New Technology Supporting Rehabilitation at Home

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Abstract

The share of elderly people is growing fast, especially in the developed and western countries for example in Finland as well as in Japan. This development means challenges for health care and social welfare services. Developing new service concepts and new technology based services and also innovative networks for producing adaptable services and service platforms could alleviate the coming problems. In addition, there is a social need to develop new cost-effective solutions to support elderly people to live at their own homes even if they would be under medical care or in the middle of a rehabilitation process. This article is based on the results and findings achieved in UUTE project (Smart Home in a Suitcase, new technologies supporting telemedicine, home care, rehabilitation and safety at home) carried out in Finland 2006 – 2008. Because the aim was to build up new service model and service concept the project consortium consisted from different kind of actors which represented research institutes, private companies and public sector. Main actors from public sector were Pirkanmaa Hospital District and Lempäälä Municipality Health Care Center.

1. Methods and technology

In the project different kind of research methods was used from the viewpoints of technical, medical and human sciences. Based on the idea that there was a need to find out the opinions of different kind of focus groups it was decided to use scenario method, interviews and questionnaires. The aim was to collect information and data from people representing users, professionals and decision-makers.
One of questionnaires was designed to collect the data from the personnel working with the patients having neurological deceases. 45 questionnaires were sent to the health care personnel working at two different departments in Tampere University Hospital. The other department was concentrating on rehabilitation and the other was a neurological care unit. The number of completed forms was 23.

1.1 Technology based concept trials

We evaluated the developed technical platform for supporting the service concepts in two small trials. The person participating in the first phase is a 70 years old woman living alone in a newly built up sheltered housing apartment. The living environment is meant for elderly people and it offers different kind of nursing and assisted living services. The second test phase was carried out in a close co-operation with a Health Care Center for a hip-surgery patient during his rehabilitation.
The measurement system used for monitoring in the testing phases was developed earlier in the project. [1] It consists of sensors, a wireless ZigBee network, a personal computer (PC), and a server. The sensors may vary according to the needed measurement data. The ZigBee network is used to send the measurement data to the PC, which analyzes the data and sends the data to the server where measurement data are stored and from where the service provider may collect the data when needed.
In the first study phase, we integrated in the system both commercial and custom made sensors. We used a commercial weight scale (DE 300K100N, Kern & Sohn GmbH, Balingen, Germany, http://www.kern-sohn.com/), a blood pressure sensor (UA-767PC , A&D Company, Ltd., Japan, Tokyo, http://www.andonline.com/), a bed sensor (Emfit Ltd, Vaajakoski, Finland, http://www.emfit.com/), a floor localization sensor (UPM-Kymmene corporation, Finland, www.upmpresence.com), and a custom made infrared heat sensor. The positions of the sensors in the test apartment are shown in Fig 1.
The bed sensor is a thin electromechanical film (EMFi) pressure sensor that measures the pressure changes of the body. It can register heart rate, body movements and sleeping duration. It was placed in the person's bed under the mattress. The infrared sensor was placed on the ceiling near kitchen stove to

measure the uncommon heat changes in the kitchen. The floor localization sensor consists of a thin laminate mat and sensor electronics. The measurement is based on measuring the change of stray capacitance between two tile electrodes. The presence of any conducting object, such as a person, in the vicinity of a mat tile changes this capacitance and can be measured. The advantage of the method is that one does not need to carry any kind of tag to be positioned, as the technology measures the presence of the person itself. This, on the other hand, means that an identification of a person by signal processing methods is very hard of even impossible, and that tracking of two or more closely situated persons is challenging. Thus, the method is well suited only to one-person households. All the data is collected the PC assembled in a footing of a wardrobe. In addition to these sensors the user was guided to measure her weight and blood pressure at least once a day.

