EAI Endorsed Transactions
on Ambient Systems

Research Article ICST.ORG

# Designing Intuitive Web Solutions for Monitoring Patients' Rehabilitation at Home

Raihana Ferdous[1,*], Silvia Gabrielli[1], Rosa Maimone[1]

[1] CREATE-NET, Via Alla Cascata 56/D, Trento, ITALY

## Abstract

This paper describes the design of web-based remote monitoring interfaces aimed at supporting therapists and caregivers in supervising motor-cognitive rehabilitation plans of care to be performed by patients at home. This work was part of a three years' research project where game-based environments for upper body motor rehabilitation of post-stroke patients were developed in collaboration with two main rehabilitation centers in Italy and Austria, for a subsequent deployment at patients' homes. The paper will specifically focus on describing the iterative design of the home rehabilitation features for clinicians over the first two years of the project to enable the delivery and monitoring of more personalized, engaging plans of care for home therapy by rehabilitation centers and services.

**Keywords:** Healthcare Technology, Web Interfaces, Tele-Rehabilitation, Plans of care, User-Centered Design.

Received on 10 August 2015, accepted on 10 August 2015, published on 01 December 2015



doi: 10.4108/eai.1-12-2015.150712

## 1. Introduction

Stroke is the second most common cause of death in Europe (EU Cardiovascular Disease statistics 2012) and it affects about 15 million people worldwide each year. Stroke survivors experience a broad range of problems that can impact their cognitive and motor systems, leading to chronic disability (e.g., hemiparesis) more often affecting the upper body (i.e., arms [1]). The goal of rehabilitation is to help survivors become as independent as possible and to attain the best possible quality of life. For over half of stroke patients, rehabilitation will be a long-term process requiring work supervised by therapists, supported by specialized equipment, lasting several months. However, increasing cost pressure on the healthcare system is leading to shorter periods of intensive rehabilitation at specialized facilities. Therefore the adoption of suitable technologies for in home rehabilitation, together with a proper training about the execution of a personalized program of exercises, can help reduce the patient's stay at the hospital, as well as the need and cost of reaching the rehabilitation facilities. In this work, we present the result of a therapist-centered design approach deployed during the REHAB@HOME European project, to develop an intuitive web-based solution for tele-monitoring motor rehabilitation plans of care assigned to patients at home. In section 2 we report recent work on tele-monitoring systems for home rehabilitation relevant to our system. In section 3 we describe the methodology and iterative design process followed to investigate therapists' requirements and test prototypes of the solution developed. In section 4 we report about the features included into the Family Station to provide a view of patient's progress during therapy to their caregivers or family members. We conclude by summarizing the main lessons learnt during this design project and our future steps for validating the solution realized in collaboration with the rehabilitation clinics involved [Fondazione Don Gnocchi Onlus Milan, Italy (FDCGO); Neurologische Therapiezentrum Gmundnerberg, Austria (NTGB)].

*Corresponding author. Email: raihana.ferdous@create-net.org

## 2. Related Work

Tele-technologies have been used in different fields of rehabilitation over the last 15 years. Tele-rehabilitation offers major benefits, particularly in terms of improved communication and access to health care over distance [2]. Increased communication allows information and medical data sharing with consequent advantage for patients, family, caregivers, clinicians, and researchers [3]. In post-stroke motor-cognitive therapy home rehabilitation has a critical role to finalize the potential recovery and to maintain the reached function. The possibility to stay in touch with the rehabilitation centers via tele-systems is relevant for the severe disabilities such as severe traumatic brain injury, chronic condition after stroke, late stage of multiple sclerosis, etc. In these cases the contact from remote with the medical doctor, the nurses, the therapist play an important role to address and solve the problems and decrease the access to the hospital. The contact is useful also to monitor exercises provided by the therapist in order to maintain the recovered function after the end of the intensive rehabilitation programs [4]. Recently, a number of virtual reality rehabilitation platforms have been developed allowing patients, discharged from the hospital, to continue intensive rehabilitation at home under remote monitoring by the hospital itself (e.g., see REWIRE EU project [5]). In the area of game-based orthopedics rehabilitation, the RIABLO platform includes a web application allowing physiotherapists to set up personalized rehabilitation programs for patients and to remotely monitor progress with therapy [6]. Another web platform recently designed to be used by healthcare staff is NeuroAtHome Professional [7].
NeuroAtHome allows rehabilitation clinicians to prescribe personalized exercises, quantify rehabilitation sessions, store all data and track patient evolution in order to provide more effective treatments in an easy and intuitive way, as it was demonstrated in [8]. Inspired by this recent work on web-based systems for tele-rehabilitation, we conducted an iterative design process to identify the required functionalities to support clinicians in using the REHAB@HOME system for home rehabilitation.

