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ECG COMPUTER ANALYSIS SYSTEM WITH THE ADVANCED FEATURES OF AUTOMATED SEARCH AND IDENTIFICATION OF IT'S DIAGNOSTICALLY SIGNIFICANT CHANGES

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Abstract:

The article is devoted to the development of program-algorithmic maintenance of automatic processing and analysis of ECG in real-time for intelligent expert system APM-cardiologist, which is one of the elements of the cardio-information space created on the basis of "Telecardiology" technology. It is shown that the implementation of the proposed approach will improve the quality and effectiveness of human-computer interaction (doctor - Intelligent Expert System APM- Cardiologist) within the transformation of a physician generated medical management solution into the diagnosis of the required reliability.

Keywords: Telecardiology-, workstation (APM), coronary heart disease, diagnostic features, automatic search, ECG, human-computer interaction, software and algorithmic support, expert system, expert evaluation, the generation management of medical solutions, diagnosis.

Introduction

It is known that in the assessment of the heart and cardiovascular system the key role plays the analysis of electrocardiogram (the record of volumetric electrical processes in the heart observed on the body surface projection in a given time). The following information shows that an electrocardiogram (ECG) contains information on both the current state of the cardiovascular system and on the pathological changes in the heart. However, it should be noted that the automatic ECG analysis is a rather complex scientific and technical task. This is primarily due to the physiological signal origin, which makes its indeterminacy, diversity, variability, unpredictability, unsteadiness, and exposure to many types of interference.

In [1-3], a group of authors proposed an algorithm to diagnose coronary artery disease (CAD) for intellectual expert system program APM-cardiologist, which is one of the elements of cardio-information space created on the basis of

"telemedicine" technology (a system of hardware and software ensuring the registration, transmission, reception, and processing of cardio-data, as well as the transfer of the generated medical management solutions (MMS) to consumers). The architecture of telemedicine network of the Russian Federation and telecommunication structure is illustrated in Figure 1 and 2, respectively.

