Telemonitoring and Home Support in BackHome

Felip Miralles, Eloisa Vargiu, Stefan Dauwalder, Marc Solà,
Juan Manuel Fernández, Eloi Casals and José Alejandro Cordero

Barcelona Digital Technology Center,
{fmiralles, evargiu, sdauwalder, msola,
jmfernandez, ecasals, jacordero}@bdigital.org

Abstract. People going back to home after a discharge needs to come back to their normal life. Unfortunately, it becomes very difficult for people with severe disabilities, such as a traumatic brain injury. Thus, this kind of users needs, from the one hand, a telemonitoring system that allows therapists and caregivers to be aware about their status and, from the other hand, home support to be helped in performing their daily activities. In this paper, we present the telemonitoring and home support system developed within the BackHome project. The system relies on sensors to gather all the information coming from user's home. This information is used to keep informed the therapist through a suitable web application, namely Therapist Station, and to automatically assess quality of life as well as to provide context-awareness. Preliminary results in recognizing activities and in assessing quality of life are presented.

1 Introduction

Telemonitoring makes possible to remotely assess health status and Quality of Life (QoL) of individuals. In particular, telemonitoring users' activities allows therapists and caregivers to become aware of user context by acquiring heterogeneous data coming from sensors and other sources. Moreover, Telemonitoring and Home Support Systems (TMHSSs) provide elaborated and smart knowledge to clinicians, therapists, carers, families, and the patients themselves by inferring user behavior. Thus, there are a number of advantages in telemonitoring and home support for both the person living with a disability and the health care provider. In fact, TMHSSs enable the health care provider to get feedback on monitored people and their health status parameters. Hence, a measure of QoL and the level of disability and dependence is provided. TMHSSs provide a wide range of services which enable patients to transition more smoothly into the home environment and be maintained for longer at home [5]. TMHSSs, as an integrated care technology, facilitate services which are convenient for patients, avoiding travel whilst supporting participation in basic healthcare, TMHSS can be a cost effective intervention which promotes personal empowerment [14].
In this paper, we present a sensor-based TMHSS, currently under development in the EU project BackHome[1]. The proposed system is aimed at supporting end users which employ Brain Computer Interface (BCI) as an Assistive Technology (AT) and relies on intelligent techniques to provide both physical and social support in order to improve QoL of people with disabilities. In particular, we are

[1] http://www.backhome-fp7.eu/backhome/index.php

interested in monitoring mobility activities; the main goal being to automatically assess QoL of people. The implemented system is aimed at automatically assessing QoL as well as providing context-awareness. Moreover, the system gives a support to therapist through a suitable Therapist Station. In this way, therapists are constantly aware about the progress of users, their status and the activities they have been performing. Although we are interested in assisting disabling people, by now we only performed preliminary experiments with a healthy user. We are now in the process to install the system in disabled people's homes under the umbrella of the BackHome project[2].

The rest of the paper is organized as follows: Section 2 briefly recall relevant work in the field of telemonitoring and home support. In Section 3 the BackHome project and its main goals are summarized. Section 4 presents the implemented sensors-based approach whereas Section 5 illustrates the Therapist Station. In Section 6 preliminary experiments aimed at monitoring daily activities and assessing QoL are presented. Finally, Section 7 ends the papers with conclusions and future work.

2 Telemonitoring and Home Support

Telemonitoring systems have been successful adopted in cardiovascular, hematologic, respiratory, neurologic, metabolic, and urologic domains [14]. In fact, some of the more common features that telemonitoring devices keep track of include blood pressure, heart rate, weight, blood glucose, and hemoglobin. Telemonitoring is capable of providing information about any vital signs, as long as the patient has the necessary monitoring equipment at her/his location. In principle, a patient could have several monitoring devices at home. Clinical-care patients' physiologic data can be accessed remotely through the Internet and handled computers [18]. Depending on the severity of the patient's condition, the health care provider may check these statistics on a daily or weekly basis to determine the best course of treatment. In addition to objective technological monitoring, most telemonitoring systems include subjective questioning regarding the patient's health and comfort [13]. This questioning can take place automatically over the phone, or telemonitoring software can help keep the patient in touch with the health care provider. The health care provider can then make decisions about the patient's treatment based on a combination of subjective and objective information similar to what would be revealed during an on-site appointment.

