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ROBOTICS FOR SOCIAL WELFARE

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Abstract: Supported by developments in the field of social robotics, virtual worlds and ICT tools it is possible to build new solutions in health and welfare. Two projects are described in this article. They are intended to improve efficiency and quality of current therapeutic procedures. The ESTIMULO project improves emotional and cognitive status of people with dementia using a reactive pet-robot. The ELDERTOY project modifies the classical concept from the toy industry to develop a new solution for the aged people. ELDERTOY involves a double purpose, fun and therapeutic. In a complementary way, these projects aim to be an example of the breaking of the technology gap both of seniors and of people with disabilities. Therefore, the ultimate goal is to promote and adapt scientific and technological knowledge to be applied to improve significantly the standard of quality of life in society.

Keywords: Social robotics, Therapy, Dementia, Well-being, Cognitive stimulation.

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Introduction

European population lives longer than ever thanks to economic growth and healthcare advances. Average life expectancy is around 80 years, and in 2020 about 25% European population will be 65 or more [1]. The increase in life expectancy supposes in many occasions the development of illnesses associated with old age, among them senile dementia [2].

The most common causes of dementia in the European Union are the Alzheimer disease (about 50-70% cases) and multi-infarct dementia, due to repeated brain infarcts (about 30%). Other relevant causes are Pick's disease, Binswanger encephalopathy, and dementia with Lewy bodies [3].

Regarding the clinical evolution experienced by patients with dementia, criteria have been established to determine the level of its intensity [4]. It is convenient to point out that not all pathologies evolve in the same way, and that in patients with the same diagnosis the disintegration of mind functions does not follow necessarily the same pattern.

The European Commission acknowledges the potential in ICT to help elder people to cope with isolation and loneliness, to better access social and commercial services but, above all, to maintain personal independency for longer.

Ageing consumers are not always taken into account in the design of products of common usage, and it's necessary for the industry to be more conscious about the abilities of senior consumers.

For instance, 21% of people 50+ years old have severe audition, sight or manual dexterity problems, so it is difficult or impossible for them to employ standard ICT equipment. It is for this reason that is unavoidable to adapt ICT to the needs of all people.

In the present paper two R&D projects are described, both centred in researching the possibilities that the new technologies offer us to enhance life quality of elder people suffering dementia.

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Both projects generate an added value and innovation for conventional cognitive stimulation therapies [5]. Those are based in the plasticity character of the brain (known as neuroplasticity), that is, the response of the brain after damage, to adapt itself to the new situation and restore the altered equilibrium.

Several researches show the ability of damaged neurons to regenerate and establish new connections. This is the case also in the aged brain, even those with dementia, though with less intensity. Given this brain capacity, there exists a basic concept for the treatment of dementia: That of psychostimulation [6].

This term refers to "the set of stimuli generated in interventional neuropsychology aimed at rehabilitation".

Cognitive stimulation techniques include exercises consisting in the presentation of stimuli, resulting from due study, that pretend to maintain or recover cognitive functions, exercising existing and altered abilities. It is in this point where the ESTIMULO and ELDERTOY projects show all their potential.

In the moderate and severe phases of dementia, neuroplasticity will be strongly limited, due to the high proportion of damaged and/or dead neurons, resulting in a diminution of the synaptic processes implied in learning. In these situations, cognitive stimulation is harder. In this stage, the ability of the patient to perceive the environment and to interpret reality is affected, constituting an important source of stress hard to mitigate, given that the causes cannot always be modified, and frequently the deficits of the subject prevent the therapeutic action.

In this context, the first of the said projects, ESTIMULO, has as a goal to enhance patient-carers interaction. On the other hand, in the ELDERTOY project, a therapy tool is built for 60+ aged people, with a shape and appearance resembling a toy. From the point of view of therapists and gerontology specialists, the results of both projects are useful as ICT tools on which to build individual and group workshops and games. The ultimate goal

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of these workshops is to stimulate the abilities of users and mitigate the cognitive worsening in the phases of dementia.

The structure of this paper is as follows. 2) The ESTIMULO project, in which details are given on the goal, scope and results of the project; 3) The ELDERTOY project, describing the singular aspects of this action and the benefits on people's life quality achievable by means of the ELDERTOY development platform; 4) Scope of application, describing the set of techniques supporting cognitive stimulation therapies involved in both projects; 5) Technology tools, treating in depth the ICT tools employed in the several cognitive stimulation workshops; 6) Conclusions and further work; 7) Acknowledgements; 8) References.

