Monitoring healthcare activities toward automatic recognition using accelerometers

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Abstract. Intelligent homes should be able to recognize human activities in order to assist people in their daily life. In particular, this is important for healthcare related activities, where people can be reminded of taking some medicine or checking their blood pressure. Not only that, an intelligent system should also be able to verify the correct performance of that activity. Nevertheless, human activity recognition is not trivial and much work still needs to be done. This paper presents a study that shows the understanding how the activity of measuring blood pressure is performed by professional nurses. It with the purpose to develop an intelligent system taking into account the way that the activities are performed by human being. A video recording of the activity along with accelerometers attached to manometers allow us to code this activity in computer readable form for posterior use by a recognition system.

Keywords: Activity recognition, accelerometers, intelligent homes.

1 Introduction

The origin of non-transmissible diseases is associated with risk factors related to harmful life styles. For example, high blood pressure is an important risk factor for predicting several disease. In order to know if a person has this factor, her blood pressure needs to be measured often [1]. Moreover, this risk factor might produce other disorders such as heart attack, cardiac insufficiency and so on. Therefore, blood pressure is an extremely important activity to human being health. However, activity recognition is a complicated process. It is due to there exists a lot of way to perform an activity. Also, the activity recognition process is associated to the object recognition. For example, an object can be related to an activity and additionally the same object can be related to another activity however the activities are performed in a different way.

Knowledge about how people perform daily activities has inspired research related to the monitoring of interactions with domestic objects associated with
the completion of each activity. For example a simple state-change sensor can be used to detect any change of state of an object which can subsequently be used to reflect the interactions of a human being with the object. In this sense, sensors transform a physical signal into an electrical signal that can be manipulated symbolically on a computer [2]. In addition, the goal of an intelligent system for human activity recognition consists of automatically analyzing and classifying activities with information gathered from different capture sources like video cameras or other sensors such as accelerometers.

In this work, we are concerned with monitoring healthcare activities, in particular the blood pressure measurement activity. This paper describes a case study in order to understand the details in a real scenario where this activity is performed by professional nurses. Therefore, we used cameras with the purpose to gain insights into the activities that people perform and to complement our investigation. We considered that this understanding is a main phase in the monitoring healthcare activities toward automatic recognition.

One of our purposes is to understand as much as possible about the users, the activities they perform, and the context of those activities, so that we can develop system that can support users in achieving their goals [3–5]. Other authors have been worked on using the data with the aim to segment data such as shown in [6], they proposed three segmentation algorithms to separate time series sensor data into segments to be further processed by an activity recognition algorithm. In this direction, we are using accelerometer data to segment the blood pressure activity based on human being movements. In [7–9] the authors focused on using several sensors, but they do not highlight any previous work related to understanding the scenario as we propose.

This paper is organized as follows. Section 2 introduces our methodology followed for this case of study. Section 3 shows the results by means of a particular example. Finally, Section 4 provides our conclusions and directions of future work.

2 Methodology

The case of study was performed in our usability lab at our university. We conducted a study with the aim of: (1) understanding how the activity of measuring blood pressure is performed by a professional nurse; (2) identifying the way a nurse handles objects when performing that activity; (3) obtaining the patterns produced by accelerometers installed in the blood pressure object (manometer). We record the data produced by the accelerometers with the purpose of recognizing when an activity is performed based on human behavior and create a story related to the scene.
2.1 Subjects

A group of 31 volunteers (7 females and 24 males) were monitored and recorded while measuring their blood pressure activity in our usability lab. The average age for the whole group was 28 years. Additionally, the activity was performed by two professional nurses. Both nurses have four years of experience. All participants were reported as healthy.

![Accelerometers’ antennas](image)

**Fig. 1.** Scenario used, a-d) Position of the cameras in the usability lab

2.2 Technical Information

The case study was recorded with four cameras: two cameras were located in the ceiling of the usability lab (Figure 1b and 1c) and the others were located close to the tools tables (Figure 1a and 1d). We obtained close to 1.5 hours of video. Additionally two accelerometers were attached to two manometers used to measure blood pressure. The accelerometers provided close to 51,000 data samples for the duration of the case study (i.e. one hour and half).

The accelerometer used in our study was a Freescale D3172MMA7455L model. It has a high sensitivity (64 LSB/g at 2 g and 64 LSB/g at 8g in 10-bit mode); a 1-pole low pass filter; the receiver supports 16 sensors per one USB stick allowing the identification of multiple objects, and the power consumption is low voltage.
operation (2.2–3.6 V). We used the default configuration for their implementation.

The information produced by the accelerometers is the acceleration measurement related to the three coordinate axes (x,y,z). Also, it is possible to use the concentrate of these values as the absolute value expressed in terms of g-force (g). Thus, this absolute value was used to show how objects are handled.

