PROGRAMMING ASSIGNMENT

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Contents

0.1 Algorithm Used

The QRS-detection algorithm used is a modified version of the one first proposed by Jiapu Pan and Willis J. Tomkins in the paper titled "A Real-Time QRS Detection Algorithm" (1985). The used method involves five steps:

0.1.1 Noice Filtering

Two separate application techniques were used to execute a band pass filter. First technique was as described by Pan and Tompkins. Instead of a band-pass filter a combination of low pass filter followed by a high pass filter was used. First, high frequency components are removed by a low pass filter. Its transfer function is given by H(z) $= \frac{(1-z^{-6})^2}{(1-z^{-1})^2}$
Then we add a high pass filter with a transfer function H(z) $= \frac{(-1-32z^{-16}+z^{-32})}{(1-z^{-1})}$

Another technique used was to directly apply a bandpass filter of 5-15 Hz. This was done using butter method of *scipy.signals* module of python. Result from both techniques yield similar efficiency.

0.1.2 Differentiating

R peak has a significant high slope. We differentiate our filtered ECG signal to detect R peaks properly.

0.1.3 Squaring

Squaring is done to further enlarge difference between distinguishable peaks and random noise peaks.

0.1.4 Moving Window Integration

Moving Window Integration is done to incorporate information about the slope and width of QRS complex together. This was achieved by convolving the squared signal with unit signal of length 24. This value is empirically chosen and discussed in the paper to be taken near about 30.

0.1.5 Detecting Peaks

We shifted the Convolved output signal in both positive and negative direction. Peaks are those points where original signal is greater than both new generated signals. This shifting was repeated x times where x is difference between two consecutive peaks, with each time shifting by t units was done with $t \in (1, x)$. Value of x was empirically found to be around 100 units.

0.1.6 Thresholding

Thresholding was done in two ways, one as suggested by the paper, with formula $NPKI + 0.25(SPKI - NPKI)$. Other way was to empirically check for a suitable threshold. The second method fails for some tricky complicated cases like Database 112.

0.1.7 Calculation of Heart Beat

Time between all consecutive peaks were calculated, let we call this time difference be rr, where it represent time between occurrence of two R peaks. Now,

$$Time\ taken\ for\ one\ heart\ beat = rr$$

$$Heart\ Beats\ per\ second = \frac{1}{rr}$$

$$Heart\ Beats\ per\ minute = \frac{60}{rr}$$

Two averages were calculated, one for 8 recent readings and other for 8 recent permissible readings(for heart beat between 60 to 100). If avg1 falls in this range: $(0.92 * avg2, 1.16 * avg2)$ normal sinus was reported. This conclusion was based on readings from paper(Pan and Tompkins).

0.2 Performance on offline database

Performance on Database Number 100, 109, 123 discussed here. These database numbers were randomly chosen and claims for efficiency of the algorithm are for the whole database.