The ESTIMULO project

For long years therapies including animals have been employed for the enhancement of the emotional and cognitive state of people with dementia [7]. The work with animals as applied to the medical treatment of people has been amply used in hospitals and in retirement homes. Works with animals are developed in two phases, animal assisted therapy (AAT) and animal assisted activities (AAA) [8].

Animal assisted therapies have concrete therapeutic goals, jointly defined by doctors, nurses, psychologists and therapists. On the other hand, in animal assisted activities the interaction between patients and animals lack specific goals.

Though the usage of animal assisted therapy has produced important results, almost all hospitals and retirement homes have dispensed with this kind of therapies due to the possibility of allergies, infections, biting, scratches, and generally the fear that certain kinds of animals can cause to the patients. Other counterproductive effects [9] resulting from animal assisted therapies are related to the sentiment of sadness arising in case of the death of the animal in the course of the therapy. After the strong affective and emotional bond ensuing during the activities, the loss of the animal can produce a strong affliction and sadness feelings in the patients.

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In the ESTIMULO project work is done with a pet-robot and with multimedia audiovisual content projection, all easily replaceable for others of similar features, in case of damage. So, the problems arising from the loss of a living being proper of animal assisted therapy, as also the problems of their disinfection, are avoided.

The therapy tools used in ESTIMULO open a new therapist-patient interaction paradigm, in offering a stimulation channel adapted to the involution model of the patient in the moderate to severe stages of dementia. In these stages, there is a loss of the ability to accomplish concrete operations, but it persists that of making exercises with real objects, moreover if they have an emotional implication. Their recognizable physical qualities are also a relevant feature in these stages, because the recognition ability is maintained by the individual.

Figure 1. PARO Seal

The usage of systems such as PARO (the pet-robot shown in Image 1) as a tool on which to build new therapies applied to people with dementia has, as its main purpose, the generation of a feeling of relaxation and pleasure in the patient. This fact will unleash the enhancement of cognitive and interaction abilities of patients with their surrounding world. This way, we can achieve that the patients become more active, receiving and communicating among themselves and with the clinical care people.

The main goal of the new therapies pursued in ESTIMULO is to produce three effects in patients with dementia:

- Psychological effect. Resulting form a better relaxation and motivation due to the activity realized.
- Physiological effect. Produced by the enhancement in his vital signs [9].
- Social effect. Activation and reinforcement of the communication both among patients and with carers [11].

Therefore, one can conclude that the main advantage that the ESTIMULO project brings in is the enhancement of well-being of senior people suffering dementia in their social context faced from different action points, such as the application of learning games, interaction with new technologies, mitigation of loneliness feelings, generation of protection instinct for a mascot, or psychomotor games.

Figure 2. Patient holding PARO

In a complementary way to the actions brought forth with the PARO tool, in the frame of the ESTIMULO project the typology of workshops and tests realized with patients according with their level of dementia are analyzed. As a fruit of this analysis, mobile applications are built allowing the health experts to compile all the information in digital form and analyze it in an efficient way. This analysis is based in the progression of each patient according to a defined series of competences. This way, it is possible to

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analyze whether a patient is showing a worsening of a given ability or, on the contrary, a noticeable improvement in a different ability or characteristic is taking place. This analysis will allow to build action strategies and totally personalized therapy workshops fitted to the state of the patient.

The ELDERTOY project

The first phase of the ELDERTOY project develops a therapy tool shaped as a toy targeted at elder people, with certain dependency degree, and to users of care centres. After that, this kind of solution is taken to other action field, the domestic one, having as its target senior people living at their own houses.

The toy has two main goals:

- Affective-recreational. Helping with the affective deficit that the elders may have in old people's homes.
- Therapeutic. To be a therapy tool, making compatible the recreational and therapeutic purposes.

The ELDERTOY platform acts in a personalized way, that is, it adapts its mood to the behaviour of the user, but also maintains constant its own personality, which represents a challenge in the games and workshops the users share.

