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# COMPUTER SYSTEM FOR ASSESSMENT THE HEALTH STATE OF A HUMAN BY DATA OF ELECTRONIC SPHYGMOMANOMETER

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Abstract. The acoustic auscultator signal and the pressure signal are recorded in personal computer by convertor and analogue to digital convertor. On this base the required parameters, blood pressure, heart rate are computed. The health state is estimated by cycling pressure and heart rate. It is defined by independent blood pressure measurements. The program procedures are written on VBA for Excel. Results are ordered and they provide enough features for the health state assessment.

## I. INTRODUCTION

The medical experience is based on cardiograph explorations, images of magnetic resonance records, cardiac indexes and cardiac outputs. The cardiograph explorations in [1] contain symptoms, rhythms, frequencies, electrocardiograph images of different deviations of cardiac operation. They use several cardiograph records of one patient and represent the most disseminated cardiac diseases. The cycling pressure defined in the book is computed by subtraction of diastolic from systolic blood pressure. It corresponds to the heart activity and it can be used for health symptom together with the heart frequency rate.

The three dimensions images of the records from nuclear magnetic resonance [2] contain variety of detail parameters as curve, volume, mass and thickness of the wall of heart and artery, required in surgery. They are useful in the immediate medical practice.

Disseminated and important is the cardiac index of a patient [3]. It is computed as hemodynamic parameter, which represents relationship of cardiac output of the left camera to the body surface in [L/min/m$^2$]. In parallel, the ankle brachial index as relationship of the blood pressure in the ankle to the blood pressure in the upper arm also is described. It is used for diagnostics of coronary arterial disease.

Till now the blood pressure signals of the electronic sphygmomanometer are not used for health state definition. Unknown remains the mathematic method for computation of the blood pressure and the heath rate frequency, as well as their independent variables.

The cardiac cycle together with the blood pressure is monitored at home bicycle. The electrodes are attached on chest. The cuff is on the upper arm. The patient is on the pedal. This intensive investigation is applied at some medical programs. But index cycle pressure plus heart rate is not used in the free medicine practise.

The methods described in [4] try to represent some new outlook on those procedures. The previous exploration show that most accurate measurement of the blood pressure can be achieved with time quantification of the pressure signal in parallel to the wave auscultator signal. This method requires numbering of the waves, what is difficult task for the software here and it is not applied in this paper.

Moreover, the constant blood pressure is that, which has mean squared deviation less than 2.5%. The heart variability is that heart operation, which is characterised by variation of the blood pressure, the heart rate, and the spectrums of signals at several or set of blood pressure measurements for one only person. If the medicines think that one only blood pressure is the disease remedy, they wrong and they (not especially) think for the heart death.

## II. MATHEMATIC METHOD

The experienced computer system is based on VBA for Excel, which language is not suitable for mass application, but is good enough for automatic decisions. The pressure signal provides data about the systolic and diastolic blood pressure. The wave

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signal provides data for the heart rate. An example of those signals is shown on fig. 1.

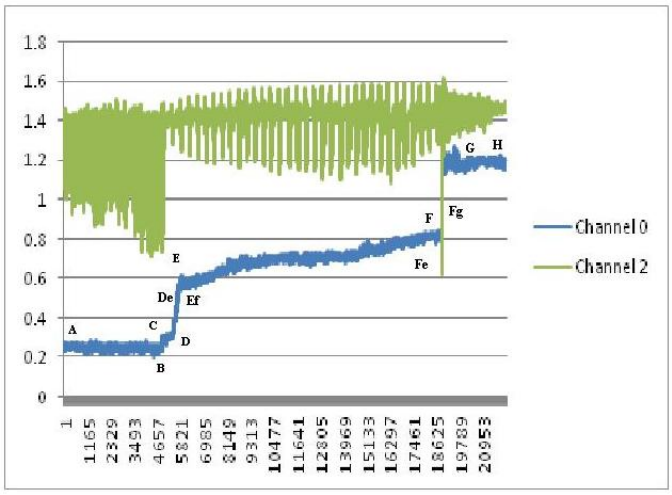


Fig. 1. The pressure signal defined by points and the wave signal of electronic sphygmomanometer.

The points of the pressure signal are automatically computed by the software and the higher level of point G or point H corresponds to the level of $L_s$ given in the formulas. The measurement constant is chosen from $L_s$. The table 1 shows the points and the time limits of the corresponding file. They are computed automatically by software.

