EMULATING AN ECG WAVE USING A SIMPLE GEOMETRIC PRIMITIVES

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ЕМУЛИРАНЕ НА ЕКГ ЧРЕЗ ИЗПОЛЗВАНЕ НА ЕЛЕМЕНТАРНИ ГЕОМЕТРИЧНИ ПРИМИТИВИ

Abstract

This paper presents an easy to implement algorithm for generating an ECG signal. The shape of the generated signal is idealized. For the base of shape of simulation model the signal obtained from lead 2 was used. The goal is to achieve the realization of a maximally economical method in terms of computing power and energy consumption for obtaining an ECG signal for use for visualization in a portable device.

Keywords: *ECG Signal; Emulation; Algorithm; Graphics.*

INTRODUCTION

The electrical signals obtained by ECG shows different parts of the cardiac contractile cycle [1], [2], [3]. Single cardiac sample rhythm is shown on Figure 1. The basic elements of a cardio cycle are:

- P-wave – low-amplitude wave;
- QRS-complex – high-amplitude part consists of one negative peak – Q, positive peak – R and ends with S peak;
- T wave – wave with medium amplitude;
- U wave – follows the T wave, it may be present or may not be present.

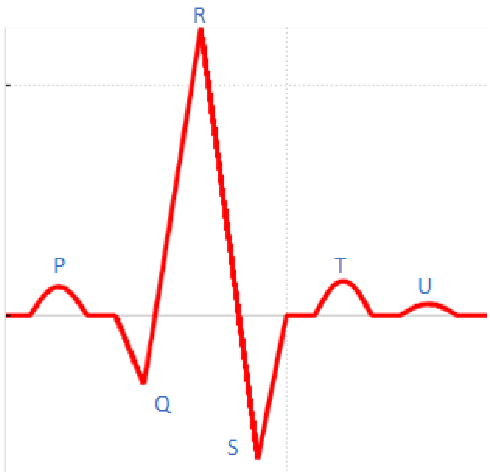

Fig. 1. Sample ECG signal

EMULATION

BASIC PRINCIPLE

There are different approaches to simulation of ECG signals [4], [5], [6]. Also there are and a commercial ones [7], [8], [9]. In this case we decided to use a different method to simulate.

To simulate an ECG signal we will use the following method. We divide one period of the signal into separate subperiods. In the specific case (Figure 2), 12 such sub-periods were selected. Figure 2 shows the individual boundaries of the resulting periods. The shape of the ECG signal obtained from lead 2 is used as a model.

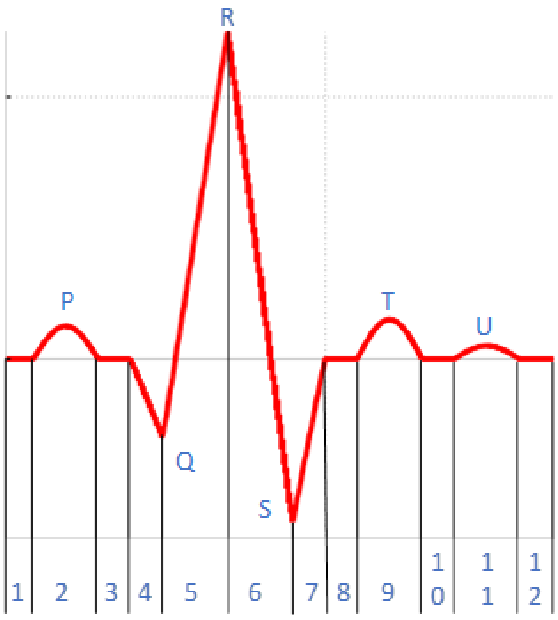

Fig. 2. ECG sample divided into intervals

As can be seen from the figure, the individual segments of the shape can be described by relatively simple geometric figures. In the specific case, two types were used: a straight line and a part of the sinusoid. This does not exclude the possibility that, if necessary, they can be replaced with other more suitable ones. For example, the line QR can be described as part of a parabola. The vertex R may not be as in the case directly joined QR and RS, but have a roundness described as part of a circle.

OPERATION

The proposed algorithm for generating the emulated ECG signal consists of several steps shown in Figure 3.

1. Begin
2. Reading the description of the next segment of the graph
3. Generate data as described
4. Display on screen/send to another device
5. Check for another description – if yes –> go to 2
6. End vertex R may not be as in the case directly joined QR and RS, but have a roundness described as part of a circle.

