Real-Time Activity Monitoring of Inpatients

Miguel Reyes, Jordi Vitrià, Petia Radeva, and Sergio Escalera

E-mail:mreyes@cvc.uab.cat, {jordi,petia,sergio}@maia.uab.es

Computer Vision Center, Campus UAB, Edifici O, 08193, Bellaterra, Barcelona, Spain
Dept. Matemàtica Aplicada i Anàlisi, University of Barcelona, Gran Via de les Corts Catalanes 585,08007, Barcelona, Spain

***Abstract*—In this paper, we present the development of an application capable of monitoring a set of patient vital signs in real time. The application has been designed to support the medical staff of a hospital. Preliminary results show the suitability of the system to prevent the injury produced by the agitation of the patients.**

I. Introduction

In the context of hospital patient care management, we have carried out experiments with the purpose of planning, developing and validating a central data collector, capable of monitoring various critical data of patients who need permanent medical care.The data collected by the application is sent in real time to the medical staff, so, health care personnel will be informed at every instant of time of the situation of the patient without having to be present. The classical data monitoring is done through networking with different sensors of vital equipment, such as oxygen concentrators, ECG, HTA, etc. The contribution we introduce is to automatically collect the amount of motion of the patient by means of computer vision techniques. In order to quantify the amount of movement, first assume that we are in a context where the patient has a continuous spatiotemporal behavior. Thus, it obliges us to analyze the relationship of information between consecutive frames to find the possible movement of the patient. For this goal, differences among visual features of consecutive frames are computed. These values are used to quantify a set of agitation degrees. Moreover, a module able to detect presence within the context of the patient is implemented. The module is used to stop monitoring of agitation data when the patient is been attended by the medical staff. The rest of the paper is organized as follows: section II describes the monitoring system, section III show qualitative results, and finally, section IV concludes the paper.

II. Method

We delimited our workspace to an area of interest defined by the user of the application. In this process, the user reduces the study of the motion to a rectangular area, choosing four points of the entire image which contain the bed of the patient.

A. Motion Description

Our goal is to obtain a visual representation of information contained in the region of interest. For this, we use a descriptor based on Histogram of Oriented Gradients (HOG) [1]. To compute such a descriptor we convert color images to gray scale intensity images. Then, within the region of interest, we define a subdivision of the area, building a grid where each cell corresponds to a HOG descriptor. The grid contains 96 (12×8) cells. Each cell is a square containing $n \times n$ pixels. For each pixel in this block we apply the Sobel operator to compute the approximate absolute gradient magnitude (normalized in the range $[0..1]$) and gradient orientation. Then for each cell we define $K(K = 9)$ orientation bins and use gradient orientation to assign each pixels to one bin. For each bin, we calculate the sum of gradients of its pixel. It means that for each cell inside the grid we obtain a vector of 9 values (sums). The 2D HOG descriptor is a vector D (normalized in the range $[0..1]$) concatenating vectors of all cells of the grid. The reason why we use a grid is to analyze and distinguish different areas where motion can occur.

B. Objective Quantification of Motion

After analyzing the image and extract visual information, we quantify and codify the system output in order to display it in an understandable way to the medical staff. So, we discretize the system output in the following states: no motion, slight motion, high motion, and gross motion. The value of the HOG descriptors difference between two consecutive frames used to compute the output of the system. The difference between the cell A at frame t and the cell A at frame $t + 1$ is estimated as the euclidean distance between the corresponding descriptors A^t and A^{t+1}. Then, we accumulate the euclidean difference for all cells of the grid in two consecutive frames. Normalizing the obtained agitation degree D in the range $[0..1]$ we finally discretize the motion in the following four levels:
$[0..0.24] \rightarrow$ no motion
$[0.25..0.49] \rightarrow$ slight motion
$[0.5..0.74] \rightarrow$ high motion
$[0.75..1] \rightarrow$ gross motion
An example of cell HOG differences and final monitoring of motion levels is shown in the example of Figure 1.

C. Data Monitoring and Alarm System

Referring to the data computed by the clinical devices, these are displayed directly on an interface of observation (Figure 2). Alarms can be programmed according to clinical parameters.

