

Diagnosis of Parkinson Disease using Handwriting Analysis

Nihar Ranjan, PhD
Professor
Department of Information
Technology
RSCOE

Divya Umesh Kumar
Student
Department of Information
Technology
RSCOE

Vaishnavi Dongare
Student
Department of Information
Technology
RSCOE

Kiran Chavan
Student
Department of Information Technology
RSCOE

Yuvraj Kuwar
Student
Department of Information Technology
RSCOE

ABSTRACT

Parkinson is a neurodegenerative disease that affects your ability to control movement. Parkinson's disease starts slowly and worsens over time. The cure for Parkinson's disease is still unknown; medications might significantly improve your symptoms. Researchers suggest that early diagnosis of Parkinson can help improve the quality of the patient's life. In this survey, handwriting or drawings is considered as an aspect for detecting Parkinson disease using machine learning algorithm such as Random Forest Classifier and for detailed analysis of the drawings we use, Histogram of Oriented Gradients (HOG). We take drawings drawn by Parkinson patients as well as healthy people as input for detecting the Parkinson disease

General Terms

Handwriting or drawings, Histogram of Oriented Gradients(HOG), Random Forest Classifier.

Keywords

Parkinson Disease(PD), Handwriting Analysis.

1. INTRODUCTION

Parkinson is a central nervous system disorder that affects movement, often including tremors. It leads to destruction of nerve cells which produces dopamine that helps to control the muscles and their movement. Parkinson's often starts with a tremor in one hand. This disease includes some other symptoms such as slow movement, stiffness and loss of balance. It has been observed that, out of every 1,000 people in the world around 1 or 2 that is one percent of the population which is above 60 years old, suffer from PD. In this disease, older age can be considered as a risk factor. Therefore, development of a feasible and reliable diagnostic method for PD detection is necessary which would help in early diagnosis of the disease and help to improve the quality of the patient's life [1]. The effects of the diseases start gradually but worsen over time

Following are the 5 stages for Parkinson's disease: Stage 1 is the mildest form of Parkinson's. At this stage the symptoms are mild so they don't interfere in daily lifestyle. So there might be chances of missing that symptom. But the changes in your posture, walk, or facial expressions it may be noticed by

your family and friends. As compared to stage 1, Stage 2 is a moderate form of Parkinson's, and the symptoms are much more noticeable than those experienced in stage 1. The symptoms like Stiffness, tremors, and trembling are more noticeable, and changes in facial expressions can occur. The middle stage is 3rd stage in Parkinson's, and it marks a major turning point in the progression of the disease. There are many symptoms which are similar to stage 1. However, you would experience loss of balance and decreased reflexes. The overall rate of movements decreases. Because of that reason falls become more common in stage 3. Independence separates people with stage 3 Parkinson's from those with stage 4. In stage 4, it's impossible to stand without assistance. But, the patient may require a walker or other type of assistance. The most advanced stage of Parkinson's disease is stage 5. Advanced stiffness in the legs causes difficulty in standing or walking.

Handwriting can be considered as an aspect in the assessment of Parkinson disease. Handwriting consists of cognitive planning, coordination, and execution abilities. To diagnose the disease and its severity handwriting problems can be considered as a prominent aspect, so changes in writing can be considered a prominent biomarker [2]. Handwriting is an very complex task. Writing a sentence requires the energetic transaction of the lower arm, wrist, and finger muscle. Currently, the detection is based on the assessment of several aspects such as facial expression difficulties, walking and speaking by Parkinson's patient. In this paper we have considered handwriting or drawing as an aspect for detecting the Parkinson disease as it is cost friendly and less time consuming [3].

2. IDENTIFY, RESEARCH AND COLLECT IDEA

In this section, the existing works that relate to the proposed work are presented. This [2] paper is divided into different phases for detection of Parkinson disease. Initial phase is data acquisition which deals with devices as well as handwriting tasks [12]. An electronic pen which considers different features like position, pressure over the writing surface, azimuth and altitude. Also the dataset includes words with repetitive letters which help to better address the motor skills.