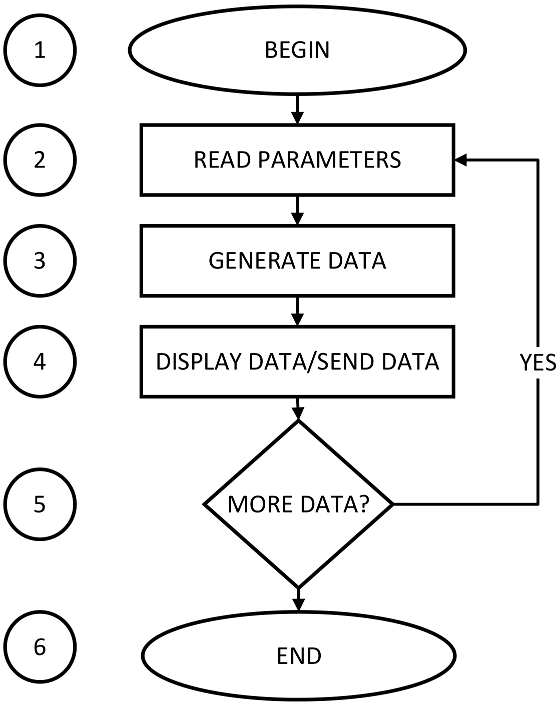

Fig. 3. Proposed algorithm

PARAMETERS DESCRIPTION

The parameters for covering one ECG period are stored in a data structure with the following description for each segment:

1. **type** – type of the graphic primitive – line, sinusoid, circle, etc.;
2. **stime** – start time of the segment;
3. **etime** – end time of the segment;
4. **params** – an array of parameters for describing the used primitive according to its type, for example: for a straight line it contains y_start and y_end, x_start x_end are equal to stime and etime respectively. For the other primitives, the descriptions are similar;
5. **num_params** – number of valid parameters in the params array. Depending on the graphic primitive used, the parameters required for its use are different, for example: for straight lines there are two, for a sinusoid there are three – amplitude, frequency and phase;
6. **name** – name of the segment.

The data structure of parameters is shown on next lines of pseudocode:
struct

```
{
    int type;
    double stime;
    double etime;
    double params[8];
    int num_params;
    char name[4];
};
```

Data Generation

The graphic data for describing one period of the electrocardiogram is generated according to the parameters of the corresponding segments using the algorithm shown on Fig. 4.

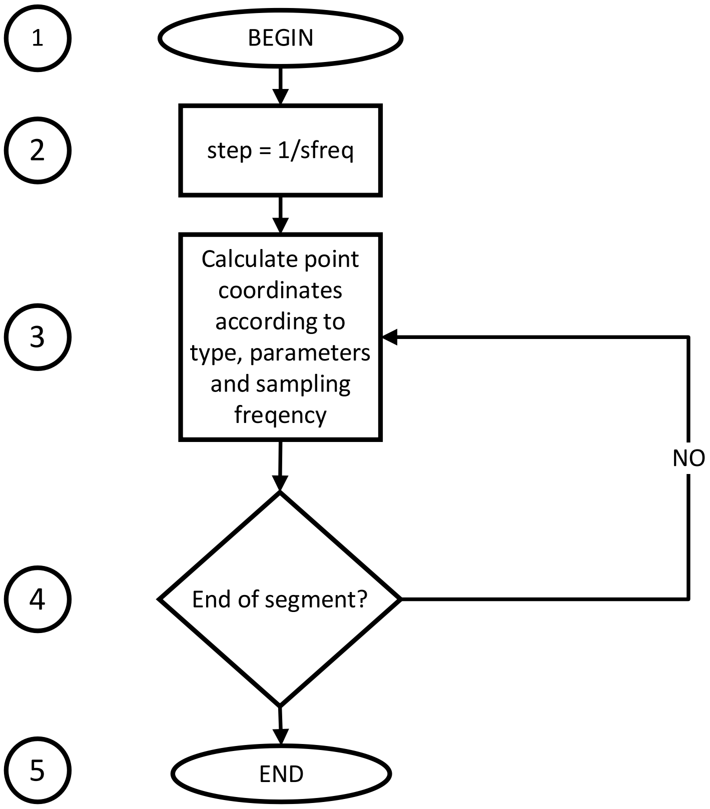

Fig. 4.