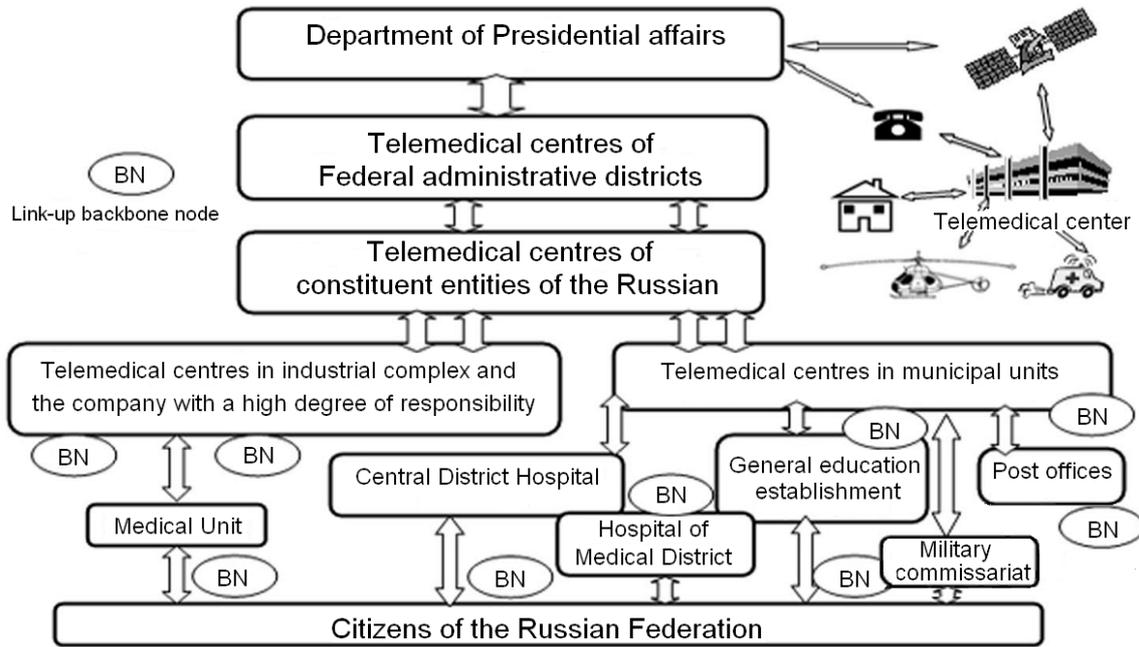


Figure 1. The architecture of telemedicine network of the Russian Federation.

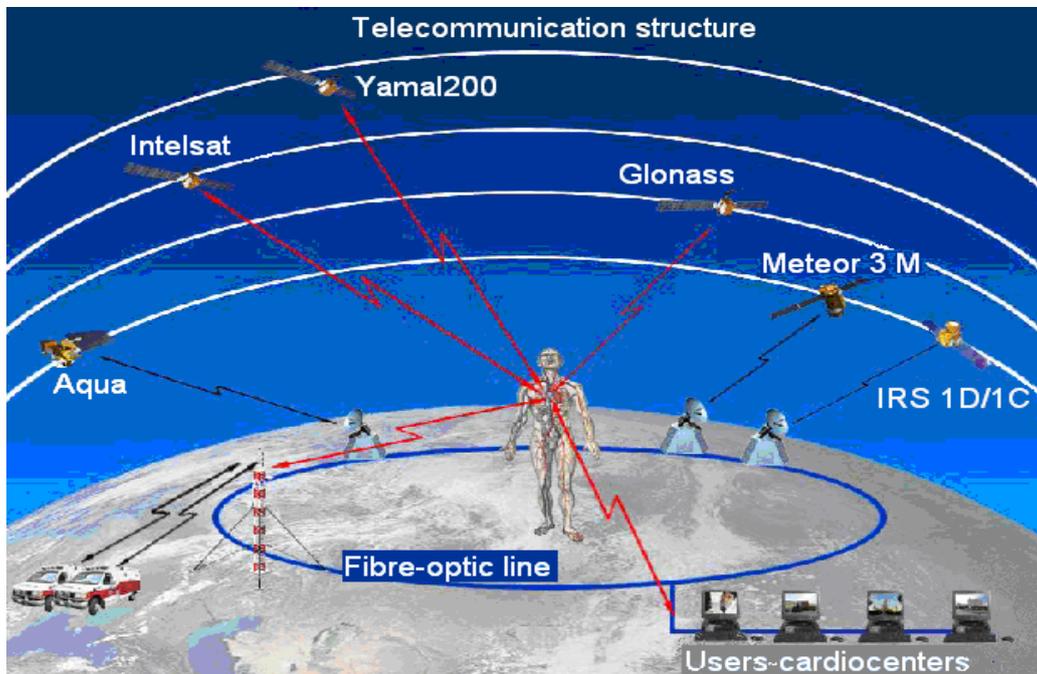


Figure 2. Telecommunication system.

The above mentioned intelligent software expert system APM-Cardiologist allows you to create a set of diagnostic features (DF) of CHD, to calculate their values for a particular patient on the basis of the analysis of various characteristics of the non-invasive monitoring of his cardiovascular system current state, including ECG parameters. At the

final stage, the program calculates the estimation of the CHD conditional risk probability and generates MMS. At the same time, we note that an intelligent program expert system APM-cardiologist does not provide the automatic search and recognition of diagnostically significant ECG changes and the subsequent formation of appropriate diagnostic signs of CHD. This somehow reduces the program intelligence and evaluation efficiency of heart and cardiovascular system condition of the patient.

Research Methodology

The article is devoted to the development of a new approach to solving the urgent problem of increasing the effectiveness of the rapid assessment of the heart condition and the cardiovascular system (including remote diagnostics), as a result of automatic processing and analysis of ECG in real time.