There are some tests mentioned which help to evaluate the motor skills of the patients. Next phase is feature extraction that deals with function and parameter features [4] [5]. And lastly the classification is mentioned based on the outputs of previous steps.

In [3] author proposed the system to detect Parkinson's disease based on handwriting analysis. Parkinson disease detection through handwriting is convenient as compared to the brain scanning and all other activities. For this system author referred PAHAW dataset [6] [7]. Machine learning algorithm CNN is used along with SVM classifier for detection of PD patients with 83% accuracy. They classify dataset using deep convolutional neural network. They have used 90% dataset for training purpose and 10% for testing purpose. They referred four most commonly used architecture for this system as AlexNet [8], GoogleNet[9], VGGNet[10], ResNet[10]. In this paper they also referred drawing dataset which consist of spiral and wave drawings. In this section they have performed different experiments using different CNN architecture to analyze dynamics of handwriting of PD patients. This paper concludes that diagnosis of Parkinson's disease can be done by complex handwriting task.

In [1] paper, the system uses Dynamic Writing Traces Warping(DWTW) to extract differences between healthy individuals and patients with PD and includes eight handwritten task. This paper includes one experiment for Parkinson's disease. Dynamic wrapping is most important condition for classify differences and similarities of between time series. It has the ability to apply time series of different length.

This system comprises of two stages:

Feature Extraction:

In feature extraction, dynamic warping is used to quantify the difference between two non-linear writing patterns of healthy people and patients with PD. Feature extraction stage focus on separation of kinematic features which fixed difference or similarities two normal and abnormal writing patterns.

Classification:

And for the classification phase, this system uses SVM classifier along with linear kernel. Classification results were evaluate with different criteria namely accuracy, sensitivity and specificity.

In [15] this Paper ,We used the PaHaw and NewHandPD Parkinson an handwriting datasets. A relatively low number of samples in NewHandPD and PaHaw datasets can cause model CNN. To improve performance, we artificially extended the dataset by using label-preserving transformations. The proposed approach is built on CNNs, with weights trained using the newly proposed multiple-fine-tuning approach. A CNN is a type of neural network suitable for tasks with input data in the form of multiple arrays CNNs consist of one input layer, one output layer, and multiple hidden layers between them. Although hidden layers are mostly convolutional layers, in some popular CNNs, such as VGG16 and AlexNet[8], a few fully connected layers are added immediately before the output layer.

In [17] this paper they have developed a medical device that can help in early diagnosis of Parkinson Disease. The patients, who are diagnosed as PD patients, further go for expert assessment. They make use of graphics tablet for analysis of patient's drawings which capture the cognitive assessment figure. They have included deep learning model to check whether the patient's handwriting shows sign of Parkinson's

disease .They have referred dataset which contains drawings of pentagon and cubes. They have also used CNN model. The system consist of different stages as follows Data Acquisition, Data Preprocessing, Architecture and training, CNN Assessment, Result and Evaluation. The system reduces burden on patients during assessment.

In [11] the paper mainly focuses on text mining which helps to find new information or to answer specific questions. In today's world large number of data is generated day by day. To handle dataset there are different algorithms in machine learning. Text mining is one of the text classification algorithm. Text mining is nothing but a method of extracting hidden information from the dataset. Text classification divided into 2 types based on static data and incremental data. Random forest classifier is used for classification of incremental data.

In [22] the paper specifies that text mining has become an important task which helps in finding relevant and useful information. The paper basically presents text categorization that utilizes semantic keywords. It can be majorly used in data preprocessing.

3. PROPOSED SYSTEM

This proposed system would diagnose a Parkinson patient using the drawings of spirals and waves which is taken as input to the system. The dataset consists of drawings of both healthy people and Parkinson patients for analysis. This system uses Histogram of Oriented Gradients (HOG) and Random Forest Classifier for the classification of the input images.