The principle of operation is as follows:

1. Begin
2. Setting the increment time step – a previously set sample rate is used
3. Calculation of the value (y coordinate) depending on the type and parameters of the graphics primitive.
4. Check for reaching the end of the segment? – if not recalculate a new point, if yes – exit
5. End

Thanks to the description of each segment with multiple points, the obtained data can be used for post-processing and experiments.

Experimental Results

According to the presented description and algorithms, a software for generating ECG signals has been created. It was written using the C++ language and the QT development environment. Fig. 5 shows the typical result of its work.

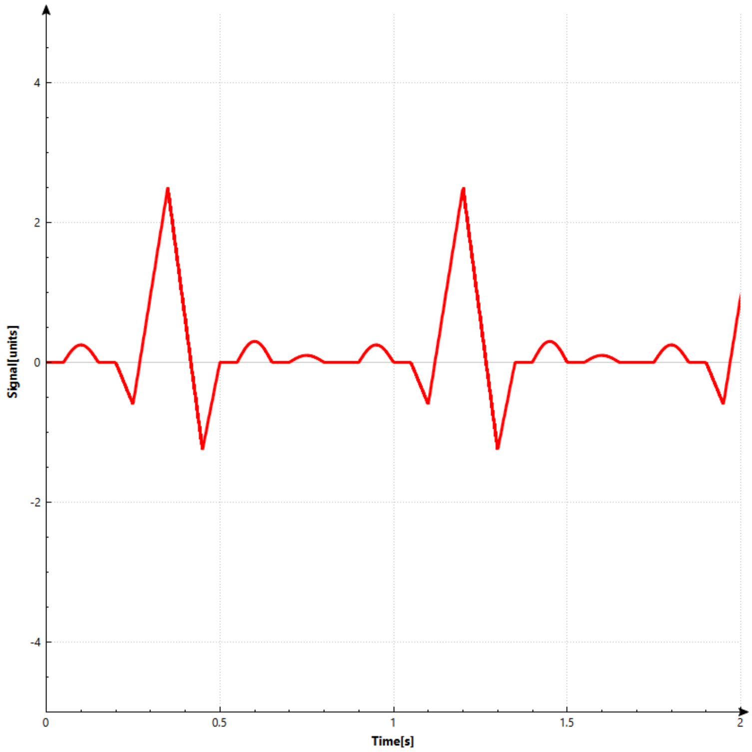

Fig. 5.

Figure 6 shows a similar signal, but without the U-wave.

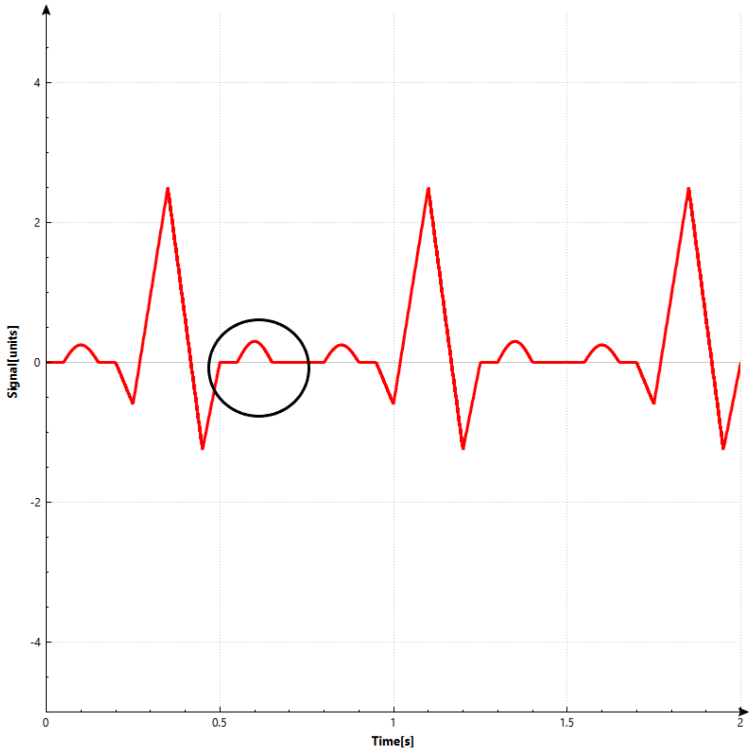

Fig. 6.

The following figure 7 shows a signal with different amplitudes of the R peaks.