For the hip surgery patient (second phase) the system included a diary, health monitoring devices and a video call environment (Arcticare Technologies Oy, Espoo, Finland, http://www.arcticare.com/). The diary contains self-assessment about sleep length and quality, daily activities, rehabilitation program, pain severity on visual analogue scale (VAS, form 0 to 10), medication information and comments. The subject sent weekly the marking to a researcher via regular mail. Morning blood pressure, morning weight and bed sensor information were collected during the study. The subject used a computer with a touch screen display once a week to make video calls with a physiotherapist to follow the progress of the rehabilitation. The video call was made and the collected data were sent from the PC to the server using the 3G based mobile network (TeliaSonera Finland Corporation, Helsinki, Finland, www.sonera.fi). A summary from the measurements and the diary markings were sent weekly to the patient and to the physiotherapist who observed the data for possible problems in the rehabilitation.

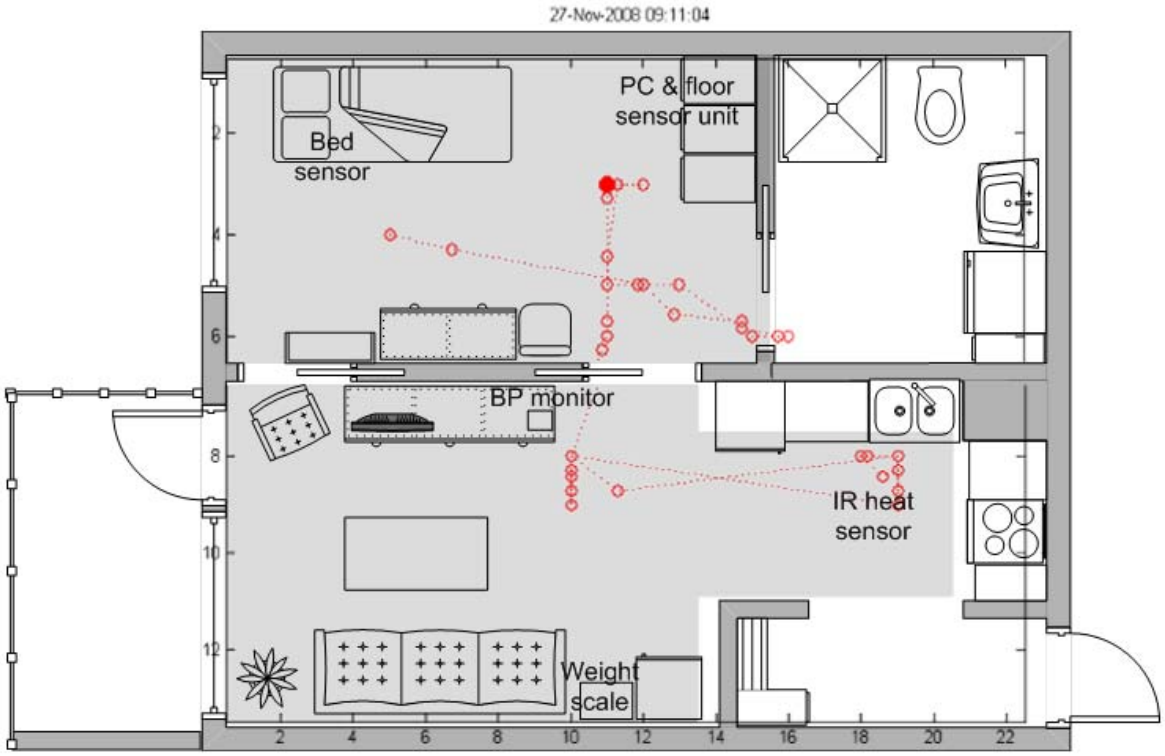

Fig. 1. The floor plan of the apartment and the position of the sensors. The area covered with the floor sensor is shown in light gray. In addition, recorded person's location inside her home during a 5 minute window is shown with red trace. The filled red dot shows the latest location. The location is measured using the floor localization sensor.