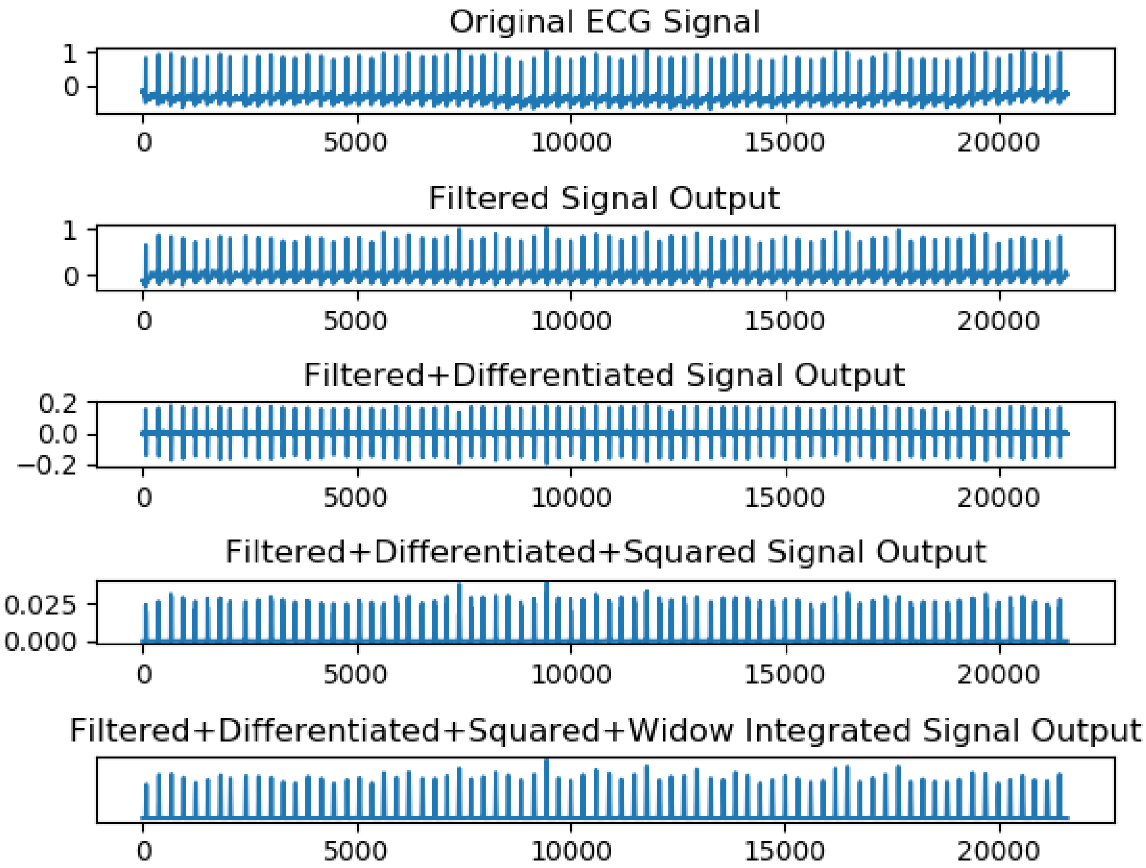
Original ECG Signal
Filtered Signal Output
Filtered+Differentiated Signal Output
Filtered+Differentiated+Squared Signal Output
Filtered+Differentiated+Squared+Widow Integrated Signal Output
0
5000
10000
15000
20000
1
0
0.2
0.0
−0.2
0.025
0.000

Figure 1: 100

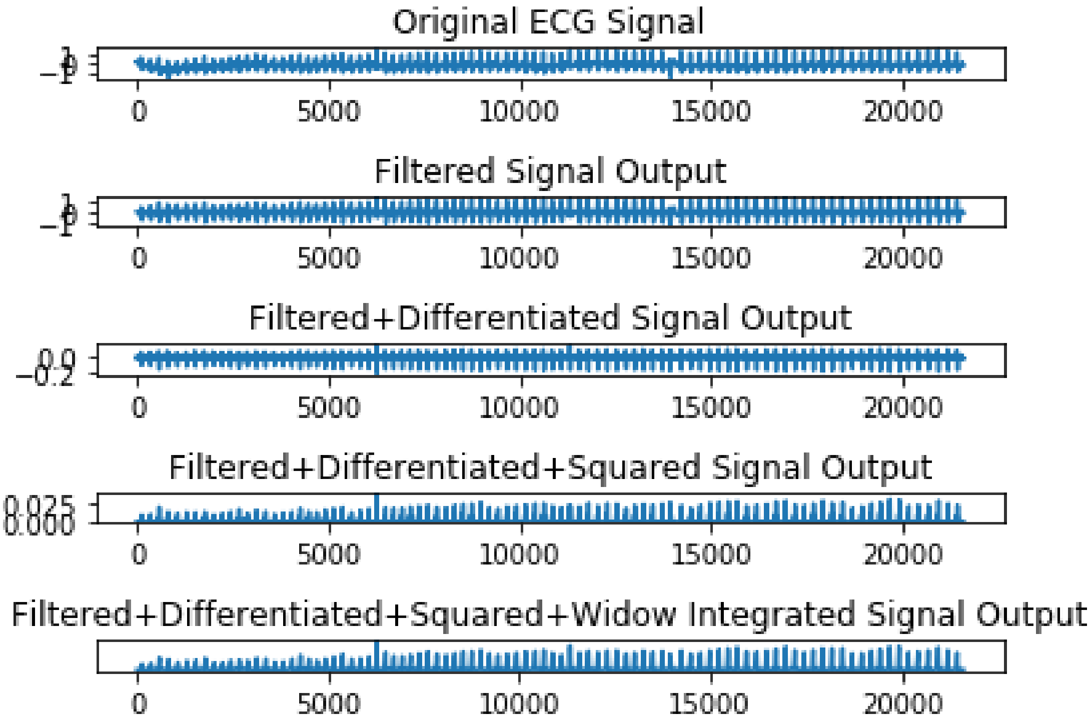

Figure 2: 109

0.2.1 100

Normal sinus with average heart beat 74.0210936612277 Our observation looks valid as in databases clearly mentioned patient is having normal sinus with heart beat in 70-89.

