

# The REHAB@HOME Project: Engaging Game-based Home Rehabilitation for Improved Quality of Life

**Lucia Pannese, Giancarlo Bo**

imaginary S.r.l., Milano (Italy), Via Mauro Macchi 50  
[lucia.pannese@i-maginary.it](mailto:lucia.pannese@i-maginary.it), [giancarlo.bo@i-maginary.it](mailto:giancarlo.bo@i-maginary.it)

**Michael Lawo**

University of Bremen, Bremen (Germany), Address  
[mlawo@tzi.de](mailto:mlawo@tzi.de)

**Silvia Gabrielli**

CREATE-NET, Trento (Italy), Via Alla Cascata 56/D  
[silvia.gabrielli@create-net.org](mailto:silvia.gabrielli@create-net.org)

The REHAB@HOME project is intended as an advanced activity – with the involvement of highly qualified medical and technical partners, as well as real patients - aimed at an extensive investigation of the issues related to long-term physical/cognitive rehabilitation processes and the identification of suitable technical solutions to efficiently support them. REHAB@HOME will enable elderly people to enjoy high quality rehabilitation for a much longer period than the Health System can currently afford. By investigating and using standard hardware components and devices, suitable medical data processing algorithms, personalized and serious-games based rehabilitation pathways, Web2.0 social and communication tools, the project will develop an efficient, effective and engaging virtual rehabilitation environment for home-based rehabilitation. The basic project idea is inspired by existing commercial platforms, like Wii and Kinect, that allow the user acting within a virtual environment and interacting with other users, thanks to special input devices and suitable technologies able to monitor the real environment and track the user's behavior. Having this in mind, REHAB@HOME aim at the user-centred design and development of an open solution capable to: provide exercises and training - based on serious-games - within a personalized, user friendly and engaging rehabilitation program, offer a cost effective and not bulky infrastructure with sensors integrated, collect relevant physical and medical parameters for patients' status inspection and relapse prevention, support off-line/on-line management and monitoring of the rehabilitation protocol, promote patient's social participation and community building. In other words, REHAB@HOME will transform the patient's home in a place where physical and cognitive rehabilitation process can be performed in an intensive and engaging though properly controlled way, while promoting social inclusion and quality of life.

**Keywords:** Physical and cognitive rehabilitation, serious games for healthcare, home-based medical solutions

## Introduction

In 1997 the number of over-65 year olds constituted 6.6% of the world's population, and this is predicted to increase to 10% by 2025. It is expected that this will lead to a rise in demand for long-term residential care. Common elderly diseases may include one or more of the following: arthritis, cancer, cardiovascular (e.g. blood pressure and heart disease), cerebrovascular (e.g. strokes), dementia, depression, diabetes, falls and injuries, gastrointestinal disorders, hearing impairment, memory, nutrition, osteoporosis, Parkinson's and Alzheimer's diseases, respiratory disease, pressure ulcers, sleep problems, thyroid disease, urinary disorders and visual impairment. In many cases considerable health gain, both

from the physical and cognitive perspectives, can be achieved by successful rehabilitation, which is concerned with lessening the impact of specific disabling conditions.

Considering that the aforementioned set of diseases is very broad, let's try to focus more on a specific kind of pathology. Stroke is the 2nd most common cause of death in Europe (1.24 million annual) and in the European Union (508,000 annual) and the 3rd cause of death in Canada (14,000 annual) and the United States (over 143,000 people each year). Meanwhile, 1.8% of Asians aged 18 years and older have had a stroke. In general, according to the World Health Organization, about 15 million people suffer stroke worldwide each year. Of these, 5 million die, 10 million survive, though showing different degrees of disabilities.

Accordingly, the costs of stroke are enormous. In Europe and the USA, 2-6% of all health care costs are spent on direct stroke care, inclusive of the costs of hospital and nursing home care, the services of physicians and other medical professionals, drugs, appliances, and rehabilitation. (Evers S, et al., "International Comparison of Stroke Cost Studies," *Stroke* 35:1209-15, 2004.) Indirect costs, defined as production losses, further increase the burden of the disease. In Europe, direct costs are in the range of 3.000-16.000 Euros per patient during the first year, whereas the lifetime direct cost may reach 30.000 Euros. Taken together, direct and indirect costs may be as high as 20.000-26.000 Euros per patient in the first year. In Europe, 22 billion Euros are spent on stroke annually [1].

