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Augmented Reality & Gesture-based Architecture in Games for the Elderly

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Abstract.
Serious games for health and, more specifically, for elderly people have developed rapidly in recent years. The recent popularisation of novel interaction methods of consoles, such as the Nintendo Wii and Microsoft Kinect, have provided an opportunity for the elderly to engage in computer and video games. These interaction methods, however, still present various challenges for elderly users. To address these challenges, we propose an architecture consisted of Augmented Reality technology (as an output mechanism) combined with gestured-based devices (as an input method). The intention of this work is to provide a theoretical justification for using these technologies and to integrate them into an architecture, acting as a basis for creating more effective games for the elderly.

Keywords. augmented reality, elderly, interaction technique, video games

1. Introduction

Following the proliferation of game consoles and their adoption of user-friendlier interfaces and interactions, the elderly population (age of 65+ [2]) is becoming more and more interested and engaged in gaming. Video games for the elderly, apart from providing a pleasant and motivating experience, can also offer several health benefits and help prevent or treat health problems that come with age, like changes in sensory-perceptual processes, motor abilities, and cognitive processes [1,2,3].

The popularisation of novel interaction methods, utilising handheld devices (Wiimote for the Nintendo Wii, Move for the Sony Playstation) and motion sensing devices (Kinect for the Microsotf Xbox 360, EyeToy for the Sony Playstation), allowed the players to move away from merely pushing buttons to control a game, but to use gestures and physical movements as their input mechanism. These new interactions form the state-of-the-art interaction techniques for video games for the elderly, which are widely used in senior centres [4,5] and are also applied in experimental games, intended for elderly people suffering from various health conditions [6,7,8].

However, gaming technologies produce systems designed for the typical user (male, fit, and with static-over-time abilities), without taking into consideration specific design guidelines, catering to the special needs of the elderly population [9,10,3].

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[2] http://www.who.int/healthinfo/survey/ageingdefnolder/en/index.html

More specifically, several studies document problems related to the current interaction techniques. Using Wii, elderly players face problems related to: the pressing of the Wiimote buttons [11,12,13,14]; the movements that are needed to perform in-game actions [15]; the cognitive load related to processing the large amount of information displayed [11,15]; and the posture necessary for interaction and the calibration issues when sitting [11,14,13,12]. Using Kinect elderly players find it difficult to hold their hands still when selecting menu options [13].

Therefore, researchers have suggested design guidelines for suitable interaction techniques for the elderly. Minimizing the cognitive burden caused by in-game functions [3,14], elderly-user-friendly controllers without unnessecary buttons [14], adaptable and flexible user interfaces that could compensate for the physical and cognitive limitations of the elderly players, and finally, an elderly-user-centered design process[14].

Following these guidelines and recommendations, we propose an architecture based on Augmented Reality(AR) and gestures, to act as a "backbone" for developing wearable and mobile interaction techniques for the elderly players. We propose a gesture-based sensing system, which supports the adaptability of the developed interaction technique to the special abilities of each individual user. AR provided a novel solution to the problem of providing the right information, at the right time, in the right place. AR also provides a feedback solution which allows gestures to be learned more easily.

The implementation of a gesture-based interaction technique will help us avoid the problems of fine dexterity required to use traditional remote controllers, but still we have to overcome individual moter skill differences in the elderly players. The element of adaptability in the proposed architecture, allows personalisation of gesture calibration. The input method includes the ability to use a set of gestures which do not need body or posture movement, and have these mapped to the normal gesture inputs. This allows sitting players to also fully interact with the games.

The choice of AR as a preferred technology for the system's output is based on the intrinsic characteristics of AR that provide solutions to the problematic interaction areas of the current techniques. By linking input and output to the real world, AR could help eliminating the need for extensive tutorials/instructions, thus reducing cognitive load and attention-switching, and promoting continuous use and physical movement [16,17,18]. It could also be beneficial for mental processes, since it can support spatial cognition and mental transformation [17].

