Uniform Sampling of ECG Waveform of MIT-BIH Normal Sinus Rhythm Database at Desired Intervals

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ABSTRACT
MIT-BIH Database is the standard ECG database which is used universally for ECG analysis purpose. MIT-BIH database for normal sinus rhythm is sampled at 128 Hz and the data is available at uniform intervals of 7.8125 ms. To use this data for analysis purpose with various techniques like artificial neural networks, correlation techniques etc., it is required to have samples at desired intervals. Hence this paper proposes an image processing method to convert the samples at desired intervals, so that the MIT-BIH database can be used widely and universally.

General Terms
ECG uniform sampling

Keywords
ECG, Database, Uniform sampling, Image processing.

1. INTRODUCTION
The MIT-BIH Normal Sinus Rhythm Database has ECG records in the form of ECG waveform as well as samples as text. The digitization was done using 12 bit analog-to-digital converter (ADC) with sampling frequency 128 Hz [1] and the samples shown in the database are at intervals of 7.8125 ms [1]. We require samples at different desired intervals when analysis is done with artificial neural network [2], [3]. The paper proposes a new method to sample the ECG waveforms of the MIT-BIH Normal Sinus Rhythm Database at uniform interval of 8 ms. So that samples at desired intervals can be used by various researchers.

The method we use in this paper to sample the ECG waveforms is based on image processing techniques. Dots per inch (DPI) are used to describe image resolution. For example a 5″× 4″ image digitized at 300 dpi resolution would result in 1500 × 1200 dots (pixel) image [4]. For ECG waveform images the image resolution specifies the number of pixels (dots)/mm.

Since 1inch = 25.4 mm,

$$Number\ of\ dots\ (pixels)/mm\ = \frac{DPI}{25.4} \qquad (1)$$

The modified lead II (MLII) ECG waveforms of the MIT-BIH Normal Sinus Rhythm Database have defined grid intervals (similar to conventional ECG chart paper). On x-axis, i.e. time axis, one grid interval is equal to 0.2 seconds and on y-axis, i.e. voltage axis, one grid interval is equal to 0.5 mV. Also the grid interval is of 5mm. So 1 second corresponds to 25 mm and 1 mV corresponds to 10 mm. Thus the relationship between pixels and time voltage values can be determined from DPI. For example a 300 dpi corresponds to 11.81 dots (pixels)/mm. This means that one dot (pixel) corresponds to 3.387 ms for x-axis i.e. time axis and to 8.47 μV for voltage axis and the sampling rate is nearly 295 Hz.

2. METHODOLOGY
Uniform samples are extracted from the ECG waveform image. The whole process is summarized in figure 1 by a flowchart.

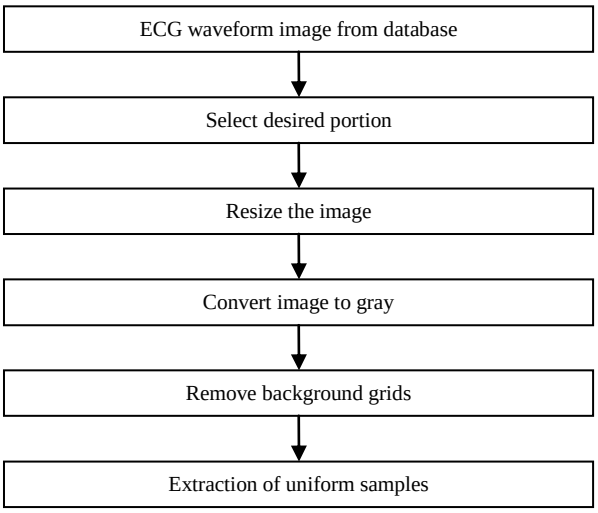

Figure 1 Flow chart describing the uniform sampling method

We describe the method to uniformly sample the ECG waveform with the help ECG waveform of record 16795 from MIT-BIH Normal Sinus Rhythm Database. Figure 2 shows the ECG waveform of record 16795. A portion from the ECG waveform is selected which is to be uniformly sampled, here we have selected the portion from 0 to 2 seconds. The selected desired portion is shown in figure 3.