Home sensor technology may create a new opportunity to reduce costs. In fact, it may help people stay healthy and in their homes longer. An interest has therefore emerged in using home sensors for health promotion [11]. One way to do this is by TMHSSs, which are aimed at remotely monitoring patients who are not located in the same place of the health care provider. Those supports allow patients to be maintained in their home [5]. Better follow-up of patients is a convenient way for patients to avoid travel and to perform some of the more basic work of healthcare for themselves, thus reducing the corresponding overall costs [1] [23]. Summarizing, a TMHSS allows: to improve the quality of clinical services, by facilitating the access to them, helping to break geographical barriers; to keep the objective in the assistance centred in the patient, facilitating the communication

[2] http://www.backhome-fp7.eu/

between different clinical levels; to extend the therapeutic processes beyond the hospital, like patient's home; and a saving for unnecessary costs and a better costs/benefits ratio.

In the literature, several TMHSSs have been proposed. Among others, let us recall here the works proposed in [2], [4], and [16]. The system proposed in [2] provides users personalized health care services through ambient intelligence. That system is responsible of collecting relevant information about the environment. An enhancement of the monitoring capabilities is achieved by adding portable measurement devices worn by the user thus vital data is also collected out of the house. Similarly, the TMHSS presented in this paper uses ambient intelligence to personalize the system according to the specific context [3]. Corchado et al. [4] propose a TMHSS aimed at improving healthcare and assistance to dependent people at their homes. That system is based on a SOA model for integrating heterogeneous wearable sensor networks into ambient intelligence systems. The adopted model provides a flexible distribution of resources and facilitates the inclusion of new functionalities in highly dynamic environments. Sensor networks provide an infrastructure capable of supporting the distributed communication needed in the dependency scenario, increasing mobility, flexibility, and efficiency, since resources can be accessed regardless their physical location. Biomedical sensors allow the system to acquire continuously data about the vital signs of the patient. Apart from the BCI system, the TMHSS presented in this paper, does not rely on biomedical sensors. All physiological information is, in fact, provided by the BCI system (i.e., EEG, ECG and EOG signals). Mitchell et al. [16] propose ContextProvider, a framework that offers a unified, query-able interface to contextual data on the device. In particular, it offers interactive user feedback, self-adaptive sensor polling, and minimal reliance on third-party infrastructure.

As for BCI users, some work has been presented to provide smart home control [10] [19] [7] [8]. To our best knowledge, telemonitoring has not been integrated yet with BCI systems apart as a way to allow remote communication between therapists and users [17].

3 BackHome at a Glance

BackHome focuses on restoring independence to people that are affected by motor impairment due to acquired brain injury or disease, with the overall aim of preventing exclusion [6]. In fact, BackHome aims to provide brain-controlled assistive technology, which can be used in the context of social reintegration, rehabilitation and maintenance of remaining capabilities of people with disabilities. Thus, BackHome aims to implement easy-to-set-up-and-use software which requires minimal equipment based on a new generation of practical electrodes. On one hand, the produced software is aimed at making BCI usable for disabled people, with a potentially flexible and extensible inclusion schedule. On the other hand, thanks to the telemonitoring and home support features, the objective system should benefit of detection of user's activity and behaviour to adapt interfaces and trigger support actions. In order to keep the user engaged, BackHome continuously provides feedback to therapist for the follow-up and for personalization and adaptation of rehabilitation plans, for instance.

The BackHome system relies on two stations: (i) the therapist station and (ii) the user station. The former is focused on offering information and services to the therapists via a usable and intuitive user interface. It is a Web application that allows the therapist to access the information of the user independently of the platform and the device. This flexibility is important in order to get the maximum potential out of the telemonitoring because the therapist can be informed at any moment with any device that is connected to the Internet (PC, a smart phone or a tablet). The latter is the main component that the user interacts with. It contains the modules responsible for the user interface, the intelligence of the system, as well as to provide all the services and functionalities of BackHome [12]. The user station is completely integrated into the home of the user together with the assistive technology to enable execution and control of these functionalities.