Stroke affects everybody differently, and it is difficult to say how much of a recovery is possible. Many stroke survivors experience the most dramatic recovery during their stay in hospital in the weeks after their stroke. But many stroke survivors continue to improve over a longer time, sometimes over a number of years. The goal of rehabilitation is to help survivors become as independent as possible and to attain the best possible quality of life. Rehabilitation does not "cure" stroke in that it does not reverse brain damage. High quality rehabilitation however is essential to regain many – if not all – capabilities to lead a meaningful, fulfilling and even productive life.

The first stage of rehabilitation usually occurs within an acute-care hospital, as soon as the patient is stable and the (initially high) risk of recurrence is lower. 10% of the survivors can return home quickly, many need to be treated into some type of medical facility. For over half of the of stroke survivors, rehabilitation will be a long-term process requiring work with therapists and specialized equipment for months or (ideally) years after the stroke.

However, increasing cost pressure on the health system will lead to shorter periods of intensive rehabilitation at specialized facilities. Within this context the adoption of suitable technical aids at home, together with a proper training about the execution of a personalized program of exercises, can help reducing the patient's stay at the hospital as well as the need for moving him/her forth and back to/from a physiotherapy unit or a paramedical structure.

## **Objectives of the project**

Rehabilitation, which may be effective in improving the physical and mental condition of older people in long-term care, is a complex set of processes usually involving several professional disciplines and aimed at improving the quality of life of older people facing daily living difficulties caused by either temporary and/or chronic diseases. Comprehensive rehabilitation needs to address a number of different levels which may be contributing to loss of function: the damaged body part and other related body elements, psychological attitudes, immediate material environment (e.g. clothing items). the surrounding indoor environment

(e.g. housing/equipment), external environment (e.g. shops, social outlets), social support networks.

In the specific case of stroke, but not only, rehabilitation is based on Neuroplasticity (also known as cortical re-mapping), which is the brain's ability to reorganize itself by forming new connections, allowing nerve cells in the brain to compensate for defects. However, neuroplasticity is only happening when there is 'right' stimulus and sustainable motivation, which are the key factors of successful rehabilitation. Rehabilitation teaches new ways of performing tasks to circumvent or compensate for any residual disabilities. There is a strong consensus among rehabilitation experts that the most important element in any rehabilitation program is carefully directed, well-focused, repetitive practice - the same kind of practice used by all people when they learn any new skill, such as playing guitar or skating.

Rehabilitative therapy begins in the acute-care hospital after the patient's medical condition has been stabilized. The first steps involve promoting independent movement because many patients are paralysed or seriously weakened. Patients are prompted to engage in passive (the therapist actively helps the patient move a limb repeatedly) or active (exercises are performed by the patient with no physical assistance) range-of-motion exercises to strengthen their stroke-impaired limbs. Rehabilitation nurses and therapists help patients perform progressively more complex and demanding tasks and encourage patients to begin using their stroke-impaired limbs while engaging in those tasks. Beginning to reacquire the ability to carry out these basic activities of daily living represents the first stage in a stroke survivor's return to functional independence.

Up to recent times it was assumed that an early rehabilitation immediately after the stroke event is the key to achieve a good functionality recovery for hands, arms or legs. No major improvements were expected from a too much delayed rehabilitation process. Recently it has been demonstrated that relevant results can be obtained also many years after the stroke, provided that a specific and very intensive rehabilitation approach is applied [2]. This opens new horizons for stroke patients and further puts the accent on the need for innovation in rehabilitation, both in terms of methodologies and technologies.

Starting from this perspective the REHAB@HOME project focuses on those medium- long-term rehabilitation steps and activities that could take place at the patient's home instead of at a dedicated treatment unit. The main objective of REHAB@HOME is to transform the patient's home in a place where the physical and cognitive rehabilitation processes can be performed in an intensive, though controlled, way. In practice after a short rehabilitative period in a specialized centre the patient can go home where, with a set of easy-to-use technical equipment, s/he is enabled to exercise in a motivating personalized program. The patient will not only be in contact with experts in the rehabilitation centre - providing guidance and feedback - but will also enjoy the participation in a sort of "virtual gym", a community-like rehabilitation environment connecting fellow sufferers to increase inclusion and motivation.

