2011 International Conference on Software and Computer Applications
IPCSIT vol.9 (2011) © (2011) IACSIT Press, Singapore

Knowledge Acquisition Implementation for Advanced Expert System Processing

Marek Penhaker

VSB-TU Ostrava, FEECS, DMC, 17. listopadu 15, 70833, Ostrava, Czech Republic

Abstract. The aim of this thesis is the processing and evaluating of plethysmographycal records giving important information about the blood vessel function. Result of this study is to present the methodology, that was named SYMPLERA (Systematic Method for Plethysmographycal Records Analysis), for classifying the records by means of mathematical methods, that would contribute to systematic evaluation of what has been found by finger plethysmography. Essence of this methodology is to make use of the wavelet and Fourier integral transformations, the mathematics base and use of which has been described in this study. Modification of the original Walsh – Paleye wavelet basis is further contribution of this thesis. The wavelet transformation has been used in order to eliminate eventual disorders and errors in scanning of the plethysmographycal record. Special partial programs have been created in order to be able to verify individual proceedings in MATLAB. Results of these programs have been used to evaluate the records by means of the experimental fuzzy expert system

Keywords: Acquisition, Processing, Implemetation, Expert System

1. Introduction

The finger pletysmography is a noninvasive method for recording pulse waves from fingertips of human extremities. Pulse wave is created by the heart activity and by penetration of blood through the vascular system. This principle is based on the model of elasticity. The model consists from a pump, wide pipe with the elastic wall and from small pipes which present peripheral resistance. The principle is in the elastic pliability which enables equable shifting of blood in periphery. If the pipe (in our case blood vessel) is from some reason without elasticity which could be caused by some illness or defect, the periphery suffers from lack of blood.

The waveform depends on the quality of elasticity of arterial walls. The pulse wave consists from two parts: anacrotic - ascendant, katacrotic-descendant. On the descendant part appears so-called dicrotic notch (or wave) and it gives a very important information about the elasticity of the vascular wall.

The variability of particular plethysmografycal records is rather wide therefore till now the definite criterions that determine limit between physiological and pathological trace were not established. It is why the analyses of records is a time consuming process and the evaluation is before all subjective and it depends on the knowledge and skill of physicians. The aim of this study is to find out the most used methods of evaluation of plethysmografycal record till this time and a proposal for evaluation with the use of new methods of processing by the help of computers and new mathematical methods.

2. The Knowledge Acquisition for Evaluation of Pulse Wave

Skilled physician did evaluation of pulse waves visually or with the help of the of the most used criterions. Some of that criterion did no take in question the possibility of a change of pulse frequency during examination and from it arose an error in reafing of parameters of pulse wave. The errors was bigger with more quick pulse frequency.

During the evaluation of the dicrotic wave is important not only has the form of the wave but also its location on the katacrotic parted of the pulse wave. In time domain is important to observe the location of dicrotic wave on the katacrotic part to the peak of the pulse wave itself because it predicates a lot of about the condition of blood vessels and their elasticity.

Now used criterions for evaluation of pulse wave are Frequency of the pulse wave, Peak time, Time of inclination, Time of descent, Time of propagation of the pulse wave, Index of elasticity, Magnitude of pulse wave amplitude, Evaluation of the dicrotic wave.

3. Supplementary Criterions for Description of Pulse Wave

In time domain it is very important to find the placement of dicrotic wave on the descendent part of the pulse wave. The advantageous is to use criterion which express the ratios of individual parameters of the pulse wave. We used such parameters, which could better define relations between single parts of pulse wave and limit the influence of the change of pulse frequency and magnitude of amplitude.

