Design and development of a mixed reality solution for gerontechnology application

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***Abstract*—In this paper we will describe an emerging new technology aiming at improving the quality of life of the aging population, based on a mixed reality table-top solution. We will present the main characteristics of the Eldergames prototype, and describe the development process that has lead to its creation.**

I. Introduction

The progressive aging of the European population has highlighted that on the one hand, we can expect to live much longer than the past generations; on the other hand, it is without doubt necessary to intervene and resolve some important issues related to the natural cognitive and physical decline associated to aging: vision impairments [1], acoustic losses [2], and general mobility problems [3]; a cognitive decline [4] with serious implications for memory [5][6] and attention skills; depression derived from the loss of independency and from social isolation [7], worsening the negative effects of the cognitive decline.

Cognitive training is recognized as an effective method to prevent and treat the natural decline derived from aging [8][9]; in its electronic and computerized versions it has attracted considerable research efforts and obtained satisfying results in terms of effectiveness. A solution that has been explored is the deployment of videogames [10], and, in a constant an effort to make technology simple and natural to users [11][12][13], the adoption of table-top systems: they both facilitate social collaboration, due to the fact that more people are looking at the same screen, and a natural approach to the interface, allowed by the touch or multi-touch screen.

The next section will present some examples of table-top technologies, either directed to normal and healthy people, or towards aging population. Last section will describe a European project called Eldergames, in which an innovative "Mixed Reality" solution combine together tabletop technology, classic videogames and a mixed-reality system.

II. Augmented Reality Tools for the Elderly

Mixed Reality (MR) refers to the *merging* of *real* and *virtual* items to produce new environments and visualizations where physical and digital elements co-exist and interact in real time; "it integrates the local and the remote and the physical and the synthetic" [14]. Other authors define Augmented Reality as "a kind of virtual reality (VR) but a broader concept than augmented reality (AR), which augments the real world with synthetic electronic data" [15].

The Mixed Reality solution we present here is called "Eldergames" and is a part of an European project for the promotion of successful aging among old people. The result of the project is the development of an interactive table-top containing various kinds of games for the improvement of cognition and sociality. In our case the *virtual* elements are the games *contents* and the *real* element is the *interface*. As regards to the *interface*, Eldergames is constituted by a 120x120 cm tabletop able to support 4 players at a time, either in the same room or connected by the Internet.

The use of table-top technologies has received particular attention in the last years, as a new and effective solution for Human-Computer Interaction. Their positive potential has been shown, among others, by TARboard, an Augmented Reality system with a tangible interface, which has proved to afford an interactive and intuitive interface [16]; Tankwar, whose evaluation has underlined how tabletop solutions could improve sociality among players, stimulating in particular communication [17]; the augmented system developed by Jang, Kim and Lee [18] has demonstrated that the use of a tabletop could make the interaction more effective, also for tools developed to convey a virtual experience of a real action such as cooking. Other tabletop solutions have been especially designed for old people: an example is TeleTable, which seeks to improve elderly social life and to convey a sense of companionship by enabling users to share digital media,

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associated to physical objects [19]; another example is SharPic, a tabletop devoted to the management and sharing of photos, enabling old people to capture, move, rotate or resize them through the use of a multi-user and multi-touch application [20].

III. ELDERGAMES PROTOTYPE

The prototype of the tabletop (*Figure 1*) we will present has been designed and developed within the "Eldergames Project" from the European Community. As mentioned above, the purpose of this project was to construct a system able to monitor elderly health status, to maintain and to improve cognitive abilities and to promote sociality. To reach this goal, games have been chosen and implemented that can be played both around the physical table, or with players located in different countries, and joining the game session through a normal Internet connection.

The platform is principally composed by: a 20x120x75 cm wood table; a 47'', 116x60 cm, LCD flat tv screen (LG 47LF65) mounted on the table and separated from the table's border by a vinyl frame, 30 cm width; four web-cams, 800x600 pixels, 30 frames per second, positioned at the corners of the table (Logitech quickcam pro 9000) to allow the mixed reality interaction with the digital objects on the screen; finally a normal PC (Dell Vostro 400) running the game application and storing data (Processor: Intel® Core 2 Duo E6850 processor 3.00GHz, 1333MHz, 4MB cache; RAM: 2 GB Dual-Channel DDR2 SDRAM, 667MHz; Graphics: 256MB NVIDIA® GeForce® 8600 GTS). All components are low costs, thereby making the whole apparatus financially affordable.

