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Real Time Detecting of Pacemaker Artifacts

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Abstract – **The pacemaker is an electronic device that can rule activity of the heart in some cases of heart diseases. Stimulation of the heart muscle is done using one or more electrodes. This paper discusses an approach for real time detection of pacemaker artifacts in ECG records.**

Keywords – **Pacemaker pulses detection, electrocardiogram.**

I. Introduction

Detecting of pace artifacts is important for testing of pacemaker functionality, as well as to remove the pace pulses influence on automatic electrocardiogram analysis.

Different types of pacemakers [1] are in use depending on the heart injury, for example:

- Single chamber pacemaker uses one electrode to stimulate the right atrium or right ventricle.
- Dual chamber pacemaker uses two electrodes to stimulate separately atria and ventricles.
- Bi-ventricular pacemaker uses se three electrodes to stimulate right atrium, right ventricle and left ventricle.

Typical pacemaker pulse is shown on Figure 1.

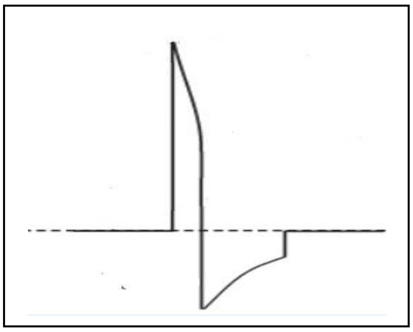

Fig.1. Typical pacemaker pulse

The pulse is bipolar, with fast rising edge – about 10μs. The amplitude of the pulse on the patient skin surface can vary between few hundred μV to several hundred mV. The width of pace artifacts is typically between 100μs and 2ms.

These parameters set certain requirements [2] for ECG acquisition and pace pulses detecting and processing algorithms like wide frequency band of analogue part of the device and fast ADC conversion rate – 10 kilo samples per second (KSPS) and more. Some solutions use a sample rate up to 128KSPS [3].

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II. Method and Algorithm

The proposed algorithm is based on calculation of the signal slope in a short period - 500 μs.

The following equation is used to calculate the slope of the ECG signal in 500 μs interval around the processed sample:

$$S_j = \left[\sum_{i=1}^{4}\left(X_j - X_{j-i}\right) + \sum_{i=1}^{4}\left(X_j - X_{j+i}\right)\right]^2 \qquad (1)$$

Slope should be in a maximum near to the peak of pacemaker pulse, where the differences are large and with the same sign. The squaring of sum highlights bigger slopes.

The algorithm of pace detecting is shown on Figure 2.

Current calculated slope is compared with the slope threshold.

If the value of the current slope (S_j) is bigger than the threshold value (S_T), current threshold becomes equal to the current slope and pacemaker pulse detection mark (PPM_j) is placed on this ECG sample. If the previous sample is marked as pacemaker pulse, its mark should be clear.

If the value of the current slope is less than the threshold value, the threshold value is reduced by 0.05% on every next sample.

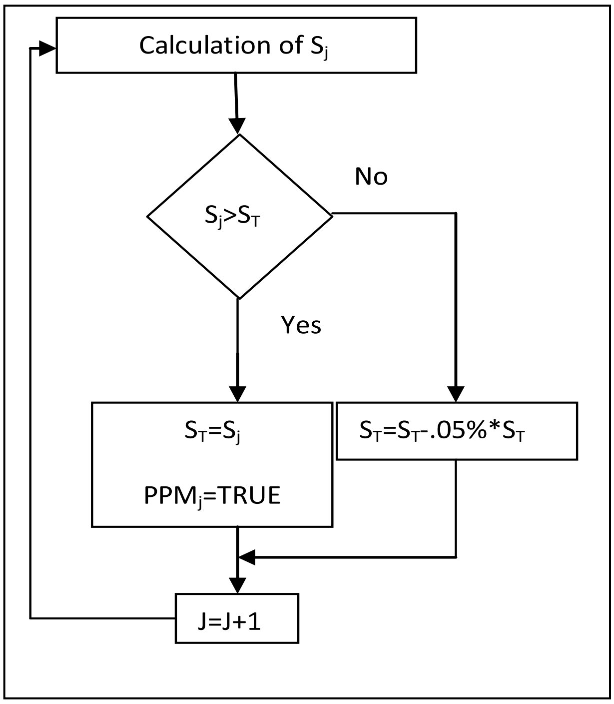

Fig.2. Pace detecting algorithm

III. ECG SIGNALS

Synthesized pacemaker pulses are added to a real ECG signal taken from AHA database (250 samples/second with 12-bit precision) and resampled at 16000 samples per second.