The very basic idea behind REHAB@HOME is inspired by existing commercial products like Nintendo Wii™, Sony PlayStation Move™ and Microsoft Kinect™: such game platforms allow the user to act and interact with other users within a virtual environment, thanks to special interaction devices and suitable technologies to monitor the real environment and track the user(s) behaviour in it. These are proprietary solutions characterized by limited extensibility and flexibility. Moreover, they are intended as gaming platforms, without any specific feature conceived and designed for a straightforward adoption in the medical practice. Having this in mind, the project will aim at the design and development of an open solution (concept, hardware/software, service) able to offer the following features and functionalities:

- proposing a set of exercises within a personalized, serious-games based, rehabilitation program, properly designed according to the patient's specific needs and able to dynamically and automatically adapt to the user's behaviour/reactions. Ad hoc, real-time, configuration of the proposed physical and visual stimulations mediated by the virtual environment where the patient is acting
- training of both the patient and his/her family members to the execution of the exercises by means of not bulky and user friendly - though highly "informative" for medical experts – devices. Off-line/on-line management of the rehabilitation protocol by the medical personnel/physiotherapist
- acquisition and recording of relevant physical and physiological parameters, by means of suitable sensors. Proper software applications will be developed within the project for analysing the collected data, with the aim of providing a qualitative and quantitative picture of the patient's status and progress
- promotion of social inclusion and community building by means of suitable Web 2.0 tools, to prevent depression and stimulate patient's reintegration within daily life.

### **Scientific and methodological approach**

The successful introduction of innovative and advanced technological solutions, like those proposed in the REHAB@HOME project, strongly and critically relies upon meeting user needs. Therefore an approach to interactive systems development is applied, which aims at making systems usable and useful by focusing on the users, their needs and requirements, and by applying human factors/ergonomics, and usability knowledge and techniques. The aim of such an approach is to enhance effectiveness and efficiency, improve human well-being, user satisfaction, accessibility and sustainability, counteract possible adverse effects of use on human health, safety and performance. Therefore the REHAB@HOME project applies a robust and consolidated research and development approach, in order to achieve the following outcomes:

- *in-depth knowledge of the rehabilitation operational context*: observation of the actual rehabilitation process, analysis of existing medical protocols, definition of a set of representative use and test scenarios, adoption of a robust requirements engineering procedure. This part of the research aims also at identifying the target users (specific disease and disabilities) that might benefit at best from the project technical achievements
- *specification and design of an in-home multipurpose rehabilitation platform*: technical specifications and design of the REHAB@HOME solution, including
  - a flexible and reconfigurable, modular, hardware platform. Conceptually, this will be a set of stand-alone components (sensors, actuators, textile items, communication modules, interaction, visualization and storage devices, etc.) that can be easily selected, aggregated and integrated according to the needs of each specific application scenario
  - an open service-oriented architecture, where each service represents a stand-alone, coherent and self-consistent sub-set of the functionalities to be provided by the solution (e.g. interaction management, visualization, information extraction, data logging, remote collaboration, e-learning/e-training, serious games and community engine, etc.)

- *demonstrator of the rehabilitation platform*: subsets of functionalities characterized by different levels of priority are going to be identified. Features of the system will be implemented incrementally according to increasing priorities. Three prototypes of increasing complexity are foreseen
- *assessment of the rehabilitation platform*: each prototype will be assessed through the involvement of real users, both patients and professionals, taking into account the Living Labs approach. Testing in the different development phases will be based on both a suitable assessment protocol and the definition of test cases and use scenarios already in the requirements engineering process. During the testing phase the need for efficient training of both patients and family members will be addressed
- *definition of an exploitation, development and commercialization plan*: this objective will aim at identifying the actual potentialities of the project outcomes in real life. Very important as part of this activity, in order to promote the actual adoption of the solution will be the definition of a “service model”, i.e. the most suitable way to integrate the new rehabilitation service within the portfolio of existing public healthcare services.

The following figure shows the different research, development and technological aspects that the project is facing up.

