

Visibility Graph Analysis of Heart Variability Series

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Nowadays, there is interest in the researchers to find other parameters from physiological signal that can be useful for the classification of different groups [1], and there are several works which study these parameters from the point of view of complexity [2].

The visibility graph algorithm (VGA) can be used for the association a complex network with a time series, such that the properties of the time series can be obtained by studying those of the network [3]. In order to perform this study, it is necessary to consider that all values of the time series become a node of the network, and the number of other nodes that it is connected to can be quantified, considering that two events are connected if they are visible to each other, and this happens if any event between them intersects the straight line that connects them. This fact produces that the degree of connectivity of a node is positively correlated with its magnitude. The slope of the regression line is denoted by $k-M$ [4], and, in this work, this parameter was calculated for the RR-interval time series from electrocardiography signal (ECG) of different contrasting groups and conditions.

The objective of this work is to study the behavior of the $k-M$ parameter for a totally different complex system: the heart rate variability time series. To do this, heartbeat time series obtained from different people in various situations are studied: first, we compare healthy young and elderly subjects, then healthy subjects and patients with congestive heart failure (CHF), and, finally, subjects at rest and while exercising. In addition, we analyze the average degree and average path length of the networks obtained for each time series. We show, in this work, that these parameters are useful to determine differences in time series and, remarkably, that the selected parameters are the simplest to obtain from a network due to the low computational costs for time and resources. It is worth mentioning that the main contribution of this work is to identify the network parameters that can be implemented for the classification of the heartbeat time series of patients with CHF vs. healthy subjects, young vs. elderly subjects, and sedentary vs. active subjects.

It was obtained that the mean of the slopes of $k-M$ plots for series of young people had lower values than those values for the older subjects, this difference was significant. However, the values obtained of average degree and average path length did not show significant differences.

Similar results were observed when comparing the healthy subjects with the congestive heart failure patients. Furthermore, in this case, the average degree and average path length calculated for these series, from which it was found that there were significant differences between healthy and diseased subjects.

On the other hand, we analyzed series taken in a rest period and during physical activity, then we obtained their visibility graph, and we calculated the parameters previously described. $k-M$ slopes, average degree and average path length obtained for the series of subjects increase during exercise, above all in series of young subjects the increase is higher compared with those from middle-aged adults. In addition, the $k-M$ is greater in subjects with a sedentary lifestyle in both groups.

These results suggest that the networks parameters used could be useful for the classification of series from healthy and ill, and even to determine the physical condition of a subject.

References

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