In the design of the ELDERTOY platform it has been taken into account that the focus is with adult people, for which reason their general preferences have been taken into account, avoiding appearances that could raise rejection for its usage [12]. A key aspect is the animal appearance, which provokes a tendency to infantilize the toy (associating it with a cuddly toy) and to compare it with a real or toy animal, rising and adverse reaction. Hence, shapes have been considered with no association with actual living beings but with animated features producing empathy and stimulating the user to interact with ELDERTOY in an easy, natural and intuitive way [13].

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ELDERTOY has two different interaction channels that allow users to communicate with the device according to their preferences (gestures, voice, touch-screen interaction, external actuators adapted to different kinds of functional diversity, etc.). Also, it has elements allowing to show emotions, in such a way that an empathy bond with the user can be created.

Inner mobility has also been added to the ELDERTOY platform with the purpose to animate it, simulate internal life and enhance its attractiveness. Additionally, it has articulated elements simulating arms reinforcing the sympathy and affectivity of the device. The structure and design of these joints is flexible and robust. Thus the risks ensuing from moving or cutting elements are avoided, as well as the break-up risk of the said components due to falls and forced manipulation.

ELDERTOY usage is conceived both by means of inner manipulation, as also by projecting of multimedia content. By inner manipulation, therapy specialists are furnished with a tool able to run games by using the sensors integrated in the platform. In this way, it is possible to utilize the integrated touch-screen, an inertial sensor and gyroscope to determine device position and movement, voice commands, integrated web-cam acquired video, etc. Therefore, by direct ELDERTOY manipulation, talking with it and/or acting on its screen, it is possible to develop several therapy workshops on coordination, memory, concept-object relationship, calculus, language, etc.

Otherwise, ELDERTOY can be used as if it were a video game console. In this way, by multimedia content projection on a monitor, TV, or using a projector, it is possible to use any video, image, or interactive game of therapeutic inspiration which allow the user to develop his physical and cognitive abilities [14]. In this working mode, it has been considered very relevant the usage of a character as a kind of helper. This help will guide users, family and specialists (according to the selected game) in the steps that must be followed to play the game in the proper way.

The goal is that both direct ELDERTOY users as also their familiars get a customary user interface. In this way, if ELDERTOY is used outside institutions, for instance in the home environment, the graphic character is

able on one part to indicate the elder person and his family the rules needed to accomplish a certain game, and on the other to advise the family about the conduct they must follow with the elder person with dementia to stimulate and reinforce him positively [15].

Scope of application

In a general way, it is possible to define three activity fields derived from the actions undertaken in ESTIMULO and in ELDERTOY. In each of these fields, tools and specific techniques have been applied to cognitive stimulation therapies.

- Virtual agent assisted therapy.
- Robot assisted therapy.
- Patient evolution management tools.

Virtual agent assisted therapy

It consists in the usage of virtual characters to make therapeutic rehabilitation activities, by using them as a stimulus and incentive [16]. In image 3 one can see the visual appearance of virtual character resembling a nurse.

Figure 3. Virtual agent.

The virtual character serves a guide the user can imitate and interact with. The ultimate goal of the virtual character is to serve as a help to health experts to conduct certain kind of tests, and also to familiars and the own

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patients in cases in which prescribed work must be continued in short term absences (for instance holidays, illnesses, etc.).

Virtual agent assisted therapy enhances personal competence and favours the consolidation and maintenance of knowledge, abilities and acquired habits, as also its application to day-to-day situations [17][18][19].

Regarding cognitive ability stimulation, a virtual agent correctly programmed can help the user to work on many areas specially including:

- Memory.
- Language.
- Thought.
- Calculus.
- Reminiscence.
- Object-meaning relationship.
- Music therapy.

In motor ability stimulation, there is collaboration with the therapist avoiding apathy and stillness. One gets high acceptability at any age, both by aged people as by children. The main aspects worked on are:

- Movement repetition.
- Coordination.
- Equilibrium.
- Object drawing ability.
- Space.
- Rythm.
- Body concept.

Many elder people living in old people's homes often enjoy holidays at the houses of their families. After these stances, and having left aside the routine, not making the daily exercises, when they return, they show a greater cognitive worsening than before.

The avatar resolves partly this problem, because it allows the patient to make home exercises he is already familiarized with. It also serves as a help

for the family in the adequate treatment of the patient, something not easy in many cases. Thus, it makes a complementary function as family educator, indicating the most adequate conduit to face the behaviours and reactions of the person with dementia.

