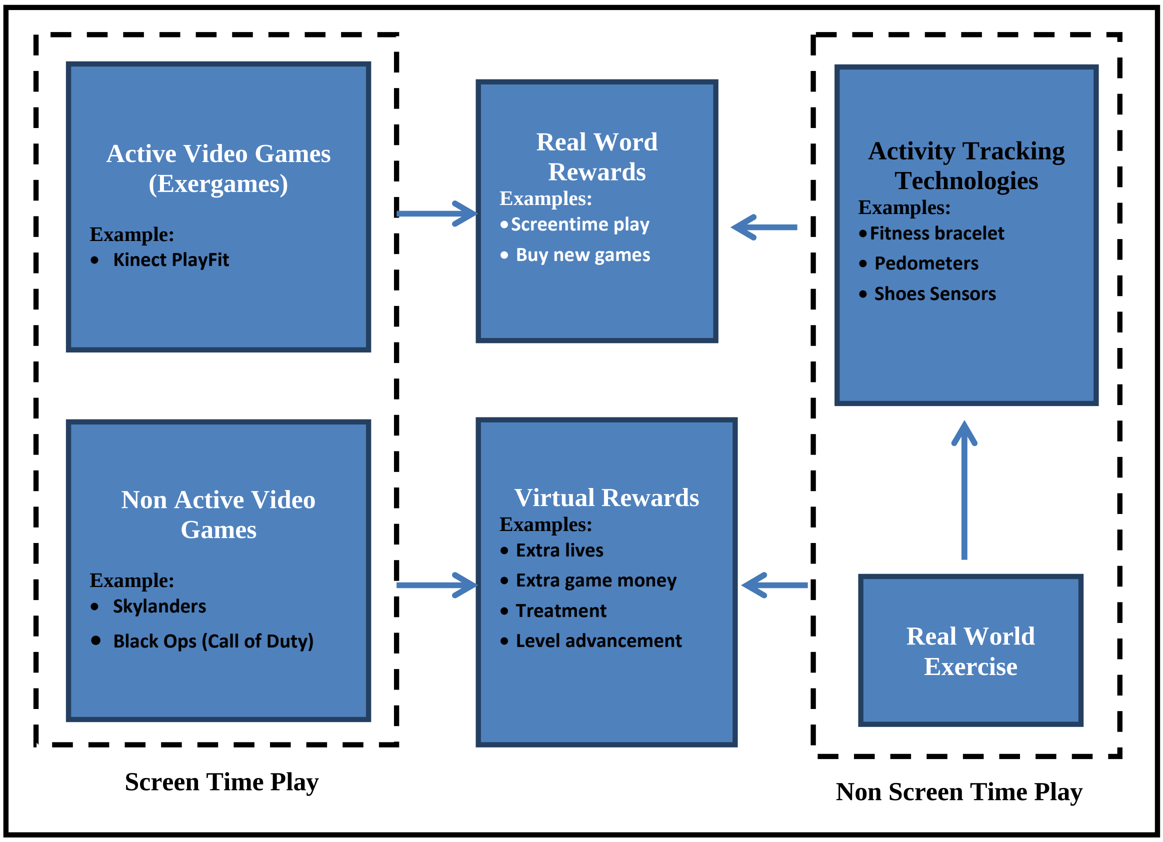

Fig. 3 Representation of the FITTER functionality

VI. Conclusion and Future Work

Active video games and non-screen based physical activity are two solutions that have been proposed to motivate children and adolescents to increase levels of physical activity in an attempt to combat the issue of obesity. There has been a large amount of time invested in both of these areas in an effort to encourage children and adolescents to become more physically active. To our knowledge, there is a lack of research in the area of integrating active video game play with non-screen based physical activity. In this paper we have proposed that developing a technology-based solution that integrates screen based exercise (through active video game play) with non-screen based exercise (through outdoor physical play) may have the potential to motivate children and adolescents to become less sedentary, and more physically active. This paper presents a novel contribution of a technical framework in this health informatics area. The conceptual design was developed as a theoretical foundation to be analyzed and critiqued before prototype implementation and testing.

Children and adolescents need to become more physically active in order to combat obesity as they advance to adulthood. There are many technology-based tools that have been developed with the aim to motivate children and adolescents to exercise more. Active video games are one type of technology that has drawn researchers' attention. However, there is lacking evidence for the ability of these games to provide a substitute for traditional outdoor physical activity. Furthermore, technologies that have been designed to measure physical activity, such as pedometers and sports bracelets, are other solutions that potentially motivate individuals to exercise. These technologies are able to detect and track users' physical activity and increase their awareness of their level of physical activity. These solutions, when combined, have been suggested to have more benefits in terms of physical activity promotion. The FITTER framework that has been suggested in this study explains the practical aspects of this integration.

This work presents only the conceptual design as we intend, in future works, to build an active video game prototype that implements our design. We plan to test this active video game prototype in real life situations with children and adolescents in order to examine the effectiveness of this integration. We also intend to examine the motivations and barriers of such a design as well as its implications on children and adolescents.

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