MONITORING ADAPTIVE EXERGAME FOR SENIORS

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ABSTRACT

This paper describes an application that aims to monitor and stimulate physical activity adapted to elderly people. The application is implemented as a part of Mobile@Old platform. The specific exercises and the speed of the trainer is adapted to the user's movements. Health parameters like fatigue, respiratory rate, heart rate (H_R), systolic blood pressure (BP_S) and diastolic blood pressure (BP_D) are recovered from the Kinect parameters or transmitted via the mobile application. The evaluations we made concern both those who wore the Kinect sensor and those who use the mobile version.

KEYWORDS: *exergame, health parameters, mobile application, adaptation*

1. INTRODUCTION

There are numerous studies showing that the elderly population is constantly growing. The US population aged 65 and over represented 12.9% of the overall population in 2009 and is expected to reach 19% by 2030 (Chao 2015). The situation is similar in Europe, where the population aged 65 and over was 17.4% in 2012 and is expected to reach 28 % by 2020. The majority of those aged 65 and over live alone/on their own (31.1%) or in a couple (48.3%) (Stula 2012), (EPRS 2016).

The year 2012 was the European Year for Active Ageing and Solidarity between Generations, which fostered a series of initiatives. The ESF-Age Network, supported by the European Social Fund, offered good practice and case-studies for the management of ageing workers management in 14 EU states. The EU Council adopted the Guiding Principles for Active Ageing, a guideline for continuing education, employment measures, improving support for healthy and independent living for elders. The project on Healthy Ageing Supported by Internet and Community (HASIC) focused on encouraging seniors over 65 to maintain a healthy lifestyle, which includes a healthy diet, physical activity, and social engagement (Stula 2012).

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Unfortunately, elderly persons tend to have a sedentary lifestyle in all developed countries. A US study revealed that 67% of the older adults were sedentary for at least 8.5 hours a day, 60% reported sitting at least four hours a day, and more than 55 % reported watching television for more than two hours a day (Chao 2015).

Activities of Daily Living (ADL) are defined as activities carried out regularly. ADL can include washing the car, cleaning the house, gardening, cooking, washing the dishes as well as other activities that are not considered physical exercise. We present several benefits of structured exercise combined with daily activities, maintaining a decent balance between: 1. weight loss by burning a number of calories over a period of time, 2. ability to combat various health problems, from cardiovascular disease to depression, 3. improved mood, 4. boost of energy efficiency caused by oxygen throughout the body, 5. better sleep, 6. improved sexual life (Lazar et al, 2007) (ADL 2016).

An important challenge for physical therapists (geriatrics) concerns patients who have a low activity level, due to age and level of physical effort in continuous decline. Patients tend to become sedentary and after a while the phenomenon called *hypo kinetics* appears - a series of physiological changes that occur due to immobility and lack of regular physical activity. This phenomenon frequently occurs when recovering from an illness as a consequence of immobility associated with it. Complications may induce decreased power, decreased range of motion (ROM) and an increased risk of falls due to low strength and balance. To counter risks associated with hypo kinetics, therapists design custom programs for fighting hypo kinetics (Dubowsky et al, 2012).

This paper presents a solution for physical activity monitoring through an exergame or a videogame, with movements and frequency adapted to the user's reactions and health parameters. After a short introduction, section 2 describes other videogames and exergame for seniors. After an analysis of senior needs we present PAT and VSM architecture as a Mobile@Old platform modules. The next section offers functional evaluation and results based on vital parameters monitoring. Conclusions and future work are described in section 3.

2. DEVELOP ADAPTIVE EXERCISES FOR SENIORS

2.1. From Videogames to Exergame

Physical exercises are a suitable solution against a sedentary lifestyle and hypo kinetics. If seniors adopt IT solutions, video games, serious games and exergame are suitable for structured exercise. Video games are "electronic, interactive games known for their vibrant colors, sound effects, and complex graphics" (Video 2015). They have a great diversity for several purposes: learning, education, physical activity, or just entertainment.

Serious games are "a mental contest, played with a computer in accordance with specific rules, that uses entertainment to further government or corporate training, education, health, public policy, and strategic communication objectives"(Video 2015). Like video games, serious games use ~~as~~ entertaining, motivating and captivating features, which are linked together based on pedagogical principles.

Exergames are part of serious video games which combine traditional game with physical

activity in order to stimulate exercise and determine people to be more physically active, based on fun and self-motivation (Chao 2015). Exergames use advanced technology: remote hand held controllers, motion sensors for capturing and monitoring body movements. Users are required to move their body to be able to play the game. Several recent exergames consoles that we could mention here are: Nintendo Wii, Playstation Move, Dance Dance Revolution and Xbox Kinect (Xbox, 2016).

