An Elderly-Oriented Platform to Simplify the Use of Physical Activity Controlled Game Consoles

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Abstract. In this paper, a new method to facilitate the performance of physical activity in the elderly is proposed. The rising number of retirees needing assistance from social security systems makes it necessary to focus resources rather on prevention than in treatment of illnesses, to allow a longer independent life in the home environment. The proposed system is based on the implementation of modern game consoles, which demand body movements to control the player's performance in a highly-motivating context. Previous studies suggest that these virtual game environments could contribute to increase physical activity. Goal of this project is to simplify the use of these new technologies for senior people, paying special attention to an elderly-oriented design both in mechanical and functional aspects. Test sessions with potential users have been performed to test whether the functionality of the developed device effectively increases the interest of the elderly in motion-controlled virtual games. Further experiments are being planned in order to receive more feedback and accordingly refine the development process.

1 Introduction

In this paper, a new method to increase physical activity of senior people is proposed, which aims to help increasing the possibilities of a longer independent life in the home environment and consequently relieve social insurance systems, overburdened due to demographical change.

The prosperity and optimism after the Great Depression and World War II led to an unusual boost of the birth rate in developed countries through the following decades [1]. The so called "Baby Boomers" generation reached his peak in the late 50`s, where only in the United States more than 4.2 million babies were born every year between 1956 and 1961 [2]. The low level of fertility during the Great Depression and this boom in births, which lasted from 1946 to 1964, combined to produce a sharp step in the population structure [3]. The migration of this step over the last six decades, together with the increase of life expectancy during the 20th century, has considerably amplified the number of retired people needing assistance from the social security and health insurance systems. Only in Germany, 20% of the population is currently older than 65 years, with an upward trend to ca. 30% expected for the year 2030 [4] (see Fig.1). This tendency, also observable in other countries of Western Europe, North America, Asia and

Australia, sets the need of focusing resources rather on prevention than in treatment of illnesses, allowing the elderly to live independently as long as possible in their home environment and, thus, contributing to relieve the already overstrained health insurance systems.

Regular physical exercising is known to be one of the best ways to prevent cardiovascular diseases [5]. However, sedentary lifestyle is unfortunately one main characteristic through the elderly that attempts against a sufficient amount of corporal activity. Professional assistance is mostly not affordable and the motivation to exercise independently decreases considerably in time due to the monotony of standard routines and the lack of new challenges according to the training progress. An interesting proposal to overcome these inconveniences is the use of modern game consoles.

2 State of the Art

During the last years, a tendency has been established in the game console's market to develop newly interactive control interfaces that demand body movements of players in order to interact with the virtual situations presented in the game. The most known example of this trend is the Nintendo Wii[1], which uses an accelerometer-based wireless controller to recognize and use the player's movements as control commands. The worldwide success of this motion-concept has motivated other market-leading companies to develop newly high-tech solutions. One example is an accurate tracking system based on a fixed camera and a sensor-packed wand including a glowing sphere, which follows the hand movements of the player and reproduces them[2]. A fixed camera is also used in a gesture recognition system that detects and utilizes whole-body movements instead of a classic game controller[3]. A more classical example of physical interaction with game consoles is based on a stationary bicycle equipped with rotation sensors connected to the handlebar and pedals that let players control games by pedalling and steering [6]. The possibilities offered by such systems have widened their use into other areas. As seen in [7], [8] and [9], the potential of modern game consoles together with some goal-oriented hardware enhancements has been exploited for rehabilitation of patients with hemiplegia or post-stroke disabilities. At the Glenrose Rehabilitation Hospital, Canada, the use of the Nintendo Wii has shown that patients work longer at therapy as they enjoy playing, focus less on the affected limb and engage in social interaction [10]. In Germany, a group of students have been taking the Nintendo Wii to diverse retirement homes throughout the country, organizing, with great acceptance, virtual sport competitions between residents[4]. A comparison study between the execution of standard routines on a Footstepper and