The combination of gestures and AR can be implemented as a wearable system, moving the player away from the confined space defined by current interaction techniques, and placing the elderly user as the "centre" of the game (Section 3). A thorough, technical description of the core architecture is given below (Section 2).

2. The core architecture

The overview of the proposed architecture is visualised in Fig. 1. Data for gesture processing is provided by either thin or fat clients. In the case of the *fat client*, gesture events are provided directly to the *gesture event queue*. The gestures from fat clients will generally be from a *context-free grammar (CFG)*, such as gestures represented in the CoGesT format [19], and can be passed directly to the gesture event queue. The *fat client* can also provide raw gesture data that need to be further processed by the *gesture recogniser*,

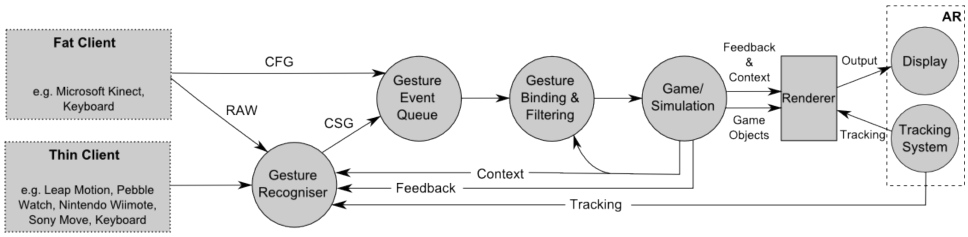

Figure 1. The proposed framework.

which implements the behavioural basis for gesture recognition, using a *context-sensitive grammar (CSG)*, based on contextual information provided by the game. Gesture data, that are provided by a *thin client*, are processed by the *gesture recogniser* and pushed to *gesture event queue*.

The *gesture event queue* contains all the gesture events, which take place in an asynchronous manner, for later processing. The gesture events are popped off the event queue and edited by the *gesture binding and filtering* system, which provides the essential adaptability of the system - a useful feature for impaired users who need to alter the default gesture mapping system. At that stage the gesture patterns are customisable to the user's preferences and abilities and the gesture data can be bound to various sets of gestures. The gesture data is then bound and filtered according to the user's preferences and they are interpreted as user input to the *game* or *simulation*.

The gesture events have three main types gStart(uID, gID, Data), gUpdate(uID, gID, Data), gEnd(uID, gID, Data). These event types have a unique event ID (uID), gesture ID (gID) and a data object containing either parameter data for the recognised gesture, or raw data. The additional data provided with a gesture is vital for online gestures, where the system is updating the linked activity with every gesture event update. For example "pinch to zoom" gestures need to continuously response to pinch distance change. This data can also provide feedback to the user through the AR system about the gestures that are being executed.

The *game* provides a broadcast service with *feedback* about the current state of the gestures being executed and a *context* to indicate which set of gestures are valid in the current game situation. The *rendering engine* listens to both of these. The game sends the *game objects* to the *renderer*, which - along with the tracking information acquired by the *tracking system* - visualises the output on the *AR display*.

The tracking system connected to the AR display must be able to provide very fast feedback on view orientation to the renderer. This allows the system to keep a tight link between the feedback from gestures and the real world that is being augmented. The tracking system also provides raw data to the gesture recognition system so that player interactions based on view direction can be integrated as a standard gesture input.

As an example of gesture feedback integrated into the AR system, gestures could be visualised as a glowing corona around the player's hand, informing him/her of the status of the performed gestured-based action.