Ratios of magnitudes of single parts of a pulse wave could easier determine the location placement of particular parts of a pulse wave with respect for the magnitude of pulse wave which could be at every single measurement variable. The parameter-ratio between peaks distance(MVV) is defined as a ratio of a distance between peaks of pulse wave and a dicrotic wave to a distance of dicrotic wave and dicrotic notch. (Figure 3)

$$MVV = \frac{x}{y} \tag{1}$$

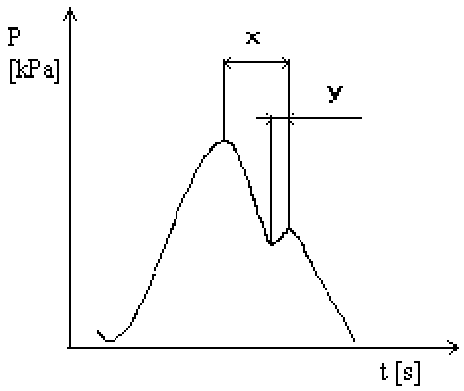

Fig. 2:Ratio between peaks distance

4. Software Architecture Implementation

For verification of proceedings at application DWT the original library of some functions was suggested and realised in the program MATLAB that solves direct and reverse wavelet transform with the use of various maternal wavelet (bases). The part of this library is original graphical users program WAV_PVP for analysis and elaboration of the pulse wave that uses functions of this library and enables transformed signals of pulse wave to analyse by the classical mathematical and statistical methods.

4.1. Scheme and Description of Elaboration

The Wavelet transform I have used in this study for the filtration of plethysmografycal record (PZ) to eliminate possible failures and inaccuracy during the scanning. The compress quality of wavelet transform I then utilised for the saving of archive space for data storage on recording mediums.

Therefore I must the acquired PZ to compress with various types of transform bases into various depth (compression to 1/2, 1/4, 1/8 a 1/16 of the original signal length), without use of filtration (zeroing). Then it was also need to determine the suitable zeroising in the relation on the type (hard, soft, kvantil, universal) and various sizes (60%, 80% a 100%).

I divided the task into three basic parts:

- Compression of the signal
- filtration of signal
- filtration and following compression of signal

It was a task to find out the best type of transform base for the compression of the signal, at the filtration the best type of zeroing (also the magnitude of zeroing) and in the end to integrate filtration and compression to save storage space on the disc. The graphical results of the transformation of the plethysmografycal record were consulted with physician. In Cupertino with the physician I had chosen as the maximum compression (at which is the signal for physician well readable – not distort) on 1/4 of its original length with the use of Daubechies base of the 2. Grade (D2). For filtration I had chosen the kvantil zeroing with the magnitude 90% - 100 % at base D8 namely at all compressions (1/2, 1/4, 1/8), from that the compression was set and the signal was decompressed. At 1/16 the distortion was manifested, and the physician could make the false diagnosis. It is why are rather better 1/2, 1/4 a 1/8. If we want to conclude, the best from physician point of view is:

- compression D2 to 1/4
- kvantil zeroing with magnitude 90% - 100% at base D8

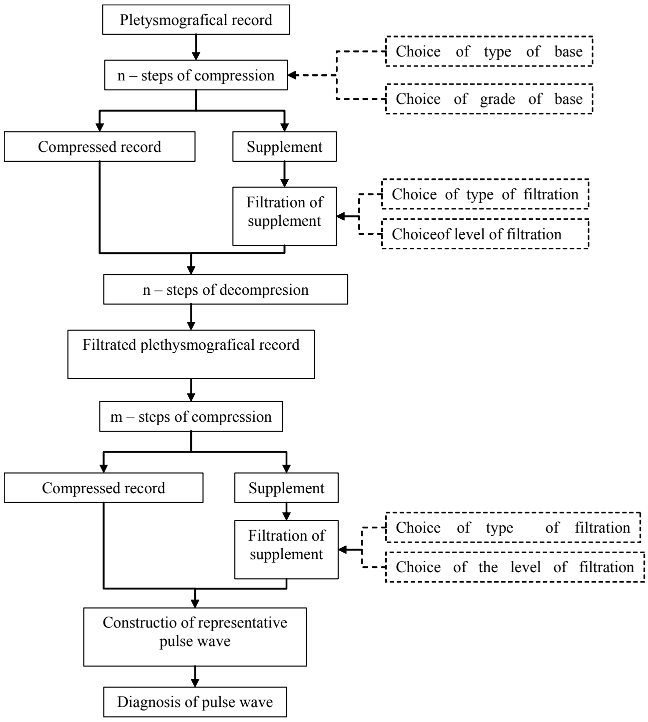

Fig. 3: Diagram of evaluation of plethysmografycal record by wavelet transformation