Table 1. The key points of the pressure signal.

| Number | TimeExtrem | DataExtrem |
|---|---|---|
| 0 | 0.002 | 0.261230469 |
| 1 | 9.81400013 | 0.258789063 |
| 2 | 9.815999985 | 0.300292969 |
| 3 | 10.93799973 | 0.297851563 |
| 4 | 11.00399971 | 0.346679688 |
| 5 | 11.46199989 | 0.576171875 |
| 6 | 11.52600002 | 0.537109375 |
| 7 | 35.7140007 | 0.830078125 |
| 8 | 35.73400116 | 0.825195313 |
| 9 | 37.73199844 | 0.99609375 |
| 10 | 37.79399872 | 1.166992188 |
| 11 | 44.19800186 | 1.188620103 |
| | 6.004 | |
| | 12.004 | |
| | 38.732 | |

The formulas for systolic blood pressure are:

$$X_{s1} = C *( L_s - ((x_d + x_e)/2))/(L_s - x_{max}) \quad (1)$$

$$X_{s2} = C *( L_s - ((x_e - x_d)/(t_e - t_d))/(L_s - x_{max}) \quad (2)$$

$$X_{s3} = C *( L_s - (\Sigma x_{de})/N))/(L_s - x_{max}) \quad (3)$$

$$X_s = X_{s1} + X_{s2} / 2 \quad (4)$$

where points D and E define the systolic interval of the pressure signal, and the $x_{max}$ is pressure at point $x_B$ , C is the measurement constant at point B and point C in mmHg and $L_s$ in V is the level after the cuff becomes out of air pressure.

The software takes the best of those results and gives it to the final systolic solution.

The corresponding diastolic blood pressure has next formulas:

$$X_{d1} = C *( L_s - ((x_{ef} + x_{fe})/2))/(L_s - x_{max}) \quad (5)$$

$$X_{d2} = C *( L_s - x_f)/(L_s - x_{max}) \quad (6)$$

$$X_{d3} = C *( L_s - ((x_{ef} + x_{fe} + x_f )/3))/(L_s - x_{max}) \quad (7)$$

$$X_{d4} = C *( L_s - ((\Sigma x_{ef})/N))/(L_s - x_{max}) \quad (8)$$

where points $x_{ef}$ , $x_{fe}$ , $x_f$ , and $x_{ef}$ define the diastolic interval of the pressure signal, C is the measurement constant at point B and point C in mmHg and $L_s$ in V is the level after the cuff becomes out of air pressure. The computer also takes the best of those results and gives it as final diastolic blood pressure.

The formula for the heart rate is:

$$P = 60 * (N_w / (t_e - t_s)) \quad (9)$$

where $N_w$ is the number of upper waves of the wave signal for the corresponding period $(t_e - t_s)$, defined by point Fg after point F and point C, which lies after point B.

It is seen that systolic and diastolic blood pressure are mathematic results, not direct results of the sensors. Thus the difference between computer and the electronic sphygmomanometer can exists. But computer computes in some manner the required data, which are close to the real ones. Some of them can look as too abnormal, but sphygmomanometer also can surprise with some abnormality.

The authors in [1] define the heart activity by cycle pressure:

$C_P = X_{sys} - X_{dias}$ (10)

It can be a parameter of the heart activity together with the heart rate:

$H_A = P + CP$ (11)

They are results of the heart operation. Naturally, their sum is a parameter of the heart condition. The normal sum is 40 + 60 = 100. But with some interval 30 around it the limits are expanded enough. Thus normal heart activity lies between 70 and 130. From one to other blood pressure measurements it can vary, and this circumstance is accepted as normal. When heart activities is over or lower of those values for many consecutive measurements it is a symptom for abnormalities. This parameter can give some useful information at our way of live.

## III. RESULTS OF THE SOFTWARE

The software takes the data about pressure signal and wave signal. It computes middle lines of the waves, upper waves and lower waves. The pressure value of beginning point (p. A) defines the variations of the pressure signal. The first transition at p. B is small. The second transition at p. $D_e$ is higher. And the third transition at p. $F_g$ define the end of measurement with transition, which is similar to that of point $D_e$ or it is some higher. For different signals it vary in small degrees and it can stop the software. These are the main points of the automatic computation the points of pressure signal. Moreover, the pressure signal is defined between upper, lower, left and right limits. Computer can computes them automatically. The results of the software are shown in table 2.

In the table 2 normal variability for the pressure, heart rate and the index are seen. Thus the health state is normal and acceptable.

The computer system reads the signals of measurements but the Excel is activated by hand. The programmer pastes the program to the file of Excel and computes the blood pressure and heart rate.

