A NEW TYPE OF SENSOR TO MONITOR THE BODY TORSO MOVEMENTS WITHOUT PHISICAL CONTACT

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Abstract: **The aim of this paper is to propose a new type of system used to monitor and determine the body torso movements and position without any physical contact and to demonstrate the validity and performance of our approach. Further, a genetic algorithm is used to compute, from the final resulting image, the body position related to the video camera point of view.**

Keywords: **body language, non-contact system, laser plane, genetic algorithm**

Introduction

What gives its real substance to face-to-face interaction and communication, in real life, beyond the speech, is the bodily activity of the people [1] and, also, the way they express their feelings, thoughts, and state through the use of their body. If we want to improve communication in virtual reality environment, human computer interaction, and the communication with a computer, in general, the detection of states through body movement can be used [2]. A “sensitive computer” can use the body movement and the position of the body, linked to the artefacts from the environment, in order to assess the state of the person such: nervosity, lack of attention, motor fatigue and agitation, confusion etc.

Method

The sensor system is compounded from a laser scanner, a video camera and a software program that controls the scanner and extracts the people’s torso position information.

The principle of the whole system relays on a laser scanner that generates a laser plane at a constant angle from the horizontal plane (consider this plane the floor). When the laser plane hits a target in the imaged area, a line of laser light appears on the target.

The system uses a single conventional video camera that is capable to acquire images from the area where the laser plane can hit the target (in our case the person’s torso). With this camera the software gets two consecutive images: first, with the laser diode on, with a line of laser light that appears on the target, and the second, with the laser diode off. Making the difference between those two images we get, as a result, only the laser line projected on the people’s torso. At this point, we know which are: the angle between the laser scanner and the horizontal plane, the position in space of the video camera and, respectively, the extracted shape of the laser line light on a trunk. Then, the depth information is calculated using a genetic algorithm and some of the basic geometric formula. Thus, we extract the real 3D-body position related with CCD camera point of view.

The Hardware System

The scanner (figure 1) has a low-power laser diode and a mechanical system with six mirrors disposed on a plate in hexagonal configuration. The plate with mirrors is attached to the system’s engine shaft. The position of each mirror can be controlled with a mechanical system – in this mode all the six mirrors will generate the laser plane with the same orientation in the 3D space.

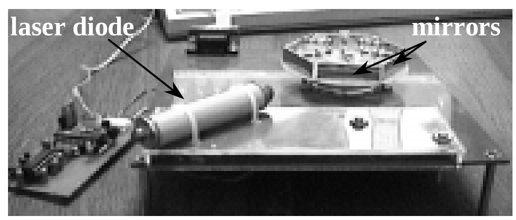

Figure 1. The scanner system

The motor is driven using an electronic control unit that provides a constant rotational speed of 5 revolution per second. The scanner system controlled by a microtroller interface board communicates with the host PC through the standard interface serial port. The microcontroller’s interface board checks the system, starts/stops the engine, turns on/off the laser diode accordingly with received command send by the PC.

The Software System

The software is composed from several independent blocks. First, the system acquires and stores the two images consecutively and synchronically with the diode laser’s state. After the extraction of the laser scanner projection, the resulting image is send to the genetic algorithm which extracts the body torso position.

The communication with the scanner is done with a DLL that, also, contains the function used to configure and set the serial port. The DLL was written in LabWindows CVI. The application that calls this DLL and does the rest of the job was written in Microsoft™ Visual C++ 6.0.

The images are acquired through SDK Microsoft™ library. The two still images are defined by two RGB triples: $I^{t+1} = (I_r^{t+1}, I_g^{t+1}, I_b^{t+1})$ and $I^t = (I_r^t, I_g^t, I_b^t)$; t is the time. All pixels of the first image, I^{t+1}, for which $I^{t+1}(x, y) \neq I^{t}(x, y)$ define the line of the laser light which appear on the user body torso. One of the problems relays in the noise that appears in the images. The problem was solved by using an experimentally obtained noise model, σ. The criterion to extract the line of laser light becomes now: $I^{t+1}(x, y) - I^{t}(x, y) > \sigma$. An example of acquired images and the resulting laser line extraction is presented in Figure 2.

Figure 2. The two acquired images and the result of processing

The other problems like shadows, light sources, saturation, background changes, do not affect the reliability of the laser line feature extraction. Mainly, this is happen because the time interval between the two images acquisition is less then 4ms and for our application, however, the noise model presented above have been proven to be sufficient.

The main goal of the genetic algorithm is to minimise the length of the vertical segment sets, the chromosome s_1, s_2, … (Figure 3). These segments have an end point at the bottom part of the image and the other end point can run freely over the all image representing the laser trace extracted from the user's torso. One chromosome codes the length of the segment (l) and the position of the vertical line related to the left image corner (x).

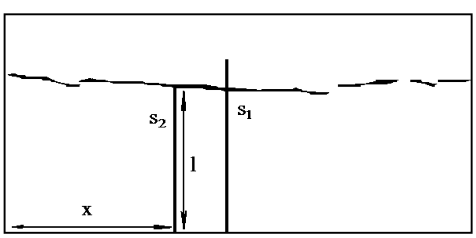

Figure 3. Two chromosomes on the image

The fitness function is calculated using two criterions: the minimisation of the vertical segment length (l) and the maximisation of the number of points that belong to the extracted laser line. Based on the standard genetic operators [3] we define our operators: reproduction, mutation and crossover.

Because the laser scanner makes an angle with the horizontal plane, the length of the best fitted chromosome is in the direct relation with the person body position. If the length is smaller, the person or the object is close to the video camera; otherwise, the analysed distance is larger.

Discussion and Results

In Figure 2, it is presented a result of the processing software. The situation presented was chosen especially to show the result in the case when the colour of the laser beam (red) is close to the colour of the sweater where it is projected. In this situation, the images used to derive the laser line are taken with a professional Sony™ camcorder (TRV78E). The similar result was obtained with a web CCD but, in this situation, we must intercalate a gamma correction circuitry (properly tuned) between the webcam and the acquisition board. The main difference between the webcam and the camcorder consists in the superior resolution of the last one; it permits a superior precision in determining the exact body position. The identification of some particular trunk position (Figure 4, left) or of the arm position - in front of the torso, (Figure 4, right) - is possible base on the geometric curve dimension and the position in the resulting image.

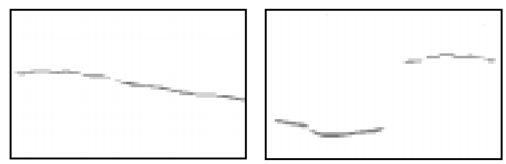

Figure 4. Two different resulting images

Conclusions

The software that controls the system is not very computationally demanding. This is mainly due to the method used to extract the laser light projection and, also, to the genetic algorithm used to find the depth or the distance to the human's torso. The frame grabber used is a TV tuner with capture capability. These characteristics make the system cheap, easy to manufacture and, hence, attractive for practical applications. This new system to supervise body movements has several advantages. First, there is the possibility to use it in a variety of applications to name only a few: medicine, industry, virtual reality, entertainment etc. In the second place, the system to acquire the body torso position is based on a non-invasive sensor and more the interface between the scanner system and the personal computer is a standard, cheap one.

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