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(71) Applicant *(for all designated States except US)*: **MEDICALGORITHMICS SP. Z O.O.** [PL/PL]; ul. Druzynowa 3/2, PL-02-590 Warszawa (PL).

(72) Inventor; and

(75) Inventor/Applicant *(for US only)*: **DZIUBINSKI, Marek** [PL/PL]; ul. Legendy 3/57, PL-01-361 Warszawa (PL).

(74) Agent: **CZERNICKI, Lukasz**; WTS Patent Attorneys, ul. R. Weigla 12, PL-53-114 Wroclaw (PL).

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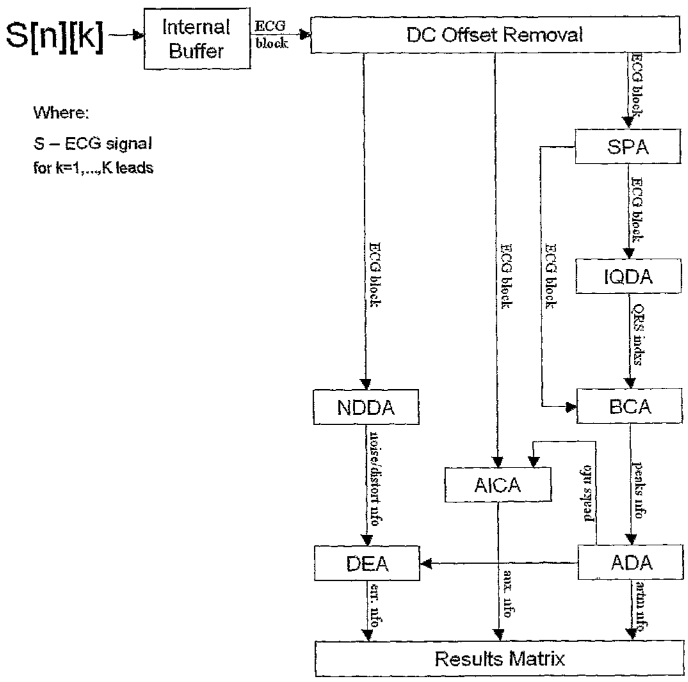
(54) **Title:** METHOD, DEVICE AND SYSTEM FOR LEAD-LIMITED ELECTROCARDIOGRAPHY (ECG) SIGNAL ANALYSIS



(57) **Abstract:** The invention is a method, device and system for lead-limited electrocardiography (ECG) signal analysis. The invention comprises steps of receiving an ECG sensor signal representative of heart activity from a plurality of ECG leads, pre-processing the ECG sensor signal and a step of identifying a heart arrhythmia and ST segment elevation by means of expert systems including neural networks.

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Method, device and system for lead-limited electrocardiography (ECG) signal analysis

Subject of the invention is a method, device and system for lead-limited electrocardiography (ECG) signal analysis.

Automated analysis of the digitized ECG signal has various applications. Algorithms operating in real-time with the ability to deal with lead limited signals are useful in external defibrillators, lead-limited monitoring systems and in Home Tele Care (HTC) applications. In the case of lead limited (particularly single lead) ECG it is sometimes very difficult to distinguish automatically between normal QRS complexes and pathological (related to ventricular contractions) ECG peaks. This is due to the fact that normally pathological complexes are significantly wider and have larger amplitude, however in some cases the situation may be the opposite. A decrease in the number of leads causes the number of misinterpreted events to increase due to stronger influence of noise and parasite impulses. In an extreme case of a single lead, it is potentially very difficult to distinguish between parasite peaks and QRS complexes due to the lack of additional leads, which could be used for reference or comparison.

Analysis of the 1, 2 or 3 lead ECG is based on computing limited number of electrocardiographic signals, originating from 2 or 3 electrodes (for single lead ECG at least 2 electrodes are required). This type of ECG is common in other medical units (excluding cardiology units) such as intensive care units etc., where patients are monitored for a long time. The main benefit of using limited lead ECG is its simplicity (mounting only few (2 or 3) electrodes is not complicated, and provides more freedom in choosing areas of the body to attach the sensors).

Analysis of single lead ECG signals is extremely difficult, because such signals contain a large number of ambiguities (signals from various patients may be very substantially different). When disturbances occur it is easy to confuse parasite impulses (peaks) with the impulses generated by the heart. In addition, such analysis (by definition) provides limited amount of information (in comparison to 12 lead ECG).

Therefore, single lead ECG analysis presents a great challenge from algorithmic point of view. Algorithms, which deal with such signals effectively are very rare.

The object of this invention is to provide a method, device and system for ECG signal analysis having the ability to automatically identify heart arrhythmias from an ECG signal gathered from a limited number of leads, preferably from a single lead, in real time.

A method for lead-limited electrocardiography (ECG) signal analysis according to the invention comprises a step of receiving an ECG sensor signal representative of heart activity from a plurality of ECG leads; a step of pre-processing the ECG sensor signal and a step of identifying a heart arrhythmia by means of expert systems. Preferably, the step of identifying a heart arrhythmia by means of expert systems comprises a step of detecting QRS complexes in the ECG sensor signal. It is also advantageous that the step of detecting QRS complexes in the ECG sensor signal is followed by a step of classifying of the detected QRS complexes. Preferably, the step of identifying a heart arrhythmia is followed by a step of verifying of identified heart arrhythmias. Furthermore, the step of identifying heart arrhythmias preferably comprises a step of detecting noise and/or distortion of the ECG sensor signal. Another advantageous feature is that the method further comprises a step of detecting auxiliary data, where the auxiliary data comprise, in particular, average heart rate and/or rhythm irregularities and/or ST segment elevation and/or AC interference and/or noise level. The expert systems identifying heart arrhythmias preferably utilize neural networks or statistical decision methods. Most significantly the method may operate even when the ECG sensor signal representative of heart activity is gathered from a single ECG lead.

A device for lead-limited electrocardiography (ECG) signal analysis according to the invention comprises input unit for receiving an ECG sensor signal representative of heart activity from a plurality of ECG leads, means for pre-processing the ECG sensor signal and means for identifying a heart arrhythmia by utilizing expert systems.

A system for lead-limited electrocardiography (ECG) signal analysis according to the invention comprises plurality of ECG leads for collecting an ECG sensor signal representative of heart electrical activity, input unit for receiving the ECG sensor signal, means for transmitting the ECG sensor signal to the input unit, means for pre-processing the ECG sensor signal and means for identifying a heart arrhythmia by utilizing expert systems.

Preferably, the means for identifying heart arrhythmias by utilizing expert systems comprises means for detecting QRS complexes in the ECG sensor signal. It is also advantageous when the means for detecting QRS complexes in the ECG sensor signal is connected with means for classifying of the detected QRS complexes. Preferably, the means for identifying a heart arrhythmia is connected with means for verifying of identified heart arrhythmias. Furthermore, the means for identifying heart arrhythmias preferably comprises means for detecting noise and/or distortion of the ECG sensor signal. Another advantageous feature is that the device/system further comprises means for detecting auxiliary data, where the auxiliary data comprise in particular average heart rate and/or rhythm irregularities and/or ST segment elevation and/or AC interference and/or disturbing noise level. Most significantly the device/system may operate even when the ECG sensor signal representative of heart activity is gathered from a single ECG lead, therefore the system may well operate with a single ECG lead. The expert systems identifying heart arrhythmias preferably utilize neural networks or statistical decision methods.