4 The Sensor-based Approach

To monitor users at home, we develop a sensor-based TMHSS able to monitor the evolution of the user's daily life activity [22]. The implemented TMHSS is able to monitor indoor activities by relying on a set of home automation sensors and outdoor activities by relying on Moves[3].

As for indoor activities, we use presence sensors, to identify the room where the user is located (one sensor for each monitored room) as well as temperature, luminosity, humidity of the corresponding room; a door sensor, to detect when the user enters or exits the premises; electrical power meters and switches, to control leisure activities (e.g., television and pc); and pressure sensors (i.e., bed and seat sensors) to measure the time spent in bed (wheelchair). Figure 1 shows an example of a home with the proposed sensor-based system.

From a technological point of view, we use wireless z-wave sensors that send the retrieved data to a central unit located at user's home. That central unit collects all the retrieved data and sends them to the cloud where they will be processed, mined, and analyzed. Besides real sensors, the system also comprises "virtual devices". Virtual devices are software elements that mash together information from two or more sensors in order to make some inference and provide new information. For instance, sleep hours may be inferred by a virtual device that meshes the information from the bed sensors together with that from the presence sensor located in the bedroom. Let us consider the case in which the user is in bed reading. In that case, the luminosity level measured by the presence sensor assesses that the user is not sleeping, yet, even if the bed sensor is activated. In so doing, the TMHSS is able to perform more actions and to be more adaptable to the context and the user's habits. Furthermore, the mesh of information coming from different sensors can provide useful information to the therapist (e.g., the number of sleeping- or inactivity-hours). In other words, the aim of a virtual device is to provide useful information to track the activities and habits of the user, to send them back to the therapist through the therapist station, and to adapt the user station, with particular reference to its user interface, accordingly.

As for outdoor activities, we are currently using the user's smartphone as a sensor by relying on Moves, an app for smartphones able to recognize physical activities (such as walking, running, and cycling) and movements by transportation. Moves is also able to store information about the location in which the user is, as well as the corresponding performed route(s). Moves provides an API through which is possible to access all the collected data.

[3] http://www.moves-app.com/

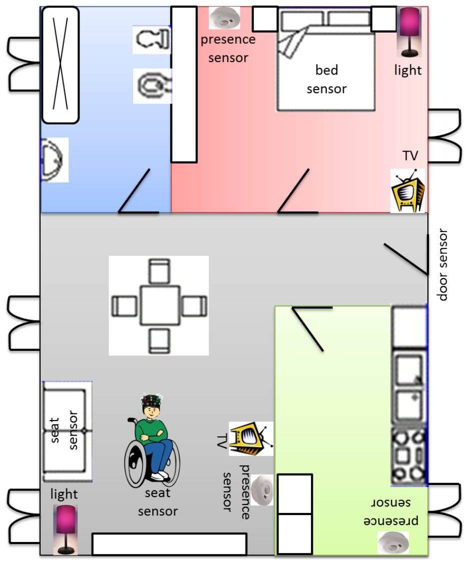

Fig. 1. An example of a home with the sensor-based system installed.

Information gathered by the TMHSS is also used to provide context-awareness by relying on ambient intelligence [3]. In fact, ambient intelligence is essential since people with severe disabilities could benefit very much from the inclusion of pervasive and context-aware technologies. In particular, thanks to the adopted sensors we provide adaptation, personalization, alarm triggering, and control over environment through a rule-based approach that relies on a suitable language [9].

Finally, monitoring users' activities through the TMHSS gives us also the possibility to automatically assess QoL of people [21]. In fact, information gathered by the sensors is used as classification features to build a multi-class supervised classifier; one for each user and for each item of the questionnaire we are interested answer to. In particular, the following features are considered: (i) time spent on bed and (ii) maximum number of continuous hours in bed, extracted from the bed sensor; (iii) time spent on the wheelchair and (iv) maximum number of continuous hours on the wheelchair, extracted from the seat sensor; (v) time spent in each room and (vi) percentage of time in each room, extracted from the presence sensor; (vii) room in which the user spent most of the time, inferred by the virtual device; (viii) total time spent at home, extracted from the door sensor; (ix) total time spent watching the TV and (x) total time spent using the PC, extracted from the corresponding power meters and switches; (xi) number of kilometres covered by transportation, (xii) number of kilometres covered by moving outdoors on the wheelchair and (xiii) number of visited places, provided by Moves. Let us note that more features can be considered depending on the adopted sensors.

