

ECE-497/BME-491: Applied Biomedical Signal Processing

Homework #1

Due at the beginning of class, December 8, 2006

In this assignment we will explore various methods for computing the normalized autocorrelation and their effectiveness in discriminating between ventricular tachycardia (VT) and ventricular fibrillation (VF). VT is characterized by a regular rhythm and wave shape while VF is characterized by an irregular rhythm and no regular pattern in the shape of the signals. The data we will be using was recorded during surgery when implantable defibrillators were being implanted in patients. We will be examining signals that would be seen by these implantable systems. We will also be comparing the effectiveness of using closely spaced bipolar electrodes, which mostly look at local cardiac activity, and bipolar electrodes which are sewn across the heart, which see a larger picture of cardiac activation. Note that it is no longer common to sew patches across the heart: less invasive procedures are now common. However, most common implantable devices have access to signals very similar to those we will be looking at. The reason for looking at efficient methods of computing the autocorrelation is that multiplication and division is more computationally intensive than addition and subtraction, and thus requires a lot more power.

a) For the signals in the compressed file **Week 1 Data.rar**, compute the normalized autocorrelation using the direct method, as well as each of the approximations listed in Table 1, for both the bipolar signal (.bi extension) and the patch signal (.pa extension). Use lags from $k = 16$ to $k = 64$.

b) Determine the peak autocorrelation for each method, and the lag at which it occurs.

c) For each of the signals you process, generate a plot showing the original signal in the top panel, the results from the different autocorrelation methods in the bottom panel (using different continuous line types and a legend), and a title which includes the peak value and corresponding lag for each of the methods of computing the normalized autocorrelation. Turn in all of your plots. Figure 1 shows a typical plot. You may want to use a title like the following (which is similar to what I used):

```
title([ {'Normalized Autocorrelation, (Direct) peak = ' num2str(peak_direct) ...
        ' at lag ' num2str(index_direct)}
        {'(Hybrid Sign) peak = ' num2str(peak_hs) ' at lag ' num2str(index_hs)}]
        {'(Modified Hybrid Sign) peak = ' num2str(peak_mhs) ' at lag ' num2str(index_
        {'(Relative Magnitude) peak = ' num2str(peak_rm) ' at lag ' num2str(index_rm)
```

d) Generate a display that shows the normalized autocorrelations for VT and VF, for each of the different methods, that shows how well the method is at discriminating VT from VF. Use your imagination here. For each method of computing the normalized autocorrelation, the idea is to show the peak values of the normalized autocorrelations for VT, and then those for VF, and show whether there is overlap. You may not be able to show all of the data to show there is no overlap, you may have to zoom in on some part of the graph. This should be done for each method being studied. There will be a total of 34 plots (yes I know this is a lot...)

Extra Credit, worth 20% of a homework grade

For each of your signals, use the lag order that corresponds to the peak autocorrelation, and determine an effective heart rate (beats/minute) for each of your signals. How would using this rate work as a method for discriminating VT from VF? Present your results clearly, as well as the method you used to determine the effective heart rate.

direct	$\rho_k = \frac{\sum_{i=k}^{i=N-1} x(i)x(i-k)}{\sqrt{\sum_{j=k}^{j=N-1} x(j)^2} \sqrt{\sum_{j=0}^{j=N-k-1} x(j)^2}}$
hybrid sign	$\rho_k = \frac{\sum_{i=k}^{i=N-1} x(i) \text{sign}(x(i)x(i-k))}{\sum_{j=k}^{j=N-1} x(j) }$
modified hybrid sign	$\rho_k = \frac{\sum_{i=k}^{i=N-1} (x(i) + x(i-k)) \text{sign}(x(i)x(i-k))}{\sum_{j=k}^{j=N-1} (x(j) + x(j-k))}$
relative magnitude	$\rho_k = \frac{2\{\sum_{i=k}^{i=N-1} \max(x(i) , x(i-k))\} \{\sum_{i=k}^{i=N-1} \text{sign}(x(i)x(i-k)) \min(x(i) , x(i-k))\}}{\{\sum_{j=k}^{j=N-1} \max(x(j) , x(j-k))\}^2 + \{\sum_{j=k}^{j=N-1} \text{sign}(x(j)x(j-k)) \min(x(j) , x(j-k))\}^2}$

Table 1: Various algorithms for estimating the normalized autocorrelation ρ at lag k .

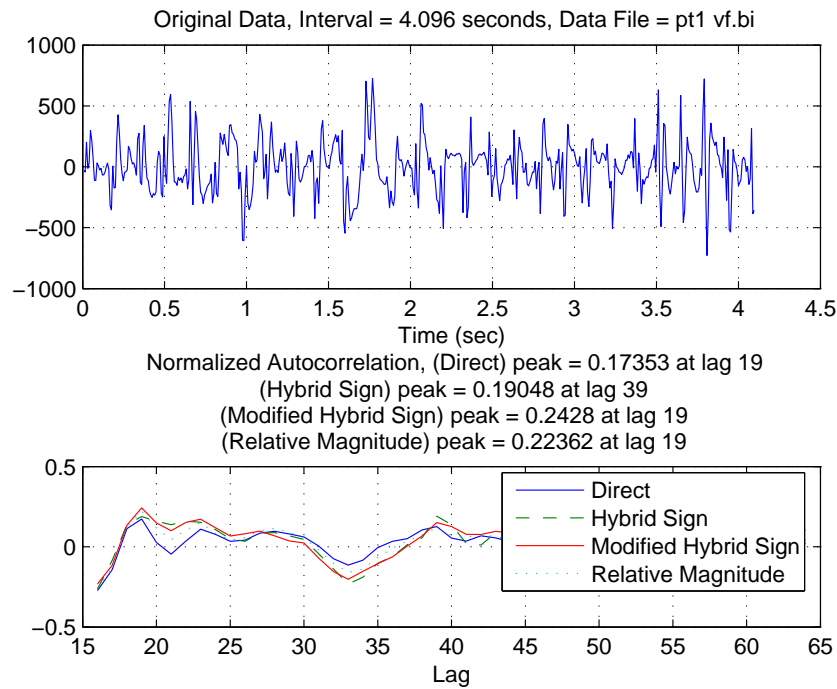


Figure 1: Results for *pt1 vf.bi*