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Original Research Paper

Engineering

REVIEW OF MACHINE LEARNING BASED APPROACHES FOR PREDICTION OF PARKINSON'S DISEASE

Ipsa Singh Yadav

Student (B.E.) Dept. of Biomedical Engg, Thadomal Shahani Engg College Bandra (W)-400050

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INTRODUCTION

Parkinson's disease (PD) is a neurological disorder effect and is a second most common neurodegenerative disorder after Alzheimers [1]. Parkinson's disease affects the movements, including speaking and writing. It involves the malfunction and death of vital nerve cells in the brain called Neurons. The dying neurons develop a chemical substance called dopamine, which sends messages to the part of the brain that controls movements and coordination and also act as a messenger between two brain areas. Substantia nigra and corpus striatum are the two brain areas used to produce the smooth controlled movements. In the brain the amount of dopamine produced decreases and it makes the person unable to control the movements normally [2].Patient is expected to raise. Although medication is available, there is no complete treatment for PD. So the early diagnosis is important to help patients and to improve the quality of their life. PD is characterized by tremor of the limbs, muscle rigidity, slowness of the movement, difficult with walking, balance and coordination, vocal impairtment and mood disturbances [3]. Recently the research in the field of neural networks has taken diversion towards processing data in the complex domain and it is applied in the areas like communication engineering, adaptive array signal processing and medical imaging which uses complex-valued signals [4]. The major drawback in the real valued neural network is that it could not process maximum information. In an ordinary neural network there will be information loss, if the real valued data is processed as a complex-valued data the information loss will be overcome [4].

The recently developed Meta-cognitive Fully Complex-valued Radial Basis Function (McFCRBF) network has been applied for predicting the Parkinson's disease. Performance comparison of the meta-cognitive fully complex-valued RBF network (Mc-FCRBF) applied for Parkinson's disease prediction shows better prediction of the disease when compared to a real-valued extreme learning machine and FC-RBF network. The improvement in performance is attributed to the self-regulatory learning mechanism of the meta-cognitive component [5].

In a different conclusion, it is observed that all the classifiers of PD performed reasonably well with boosted logistic regression giving the best performance with 97.16% accuracy and 98.9% area under the ROC (AUC). It is found that the accuracy and area under the ROC curve are nearly same among the different classifiers used. The present work and [3] have the advantage that the dataset used is very large as compared to others. However, it is noted that the PPMI study includes subjects who are in early stages of PD and healthy normal, however it doesn't include subjects who are having premotor symptoms but are not diagnosed as PD due to lack of motor symptoms.

And in a publication by Brewer et al. [7], a similar approach has been used to predict UPDRS scores. Here twenty-six participants (all PD patients) were exhibiting pressure on force and torque sensors while they were performing wave tracking tasks. The authors used the same parameters to summarize the participants ability to properly track waves (i.e. spectral density, RMS error and lag). These features were evaluated in terms of their ability to predict UPDRS scores. The authors present four approaches: PCA, least squares linear regression, lasso regression and ridge regression. Their results indicate that ridge regression works best with an absolute error of 3.5 UPDRS points. This is followed by lasso regression (i.e. 4.5 UPDRS points) and PCA (i.e. 7 UPDRS points). Similarly, Kondraske et al. [8] utilize ordinary computer hardware for specialized PD tests. The authors present an initial evaluation of three objective, self-administered and web-based tests (i.e. alternating movement quality, simple visual-based response speed and upper extremity neuromotor channel capacity). Each test has an equivalent version in the real-world based on atesting device called "BEP 1". Twenty-one subjects (i.e. eight healthy controls and thirteen PD patients) enrolled in their evaluation where both lab-based and web-based tests were performed. The results indicate an encouraging well correlation by lab-based and web-based "rapid alternating movement" and "`neuromotor channel capacity" tests. The correlation for the "simple visual" test did not show expected results. The authors envision a three-tiered approach that first involves digital, web-based tests then lab-based tests and finally screening by an expert. As suggested by its nature, web-based tests are easily accessible to a broad population. They provide objective measurements within an uncontrolled environment and may provide an initial assessment on whether any signs of PD are apparent. The second tier can then be used for a complementary assessment in a controllable environment. Afterwards a proper clinical screening can be performed by a neurologist if previous results suggested parkinsonian behavior. An automatic evaluation approach for early detection of PD is presented by Jobbágy et al. [9]. The authors propose and evaluate a set of tests that were specifically designed to highlight features of PD symptoms. They employ a motion tracking system, called precision motion analysis system (PRIMAS), for recording movements patterns. The system uses a combination of infrared (IR) light, passive markers (i.e. small, lightweight reflective disks mounted on body) and cameras in order to track the participants' movements of their fingers and hands. Jobbágy and colleagues aim at providing tests and / or measures to indicate the presence of early to moderate PD and subtle changes in its progression. Twenty-nine participants took part in their study (i.e. thirteen young healthy subjects, ten elderly healthy subjects and six subjects afflicted with PD). Three tasks were performed: tapping task, twiddling task as well as a pinching and circling task. The authors describe their analysis of raw movement data from their tracking system and highlight their chosen features (e.g. frequency, symmetry, dexterity, amplitude, etc.). Based on these parameters a score (between zero and one) is proposed in which people with PD achieve higher score-values (as in UPDRS). Their empirical results indicate that their scale does indeed separate PD patients from healthy subjects.

It is apparent that indication of PD motor symptoms in time series data is clearly not an unwritten page. Alone in the past decade a great number of publications with a focus on this very topic have been seen. Some of the mentioned authors have published their work on several symptoms. In recent years, accuracy of symptom indication and severity indication have reached percentages well above 90%. However it should be noted that datasets vary greatly in quality and quantity (e.g. from a few minutes to several hours or days of data). The accuracy increases and decreases with the used datasets and employed algorithms. Authors with small datasets or even synthetic datasets tend to achieve higher accuracies than those that utilise medium-sized or large datasets from real people.

Another aspect of quality is the task / activity which have been performed during recording sessions (i.e. scripted vs. unscripted, constrained vs. unconstrained, etc.). Here, preference has been given to those publications that were not using standardized motor tasks to identify symptoms (and their severity). Sensitivities in the range of 90%-95% (sometimes even greater) were achieved with today's methods, but usually at the cost of a lower specificity.

FUTURE WORK

Despite the fact that fairly high accuracies has already been reached, the presented results still allow for some improvements. I would like to employ a rather untraditional set of algorithms for indicating the presence of the mentioned PD motor symptoms in time series data (e.g. StreamKM++, ClusTree and LogLog algorithm). It is their intention to evaluate whether these approaches can perform on a similar level of accuracy or maybe even outperform the mentioned publications. A suitable framework, called MOSIS, for evaluating these approaches is actually under development (publication is pending; download available on mloss.org).[6]

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