The 16th International Conference on Brain Informatics (BI 2023)

Abstract Note

August 1-3, 2023

Hoboken - New Jersey - USA

https://wi-consortium.org/conferences/bi2023/

Brain-Machine Intelligence and Brain-Inspired Computing

B247 Workshop Proposal

B252 Developing a Hidden Markov Model - Gaussian Mixture Model Framework to Classify Gait Patterns in Huntington’s Disease

B264 Visual Cortex Doesn’t Change, Why should Convolutional Layers?

B274 A Bayesian Hierarchical Method for Mental Disorders Subtyping Using Integrated Multi-modality Data

B291 Biologically Plausible Credit Assignment with Top-down Dendritic Gating of Plasticity

B298 Differential Neural Activity During Decision Making Reflects Both Reward-Impulsivity and Decision Difficulty

NO. B252

Developing a Hidden Markov Model - Gaussian Mixture Model Framework to Classify Gait Patterns in Huntington's Disease

Natalie Yi Yeung
Wycombe Abbey School, United Kingdom
natalieyiyeung@gmail.com

Abstract:

Background: Gait abnormality is a potential diagnostic sign which can occur even in the early, pre-manifest stages of neuro-degenerative diseases such as Huntington's disease (HD). Gait patterns in such patients are characterized by irregular, shortened stride lengths and jerky movements. Hidden Markov Models (HMMs) offer a straightforward and effective framework for disease progression prediction and pattern recognition. Methods: We propose a two-class Hidden Markov Model (HMM) where a stride model and a transition model were trained individually to identify distinct patterns and abnormalities during the gait-phase transition to distinguish between HD patients with moderate to severe motor dysfunctions and healthy controls. A left to right HMM was used to represent the stride model. The HMM for the transition model was extended to allow transitions to occur at any point. A 2-dimensional Gaussian Mixture Model was chosen to represent the hidden states of the HMM due to their ability to model diverse and personalised gait patterns. To estimate the parameters of the GMMs, the hidden states were initialized by dividing the strides into 2 equally spaced sections. The parameters were then optimized using the Baum-Welch algorithm with a maximum of 15 iterations. The threshold of convergence was set to 0.0001. Our HMM-GMM approach was applied on pre-existing data from an open source dataset from physio.net. 25% of the records was used to train the model while the other 75% was used during the recognition phase. Results: Our proposed HMM-GMM approach outperformed most standard algorithms, achieving the highest average F1 score of 81.76%. The results obtained by the HMM model is almost the same as the highest performing SVM classifier with only a 0.55% difference in terms of F1 score (81.21%). Moreover, it achieved the highest accuracy rate of 86.66%, suggesting that the use of HMM is suitable for classifying time-varying motion such as gait. Additionally, we observed that both supervised algorithms, Support Vector Machine (SVM) and k-Nearest Neighbours (kNN) achieved relatively high classification accuracy rates of 81.00% and 76.66% respectively. Only 54.04% of instances were classified correctly using k-means clustering with a significantly high standard deviation of 3.429, possibly due to its high sensitivity to outliers and the irregular distribution of data points. Conclusion: The obtained results are very promising since the HMM-GMM performs within an unsupervised context and do not require labelled data during the training phase, making them much easier to implement. In the future, the study could initially be undertaken without the effect of medication and the changes in gait patterns should be monitored continuously either as the disease progresses or with the use of medication.

Keywords:

Machine Learning, Neurodegeneration, Huntington’s Disease, Gait Analysis, Hidden Markov Models