The introduction of ECG computer analysis into cardiology practice allows to solve the following tasks: to set the cardiologist free from the main part of the routine work; to universalize MMS; to make storage and retrieval of information automatic.

The computer analysis of the ECG provides for implementation of the following stages:

1. Preparation of the input data.
2. Recognition of singular points and ECG segments (individual dens, QRS, QT complexes, etc.).
3. Automated analysis of the results obtained in step 2.
4. Generation of MMS

At the first stage the cardiac information is collected and entered it into doctor's computer - workstation (APM). For the implementation of this phase the variety of tools can be used, from the electrocardiograph, interlinked with the doctor's APM to complex network systems that allow the collection of information from the ECG of different types via wired and wireless communication channels. Cardiographic data collection system generally can be configured for the desired level of complexity.

The second stage is usually carried out in an automatic mode with the help of special digital signal processing algorithms. There are a number of such algorithms. In [4] the results of testing of 12 of these algorithms are shown. The comparative analysis of the algorithms was performed for the following parameters: Methodology, noise-resistance, the accuracy of detection of the special ECG points, the possibility of setting, the processing time, etc. In this work it was concluded that the algorithm presented in [5], has the lowest time of signal processing and defines the specific point of ECG well.

The third step is generally performed via algorithms that implement the various ECG analysis technique [6-8].

The final stage is performed by the doctor. In this case the computer is used for automated search, input and data storage.

Results and Discussion

The use of computer ECG analysis by physician for diagnosing can significantly reduce the time to solve this problem and avoid major medical errors. At the same time one of the most promising ways to improve human-computer interaction (doctor - expert system ARM-cardiologist) is to improve the user interface of doctor's APM.

We can distinguish the following approaches to solving this problem:

1. Adherence to the principles of usability.
2. The improvement of the algorithms' quality of automated search for ECG specific points.
3. Implementation of automated search of the ECG specific sections

In this article, a group of authors proposed a system of computer ECG analysis, which uses the automatic recognition of the special points of the ECG (electrocardiogram annotation) and implemented advanced automated search of ECG specific sites (lines). Each ECG singular point (annotated point) is assigned a specific code (code annotation). Each line corresponds to the portion of the ECG, beginning at a specified point with the annotated code, including this point and ending in the following annotated point with a predetermined code, not including this point. Currently we implemented a prototype ECG computer analysis system with enhanced automated search of specific sites. In particular, the prototype has the following functions:

1. Input ECG data from files in PhysioBank format [9].
2. Viewing the ECG signal on the chart with the individual ECG sections (windows) selectable and viewable.
3. Saving the settings of selected windows and movement on them.
4. ECG automatic annotation.
5. Moving on special ECG points.
6. Automatic search of ECG lines.
7. Moving on selected ECG lines.

The implementation of a system prototype of ECG computer analysis with advanced features automated search of specific sections was performed in LabVIEW environment [10]. This choice stems from the fact that LabVIEW offers a variety of signal processing and allows you to create functional, flexible, and scalable applications quickly.

When implementing ECG automatic annotation source code library presented in (ECG Annotation C) was used. The interaction of information processes in the system prototype ECG computer analysis is illustrated by the diagram IDEF3 (Figure 3).

First, you have to select the required file and ECG channel. After this choice ECG data is loaded into the computer memory and displayed on the screen in graphical form. It also displays the name of the downloaded file, the number of channels, the selected channel number, time of the ECG, the number of counts, capacity, frequency and amplitude of the ECG signal. After reading the ECG data the annotating is performed automatically. Basic annotation codes are summarized in Table 1 below. Also the points R-R, or QS-QS are highlighted, they are the interval between contractions of the ventricles.