Table 2. The blood pressures, heart rates and diagnostic indexes.

| File No | Systolic BP, mmHg | Diastolic BP, mmHg | Heart rate, p/min | Cycle Pressure mmHg | Index (CP+P) |
|---|---|---|---|---|---|
| 1 | 128 | 83 | 73 | 45 | 118 |
| 2 | 116 | 85 | 42 | 31 | 73 |
| 3 | 121 | 84 | 61 | 37 | 98 |
| 4 | 120 | 83 | 54 | 37 | 91 |
| 5 | 119 | 79 | 59 | 40 | 99 |
| 6 | 129 | 82 | 60 | 47 | 107 |
| 7 | 136 | 83 | 60 | 53 | 113 |
| 8 | 135 | 84 | 60 | 51 | 111 |
| 9 | 136 | 82 | 59 | 54 | 113 |
| 10 | 133 | 82 | 59 | 51 | 110 |
| 11 | 136 | 87 | 60 | 49 | 109 |
| 12 | 111 | 78 | 60 | 33 | 93 |
| 13 | 129 | 81 | 74 | 48 | 122 |
| 14 | 123 | 81 | 61 | 42 | 103 |
| 15 | 126 | 79 | 51 | 47 | 98 |
| 16 | 131 | 80 | 61 | 51 | 112 |
| 17 | 125 | 80 | 44 | 45 | 89 |
| 18 | 116 | 79 | 52 | 37 | 89 |
| 19 | 125 | 81 | 45 | 44 | 89 |
| 20 | 114 | 81 | 40 | 33 | 73 |
| 21 | 111 | 79 | 65 | 32 | 97 |
| 22 | 114 | 81 | 52 | 33 | 85 |
| 23 | 127 | 81 | 69 | 46 | 115 |
| 24 | 117 | 79 | 60 | 38 | 98 |
| 25 | 121 | 79 | 59 | 42 | 101 |
| 26 | 153 | 80 | 92 | 73 | 165 |
| 27 | 127 | 79 | 48 | 48 | 96 |
| 28 | 109 | 82 | 47 | 27 | 74 |
| 29 | 103 | 80 | 60 | 23 | 83 |
| 30 | 130 | 82 | 79 | 48 | 127 |
| 31 | 121 | 78 | 66 | 43 | 109 |
| 32 | 117 | 79 | 47 | 38 | 85 |
| 33 | 136 | 83 | 60 | 53 | 113 |
| 34 | 122 | 81 | 60 | 41 | 101 |

| File No | Systolic BP, mmHg | Diastolic BP, mmHg | Heart rate, p/min | Cycle Pressure mmHg | Index (CP+P) |
|---|---|---|---|---|---|
| 35 | 133 | 81 | 61 | 52 | 113 |
| 36 | 117 | 77 | 56 | 40 | 96 |
| 37 | 130 | 83 | 87 | 47 | 134 |
| 38 | 118 | 81 | 64 | 37 | 101 |
| 39 | 116 | 78 | 75 | 38 | 113 |
| 40 | 111 | 85 | 53 | 26 | 79 |
| 41 | 138 | 84 | 62 | 54 | 116 |
| 42 | 132 | 76 | 71 | 56 | 127 |
| 43 | 130 | 80 | 41 | 50 | 91 |
| 44 | 129 | 79 | 49 | 50 | 99 |
| 45 | 127 | 81 | 77 | 46 | 123 |
| 46 | 124 | 81 | 54 | 43 | 97 |
| 47 | 137 | 85 | 61 | 52 | 113 |

Some time the blood pressures are not computed. The reason is in the thresholds, which must be modelled in the corresponding instructions.

Thus many files can be assessed for health state. They are shown in the table 2. The difference between computed and measured blood pressure data is around 10% and rarely is over 20%. It never exceeds 30%.

This approach to health state assessment can be useful for active human life. It can be applied to handmade assessment of own health state with electronic sphygmomanometer.

## IV. CONCLUSIONS

The intensive cardiac bicycle test is based on monitor the cardiac cycle and the blood pressure. It is not applied in medical practise as a stationary test. The electronic sphygmomanometer provides data about blood pressure and the heart rate. These data are used in the explorations of the current paper. They are enough for preliminary medicine diagnostics, based on the corresponding index Cycle blood pressure plus Heart rate. The software of the computer system automatically computes the required parameters and generates data about cycle blood pressure and heart rate. The diagnostics is for the doctors, but the tables show a normal heart activity.

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