Furthermore, means for transmitting the ECG sensor signal are operative of remote transmission, where the input unit is operative to receiving the ECG sensor signal remotely. The system may be a portable system. It may be further equipped with means for identifying critical data concerning identified heart arrhythmias and/or pathological ST segment elevation as well as with means for transmitting the critical data concerning identified heart arrhythmias. Preferably, the system further comprises means for deciding on method of transmitting the critical data concerning identified heart arrhythmias and/or pathological ST segment elevation, for example by a multimedia message system - MMS, short message system – SMS, an electronic message (email), or file transferred with the use of File Transfer Protocol - FTP, or other type of data transfer protocol when the system is within a range of a “hot-spot” or GPRS network.

The method / device / system detects several arrhythmias and cardiac events such as asystole, pause, idioventricular rhythm, accelerated idioventricular rhythm, ventricular tachycardia / ventricular fibrillation, group of ventricular beats, ventricular bigeminy, ventricular trigeminy, ventricular premature beat, ventricular premature beat "R on T" type, supraventricular tachycardia, atrial bigeminy, atrial trigeminy, atrial premature beat, sinus bradycardia, missed beat or atrial fibrillation.

The device / system also provides auxiliary information related to the analysis such as average heart rate (HR), rhythm irregularity indicator, ST segment elevation, AC interference level, error or disturbance detection.

The invention may be better understood by reference to accompanying drawing in which:

FIG. 1 is a flow-chart of a preferred embodiment of the lead limited ECG signal analysis algorithm.

FIG. 2 schematically illustrates the system for the lead limited ECG signal analysis.

FIG. 3 schematically illustrates the device for the lead limited ECG signal analysis.

FIG. 4 shows graphical representation of asystole.

FIG. 5 shows graphical representation of pause.

FIG. 6 shows graphical representation of ventricular tachycardia & group of ventricular beats & (accelerated) idioventricular rhythm.

FIG. 7 shows graphical representation of ventricular bigeminy.

FIG. 8 shows graphical representation of ventricular trigeminy.

FIG. 9 shows graphical representation of premature beat.

FIG. 10 shows graphical representation of ventricular premature beat ("R" on "T" type).

FIG. 11 shows graphical representation of supraventricular tachycardia.

FIG.12 shows graphical representation of atrial bigeminy.

FIG.13 shows graphical representation of atrial trigeminy.

FIG.14 shows graphical representation of atrial premature beat.

FIG.15 shows graphical representation of bradycardia.

FIG.16 shows graphical representation of missed beat.

FIG.17 shows graphical representation of atrial fibrillation.

FIG 1. demonstrates an embodiment according to the invention, where a signal S[n][k], k-representing number of leads is subject to the number of processing steps. The presented embodiment must be considered as an example of putting the invention into practice and, therefore, should not be interpreted as limiting the scope of the protection claimed.

The Signal Pre-processing Algorithm (SPA) is responsible for AC interference elimination which is performed by linear phase notch filter. It also removes DC offset and ultra low frequency baseline drift, utilizing delay free linear phase filtering routine, originally developed for the invention. Noise reduction algorithm supported by Heuristic Periodicity Analyzer removes broad band noise and impulsive disturbances and is used for noise level estimation.

Further, QRS detection is performed by statistics based methods in an Intelligent QRS Detection Algorithm (IQDA), which is utilizing information about average HR, higher order statistics description of the rhythm evolution, QRS complexes properties, such as shape and amplitude, T wave shape, base line behavior, noise level and many others, providing very robust decision results.

Next, a Beat Classification Algorithm (BCA) is used. Based on feature vector (FV) containing description of currently analyzed beat, statistical classifier and ANN system (Artificial Neural Network) performs classification with accordance to peak shape, width, amplitude and with reference to previously calculated feature vectors describing past beats. After primary recognition, BCA performance is evaluated with reference to multidimensional prediction coefficients, describing evolution of the feature vectors. Based on the Euclidean distance between predicted FV and measured FV, unpredictability measure parameter for the current beat is estimated and primary recognition improved.

Further, an Arrhythmia Detection Algorithm (ADA) is utilized. After beats classification, ADA performs arrhythmia detection with accordance to predefined logic rules, however similarly to BCA primary recognition process, the decision making module in ADA is based on statistical classifier which adaptively (to the rhythm behavior) performs classification task.

Next, a Detection Evaluation Algorithm (DEA) is employed. Beat recognition and arrhythmia detection is performed for all fragments (even extremely distorted) of the ECG signal. In some cases, however, distortions and noise level may cause misclassifications. Based on the base line drift, peak shape unpredictability, T wave shape behavior, and other parameters, DEA performs evaluation of the calculated results, giving additional information describing the accuracy of the results.

At the same time a Noise and Distortion Detection Algorithm (NDDA) is used. Independently to the peaks FV behavior (used in DEA), nonlinear distortion detection algorithm and broad band noise detector analyze the entire ECG signal block and in case of high level disturbances, classifies detection results as possibly erroneous.

An Auxiliary Information Calculation Algorithm (AICA) is employed as well. AICA module is responsible for calculating average HR, irregularity indicator, ST segment elevation and AC interference level. AC interference calculation algorithm is high performance, inner product based routine providing very precise results (exceeding standard FIR, IIR filtering operations or Fourier analysis performance).

The invention is optimized to operate in hard conditions, where noise and other distortions might be present and life threatening arrhythmias or pathological ST segment deviation have to be detected with short delay and limited information. The method is able to perform very effectively on one lead ECG, however might be used for any number of leads. The method has ability to adopt to analyzed signal and due to learning procedures deals effectively with various and different ECG signals. The method operates in real-time and returns information about detected arrhythmias with very short delay, while maintaining low CPU usage.

The invention results in an automatic analysis of the signal lead ECG in order to detect arrhythmias and pathological ST segment deviation, especially those related to sudden cardiac death (efficiency in such cases is a key issue, since in case of undetected arrhythmias patient may die). On the other hand „too sensitive" arrhythmia detectors often tend to pick disturbances (parasite peaks) and treat them as a serious arrhythmia, raising alarm far too frequently, which results in decrease of the medical staff's vigilance.

Some arrhythmias occur very rarely and in case of mobile devices (such as holters) problems of limited storage space and extensive post-processing time requirements arise, since long (several days) constant ECG signal needs to be stored and analyzed. Based on efficient ECG analysis algorithm it is possible to store only interesting fragments of the signal which allows to reduce memory usage of the device and post-processing analysis effort. On the other hand, based on the real time analysis there is a possibility of sending an electronic message of any form (Multimedia Message - MMS, Short Message - SMS, file or email via GPRS, or via Wi-Fi) describing the cardiac event to an appropriate medical specialist.

Fig. 2 represents a schematic representation of an embodiment of the system according to the invention. The system may be called a pocket ECG system, which is a real-time monitoring system designed for long-term automated ECG arrhythmia analysis and short-response-based monitoring for myocardial infraction and sudden cardiac death detection. The system in FIG. 2 comprises ECG digitization and transmission unit A, operating on 2 electrodes (single channel), or 3 electrodes (2 channels), PDA with GSM phone unit B, Pocket PC software for real-time ECG monitoring and GPRS transmission unit C and PC based software/server for data management and ECG visualization unit D. The idea of the system is simple. It is designed to monitor ECG signal in real-time, at any location of the patient. After the system detects any pathological cardiac event it will automatically take a predefined action, which may in particular perform:

- raising a sound alarm on the PDA (i.e. to wake up the patient), and/or
- sending a relevant ECG signal fragment with analysis report to the server for further analysis and diagnosis confirmation and/or for archiving, and-or
- storing ECG fragment with analysis report on the PDA memory card for later reference.