5 The Therapist Station

The therapist station is a web application that provides functionality for clinicians/therapists regarding user management, cognitive rehabilitation task management, quality-of-life assessment, as well as communication between therapist and user.
Therapists are able to interact with users remotely in real time or asynchronously and monitor the use and outcomes of the cognitive rehabilitation tasks, quality-of-life assessment as well as performed activities and BCI usage. In fact, the ability for the therapist to plan, schedule, telemonitor and personalize the prescription of cognitive rehabilitation tasks and quality-of-life questionnaires using the therapist station facilitates that the user performs those tasks inside his therapeutic range (i.e. motivating and supporting her progress), in order to help to attain beneficial therapeutic results.

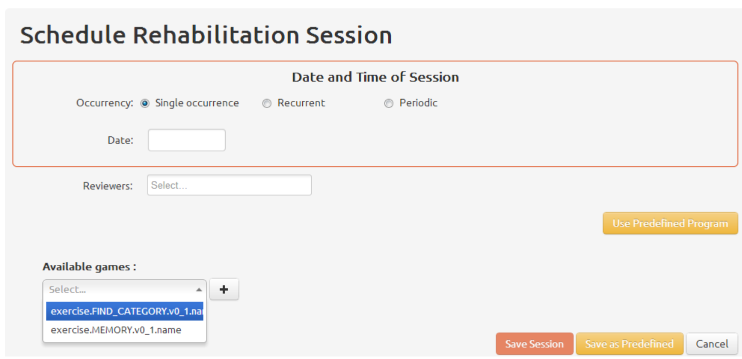

Fig. 2. Scheduling cognitive rehabilitation tasks.

As for the cognitive rehabilitation sessions, using the therapist station, healthcare professionals can remotely manage a caseload of people recently discharged from acute sector care. They can prescribe and review rehabilitation sessions (see Figure 2) [20]. Through the therapist station, rehabilitation sessions can be configured, setting the type of tasks that the user will execute, their order in the session and the difficulty level and specific parameters for each one of them. Additionally, the therapist station allows healthcare professionals to establish an occurrence pattern for the session along the time. If the same session must be executed several times, professionals can set the type of occurrence and its pattern to make the session occur at programmed times in the future. Once the session is scheduled, users will see their BCI matrix updated on the user station the day the session is scheduled. Through that icon, the user will start the session. The user can then execute all the tasks contained in it in consecutive order. Upon completion of the session execution on user station, results are sent back to the therapist station for review. At this point, those healthcare professionals involved in the session -the prescriber and the specified reviewers– will be notified with an alert in the therapist station dashboard indicating that the user has completed the session. Healthcare professionals with the right credentials can browse user session results once they are received. The Therapist Station provides a session results view and an overview of completed sessions to map progress, which shows session parameters and statistics along the specific results (see Figure 3).

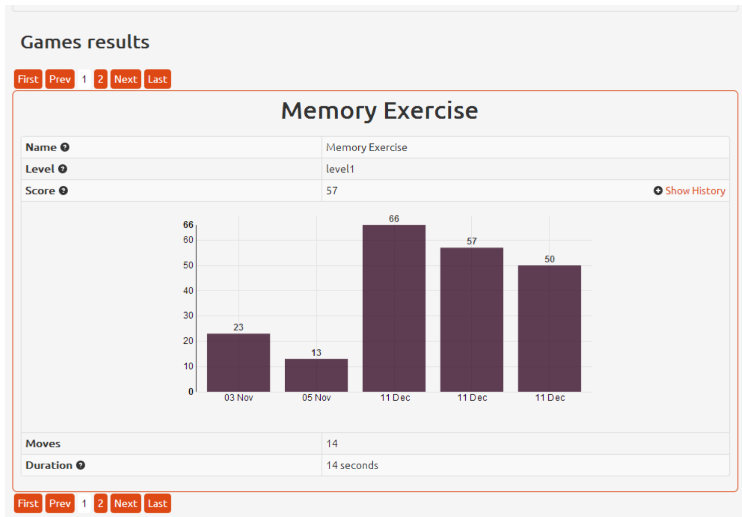

Fig. 3. Task results of the memory-cards task.