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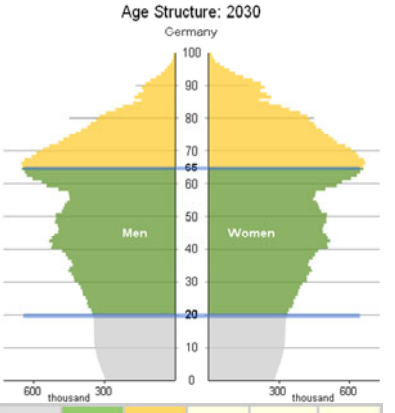

<20	20–64	65+	Total		AQ
12.9	42.1	22.3	77.4	Mill.	53
17	54	29	100	%	

Fig. 1. Expected demographic distribution in Germany in 2030 [4]

equivalent routines on the Wii Balance Board showed that interactive multimedia training methods are quickly adopted and enhance the motivation to improve physical performance [11]. Moreover, the American College of Sports Medicine (ACSM) and the American-Heart-Association (AHA) give advice that balance exercises on the Wii Balance Board help train the body perception, with a consequent reduction of fall risks in people over 60 years old [12].

The experience gathered in these studies suggests that virtual game environments are a perfectly suited approach to successfully increase physical activity. Due to their recreational characteristics, they could also contribute to enhance group activities and social relationships, not only within the retirement home environment but also inside the family circle, helping to bridge the generation gap between the elderly and the technology-adapted youth. However, initiatives are still missing that aim to provide an easy-to-use, cost-effective and elderly-oriented platform to improve fitness in the home environment and, therefore, prevent diseases.

3 Challenges

The advantages of game consoles have been mainly used in rehabilitation scenarios. But, when aiming to develop a technological, game-console-based solution, whose purpose is to allow the elderly to perform physical activity in a homely environment, different aspects missing in the referenced projects have to be considered:

3.1 Self-explanatory Human-Machine Interface

The main goal is to focus on simplifying a new technology for the elderly by making things easier to do without underestimating their abilities. The referenced projects show the permanent need of a support person when introducing elder people into handling a

new system. Not only to explain how it works, but also to assume the sometimes tricky manipulation and solve the annoying technical difficulties that may occur, situations that could end up fading the user's motivation Therefore, a simplified human-machine interface is needed in order to allow seniors to interact with the system independently and whenever they want to, not sporadically when personal guidance is present. This interface has to be self-explanatory and provide just the necessary functions.

3.2 Elderly-Oriented Design

Since game consoles are designed for a younger target population, the appearance and functionality have to be adapted to meet the requirements of an elderly audience. Important aspects are simple and precise written hints with big sized fonts, high contrast colours, the use of few big distinguishable buttons and a robust construction.

3.3 Wireless Operation

An elderly-oriented device must cause as less inconveniences as possible in everyday life. A battery-powered system and wireless communication between components are essential to assure the absence of surrounding cables that difficult its installation and limit its employment.

3.4 Record of Activity

A chronological register can show if a person has been doing enough exercise according to its individual requirements and give advice about anomalous routine alterations that might predict a change in health status. Relatives or nursing care may profit of this record to perform periodical evaluations. In addition, the system itself should be able to customize the difficulty level according to the progress or regress of every user, assuring to maintain the will to exercise for a long period of time.

3.5 Low System Cost

As the final product should be as inexpensive as possible, design and development have to be economically carried out and the whole system has to be based on an existing commercially available platform, avoiding software and hardware modifications.

All these considerations have to be borne in mind during the development process, in order to allow spreading the use of the created solution.