2. The results

The results based on the survey carried out with health care personnel show that 19 of 23 were interested in new technical solutions and applications if they will be helpful at work and will support rehabilitation at home and also the follow-up of rehabilitation. According to the opinions devices and solutions should be simple, solid, easy to use and easy to learn also from the patients' point of view. The forms were filled up by 14 nurses, five physiotherapists, one speech therapist, one occupational therapist, one social worker and by one practical nurse. One of the staff was in a leading position, but her answer was quite similar compared to the others. According the personnel the lack of time is the most important obstacle when learning the use of new technology. They wish that employer would arrange extra time to practice the use.

One important and interesting topic to ask was, how new possibilities come into use, is there any problems to get them on the working places and to the patients. Based on the answers the new solutions find their way to the hospital and to the use varies a lot and often is quite slow and sometimes they are not available at all. Only one person expressed that it is very easy. Anyway the general opinion was that it is important to develop new services and new technical solutions to assist both patients and personnel in the rehabilitation processes and every day life. Most of the personnel saw that is also important to develop the outpatient home care and so called “home hospital” possibilities where the information would flow between home and hospital when needed to support the rehabilitation phase at home.

During the first study phase the developed prototype system functioned without big problems during the first test period. Some problems were found concerning for example the robustness of the floor tracking system and reconnection of the mobile network. This, however, gave us more information about how to build such systems. Technical aspects and some enhancements are presented in [1].

From the measured data, several long and short term diagrams were calculated, such as heart rate and weight trends over time, bed times during the week, and daily activity graph calculated from the floor localization sensor. Fig. 1 shows person’s location during a five minute window. Such information would be useful for example for a personnel responding to an automatic alarm in a case when the person could not be reached by phone.

The user in the first study phase reported that she felt uncomfortable with the bed sensor as it was placed in such a close proximity to the body for relatively long times each day. The fear was caused by the consequential suspected radiation effect. The fear did not fade, although, it was explained to the user that the sensor would not cause any radiation due to the measurement principle of the pressure sensor. Despite of this, the user wanted the sensor to be excluded from the study after a use of 7 days. Within this phase the laminate was also used to follow-up if the person is doing her home gymnastic exercise program regularly and where in the flat she is doing it. Based on the test period it was found out that the laminate could be one possibility to follow if the exercises are done, but there is still a need to develop the technical application further.

The second study phase lasted for one month (19.11.2008-18.12.2008). The blood pressure monitor malfunctioned in the beginning of the study and it had to be replaced with a regular one (Omron 705IT) until 2.12.2008. The subject wrote down the blood pressure monitor results to the diary due the malfunction, but continued this routine after the new blood pressure monitor was installed in the system at 3.12.2008. The ZigBee based wireless home network worked without any problems during the second study phase when concerning the blood pressure monitor and bed sensor readings. Weight information was only collected with the wireless network and the network reliability cannot be evaluated correctly in this case. 69% of the weight measurements (20/29), 86% of the blood pressure measurements (24/28), and 100% of the bed sensor readings were realized from the instructed. In the Fig. 2 are illustrated the collected data during the study period. We did not meet any technical problems in the data collection with the technology ignoring the broken blood pressure monitor in the beginning.

3. Conclusions

During the first phase of the study one usability drawback was excluding of the bed sensor due to the anxiety caused by the technology. These kinds of fears may be common while introducing novel technology. This needs to be taken into account by service providers of such system. However, during the second study phase similar accidents were not met which tells from a different willingness and need to use these systems.

In the second study phase the compliance was high (from 69% to 100%). 70% to 90% of weight and blood pressure measurement activity have also been documented in other long-term studies involving either healthy or sick persons [2, 3 & 4]. Self reported sleep time and bed occupancy time of the bed sensor during the night have good correlation with this user (Fig. 2).

The physiotherapist reported that the feedback during the rehabilitation was interesting. By viewing the Fig. 2 a slight rehabilitation response could be seen in the self reported sleep quality and pain severity. However the material is too small to draw any conclusions concerning this issue.

The ZigBee based network was placed in a single room and possibility when selected sensors are more scattered was not tested in the study and have to be evaluated in a real life use in coming studies. The diary could be filled via the PC which should be studied integrated in this type of systems.

