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Elder Monitoring Workflow System for Independent Living

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Abstract: This paper presents an automatic workflow framed in a gerontechnology solution, as part of the Active and Assisted Living (AAL) platform in Mobile@Old project. Our solution aims to increase or preserve cognitive functions, to track medication and coordinate physical activity through an exercising game (exergame). The exergame is customized according to each elderly person's reactions and specificities. The workflow involves doctors, physiotherapists, the elderly person and their caregivers, in an ecosystem designed to ensure well-being and independence.
Keywords: workflow management systems, gerontechnology, personalized medicine, control.

1 Introduction

Elderly population is increasing around the world and technologies for this area should be more and more common. EU statistics show that by 2025 more than 20% of population will be over 65 years old, and a significant percent of them over 80. The European Commission has committed to offer healthy and dignified ageing for older people, in order to allow them to enjoy a good quality of life and their independence, as well as to remain active in society and their families. Healthy Life Years (HLY) or "disability-free life expectancy" indicator is the number of years a person of a certain age can expect to live without disability [11, 12]. HLY indicator is part of the core set of European Structural Indicators, recognized in the Lisbon Strategy [11, 12].

In this area we can mention several prominent research projects for elders' well-being and independent living: ASPA (Activating senior potential in ageing Europe); Demhow (Demographic change and housing wealth); LEPAS (Long-run economic perspectives of an ageing society); Maggie (Major ageing and gender issues in Europe); Multilinks - How demographic changes

shape intergenerational solidarity, well-being and social integration: a Multilinks framework ; Sharelife - Employment and health at 50+: a life history approach to European welfare state interventions; SPReW - Generational approach to the social patterns of relation to work; Recwowe - reconciling work and welfare in Europe [6].

Following standard assumptions, we take an elderly person to be defined as being at least 65 years old. Most elderly people are retired and are affected by several chronical conditions, most commonly related heart problems, mobility and mental deficiencies. Clinical studies show that the elderly's cognitive abilities are affected by various degrees, ranging from simple forms of amnesia, mild cognitive impairment (MCI) or mild to severe age-associated memory impairment (AAMI), to mild or severe dementia and Alzheimer [1, 7]. For these reasons, the Active and Assisted Living Joint Program (AAL JP) encourages several research programs for assistive technology and ubiquitous computing in order to offer several e-heath or m-heath solutions for independent living [6]. In recent years, gerontechnology has developed a symbiosis between gerontology and technology, an interdisciplinary research into technology for an ageing society, for improving the quality of life of elderly individuals [1].

Elderly monitoring activities can be assimilated with a workflow due to the repetitive character of the steps to be followed as well as the daily activities specific to the elderly. For this reason we offer a gerontechnology solutions based on an automatic, as a module of AAL platform Mobile@Old. Workflow based on to elderly personalized treatment, track medication and feedback for increasing or preserving cognitive function, physical activity focused on personalized exercises and wellbeing. Section 2 describes software and AAL solutions for elderly people, used as assistive technologies in the rehabilitation domain. Workflow description and business process analysis is given in Section 3. Section 4 presents a usability elders' test of the proposed workflow. Conclusions and future work are discussed in the last section.

2 Related work

Ambient assistive living technology (ALT) improves the elderly's lives, especially those with numerous conditions as a barrier to quality of life. The two major barriers are cognitive and physical in nature. Physical barriers consist of loss of physical function (lack of mobility, hemiparesis, paresis or failing eyesight and hearing) and cognitive barriers consist of loss of cognitive function, starting with amnesia, AAMI, MCI, evolving to severe MCI, dementia or Alzheimer [7, 8].

For these reasons, for most elderly people, drug therapy is part of their everyday life. Many important mobile applications are focused on medication management and reminders of daily activities or medical tests and appointments in order to offer personalized medicine based on companion diagnostic, monitoring and disease surveillance [9].

MyMeds is an application available for Android and iOS devices, as well as on the Web. It manages medication by sending daily reminders by text, email or push notification. The application shows medication that should be taken and its use, tracks the elderly's medication, saves and analyzes personal history. MyMeds has notifications on refilling prescriptions and suggests the best price for each upcoming prescription.