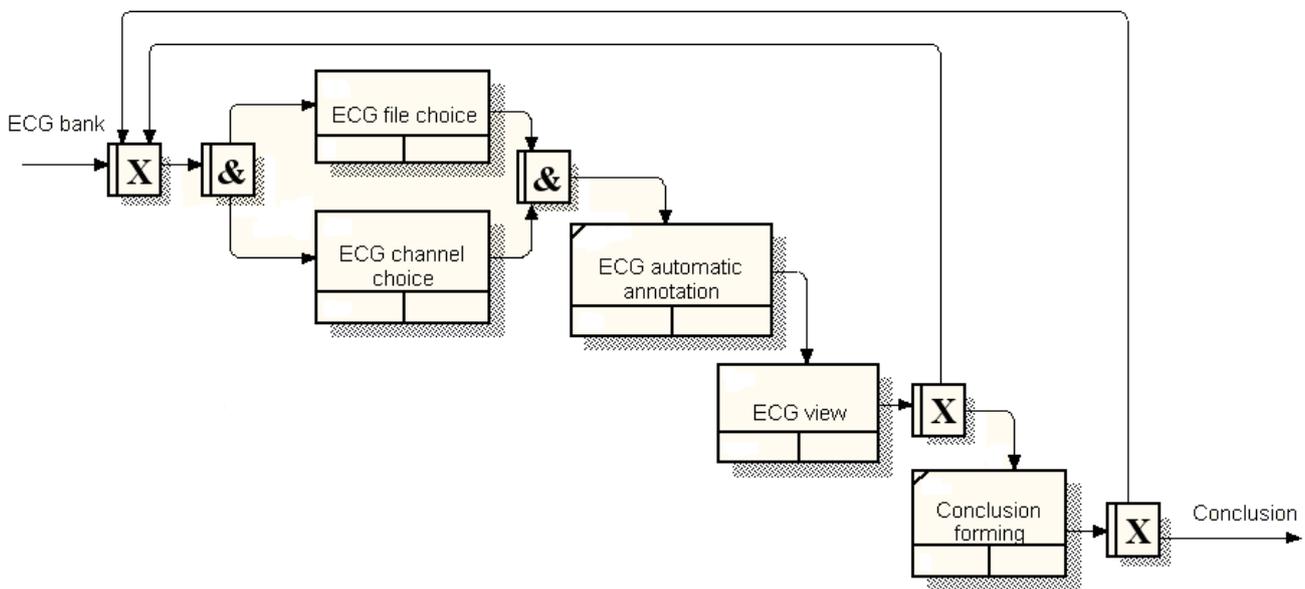


Figure 3. Diagram IDEF3, illustrating the interaction of information processes in the prototype ECG computer analysis system.

Table 1; Annotation codes.

№	Code	Annotation	№	Code	Annotation
1.	NotQRS	No QRS complex	23.	STCH	ST change
2.	N	Normal rhythm	24.	PACESP	Blocking
3.	LBBB	Left bunch brunch block	25.	T	T wave
4.	RBBB	Right bunch brunch block	26.	RTM	Rhythm change
5.	ABERR	Premature auricular extra systole	27.	LEARN	Learn
6.	PVC	Ventricular premature contraction	28.	FLWAV	Waves of ventricles flutter
7.	FUSION	The fusion of the ventricular and normal rhythm	29.	VFON	The start of fibrillary contraction
8.	NPC	Nodal escape	30.	VFOFF	The end of fibrillary contraction
9.	APC	Auricular extra systole	31.	AESC	Atrial escape beat

