Article **Journal of Physiotherapy and Medical Technology**
December, 2022 Vol.6 No.16 27-32

Use of image processing for the detection of Parkinson's disease

Uso de procesamiento de imágenes para la detección de Parkinson

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DOI: 10.35429/JP.2022.16.6.27.32 Received July 12, 2022; Accepted October 15, 2022

Abstract

In recent years, the use of image processing has increased considerably in the area of health sciences. The use of artificial intelligence techniques helps to strengthen diagnosis and/or to follow up medical treatments. In this work we present a method that allows the identification of Parkinson's disease by processing images corresponding to spirals and waves made by suspicious patients. This set of images was specially developed for this purpose and corresponds to a public database. Results obtained in two classification scenarios and four different learning methods are presented. Standard evaluation metrics are used to measure the performance of the implemented classification system. The results obtained are of the order of 90% accuracy which allows to see the effectiveness of the implemented methodology.

Machine Learning, Parkinson, Cross Validation, Training and Testing Set

Resumen

En los últimos años, el uso del procesamiento de imágenes se ha incrementado considerablemente en el área de ciencias de la salud. El uso de técnicas de inteligencia artificial ayuda a fortalecer el diagnóstico y/o dar seguimiento a tratamientos médicos. En este trabajo presentamos un método que permite identificar la enfermedad de Parkinson mediante el procesamiento de imágenes correspondientes a espírales y ondas realizadas por pacientes sospechosos. Este conjunto de imágenes fue especialmente desarrollado para este fin y corresponden a una base de datos publica. Se presentan resultados obtenidos en dos escenarios de clasificación y cuatro métodos de aprendizaje distintos. Para medir el desempeño del sistema de clasificación implementado se utilizan métricas de evaluación estándar. Los resultados obtenidos son del orden de 90 % de precisión lo cual permite ver la efectividad de la metodología implementada.

Aprendizaje automático, Parkinson, Validación Cruzada, Conjunto de entrenamiento y prueba

Citation: MORALES-CASTRO, José Carmen, RUIZ-PINALES, José, LOZANO-GARCÍA, José Merced and GUZMÁN-CABRERA, Rafael. Use of image processing for the detection of Parkinson's disease. Journal of Physiotherapy and Medical Technology. 2022. 6-16: 27-32

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1. Introduction

Parkinson's disease is a disease that affects the nervous system, usually manifested by a loss of coordination of movement [1].

These symptoms usually present with tremors, rigidity or decreased movement. Parkinson's disease cannot be cured, but medication can help to significantly improve symptoms.

The first symptoms of Parkinson's can be mild, often starting on one side of the body, and may include tremors, slowness of movement, muscle stiffness, loss of balance, and changes in speech and handwriting.

The disease can run in families, and although there is no specific diagnosis to detect it, the neurologist will rely on the patient's medical history to support a correct diagnosis.

The diagnosis is based on different tests or analyses such as MRI scans, CT scans, ultrasound scans of the brain to rule out other disorders.

An estimated 10 million people in the world live with Parkinson's disease, while in Mexico there are no exact figures for this disease, the National Institute of Neurology and Neurosurgery estimates a prevalence of 50 new cases per 100,000 inhabitants per year.

The incidence of Parkinson's disease increases with age, with the average age of onset worldwide being around 60, although an estimated 10% of people are diagnosed before the age of 50.

Artificial intelligence according to [2] is defined as "An ability of computers to perform activities that normally require human intelligence" i.e. the ability of machines to use algorithms, learn data, and use what they learn to make decisions as a human being would.

In his work [3] he shows image processing to analyse a digital image where the tools are organised according to the level of information contained in a digital image, forming a processing chain as shown in the following figure.