4 System Description

The developed system is based on the Nintendo Wii; however, the concept has been developed to be applicable to any similar game console. This choice was made due to the project-well-suited console's intrinsic characteristics, such as intuitive playing modalities, continuous storage of the player's progress and the stimulus to improve one's performance thanks to comparison and competition with other users. The main input device of the game console is a wireless remote-control that detects the player's hand movements using an acceleration sensor and an IR-Tracking system. These

movements, together with the pushing of several buttons, are then interpreted by the game console for the needed set-up steps and to accordingly move the avatar representing the user in the virtual world.

Elderly people are mostly not used to handle with new technologies and the learning process for it, if carried out, is frequently overwhelming. Usually, when using the game console, playing with body movements is easily understood after a few tries. Yet, the numerous set-up steps needed before actually getting to play increase the difficulty and might diminish the will to play. The constructed solution has been conceived as an enhancement accessory for the Nintendo Wii to help simplify and automate the game-loading process. The so called Simple-Use-Wii (SUW) unit performs all the required configurations and game relevant choices following a unique user instruction. A scheme of the whole system arrangement is shown in Fig. 2.

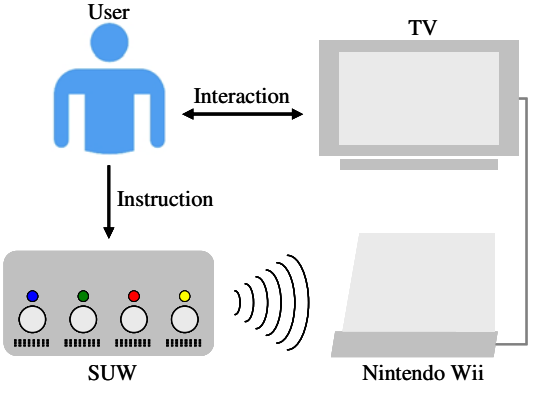

Fig. 2. Diagram of the system's configuration

4.1 Hardware and Construction

The internal architecture is based on an Atmel AVR ATmega 644V microcontroller and a proprietary radio-frequency transceiver working on the 2.4 GHz band. A microSD card is included as a removable non-volatile memory expansion for the microcontroller to save relevant user data. A built-in real time clock serves for precise time-logging of the system activities and a Bluetooth adapter is incorporated to achieve the communication between the SUW and the game console. The power supply is attained thanks to a 3.7 Volts and 1600 mAh rechargeable lithium-ion polymer battery, which lasts approximately 6 days in stand-by modus and about 20 hours when used continuously. Thanks to the wireless communication, battery-powered electronics and since no hardware modifications of the game console are required, the device can be directly used with any Nintendo Wii without complicated installations. The SUW unit measures 15x9x3 cm (HxWxD) and has only four buttons located on top of it, each one of them with a coloured LED over it and a written label under it, indicating one of four predefined sport games that can be played: Tennis, Bowling, Golf and Box.

4.2 System Operation

When a user presses the button corresponding to one of the four available sports, the SUW assumes the loading process by first turning on the game console and then performing the configurations that are normally supposed to be carried out by a person by means of the remote-control. In order to achieve all this, the device sends, via Bluetooth, the proper formatted data of IR-Tracking (pointer position) and confirmation commands (remote-control buttons) to the Nintendo Wii. During this process, the user just needs to wait for his chosen game to be loaded, what takes about one minute depending on the selected sport. At this point, the player can take a normal Nintendo Wii remote-control and play, following the Nintendo's original play modality. If the game has ended or the person wants to end it, pressing again the button causes the SUW to take over the control of the console and turn the whole system off.

4.3 Record of User's Activities

There are two methods to record and quantify the amount of physical activity executed by a person using the system.

The first one is based on the console's intrinsic evolution of the avatar (Mii) that characterizes the user in the virtual world. Each one of these virtual players has his own identity and different users are represented by means of different avatars that can be configured in the game console, which are then selected during the game loading process. If the Mii succeeds or regresses in a certain sport, i.e. the real person as well, the difficulty level is correspondingly adjusted. In this manner, the system encourages the user to improve his performance as the difficulties are neither overwhelmingly high nor boringly low, helping to keep the person motivated for a long period of time. The progress and usage frequency are registered for each Mii, serving as a record of the physical activity of a person using the system. Since the SUW unit automatically performs all the configurations when loading a game, the person is not able to directly choose his own virtual player. Therefore, the link between the avatar and the real user is periodically saved in the SUW μSD card, guaranteeing the accordance in the progression of both of them.