## 3. Professional Station Design

### 3.1 Requirements & Mockups

During the first year of the research project we conducted a series of semi-structured interviews with clinicians and rehabilitation therapists at FDCGO and NTGB to understand their needs and preferences in conducting remote monitoring of progress during patients' therapy at

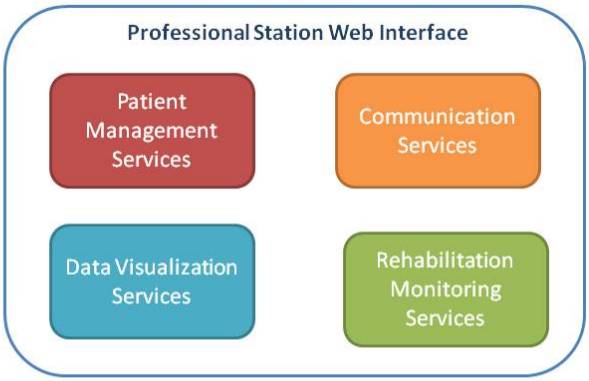


**Fig.1:** The Professional Station main services

home. Overall, ten clinicians were involved in the individual interviews. Their main expertise concerned rehabilitation of patients with motor disabilities (as a consequence of stroke, Multiple Sclerosis, etc.) and mild cognitive impairments. Initial wireframes of the REHAB@HOME Professional Station were developed based on the results of the interviews in order to elicit a more detailed discussion with clinicians on the specific features and information needed. Mockups were developed by using the *JustinMind* Prototyper 5.6 tool and presented back to therapists at FDCGO-NTGB to collect their feedback. The main functionalities prototyped provided the following services (Fig. 1):

- Patient Management
- Rehabilitation Monitoring for progress tracking
- Data Visualization of exercises/games played
- Therapist-Patient Communication

Seven therapists were invited to access the prototype during individual sessions, lasting about 1 hour each, and asked to walkthrough the different features for evaluating their usability and user experience. Audio recording of the therapists' comments during the prototype walkthrough was set for subsequent analysis.

#### 3.1.1 Evaluation Results

Through this initial evaluation round it was possible to identify the main areas of improvement required by our prototype design. Three main lessons were learnt which are summarized below:

a. The design of the procedure and screens to configure a plan of care to be assigned to a patient, had to be refined and made more intuitive to complete. Therapists needed more effective support on deciding which games to assign for therapy, according to the patient's profile, on how to configure their level of difficulty to fit the patient's range of movement and motor-cognitive skills.

b. Some improvements were required by the visual widgets used by the web interface (e.g., icons on calendar feature) in order to better grasp the therapist attention on

relevant changes occurred during therapy and get an overview of patient's progress at a glance.

c. Additional work was needed to improve the graphical representations enabling a therapist to remotely monitoring the progress of patient over rehabilitation sessions at home. Key game and performance parameters had to be identified with therapists and properly visualized through infographics representations.
Based on these results we started a second round of design and prototyping of the Professional Station features (Fig. 2), this time by implementing its frontend in html and javascripts.

## 3.2 Formative Evaluation

The web prototype of the Professional Station was tested in the second year of the project by involving five therapists at FDCGO and NTGB in a second round of collaborative walkthrough of its features. This time therapists had available a more complete working version of the web client to comment on. The therapists involved had 1 to 6 years of work experience in the rehabilitation field. All of them were familiar with gaming platforms like Wii or Kinect, for private use or professional deployment.
Regarding the *Patient Management* features, therapists asked to add the possibility of including notes to a patient's record to keep track of main issues or criticalities that might occur during the rehabilitation program.
Comments on the *Rehabilitation Monitoring* features mainly concerned the need to automatically filtering out rehabilitation games available, based on the type of movement to be performed during a plan of care.