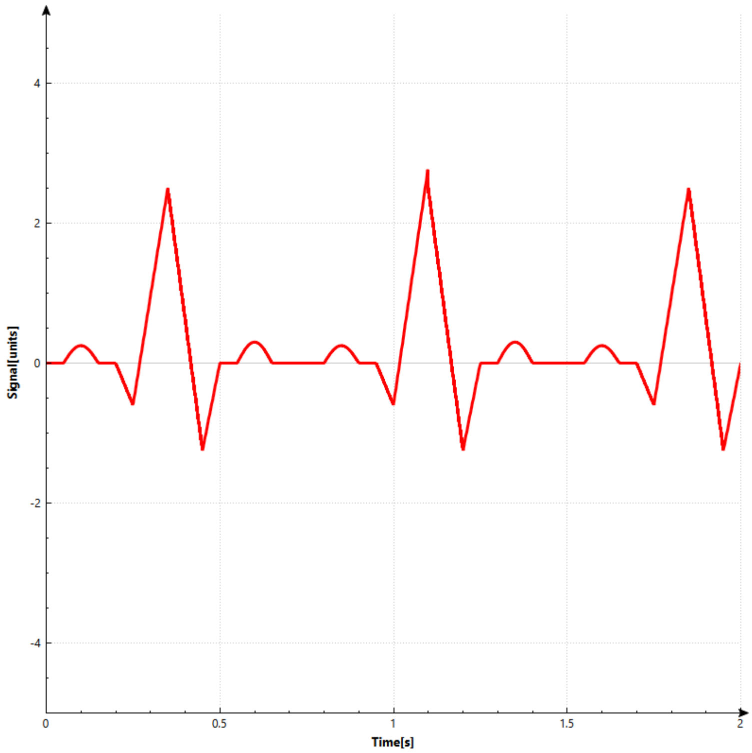

Fig. 7.

The signals shown above were generated with a sampling rate of 1000Hz. Figure 8 shows a signal with a sampling rate of 40Hz. Due to the low sampling rate the resulting signal is not ideal.

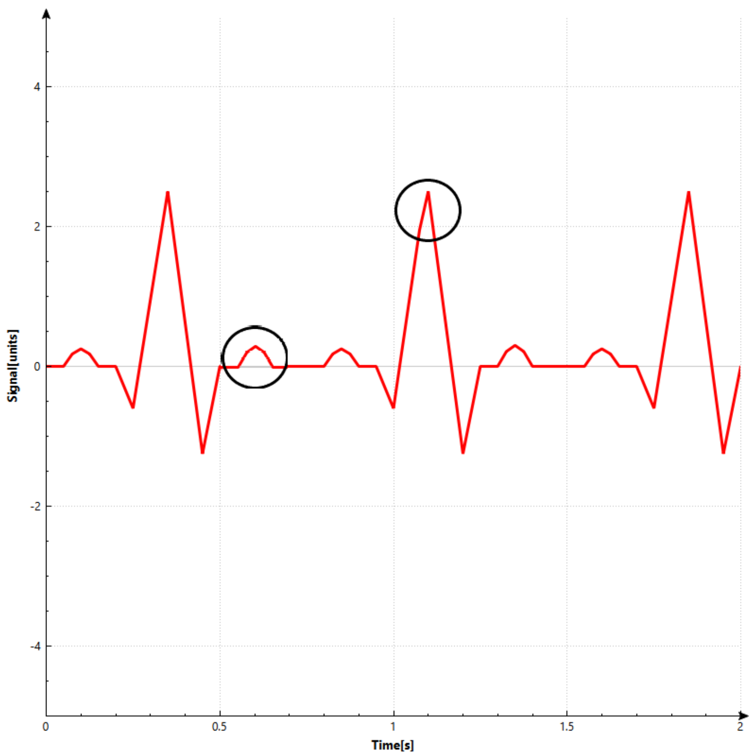

Fig. 8.

Future Work

The current realization of the proposed method for generating ECG signals has some drawbacks – it is not possible to dynamically generate signals according to a set algorithm. The use of other graphical primitives such as circles, parabolas, etc. is not implemented. In future research on the topic, this functionality will be added. It will also be added a possibility to synchronize the R peaks of the generated signal with those obtained from the recording of the human ECG.

Conclusions

The article presents a method for emulating ECG signals using simple geometric figures. Algorithms for generating ECG signals have been created and the result of their implementation is shown. The data generated by the method explained above can be used as source for analysis using different algorithms like [10], [11] and others. On the other hand it can be used for comparative analysis with real data obtained from a persons making generated data more credible.

Acknowledgments

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