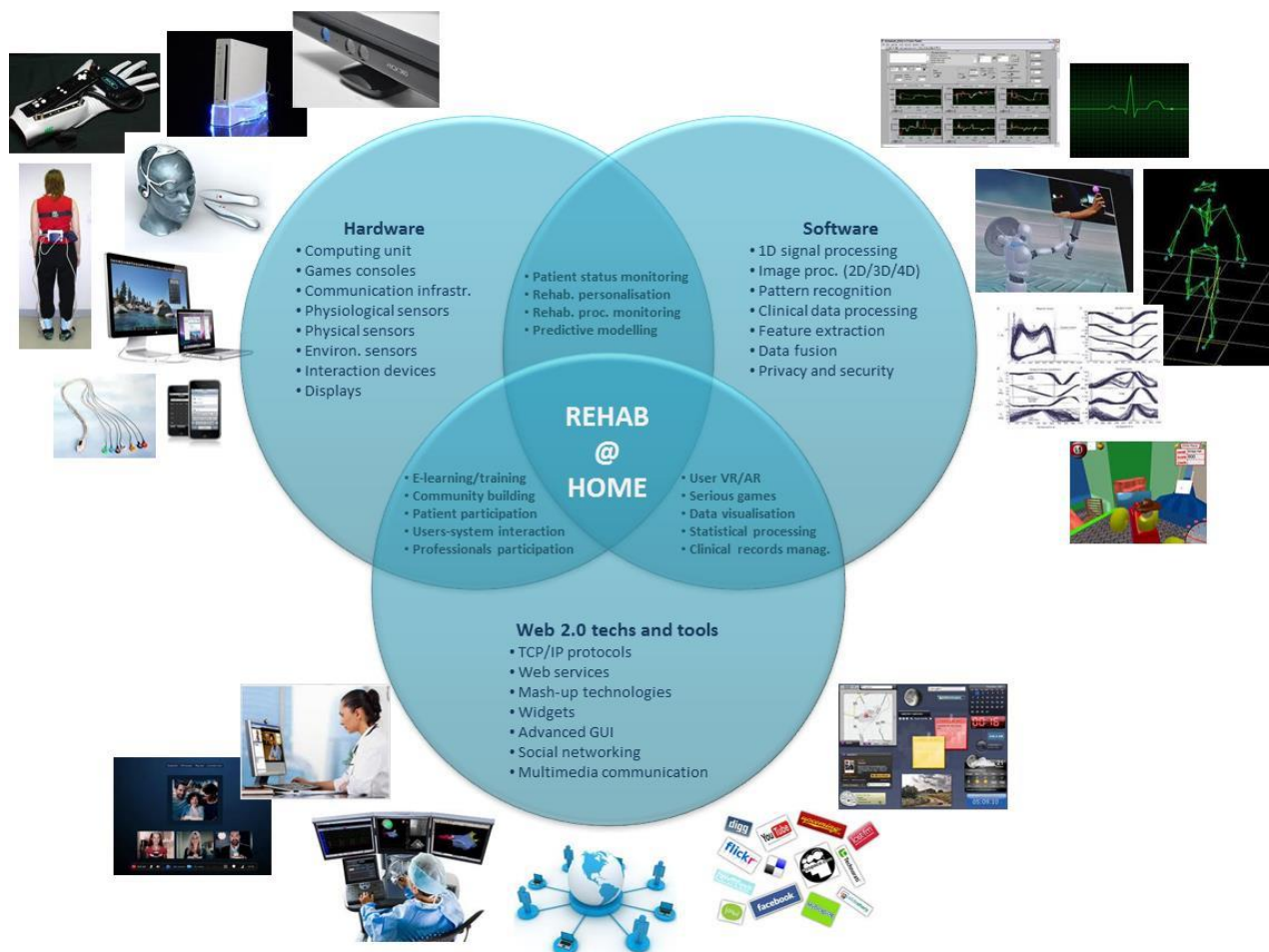


Figure 1: Research and technological dimensions in REHAB@HOME.

## Conclusions

The REHAB@HOME project is focusing specifically on home-based rehabilitation with the aim of developing a complete and advanced hardware/software platform able to overcome the current lack of suitable equipment, thus offering:

- a low-cost and user friendly, though hi-tech, solution that can be exploited at home
- support to long-term rehabilitation programs
- remote monitoring and tutoring by specialized personnel
- involvement of the family members in the rehabilitation process
- integration of the patient into a virtual “rehabilitation social network”
- improvement of the quality of patient’s daily life
- integration of the public healthcare systems with new services that can help reducing costs while improving the quality of life for patients and family members.

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## References

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