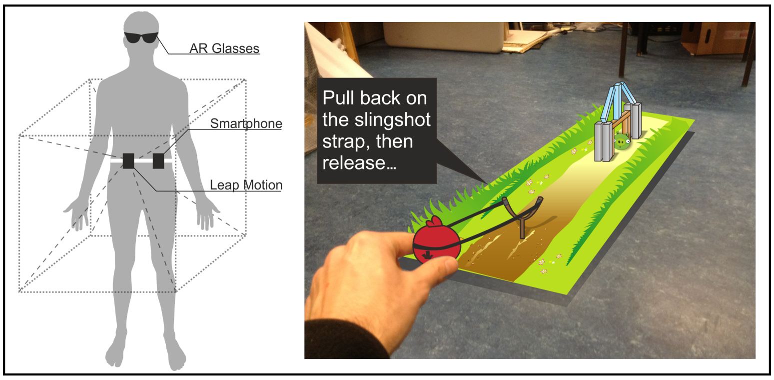

Figure 2. *Left side:* the placement of the devices on a silhouette figure; *Right side:* a mockup of the interaction through the view of the AR glasses, when playing a 3D Angry Birds-like game

3. Case study

The proposed architecture describes a wearable system based on the use of AR and on gesture-based input devices. More specifically, we focus on AR glasses, since glasses are an accepted way of altering our perception of the world. Usually they provide either improved focus or protection from glare, whereas AR glasses will add digital content, without blocking the perception of the real world, allowing the rest of the body to interact either with in-game elements or the physical world.

For the proposed architecture, devices like Google's project Glass or Vuzix's Smart Glasses M100 are proposed as output mechanisms. For input purposes, we propose using gesture sensing technologies like: the Pebble watch, the Microsoft's Digit project, and the Leap Motion.

As an example, a description of an interaction technique based on the proposed architecture is presented at the left side of Fig. 2. In this figure, we visualize the experimental use of the devices of AR glasses (like Google Project Glass), as an output device, the Leap Motion (or a Leap Motion-like device) as a gesture based input device, and a smartphone as the main processing unit. The Leap Motion creates an interaction space of 1 cubic meter in front of the users' waist, so the user can interact and manipulate the in-game elements that appear on the AR screen/glasses. The Leap Motion and the AR glasses are connected to a smartphone where the game and the devices' software are installed. The Leap Motion and the smartphone are placed on the user's belt allowing continuous movement and creating a user centric interaction space. This combination requires a belt and a pair of glasses, both of which are familiar objects for most elderly people.

The proposed architecture mainly favours video games that have to do with the manipulation of a digital object (i.e. Angry Birds, Worms, Wii Sports, Jenga et al.). Therefore, we present a mockup of a 3D Angry Birds-like game, as seen through the AR glasses view of an elderly player (Fig. 2). The player's view defines the position of the game terrain, the player can move around the terrain exploring the in-game objects, they can get instructions about the in-game actions that they should take and, potentially in multiplayer mode, could see the avatar of a remote opponent as the other player moves around the terrain.

4. Discussion

The existing literature and the experimental results suggest that an AR and gesture-based architecture for elderly video games could result in a significant improvement in player experience. Games that adopt concepts popular amongst the elderly, like Wii Bowling, could have more beneficial cognitive, physical and social effects if they were supported by an interaciton system that is more suitable to the elderly players.

The proposed architecture could help in developing interaction techniques that affect many stakeholders related with personalised health care and gaming. The elderly players would have a more personalised and entertaining gaming experience with multiple benefits (depending also on the development quality of the game played). Medical experts could also benefit, since having a safe and efficient interaction technique would increase health games' effectiveness for their elderly patients. Game developers would have the opportunity to explore new gaming concepts taking full advantage of the possibilities that new, personalised, and flexible interaction techniques could offer to a niche market. Lastly, taking into consideration the documented gaming/entertainment needs of the elderly, familiarising them with the latest emerging technologies and preparing them for the near future when technologies like Augmented Reality or gestures will be part of smart homes [20,21], could offer a higher quality of life, a beneficial effect for the public and society, in general.

5. Future Work

The next stage of this project is to implement an interaction technique based on the proposed architecture, using some of the aforementioned devices, and testing it on elderly players inside a game concept. This will include an iterative, elderly-user-centered design process and a usability testing, aiming to reveal the potential problems of the proposed architecture.

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