

# Function Monitoring of Human Body by 3D g-sensor

**György Györök**

Department of Computer Technology, Budapest Tech  
Budai út 45, H-8000 Székesfehérvár, Hungary  
gyorok.gyorgy@sztg.bmf.hu

*Abstract: The continuous investigation and analyses of the physical condition of both the workers working in dangerous environment and patients is most important. In the case of such an investigation the typical input parameters are the heartbeat, i.e. E.C.G., the saturation of oxygen, and breathing. Defining the position and the movements are at least of the same importance. A microprocessor data collector device is used, which monitors the 3 D signals of an acceleration sensor. The momentary acceleration, the velocity and the position of the body can be determined from this register. We can also make references to the character of the movement by the help of the co-variant, from a pattern database.*

*Keywords: human body activity monitoring, g-sensor, cross-correlation, probability, automatic function detecting*

## 1 What is the Aim of this Activity

The possibility of remote monitoring both the workers working in dangerous environment and the patients may be most important. Such remote monitoring devices are at our disposal and usage. They can either register certain physiological state, sometimes in correlation with the environmental circumstances, or transmit the data to a central monitoring system. Its use for specific parameter investigation can be also important. In case of such a monitoring a typical input parameter is the heartbeat, i.e. E.C.G., the saturation of O<sub>2</sub>, and breathing. Defining, measuring and registration of the position and the movements are at least of the same importance. For the definition of certain, specific resolution of a momentary state a GPS sort of device can be applied, but in different circumstances, these devices cannot be used.

During recent years such integrated electrical circuits sensing acceleration that can sense 2D or 3D acceleration are to be found in the market. By means of these sensors the vectors of the body acceleration can be observed, respectively, by they help can be registered in function of time. In case the sampling is fast enough, out

of the acceleration vector, first the velocity vectors can be derived, then, out of the integrated velocity vectors, the movement vectors can be calculated. This way we can define not only the momentary movement activity, but the acceleration of the body, but also its momentary velocity and its relative coordinates. Online detection and monitoring the character of the movements of workers working in dangerous environment, soldiers or non-cooperative patients can be very important. We can define the type of movement from the series of samples. This way we can make a difference between walking, running, doing sports, standing up, sitting down, etc. (Figure 1)



Figure 1  
The „sit down” „measuring arrangement”

## 2 HW and SW Solution

There is a possibility of application of two pair *2D* sensor (ADXL220) of acceleration in the case of sensing *3D* acceleration as well as the possibility of making a redundant sensor<sup>1</sup>. If all the three acceleration coordinates are known ( $a_x, a_y, a_z$ ), the kinetic energy ( $W_k$ ) of the person with mass  $m$  can be defined:

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<sup>1</sup> ADXL330 3D can be found in the market soon

$$W_k = 2^{-1} m t^2 (a_x^2 + a_y^2 + a_z^2) \quad (1)$$

Where:  $W_k$ : the kinetic energy  $m$ : the mass of human body,  $a_n$ : the acceleration

Moreover we also have the possibility to define the character of the movement, namely, from the position of the body of the person to be investigated (standing, lying), and from the sort of movement. We would like to recognize the changes of position of the body: sitting down, standing up, lying down, getting up, etc. as well as to recognize certain movement activities: walking, running, traveling by some means, etc.

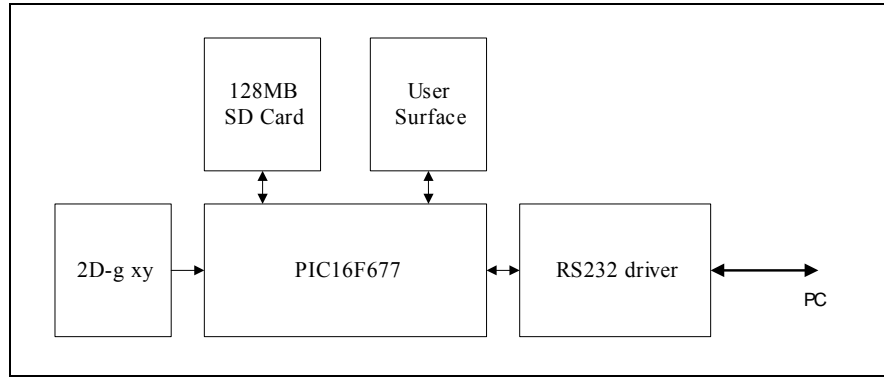


Figure 2  
The architecture of MC unit

In order to differentiate these functions we would like to calculate the correlation between these 2D and (3D) movement data and a sample database. (2)

$$k_{xs}(t_1) = \lim_{T \rightarrow \infty} \frac{1}{2T} \int_{-T}^T x(t)s(t)dt \quad (2)$$

Where:  $k_{xs}$ : the value of correlation,  $x(t)$ : g registrant,  $s(t)$ : pattern,  $T$ : time of integration

For implementation, in this stage of development, we use the appropriate functions of the output of this is such a function that renders target hit probability to an amount of time, for instance 78% running, 93% sitting down. We get the value of the correlation (3)

$$\left(\frac{a+b}{2}\right)^2 - \left(\frac{a-b}{2}\right)^2 = ab \quad (3)$$

Where:  $a$ : the value of acceleration,  $x(t)$   $b$ : the value of  $s(t)$  sample

By means of MATLAB we also implement the communication between the  $\mu$ C and PC.



