International Journal of Research Publication and Reviews, Vol 4, no 12, pp 4058-4061 December 2023

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Detection of Parkinson's Disease through Spiral Image Classification and Machine Learning

Vrishabh Bansal, Mehul Lahot, Kunal

Department of Information Technology, Maharaja Agrasen Institute of Technology, Rohini, Delhi-86

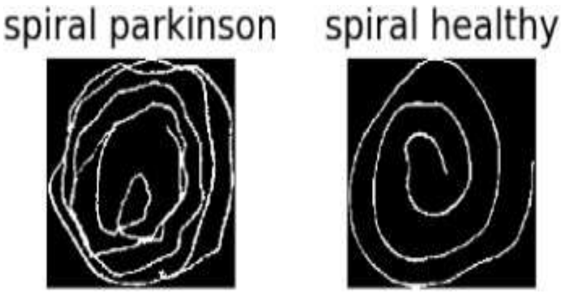
ABSTRACT:-

Parkinson disease (PD) is a common brain condition that messes with how the body moves, making it hard to coordinate and causing shaky rest and stiffness. People with PD often have trouble with their handwriting, and a big sign is something called Micrographia. This study looks into PD patients' Static Spiral Tests (SST) using a smart computer program called Machine Learning. It's like a brain for computers that can learn things. We use a smart algorithm called KNN to figure out if the spirals drawn by healthy people look different from the ones drawn by PD patients (Archimedes Spiral). The idea is to find PD early because going to the doctor for PD is expensive and takes a lot of time. If a computer can help with this test, it could save time and money for patients, people who take care of them, and doctors. The results are cool – the computer is really good, like 96.07% good, at telling apart the drawings of PD patients and healthy folks. Even in a different set of pictures used just for checking, it still got it right about 90% of the time. So, to make it easy for everyone to use, we made a simple computer program called "PD Detector." It's like a quick checker based on what we learned.

Keywords: Machine Learning, KNN, Parkinson's disease Spiral Drawing Analysis.

INTRODUCTION

Parkinson's Disease is this common brain thing that impacts a ton of population around the globe. It brings some classic signs like having a tough time getting movements going, losing the smoothness in moving automatically, dealing with tremors, stiff muscles, changing posture, and having a hard time with stuff like smelling, sleeping, and swallowing.



The main cause is losing these neurons in the midbrain, especially the dopaminergic ones, but it messes with other neurons all over the place. People dealing with Parkinson's also often struggle more with drawing and writing, and the worse the disease, the tougher it is for them. So, this paper throws out an idea about checking out how people draw Archimedes Spirals, both those dealing with Parkinson's and those without it. There's this test where you draw a never-ending spiral, showing if there are tremors and how bad they are. Doing this helps to figure out what's up with the tremors, checking how a person is doing over time, and seeing if they're responding to treatment. Keeping an eye on the spiral over time is easier for doctors to catch any tremors, whether they're small or big. The Archimedes test is like a tool for doctors to get a handle on how bad the tremors.

METHODOLOGY

Tremors, a common Parkinson's symptom, undergo examination through the Static Spiral test, where individuals draw continuous spirals. This assists doctors in identifying even the most subtle tremors. Employing a Machine Learning approach, we categorize images into two groups: (i) Spirals created by healthy individuals and (ii) Spirals created by Parkinson's patients. Utilizing the K-Nearest Neighbours (KNN) algorithm, our model achieves an impressive 96.07% accuracy. Image processing techniques optimize and extract vital information from flattened 1D arrays of pixel values. This analysis aids in predicting Parkinsonian traits. In our PD Detector web application, users upload Archimedean spiral images, which undergo resizing and flattening.

KNN, with three nearest neighbors using the Euclidean principle, determines the best matches, predicting the image's category. It's a pixelated enchantment, distinguishing between spirals in the virtual realm.

K-Nearest Neighbours (KNN) - K-Nearest Neighbors, a fundamental and crucial classification algorithm in Machine Learning, falls under supervised learning and has extensive applications in pattern recognition, data analysis, and intrusion detection.

