Utilizing Histogram to Identify Patients Using Pressors for Acute Hypotension

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Abstract

In our approach, we propose to process the mean arterial pressure recordings like a signal but yet do analysis like an image in order to differentiate recordings from patients using pressors to treat their acute hypotension and from patients with no such conditions. Mean arterial pressure values recorded over time is numerical representations over time and hence signal processing techniques can be used to on such recordings for filtering purposes. Onset of hypotension in a pre-recorded reading, characterized by exhibiting 90% low mean arterial pressures values anytime within a 30 minutes window, is similar to images exhibiting certain percentage of colours within its draw space. Hence, it can be pattern-matched similarly in image processing using histograms. By combining the 2 methods together, we are able to differentiate the 2 groups of patients for the first event of the Physionet/Computers in Cardiology Challenge 2009.

1. Introduction

In this challenge, 5 sets of recorded mean arterial pressure data, 10 hours each at a sampling frequency of 125Hz, are to be identified to have Acute Hypotensive Episodes (AHE) from a series of 10 sets [1]. Numerical states observed over the period of time are viewed as signals. Therefore, mean arterial pressure recorded over a period of time is no exception to this rule; blood pressures recorded over time can also be viewed as a signal and therefore be processed like a signal.

We propose to process the mean arterial pressure recordings like a signal but yet do analysis like an image in order to differentiate recordings from patients using pressors to treat their acute hypotension and from patients with no such conditions. Mean arterial pressure values recorded over time is similar to numerical representations over time and hence signal processing techniques can be used to on such recordings for filtering purposes. Onset of hypotension in a pre-recorded reading, characterized by exhibiting 90% low mean arterial pressures values in a 30 minutes window, is similar to images exhibiting certain percentage of colours within its draw space. Hence, it can be pattern-matched similarly in image processing using histograms. By combining the 2 methods together, we are able to differentiate the 2 groups of patients for the first event of the Physionet/Computers in Cardiology Challenge 2009.

2. Methods

In this section, we will discuss the assumptions we took in processing the mean arterial pressure values. We will also discuss how we used the assumptions in formulating a band pass filter in processing the mean arterial pressures. After processing the values, we adopted a divide and conquer strategy in evaluating the data sets using histograms. This is a similar strategy used in image processing in matching certain features of the image with another.

2.1. Assumptions

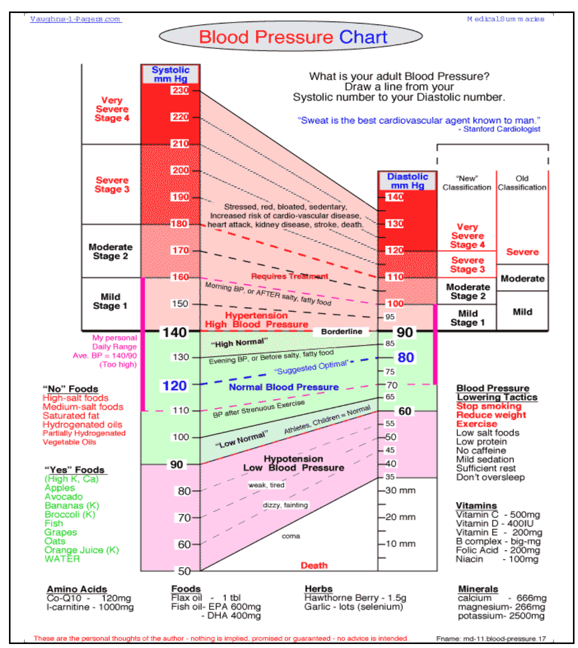

Figure 1. Blood pressure chart depicting the different significance in the level of blood pressure in humans

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Medically, different blood pressures values have different significance and therefore different medical implication on a patient.

The recordings contained only data from 2 different groups of people; the group suffering acute hypotension and were under pressors and the group that had no recorded episode of acute hypotension. Hence, cases of hypertension can actually be ruled out; borderline cases of hypertension were not. The latter was so because it was observed that even under pressors, the elevation of mean arterial pressure was sufficiently equivalent to those having borderline hypertension.

There is also another assumption that the mean arterial pressures below 35 mmHg can also be deemed as noise. These values would mean that the patient is either comatose or dying [2].

