Hipperbox:

A portable toolbox for rehabilitation from a hip surgery using sensors

Ahmed Nait Aicha, Sven Haitjema, Pascal Wiggers
The department of Computer Science
Amsterdam University of Applied Sciences
Amsterdam, The Netherlands
a.nait.aicha@hva.nl

ABSTRACT

Since the rehabilitation process after a hip surgery is increasingly performed at home, professional caregivers experience a lack of insight in the rehabilitation of their patients. In this demo we present a portable sensor system for remote monitoring, consisting of both wearable and ambient sensors and a gateway with 4G for transmission of the data to the server. The collected sensor data is processed and analyzed to provide information about how active the patient is and which activities of daily living he is performing. The system gives insights in the progress of the rehabilitation to both the therapist and the patient. During the first pilot, ten patients and five therapists have tested the first release of the rehabilitation sensor system. They experienced that the sensor system can be used effortless, facilitates the dialogue between the patient and the therapist and can support the self-management of the patient.

Figure 1: The Hipperbox consisting of a Raspberry Pi, a set of sensors and a tablet.

CCS Concepts

•**Information systems** → Sensor networks; •**Applied computing** → Health care information systems; Health informatics; •**Human-centered computing** → Ubiquitous and mobile computing systems and tools;

Keywords

Rehabilitation; Hip surgery; Sensor monitoring

1. INTRODUCTION

As a consequence of increasing health care costs, the rehabilitation process after a hip surgery is performed increasingly at home. Professional caregivers (physical and occupational therapists) experience a lack of insight in the effectiveness of the rehabilitation in this new situation. The professionals have no overview of the improvement of the patients during the rehabilitation phase. As part of the research project Hipper, researchers of our university (ICT and Health departments) together with therapists and clients of four care centers are developing a new treatment protocol where sensors are used to support the rehabilitation process.

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2. APPROACH

The requirements of the rehabilitation system are obtained from several focus group interviews. The development of the system is according an agile method consisting of short sprints and a multi-disciplinary team involving therapists, developers and data scientists. The most important findings with regard to the technology were: a) the revalidation is aimed at activities, b) the system and the protocol should increase self-management and c) the technology should be easy to install and comfortable to wear. Based on these requirements we chose to use a combination of a wearable sensor to measure the physical activity of the patient and motion sensors that provide information on the activities of daily living.

Our research group has several years of experience in long-term monitoring elderly activities using off-the-shelve wireless sensor networks [3]. For this specific short-term application, the used off-the-shelve sensor networks have two big disadvantages. The installation of the sensor networks takes a lot of time due to the involvement of an internet provider company and fusing other types of sensors to the network is not possible. To address these problem, a portable easy to install toolbox supporting different types of data communications has been developed.

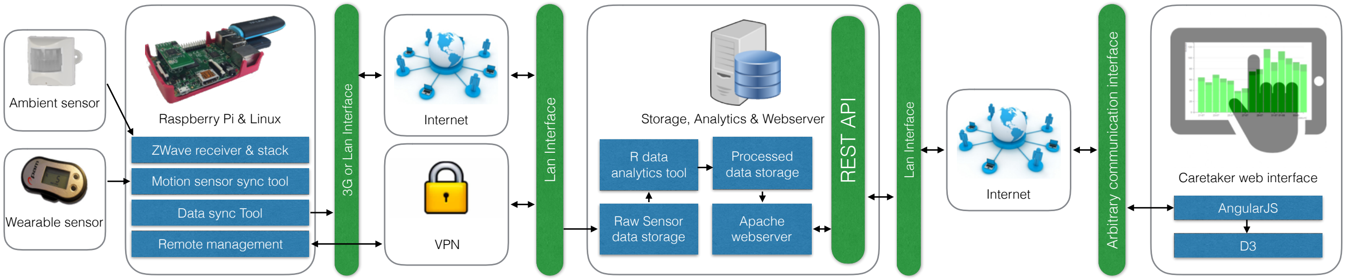

Figure 2: The hardware and software architecture of the system used for the Hipperbox.

3. SYSTEM ARCHITECTURE

Figures 1 and 2 show a picture of the toolbox and an overview of its corresponding architecture.

3.1 Hardware Architecture

The gateway consists of a Raspberry Pi extended with a Z-wave shield for the communication with the ambient sensors, a Bluetooth adapter for the communication with the wearable sensor and a 4g dongle for the connection with the remote server. The sensor data collected by the wearable sensor is stored on the device and sent to the gateway (the Raspberry Pi) when the patient is in nearby. The data collected by the ambient sensors is stored on the gateway and sent to a secured remote ftp-server. Different visualizations of the data can be accessed by both the therapist and the client using a portable device e.g. a tablet.

3.2 Software Architecture

The visualization system is a web application consisting of three main blocks:

- A front-end consisting of the graphs and controllers showing the activities and the intensity of the movement of the patient during the day. The front-end is developed using Angular and d3 JavaScript libraries.
- A back-end consisting of R-scripts for the processing and analysis of the raw sensor data. Algorithms developed for the detection of ADLs, the detection of the visits and continuos measurement of the gait velocity are implemented in this block [1][2].
- An application programming interface (API) consisting of code to make the communication between the front-end and the back-end possible. The API is a Representational State Transfer (REST) compliant interface.

The advantages of such a loosely coupled software architecture are scalability, security and the ease of maintenance.

4. EVALUATION

The first release of the rehabilitation system has been tested, at three different care centers, by ten clients and five health professionals. These field tests resulted in some unexpected issues such as a washed wearable sensor. The overal impression of the end-users about the rehabilitation system is impressive. Some quotes given by the therapist and the clients: Patient X: "I didn't know this is possible", Therapist Y: "the ambient sensors help me very much to engage in a conversation with the client and to discuss goals".

5. CONCLUSIONS AND FUTURE WORK

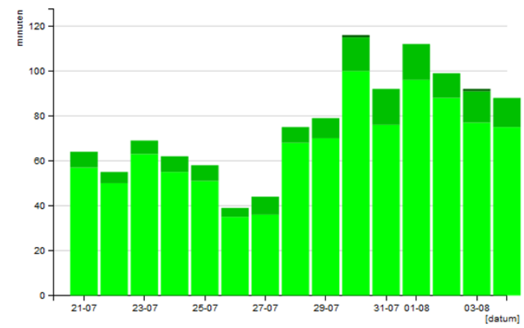

Figure 3: The intensity of movement in minutes per day recorded using the wearable sensor.

From the first pilot, we can conclude that the Hipperbox has the potential to be a portable system for supporting the clients recovering from a hip surgery at home. The system is easy and quick to install and supports different types of data communication. The therapists experienced that the system can facilitate the dialogue with their clients and can support the self-management of the client. More clients and therapists will be involved in the second pilot starting in April 2016. While the focus of the first pilot was on visualization of the sensor data, the second pilot will also provide functionalities to support the communication between the client and the therapist and a feedback system to increase the self-management of the client.

6. ACKNOWLEDGMENTS

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7. REFERENCES

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