Support Vector Machine (SVM) - SVM is a comparatively easier **Supervised Machine Learning Algorithm** used for classification and/or regression. It is preferred for classification but in some cases useful for regression as well. SVM finds a hyper-plane that draws a boundary between the type of data. In 2-d space, this hyper-plane is nothing but a line.

Random Forest is an ensemble learning technique widely utilized in machine learning. During training, it constructs multiple decision trees and outputs the class mode in classification job or mean prediction in regression job . This method significantly enhances accuracy and mitigates overfitting concerns, making it a preferred choice for diverse applications in data science and artificial intelligence. The term "random" in Random Forest pertains to the introduced randomness during the training process, involving bootstrapped samples and feature subsets. This randomness contributes to the model's robustness and generalization capabilities. The versatility of Random Forest positions it as a valuable tool for jobs like classification and regression in the zone of machine learning

LITERATURE SURVEY

Muhammad Usman and Yaseen investigates Parkinson's disease (PD) using the Hilbert-Huang Transform (HHT) for assessing impairment in spiral drawings. Despite dimension reduction with PCA and classification using the C4.5 classifier, results indicate the computer method's difficulty in accurately assessing drawing impairment causes. This may stem from no discernible difference between the two classes or potential influence from patients' self-ratings displayed in the web application[2012][1]. Jinwei Wang; Dan Long; Zengsi Chen presented a method for early Parkinson's disease (PD) detection, analyzing integrated structural data from 116 regions of interest via PCA. Trained with an RVM-based classifier, it achieved 89.13% accuracy, 78.95% sensitivity, and 96.30% specificity on a dataset of 19 PD patients and 27 controls. This approach holds promise for improving early PD diagnosis and treatment evaluation[2013][2].Muhammed Erdem Isenkul leads a study on Parkinson's disease (PD) progression monitoring, emphasizing the challenges faced by elderly patients during traditional clinic visits. To address this, self-administered telemonitoring applications enable patients to collect data at home, offering a convenient solution. The study focuses on handwriting motor abilities affected by PD, collecting samples via a graphics tablet. Introducing a dynamic spiral test (DST), performed electronically, the study showcases comparative results with the traditional static spiral drawing test (SST). These results highlight the potential of using computerized handwriting samples to develop generalizable PD telemonitoring stems[2014][3].Clayton R Pereira, Danillo R Pereira, Francisco A. Da Silva, Christian Hook, Silke A.T. Weber, and Luis A.M. Pereira investigated Parkinsons disease (PD) diagnosis using computer vision techniques on a substantial dataset. A key contribution to a joint research project on early PD diagnosis, the dataset includes handwriting clinical exams analyzed through image/photo processing and machine learning. Encouraging initial results were obtained, along with the introduction of a new quantitative method, Mean Relative Tremor, measuring an individual's handwritten tremor[2015][4]. Zehra Karapinar Senturk's proposed diagnostic approach incorporates feature selection making use of Feature Importance and Recursive Feature Elimination, employing Classification and Regression Trees, Artificial Neural Networks, and Support Vector Machines for classification. Notably, Support Vector Machines combined with Recursive Feature Elimination achieved the highest accuracy at 93.84% with minimal voice features for Parkinson diagnosis[2020][5]. Ferdib-Al-Islam's study on Parkinson's disease utilized Gradient Boosting and K-Nearest Neighbors for enhanced accuracy, sensitivity, and specificity. Gradient Boosting achieved 86.67%, 93.33%, and 80.33%, while K-Nearest Neighbors reached 89.33% accuracy and 91.67% sensitivity[2020][6]. Matt Ervin Mital’s Parkinson's study used SST and DST alongside transfer learning. Among 14 pre-trained models, MobileNetV2 led with 93.94% accuracy, while Vgg-19 scored 27.27%. Stochastic Gradient Descent with Momentum (sgdm) and Adaptive Momentum (adam) were favored on top of rmsprop. The study underscores the importance of DST images over SST or a combination [2021][7]. José Carmen, Morales-Castro introduced an AI method for Parkinson's identification using images of spirals and waves from a opensource database. Results from two events and four learning methods demonstrated approximately 90% accuracy. This underscores the methodology's effectiveness in aiding diagnosis and treatment follow-ups through artificial intelligence techniques[2022][8]. Researchers Lerina Aversano, Mario Luca Bernardi, Marta Cimitile, Martina Iammarino, and Chiara Verdone address Parkinson' disease, a prevalent neurodegenerative condition affecting movement. Their study proposes an AI-based approach, combining artificial intelligence with spiral test for early Parkinson’ diagnosis. Utilizing an Echo State Network and an MLP layer for classification, the ESN-based classifier achieves a remarkable F Score of 97.8%. These highly promising results suggest the approach's significant potential in advancing Parkinson's diagnostics[2022][9].Isabel Sarzo Wabi, Daniel-Alejandro Galindo-Lazo & Roberto Rosas-Romero proposed a method for Parkinson' disease (PD) diagnosis using static spiral drawings. Utilizing an affordable dataset from a balanced PD and control population, the study focused on feature extraction and selection. Employing k-nearest neighbors, multi-layer perceptron, and support vector machine classifiers, the best achieved performance was 86.67% accuracy, 80.00% sensitivity, 100% specificity, 100% positive predictive value, and 82.35% negative predictive value[2023][10]. Olanloye D.O developed a Parkinson's early detection system using Random Forest, achieving 100% accuracy in wave and spiral classifications. Logistic Regression and Dummy Classifier had lower accuracy. The chosen model, Random Forest, with 100% accuracy, outperformed existing methods in system efficiency[2023][11].