3.1 Histogram of Oriented Gradients:

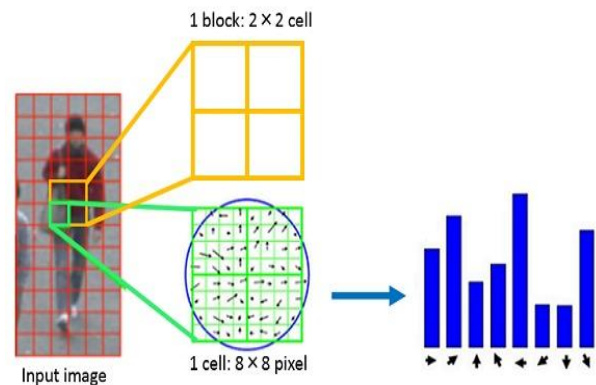


Fig. 1 Histogram of Oriented Gradients

Histogram of Oriented Gradients or HOG is a feature descriptor which represents the image in a simplified manner and contains the most important information about the image. HOG descriptor mainly deals with the structure and the shape of an object. HOG provides edge direction as well which is done by extracting the gradient and orientation of the edges. These orientations are calculated in 'localized' portions. This means that the complete image is divided into smaller regions called cells and for each cell it computes HOG for pixels which are present within the cells. Then the histograms across multiple cells are combined to form the feature vector.

3.2 Random Forest Classifier:

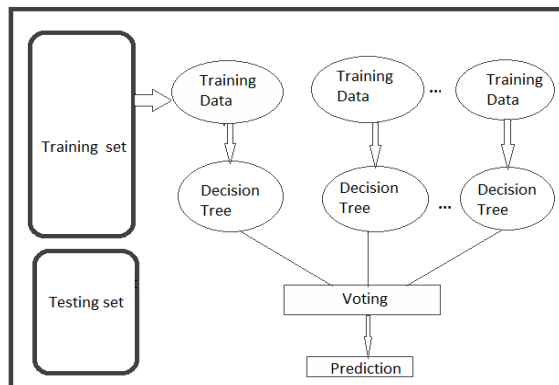


Fig. 2 Random Forest Classifier

Random forest is a supervised learning algorithm. Random forest consists of large individual decision trees that operate as an ensemble. Decision tree is the core unit of random forest classifiers. The decision tree is a ordered structure that is built using the features of a data set. Every node of the decision tree is break according to a measure associated with a subset of the features. The random forest is a collection of decision trees that are linked with a set of bootstrap samples that are generated from the original data set. The nodes are subdivided based on the entropy of a selected subset of the features.