The usage of this kind of virtual agents, as also of the associated multimedia content, works when ELDERTOY is used in game console mode, or alternatively, by means of a web browser accessing a given platform in which the games and the workshops for a given patient (in the ESTIMULO case) are personalized.

Robot assisted therapy

It consist in the implementation of new gerontology therapies including the usage of robots endowed with motion and communication abilities [20][21].

The usage of robots connected with the user helps their relaxation and enhances communication among patients, and of these with their families and therapists.

Both the PARO robot platform, used in the ESTIMULO project, as well as the ELDERTOY platform, seek the affinity with users suffering dementia and with the people in their environment, being attractive at all ages, fostering intergenerational relationship.

They allow to work both in the strengthening of bonds as well as the carrying out of workshops.

The main bonds to reinforce are:

- Affective.
- Emotional.
- Happiness feeling.
- Relaxation.
- Motivation.
- Commitment.
- Responsibility.
- Self esteem.

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In order to get good results and reinforce both cognitive abilities as also the bonds mentioned, the following workshops are realized:

- Memory.
- Language alteration.
- Object recognition.
- People recognition.
- Planning.
- Organization.
- Motor abilities.

Patient evolution management tools

In patient monitoring it is fundamental to have a proper record of the therapy indications received and his evolution along therapy sessions. To that end, several techniques are employed for storage and data analysis that facilitate the health professionals the control of the information generated.

These tools are a warrant of success and of future in the field of applied robotics in healthcare. Is needed to show the progression of patients to extend these good practices and achieve that the community can take advantage of its benefits.

Once all the data obtained through the realization of tests have been analyzed, the system integrated in the ESTIMULO project is able to evaluate the competences and abilities of each patient depending on a series of basic rules provided by the health experts. In this way, the timely progression of the cognitive abilities can be checked, grave conditions are detected and a personalized therapy is planned aiming at the mitigation of the cognitive worsening detected.

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Technology tools

Here we deal with the technical and functional characteristics of the ICT tools deployed in the ESTIMULO and ELDERTOY projects. Concretely, we attend to the ELVIRA solution, consisting in a virtual conversational agent, the PARO robot, and the ELDERTOY device.

ELVIRA

ELVIRA (the virtual agent) is a last generation user interface combining computer graphics techniques for the presentation of a virtual assistant and computer vision techniques for face recognition, eye contact simulation, with voice and gesture interaction. In those cases where verbal and gesture communication isn't efficient enough due to the involved complexity, the virtual agent interface is accompanied by an accessible interface, allowing a direct interaction with the contents in an easy and intuitive way.

Avatar modelling and the affective model are the means to enhance the closeness perceived by the system user. The model is personalized depending on the way the user works with the system, with the objective of giving him a treatment continuously adapted to the user profile. In turn, the affective model seeks to mitigate the mechanistic feeling of the interaction enriching it with expressive facial gestures complementary of the dialog.

Such agents are a response to the challenge generated by the increasing complexity of digital services offered to citizens, so they can break the actual digital divide. The guiding principle in these systems is that the closer the interaction with a machine is to human attention, the greater its usefulness, thus diminishing entry barriers for users who are not technologists or need further assistance.

The virtual agent ELVIRA handles a wide range of technologies including voice dialogue, artificial affectivity and domain decoupled problem solving, supported by Cognitive Computing techniques by means of a reasoning engine based on emerging semantic standards. This allows an increase in the

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maintainability of the affective models, of dialog management, personalization, and domain pragmatics.

As a support for interaction, Affective Computing research results such as formal models of Appraisal Theory coming from the cognitive psychology have been used [22][23]. In the dialog area, Computational Linguistics results on syntactic and semantic analysis allow to relate logic forms to plain text [24]. As for dialog management, phenomena such as interruptions or context management have guided goals more ambitious compared to actual automatic vocal systems [25].

The interaction is multimodal, bidirectional audiovisual, offering virtual reality, speech synthesis and context-dependent speech recognition, in addition to using artificial vision techniques. These techniques allow the recognition of users, both facially and by voice footprint, enhancing the feeling of familiarity of the user.

User history with the system, previously registered, allows to choose how to make the treatment more efficient and provide a personal touch such as greeting by name, remembering preferences, or adapt to specific needs.

