Movement Analyses by Pattern Correlation

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Abstract: The physical state of people working in dangerous environment or ill ones is important to be monitored and analyzed. For such an investigation a typical parameter is the heartbeat rhythm, the ECG, the saturation of oxygen and breathing. Defining the body mobility state as well as its position may be also of the same importance. In order to achieve this microprocessor data collector device is used, which stores the 3D velocity sensor signal. The momentary velocity, acceleration and position can be defined from these accumulated data. By the help of co-relation calculus, from a sample database an approach of the character of mobility can be determined.

Keywords: sensing biological signals, recognition of signal forms, co-relation, co-variance, life function identification, pattern databases

1 The Hardware Architecture of the Acceleration Sensor

In this stage of development an electrical circuit was implemented according to a system plan (Figure 1) by the help of which the measurement of 2 dimensions was possible. Besides this PIC processor a 2D acceleration sensor was implemented (ADXL202) and a 128Mb capacity SD card HW/SW adjustment, and RS232 communication respectively. The microprocessor makes the signal processing of the acceleration sensor (the measurement of filling factor), writes the output signals respectively (according to function) into the memory. Only the most needed tasks are fulfilled by the microcontroller and its environment. The calculus task is fulfilled by the PC. The latter does not necessarily performs a real-time processing. There is a possibility of using two acceleration sensor pairs for 3D acceleration sensing and a redundant sensor development.

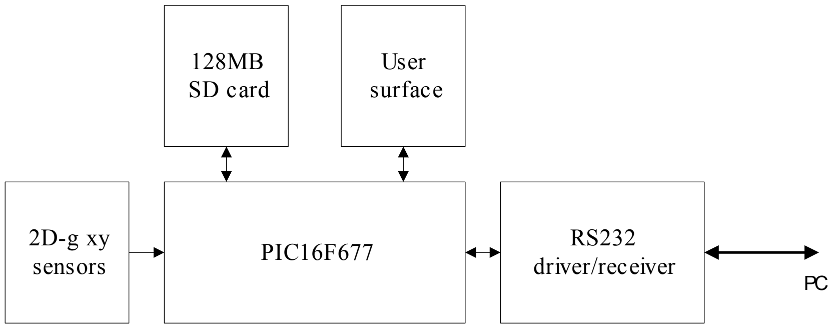

Figure 1
Architect of microcontroller system

2 Possibilities of Analyses of Moving Signals

If all the three acceleration co-ordinates (a_x, a_y, a_z) are known, the kinetic energy of the person with m mass can be defined as: (1,2)

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

Where: W_k, the kinetic energy,
m, the mass of the suspected body,
a_n the acceleration in n direction

In case of adequately fast measurement the rotation and spinning movement can be approached with direct/ straight velocity vector.

To get the result of the measurement W, the connection between the *O* and *P* points must be made, in order to generate eventual warning signals, with remote supervision character.

$$\bar{A}=\bar{W_k}\times\bar{O}\times\bar{P} \quad (2)$$

Where: *A*, warning signal (in 3D space)
W_k, the kinetic energy,
O, a point of the suspected body,
P other important point of the body

Once the three scalar quantities closing a 120 degree one by one mean the absolute value of the vector in one and the same field /plane, A indicates such a surface having 'critical' surface elements which should generate alarm.

Moreover there is a possibility to define the quality of the mobility. This is very important in case the patient is non co-operative. The position of the investigated person's body (standing, lying) or the kind of movement should lead to recognition of changing of position.

Sitting down, standing up, lying down, getting up, etc., or recognition of certain movements: walking, running, travelling in a vehicle, etc.

By the help of mathematical program package not to difficult to solution of the linear regression searching (Brute Force). In this case we must do in parallel the amplitude and the time regression. (3)

$$C=(R_a \oplus S_a)\otimes(R_t \oplus S_t) \quad (3)$$

Where: C, correlated signals
R_t, the recorded acceleration signal in t function,
R_a, the recorded acceleration signal in amplitude function,
S_t, the stored acceleration signal in t function,
R_a, the stored acceleration signal in amplitude function.