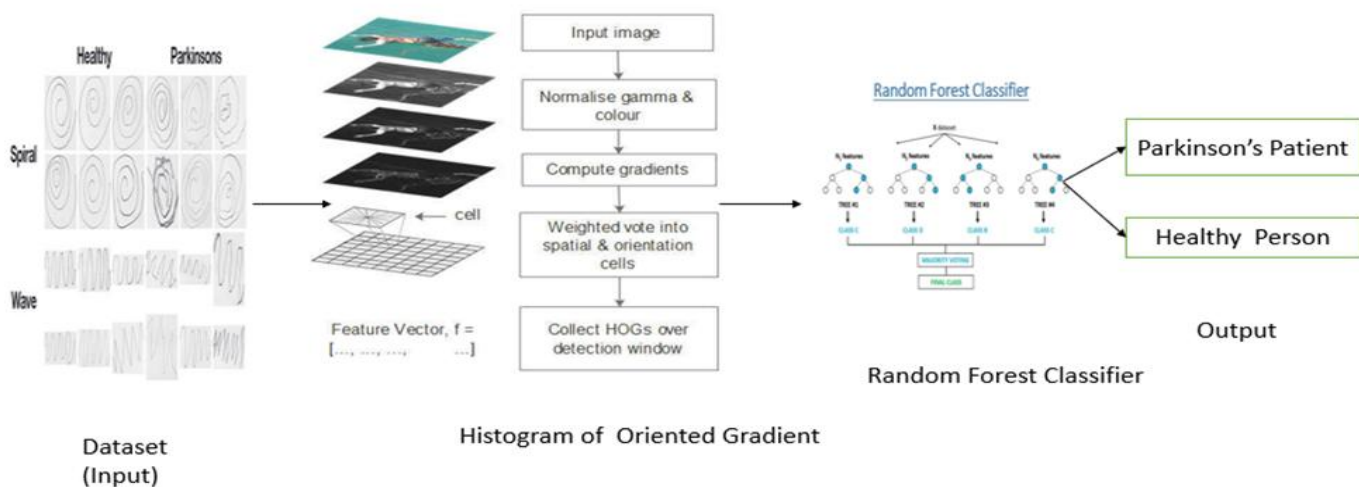


Fig. 3 Proposed system

4. CONCLUSION

There are systems which use devices like electronic pens or have interview processes based on which detection of Parkinson disease takes place. These processes sometimes become very tiring for the patients and also they are very time consuming. The proposed system is more beneficial. It is cost efficient as we avoid use of electronic or smart pens. The system is easy to understand. As we have used HOG descriptors, they are very powerful descriptors which are extremely helpful in describing the structure, shape and appearance of the input image.

5. FUTURE SCOPE

Parkinson disease doesn't have any cure. Detection of Parkinson's disease at early stage is tedious task, as the patient's shows very mild symptoms so doctors cannot detect the disease at early stage. But the only way to make the patient's life easier is early diagnosis of this disease. So in future, systems which diagnose this disease at the initial stage will be very helpful. In future, this system can be made a mobile application so that it can be accessed anytime and anywhere.

6. ACKNOWLEDGMENTS

Finally, I wish to thank all our friends and well-wishers who supported us in completing this paper successfully I am especially grateful to our guide Dr. NIHAR RANJAN for keeping time to time review of our project and very much needed valuable guidance. Without the support and encouragement of our guide, this paper would not have been completed on time.

7. REFERENCES

- [1] ElhamDehghanpurDeharab Faculty of Biomedical Engineering Sahand University of Technology Tabriz, IranPeyvandGhaderyan Computational Neuroscience Laboratory, Faculty of Biomedical Engineering Sahand University of Technology Tabriz, Iran
- [2] DonatoImpedovo, Senior Member, IEEE, and Giuseppe Pirlo, Senior Member, Dynamic Handwriting Analysis for the Assessment of Neurodegenerative: A Pattern Recognition Perspective , IEEE REVIEWS IN BIOMEDICAL ENGINEERING, VOL. 12, 2019
- [3] Imran RazzakIqra Kamran† ,SaeedaNaz Department of Computer Science, GPGC, Abbottabad, KPK, Pakistan School of Information Technology Deckin,University,Geelong,Australia

