Position statement: Telemonitoring - a too limited view on the wellbeing of the patient

Bart Jansen

Department of Electronics and Informatics
Vrije Universiteit Brussel, Pleinlaan 2, 1050 Brussel, Belgium
bjansen@etro.vub.ac.be
http://www.etro.vub.ac.be

1 Introduction

A variety of biomedical parameters including blood pressure, body temperature, blood glucose level, heart rate variability, blood oxygen saturation and many others can currently be measured at home. Tele monitoring applications are mainly focusing on chronic diseases and elderly patients, as they have the biggest benefit from being treated at home. The vast majority of the telemonitoring projects are focussing on the monitoring of a vital sign. Even when multiple vital signs are taken into account, telemonitoring applications do not manage to provide a measure for the global wellbeing of the patient. By monitoring the physical activity of the subject and detecting trends and changes herein, one could get a better insight in the well being of the patient, long before changes in vital signs occur. This position statement argues for the usage of time-of-flight cameras for the monitoring of physical activity.

2 Technologies for the monitoring of physical activity.

Accelerometers are often employed to detect activity, to count steps, to estimate the distance walked [1, 2], to detect falls [3] and even to distinguish between several physical activities (walking, running, walking stairs) [4–9]. Such techniques provide information on the level of activity of the subject and are very useful over a long period of time, as a decrease in activity often precedes or correlates to several conditions. Examples of work showing correlations between accelerometer measurements and health status, can be found for instance for COPD [10, 11], Chronic Fatigue Syndrome [12], Chronic Pain Syndrome [13], low back pain [14], Migraine [15] and Fibromyalgia [16]. Other work is focusing on extracting more detailed activity information, for instance by monitoring the transitions between rooms (e.g. using infrared sensors [18, 19] or RFID tags [20]).

Camera based systems for the detection of activity patterns form a growing research field. A major disadvantage of existing camera based systems for this task (e.g. [21]) is that regular camera systems provide insufficient spatial information. For instance, it is very hard to calculate the location of a subject or an

Dagstuhl Seminar Proceedings 07462
Assisted Living Systems - Models, Architectures and Engineering Approaches
http://drops.dagstuhl.de/opus/volltexte/2008/1463

object in a room out of a sequence of camera images. The advent of stereo vision systems was important, as stereo vision systems provide information on the distance between object and camera. Given a mathematical model of the properties of the cameras and an accurate estimate of their relative position, 3D positions of objects can be calculated with stereo vision cameras. However, correct spatial information relies on the automatic matching between corresponding pixels in each image. This process is computationally expensive, moreover it is not always reliable. For instance pixels in low texture areas are very hard to match.

3 Time-of-flight cameras as an alternative.

Recently, 3D cameras have been developed which provide spatial information of the pixels, by using the time-of-flight principle. The camera emits modulated infrared light and the camera is measuring the time of flight of the light. This provides highly accurate depth information without complex pixel matching algorithms [22, 23]. Although 3D cameras are currently highly experimental devices and have low resolution, we investigated the usage of a 3D camera for the monitoring of physical activity. Using image processing techniques, we segmented the subject in the image, fitted an ellipse around the resulting blob and transformed the position of the subject from camera based coordinates into room based coordinates. As a result, the position of the elderly patient in the room is known up to an error of a few centimeters. This position is a 3D position, such that the height of the person above the ground is also known. This is important for instance for fall detection. From these 3D positions, we can calculate various features such as the distance walked per time unit, the amount of time in bed, in a sofa, walking, etc. Also the number of transitions from one pose to another is derived. This initial prototype is described in [24–29]. Evaluation of this prototype in the laboratory shows that the position information of the subject can be calculated very accurately, on condition that the technology is employed in a controlled environment (with respect to daylight changes, subjects entering the room, furniture being moved, etc). Currently, we are performing an initial evaluation of this technology in the geriatrics department of a hospital [30].

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