Care4today is another mobile health manager for seniors in both assisted living and independent living. It manages medication with reminders, tracking and connectivity. Through a user-friendly interface, it offers medication reminder tiles with information on timing, dosage, adherence tracking and dates for prescription refills. Each drug can be selected from a medication database built into the application. The tracking of medication schedule provides reports for every type of medication. Care4today can share these records with doctors directly from the screen and can connect with healthcare providers and caregivers [10].

There are also several applications for failing eyesight and hearing. *Dragon Dictation* is a free application that offers the possibility to dictate text and then send it as an email message. In the same manner, caregivers or seniors can dictate reminders to them and post on *Facebook* and *Twitter*. *VizWiz* is designed for partially sighted elderly people, to help them use their phone for taking photos, ask questions and get spoken answers. *Read2Go* provides a choice of font size and settings and offers several functions as an e-book reader: browse, search and download books [10].

If the elderly accept a physical activity based on exergames they get a relaxing daily fun and self-motivation [4]. Exergames use remote hand held controllers, motion sensors for capturing and monitoring body movements. Some of the exergames that we could mention: Nintendo Wii, Playstation Move, Dance Dance Revolution and Xbox Kinect [14].

3 Workflow automations for elders monitoring

3.1 Business process in exergame elders monitoring

Physiotherapy for the elderly is an essential component of their well-being. Its main goal is to preserve balance while walking and maintain core physical gestures that allow them to perform basic daily activities on their own - eating, drinking, getting (un)dressed, washing, combing, shaving, walking etc. The loss of any one of these abilities leads to loss of independence. Most common causes for loss of physical abilities are neurological conditions (paraplegia, hemiplegia, Parkinson), psychopathy (AAMI, MDI, Alzheimer, dementia), conditions affecting the locomotors system. In many of these cases, as well as in the case of seniors who do not suffer from any serious conditions, it is recommended to have occupational therapy, which focuses on daily activities to increase mobility and muscle tonus, as well as improve state of mind and reduce any form of psychopathy [5].

The main participants involved as users are: the *Elder* - defined as a person who has over 65 years - and sometimes Carers as supervisors that receive notifications from application. Carers cooperate with elderly and will be alerted when health conditions decrease or new health worrying symptoms appear. Carers can be husband, wife, children, other relatives or friends. Another participant is the Doctor, with a key role in the elderly's examination and monitoring. All messages, alerts, health monitoring parameters, daily habits, and time schedule for medication are set by the Doctor and all physical exercises or exergames are set by the Physiotherapist (*Kinetotherapist*). Both are main actors in Mobile@Old platform and coordinate automations of the elderly person's communication, in order to ensure their well-being [2, 3].

Since most elderly suffer from various diseases and health conditions, a *Preliminary evaluation* is necessary, carried out by one or several medical specialists (Step 1, Figure 1). The physicians fill the module *Recommendation* with information on the patient's health, chronic conditions, necessary medication, recommended behavior and lifestyle, as well as the module *Restrictions*, if applicable. They also determine the frequency of *Periodical Evaluations*. In this case the senior person will repeat Step 1 through Step 4 whenever necessary (Figure 1). 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. As a result of the reservations expressed by our participants, the module Physical Activity Trainer (PAT) was conceived in two different versions. For each exercise in *Exercise Database* we store several specific fields like: exercise category, difficulty level, exercise name, relevant joints for the exercise, repeating time, exercise description [2, 3]. If the elders refuse to join Exergame program, they must follow medical recommendations. In this case, the person is not a user in Physical Activity Trainer (PAT), but if she changes her mind later all medical examinations can be used by the physiotherapist