Technique and Year	Accuracy	Specificity	Sensitivity
Hilbert Huang Transform(HHT), 2012	NA	NA	NA
Relevence Vector Machine(RVM) 2013	89.13 %	96.30%	78.95%
spiral drawing test, 2014	NA	NA	NA
computer vision-based techniques, 2015	NA	NA	NA
Support Vector Machine(SVM), 2020	93.84%	NA	NA
Decision Tree, Gradient Boosting, K-Nearest Neighbor, Random Forest, and others, with the HOG (Histogram of Oriented Gradients) feature descriptor algorithm., 2020	89.33% 86.67%	91.67% 93.33%	NA 80.33
static and dynamic spiral tests, 2021	93.94%	NA	NA
Standard evaluation metrics, 2022	90%	NA	NA
boosting decision trees based, 2022,	97.8%	NA	NA
k-nearest neighbors(knn), multi-layer perceptron, and support vector machine(svm), 2023	86.67%	100%	80.00%
Random Forest , 2023	100%	NA	NA

RESULT

The study focuses on assessing machine learning tools employed for the binary classification of spiral drawings into healthy and patient categories. This distinctive analysis involves a limited dataset comprising static spiral drawings, a novel exploration not previously undertaken. The performance metrics showcase the effectiveness of different models, with Logistic Regression and Random Forest Classifier standing out for their precision, recall, and F1 score, indicating reliable predictions. Precision, emphasizing correctness, and F1 score, a harmonic blend of precision and recall, together validate the models comprehensively.

CONCLUSION

Our recent investigation presents an inventive method tailored to evaluate motor symptoms in individuals grappling with advanced stages of Parkinson' Disease, specifically those contending with motor fluctuations. The system we've developed attains a commendable level of precision, making substantial strides in Parkinson's Disease detection. The primary motive is to extend the applicability of this diagnostic approach to remote areas where access to comprehensive healthcare remains a challenge. The incorporation of a user-friendly web application elevates the practicality of our model. Going beyond its adept categorization of spiral drawings, the application also furnishes a nuanced assessment of disease severity, expressed in relative percentages. This research strives to narrow the diagnostic and management disparities in Parkinson's Disease, prioritizing accessibility and user-friendliness, and may furnish valuable insights into the condition's progression, especially in regions grappling with constrained healthcare resources.

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