Based on the experiences and information in this project and during different field studies and testing phases it must be expressed that the role of health care personnel and experts is crucial when developing new services, concepts and technology for the social welfare and health care field. The attitude towards technology and new proposals and solutions can be decreased in this way.

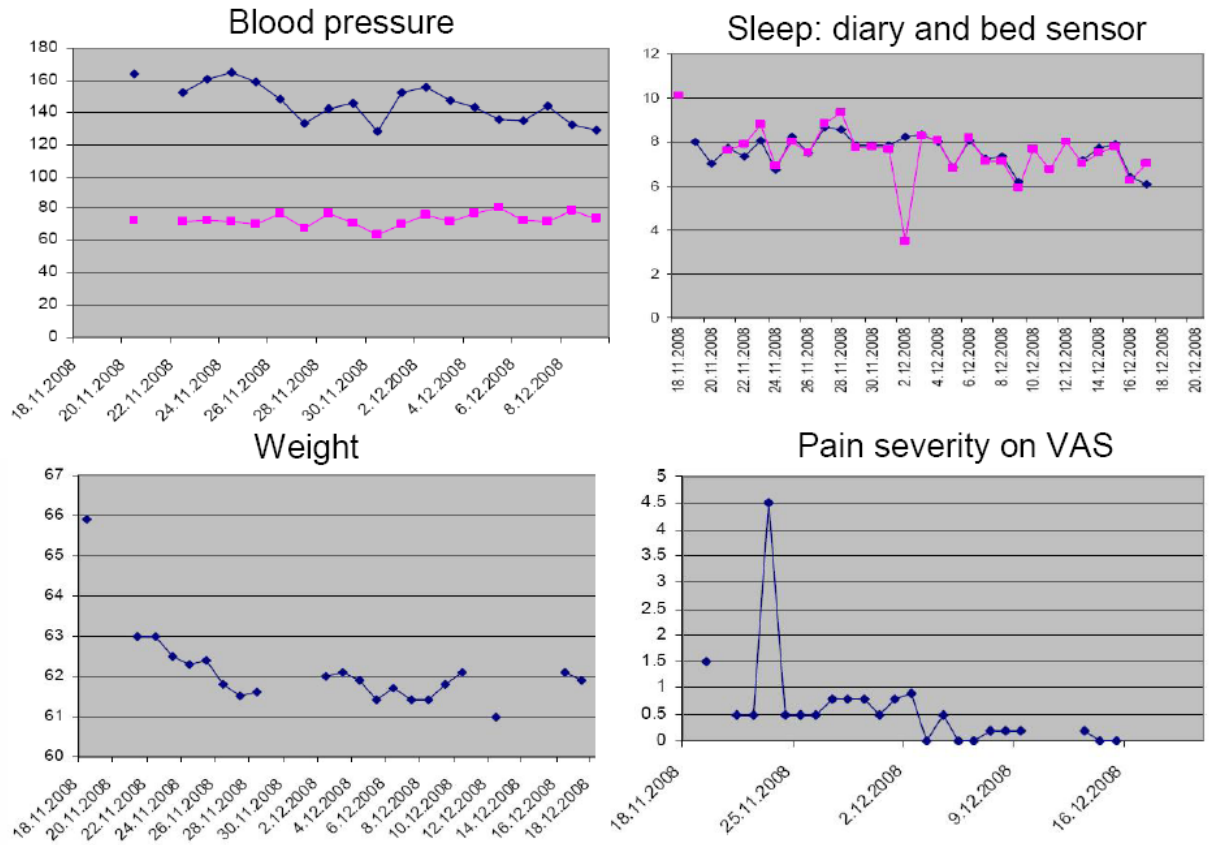

Fig. 2. Blood pressure, sleep time from the diary, bed time from the bed sensor, weight and daily pain severity evaluated on VAS (0 to 5) readings during the second study phase with the hip surgery patient.

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