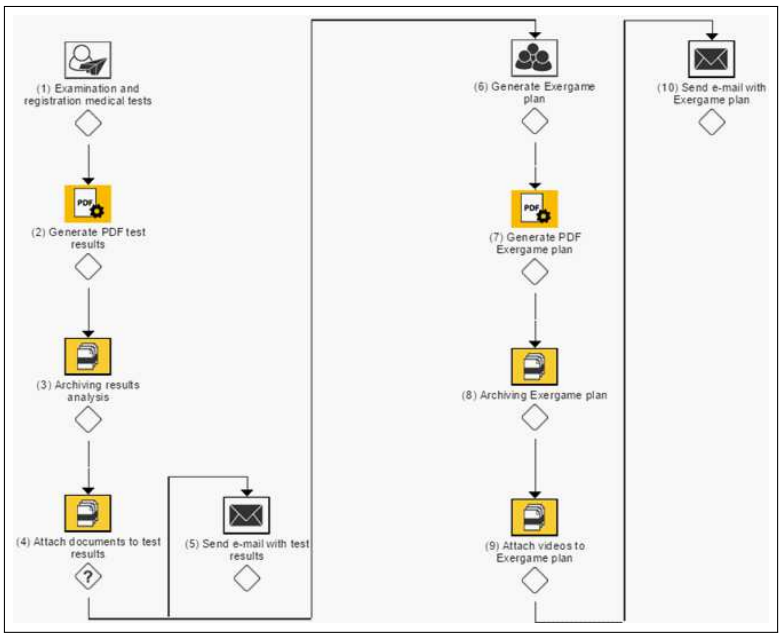

Figure 1: Elder monitoring workflow

to prepare a personalized exergame.

If the elderly person does not use Kinect and interaction with Physiotherapist is done only by tablet and smart mobile, the Physiotherapist records personalized exercises as a Videogame in *Reference Exercises* [2, 5].

For elderly person who accepts Kinect, PAT implementation offers several exergames as video serious game, designed in a customized manner, depending on the restrictions imposed by the chronic elderly. Every exergame has two avatars: one for user and one for trainer. Physiotherapist's recommendation takes into account personal elder profile, which includes diseases information, medical recommendation, sex, age, aso. All type of physical exercises is personalized, depending on the restrictions imposed by the chronic disease of the elderly. Physiotherapists will register a set of exercises with gradually levels of difficulty. All monitoring processes and elders' performance are directed by procedures associated to Kinect parameters which are recorded in *Exercise Database* [3].

3.2 Elders monitoring workflow

This workflow ensures automatic monitoring for PAT and Vital Sign Monitoring (VSM) module as a part of Mobile@Old platform. Daily analyzes and health parameters (systolic and diastolic blood pressure, pulse, glucose value, breathing rate) are repetitive activities that can be easily coordinated by a workflow. Caregiver intervention is justified only when they exceed normal limits, in which case the designed workflow alerts the physician and caregiver. To monitor physical exercise for the elderly who does not accept Kinect as an automated solution, the proposed workflow automates this process. Daily analyzes and health parameters (systolic and diastolic blood pressure, pulse, glucose value, breathing rate) are repetitive activities that can be easily coordinated by a workflow. Caregiver intervention is warranted only when they exceed normal limits, in which case the projected workflow alerts the doctor and caregiver.

Technical tools for workflow development was provided by JobRouter AG, consist on cloud storage with JobTable, JobSub, JobPDF, JobSelect and JobArchive modules. The designed workflow was tested in several browsers like: Firefox 47.0.1, Google Chrome Version 51.0.2704.106

m (64-bit), Safari 5.1.7 (7534.57.2), Opera 38.0 Version 38.0.2220.41 and Internet Explorer 11 Version 11.0.9600.17416. All tests passed with success. Designed workflow involves the following steps (Figure 1):

(1) Examination and registration medical tests are a Start Step. The designated doctor (*Doctor*) fills the form with basic information on the patient, common medical measures (blood pressure, heart rate), dates for various medical tests, information on whether these have been taken before or after meals, and optionally, details on other conditions or restrictions due to any chronic disease. Files documenting additional tests can be added. The patient can decide whether he wants to start Exergame or not. Doctor, a specialized professional, has the rights to determine the senior patient's examination, to indicate or change medication, to access for add, modify or delete the elderly's records and/or fields in several tables, such as: *Daily_ Habit*, *Elder_ Disease*, *Disease_ Type*, *Generic_ Drug*, *Drug*, *Normal_ Analysis*, and *Schedule for LAB Analyse*. *Doctor* decides *time management* for the medication: before or after eating, how long before lunch, 3/2 times per day (morning, lunch, evening), weekdays or even afternoon table, indication and contraindication for exercise and daily activities at home, and also follows and decides prescriptions based on *Analysis/ Medication Administration History* table. This information serves as a guide for *Physical Therapist* in the exergame individual plan [3, 13].

