Physically Healthy Game Interfaces

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ABSTRACT
The scope of this paper is to explore the viability for physical interfaces to introduce exercise into computer interaction, especially in the area of games (Exergames). Particular focus is made on the ability of physical interfaces to effectively provide healthy exercise, and their ability to be attractive, so that a player will be encouraged to interact through these interfaces.

Physically exertive interfaces can be beneficial to the player through healthy exercise, communication, and enjoyment. The goal when designing many interfaces is to accurately interpret a players input with the least amount of the players physical and mental effort. With physical interfaces however, the goal of design can shift to creating an environment which promotes exercise, a greater variety in the methods of controlling input, or for creating a more realistic metaphor by creating an interface which resembles a real world physical interaction. Some interfaces which exist in this area are Wii controllers, arcade dancing pads, balance boards, and EyeToy like camera controlled games.

It is commonly accepted that there is a health benefit to the player from the use of more physically interactive interfaces, rather than standard mouse and keyboard input. However, physical interfaces which are healthy and capture people interest for a prolonged period of time are hard to design.

MOTIVATION
There are many reasons for designing interfaces with a greater range of physical interaction. By creating physical computer interfaces it is possible to gain important skills which would be dangerous to learn in a non virtual environment. Examples are flight simulators capable of simulated motion [15]. Other reasons for creating a variety of physical interfaces include, making computers accessible for the disabled, helping to prevent repetitive stress injury, and allowing a greater range of input for example using feet on foot pedals as well as hands on a steering wheel.

Perhaps the greatest set of benefits to be gained from the more exertive physical interfaces, are the health benefits.

Obesity, especially in adolescents, is increasingly becoming more of a problem in advanced countries [8,9,10,11]. Many adolescents in particular have a sedentary lifestyle[9] and time spent at computers is not very physically productive. Adolescents also tend to spend a large amount of time on computer games[9], and it is difficult to persuade them to relinquish these screen based activities[9]. The decline in physical activity of adolescents is one of the main factors predisposing children to obesity. Since children between the ages of 8 and 18 spend more time in front of a computer, television, and game screens (44.5 hours per week) than any activity other than sleeping[11]. What makes this number so concerning is that with each hour spent playing electronic games, there is nearly a two fold increase in the risk of obesity [5].

The change towards a sedentary lifestyle is not limited to children and is evident across society. Exergames are video games which also provide an element of exercise. It makes sense that working physical activity and games into the sedentary activities people are reluctant to relinquish, will help to combat the problem.

TYPES OF PHYSICAL INTERFACES
There are many types of physical game interfaces in existence. Many arcades currently feature games which you can control by dancing, playing virtual drums, guitars, punching bags, and even shifting your weight around on a virtual skate board. From a different angle there is also a range of gaming elements which have been introduced into gymnasium equipment to distract patrons from the tedium of the exercise. Some different kinds of physical interfaces are discussed in the following sections.

Exercise Equipment
Many people are conscious of the need to exercise and use exercise equipment or gyms to do so. Exercise in general however tends to be quite tedious and unexciting. The idea of working game interfaces into existing exercise equipment has been around for decades[11].

Exercise bikes are one example of a piece of exercise equipment which has commonly been mixed with games to promote exercise. One of the earliest examples of this was the top secret Atari Puffer in 1982[11,18]. Atari prototyped a game controller which replaced the grips of an existing exercise bike, allowing the bike and a game console to be connected. The grip had a couple of buttons to interact with the console, and the speed of the peddling controlled the movement within the games (Figure 1).

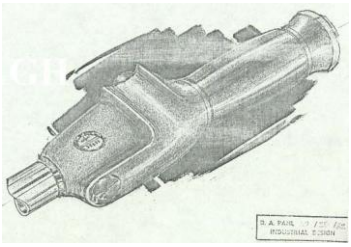

Figure 1. 1982 Atari Puffer game controller prototype[1].

A version of Pac-Man was even created for the puffer to show the limits of such a system. Atari never commercialised the Puffer, but similar systems soon emerged. Some of these similar systems include Autodesk's HighCycle from the mid 80's, to a range of modern exercise bikes such as the Exertis bike which has its own embedded computer and set of arcade style games (Figure 2).

Figure 2. Exertis Exercise Bike [7](Left), TACX Fortius Trainer[22](right)

More modern exercise bikes, like the TACX Fortieus Trainer have sets of virtual worlds the player can cycle through[10] (Figure 2). The Virku (Virtual Fitness Centre) research project used an exercise bike to develop a fitness computer game using virtual surroundings[18] (Figure 3).

Figure 3. Virku system test in the Usability Laboratory of VTT Information Technology[18].

This game aimed to make the exercise session more motivating and a richer experience. The Virku project found that using a virtual environment did help to make exercising a more enjoyable event[18] although participants in their tests felt they were exercising rather than playing a game.

Foot Pads

A large range of physical input interfaces, using other methods of input, have been developed, such as foot operated pads and motion sensors. In 1983 Amiga released a stand-on-pad called a Joyboard, which allowed the player to control games by shifting weight around the board[11] (Figure 4).