2.1 Resizing of image
Since we have to achieve a uniform sampling interval of 8 ms in the data to be extracted from the ECG image, we require that 1 dot (pixel) corresponds to 8ms for horizontal axis. So 1 second duration should have 125 dots (pixels). As we have already mentioned that 1 grid interval is of 5mm and on time axis, one grid interval is equal to 0.2 seconds and on

Figure 2 ECG waveform of record 16795 from MIT-BIH Normal Sinus Rhythm Database

voltage axis, one grid interval is equal to 0.5 mV. So 1 second corresponds to 25mm. Therefore in 1mm there should be 5 pixels, i.e. number of dots (pixels) / mm = 5. Thus the required resolution is 127dpi.

To get the resolution of 127 dpi we resize the image by 127 percent horizontally as well as vertically, which gives us the image equivalent to resolution of 127dpi shown in figure 4. We have used Microsoft Windows Paint (version 6.1) to resize the image. Figure 4 shows the resized image of the desired portion.

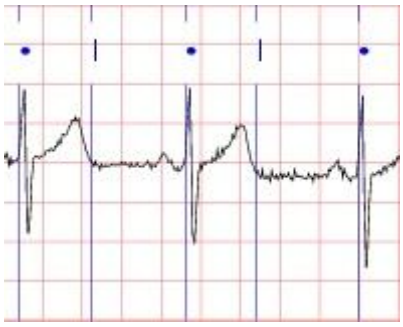

Figure 3 Desired Portion

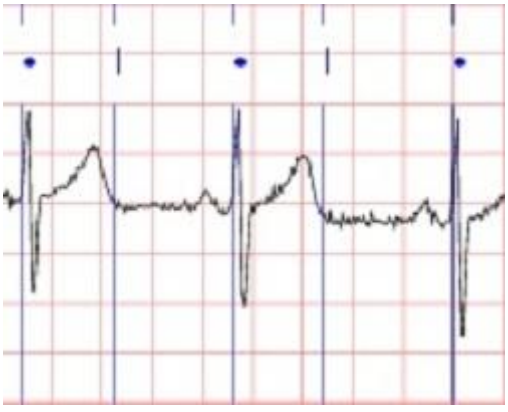

Figure 4 Resized Image

2.2 Gray conversion of resized image

The resized image is converted to gray image with the help of MATLAB Simulink [5]. A color space conversion block is used for converting the RGB resized image to intensity image. Figure 5 shows the gray image obtained after the color conversion.

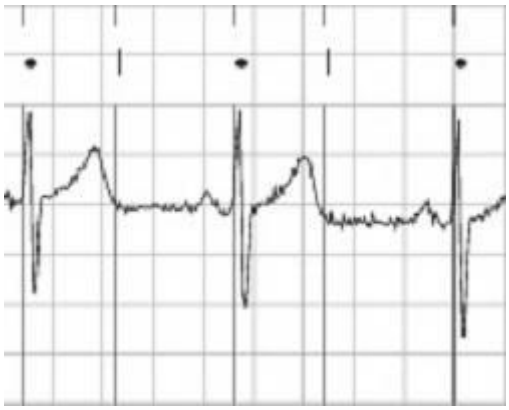

Figure 5 Gray Image

2.3 Removal of background grids

We separate background grid from ECG waveform [6], [7]. For removing background grids we have used a thresholder simulink model in MATLAB.

Figure 6 ECG waveform without background

This model based on the pixel values removes all the pixels that have values below an applied threshold. Thus we get an image which has only ECG wave shape with white background as shown in figure 6. If some unwanted dots remain, they should be removed.

2.4 Extraction of uniform samples

The image after background removal is filtered with a contrast-enhancement filter. The ECG waveform is characterized by black pixels. The pixel locations are denoted by x-y Cartesian coordinates. The image shown in figure 6 is transformed from image form to Cartesian coordinates (x, y) of pixels. Figure 7 shows the pixel plot of ECG waveform in terms of its horizontal and vertical location of its pixels.

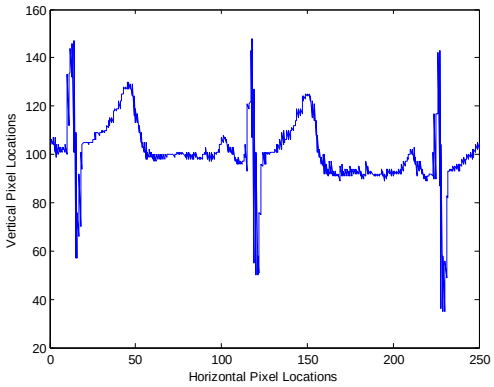

Figure 7 Pixel plot

The time and voltage values are obtained by first setting the y-axis reference. Then scaling is done where one dot (pixel) corresponds to 8 ms for x-axis i.e. time axis and to 0.02 mV for voltage scale. The plot in terms of time and voltage from the ECG image is shown in figure 8.