(2) Generate PDF test results is a System Step processed by JobPDF module. Based on a previously designed template, a PDF version of the form is generated.

(3) Archiving results analysis is a System Step processed by JobArchive module, archive action. The previously mentioned PDF is archived. It can be accessed by doctors or elderly patients for monitoring and disease surveillance.

(4) Attach documents to test results is a System Step processed by JobArchive module, clip action. It allows the addition of test results to the form archived in step 3.

(5) Send email with test results is next System Step processed by Send E-mail automatic procedure, with a document that contains the results of medical tests. If the patient does not wish to continue the Exergame course of treatment, he receives an email confirmation of this decision.

(6) Generate Exergame plan is a User Step directed by the *Physical Therapist*. If the patient accepts the Exergame program, the designated physiotherapist receives the test results and a request to design an appropriate course of treatment. He must then fill the corresponding form with the following information: name of the exercise, number of repetitions (5/10/20 ...), and frequency (once, twice or three times a day). Optionally, a video demonstrating the exercises can be added. It should be mentioned that one and the same video may come with different indications (for example, different number of repetitions), depending on the elderly's patients physical abilities and health condition [2, 3, 5].

(7) Generate PDF Exergame plan is a System Step processed by JobPDF module. Based on a previously designed template, a PDF corresponding to the course of treatment is generated.

(8) Archiving Exergame plan is a System Step processed by JobArchive module, archive action. The PDF is archived.

(9) Attach videos to Exergame plan is a System Step processed by JobArchive module, clip action. Videos corresponding to each exercise are attached to the form archived in step 3.

(10) Send e-mail with Exergame plan is a System Step processed by Send E-mail automatic procedure. After the completion of the treatment plan, the patient and/or the caregiver receive an e-mail with the treatment plan and corresponding test results.

System Steps of all types (JobPDF, JobArchive or Send E-mail) are automatically processed by the system. If further needs will arise and multiple Doctors and Physiotherapist will be involved for a single elder, we can implement parallelization steps as a beginning and ending sub-process. For this case we used only User steps (directed by doctor, physiotherapist and elder) and System steps (7-10).

The physician or physical therapist (as workflow users) can access periodic reports detailing the evolution of the medical condition of the elderly included in the AAL program, the accepted or refused personalized exercise program as well as the performance and evolution of each elderly person. Monitoring exergame program, tests, performance and evolution are directed by the PAT module which involves Kinetics and other wearable technologies and is detailed in other papers [5, 13]. Moreover, if a patient is transferred from one doctor to another, the last one will have access to a full patient medical history (Figure 2).

