SYSTEM FOR ADJUSTMENT AND TEST OF ALGORITHMS FOR ECG-DATA PROCESSING

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The paper presents a high-performance system for adjustment and test of algorithms for data processing, embedded in real ECG devices. An additional advantage of the system is the possibility for simultaneous visualization of the applied test signal and the result after processing. This may be a beneficial tool and considerable reduce the difficulties in design and debugging of software methods for ECG analysis.

Keywords: ECG simulator, ECG signal, ECG-data processing

1. INTRODUCTION

The new generation of microcontrollers, DSP-s, Computers, etc. applied in the medical devices and in the medical practice, considerably improves the quality of diagnostics. Large variety of methods for automated processing and analysis of biomedical signals have been proposed and used. Accounting the importance of the cardiac activity, the major efforts for improving the cardiac diagnostics are directed towards development of new algorithms for automated analysis. The analysis of the QRS complex as the most characteristic wave in ECG is the widely accepted approach to study and to classify cardiac dysfunctions. The normal ventricular contractions are represented with QRS complexes with a relatively constant waveform and a relatively regular appearance of each heartbeat. In healthy persons, there is only a slow natural variation of the interbeat RR intervals, corresponding to the respiratory activity. Any cardiac dysfunction associated with excitation from ectopic centers anywhere in the myocardium leads to premature contractions (with supraventricular (atrial) or ventricular origin), that alter the RR interval duration and/or the QRS waveform. Many studies for QRS features estimation are reported in the literature based on the QRS morphology [1] combined with interbeat intervals analysis [2], wavelet transform [3], etc.

The general society of software developers usually applies the commonly accepted databases [4] during initial development and testing of the algorithms for automatic diagnosis. However, the testing and validation of these software methods implemented in real ECG devices demand of precise long-term ECG simulators [5]. The present work describes an inventive approach for fast adjustment and test of the algorithms build-in devices for ECG analysis. A key element in our solution is ECG simulator, allowing load and translation of signals from databases (AHA, MIT-BIH).

2. TEST SYSTEM – HARDWARE CONCEPT

The proposed test system obtains the next features:

- User interface allowing to load a broad spectrum of input data formats;
- No limits of the sampling rate and the amplitude;
- 12 ECG leads;
- Feedback to the computer.

The block diagram of the system is shown in figure 1. It includes simulator, connected with Personal Computer through the serial port. The selected signal from database converts in voltage by the simulator. The simulator is realized using the PIC18F458 Microchip's microcontroller, because of its low power consumption and extended built-in periphery. The SPI is used to control the digital-to-analog ECG data conversion, which is realized by 12-bit D/A converter. The D/A converted voltage is passed through attenuator realized by resistive cascade. The role of the cascade is to form voltages correspond to the all-12 ECG leads. The tested ECG device is connected to the simulator's outputs (resistive cascade). If ECG device owns some interface, it is possible to realize close feedback to the computer.