Similarly, the application of machine learning techniques allows the detection of emotion from voice and facial appearance or the detection of a repertoire of gestures.

In parallel, user rapport is achieved by means of a convincing reactive behavior on behalf of the virtual agent. The realization of this behavior is done by template-based phrase generation or using syntactic synthesis [26]. Regarding non-verbal behavior, this includes the adoption of facial expression, and the performance of gestures and scene movements. This channel is necessary in emotion synthesis. In this tasks real-time computer graphics techniques with shape blending and character animations are employed. The creation and manipulation of computer graphics content is made through a hub of computer graphics software based on a common standard for asset exchange, for tasks such as modeling, lightning or animation.

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PARO Robotic Platform

PARO (Personal Assistant RObot) is a japanese robot designed with the aspect of a baby seal. It has several sensors distributed in its body to react to people contact. It has also memory that allows it to react to its name when uttered. It makes gests, opens and shuts its eyes, and emits sounds resembling a real seal. It has been developed during the last 15 years by the Japanese National Institute of Advanced Industrial Science and Technology and it has been awarded with numerous international prizes.

Since 2008, the Danish Technological Institute works on applications of the robot seal as a therapeutic tool, above all in aged people with brain deterioration. Its psychological benefits have already been checked (it reduces stress level), the social benefits (enhances patient communication), and physiological (diminishes blood pressure, heart rate and muscular stiffness).

In advanced stages of dementia, through touch and caresses, motor function is stimulated, as also is the coming out of the state of self absorption.

PARO fosters the development of experiments stimulating certain cognitive abilities of the patients, mainly focused on touch sensations, sight contact, sound activity, etc. In a percentage near 75%, PARO has adopted a mediating role, establishing a bond between the carer and the patient, in a way that does not irritate or make the patients uneasy, but also promoting their mutual communication.

ELDERTOY development platform

The ELDERTOY development platform consists in a robot-toy with a friendly appearance, including mainly a touch screen, a gyroscope, an accelerometer, USB and HDMI connectors, webcam, microphone, speaker and touch sensors.

ELDERTOY allows user interaction through several channels (touch screen, voice, gesture, etc.). The screen is the support for games and for the addition of expressivity to the final design of the toy. The gyroscope allows

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to get the orientation of the toy so it can take part on the games. Connectors make possible to use the toy for video games, or the expansion by complementary devices (joysticks, external actuators, etc.). The camera, microphone and speaker aim that the user identifies himself with the toy, endowing it with expression. By means of these devices the ELDERTOY platform gets its contents displayed in a multimodal way, is able to recognize voice, and to detect the presence of people around it.

The ultimate goal is that patients get relaxed by interacting with ELDERTOY, begin to spontaneously chat with each other, families and health staff, and that in the companion of the ELDERTOY platform they get involved in several activities that wouldn't be realized without external stimuli. These activities have a therapeutic intention forcing mind stimulation and exercising resulting in a mitigation of different cognitive impairments that may occur at a certain age.

In short, it seeks to improve relationships between patients, improve cognitive responses and to get them to reduce anxiety states, depression and loneliness that may be present.

Conclusions and further work

The ESTIMULO and ELDERTOY projects are being developed in the actual context of ageing population and new research using social robotics to enhance life quality in elder people.

The ESTIMULO project achieves the results of animal therapy using the PARO robot mascot, avoiding the counterproductive effects of the former, and allows also the extraction of patient data evolution. The activities developed in the ESTIMULO project concern in picking patient state data by means of tests conducted before, during and after the workshops using with the robot. As a future work, the data collected on a population of 24 elder people with a varying grade of dementia will be evaluated. The goal of this evaluation is to determine the effect of the workshop including the seal-robot, analyzing the progress or regression on differing personal competences in comparison with the expected natural process. The ELDERTOY project develops a

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therapy toy for elder people having a playful and therapeutic purpose. This project encompasses everything from the physical construction of the toy to the software development necessary to cover both the playful-affective and the therapeutic aspects.

We establish as future work for the ELDERTOY project the testing of the progress of the users regarding coordination, memory, object-concept relationship, calculus and language, after the usage of the robot-toy.

Both projects act in three fields: virtual agent assisted therapy, robot assisted therapy, and patient evolution management tools. To that end, three technology tools are used: Elvira, as a virtual conversational agent, the PARO robot, and the ELDERTOY device.

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