In addition the system is designed to send daily recording summaries to the server for storage and further analysis.

The system may be applied in particular in ECG monitoring for detecting heart attack. It is especially important during the night, where the patient cannot feel any symptoms (this is a very common reason of heart failure). Also many cardiac events are asymptomatic, therefore monitoring during the day is of importance. Another important application is post-ablation monitoring, where some arrhythmias may occur very rarely, therefore it is important to monitor the patient for long period of time. Further, since PDA has become a very popular tool among the medical community (doctors), especially in the USA, extending the device by ECG real-time monitoring (e.g. during home visits) would be an easy and inexpensive way to provide more complete service for the patient. It is also possible to apply the system for ECG monitoring during patients transportation inside a hospital (where a stand-alone device cannot be used). Also monitoring in trauma scenes and ambulances. Finally, veterinary medicine applications are possible, where wireless (Bluetooth in this case) ECG transmission is the major added value, while animal can carry the lightweight BT transmitter and move around an apartment (in case of dogs) or a paddock (in case of horses). It is important to emphasize that certain breeds of dogs and racing horses may suffer form some of the arrhythmias and ECG analysis in such cases is a common procedure.

Fig. 3 schematically illustrates an embodiment of the device for the lead limited ECG signal analysis according to the invention. The ECG signal S obtained from a patient is put into the device K, where E represents a DC removal unit. From the DC removal unit signal enters into unit F responsible for performing the signal pre-processing, QRS detection and beat classification according to the method described in detail above. From F unit the signal is next provided to unit H, responsible for arrhythmia detection according to predefined logic rules utilizing expert systems. In particular the expert systems may employ neural networks, fuzzy logic, statistical methods, etc. At the same time signal from unit E is provided to unit G, where detection evaluation, noise and distortion detection as well as auxiliary information calculation takes place. Signals from unit G and H are then fed to unit L for final processing, which includes preparation of information V in the user-readable format.

It is important to note that the invention also relates to and may be used as a diagnostic method, therapeutic and a decision-making method.

The system constitutes a very flexible tool, designed to operate on ECG signals with all types of bit resolutions (fixed or floating point) and any sampling rates. Many arrhythmia recognition, peak classification and auxiliary information algorithm blocks operate on predefined, or adaptively calculated parameters. The table below presents parameters that are accessible by the user, and those, which are important for classification purposes. Arrhythmia classification is performed after peak recognition, according to the rules shown below. Default values of the parameters and methods to access the parameters settings are also described below.

Parameter	User access	Default value
minPauseDuration	yes	2.0 sec
maxPauseDuration	yes	3.5 sec
nVTpeaks	no	3 or 5
VTrate	yes	100 BPM
AIVRrate	yes	VTrate—BDrate
IVRrate	yes	BDrate
nBG	no	3
nTG	no	3
RTratio	no	Adaptive
nSVTpeaks	no	5
SVTratio	yes	130 BPM
nABG	no	3
nATG	no	3
SVratio	yes	0.85
nBDpeaks	no	adaptive
BDrate	yes	50 BPM
MBratio	no	adaptive

nAFpeaks	no	adaptive
AFratio	no	adaptive
ampThLev	yes	0
pthWidth	yes	120 ms
nHRpeaks	yes	10
nIRRpeaks	yes	30
ACintrFreq	yes	(SmpRate/6) Hz
recogMaxDelay	no	3.5 sec

FIG. 4 shows graphical representation of asystole. From the reference table we see that this condition is recognized in an embodiment according to the invention when a pause exceeds a value X of a pre-determined parameter called a maximum pause duration (*maxPauseDuration*), e.g., is longer that 3.5 seconds. FIG. 5 shows graphical representation of a pause. From the reference table we find out that this condition is recognized in an embodiment according to the invention when a pause duration X is longer than minimum pause duration (*minPauseDuration*), e.g., 2.0 seconds but still shorter than a maximum pause duration (*maxPauseDuration*). FIG. 6 shows graphical representation of ventricular tachycardia & group of ventricular beats & (accelerated) idioventricular rhythm. In the specific embodiment ventricular tachycardia is recognized when number K of ventricular tachycardia peaks (*nVTpeaks*) equals to or is greater than 3 (or 5 – to be determined by a user) and the average heart rate (A*verageHR*) is greater than ventricular tachycardia rate (*VTrate*), where the value of *VTrate* parameter is set to 100 beats per minute (BPM). Further, accelerated idioventricular rhythm is recognized when *nVTpeaks* parameter equals to or is greater than 3 (or 5), i.e. K>=3 (or 5), and the average heart rate (A*verageHR*) equals to or is greater than *VTrate* parameter and is smaller than accelerated idioventricular rhythm rate parameter (*AIVRrate*), where *AIVRrate* is a difference between *VTrate* parameter and bradycardia rate parameter (*BDrate*). In the embodiment the value of the *BDrate* parameter is set to 50 BPM. Next, idioventricular rhythm is recognized when *nVTpeaks* parameter equals to or is greater than 3 or 5, i.e. K>=3 (or 5), and the average heart rate (A*verageHR*) equals to or is greater than *AIVRrate* parameter and is smaller than idioventricular rhythm rate parameter (*IVRrate*), where the value of the *IVRrate* parameter equals the value of the *BDrate* parameter, i.e. 50 BPM. Also, group of ventricular beats may be recognized when the average heart rate is greater than the value of the the *VTrate* parameter and *nVTpeaks* parameter is smaller than 3 or 5 but still is recognized, i.e. K>1 but K< 3 (or 5 – to be determined by a user). FIG. 7 shows graphical representation of ventricular bigeminy. This condition is recognized in an embodiment of the invention when a number K of ventricular bigeminy groups parameter (*nBG*) equals to at least 3. In FIG. 8 graphical representation of ventricular trigeminy is shown. This condition is recognized in an embodiment of the invention when a number K of ventricular trigeminy groups parameter (*nTG*) equals to at least 3 as well.