Diagram of evaluation of plethysmografical by wavelet transform (fig. 8) contains the construction of representative pulse wave until the end because during the transformation rises distortion in some initial points of evaluated signal and it depends on the type of used base and it could affect the form of the resulting pulse wave. Therefore in contrast from the scheme of evaluation plethysmografycal record in time domain is better as a transformed signal to choose the whole plethysmografycal record and after the processing by wavelet transform then the representative course of pulse wave to create. The entire processing I did with plethymografycal record its length is given in the number of points and not in seconds what is in virtue of discretisation. For these purposes it is more advantageous. Finally I can the number of points transfer on a time scale in seconds with the help of sampling frequency that is 100 points.s^{-1}, e.g.512 points is 5,12 s.

5. Expert System Testing

The testing of expert system I divided into three groups according to input variables represented by three base knowledge A, B, C.

The testing of quality of the linguistic model was done by interactive setting of question x1 till x4 (setting of values input variable) and expert appreciation of the constructive answer quality (determined diagnosis) with the use of particular knowledge bases A, B, C. Experimental verification of diagnostic effect of suggested method for evaluation of plethysmografycal records was done on four real records. These test records serve for verification of predicative abilities of suggested bases and for verification of estimation accuracy of diagnostic effect. The results of testing for particular bases are shown on fig. 31 till 46.

The problem orientation of fuzzy model system LMPS is done on the basis of expert evaluation of the real data measured by analyses of real plethysmographycal records and supplemented with diagnosis declared by doctor. In the present the system is able to recognize two chosen diagnoses II and I. The set of 28 measurements was used for testing method SYMPLERA (Figure 4). The expert system proved in use good results. Its fruitfulness at determination of diagnosis was 90 %.

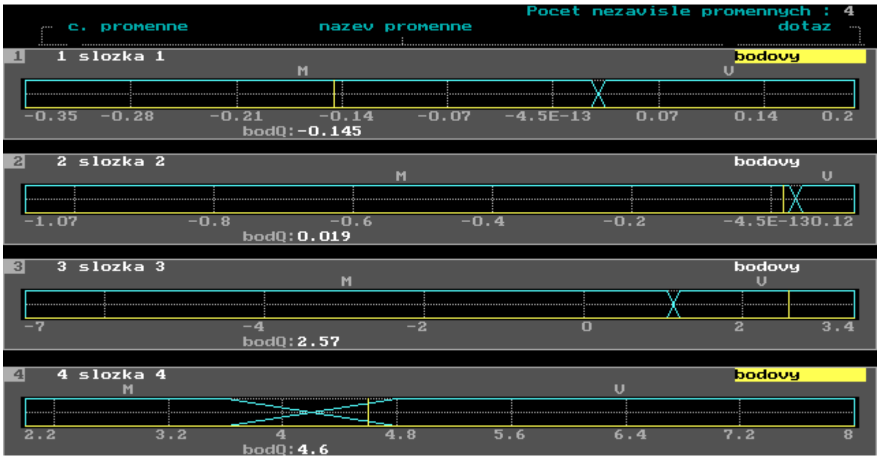

Fig. 4: Question setting for record number 4.

6. Conclusion

Our research about possibilities for automatic evaluation of finger plethysmography is possible to divide into two essential parts. The first one is the effort to find out how to make the evaluation more exact and more objective with the use of mathematical methods . For this purpose it seems to us is the most effective the Fourier transform.

In the second part we concentrated on the possibility of signal compression with the appropriate use of filtration. We used for it wavelet transform. But it is only one of a lot of options which wavelet transform offers. Only the further research will declare if it is possible to use this transform more often for analysis of a plethysmographycal record.

This method was already successfully proved on the small tested group of 16 people. But we need to perform more explorations on much bigger set of patients to find out the answer to the question if this method is really effective for elaboration of correct diagnosis, monitoring of a development of diseases of the vascular system and effect of the treatment.

Thereafter will be done the final appraisal of this method. For the present we still cannot to enunciate definitely if the answer is positive or negative. But even the negative conclusion could have an informative value.