As for the quality-of-life assessment, as described in the previous session, one of the goal of the TMHSS is to automatically assess QoL of the users. Accordingly, results and statistics are sent to the therapist station in order to inform the therapist about improvement/worsening of user's QoL. Moreover, the therapist may directly ask the user to fill a questionnaire (Figure 4). Seemly than cognitive rehabilitation sessions, the therapist can decide the occurrence of quality-of-life questionnaire filling and, once scheduled, the user receives an update in the BCI matrix. Once the user, with the help of the caregiver, has filled the questionnaire, results are sent to the therapist that may revise them.
Finally, through the Therapist Station, therapists may consult a summary of activities performed at home by the user; e.g., visited rooms, sleeping hours and time elapsed at home. Moreover, also the BCI usage is monitored and high-level statistics provided. This information includes BCI session duration, setup time and training time as well as the number of selections, the average elapsed time per selection and a breakdown of the status of the session selections. Therapists have also the ability to browse the full list of selections executed by a user, such as context information as application running, selected value, grid size and selected position.

6 Experiments and Results

The system is currently running in a healthy user's home in Barcelona. The corresponding user is a 40-year-old woman who lives alone. This installation is cur-

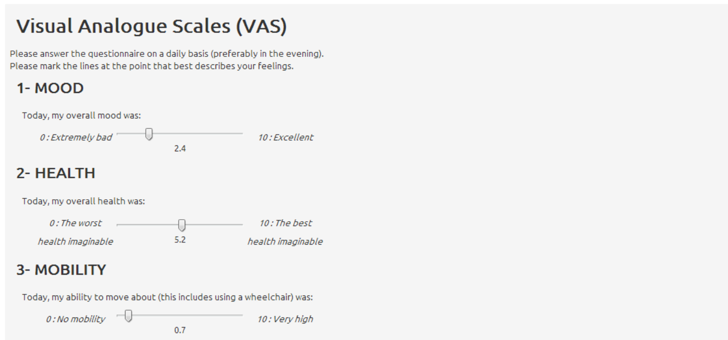

Fig. 4. The first three questions of the adopted quality-of-life questionnaire.

rently available and data continuously collected. According to the home plan, the following sensors have been installed: 1 door sensor; 3 presence sensors (1 living room, 1 bedroom, 1 kitchen); 3 switch and power meters (1 PC, 1 Nintendo WII, 1 kettle); and 1 bed sensor. Moreover, the user has installed in her iPhone the Moves app.

A useful interface allows technicians to remotely view, manage and/or change the configuration of the system and to have a view of the collected data, when needed (see Figure 5).

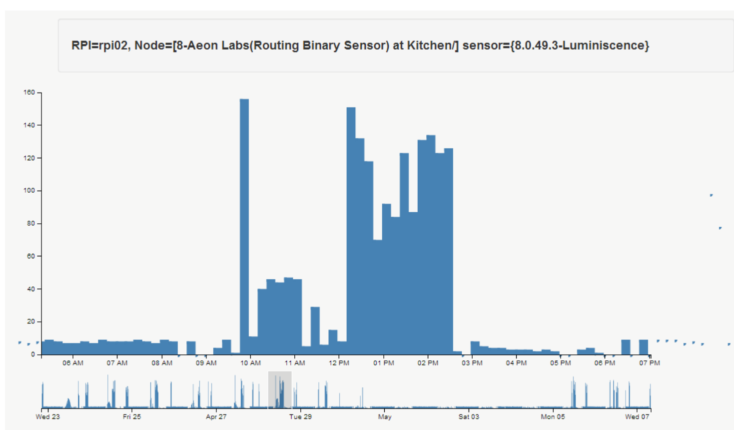

Fig. 5. Status of luminescence of a given sensor.

Collected data have been used to recognize habits as well as to a preliminary study aimed at assessing QoL.