FIG. 9 shows graphical representation of premature beat. FIG. 10 shows graphical representation of ventricular premature beat ("R" on "T" type). This condition is identified in the embodiment according to the invention when a relation X_{i-1}/X_i < RTratio is satisfied, where RTratio is an adaptive parameter and X_{i-1} and X_i denote duration between particular events (beats) as shown in FIG. 10. Further, FIG. 11 shows graphical representation of supraventricular tachycardia, which is recognized when number K of supraventricular tachycardia peaks (*nSVTpeaks*) equals at least to 5 and the average heart rate is greater than supraventricular tachycardia rate (*SVTrate*), where the value of *SVTrate* parameter in the embodiment is set to 130 BPM. FIG.12 shows graphical representation of atrial bigeminy, which is recognized when a number K of atrial bigeminy groups (*nABG*) equals to at least 3 in the embodiment. Similarly, atrial trigeminy shown in FIG.13 is recognized when a number K of atrial trigeminy groups (*nATG*) equals to at least 3 as well. FIG.14 shows graphical representation of atrial premature beat. This condition is determined in an embodiment, when a relation X_{i-1}/X_i < SVratio is satisfied, where SVratio (supraventricular ratio) is set in the embodiment to the value of 0.85 and X_{i-1} and X_i denote duration between particular events (beats) as shown in FIG. 14. FIG.15 shows graphical representation of bradycardia, which is recognized when the average heart rate is greater than bradycardia rate (*BDrate*), where the value of the *BDrate* parameter is set in the embodiment to 50 BPM and number K of bradycardia peaks (*nDBpeaks*) equals to or is greater than the value *nDBpeaks* parameter, which is an adaptive parameter. FIG.16 shows graphical representation of missed beat. This condition is identified when the condition *AverageHR/X=MBratio* is satisfied, where *AverageHR* parameter is the average heart rate, X is time between consecutive beats and *MBratio* is a predetermined adaptive parameter. Finally, in FIG.17 another embodiment according to the invention allows to identify atrial fibrillation. This condition is determined when K>=nAFpeaks-1, where *nAFpeaks* is a number of atrial fibrillation peaks and when heart rate irregularity (*HR irregularity*) is greater than atrial fibrillation ratio (*AFratio*) and the condition *HR irregularity* = $F_{HRI}(X_{i-K}, \ldots, X_i)$ is satisfied, where *nAFpeaks* and *AFratio* parameters are adaptive parameters and X denotes timing of particular events as shown in FIG.17.

Further parameters used in the embodiments according to the invention comprise minimum amplitude of the peak (*ampThLev*), minimum width of pathological beats (*pthWidth*), number of peaks used for average heart rate (HR) calculation (*nHRpeaks*), number of peaks used for irregularity indicator (*nIRRpeaks*), where *ampThLev* is set to 0, *pthWidth* equals to 120 ms, *nHRpeaks* is set to 10 and *nIRRpeaks* is set to 30.

All of the predefined parameters are used as reference values, however the decision process is very complex and additionally depends on adaptively changing variables with accordance to analysis conditions (properties of the ECG signal).

CLAIMS

1. A method for lead-limited electrocardiography (ECG) signal analysis comprising steps of:

receiving an ECG sensor signal representative of heart activity from a plurality of ECG leads;

pre-processing the ECG sensor signal;

characterized in that the method further comprises a step of identifying a heart arrhythmia by means of expert systems.

2. A method as claimed in claim 1 characterized in that the step of identifying a heart arrhythmia by means of expert systems comprises a step of detecting QRS complexes in the ECG sensor signal.

3. A method as claimed in claim 2 characterized in that the step of detecting QRS complexes in the ECG sensor signal is followed by a step of classifying of the detected QRS complexes.

4. A method as claimed in claim 3 characterized in that the step of identifying a heart arrhythmia is followed by a step of verifying of identified heart arrhythmias.

5. A method as claimed in claim 4 characterized in that the step of identifying heart arrhythmias comprises a step of detecting noise and/or distortion of the ECG sensor signal.

6. A method as claimed in any preceding claims characterized in that the method further comprises a step of detecting auxiliary data.

7. A method as claimed in claim 6 characterized in that the auxiliary data comprise average heart rate and/or rhythm irregularities and/or ST segment elevation and/or AC interference and/or noise level.

8. A method as claimed in any preceding claims characterized in that the expert systems identifying a heart arrhythmia utilize neural networks.

9. A method as claimed in any preceding claims characterized in that the ECG sensor signal representative of heart activity is gathered from a single ECG lead.

10. A device for lead-limited electrocardiography (ECG) signal analysis comprising:

input unit for receiving an ECG sensor signal representative of heart activity from a plurality of ECG leads;

means for pre-processing the ECG sensor signal;

characterized in that the device further comprises means for identifying a heart arrhythmia by utilizing expert systems.

11. A device as claimed in claim 10 characterized in that the means for identifying a heart arrhythmia by utilizing expert systems comprises means for detecting QRS complexes in the ECG sensor signal.

12. A device as claimed in claim 11 characterized in that the means for detecting QRS complexes in the ECG sensor signal is connected with means for classifying of the detected QRS complexes.

13. A device as claimed in claim 12 characterized in that the means for identifying a heart arrhythmia is connected with means for verifying of identified heart arrhythmias.

14. A device as claimed in claim 13 characterized in that the means for identifying heart arrhythmias comprises means for detecting noise and/or distortion of the ECG sensor signal.

15. A device as claimed in any claims from 10 to 14 characterized in that the device further comprises means for detecting auxiliary data.

16. A device as claimed in claim 15 characterized in that the auxiliary data comprise average heart rate and/or rhythm irregularities and/or ST segment elevation and/or AC interference.

17. A method as claimed in any claims from 10 to 16 characterized in that the expert systems identifying a heart arrhythmia utilize neural networks.

18. A method as claimed in any claims from 10 to 17 characterized in that the ECG sensor signal representative of heart activity is gathered from a single ECG lead.

19. A system for lead-limited electrocardiography (ECG) signal analysis comprising:

plurality of ECG leads for collecting an ECG sensor signal representative of heart electrical activity;

input unit for receiving the ECG sensor signal;

means for transmitting the ECG sensor signal to the input unit;

means for pre-processing the ECG sensor signal;

characterized in that the device further comprises means for identifying a heart arrhythmia by utilizing expert systems.

20. A system as claimed in claim 19 characterized in that the means for identifying a heart arrhythmia by utilizing expert systems comprises means for detecting QRS complexes in the ECG sensor signal.

21. A system as claimed in claim 20 characterized in that the means for detecting QRS complexes in the ECG sensor signal is connected with means for classifying of the detected QRS complexes.

22. A system as claimed in claim 21 characterized in that the means for identifying a heart arrhythmia is connected with means for verifying of identified heart arrhythmias.

23. A system as claimed in claim 22 characterized in that the means for identifying heart arrhythmias comprises means for detecting noise and/or distortion of the ECG sensor signal.

24. A system as claimed in any claims from 19 to 23 characterized in that the system further comprises means for detecting auxiliary data.

25. A system as claimed in claim 24 characterized in that the auxiliary data comprise average heart rate and/or rhythm irregularities and/or ST segment elevation and/or AC interference.

26. A system as claimed in any claims from 19 to 25 characterized the expert systems identifying a heart arrhythmia utilize neural networks.