Different types of pacemaker pulses are added at specific points of the ECG signal:

- before the P-wave –simulates pacing of the atrium;
- before the QRS complex –simulates pacing of the ventricle;
- 2 pulses before the QRS complex –simulates bi-ventricular pacing mode;
- different combinations of the above-listed pace pulses positions –simulate different pacemakers.

The artificially mixed pure ECG and pace pulses allow the estimation of the algorithm reliability.

IV. RESULTS

The test procedures of the proposed algorithm are executed in MATLAB with the described above artificially mixed signals. The operation of the algorithm is illustrated with some examples (Figures 3-8). The dimensions of all Y-axes are in mV.

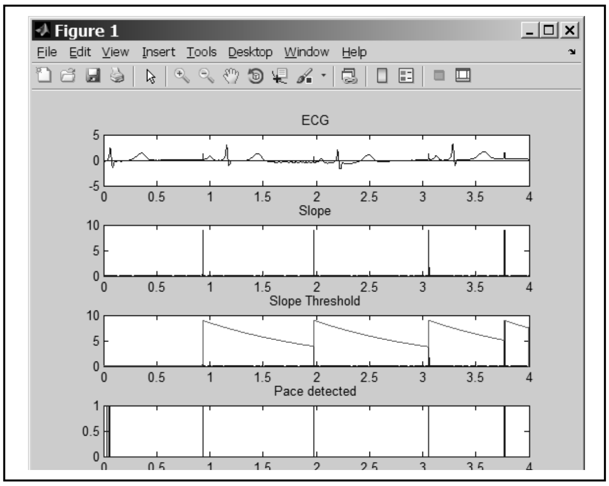

Fig.3. Single pacemaker pulse pacing right atrium with 1 mV amplitude and 1mS width