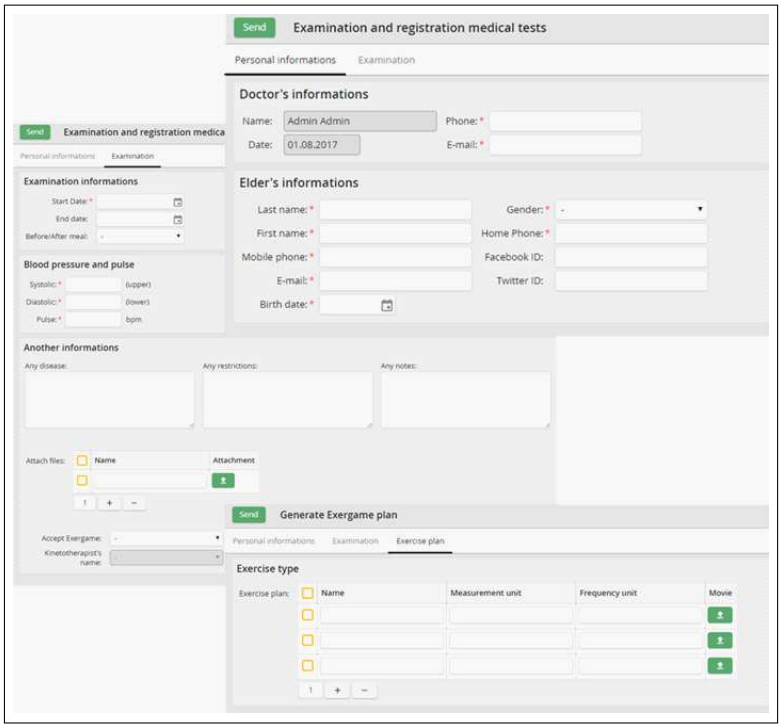

Figure 2: GUI for personal information, examination and exercise plan

4 Experimental results

We offer the doctor same level of importance as the patient on the platform, based on the analysis of response related to health issues. Needs analysis started with a questionnaire with 61 items, that was applied to 69 persons, elderly people between 60 and 87 years (median 67,4), with chronic or severe diseases, and several of them (12% - 8) with disabilities. These results (Figure 3) showed that most of the elders suffer from at least one chronic disease (95%), or two

chronic illnesses (62%) even 3 chronic diseases (47%) and some of them have impairments or disabilities [3, 5].

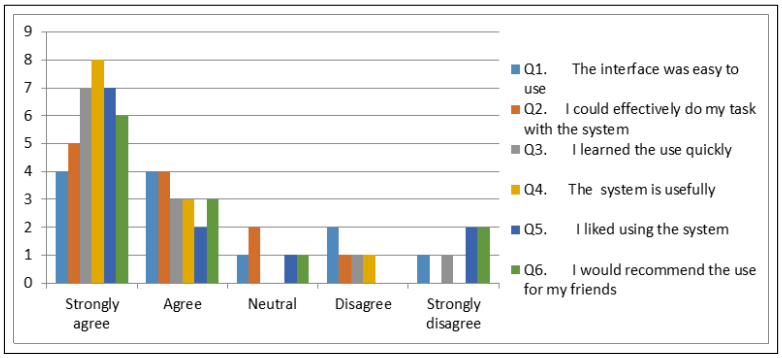

Figure 3: Feedback from elders

Out of the elderly that participated in our study, only 8 out of 69 (12%) accepted to use the proposed workflow as an automatic solution to monitor their health parameters and exergames, and accepted to use the mobile application made available to them. Only 4 out of 69 (6%) accepted monitoring exergames via Kinect. The target audience has coronary heart disease (7), Myopia (6), Hypertension (5), Hypermetropia (4), AAMI (4), Osteoporosis (4), Diabetes (3), MCI (3), Thyroid disorders (2), overweight (3) or Angina (2). Only two of them have disabilities: Hemiparesis. All of them are computer literate users (CLUs) and have a healthy life style. Elders accepted our proposal about workflow and usability evaluation [3, 5, 13].

On the other site, we invited several CLUs: doctors (5) physiotherapists (3) and caregivers (6) to use our workflow and evaluate usability based on a questionnaire with 15 items. They interacted with workflow as users and with elders as patients. In fact, everyone has a user role in our proposed workflow. We presented several relevant results related to the elderly because all the others (doctors, physiotherapists and caregivers) gave only answers that were strongly agree or agree. Seniors find the system useful (Q4), learn to use it quickly (Q3) and like it (Q5). Only few of them dislike the interface (Q1), not recommended it to others and are neutral to performing tasks with the system (Q2). Figure 3 shows details about 6 of 15 answers, the rest included open questions (4) related to CLU (3) and wearable technologies (2).

5 Conclusions

This paper presents an automatic workflow for monitoring of the elderly. We focused on two major problems of third age: monitoring health parameters and chronically disease and monitoring exercise plans. We discussed three major participants in the workflow system: (i) the doctor, who coordinates periodic medical examinations and personalized treatment, (ii) the physiotherapist, who follow doctor's indications and contraindications and coordinate exercise plans and daily activities at home and (iii) the elder person, who is the core beneficiary.

All steps are only User steps conducted by the doctor, physiotherapist and the senior user or System steps. System steps use several database tables managed by Mobile@Old platform and generate several documents, such as medical examination reports, medication schedule or exergame plan.

All actors involved in the workflow testing are computer literate users (CLUs) and have accepted our questionnaire related to system usability. Moreover, the consulted seniors have a healthy life style and find our solution useful and easy to learn. A real benefit seems to be

for doctors, physiotherapists and caregivers, who appreciated asynchronous communication and message automation.

As future improvement, we intend to develop new functionalities and to adapt the application to new requirements in order to best fit elders' needs in this area.

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