27. A system as claimed in any claims from 19 to 26 characterized the system comprises a single ECG lead.

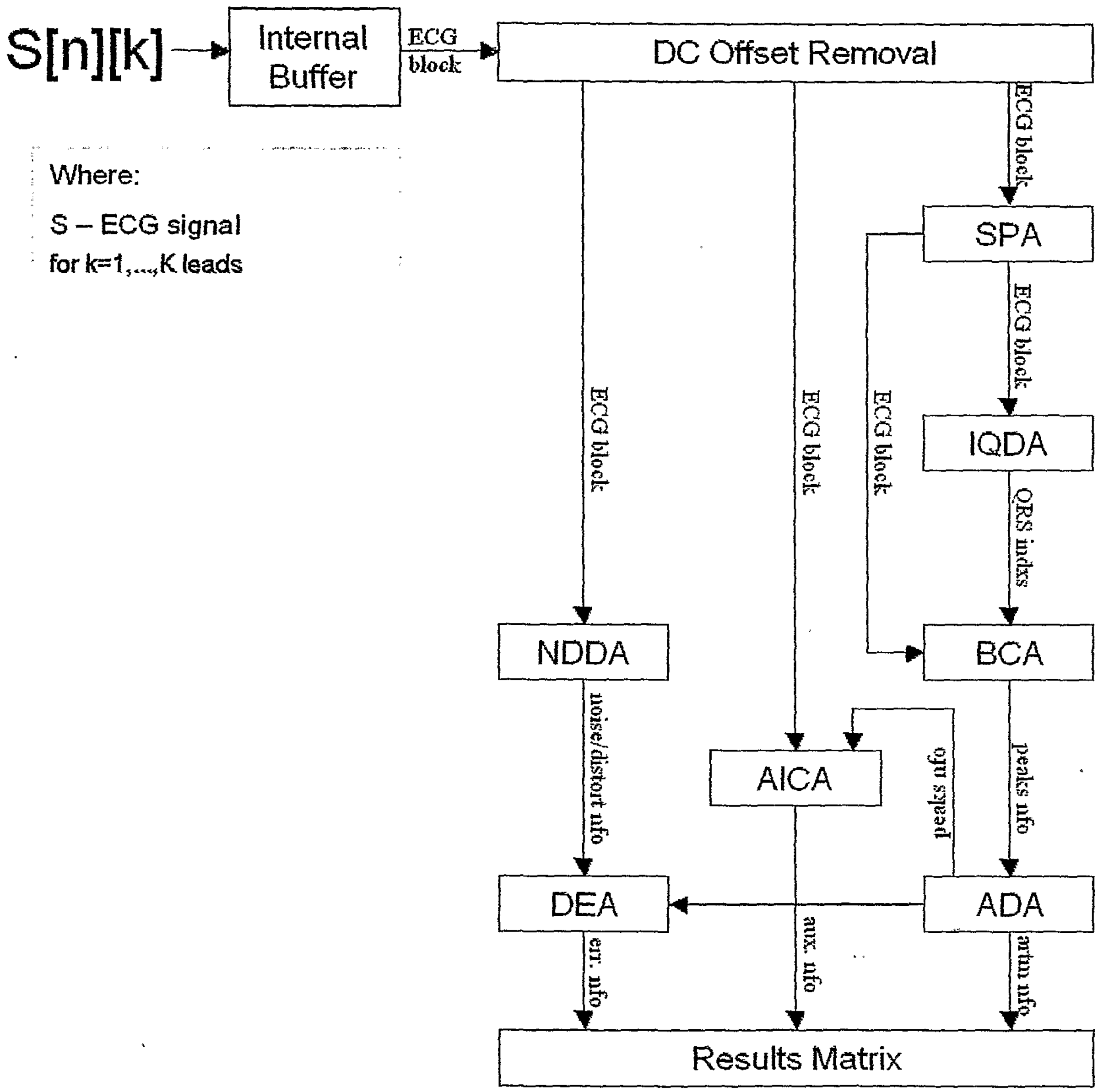
28. A system as claimed in any claims from 19 to 27 characterized in that the means for transmitting the ECG sensor signal are operative of remote transmission, where the input unit is operative to receiving the ECG sensor signal remotely.

29. A system as claimed in any claims from 19 to 28 characterized in that the system is a portable system.

30. A system as claimed in claim from 27 to 29 characterized in that the system further comprises means for identifying critical data concerning identified heart arrhythmias and pathological ST segment elevation.

31. A system as claimed in claim 30 characterized in that the system further comprises means for transmitting the critical data concerning identified heart arrhythmias.

32. A system as claimed in claim 31 characterized in that the system further comprises means for deciding on method of transmitting the critical data concerning identified heart arrhythmias.


S[n][k]
Internal Buffer
ECG block
DC Offset Removal
Where:
S – ECG signal
for k=1,...,K leads
ECG block
SPA
ECG block
IQDA
QRS indxs
ECG block
ECG block
ECG block
NDDA
BCA
noise/distort nfo
AICA
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ADA
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artm nfo
Results Matrix