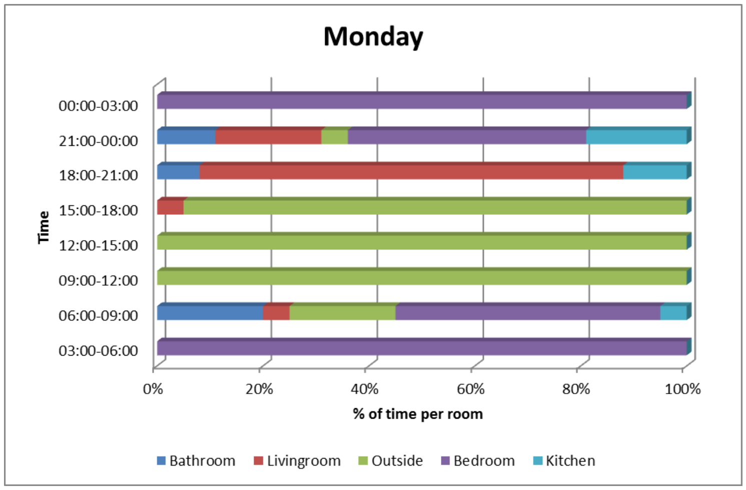

Fig. 6. User's habits: full-time workday.

6.1 Activity Recognition

To recognize user's habits, we performed a preliminary experiment considering indoor habits and relying on presence sensors (one for each monitored room) and the main door sensor (to know when the user enters or leaves the premises). We collected data from one month (November '13 – December '13) and we considered time slot of 3 hours. Our preliminary results show that we can note three different habits depending on the kind of the day: workday, part-time workday and weekend. Results show that it is possible to note changes in the habits of the user depending on the day of the week. In particular, it could be noted the hours in which the user is at home and the room(s) in which passes the majority of the time. Figure 6 and Figure 7 show an example of recognized habits for a full-time (i.e., Monday) and a part-time workday (i.e., Friday), respectively.

6.2 Quality of Life Assessment

As already said, data collected by the TMHSS will be also used to automatically assess QoL of people. Let us summarize here our prelilminary results obtained to assess the movement ability of the given user. The interested reader may refer to [15] for a more deep explanation of the approach.
To assess movement ability, we considered a window of three months (February '14 – April '14) and made comparisons of results for three classifiers: decision tree, k-nn with k=1, and k-nn with k=3. During all the period, the user answered to the question "Today, how was your ability to move about?", daily at 7 PM. Answers have been then used to label the item of the dataset to train and test the classifiers built to verify the feasibility of the proposed QoL approach. Given a category, we consider as true positive (true negative), any entry evaluated as positive (negative) by the classifier that corresponds to an entry labeled by the user as belonging (not belonging) to that class. Seemly, we consider as false positive (false negative), any entry evaluated as positive (negative) by the classifier

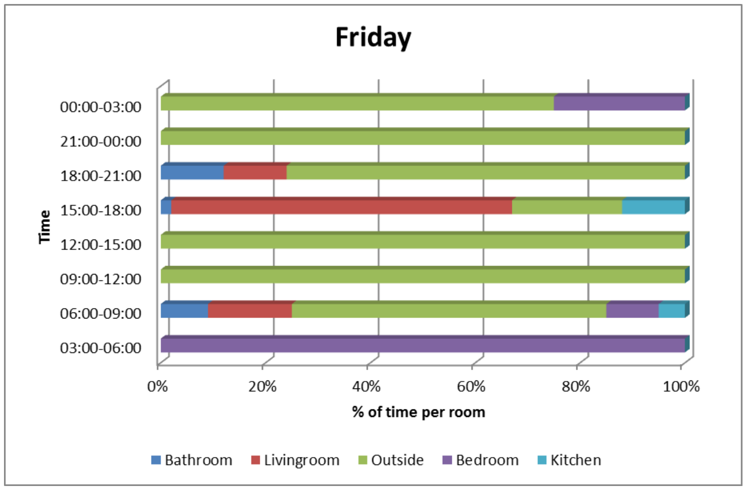

Fig. 7. User's habits: part-time workday.