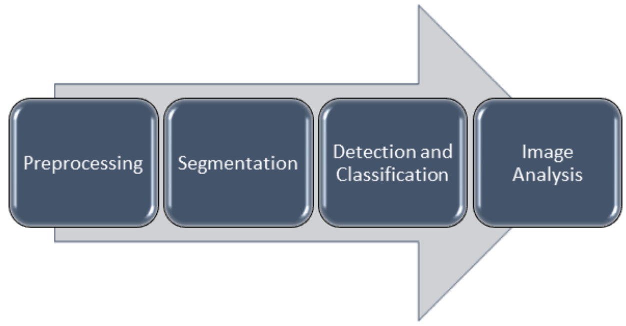

Figure 1 Processing Levels

– *Pre-processing.* - Pre-processing is a series of operations that adapt a preset image. Within this section the image can change image characteristics such as brightness, contrast, size, etc. according to the needs that the analysis requires.
– *Segmentation.* - Operations that partition an image into different regions that show the information necessary for the problem to be solved.
– *Object detection and classification.* - Determines and classifies the objects contained in an image.
– *Image analysis.* - Obtains information about what an image shows.

It is important to recognise the importance of image processing for pattern recognition, due to the large amount of information that digital images contain that is difficult to interpret, as it has catapulted into a variety of applications including medical diagnosis.

2. State of the art

In the work of [4] they present a motor symptom tracking and management system. In this work they discuss that it has its origin in a European research project called PERFORM. In it a set of classification algorithms were evaluated, e.g. SVM, k-nearest neighbours, decision tree, with the result that SVM achieved the highest accuracy of 86%. The corresponding dataset consists of acceleration data from twenty patients performing a set of activities of daily living. A standard analysis procedure is used by the authors, where as a first step, a Butterworth filter is applied to the raw sensor data and then the data stream is staggered into five-second segments with an overlap of 50 %, where a set of features is then calculated for each segment and passed to classification algorithms, the algorithms classify the presence and severity of bradykinesia (slowness in physical movements).

Interestingly, the severity is not derived from standard motor tasks, but from activities commonly performed on a daily basis.

[5] achieved 87% accuracy in tremor detection within an accelerometer-based dataset with 23 participants, where they performed daily activities in laboratory analysis conditions, where the flow time is divided into 3-second windows with 50% overlap, where using the Hidden Markov Model (HMM) tremor episodes can be detected by applying standard filtering and analysis techniques where the most common approaches are based only on spectral features while other works are based on results from SVM support machines.

[6] proposed two structures based on convolutional neural networks to control Parkinson's disease using sets of vocal features. The system includes sets for the same information layers that are associated with the convolution layers. The deep reflections of each equal branch are removed at the same time and merged into the combined layer.

Test results indicated that the posterior structure obtained an accuracy of 86.9%. The subsets of components were sent to several classifiers and the classifiers' predictions were combined with the learning datasets. The results indicated that TQWT has superior or similar performance to best-in-class speech signal handling strategies used in PD clustering. Each tree is developed by an example from the data using arbitrary variable selection and looting strategies.

Some authors such as [7] have used databases similar to the one we used in this research work to correctly identify biomarkers more accurately for better medical diagnosis, similarly they have used both types of wavelet and spiral images for the two types of patients, however the one designed by the authors was developed with convolutional neurons, the data from the database used by the authors correspond to 55 patients whose subjects belonged to the healthy class and 27 subjects with Parkinson's reaching an overall accuracy of 93.3 %.

In the work of [8], the authors designed their database by compiling the drawings into a digitised graph, asking the patients to make spiral drawings.

The set of patients consisted of 77 people, of which 15 healthy people from the control group had Parkinson's disease, who used their permits to display and interact with digital pen, five time series were recorded for the drawing, each record includes information of pressure coordinates and grip angle obtained from the API of the device, they took the usage frequencies of 110 Hz and 140 Hz, in order to have uniform data, they used Fast Fourier Model transformation, in order to perform data pre-processing, once the data was obtained, they used a CNN based on deep learning.

In the work of [9] they present an investigation of the automatic classification set of pyramidal neurons of young and adult monkeys, where the performance of 4 machine learning methods such as SVM, KNN, RL, and ROC using WEKA software is evaluated. The results for the area under the curve (ROC) are 86.6% for logistic regression and 91.2% for KNN.

3. Methodology.

In the present work, the analysis of drawings carried out by patients with Parkinson's disease and patients without this disease was carried out, consisting of a series of drawings in the form of waves and spirals that helped to classify them automatically.