Fig 1

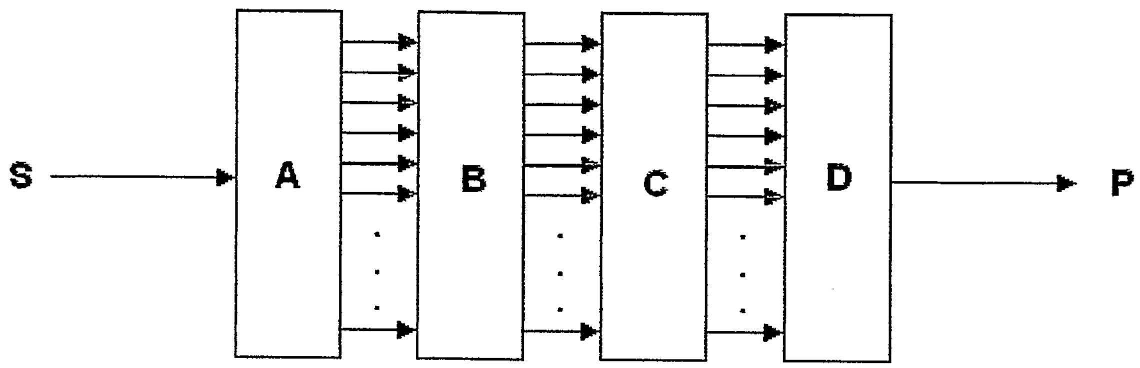

Fig. 2

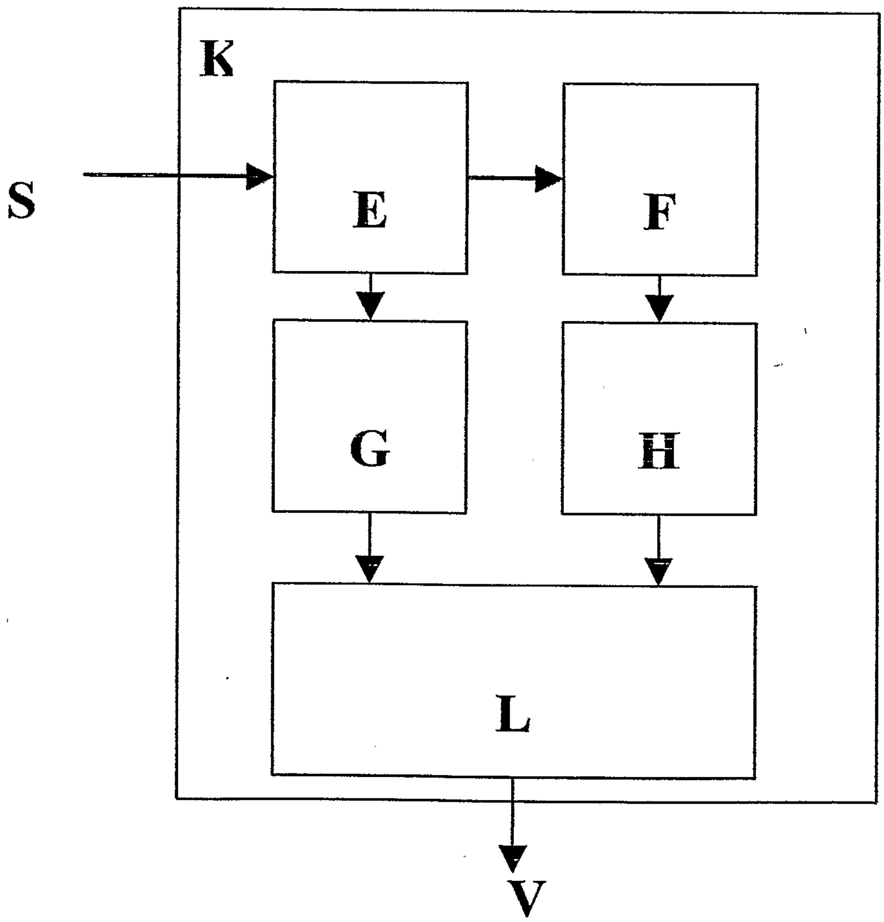

Fig. 3

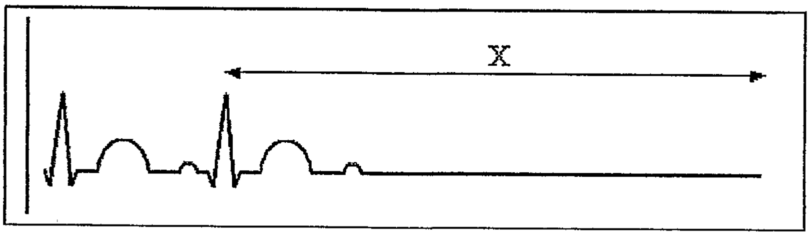

Fig. 4

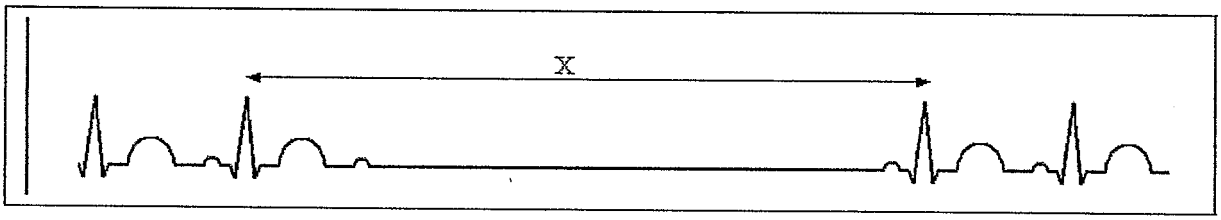

Fig. 5

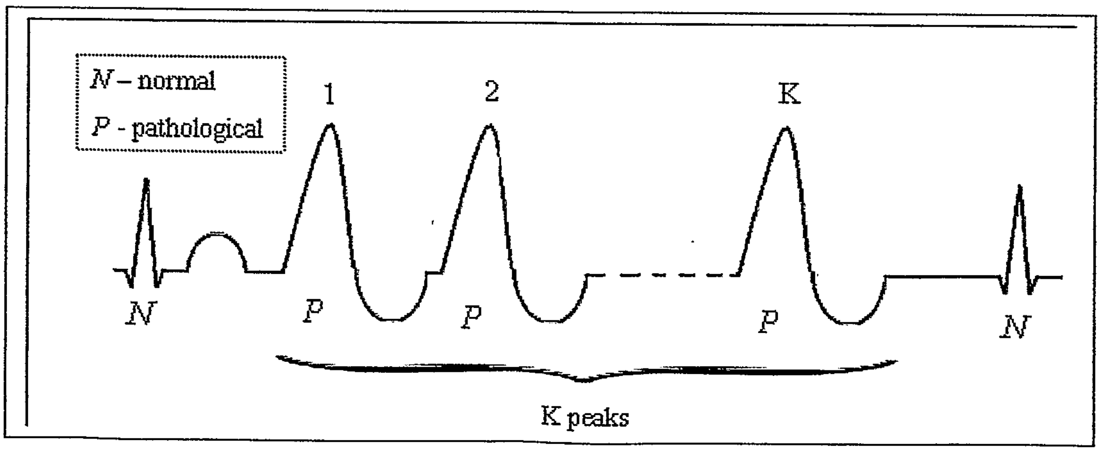

Fig. 6

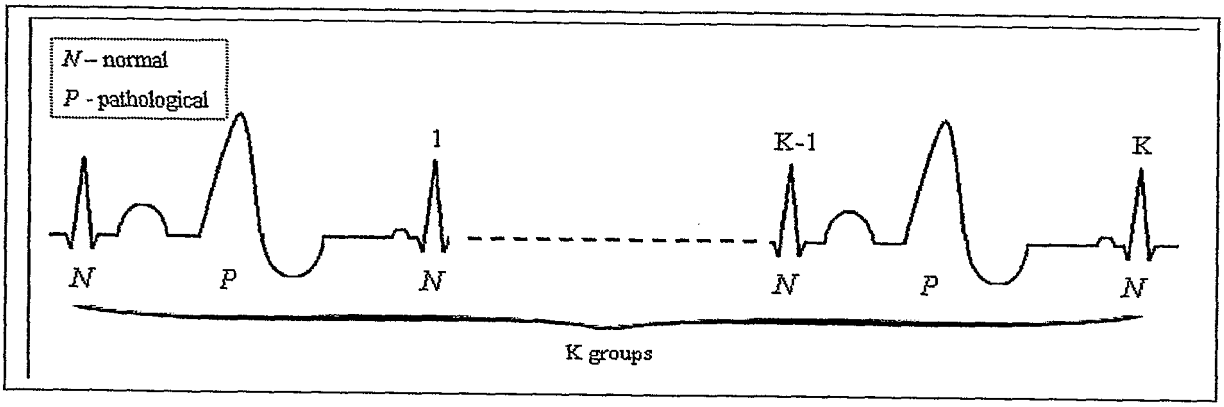

Fig. 7

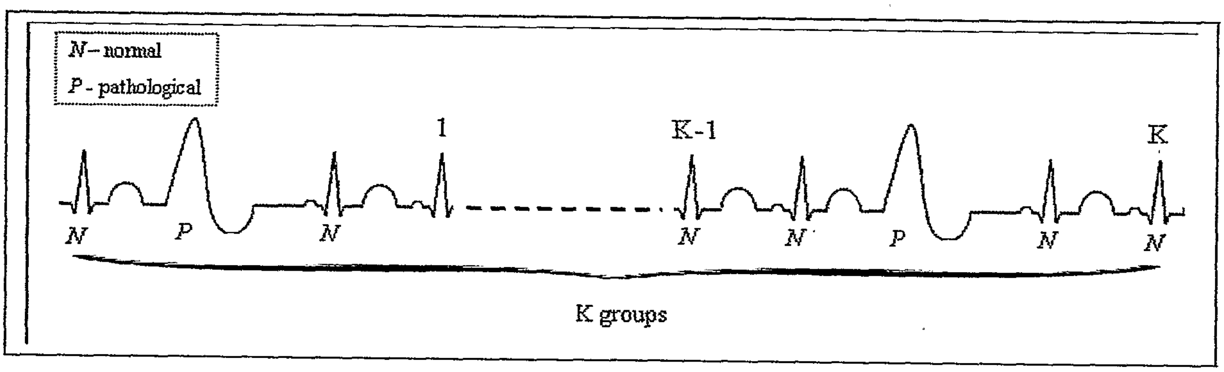

Fig. 8

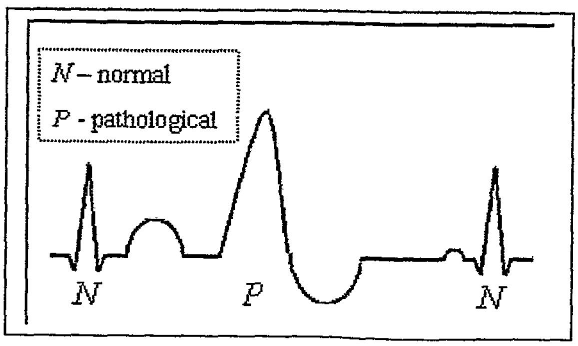

Fig. 9

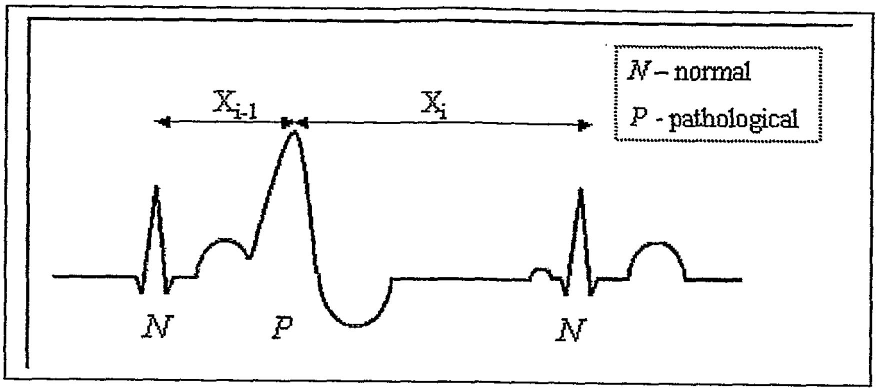

Fig. 10

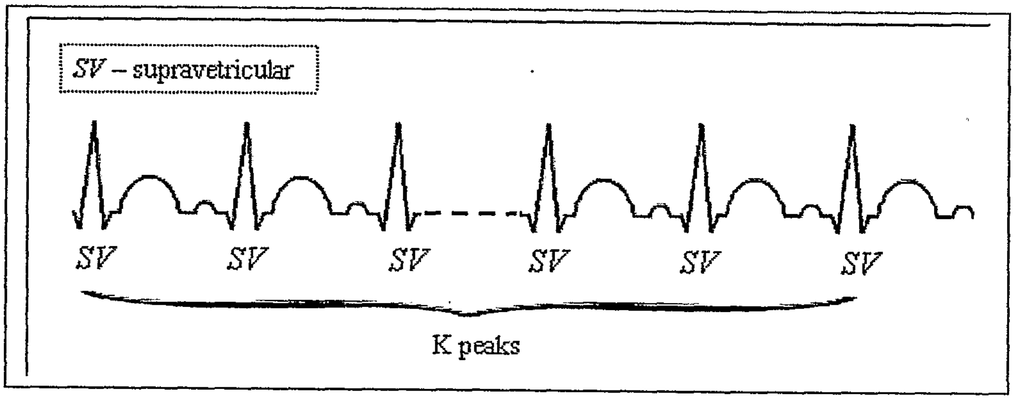

Fig. 11

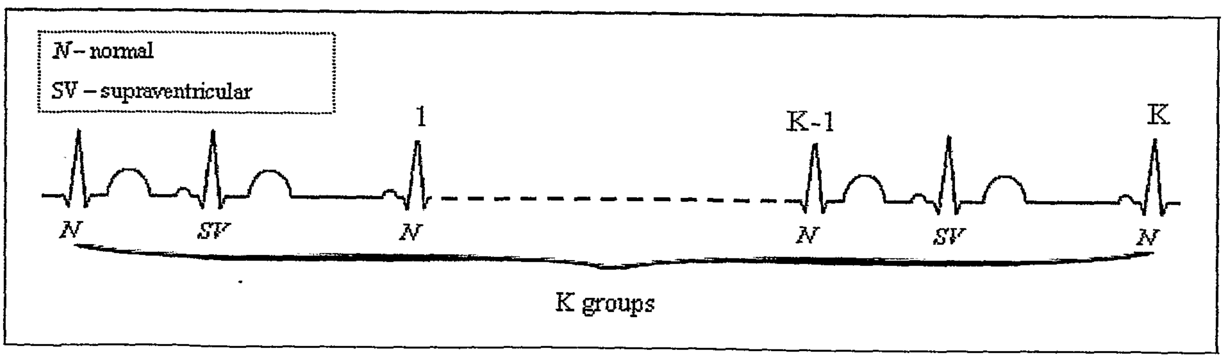

Fig. 12

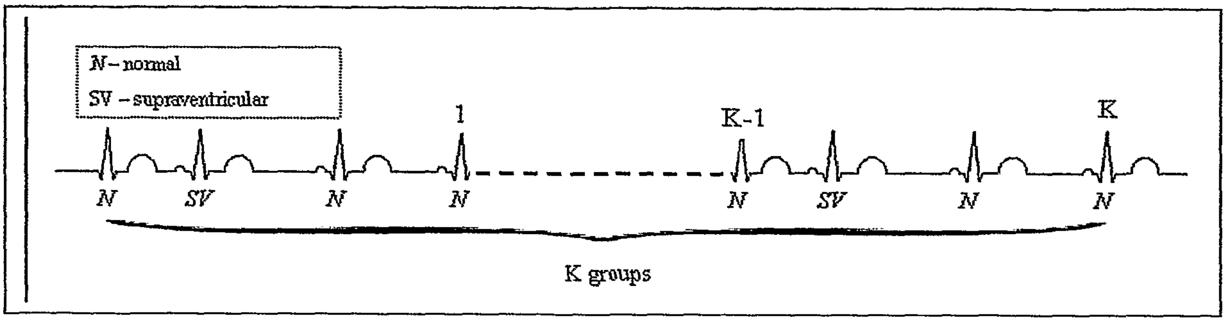

Fig. 13

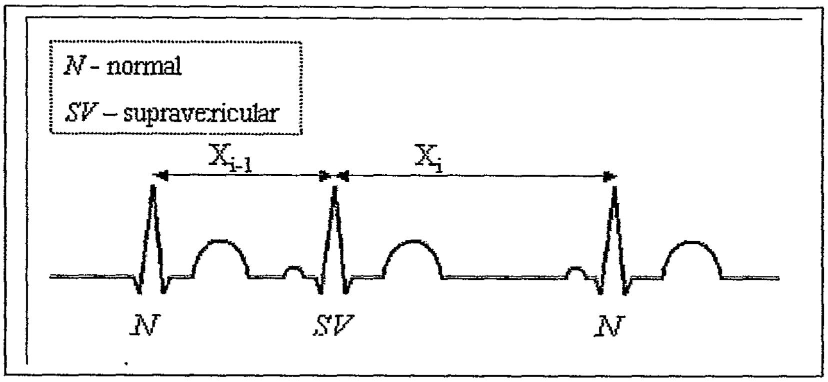

Fig. 15

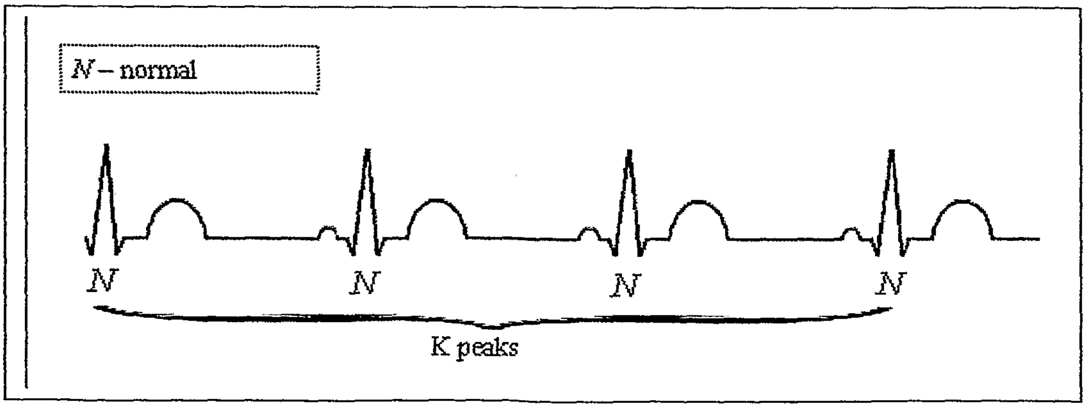

Fig. 16

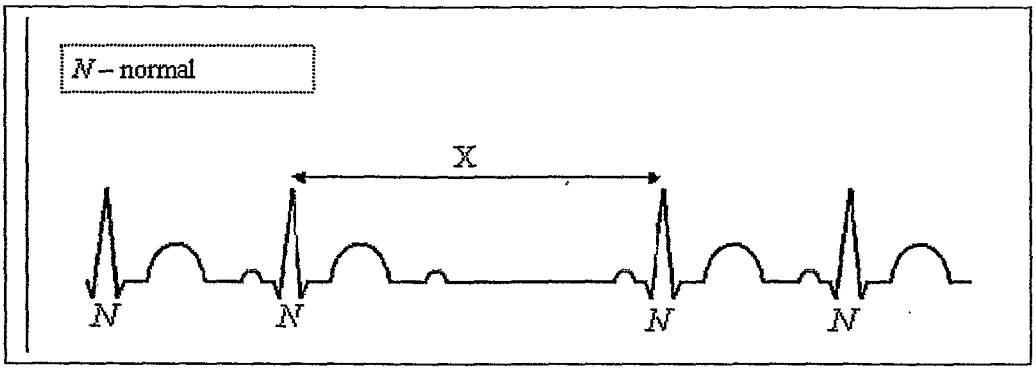

Fig. 17

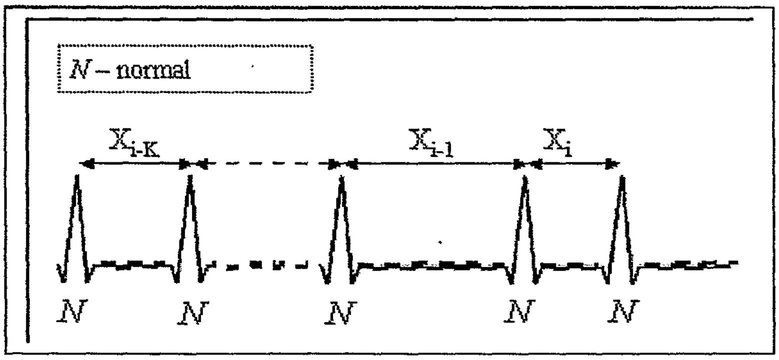

Fig. 18

INTERNATIONAL SEARCH REPORT

International application No
PCT/PL2006/000068

A. CLASSIFICATION OF SUBJECT MATTER
INV. G06F19/00 A61B5/0452 A61B5/00
ADD. A61B5/046 A61B5/0464

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G06F A61B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 819 007 A (ELGHAZZAWI ZIAD F [US]) 6 October 1998 (1998-10-06)	1-27,30
Y	column 5, line 24 - column 7, line 10 column 13, lines 22-56 figures 1-3 -----	1-32