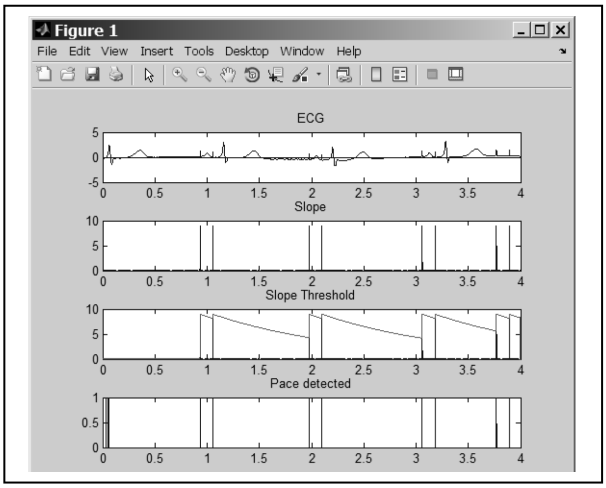

Fig.4. Two pacemaker pulses with 1 mV amplitude and 1ms width

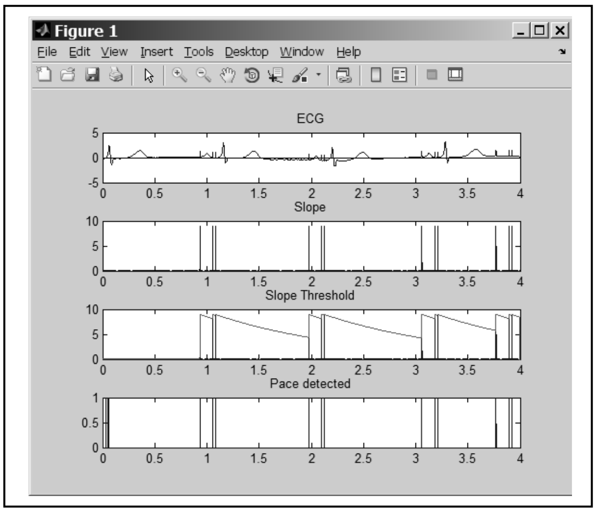

Fig.5. Three pacemaker pulses with 1 mV amplitude and 1mS width

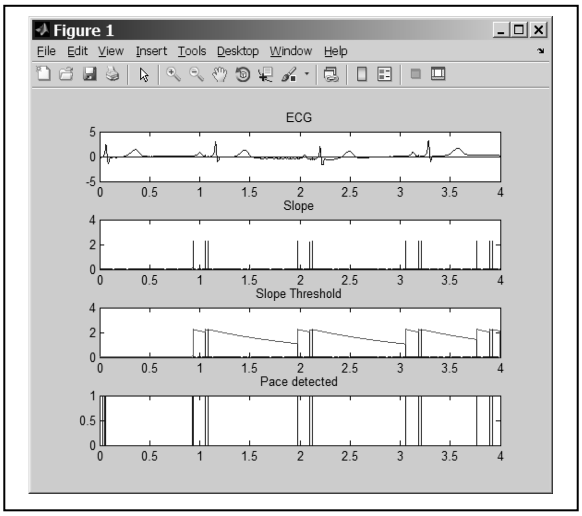

Fig.6. Three pacemaker pulses with 100 µV amplitude and 120µS width

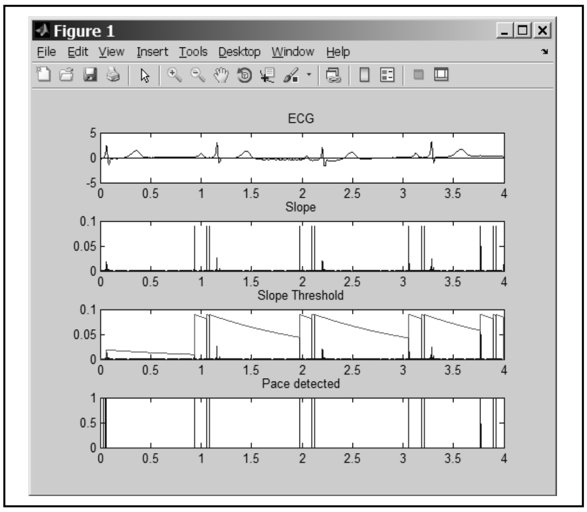

Fig.7. Three pacemaker pulses with 100 µV amplitude and 1mS width

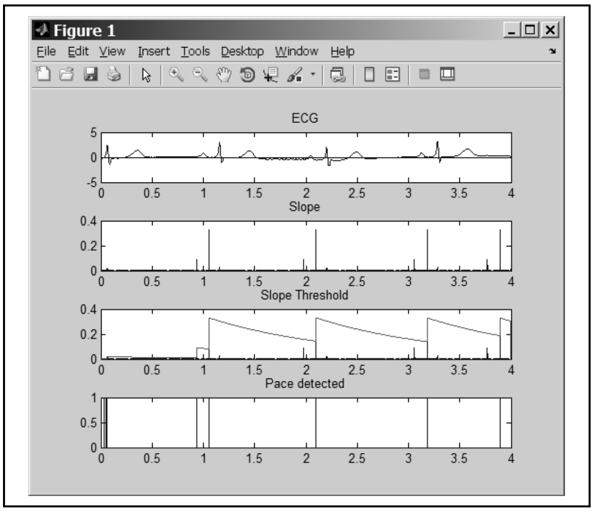

Fig.8. Single pacemaker pulse with 100 µV amplitude and 1mS width

V.CONCLUSION

The preliminary results show adequate performance of the algorithm to detect different numbers of pacemaker pulses in wide parameters range. Also, the algorithm has a possibility to be realized with integer digits and calculations only. The preliminary results show adequate performance of the algorithm

REFERENCES

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