Therapists requested to add a contextual help next to the plan of care configuration options, to facilitate clinicians in understanding the specific parameters to be set at each particular configuration step. As an overall approach to facilitate plans of care configuration it was decided to preset default parameters' values for each of the three difficulty levels of the rehabilitation games provided. This approach allows therapists to go faster through the configuration setting, but at the same time it provides enough flexibility for a therapist to change specific game/exercise parameters that may better fit a patient's skills.

For what concerns the *Data Visualization* features, therapists commented on the level of intuitiveness of the different infographics proposed to represent patient's performance and results over the rehabilitation program. Column, line and area charts were among the favorite representations for therapists to track patient performance over a session or to enable comparison of performance over multiple sessions. Feedback from the therapists interviewed was consistent and converging on the need of visualizing results of the initial calibration phase to measure patient's range of arm movement at the start of each rehabilitation session. They also required to visualizing graphs of total score achieved per game session, for each 5 seconds interval during a game session, as well as bio-graphs of heart-rate variation over a game session (to detect any risk or criticality for patients suffering cardiovascular comorbidities). In order to track patient performance comparison over different sessions, therapists expressed their interest for comparing scores achieved by patient over sessions together with the

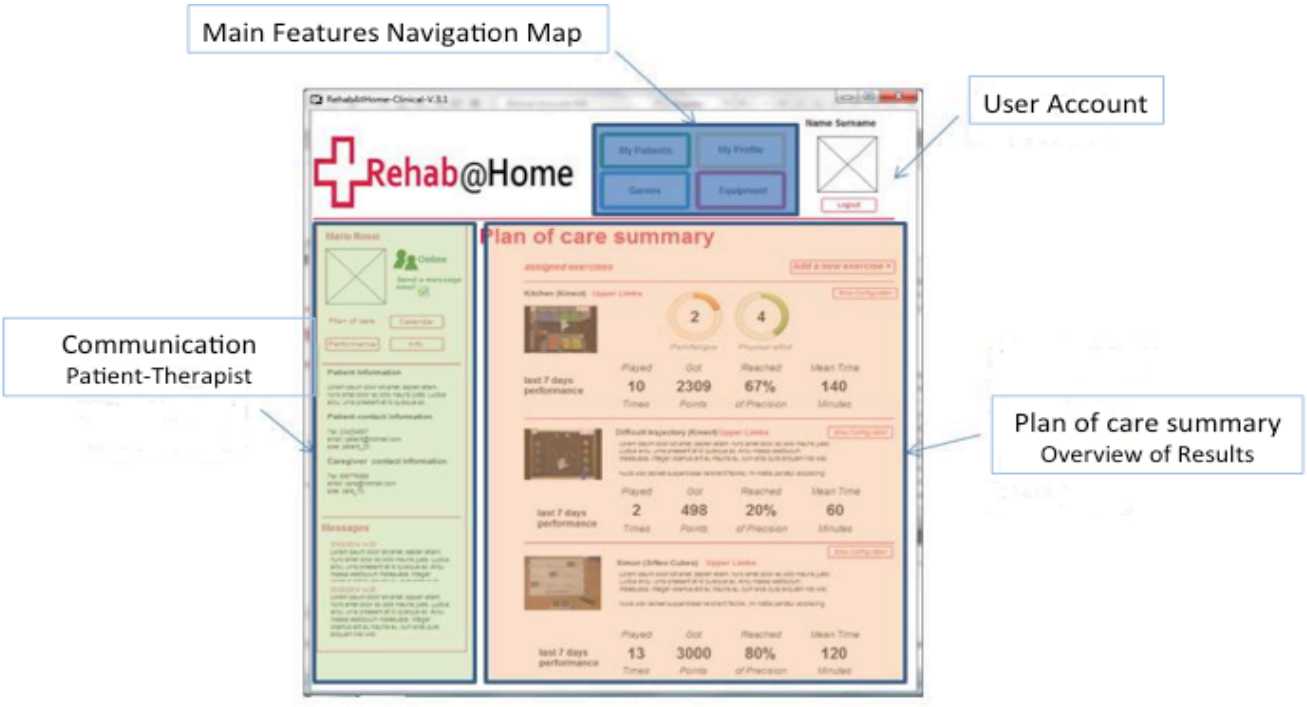


**Figure 2:** Overview of the Professional Station main features

indication of the level of difficulty experienced during the game played, as well as the possibility of changing the time interval of the data visualized (e.g., last 3 sessions played, 1 week, 1 month, etc.).