As was mentioned above, the 4 cameras allow the mixed reality interaction with the tabletop, based on the recognition of marks. The cameras record the position of a preselected mark and, through a Binary Mark Reconnaissance Library, analyzes the position and orientation of the binary marks in the 3D world. The marks are squares with sides of 4 cm. To fix the orientation and the position of the mark in the virtual world, the system has to search the black borders and counts the black squares inside it to identify the mark number. After that, the system calculates the relative position between cameras and screen (thanks to a previous registration of the screen) in order to transform the position of the markers (in the real world) to positions in the game (in the virtual world). When all the cameras of the system recognize the marks, a transformation matrix is generated that allows mapping real and virtual coordinates.

The binary marks are positioned on the top of a pen (*Figure 2*), which is used to interact with the objects shown on the screen: the center of the mark goes up when the user presses the screen with the pencil, and then a Binary Mark Reconnaissance Library analyzes and recognizes the position and orientation of marks in the 3D world. In the future, binary marks could be positioned also on other kinds of objects.

Fig. 1. Protoype of the Eldergames table.

Another possible solution, not yet implemented, is interaction by "touch", where user/table interaction is performed directly through the hand. In this case, when the user touches a mark, displayed in the screen, the mark becomes invisible to the system, which detects the "touch". In this way, there will be no problem if the user touches the screen with his/her finger or palm.

Fig. 2. Pen used to interface with table-top games.

The Eldergames Mixed Reality system here presented is a prototype currently under study. It has been constructed according to usability and ergonomic criteria outlined in earlier stages of the project, and has been refined according to an ergonomic evaluation test carried out on the first prototype. On the basis of the ergonomic evaluation the structure of the table has been changed and more space has been offered to users around the table: players can now comfortably sit with an adequate space for their legs, thanks to the fact that the depth of the table has been reduced to 13 cm. Moreover the touch-screen interface has demonstrated to have some limitations; for example users tend to put their hands on the screen, interact incorrectly with the interface if they have

arthritis, or bend the hand a lot to touch the screen if they have long nails. For these reasons we have chosen to position marks on a pen and to avoid touch-screen

interaction. Objects, words, letters, colors and all the other elements visualized over the screen were specifically selected in accordance with the special perceptual needs of elderly people to facilitate their detection and comprehension.

As mentioned above, the main activity that elderly carry out on the interactive table is playing. Eldergames contains several games, specifically design to allow old people to train their cognitive ability, under the monitoring of experts. Games and in particular videogames have been demonstrated to be a tool for learning and cognitive stimulation, at all stages of life and numerous examples in the scientific literature show the effects of leisure on emotional and cognitive enhancement, as well as on the improvement in the objective and subjective health of the elderly [10]. The software comprises two kinds of game: in the Eldergames zone users can play a Memo game, whereas in the Minigame zone they can play several games, chosen by experts on the basis of each one's needs. Eldergames platform enables also players to communicate each other through a internationalized chalkboard.

The games selected and included into the platform, have been chosen after a validation process, carried out with different experts coming from different scientific fields and with potential users. The following tables present an overview of the expert (*Table 1*) and users (*Table 2*) profile involved in the consultation process.

Experts' profile	Numbers of expert
Nurses	7
ICT experts	7
Occupational Therapist	4
Social Educator	2
Medical Doctors	3
Psychologists	8
Social Workers	12
Physiotherapist	2
Ergonomists	1
Sociologists	1
Others	15
Total	**62**

Tab. 1. Expert profile overview.

	MEN		**WOMEN**		**TOTAL**
	65-70 YEARS OLD	**70-75 YEARS OLD**	**65-70 YEARS OLD**	**70-75 YEARS OLD**	
Primary level of education	7	7	8	8	**30**
Secondary level of education	7	7	8	8	**30**
TOTAL	**14**	**14**	**16**	**16**	**60**

Tab. 2. User profile overview.

The experts were involved in focus groups, investigating firstly which cognitive abilities were most affected by the aging process and secondly which were the most important ones during old age. Attention, executive functions and memory turned out to be the cognitive abilities which suffer from the greater deterioration, whereas memory and executive functions were mentioned as the most important ones. Later on, experts were asked how the ElderGames prototype could improve and monitor each one of the different abilities. Experts reported that attention, memory, and executive function were the most relevant areas of intervention for Eldergames. In addition, experts individuated some subcategories of cognitive abilities that, for their importance during aging, should be included within the pre-commercial prototype activities and monitoring tools: selective attention, divided attention, short-term memory, categorization processes, problem solving, and fine psychomotor skills.

Regarding the specific games to be included in the Eldergames platform, experts selected them by taking into account the techniques generally used for improving/maintaining cognitive abilities, and their suitability as leisure activities, and to the Eldergames concept. Game typologies and their relationship with the cognitive abilities previously mentioned were chosen using the ESAR system for classification. Games were evaluated also by groups of final users in Spain, Norway, and the UK and their suggestions about possible characteristics of the games were considered for the final design of the tool.

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