By this solution we can only the stored (for example 24 hour) signals correlated by the samples. Bottleneck in this case the computer capabilities, and the greatness of the storages devices. In practise for the 24 hour acceleration samples in 20 ms resolution necessaries about 60MB. (Figures 2-5)

In order to differentiate these functions we would like to calculate the *2D*, or *3D* mobility data by means of co-relation with a sample database. In this stage of development we make use of the adequate functions of MATLAB-7 program.

Figure 2
Registration of a 'sit down' signal

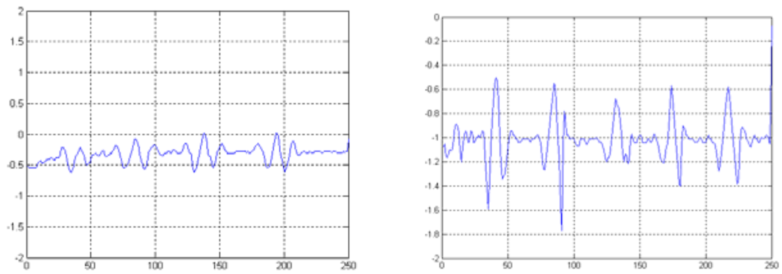

Figure 3

The a_x and a_y t function of a quick walk can be seen.

The granularity of axis x is 20 ms.

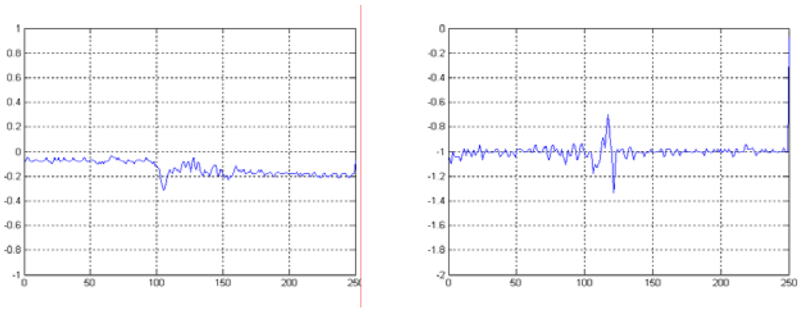

Figure 4

The a_x and a_y t *t* function of a 'sit down' movement.

The granularity of axis x is also 20 ms.

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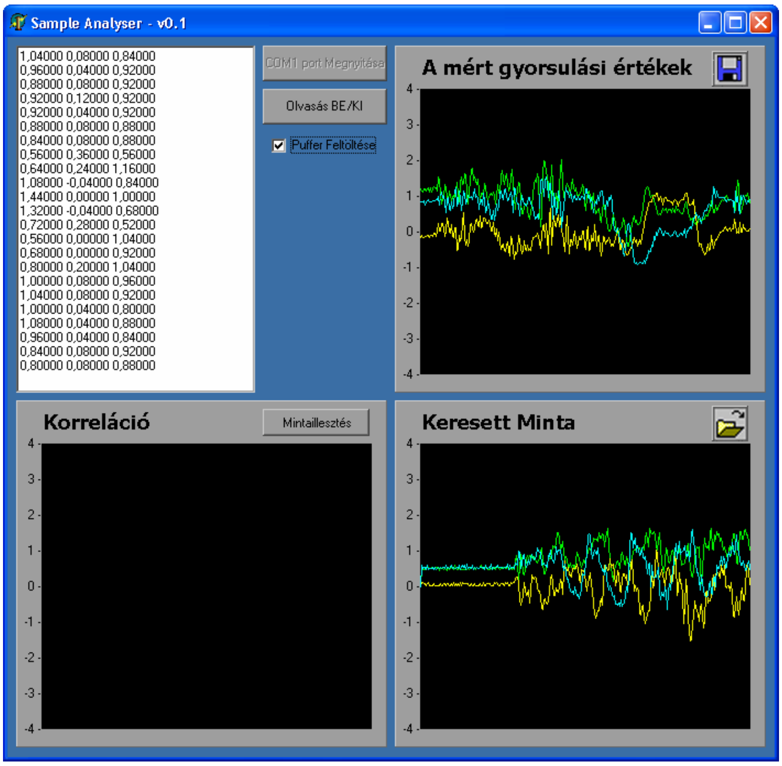

Figure 5
The screen of the sample recognition program