2.2. Related Work

Nintendo Wii is one of the most accessible exergames for rehabilitation and long-term care settings. It has different activity levels, and seniors can play in standing or sitting positions. Wii exergames has Wii Sports and Wii Fit and is focused on improving cognition, balance, balance confidence, mobility, strength, flexibility, fitness, and health-related quality of life. Nintendo Wii can be used for decreased anxiety and depression in older adults. Unfortunately, Wii exergames are not sensitive enough to measure certain levels of functional ability, and can give negative auditory and visual feedback when older adults cannot move as fast as the system requires (Chao 2015).

Sony PlayStation 2 Eye Toy is another exergame which uses webcam-like camera for image registration, computer vision and gesture recognition to process images. The camera and built-in microphone allow users to play games using their body movements and sounds (Chao 2015).

Microsoft Kinect has two commercial solutions: XBox One, and XBox 360 based on a motion-sensing input device that allows users to interact and control the device through gestures and spoken. The Kinect offers an adaptable stepping exercises and simultaneously measures step performance. The system improves balance, flexibility, strength, and endurance of seniors, reduces fall risk and improves performance of daily activities. This system was used in Mobile@Old applications (Xbox, 2016).

2.3. Senior needs analysis

We elaborated a questionnaire with *61 items*, that was applied to 69 persons, elderly people between 60 and 87 years, with chronically or severe diseases, and several of them (12% - 8) with disabilities. Most of the participants (94% - 65) did not have a smartphone, most had a mobile phone (98%-68) and tablet (12%-8), or PC (64%-44). Based on the elderly IT profile, we obtained the following results:

Group IT_A: good knowledge of IT environments: use mobile phone, smartphone possibly, mail, browser, search engine, Skype rarely (12%) with skills to use social networks (28%-19).

Group IT_B: acceptable IT knowledge: use mobile phone, smart phone (rarely), often refuse mail, browser, search engine. A small number/subset/group use Skype frequently and have relatives abroad (10-15%) or have advanced knowledge in IT (39%-27).

Group IT_C: poor IT knowledge (33%-23) group that answer or talk on mobile phone, possibly write messages (rarely, if they use glasses).

Analyzing the socio-demographic issues, we find that the majority of IT_A and IT_B groups are from urban areas, 90%-17 out of 19 for IT_A and 59%-16 out of 27) for IT_B, and IT_C includes 8 seniors from urban areas and 83%- 19 seniors from rural areas. The distribution of education level consists of: medium level education (48%-33), high school (36%-25), college (16%-11) and 1 of them with Ph.D. As for the level of acceptance of technology, there is no relevant difference between the three IT groups. For most participants (82%-57) AAL (Ambient Assisted Living) devices and applications (Blood Pressure Meter, Diabetic Monitor, Thermometer, Glucometer, Pulse Oximeter, Medicine Reminder, Diet Advice, Games) are easily accepted. Concerning the agreement to test Mobile@Old results: YES (53%-37), NO (36%-25), Neutral (11%-8), only small percent (9%-6) accept e-textile and (6%-4) accept wearable sensors. Most seniors with disabilities accept Mobile@old solutions (6 out of 8 seniors- 75%). This group is made of elderly people aged 60 to 74 years.

Out of the elderly that participated in our study, only 8 out of 69 (12%) accepted to monitor their health parameters using the mobile application made available to them and only 4 out of 69 (6%) accepted monitoring via Kinect. A significant number of the participants have intense daily outdoor activity (more than 5 hours a day), e.g. gardening, especially in the case of those from rural areas (12 out of 19 seniors from rural areas). These activities qualify as ADLs, and are equivalent to the 7 exergames designed by the GameUp project, for mobility, strength and balance.

2.4. Monitoring exergame for elders

The phenomenon called *hypo kinetics* appears at all older patients who become sedentary, and it involves a lot of physiological changes that occur due to immobility and lack of regular physical activity. Even if it is specific in recovering from an illness, long period of immobility can also be seen at sedentary elderly people. Hypo kinetics complications may induce decreased power, decreased range of motion (ROM) and an increased risk of falls due to low strength and balance. To avoid it, therapists design custom programs for fighting hypo kinetics (Lazar et all 2007).

