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Classification of electromyogram using recurrence quantification analysis

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Abstract
Clinical analysis of the electromyogram is a powerful tool for diagnosis of neuromuscular diseases. Therefore, the classification of electromyogram signals has attracted much attention over the years. Several classification methods based on techniques such as neuro-fuzzy systems, wavelet coefficients, and artificial neural networks have been investigated for electromyogram signal classification. However, many of these time series analysis methods are not highly successful in classification of electromyography signals due to their complexity and non-stationarity. In this paper, we introduce a novel approach for the diagnosis of neuromuscular disorders using recurrence quantification analysis and support vector machines. Electromyogram signals are transformed into recurrence plots and a set of statistical features are extracted using recurrence quantification analysis. Support vector machine employing radial basis functions is used for classifying the normal and abnormal of neuromuscular disorders. Examining the acoustic patterns in electromyogram, we classify the signals into one of the three categories: healthy, neuropathy, and myopathy. The results show that the proposed method classifies these signals with 98.28% accuracy; it is a significantly better accuracy than what has been reported in the literature thus far. The accurate results indicate that proposed diagnosis method of neuromuscular disorders is very effective. © 2011 Published by Elsevier Ltd.

Author Keywords
Classification; Dynamical system; Electromyogram; Recurrence quantification analysis

References
\begin{itemize}
  \item Nihal, F.G., Sabri, K. Classification of EMG signals using PCA and FFT (2005) Journal of Medical Systems, 29 (3).
  \item Filigoi, G., Felici, F., Vicini, N., Rosponi, A. Recurrence quantification analysis of surface electromyogram
\end{itemize}
Zbilut, J.P., Koebbe, M., Loeb, H., Mayer-Kress, G.  
**Use of recurrence plots in the analysis of heart beat intervals**  

Marwan, N., Wessel, N., Meyerfeldt, U., Schirdewan, A., Kurths, J.  
**Recurrence plot based measures of complexity and its application to heart rate variability data**  

Eckmann, J.P., Kamphorst, S.O., Ruelle, D., Ciliberto, S.  
**Liapunov exponents from time series**  

Takens, F.  
**Detecting strange attractors in turbulence**  