The second method is based on the storage of user related information in the μSD card. Data are saved in form of text files in three different types of files. The first one, named "SUW.txt", is unique and contains system-relevant values associated to the total number of users, the link between them and the distribution of the Miis in the Wii selection Menu and the last game played. The second file, "TIME_LOG.txt", saves the time and date information of all the last SUW activities by means of the integrated real time clock chip. There is one text file in the μSD card, "ID_Nr.txt", associated to every registered player in the system, where "Nr" is replaced with a number ranging between 1 and the total number of users. An example of the internal structure of this file can be seen in Fig. 3.

Every player has a distinctive numbered user identity that is consistent with the value of "Nr" in the file name. The last game played is saved with a number, where 0 represents Tennis, 1 Bowling, 2 Golf and 3 Box. The amount of times each one of

ID_01.txt

MiMed - SUW User Record	
User_ID:	001
last_game:	000
nTennis:	013
nBowling:	017
nGolf:	008
nBox:	002
T_last:	14
T_total:	087

Fig. 3. Example of a text file with user information

these sports has been loaded is recorded, together with the duration in minutes of the last game played and the total play time. Since data are stored as text files in a removable unit, it can be easily accessed using any computer by relatives or nursing care, allowing effectively, periodically checking to see if a senior has been exercising enough or if his activity routines have suffered unexpected alterations that might predict a change in health status.

5 Experiments

5.1 Test Sessions with Potential Users

To analyze the acceptance and functionality of the SUW unit, two test sessions with different groups of seniors were performed. For the first one, 48 volunteers (16 women, 32 men, age range from 59 to 85 years, mean value 68.4 years) were recruited through local press. All of them used lenses, four needed a hearing device and none of them required walking assistance. 44.9% had practiced technique-oriented jobs in their professional life and a bigger percent of them employs daily common technologies (see Fig. 4). A personal computer is often used in 83.3% of the cases, Internet in 75% and TV in about two-thirds of them. A considerable difference regards the use of a game console: 68.8% of the volunteers don't even have one, while a 27.1% never uses it. During five three-hour sessions, groups of 9 to 10 participants were initially introduced into the Nintendo Wii, without using the SUW unit. Their mission was to turn on the system, start and try one of the different sport games and finally change to another sport program. Once the subjects were familiarized with the game console, the SUW unit was introduced and put into practice. They had to start a game with it, play for a while, and then turn the system off. The evaluation of the experimentwas done by observing how the volunteers coped with the different tasks and, in a group discussion at the end of the session, each person had the chance to express his opinion about the experience.

The second test session was performed with 10 residents of a nursing home (6 women, 4 men, age range from 72 to 96 years, mean value 82.9 years), recruited by

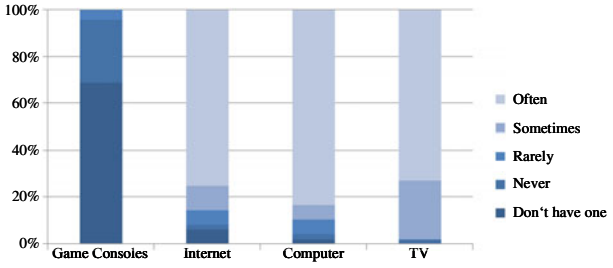

Fig. 4. Volunteer's employment of daily life technology

the home's administrator. All of them used lenses, one needed a hearing device and four required walking assistance. Only one had practiced technique-oriented jobs in his professional life, eight of them use regularly a TV and one uses a computer and Internet. None of them has a game console. In one two-hour sessions, each person had the chance to individually test the SUW unit and to use the Wii console "normally". For each trial, the task consisted of starting a game, play for a while and shutting the system down. The evaluation of the experiment was done by observing how the volunteers performed the assigned tasks and also by responding a specially designed questionnaire. 2 participants left the session before its end due to health reasons and another 2 questionnaires weren't evaluable.