that corresponds to an entry labeled by the user as not belonging (belonging) to that class. Results have been then calculated in terms of precision, recall, and F_1 measure.
Let us stress the fact that in this preliminary experimental phase, we are considering data coming from a healthy-user. Thus, while analyzing data, the following issues must be considered: tests have been performed with only one user; the user is healthy; and a window of less than 4 months of data has been considered. As a consequence, results can be used and analyzed only as a proof of concept of the feasibility of the approach.
The best results have been obtained using the decision tree. In fact, in that case, on average we calculated a precision of 0.64, a recall of 0.69 and a F_1 of 0.66. It is worth noting that, as expected (the user is healthy and not have difficulty in movements), the best results are given in recognizing "Normal" mobility. In fact, in this case we obtained a precision of 0.80, a recall of 0.89 and an F_1 measure of 0.84.

7 Conclusions and Future Work

Telemonitoring and home support systems help people with severe disabilities as well as their therapists and caregivers. In fact, users may take advantage of telemonitoring and home support to easily come back to their normal life. Moreover, therapists and caregivers can be aware of users' activities providing them support in case of emergencies. For all those reasons, in BackHome a telemonitoring and home support system has been developed. The system consists of a set of sensors installed at user' home as well as of a web application that allows therapist to monitor user' status and activities. Currently, the system is installed in a healthy user's home in Barcelona. Preliminary results show that the system is able to collect and analyse data useful to learn user's habits and it looks promising to assess quality of life.

The next step consists of installing the overall system under the umbrella of BackHome project. In fact, we are currently setting up the proposed telemonitoring and home support system at BackHome real end-users' homes at the facilities of Cedar Foundation[4] in Belfast. Such installation is scheduled in November 2014. As for future work, starting from data coming from the real end-users, users' daily activities will be deeply monitored, alarms sent back to therapists, and further actions performed to provide home support and context-awareness. Moreover, experiments will be performed to assess quality of life of people, not only "Mobility" but other ambitious items such as "'Mood".

Acknowledgments

The research leading to these results has received funding from the European Communitys, Seventh Framework Programme FP7/2007-2013, BackHome project grant agreement n. 288566.

References

1. Artinian, N.: Effects of home telemonitoring and community-based monitoring on blood pressure control in urban African Americans: A pilot study. Heart Lung 30, 191–199 (2001)
2. Carneiro, D., Costa, R., Novais, P., Machado, J., Neves, J.: Simulating and monitoring ambient assisted living. In: Proc. ESM (2008)
3. Casals, E., Cordero, J.A., Dauwalder, S., Fernández, J.M., Solà, M., Vargiu, E., Miralles, F.: Ambient intelligence by atml: Rules in backhome. In: Emerging ideas on Information Filtering and Retrieval. DART 2013: Revised and Invited Papers; C. Lai, A. Giuliani and G. Semeraro (eds.) (2014)
4. Corchado, J., Bajo, J., Tapia, D., Abraham, A.: Using heterogeneous wireless sensor networks in a telemonitoring system for healthcare. IEEE Transactions on Information Technology in Biomedicine 14(2), 234–240 (2010)
5. Cordisco, M., Benjaminovitz, A., Hammond, K., Mancini, D.: Use of telemonitoring to decrease the rate of hospitalization in patients with severe congestive heart failure. Am J Cardiol 84(7), 860–862 (1999)
6. Daly, J., Armstrong, E., Miralles, F., Vargiu, E., Müller-Putz, G., Hintermller, C., Guger, C., Kuebler, A., Martin, S.: Backhome: Brain-neural-computer interfaces on track to home. In: RAatE 2012 - Recent Advances in Assistive Technology & Engineering (2012)
7. Edlinger, G., Holzner, C., Guger, C.: A hybrid brain-computer interface for smart home control. In: Proceedings of the 14th international conference on Human-computer interaction: interaction techniques and environments - Volume Part II. pp. 417–425. HCII'11, Springer-Verlag, Berlin, Heidelberg (2011)
8. Fernández, J.M., Dauwalder, S., Torrellas, S., Faller, J., Scherer, R., Omedas, P., Verschure, P., Espinosa, A., Guger, C., Carmichael, C., Costa, U., Opisso, E., Tormos, J., Miralles, F.: Connecting the disabled to their physical and social world: The BrainAble experience. In: TOBI Workshop IV Practical Brain-Computer Interfaces for End-Users: Progress and Challenges (2013)