2.2. Signal processing

The mean arterial pressures given were raw and unprocessed. These values contained noise as well as data that were nonsensical. Given the above assumption, a band pass filter of 35mmHg to 140 mmHg was applied on the recordings. This was because mean arterial pressures above 140 mmHg is the ceiling borderline before Hypertension while 35mmHg is the floor where anything else lower would mean that the suspect is comatose or dying [2]. The latter assumption is again reasonable in this challenge as it was stated that the first event contained at least 10 hours of recording with an additional hour after the initial 10. Hence, cases where mean arterial pressures below 35 mmHg can be deemed as noise also. These values are specially marked at this stage so that the time-spatial property is still preserved. These values will not participate in the weighted averaging in the later stage. This is because noise should not skew the distributions.

The next step would be to discretize the mean arterial pressure values. This is done so that the histograms can deal with more discrete and compact bin values. Discretization was done by conducting a simple numerical round to the nearest integer. Nonsensical values occurring in '-' are removed and replaced with a '0'. Replacing it with '0' introduces a lot of redundant values and would affect total sample count. However, in the later part, this issue will be removed when the mean arterial pressures are being averaged to per second value. Hence, it does not matter to leave the value as it is in the processing of the signal.

2.3. Windowing and averaging

In accordance with the definition given by the challenge that any 30 minutes interval with a minimum of 90% of its mean arterial pressure of 60mmHg and below can be classified as a case of AHE, it is no surprise that a window period of 30 minutes is also chosen for our analysis. However, the amount of mean arterial pressure data for a 30 minutes window is massive. Moreover, in order for a thorough search, a running window technique would have to be adopted. This would make the search even more computationally intensive.

To combat this dilemma, the amount of data to be processed would have to be reduced. Several methods to compress the data were tried and tested and the best method to date would be to do an average on the sampling frequency of the data of 125Hz to 1Hz. Compression of the data at several levels was tested. Bearing in mind, compression means information loss but it also means reduction in time needed to conduct the search. A large compression would mean a rough search compared to a small compression. Yet compression should be significant to augment the speed of processing the huge amount of data. Hence, a 30 minute running window with an averaging compression of 125Hz to 1Hz was adopted in this detection program. Therefore, each window has 1800 samples for processing.

2.4. Histograms

After the mean arterial pressures have been processed in their 30 minutes window frame, they can be allocated into bins to form a histogram for analysis. Color Histograms has been a very well known method in computer vision and pattern recognition [3]. The histogram's capability to retain the amount of color without the concept of space proved to be very useful for pattern recognition in images. Similarly it is this function that can be utilized to recognize the amount of low mean arterial pressures that would define acute hypotension. With the training data set, it has been observed that that the data from patients using pressors to treat their acute hypotensive conditions contained from at least 1.88% to at least 17.18% of mean arterial pressure values that were below 60 mmHg. Hence, 3 levels of separation can be deduced.

Amt of MAP Values Within 30 Minutes Window	Conclusion
Less than 1.88%	No AHE
Between 1.88% and 17.18%	Maybe
More then 17.18%	Have AHE

Figure 2. 3 Levels of Separations

The histogram used in this paper do not increment the count if the filtered mean arterial pressure values is zero; the counts of zero is ignored and would not contribute towards the final count. This is done for the same reason as above; not to skew the distribution count due to noise.

2.5. Analysis

After the 30 minutes recording has been binned into the histogram, it can then be analyzed to observe for the features mentioned earlier. During this stage, it becomes a simple act of finding the percentage of samples falling between 35 mmHg and 60 mmHg given the total number of samples in the histogram.

A running window frame of 30 minutes with increment of 1 minute was utilized to scan through all the data. Hence, each 10 hours recording would produce 600 running histograms for analysis. For each histogram, the amount of mean arterial pressures is compared against the upper bound value obtained from using the training data. To reduce the amount of false positive, 17.18% was selected as the cut-off point for the detection.