Figure 4. Amiga Joyboard[16].

This kind of physical control was used for a skiing and a surfing game, as well as a fighter pilot and pattern matching game. The Joyboard is not physically very intensive and it is rumoured that when Amigas developers became frustrated, in the early days of developing their operating system, they would use the Joyboard for relaxation[4]. The developers would attempt to sit still on the board without triggering the movement sensors[4]. More recently, Nintendo has created a similar device with the idea of fitness in mind. The Wii Balance Board, which will work with their new Wii Fit video game. The Wii Balance Board is similar to a bathroom scale and has pressure sensitive areas, mainly controlled by the users feet, but can also be used to track interaction through hands, such as push-ups (Figure 5).

Figure 5. Wii Balance Board[19].

The Wii Balance Board is designed for a range of activities including aerobics, yoga, muscle exercises, and other games. Wii Fit also allows players to track their Body Mass Index, and scores via daily progress charts.

Other feet controlled games have been developed such as Nintendo's 1987 Power Pad, and the more modern Andamiro "Pump It Up", Roxor Games "In the Groove", and the Japanese, Konami "Dance Dance Revolution", which all consist of a mat with pressure sensitive areas[8,11].

The most popular use of these feet pads is dancing games where the player steps on specific tiles in time with music. Dance Dance Revolution (DDR) is one of the most famous dancing interface[10] (Figure 6).

Figure 6. Dance Dance Revolution Console[6].

Although the DDR was never designed with weight management in mind[5], its health implications were soon discovered prompting Konami to invest in gyms and give out 30 day trials to "24 Hour Fitness" gyms[5]. Many home versions now have functionality to estimate the amount of calories burned and there are many reports of DDRs being introduced into schools to encourage physical activity[5,13]. There are many personal accounts of successful weight loss using DDR, including Tanya Jessen who claims manager her weight and lost over 40kgs from its use [13,20].

Motion Sensors

Motion sensors like Sony's 2002 EyeToy, allow the players to move around and have their movement captured by a camera. This is then interpreted into actions. [8,11].

Figure 7. Sony EyeToy (left). Screenshot of a game played through an EyeToy[6].

The EyeToy can detect colour and even sound through a microphone. Many EyeToy games allow the players to see themselves while they play creating a more immersive environment (Figure 7).

The most recent example of a successful physically active interface for games is Nintendo's 2006 Wii. The Wii has a small handheld pointing device and uses motion sensors to detect acceleration in 3 dimensions[9,11] (Figure 8).

Figure 8. Wii with Wiimote[24].

By waving the Wii remote around, games can simulate actions such as swinging swords, playing tennis, boxing, paddling, and even flapping wings. Similarly to the DDR, the Wii has generated stories of weight loss success[3].

SUCCESS OF PHYSICAL INTERFACES

Exergames differ from standard exercise equipment and keyboard mouse games, as they try to use a game or mental stimulus to distract the player from the tedium and effort of using a physically demanding interface. For a physical interface which mixes elements of exercise and play to be successful, it should have an element of effectiveness and attractiveness to it.

If the interface does not provide an effective amount of exercise then any ongoing health benefits may be minimal, and if people are not motivated to use the system, then any exercise they do get is still a chore. Creating exergames is not an easy task and there is no general framework that takes into account the many different methods to evaluate

player experience and related concepts, to show what kind of methods should be used to evaluate interaction concepts used in game design[17].

The paper [11] discusses how effectiveness is whether or not the system meets exercise requirements, and attractiveness is if the system is fun and captivating enough to compel the player to play and exercise an effective amount.

One of the major factors contributing to both the effectiveness and attractiveness is the player's personal drive to exercise. If a person is driven to exercise, they may continue to use a system even if it is not particularly attractive [11].

In Mueller's paper, "Evaluating a Distributed Physical Leisure Game for Three Players" [8] he explores a prototype of a table tennis game which can be played over a conference like setup. For this system he notes that some people are willing to overlook shortcomings in the accuracy and quality of a system, while other players can become distracted with the interface and easily frustrated.

Effectiveness

The goal with exercise is to help maintain physical fitness, which can help with managing a healthy weight, bone density, muscle strength, and joint mobility. Any amount of fidgeting or moving around helps to burn energy[10]. But for aerobic exercise which improves oxygen consumption in the body, a rough guideline would be activity which raises the heart rate to 80% of its maximal rate, for a period of 30 minutes, three times a week[11]. The activity to meet this requirement can differ from person to person. The person's current physical level of fitness, gender, and age for example will all play a part in determining how effective any exercise will be.

In a study done on the energy expenditure by adolescents playing new generation active computer games such as those on a Wii, over games of a sedentary nature such as those on an XBOX360, it was found that active computer games use significantly more energy than playing sedentary computer games[9].

Using an IDEEA system to predict energy expenditure, five girls and six boys played on a relatively inactive game (Project Gotham Racing 3) and then a range of active Wii Sports games. The results confirmed that the energy expenditure during active gaming was at least 51% greater than during sedentary gaming. While this may only account for less than 2% of the total weekly energy expenditure in these adolescents, it may contribute to weight management[9].

