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Application of Serious Games to, Sport, Health and Exercise

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Use of interactive entertainment has been exponentially expanded since the last decade. Throughout this 10+ year evolution there has been a concern about turning entertainment properties into serious applications, a.k.a "Serious Games". In this article we present two set of Serious Game applications, an Environment Visualizing game which focuses solely on applying serious games to elite Olympic sport and another set of serious games that incorporate an in house developed proprietary input system that can detect most of the human movements which focuses on applying serious games to health and exercise.

Index Terms **— Serious Games, Virtual Reality, Virtual environments.**

I. INTRODUCTION

ACCORDING to popular definition, Serious Games are "games that do not have entertainment, enjoyment or fun as their primary purpose" [1]. Serious games are designed to solve real life problems through the use of games. Although serious games can be entertaining, the main objective of a serious game is, but not limited to teach, train, investigate or advertise. These interactive products are currently been used by industries such as defense, education, scientific exploration, health, medicine, news, city planning, Engineering, Emergency management, business and politics, but not in elite sports. Typically, video game genres are categorized by game play, where serious games are not a game genre but a category of games with a different purpose [2].

This article is a case study which presents two different serious game projects developed by authors in collaboration with Sheffield Hallam University Centre for Sports Engineering Research (CSER) and discusses its impact on sports, health and exercise.

The first example is an environment visualizing serious game which won the 2009 Ideas4Innovation new researchers award sponsored by UK Sport (the body responsible for elite sport in the UK) [3]. This was developed for a specific elite sport with the collaboration of UK Sport and Sheffield Hallam University Centre for Sports Engineering Research (CSER). While the actual end user is confidential, the award was announced as "the successful project was based on the development of a novel tool to assist athletes in their preparation for performing at, and in sight of, competition venues, providing a means for the athletes to familiarize themselves with their competition arena and all visual cues to assist strategy prior to any competitive race."[3], [4].

The second example is a suite of serious games that incorporate an in house developed proprietary input system that can detect most of the human movements. Named 'Smart Floor', it focuses on several key areas of health and exercise. 'Smart Floor' at its core can be divided into two parts: (1) hardware with load cells to detect a variety of human movements and (2) software implementation of serious games

to take advantage of the unique hardware input system features. The hardware consist of a collection of half metre by half metre tiles with load cells on each corner and interpreting software build into it, that can be placed physically according to the end user. "The aim of this project is to develop algorithms to extract individual movement patterns from the ground-contact data and to develop software applications driven by these data"[5].

Later parts of the article describe the designing process of these serious games, from game design to technological choices, as well as the intended audience for each game.

II. CONTEXT

A. Environment visualizing serious game

The need for environment visualization or simulation has been more apparent than ever. In certain industries serious games and simulations are been used regularly to enhance the quality of learning and safety of the individual who uses it. Even though there are a lot of industries focusing on serious games as an alternative avenue to teach, train, investigate or advertise, authors would like to draw attention to a few dominant sectors to analyze the problem which led to development of this particular environment visualizing game.

TABLE 1 HERE

As shown in Table I, military has video games as well as serious games. As shown, the "Call of Duty: Modern Warfare" game is a first person shooter game while "DARWARS Ambush" is a serious game that provides military training based on experiences of personnel in the field [6]. "Formula One" is a well known racing game that lets the player control an F1 car and races it around the track with other computer controlled cars. Red Bull F1 simulator consists of a Formula One car cockpit where the driver can feel even the slightest force change as in the actual racing arena. Furthermore it collects data while playing to compare with the actual data collected from the real racing track. F1 drivers can practice cornering, timing of specific turns, how specific tyres work on the track as well as develop strategies without ever stepping onto the track. There are many cycling

video games like "Pro Cycling Manager", while serious games like "TacX virtual reality trainer" is generally used to relieve the boredom while cycling, without focussing on training and strategy.

A gap arises when this pattern of thinking is applied to elite sports. It is possible to find ample video sport games like "Beijing 2008", but there is no counterpart serious game used in coaching or strategy development. This was the gap filled by the UK Sport sponsored project.

B. Smart-floor

"A sedentary lifestyle is linked to many diseases, including diabetes and heart disease, as well as ailments such as obesity, which is becoming the major root cause of early death in most industrialized countries." [8].

A common method of encouraging exercise in such individuals is to use Exergames. Exergames are a type of serious games that encourages physical activity and exercise through use of games. The set of serious games that was developed using the Smart-floor input system can be categorized as exergames.