X	WO 01/93758 A (CARDIONETICS LTD [GB]; HARRIS THOMAS JOHN [GB]; NEEDHAM PHILIP [GB]) 13 December 2001 (2001-12-13)	1-27,29,30
Y	page 4, last paragraph - page 7, paragraph 4 page 9, paragraph 1 - page 11, paragraph 4 page 12, last paragraph - page 16, paragraph 1 figures 2-7 ----- -/--	28,31,32

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
13 February 2007	26/02/2007

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Fischer, Olivier

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	KRISHNA PRASAD G ET AL: "Classification of ECG arrhythmias using multi-resolution analysis and neural networks" IEEE TENCON 2003. CONFERENCE ON CONVERGENT TECHNOLOGIES FOR THE ASIA-PACIFIC REGION. BANGALORE, INDIA, OCT. 15 - 17, 2003, IEEE REGION 10 ANNUAL CONFERENCE, NEW YORK, NY : IEEE, US, vol. VOL. 4 OF 4. CONF. 18, 15 October 2003 (2003-10-15), pages 227-231, XP010687073 ISBN: 0-7803-8162-9 the whole document	1-4,8, 10-13, 17, 19-22,26
Y	EP 1 473 667 A2 (TOPVINE MEDICAL MICROSYSTEMS L [GB]) 3 November 2004 (2004-11-03) column 4, line 16 - column 6, line 9 column 7, line 33 - column 9, line 29 figures 1-4	1-32