- [4] S.Müller, O. Preische, P. Heymann, U. Elbing, and C. Laske, "Diagnostic value of a tablet-based drawing task for discrimination Of patients in the early course of Alzheimer's disease from healthy individuals," *J. Alzheimer's Disease*
- [5] J.Kawa, A. Bednorz, P. Stępień, J. Derejczyk, and M. Bugdol, "Spatial and dynamical handwriting analysis in mild Cognitive impairment," *Comput. Biol. Med.*, vol. 82, pp. 21–28, 2017.
- [6] P.Drotar, J. Mekyska, I. Rektorová, L. Masarová, Z. Smékal, and M. Faundez-Zanuy, "Evaluation of handwriting kinematics and pressure for differential diagnosis of parkinson's disease," *Artificial intelligence in Medicine*, vol. 67, pp. 39–46-2016.
- [7] Analysis of in-air movement in handwriting: A novel marker for parkinson's disease," *Computer methods and programs in biomedicine* vol. 117, no. 3, pp. 405–411, 2014
- [8] A.Krizhevsky, I. Sutskever, and G. E. Hinton,, "Imagenet classification with deep convolutional neural networks," in *Advances in neural information processing systems* 2012, pp. 1097–1105.
- [9] C.Szegedy, W. Liu, Y. Jia, P. Sermanet, S. Reed, D. Anguelov, D. Erhan, V. Vanhoucke, and A. Rabinovich, "Going deeper with convolutions," in *Proceedings of the IEEE conference on computer vision and pattern recognition*, 2015, pp 1-9.
- [10] K.Simonyan and A. Zisserman, "Very deep convolutional networks for large-scale image recognition," *arXiv preprint arXiv:1409.1556*, 2014.
- [11] Nihar Ranjan, Midhun Chakkaravarthy "A Brief Survey of Machine Learning Algorithms for Text Document Classification on Incremental Database" *TEST: Engineering & Management*, ISSN: 0193-4120, pp 25246 – 25251
- [12] C. E. Anderson and M. P. Fisher, "Signatures of persons with Parkinsonism and hepatic encephalopathy as comparison standards," in *Proc. 9th Biennial Conf. Int. Graphonomics Soc.*, 1999, pp. 15–18.
- [13] Nihar Ranjan, Rajesh Prasad," LFNN: Lion fuzzy neural network-based evolutionary model for text classification using context and sense based features", *Applied Soft Computing*, ISSN: 1568-4946, July 2018, pp 994-2018
- [14] P.Drotár, J. Mekyska, I. Rektorová, L. Masarová, Z. Smékal, and M. Faundez-Zanuy, "Evaluation of handwriting
- [15] Kinematics and Pressure for differential diagnosis of Parkinson's disease," *Artificial intelligence in Medicine*, vol. 67, pp. 39-46, 2016.
- [16] Nihar Ranjan, Rajesh S. Prasad " Author Identification in Text Mining for used in Forensics" ISSN 2321- 9637, Volume 1, Issue 5, December 2013, pp. 568-571
- [17] A.Krizhevsky, I. Sutskever, and G. E. Hinton, "ImageNet classification with deep convolutional neural networks," in *Proc. Adv. Neural Inf. Process. Syst.*, 2012, pp. 1097–1105.
- [18] Mohamad Alissa¹, Michael A. Lones², Jeremy Cosgrove³, Jane E. Alty⁴, Stuart Jamieson³, Stephen L. Smith⁵,
- [19] Marta Vallejo⁶, Parkinson's disease diagnosis using convolutional neural networks and figure-copying tasks, *Springer*, 2020.
- [20] K. He, X. Zhang, S. Ren, and J. Sun, "Deep residual learning for image recognition," in *Proceedings of the IEEE conference on computer vision and pattern recognition*, 2016, pp. 770–778.
- [21] Nihar Ranjan, Rajesh Prasad, "Automatic Text Classification using BPLion- Neural Network and Semantic Word Processing" , *Imaging Science Journal Print* ISSN: 1368-2199, Online ISSN: 1743-131X, July 2017, pp 1-15
- [22] P.Drotar, J. Mekyska, I. Rektorová, L. Masarová, Z. Smékal, and M. Faundez-Zanuy, "Analysis of in-air movement in handwriting: A novel marker for Parkinson's disease," *Computer methods and programs in biomedicine*, vol. 117, pp. 405-411, 2014.
- [23] K.Simonyan and A. Zisserman, "Very deep convolutional networks for large-scale image recognition," in *Proc. Int. Conf. Learn. Represent. (ICLR)*, 2015, pp. 1–14.
- [24] Nihar Ranjan, Midhun Chakkaravarthy, "Evolutionary and Incremental Text Document Classifier using Deep Learning" *International Journal of Grid and Distributed Computing* Vol. 14, No. 1, (2021), pp. 587-595.