The Smart-floor at its most fundamental stage is a proprietary input system that can detect a range of human movements. The load cells in the four corners of the square tiles allow the total load and centre of pressure to be calculated. Coupling tiles together allows motion across a floor to be determined with algorithms used to detect specific types of movement from the temporal patterns in the detected forces. This information is then encoded as input to animation software to create serious games. The Smart-floor currently exists in a 12 tile 3 x 1 metre configuration and a 36 tile 3 x 3 metre configuration.

FIG. 1 HERE

Fig.1 shows the basic configuration of a Smart-floor system with 12 Smart-floor tiles and a front projection setup for use in an exhibition to demonstrate human movement. The setup was used to create three serious games with both front and downward projection. This allows games authors to have two different output screens for each of the games. The three different serious game projects were *musical statues, balance and pong*. These games were designed to encourage cardio-vascular exercise, balance and reactions.

III. Game technologies

Interactive entertainment in general is a constant evolving industry. Game developers have an obsession to strive for performance improvements on top of stunning visuals, even if it means one more CPU clock cycle worth of performance gain or one free block of memory space. It is one of the many reasons games encapsulate some of the most advanced technologies in computer science. [6].

FIG. 2 HERE

Fig.2 shows six core technologies related to game design. At every games heart whether it be serious or for entertainment, is the *3d engine*. It manages all the art assets, handle every user input and renders a beautiful, accurate and realistic visualization on screen that will in turn, engage and immerse the player in the simulated world. The *3d engine* is considered to be at the heart of any game, where without it would be no interaction between the player and the game. The *Graphical User Interface* is the menu system where the player can navigate through to get to functionality otherwise would be unavailable. It also enables the player to immediately start using the game without the need to read an instruction manual. *Physics Models* help to create a believable environment around the player, where the game would adhere to the physical properties of the world. It is an essential part of every game where without it would fail to create a sense of immersion which in turn demolishes the overall experience. *Artificial Intelligence* allows the in-game computer controlled characters to be smart enough to challenge the player or to work with the player toward a common goal. It also helps to create an adaptive experience to the player. *Networking* allows the game to incorporate multiple players from around the world. Last but not least *Persistent Worlds* allows game worlds to exist for days, months or even years without the active participation of the player.

A. Environment visualizing serious game

For this environment visualizing game, the authors decided to use a free and open source *rendering engine* called Ogre3d. Ogre (Object Oriented Rendering Engine) is a scene based, flexible rendering engine written in C++ in a modular architecture [7]. This makes it the ideal candidate for a large environment visualization game such as this. Active community support around Ogre3d is an added advantage over the competition. However Ogre is not a complete *game engine* that has all the sub systems build into it such as a sound system, graphical user interface system, physics system or an artificial intelligence system. This can be advantageous in a case where customization of an existing full 3d engine is overkill. And the modular architecture allowed authors to plug-in additional system such as sound and graphical user interfaces.

B. Smart-floor

For the *musical statues* game the authors decided to use Microsoft XNA Game Studio as the primary game technology. XNA is considered to be a rapid prototype development tool and a framework. It has the added advantage of having a built in audio manager, which is a key feature in the game.

The other two serious games, particularly the balance game, proved to have some technical difficulty if the XNA

route was chosen. This is due to the fact that it needed to couple huge environments that the XNA framework might have problems dealing with. Additionally, the authors needed to come up with a framework to support future Smart-floor based games. Since using the XNA framework limits authors to a certain level where as using Ogre 3d enables them to create any game they choose, it is agreed upon to use Ogre 3d for the future Smart-floor related developments which included the two serious games, *balance* and *pong*. Since the input handling codebase was developed to be modular, there will be no issues integrating it to the Ogre 3d framework.

IV. DESIGN PROCESS

A. Environment visualizing serious game

The environment visualizing serious game was developed focusing on a particular elite sport with the collaboration of UK Sport and Sheffield Hallam University Centre for Sports Engineering Research (CSER). It was designed to help athletes familiarize and prepare for a particular event prior to the actual competition. Achieving realism in terms of the environment as well as visual cues was a priority.

This serious game was also intended to be used as a coaching and training tool. For that to become a reality authors integrated a world editing software bundled with the game software so that end user can customize and add additional visual cues long after the delivery of the product. The specifications of the game were as follows:

- It should match the physical dimensions of the sporting venue at the London 2012 Olympics;
- It should incorporate visual assets such as furniture, and internal and external landmarks which could be used for strategy development;
- It should allow notation to be incorporated into the game by the coach for use by the athlete;
- The physical motion of the athlete in the game should be controllable either by games controllers or physical movements of the athlete using it.

B. Smart-floor

The three serious games developed using Smart-floor system was code named *musical statues, balance and pong*.