5.2 Test Results

A recurrent observed conduct was that the volunteers gradually learn how to use a game console after repetitive indications and with immediately available assistance. Yet, they tend to forget it when not using the system continuously by themselves, a behaviour that strongly accentuates in the second group. The most critical factor was to identify the buttons on the remote control and to recognize when and which one of them had to be pressed. Independent of the volunteers age, they were initially reticent to perform real sport-like movements, what gradually changed with the familiarization with the game.

Opinions of the first group, like *"this is good for lonely living people"* or *"this would be a proper way to spend the free time in a nursing home"*, propose that the use of a game console could be accepted by an elderly audience. Some inherent game characteristics were evaluated as irritating or confusing (automatic replays, screen splitting), and the Wii's navigation menu was generally stated as understandable but to long before a game could be started. Regarding the SUW unit, the handling of it was easily understood and performed straightforward. Some opinions, like *"it's more suited for people with cognitive impairments, since fit healthy persons would want to perform the configurations by themselves"*, suggest that people around the mean age of the first group, a generation more used to daily life technologies, would still be able to learn how to successfully use a new system like a game console.

According to the 6 valid questionnaires of the second group, 4 users found the SUW unit helpful and 2 of them considered it as a determinant factor for a more frequent use of the game console. Although 4 players said that they would be able to

perform the initial configurations by themselves, the test experience showed that this would be inconceivable without permanent personal support.

A significant finding of the test sessions is the importance of the target population, exemplified by the age difference between both groups (ca. 15 years in average). Generally speaking, people around 75 years old or more weren't used to deal constantly with new technologies during their lives, which now affects their ability to get along with them. In contrast, the "now-aging" generation, around 55 years and more, has faced constant new technology developments during the last 30 years, broadening their acceptance to the implementation of new systems like the one proposed. However, the development process should not ignore the requirements and characteristics of the older group, as it represents the most important reference for aspects like design, usability and functionality.

6 Conclusions

In this paper, a new method to facilitate the performance of physical activity in the elderly, based in the implementation of a modern game console, was proposed. The Simple-Use-Wii (SUW) unit is a tiny microcontroller-based device that simplifies the use of the Nintendo Wii. It was developed to allow senior people to profit of characteristics like intuitive play modality through body movements and continuous storage of player's progress. The SUW has only four clearly labeled buttons, each one of them representing one possible sport game. When the user presses one, the unit automatically performs all the necessary configurations to start a game. By doing so, the person just needs to exercise itself while playing, without needing to repeatedly navigate through the console menus by means of the not-elderly-conceived remote control. The unit works with an internal rechargeable battery and every data communication within the whole system is performed wirelessly. Since no hardware modifications of the game console are required, the SUW unit can be used with any Nintendo Wii without complicated installations, while leaving untouched the original play modality. A removable µSD card saves the user's progress in time, permitting relatives or nursing care to supervise eventual change of activity routines over time.

Test sessions with more than 50 potential users showed that game consoles could be accepted by the elderly as a suitable way to perform physical activity in the home environment. The observed behaviours and the volunteer's opinions suggest that the SUW unit, by simplifying the usability of such systems, would boost this acceptance. The tests elucidated the need to focus the system's improvement on the target population (above ca 55 years) that would most profit of its benefits according to the demographical change trend.

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The scope of the research consortium is to develop technology based solutions which will help elderly people in their future living environment comprising home and workplace as well as in communication and transportation. Eventually not only elderly people but also all social groups should profit from these solutions.

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