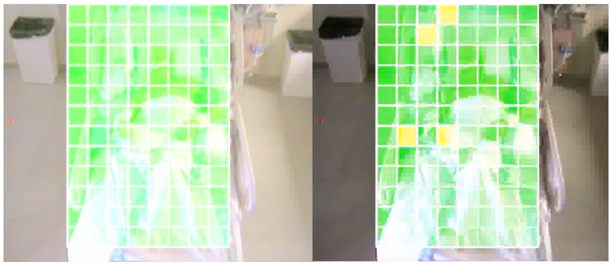


Fig. 1. Motion analysis under different illumination conditions

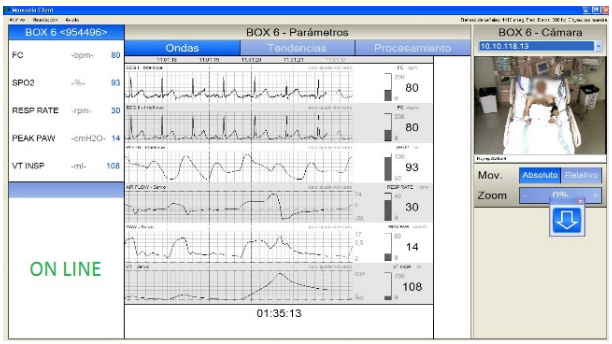
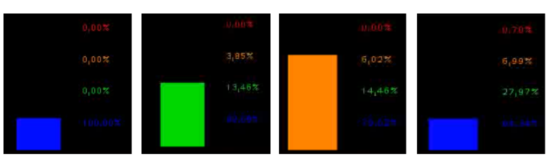


Fig. 2. Monitoring interface

These parameters will be set by the medical staff through the interface of configuration. Regarding the monitoring of the motion, the user sets a period of observation. In this way, the system displays the percentage of time in which the patient has been at each level of motion. From the interface configuration, the user sets the maximum values of motion to start the alarm system. Figure 3 shows the percentage of agitation of a patient for a period of time.

III. Results

In order to assess the robustness of the system the application has been tested on a video sequence of 8000 frames,



(a) $t = 0s$ (b) $t = 10s$ (c) $t = 40s$ (d) $t = 60s$

Fig. 3. Historic of patient activity for a period of time

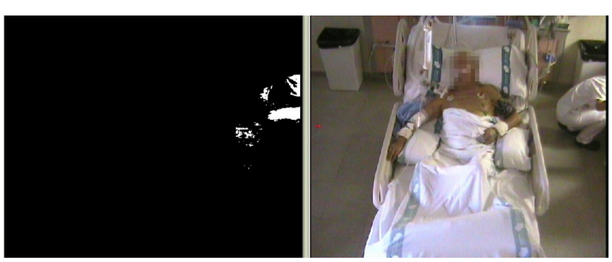


Fig. 4. Example of presence detector

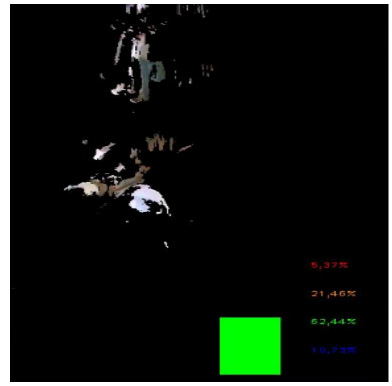


Fig. 5. Adaptive pixel foreground motion segmentation

with a frame of rate 5 FPS. The resolution of the frame is 640×480 pixels. The video corresponds to a real patient from the Hospital de Sabadell, Parc Tauli. In this first test we can see the robustness of the system, detecting the different levels of motion under different light conditions and different periods of time (Figure 1). Additionally, we show an example where the presence detection module detects a medical staff in the environment of the patient (Figure 4). This has been implemented using classical background substraction methodologies [2].

IV. Conclusion

We presented a methodology to detect and quantify the motion of patients in hospitals. The method is based of HOG descriptor differences. Additionally, a presence detector module was implemented. Preliminary results show that the system robustly detects and quantifies the motion of the patient at the same time that shows an historic of the patient activity. We are currently on the analysis of alternative motion quantification methodologies able to identify the level of agitation at pixel level by means of adaptive pixel foreground models (a preliminary result is shown in Figure 5).

Acknowledgment

The authors thank to Hospital de Sabadell, Parc Tauli for its collaboration.

This work has been supported in part by projects TIN2009-14404-C02, La Marató de TV3 082131, and CONSOLIDER-INGENIO CSD 2007-00018.

References

[1] N. Dalal and B. Triggs. *Histograms of oriented gradients for human detection.*, IEEE International Conference on Computer Vision and Pattern Recognition, volume 2, pages 886-893, 2005.

[2] Massimo Piccardi. *Background subtraction techniques: a review*, IEEE International Conference on Systems, Man and Cybernetics, 0-7803-8566-7/04 2004.

MICCAT Conference, October, 2010