3. Results

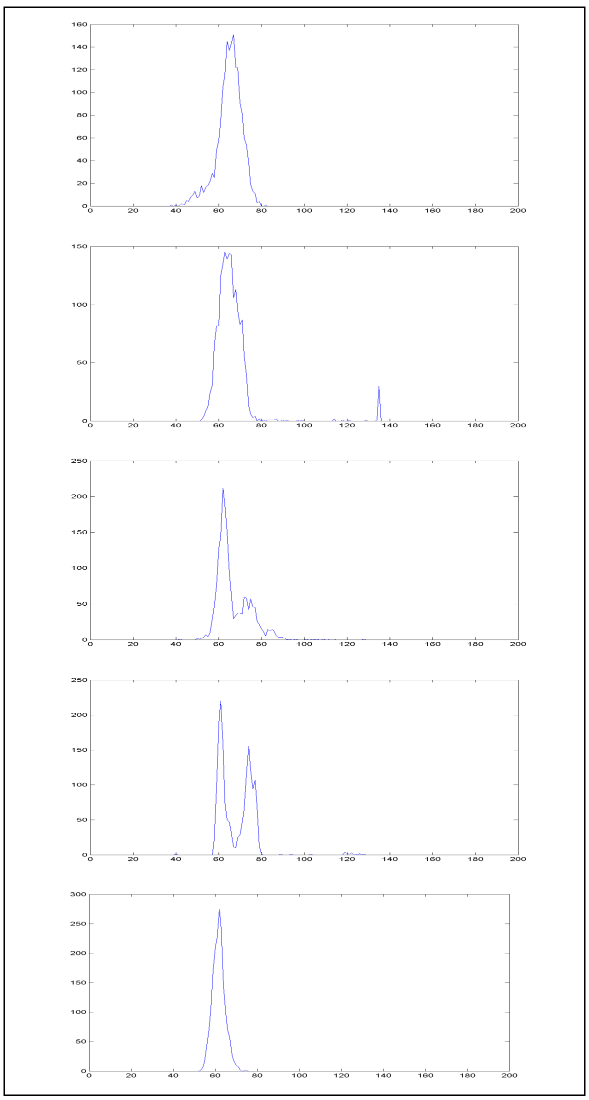

Figure 3. Histograms of data sets detected with AHE

The results for this challenge using the methods discussed in section 2 obtained a score of 10/10. The data sets that have episodes of AHE can be distinctively seen in the histograms below analyzed via Matlab.

It can be seen that all 5 detected dataset shown significant amounts of mean arterial pressure values that are within the bounds of 35mmHg and 60mmHg. Whereas the data sets with no AHE, the mean arterial pressure values indicative of AHE are clearly absent.

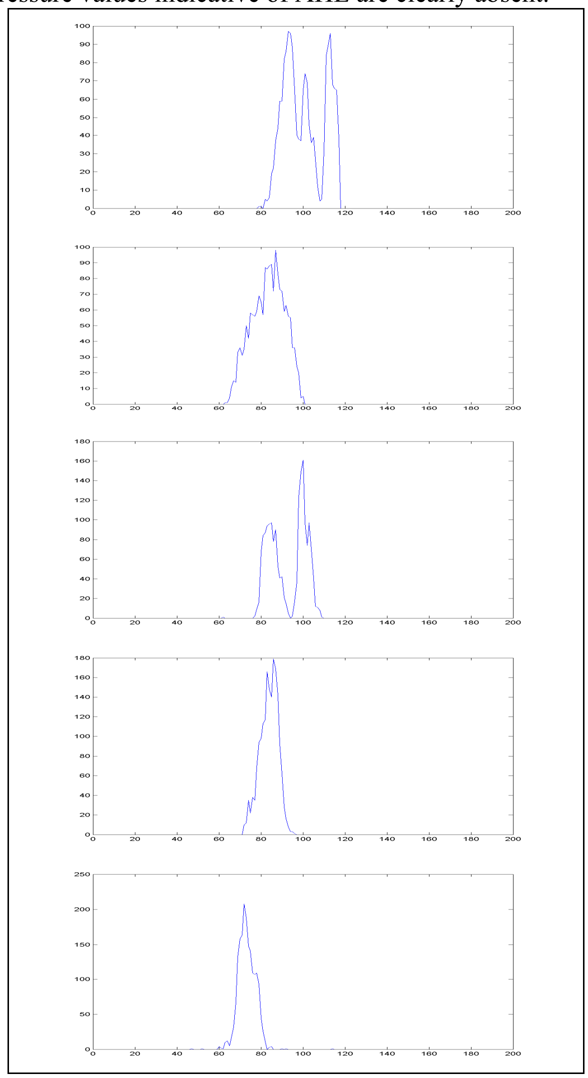

Figure 4. Histograms of data sets with no AHE

All histograms shown are derived from using per second averaging compression. This compression retains sufficient details for the running window detection process on all 10 records to be completed in 21 minutes and 13 seconds. The time for the computation can be increased but the penalty would be the greater loss of information for the detection.