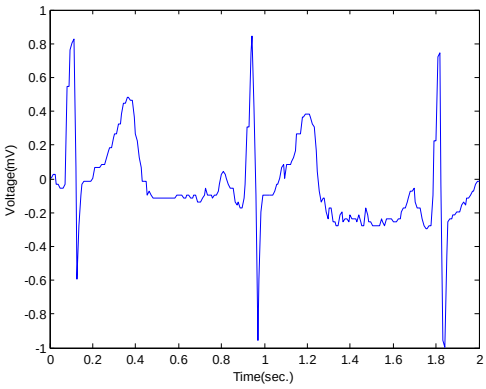

Figure 8 Plot of extracted uniform samples

3. RESULT

The samples obtained by our method are at uniform interval of 8 ms. The plot obtained by uniform samples is shown in figure 8 and the plot obtained by samples from database is shown in figure 9. We can see that the plots are similar. A comparison of 30 samples obtained from database and by our method is shown in table 1. We can see in table 1 that the extracted samples are at uniform interval.

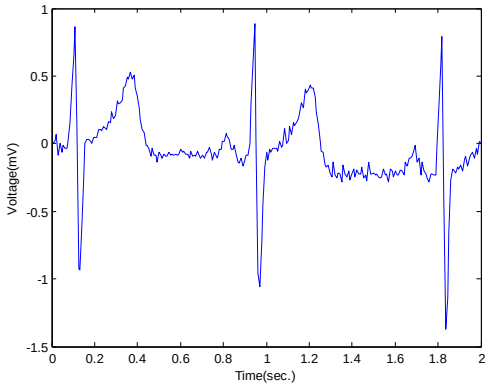

Figure 9 Plot of database samples

Table 1 Samples from database and uniform extracted samples of record 16795

Database samples of record 16795		Uniform samples of record 16795	
Time(sec)	**Voltage(mV)**	**Time(sec)**	**Voltage(mV)**
0.008	0.005	0.008	0.005
0.016	0.025	0.016	0.025
0.023	0.065	0.024	0.025
0.031	-0.085	0.032	-0.035
0.039	0.005	0.04	-0.035
0.047	-0.065	0.048	-0.055
0.055	-0.015	0.056	-0.055
0.062	-0.035	0.064	-0.055
0.07	-0.035	0.072	-0.035
0.078	0.015	0.08	0.545
0.086	0.155	0.088	0.545
0.094	0.435	0.096	0.765
0.102	0.655	0.104	0.805
0.109	0.865	0.112	0.825
0.117	0.125	0.12	0.065
0.125	-0.925	0.128	-0.595
0.133	-0.935	0.136	-0.275
0.141	-0.615	0.144	-0.095
0.148	-0.235	0.152	-0.035
0.156	0.005	0.16	-0.015
0.164	0.035	0.168	-0.015
0.172	0.035	0.176	-0.015
0.18	0.015	0.184	-0.015
0.188	0.005	0.192	-0.015
0.195	0.045	0.2	0.005
0.203	0.045	0.208	0.065
0.211	0.045	0.216	0.065
0.219	0.105	0.224	0.065
0.227	0.105	0.232	0.065
0.234	0.095	0.24	0.085

4. LIMITATION OF THIS STUDY

The samples extracted by our method are at uniform intervals of 8ms but due to the blue marker lines available on the ECG waveform image taken from MIT-BIH database, the negative peak values obtained are less in amplitude than the original negative peak values. This will not affect any analysis much because negative peak values are clinically not very much significant.

5. CONCLUSION

The samples obtained from the ECG waveform image by our method are at uniform intervals of 8 ms. Such uniform sampling is useful to use the data for analysis purpose with various techniques like artificial neural networks, correlation techniques etc. Any analysis done by these uniform samples will improve the accuracy. MIT-BIH Arrhythmia database has samples at interval of (1/360) sec whereas MIT-BIH Normal Sinus Rhythm database has samples at interval of (1/128) sec. To use the samples of these databases widely for analysis purpose, it is desired to have samples at a uniform intervals of desired time, which can be obtained by the method proposed in this paper, so that wide database will be available for analysis purpose by any technique.

6. REFERENCES

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