Therapists appreciated the improvements made to the visual widgets of the calendar feature, displaying an overview of the games assigned, completed, missed or performed only partially by a patient over the rehabilitation plan. They asked also to have the chance of adding notes to the calendar as possible reminders of specific issues with a patient and her assigned plan of care.
Concerning the *Communication* features enabled by the Professional station, therapists appreciated the chance to receiving preset notifications from patients (e.g., alerting about problems with playing the games, pain experienced, etc.) as well as the possibility of editing text messages to be sent to the Patient Station and displayed before the start of each rehabilitation session (e.g., ensuring a correct execution of limb movements without compensation).
For facilitating the adoption of the REHAB@HOME solution by clinics and therapists we also added to the Professional Station a *Games and Equipment Catalogs* area. This is intended to provide videos and guidelines regarding the set up and use of the Kinect, LeapMotion devices and games to be used by the patient for the therapy at home. All therapists found useful to be provided with such catalogs in case more detailed explanations and support was needed to use the REHAB@HOME solution for assigning plans of care or providing help to patients.

## 4. The Family Station

During the user research phase of the project we also realized the importance of addressing the needs of caregivers and family members as relevant stakeholders of the REHAB@HOME solution, whose role over therapy and requirements had to be investigated for accomplishing a successful system design. We conducted individual interviews with some representatives of this stakeholders' group during the requirements collection and pilot evaluations of REHAB@HOME patient and professional stations.
Results of these interviews showed that about half of our patients were supported by a caregiver or family member during the rehabilitation program. Very often the caregiver was playing a key role in sustaining motivation of the patient over the therapy, by helping to overcome initial difficulties and raising patient's compliance with the plan of care assigned.
Both therapists and the caregivers' groups involved in the study expressed their interest for being provided with a dedicated web tool enabling caregivers to track and support progress of patient therapy at home, although with a less detailed data view with respect to the tracking features provided to clinicians.

order to fulfill this requirement we developed a web-based Family Station providing an adapted subset of the features included in the Professional Station. By accessing the Family Station a caregiver can only access the data of the patient s/he is assisting for a rehabilitation therapy. Regarding the *Data Visualization* features, a caregiver is provided with a general view of the scores achieved by the assisted patient over the rehabilitation games played. S/he is also provided with the calendar view of the plan of care assigned to the patient, in order to easily identify if the patient is on track or s/he is missing or having problems in following the rehabilitation plan assigned.
With respect to the *Communication* features, the caregiver is provided with a view of the messages exchanged between the assisted patient and her therapists, to be informed and aligned with any criticality occurred.
Finally, the Family Station provides access to the *Games and Equipment Catalogs,* to provide instructional materials that could help the caregiver to help in the setup and usage of the REHAB@HOME solution in home environments. This material could also turn useful in order to offload clinics and therapists from the need of providing technical support to patients during the initial phase of usage of the game-based rehabilitation solution at home.

## 5. Conclusion and Future Work

The user research and iterative design process followed in the first two years of the project allowed us to better understand the needs and preferences of clinicians and caregivers in supporting the remote monitoring of rehabilitation programs performed by patients with motor-cognitive impairments at home.
A main lesson learnt over this project was that clinicians need to be provided with very intuitive and familiar interfaces enabling them to remotely supervise more patients exercising at home, and to quickly identify criticalities when they occur in order to properly intervene and provide support.
Therapists require functionalities that are easy to learn and similar to other digital tools used by their clinics (e.g., patient management systems), allowing a flexible adaptation of plan of cares to the specific rehabilitation needs of their patients. By conducting our design work in close collaboration with therapists we were able to realize a plan of care configuration process for game-based rehabilitation at home that was fast to setup by the user, but at the same time open to adaptation to a wide range of patient specific requirements. We were able to realize data visualization screens and representations enabling therapists to easily assess the level of patient progress over therapy and to make comparisons on patient performance between multiple sessions.
A main challenge to address in order to increase clinicians' acceptance and adoption of innovative rehabilitation solutions is to design systems that are easy to integrate into the preexisting care practices and that do