This kind of technology is very sensitive to movements, so the variations begin to be recorded when the accelerometer starts to move. An important thing to note is the effective area of the receiving antenna, which is large enough to recognize several objects that could be used in a given setting. Also, because of this sensitivity it is necessary to establish a threshold to interpret the input signal. With a threshold, even if the signal is very variable, we can infer that the accelerometer is being used, otherwise we assume that it is immobile.

The camera used was a wvc53gca Linksys model. The video was captured using MPGe-4 format having a resolution from 320 X 240 pixels, the frame rate was 10 per second.

2.3 Description

The study allows us to acquire data related to the behavior of the blood pressure measuring device, which in turn represents the activity for blood pressure testing. Each behavior made a pattern when the activity was performed. Two accelerometers and two antennas were used, where each accelerometer sent signals every time it was moved around, and each antenna received the accelerometer’s signal.

Additionally, we created a system with the purpose to acquire the accelerometer’s signals. This system is able to link the accelerometer signal to the video sequence. Two cameras were synchronized to one of the accelerometers. Hence, two video sequences were produced for each accelerometer.

The implemented process in the study was as follow:

Two antennas were installed and connected to two computers at the back of our usability lab. Each antenna received the data related to its corresponding accelerometer. Each accelerometer was attached to a blood pressure device.

The data were stored and processed in a database on each computer. Two threshold values were established. When an accelerometer remains immobile, the received value is approximately 1.0, therefore we established two values as thresholds (1.5 and 0.5). If the accelerometer remains in the range this means that the object is immobile on a base location (tools table), otherwise it means
that the object has been handled.

Taking into account the above description, two professional nurserers measured the blood pressure to the participants. They were attended by one by one. The manometer was placed in the tools table whenever it was immobile.

3 Results

We analyzed the data gathered from the two accelerometers and their corresponding video sequences manually. This resulted in 29 patterns produced by behavior when activity was performed. Two patterns were not recognized due to the fact that the signal was lost. This happened because the antennas were installed near to a window metal, so the signal was lost while the antenna was on that place.

As mentioned above, 51,000 samples were obtained and stored in a database. 28,000 samples were obtained by one antenna, and 23,000 by the another antenna. The data consists of an ID related to each signal produced by accelerometer, and the information produced by the accelerometers. The absolute value of the accelerometer was used to show how the objects are handled. Also the date and time were stored in a database. Finally, the number of each frame and the name of the video file were stored. The latter was linked to each signal produced by one accelerometer. So each time a change from 0 to 1 (or vice versa) happened a sample was recorded in the database.

3.1 Understanding the activity of measuring blood pressure

On average, the whole activity of measuring blood pressure used 1,200 samples (i.e. two minutes approximately). This happened each time the nurse performed the activity. Figure 2 shows an example of one pattern for the duration of a single activity. This is described as follows:

1. The nurse grabs the blood pressure device from the table (Figure 2b).
2. The manometer is placed around the arm of patient (Figure 2c).
3. The nurse starts to pump rapidly with her hand and let the air out slowly (Figure 2d).
4. The nurse starts to remove the manometer from the patient’s arm (Figure 2e).
5. The nurse removes the manometer, which produces a stronger movement of the device (Figure 2f).
6. The manometer is placed on the table (Figure 2g).

This list shows specific and important events related to the way in which a professional nurse performs the activity. As mentioned above, the accelerometers
are very sensitive to movements, so the variations begin to be recorded when the accelerometer starts to move, as can be seen in Figure 2a). Firstly, at sample number 27, the accelerometer signal was a little high. It was produced by the patient when she hits the table. Therefore, the activity started in that point.

As mentioned above, two cameras were synchronized to an accelerometer's signal. It allows us to create a visual story based on movements or events as shown in Figure 2, and also a meaning produced by each event when the object was handled within the activity.

Another important event is related when the activity was performed, it was included in Figure 2d-e. It is important to note that, the total time of the activity was 96 seconds but only 33 seconds were used for the actual measuring of the blood pressure. The rest of the time was used for preliminary or supplementary events.

As a result of this analysis, we identified the way in which measuring the blood pressure is performed by a professional nurse. Moreover, we obtained the data of the accelerometers used when performing such activity based on human behavior.
4 Conclusions

We conclude that activity recognition is a complicated process, so it is necessary to take into account several details related to human activities such as we shown in this paper.

The accelerometers are very sensitive to movements, so the variations are an important cue when it is attached to object. It is because each movement is an event produced by the object while an activity is performed. Each event provides a meaning of the activity based on how objects are handled, as well as human behavior. Therefore, the understanding was obtained and we believe that our study is necessary to get important insights such as needs, requirements, capabilities, current tasks and goals, the conditions under which the object will be used and constraints on the object’s performance within activities that human being performs.

The results obtained in this work will be used to develop an intelligent system. As a future work, we wish to apply data mining and artificial intelligence techniques in order to infer new activities based on the behavior of humans.

References