0.2.2 109

Not a Normal sinus with average heart beat 85.77048007626523 Our observation looks valid as in databases clearly mentioned patient is having normal sinus with heart beat in Normal sinus rhythm 77-101.

0.2.3 112

Observed: Not a Normal sinus with average heart beat 51.566344165626276. Our observation looks valid as in databases clearly mentioned she is a 63 year old person suffering Ventricular ectopy with heart beat in 41-65.

1. SMART: Specific, Measurable, Actionable, Realistic, Time-based.
2. Ex. I will write 2 pages of my report by 1/30/19.

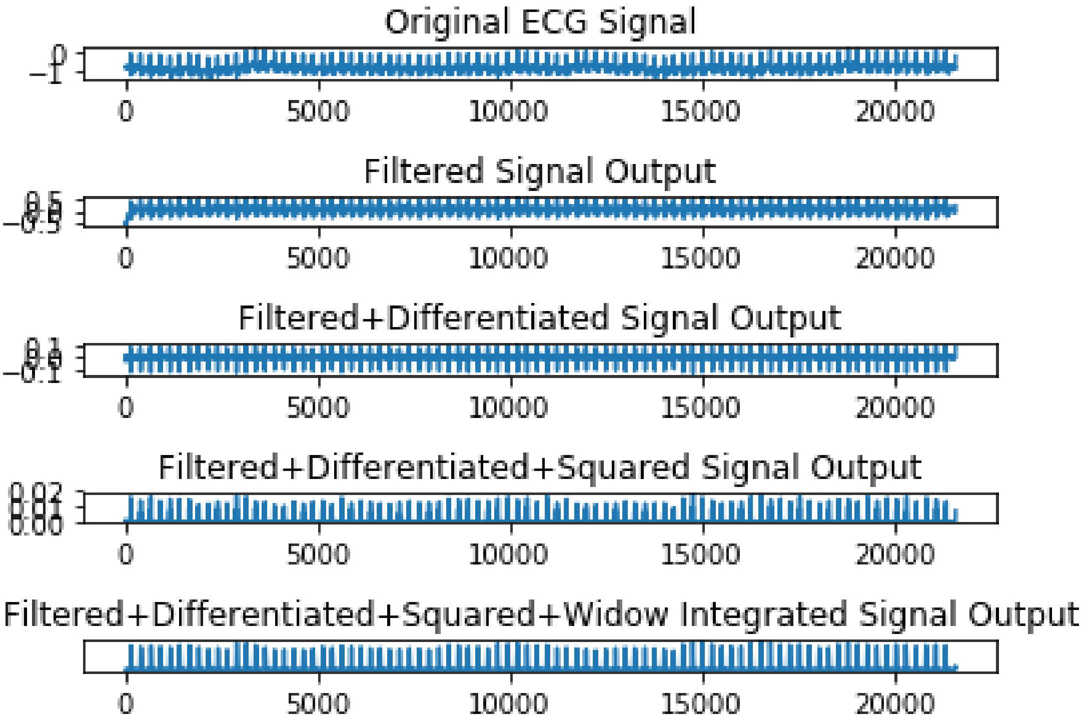

Figure 3: 112

3. Ex. I will gather feedback from 2 peers about my idea by 1/30/19.

4. Ex. I will research a new theory for 2 hours by 1/17/19.

Papers you are working on, target conf/journal and date, etc.

0.3 References

1. N. V. Thakor, J. G. Webster, and W. J. Tompkins, "Design, implementation, and evaluation of a microcomputer-based portable arrhythmia monitor," Med. Biol. Eng. Comput., vol. 22, pp. 151- 159, 1984.

2. Pan-Tomkins algorithm (Pan J., Tompkins W. J., A real-time QRS detection algorithm, IEEE Transactions on Biomedical Engineering, Vol. BME-32, No. 3, March 1985, pp. 230-236).