If per minute averaging compression was used, 2 out of the 5 data sets of AHE would be undetected. The information loss is greater than if per second averaging compression was to be used. The processing time in the detection was only marginally decreased to 20 minutes but the results were reduced also by 40%.

4. Discussion and conclusions

The main research in this work was to obtain data points that are actually viable to work with and that allows for detection in viable time. Although the sampling frequency is not that high, the effort to go through 10 hours worth of data would still be Herculean.

The detection algorithm using a histogram is not that far-fetched when similarities can be made between image processing to this case of blood pressure processing. Essentially, locating certain low mean arterial blood pressure values is similar to locating for certain colours in an image. The transposition of this would be the different types of mean arterial pressure values to the different colour values.

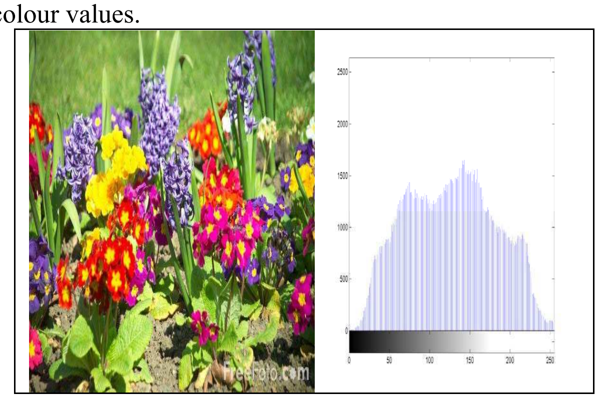

Figure 5. Image of flowers with its corresponding colour intensity histogram

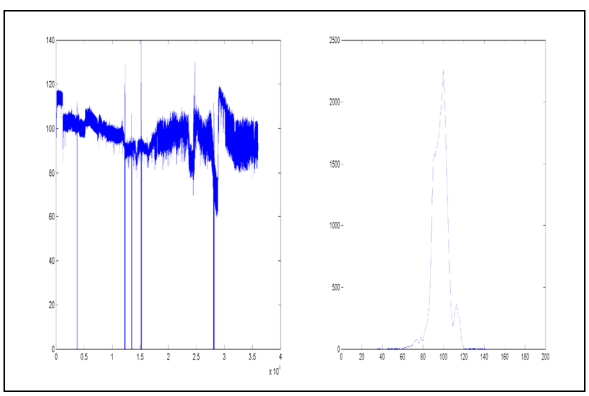

Figure 6. Recording of mean arterial pressure values with its corresponding mean arterial pressure distribution histogram

Hence, we need only compare the frequency distributions of mean arterial pressure values within 35mmHg to 60mmHg to the overall amount of mean arterial pressure values to draw a conclusion to whether the segment is attributed by AHE.

As mentioned previously, the main point of this research is to obtained signals as clean as possible for the detection. Filtering the signal for nonsensical noise therefore is very important. This noise would otherwise influence the detection to arrive at a wrong conclusion. Nonsensical values include but not limited to non-numerical values, negative values, values greater than 200mmHg, etc.

Assumptions also played a very important part in the attrition of values that were sensible but are considered as noise in the detection. One such plausible assumption would be that a patient could not be both suffering from hypotension and hypertension at the same time. The effect this have would be mean arterial pressure values greater than 140mmHg can be ruled out. These values most probably are noise and could potentially throw the detection off. Another plausible assumption would be there are no patients on the verge of dying or being in a coma. This again would have the effect that any values between 0mmHg to 35mmHg are also noise. Assumptions will also reduce the amount of data points that needs to be processed. However, it is a lossless reduction as it actually reduces the amount of redundant data points.

Even after eliminating redundancy, the amount of data points to be process is still massive. Hence, a viable compression method has to be chosen. In the experiments, the average, the mode and the median was tested. Mode and median is skewed if there are a lot of values favouring either the top or low end. Average came out with the correct results as the values were centralized.

This detection has done well in this Physionet challenge. However, it will take more research before the viability can be considered for clinical trials and usage.

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