Y	US 5 749 367 A (GAMLYN LEE [GB] ET AL) 12 May 1998 (1998-05-12) column 4, lines 3-51 column 5, line 50 - column 6, line 60 column 7, line 62 - column 9, line 13 column 13, line 49 - column 16, line 37 figures 1-7,15-24	1-32
Y	WO 2005/006209 A (UNIV COLLEGE DUBLIN NAT UNIVER [IE]) 20 January 2005 (2005-01-20) page 4, paragraph 4 - page 5, paragraph 4	9,18,27

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/PL2006/000068

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
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			EP	1289413	A1	12-03-2003
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			NZ	316566	A	26-08-1998
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WO 2005006209	A	20-01-2005	NONE			

patsnap

专利名称(译)	用于铅限制心电图（ECG）信号分析的方法，装置和系统		
公开(公告)号	EP1952291A1	公开(公告)日	2008-08-06
申请号	EP2006812860	申请日	2006-10-16
[标]申请(专利权)人(译)	MEDICALGORITHMICS		
申请(专利权)人(译)	MEDICALGORITHMICS SP.动物园.		
当前申请(专利权)人(译)	MEDICALGORITHMICS SP.动物园.		
[标]发明人	DZIUBINSKI MAREK		
发明人	DZIUBINSKI, MAREK		
IPC分类号	G06F19/00 A61B5/0452 A61B5/00 A61B5/046 A61B5/0464		
CPC分类号	A61B5/0464 A61B5/7203 A61B5/7264 G16H50/20		
优先权	2005077368 2005-10-14 EP		
外部链接	Espacenet		

摘要(译)

本发明是一种用于铅限制心电图（ECG）信号分析的方法，装置和系统。本发明包括以下步骤：从多个ECG导联接收表示心脏活动的ECG传感器信号，预处理ECG传感器信号;以及通过包括神经网络的专家系统识别心律失常和ST段抬高的步骤。