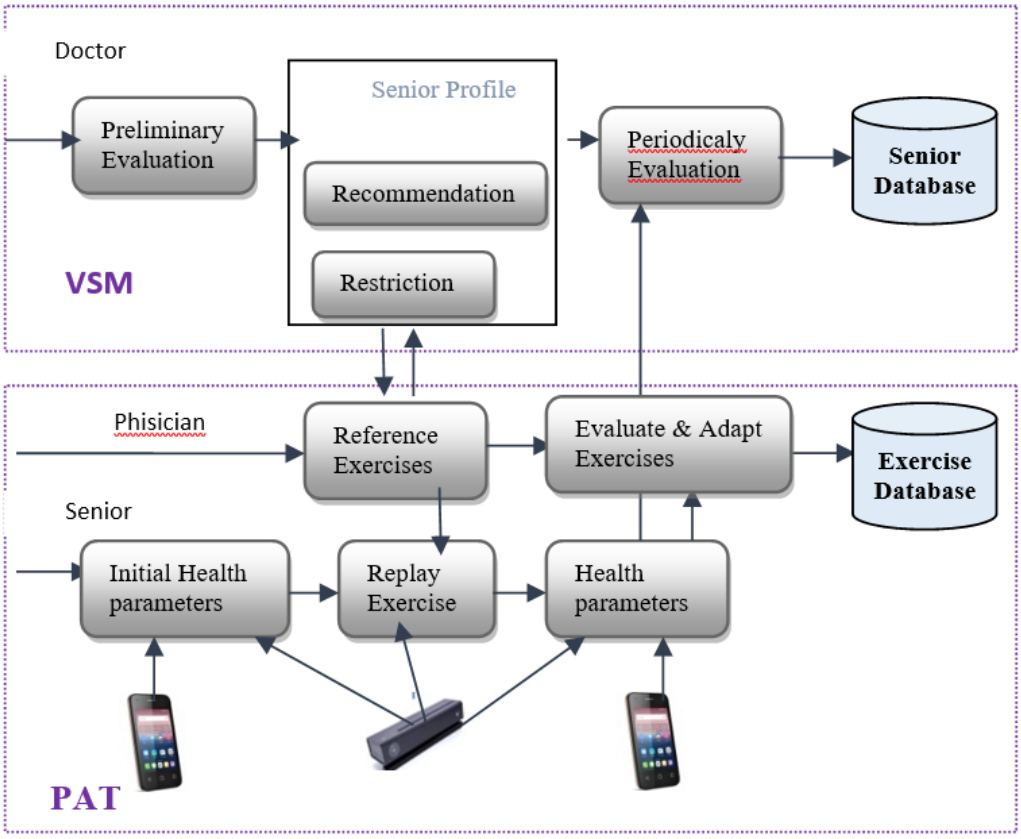

Figure 1. PAT and VSM architecture

These programs are managed in PAT (Physical Activity Trainer) and VSM (Vital Sign Monitoring) module as a part of Mobile@Old platform. Since most elderly suffer from various diseases and health conditions, a *Preliminary evaluation* is necessary, carried out by one or several medical specialists. The physicians fill the module *Recommendation* with information on the patient's health, chronic conditions, necessary medication, recommended behaviour and lifestyle, as well as the module *Restrictions*, if applicable. They also determine the frequency of *Periodical Evaluations*. All the data is handled in *Senior Database*. The data concerning the patient's health is updated daily/weekly/periodically according to the relevant parameters. (*Figure 1*). As a result of the reservations expressed by our participants, the module Physical Activity Trainer (PAT) was conceived in two different versions.

V1. PAT is implemented like an *exergame* that helps users to perform physical activities. The game consists of two avatars: the avatar of the user and the avatar of the trainer. Based on a physiotherapist recommendation we register a set of exercises with different levels of difficulty. Each user will be registered with a personal profile (containing medical information and recommendation on the type of physical exercises). All monitoring processes are directed by procedures associated to Kinect parameters which are recorded in *Exercise Database*.

V2. PAT module does not use Kinect and interaction between physiotherapist and seniors, only tablet and smart mobile. In this case the physiotherapist records personalized exercises as a *Videogame* in *Reference Exercises*. For each exercise in *Exercise Database* we store: exercise name, exercise description, exercise category, difficulty level, relevant joints for the exercise, repeating time.

The elderly introduce *Initial Heath parameters* before starting the exercises. They are then compared with the maximal values introduced by physicians in the initial evaluation. Next, they perform the recommended series of exercises (through videogames), using the module *Replay Exercises*.

The module *Evaluations & Adapt exercises* adjusts intensity, movement amplitude, duration, number of exercises according to the parameters provided by the module *Health parameters*.

2.5. Evaluating the proposed solution

Let us now review the main rules and basic principles that apply to the practice of physiotherapy for the elderly and have been followed by the research team. They concern the two main participants: the elderly and the physiotherapist. The exercise sessions are organized in light, well ventilated rooms, before or two hours after the meals. The rules that the patient must follow include: comfortable (cotton or wool) training equipment, active participation in all exercises, repeated and periodic practice of the exercises. The training sessions must take place 3-4 times/week or even daily. In PAT, we used periodical trainings of 3-4 times/week, with daily trainings only for a subset of users.