Figure 3

The MC developing environment with the 2D sensor

The above presented measurement arrangements (Figures 2-3) need a microcontroller card, which operates as a data store on one hand and as a data send to the PC on the other hand. The input parameter of this micro controller is the momentary signal from the three acceleration sensors and, of course the other latent time parameter in minutely adequate sequence. The micro controller device monitors the acceleration parameters on a 128 MB SD card or it transfers them to a computer through a RS232 interface.

During the continuous 2D data collecting we have at our disposal a base consisting of 30 measured persons as samples, nearly 50 MB. In figure 3 such a measurement can be seen. In Figure 4, the  $x$  and  $y$  direction of the acceleration-time function of the find can be observed. The time axis in this case is 20 ms resolution.

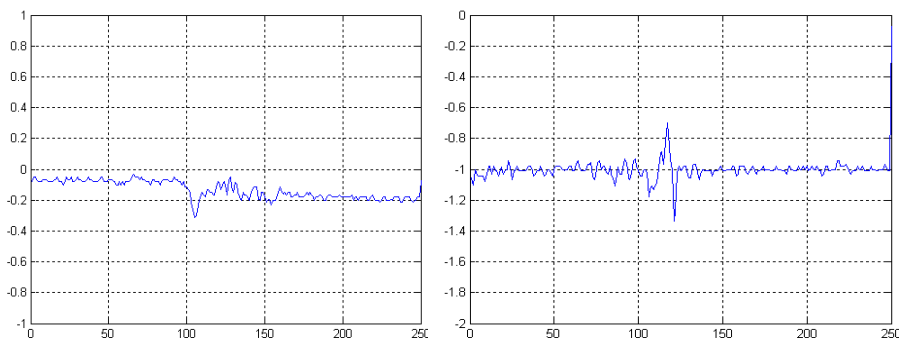


Figure 4

The  $g_x$  and  $g_y$   $t$  function of a “sit down” movement. The granularity of axis  $x$  is also 20 ms.

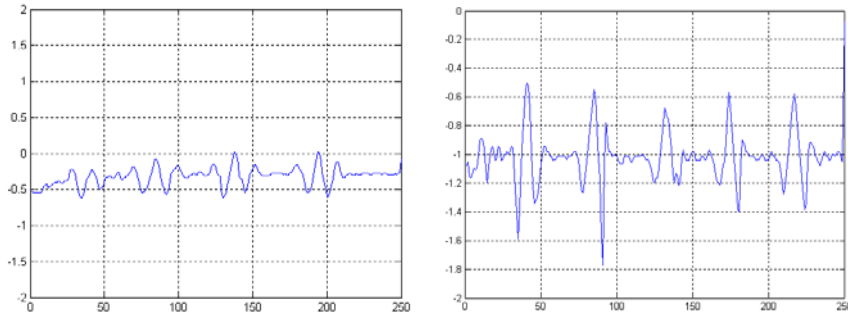


Figure 5

$g_x$  and  $g_y$   $t$  function of a quick walk  $g$  and  $g$  time function can be seen.

The granularity of axis x is also 20 ms.

The personal computer is connected through the interface to the micro controller card, from where it reads the information stored in SD RAM. A *Mat Lab*<sup>2</sup> program runs on the computer. The serial communication is implemented within the frames of the program package, and it is also the program package that implements the recognition of certain movements by the help of the sample-registered data. To achieve this we have to calculate the co-variant of the 3 D acceleration time function and the 3D sample register. As a result of covariant or regressive calculation we obtain a function that gives a value according to the time function for comparing different types of movements. If so, we obtain different co-variant function values for running, exercise, stepping, and so on.

By means of such acceleration sensors we can identify the different momentary positions of the body while sitting, standing, tossing left or right and so on. So that the letter movement analyses can be implemented a great performance device, namely a personal computer, is needed.

For some co-variant functions we can associate absolute values or limit values, even more than one, as a result of which we obtain probability values for a sequence of movements. These probabilities, through some target values, can make us aware of the percentage of certain movements.

### Conclusions

By the help of suggested arrangement and algorithm the applicability of the device is proved as the cooperation of the investigated person is not necessary so that the different activities can be identified.

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<sup>2</sup> Version 7.02

### **Acknowledgement**

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