The result of this work was the creation of the original algorithms for determination of new criterions and a suggestion of the expert system of computerized evaluation of plethysmografical record that uses these criterions. The testing of this expert system verified the good predicative ability of suggested criterions and thanks to it even the expectation that these criterions bring the information about the condition of the vascular system. The diagnoses that were made by this expert system were in coincidence with consultants. The expert system is prepared for further checking in clinical praxis.

7. Acknowledgements

The work and the contribution were supported by the project Grant Agency of Czech Republic – GAČR 102/08/1429 "Safety and security of networked embedded system applications". It was also supported by the Ministry of Education of the Czech Republic under Project 1M0567. Students Grant Agency SGS SV450021," Biomedical Engineering Systems VII"

8. References

[1] G. Garani, G. K. Adam, Qualitative modelling of manufacturing machinery *In Book - 32nd Annual Conference on IEEE Industrial Electronics*, IECON 2006 VOLS 1-11 p. 1059-1064, 2006 , ISSN: 1553-572X, ISBN: 978-1-4244-0135-2

[2] Černý, M.: Movement Monitoring in the HomeCare System . *In IFMBE proceddings. Ed. Dossel-Schleger, Berlin:Springer*, 2009, issue. 25, ISBN 978-3-642-03897-6; ISSN 1680-07

[3] T. Sikora,. Wear-Out Characteristics of Electric Distribution System Components. EPE: *Proceedings of the 9th International Scientific Conference Electric Power Engineering* 2008, 2008, p. 432.

[4] L. Prokop, S. Misak, And Krejci, P. Analysis of Long time WPP PowerFlows Measurement. edited by S. RUSEK AND R. GONO. Edtion ed., 2009. 373-378 p. ISBN 978-80-248-1947-1.

[5] Z. Machacek, V. Srovnal, “Automated system for data measuring and analyses from embedded systems”, *In 7th WSEAS International Conference on Automatic Control, Modeling and Simulation*, Mar 13-15, pp. 43-48, Prague, Czech Republic (2005)

[6] J. Skapa, V. Vasinek, P. Siska, Analysis of Optical-Power Redistribution for Hybrid Optical Fibers *In Book Fiber Optic Sensors and Applications Volume 6770*, 2007 ISSN: 0277-786X, ISBN: 978-0-8194-6930-4, DOI: 10.1117/12.752587

[7] Cerny, M. Movement Activity Monitoringof Elederly People – Application in Remote Home Care Systems In Proceedings of 2010 Second International Conference on Computer Engineering and Applications ICCEA 2010, 19. – 21. March 2010, Bali Island, Indonesia, Volume 2NJ. IEEE Conference Publishing Services, 2010 p. ISBN 978-0-7695-3982-9

[8] Vasickova, Z., Augustynek, M., New method for detection of epileptic seizure, Journal of Vibroengineering, Volume 11, Issue 2, 2009, pp.279-282, (2009) ISSN 1392 - 8716

[9] Kašík, V.: The Laboratory for PLD Education - Technical Equipment Design and Development. In *conference proceedings PDS 2003*, Oxford :IFAC, Pergamon, **2003**, p. 391 – 394, ISBN 0-08-044130-0, ISSN 1474-6670

[10] O. Krejcar, Problem Solving of Low Data Throughput on Mobile Devices by Artefacts Prebuffering. EURASIP Journal on Wireless Communications and Networking, 2009, Article ID 802523, 8 pages. Hindawi publishing corp., New York, USA, DOI 10.1155/2009/802523

[11] O. Krejcar, R. Frischer, Non Destructive Defects Detection by Performance Spectral Density Analysis, Journal Sensors, MDPI Basel, Vol. 11, No. 3., pp. 2334-2346. (2011)

[12] O. Krejcar, R. Frischer, Detection of Internal Defects of Material on the Basis of Performance Spectral Density Analysis, Journal of Vibroengineering, 2010 – Vol. 12, No. 4 - pp. 541-551.

[13] O. Krejcar, D. Janckulik, L. Motalova, Complex Biomedical System with Biotelemetric Monitoring of Life Functions. In Proceedings of the IEEE Eurocon 2009, May 18-23, 2009, St. Petersburg, Russia. pp. 138-141. DOI 10.1109/EURCON.2009.5167618