Main rules for the physiotherapist (ADL 2016):

- to inform the patient about the importance of physical therapy, the type of therapy in use, its means and effects, the evaluation method and periodical check-up;
- to maintain a constant dialogue with the patient, with calm, patience and empathy in order to establish good cooperation with elderly;
- to constantly analyze, select and adjust the sets of exercises, taking into account the clinic situation and condition of the patient
- to choose the most stable physical positions for the elderly

In order to ensure an efficient collaboration between the physiotherapist and the elderly patient, the following steps are necessary

- to carry out an initial test effort
- to design a functional and analytic exercise program
- to take into account the health and lifestyle conditions of the patient, as well as his endurance, and adapt the program accordingly
- to correlate breathing and movement, exercise and relaxation

The training intensity and the number of repetitions for each exercise are determined by the installation of fatigue and by the permanent monitoring of three parameters: 1. respiratory rate, 2. heart rate (H_R) and 3. systolic (BP_S) and diastolic (BP_D) blood pressure.

The medical recommendations state that the highest value for $H_R$is 70-75% from $H_{R\ max}$ and BP_{Smax} = 170-180, respectively BP_{Dmax} =105-110, the movement amplitude is in this case moderate and the training intensity is inversely proportional to its duration.

Fatigue or exceeded values must result in the immediate cessation of physical effort until the regular functions are restored.

Contraindications regarding most of the elderly patients include: prolonged orthostatism, prolonged sitting and prolonged physical effort with closed glottis, anaerobic effort, lifting heavy loads, exercises where the body goes below its horizontal axis, sudden changes of position, exercises with narrow support base.

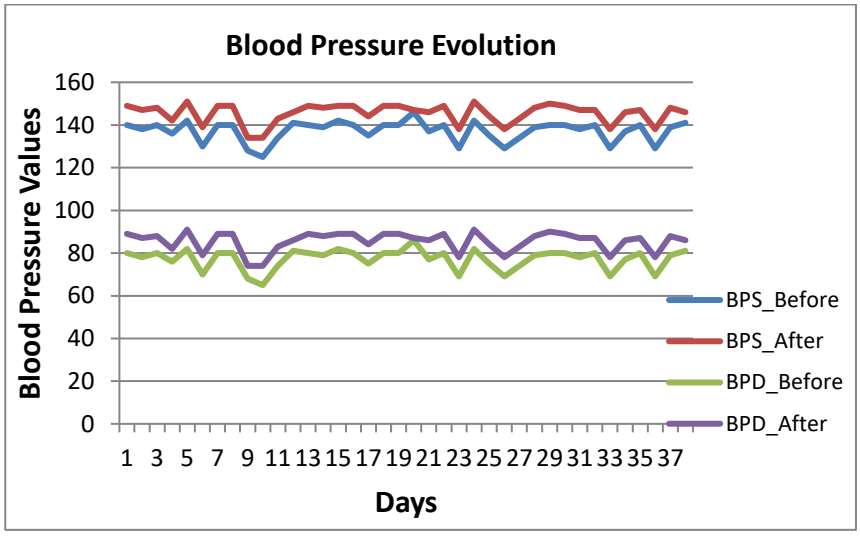

Figure 2. Evolution of vital parameters

For each patient who agreed to take part in this project we measured the health and vital parameters: *fatigue, respiratory rate, heart rate (H_R), systolic (BP_S) and diastolic blood pressure (BP_D)* while performing the exercises. The frequency of the training is determined by the patient's health condition and contraindications and its duration cannot exceed 20-30 minutes/day. The patient is a 68 years old male who suffers from painful ischemic heart disease, hypertension and arthritis. Figure 3 presents the evolution of these parameters during 2 months of training, 3 times/week, 20 minutes/day.

Effort needs to be progressively increased in order to allow the body to adapt. The content of the exercise program varies according to necessities and responds to the personal needs of each patient. The movement amplitude follows individual ability avoiding overloading the joints or causing pain especially in the spine. Exercises prescribed for large skeletal muscles must be tackled gradually from low to high intensity.

It is important to mention that most of the patients living in rural areas who did not accept the prescribed exercises but perform physical labor, have vital parameters comparable to values presented by subjects tested with PAT and VSM.

CONCLUSIONS

This papers presents a modern solution for monitoring physical exercise game adapted to the elderly people. We developed PAT (Physical Activity Trainer) and VSM (Vital Sign Monitoring) module as a part of Mobile@Old platform. Doctor and kineto-therapist are working in collaborative maner to develope a set of physical exercises.

These are recorded as a recomandation of a kineto-therapist, based on preliminary senior evaluation. The exergame is composed of two avatars: users and trainer. The kineto-therapist recives vital parameters like fatigue, respiratory rate, heart rate (H_R), systolic blood pressure (BP_S) and diastolic blood pressure (BP_D) are recovered from the Kinect parameters or transmitted via the mobile application.

Each exercise program is adapted to the user condition and these health parameters. Based on experimental measurement we shown that adapted game can offer a good condition for eleder people if they practice physical exercises.

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