not overload therapists with additional tasks and information to which dedicating their attention. In the case of home rehabilitation, a therapist needs to be facilitated in supervising more patients at the same time, thus saving time/effort in her daily rehabilitation sessions at the clinic, by ensuring the provision of a good quality of service without creating excessive expectations on the patient side (e.g., request for synchronous communication and support during home therapy sessions). We addressed this challenge by enabling asynchronous communication exchanges between patient and clinician over therapy that are functional to the typical problems occurring during long-term rehabilitation programs, without requiring too much effort and attention resources from the clinic staff.

By means of the Family Station provided we involved additional support from caregivers and family members in the rehabilitation service loop. Caregivers can be key resources for providing psychological and motivational support to patients at home, in order to raise compliance with the rehabilitation therapy. If provided with adequate tools and views on patient's progress, caregivers can actively support the rehabilitation program and help patients to overcome technical issues or fear of new technological solutions.

The iterative design process described in this paper has led to the realization and full implementation of the REHAB@HOME platform during the third year of the project. The complete rehabilitation solution is now ready for testing in realistic home settings in collaboration with our partner clinics.

A longitudinal trial of the REHAB@HOME solution will be carried out in June and July 2015 in Italy and Austria by involving 20 patients enrolled in post-stroke, Multiple Sclerosis rehabilitation programs, together with their therapists and caregivers.

Patients will be asked to familiarize with the new rehabilitation solution at the clinic initially, and then their therapists will configure personalized plans of care to be assigned and supervised by using the Professional and Family Stations, by covering 12 consecutive home therapy sessions at home (lasting approximately a period of one month of usage).

The trial is aimed to assess the benefits provided by the REHAB@HOME solution in terms of functional improvement of patients in their upper body motor-cognitive skills, but also to test the usability, quality of user experience and motivation of users (patients, therapists, caregivers) in adopting the new rehabilitation solution over an extended period of time and within a realistic usage setting.

We expect that the results of this investigation will help to extend and verify the indications provided by our stakeholders during the design phases of our project.

This knowledge will enable us to further refine our solution so as to make the REHAB@HOME platform an effective and innovative tool to be used by clinics and their staff to better manage the remote delivery of rehabilitation services which are engaging for patients to use as well as cost effective to adopt by the healthcare system.

## 6. Acknowledgments

This work has been supported by the FP7 STREP Project REHAB@HOME N. 306113.

## 7. References

[1] Dobkin, B.H. (2005), Rehabilitation after Stroke. N Engl J Med, 352. 1677-1684 April 21, DOI: 10.1056/NEJMcp043511

[2] Torsney K. (2003), Advantages and disadvantages of tele-rehabilitation for persons with neurological disabilities. NeuroRehabilitation 2003;18:183-5

[3] Burns RB, Crislip D, Daviou P, Temkin A, Vesmarovich S, Anshutz J, Furbish C, Jones ML (1998). Using tele-rehabilitation to support assistive technology. Assist Technol 1998;10:126-33.

[4] M. Zampolini, E. Todeschini, M. B. Guitart, H. Hermens, S. Ilsbroukx, V. Macellari, R. Magni, M. Rogante, S. S. Marchese, M. Vollenbroek, and C. Giacomozzi, (2008). Tele-rehabilitation: present and future. Ann Ist Super Sanita, vol. 44,no. 2, pp. 125–134, 2008.

[5] REWIRE Project: http://www.rewire-project.eu

[6] Costa C. et al. (2013), Riablo: A game system for supporting orthopedic rehabilitation, in Biannual Conference of the Italian Chapter of SIGCHI, 2013, pp. 11:1–11:7.

[7] NeuroatHome: http://www.neuroathome.net/p/home.html

[8] Larson, E.B., Feigon, M., Gagliardo, P., Assaf Y. Dvorkin A. (2014). Virtual reality and cognitive rehabilitation: A review of current outcome research. NeuroRehabilitation, May 2014.