The energy expended during these simulated sports was still less than what would be expended during authentic boxing, bowling, or tennis. These simulations were still not intense enough to contribute towards the recommended daily amount of physical activity for children[9].

Attractiveness

Attractiveness is what gives exergames an advantage over traditional exercising techniques. This is because games create new ways in which exercise can be fun. When given the choice of activities, a study found that children would rather physically cycle a bike to access television, videos or computer games, than partake in reading or drawing without the need to cycle[11]. Players using physical systems are willing to undertake the physical exertion to play video games, but they can become frustrated if the physical interface requires too much conscious attention[8].

For video games with physical interfaces to be a prolonged success, Thomas Malone identified three qualitative factors which affect the attractiveness of computer games; challenge, curiosity, and fantasy[11,21]. The challenge and curiosity of a game is different amongst individuals, and for physical interfaces, the added physical challenge can impact on the attractiveness[8,11]. Where most games become more difficult as skill increases with time, physical games can lead to exhaustion and failure after lengthy sessions.

The idea of "flow" is presented in [2,11,12]. Flow represents the feeling of complete and energized focus in an activity, with a high level of enjoyment and fulfilment [12]. When a player is in a state of flow, they tend to lose track of time and worries[12]. Flow encompasses a set of qualitative characteristics which help describe how engaging an activity is [11]. Flow can apply to many areas including sports and games. The paper "GameFlow: a model for evaluating player enjoyment in games" [14] adapts this and focuses on a set of eight flow characteristics which make up 'gameflow'. These are

1. Concentration: games should require concentration, and the player should be able to concentrate on the game. The game should provide a lot of stimuli and these should come from different sources.
2. Challenge: games should be sufficiently challenging and match the player's skill level. There should be different levels of challenge for different players.
3. Player skills: games must support player skill development and mastery. This includes aspects such as being able to start playing without the need for a manual and rewards as players become more skilled.
4. Control: players should feel a sense of control over their actions in the game. This includes the feeling that they are in control of the input devices by doing what the player wants.
5. Clear goals: games should provide the player with clear goals at appropriate times.

6. Feedback: players must receive appropriate feedback at appropriate times.
7. Immersion: players should experience deep but effortless involvement in the game. They should become less aware of their environment and more focused on the game.
8. Social interaction: games should support and create opportunities for social interaction.

Of these heuristics, concentration is one of the most important with regard to physical interfaces[11]. If the user is too busy concentrating on the form of input, then they will find it hard to concentrate on the virtual game aspect. The same is true for games where the users feel they are being held back by a non-intuitive interface that they have to keep thinking about. The DDR is an example of an interface which requires a lot of focus on the method of input[11]. Most of the player's concentration is taken up trying to step on dance pads at the right time. The game itself however is fairly simple with falling arrows showing which pad to press next.

DOWNFALLS OF PHYSICAL GAMING INTERFACES

Unlike most games, exergames have to be designed for both exercise and game play. This means the physical condition of players has to be taken into account. With most games, there is an increasing level of difficulty and required skill as player progresses over time. For players using exertive interfaces players may become less skilful as they begin to fatigue and an increasing difficulty may go beyond an enjoyable level[11]. An adaptive technique of assessing the player's skill and adjusting the difficulty accordingly is one possible way of addressing this.

Exertive interfaces usually require a lot more movement than existing interfaces and there is the danger of bumping into things. Many exergaming interfaces are designed for an indoor environment where there is usually limited space. Devices such as the Nintendo Wii for example, are already known for their danger when swinging the devices around a living area. Nintendo offer a replacement wrist strap for old versions of their Wiimote, which are known to snap and "fly across the room" if they are swung around too violently[25]. There is even a blog about accidents with Wiis[23]. Although active video games appear to create the opportunity for injury until recently there have not been all that many reports[13].

SUMMARY

People, especially adolescents, are becoming increasingly sedentary. Any amount of added physical activity is beneficial and physical interfaces and in particular exergames are a step in the right direction. The amount of exercise gained from many interfaces which try to simulate sports however is not as great as actually participating in those sports. Using physical interfaces instead of sedentary alternatives can make the difference in maintain a healthy weight.

For physical interfaces promoting exercise to be popular and a commercial success, they need to have elements of attractiveness and effectiveness. Designing physical interfaces is not easy as the physical ability of users has to be taken into account. Currently there is no general framework for showing what methods should be used to evaluate interaction concepts in games[17]. There have been many different interfaces designed but they are not as prolific as more sedentary alternatives.

FUTURE WORK

There is a good amount of research in the area of determining what aspects of games make them interesting and attractive. There is also a large amount of knowledge about what kind of activity is healthy and good for exercise.

A framework for evaluating aspects of game interaction needs to be developed[17]. There is not a lot of research into the effectiveness of computer games as a method for overcoming the tedium of physical exercise. People seem to appreciate games for making the exercise more enjoyable, but physically exertive games which seem to take away the sense of effort.

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