1) Musical statues

This serous game consists of 12 Smart-floor tiles side by side and a three by four meter front projection screen. This was designed to be installed in Western Park Museum in Sheffield. It was a game where three participants can compete with each other. The individual player had to move as much as they can when music plays and stand still when the music stops. The intensity or the frequency of the dance reflected more score for the player. This was designed for all age groups but specially focusing on children who makes up a significant percentage of visitors to the museum. The main objective is encouraging people to exercise while having fun.

Along with suggestions from the staff of the museum, authors referred several studies done on exergame design [8], [9].

Another version of this game was developed which consist of 36 Smart-floor tiles for multiple players.

2) Balance

The concept behind this was that the individual is given a narrow path to navigate on and they must walk along that path without stepping outside of the path. This game consists of two projections which meant that one could see an environment in front of oneself as well as beneath one self. Coupled with a set of outdoor environments this exergame was focused on older people with balance deficits over a medium term period.

3) Pong

This exergame is a two player game, where each player controls a base and moves themselves so that the bouncing ball hits their square and bounces back. This game consists of two projections but with rudimentary graphics to emulate the vintage look and feel. It focuses on reaction speed of the players and is not targeted for a particular age group.

V. DISCUSSION

While the details of the elite sport serious game have to remain confidential until the 2012 Olympics, data on its use will be collected and used to stimulate future projects for elite athletes. Indications are that virtual reality games can be used to give younger athletes experience of tournament conditions prior to them to allow psychological acclimatization.

There are a number of studies into exergaming which explain the impact on playing serious games on health related issues, particularly on maintaining cardiorespiratory fitness [10]. Studies show that even though one would need to play for an extended amount of time on an exergame to maintain or improve cardiorespiratory fitness or to lose weight, it is much shorter than anticipated [10].

Sinclair et al. [9] commented that "exergaming has not really had any systematic research carried out on it with the dual requirements of entertainment and effectiveness."

With all the games described here, it is intended to collect information on the performance of the user to facilitate the design of future gaming technologies for specific tasks. It is intended that the Smart-floor will be a technology that could be used with any age of participant and for a large range of multiple physical activities that could be used to encourage participation or physical rehabilitation.

VI. CONCLUSIONS

It was noted that a gap exists in the use of serious gaming in elite sport. A serious game was created for use by Olympic athletes to allow training prior to the 2012 Olympics. Its use is currently being assessed and will be used as a template for future serious games for elite athletes.

A Smart-floor was developed that consisted of instrument 0.5x0.5 metre tiles with the ability to track the user's motion and projection facilities to recreate virtual environments. This was used to drive three serious games used to encourage physical activity, and assess balance and reaction times.

ACKNOWLEDGMENT

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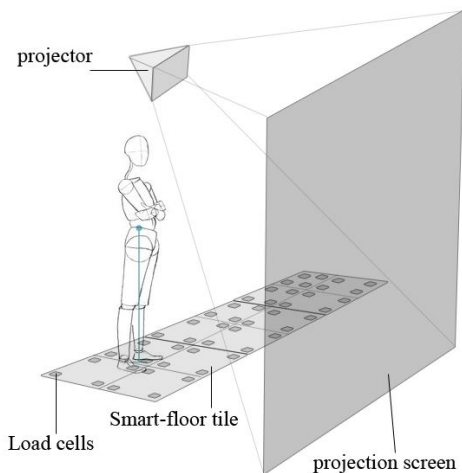
TABLE I
VIDEO GAMES AND SERIOUS GAMES COMPARISON

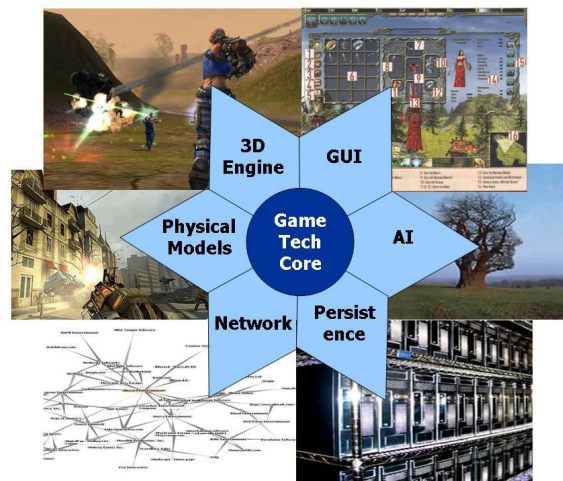|	Video Games	Serious Games
Military	Call of Duty : Modern Warfare	DARWARS Ambush
Driving	Formula one	Red bull F1 simulator
Cycling	Pro cycling manager	TacX virtual reality trainers.
Elite Olympic Sports	Beijing 2008 video game	?

Fig. 2. – Six core technologies behind video games. [9]

Fig. 1. – Overview of a basic Smart-floor tile with only one (front) projector.