[4] http://www.cedar-foundation.org/

9. Fernández, J.M., Torrellas, S., Dauwalder, S., Solà, M., Vargui, E., Miralles, F.: Ambient-intelligence trigger markup language: A new approach to ambient intelligence rule definition. In: 13th Conference of the Italian Association for Artificial Intelligence (AI*IA 2013). CEUR Workshop Proceedings, Vol. 1109 (2013)
10. Holzner, C., Schaffelhofer, S., Guger, C., Groenegress, C., Edlinger, G., Slater, M.: Using a p300 brain-computer interface for smart home control. In: World Congress 2009 (2009)
11. Intille, S.S., Kaushik, P., Rockinson, R.: Deploying Context-Aware Health Technology at Home: Human-Centric Challenges. Human-Centric Interfaces for Ambient Intelligence (2009)
12. Käthner, I., Daly, J., Halder, S., Räderscheidt, J., Armstrong, E., Dauwalder, S., Hintermüller, C., Espinosa, A., Vargiu, E., Pinegger, A., Faller, J., Wriessnegger, S., Miralles, F., Lowish, H., Markey, D., Müller-Putz, G., Martin, S., Kübler, A.: A p300 bci for e-inclusion, cognitive rehabilitation and smart home control. In: Graz BCI Conference 2014 (2014)
13. Martń-Lesende, I., Orruño, E., Cairo, C., Bilbao, A., Asua, J., Romo, M., Vergara, I., Bayn, J., Abad, R., Reviriego, E., Larrañaga, J.: Assessment of a primary care-based telemonitoring intervention for home care patients with heart failure and chronic lung disease. The TELBIL study. BMC Health Services Research 11(56) (2011)
14. Meystre, S.: The current state of telemonitoring: a comment on the literature. Telemed J E Health 11(1), 63–69 (2005)
15. Miralles, F., Vargiu, E., Casals, E., Cordero, J., Dauwalder, S.: Today, how was your ability to move about? In: 3rd International Workshop on Artificial Intelligence and Assistive Medicine, ECAI 2014 (2014)
16. Mitchell, M., Meyers, C., Wang, A., Tyson, G.: Contextprovider: Context awareness for medical monitoring applications. In: Conf Proc IEEE Eng Med Biol Soc. (2011)
17. Müller, G., Neuper, C., Pfurtscheller, G.: Implementation of a telemonitoring system for the control of an EEG-based brain-computer interface. IEEE Trans. Neural Syst Rehabil Eng. 11(1), 54–59 (2003)
18. S.Barro, D.Castro, M.Fernndez-Delgado, S.Fraga, M.Lama, J.M.Rodrguez, J.A.Vila: Intelligent telemonitoring of critical-care patients. IEEE ENGINEERING IN MEDICINE AND BIOLOGY MAGAZINE 18, 80–88 (1999)
19. Tonin, L., Leeb, R., Tavella, M., Perdikis, S., Millán, J.: A bci-driven telepresence robot. International Journal of Bioelectromagnetism 13(3), 125 – 126 (2011)
20. Vargiu, E., Dauwalder, S., Daly, J., Armstrong, E., Martin, S., Miralles, F.: Cognitive rehabilitation through bnci: Serious games in backhome. In: Graz BCI Conference 2014 (2014)
21. Vargiu, E., Fernández, J.M., Miralles, F.: Context-aware based quality of life telemonitoring. In: Distributed Systems and Applications of Information Filtering and Retrieval. DART 2012: Revised and Invited Papers. C. Lai, A. Giuliani and G. Semeraro (eds.) (2014)
22. Vargiu, E., Fernández, J.M., Torrellas, S., Dauwalder, S., Solà, M., Miralles, F.: A sensor-based telemonitoring and home support system to improve quality of life through bnci. In: 12th European AAATE Conference (2013)
23. Vincent, J., Cavitt, D., Karpawich, P.: Diagnostic and cost effectiveness of telemonitoring the pediatric pacemaker patient. Pediatr Cardiol. 18(2), 86–90 (1997)