10.	SVPB	Premature or ectopic supraventricular extra systole	32.	SVESC	Supraventricular escape beat
11.	VESC	Ventricular rhythm	33.	NAPC	no P wave
12.	NESC	Atrioventricular nodal rhythm	34.	PFUSE	Change into sinus rhythm
13.	PACE	Rhythm	35.	FLWAV	Waves of ventricles flutter
14.	Q	Q wave	36.	RONT	Premature ventricular beat from R to T type
15.	ARFCT	Isolated QRS complex	37.	(p	The start of P wave
16.	STCH	ST change	38.	p)	The end of P wave
17.	TCH	The change of T deflection	39.	(t	The start of T wave
18.	SYSTOLE	Systole	40.	t)	The end of T wave
19.	DIASTOLE	Diastole	41.	ECT	Pacemaker
20.	MEASURE	Annotation setting	42.	R	R wave
21.	P	P wave	43.	S	S wave
22.	BBB	Left or right bundle of Atrioventricular bundle	44.	RONT	Premature ventricular beat from R to T type

After the automatic annotation the user can view the ECG. The steps are illustrated in Figure 4. At any time it is possible to display an arbitrary portion (window) of ECG. To do this, you need to use cursors to choose the window border. Dedicated windows can be remembered. It is also possible to carry out the movement sequences stored on the windows, on the singular points and ECG lines.

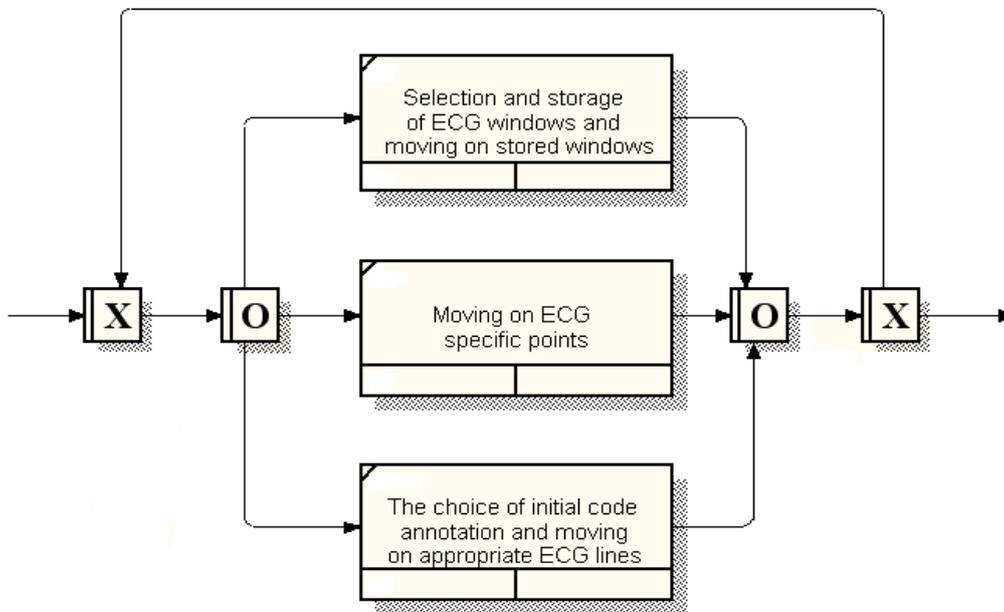


Figure 4. Chart IDEF3, detailing the block "Viewing the ECG"

Moving on specific points of the ECG is carried out in two modes: moving on an annotated ECG points and move on R-R or QS-QS points. In the ECG window, the current point is marked with the corresponding cursor. The screen

Olga A. Efremova et al. International Journal Of Pharmacy & Technology* displays the number of critical points in the selected ECG window. For the current terms of reference the number of ECG signal, code annotation and annotation it is also shown.

For the convenience of the search specific sites (lines) of ECG you can select the start annotation code. After this selection line search is done automatically. The line can occur several times in the ECG. If you select a line, moving the start point of the line is similar to the movement for special ECG points. The ECG window, the start point of the selected line is also marked with the corresponding cursor.

Conclusion

Thus, the above mentioned computer analysis ECG system with advanced features of automated search and identification of areas with diagnostically significant changes can be classified as a tool to improve the quality and efficiency of human-computer interaction (doctor - expert system APM cardiologist) at diagnosing the disease.

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