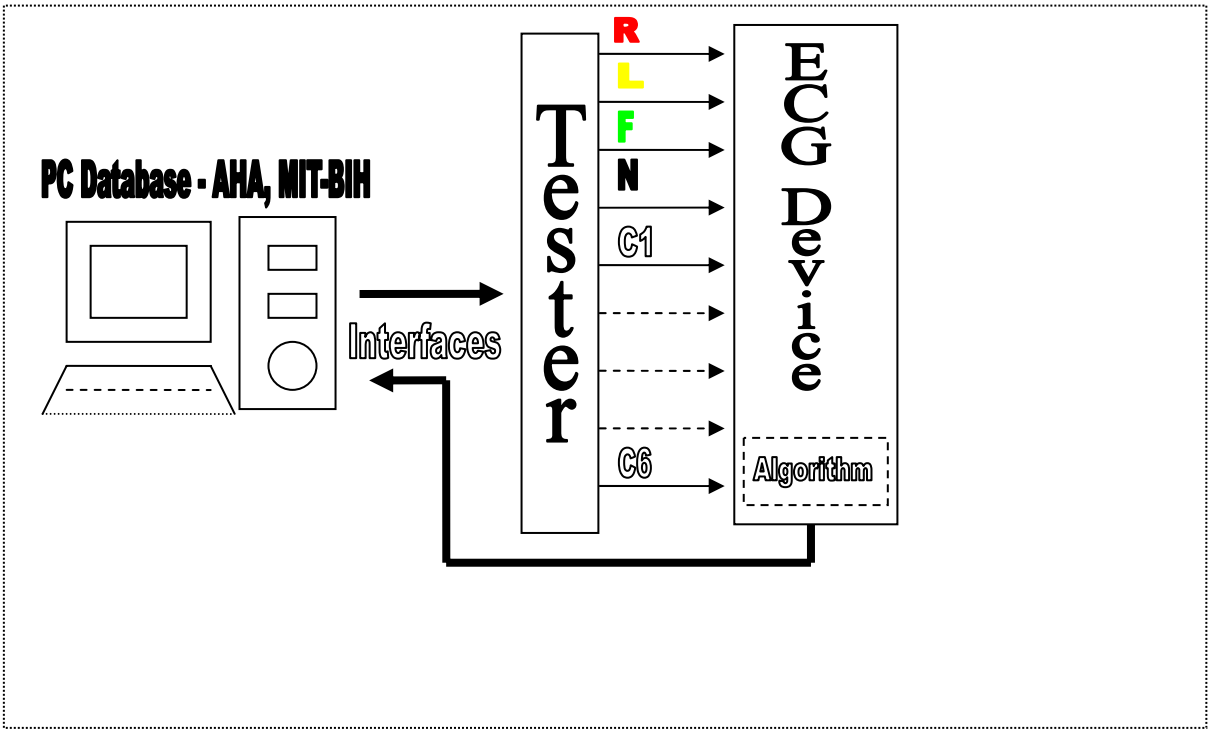

Fig. 1

3. TEST SYSTEM – SOFTWARE CONCEPT

In-house developed PC software running under Windows platform is used in work mode. It enables opening of ECG records with different data formats, set phase shift and visualize the selected signal. Figure 2 shows general view of user interface.

The part of a selected signal (8004d1.dat from AHA database) is shown. The start of data row can select by moving the bar placed bottom.

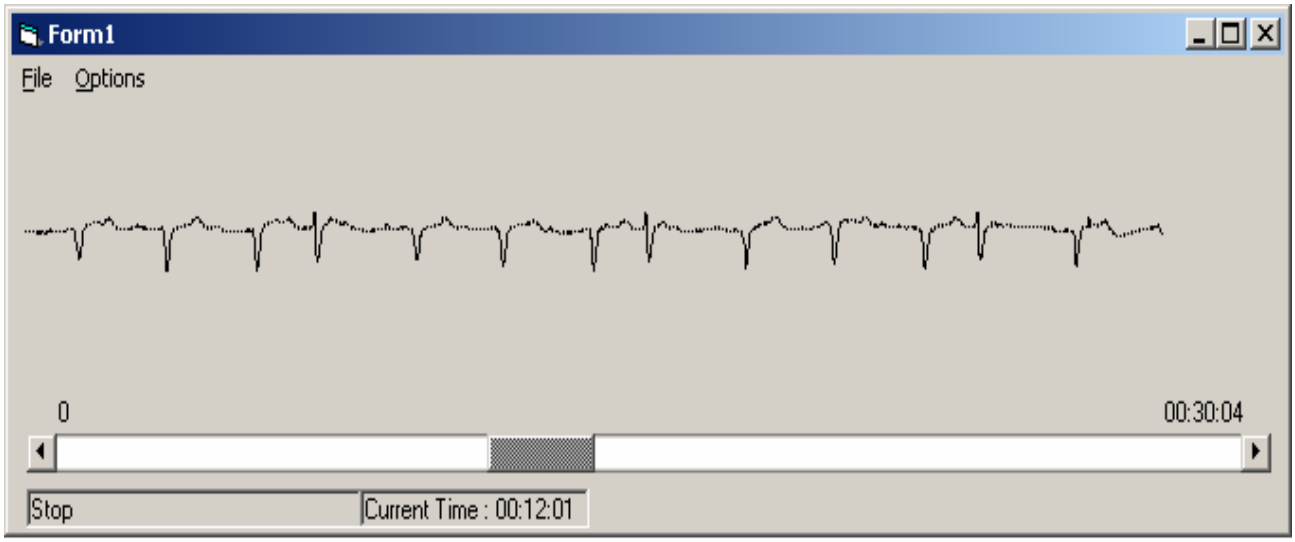

Fig. 2. General View of the PC software for ECG simulation

4. RESULTS

The proposed test system was implemented in the process of development and adjustment of a new algorithm for ECG processing, build-in a system for long-term high-risk patients observation. Its specific features are:

- The analysis is applied over single-lead ECG signal, sampled at low rate of 250 Hz and with reduced resolution of 8-bit in the full amplitude range.
- The online monitoring of the ECG signal samples involves application of simplified amplitude and slope criteria for maximal-amplitude R-peak detection.
- Only a limited number of samples, selected around the detected R-peak are processed with adequate amplitude approximation, in order to be accumulated into a reduced-size ECG pattern matrix, which is representative for the ECG rhythm history;
- Simplified criteria are applied to update dynamically the content of the small-sized ECG pattern matrix;
- The detection of pathologic cardiac events relies on simple triggering algorithm, which is based on the ECG pattern matrix plain calculations and RR-intervals measurements.

In the process of adjustment the tested system was connected to the PC through the serial interface. The accuracy of QRS detection and ectopic beats identification is shown on fig. 3. The dots indicate the places of detected cardiac (valve) activity, the vertical lines indicate the detected extrasystoles.

Fig. 3. General View of the algorithm for QRS detection and ectopic beats identification

4. Discussion and Conclusion

The main advantage of the presented test system is the simultaneous visualization of the selected signal from database and the result after processing by the embedded algorithm. The user interface allows selecting signals from database without limitations. The general application of the simulator is for development and test of automatic diagnosis algorithms, embedded in real ECG devices.

Acknowledgment: This work has been supported by the National Fund "Scientific Research" Grant BY-TH-101/2005.

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