The database used in the realization of this research work is called "Distinguishing Different Stages of Parkinson's Disease", which was developed by Kevin Mader, in this database is a set of images made by healthy people and people detected with Parkinson's disease who made a work of 102 images in total of waves and spirals, which will support us to make an automatic classification of the drawings made by both patients. Illustration 2 shows on the right side the drawings created by patients with Parkinson's disease and on the left side those without Parkinson's disease.[1]

[1] https://www.kaggle.com/kmader/parkinsons-drawings

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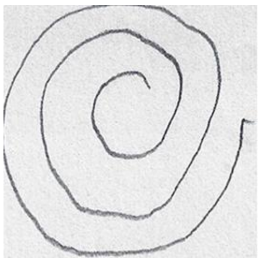
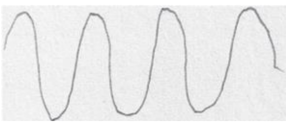
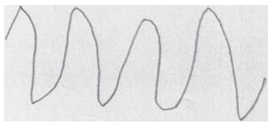
Parkinson's Drawings	
	
	
Drawings of people **WITHOUT** Parkinson's disease.	Drawings of people **WITH** Parkinson's disease.

Figure 2 Drawings of patients with and without Parkinson's disease

Two classification scenarios were used for image classification:

- Cross Validation
- Training and Test Sets

These scenarios were developed in Python, firstly, Resnet50 is a residual neural network created as a Keras model that helps the extraction of features from the images, it was taken as a comparison the use of the Oriented Gradient Histogram which helps us as a feature descriptor, this in order to detect which of the two allowed us to obtain better results in the classification of the images. Both using 4 classification methods which are named as follows:

- SVM (Support Vector Machine)
- RL (Logistic Regression)
- KNN (Nearby Neighbours)
- Bayes

Support Vector Machine (SVM)

It is a method based on learning that helps us in problem solving through classification and regression, which is based on a training phase and a problem solving phase; this method can be compared to a "black box" that will provide an answer (output) to a set problem (input) [10].

Logistic Regression (RL)

This method [11] is defined as a machine learning classification algorithm used to predict probability and data using a straight line, where the dependent variable is required to be binary.

Nearest Neighbours (KNN)

In the work of [12] mentions that KNN is a classification algorithm that finds a fairly intense application in pattern recognition, data mining and intrusion detection, it can be used to classify new sample data or to have predictions of continuous values. It belongs to the domain of supervised learning, which helps us to classify values by looking for the most similar data in the training mode.

A pre-processing is made to the images that are in our database having two important parts in this pre-processing

- Padding
- Resizing

These two sections are performed after the extraction of the images resulting in a matrix for each input image with dimensions of 224x224 in 3 channels (RGB) because the network requires that the matrix complies with these dimensions. Once they have been made, they enter the ResNet50 network, in order to extract the characteristics of each of the images. This network will take as input data the generated matrix forming extraction maps.

The penultimate layer of the network will generate a vector of dimension 2048 which contains general characteristics of the images which contain data such as intensity, luminosity, intensity, etc.

Training and test set

This is a classification scenario that gives percentages to the sets of images in our database, creating a set of features and labels, giving a percentage for each training and test scenario. The main advantage of this scenario is that the training set never sees the test set. The following diagram shows the sequence used for this type of sets.

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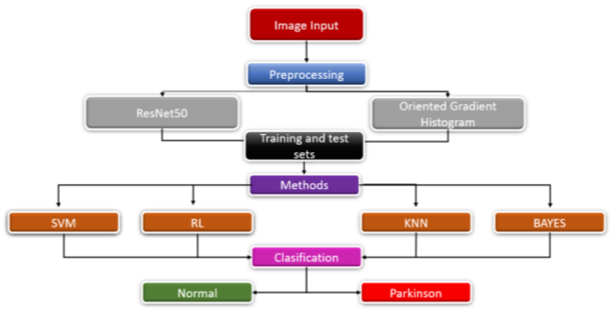


Figure 3 Diagram for Training and test sets Cross Validation

This is a classification scenario where the arrays of TB and normal image features are obtained, creating labels to name each of the images that will be used in the training of the programme. Within the program, arrays are created using the relationships between the features and the previously created labels.

The program sorts the data for interpretation in a ratio of 0 and 1; and then starts with the classification methods (Logistic Regression, K-Neighbor Classifier, Support Vector Machine, and Bayes). The following diagram shows the sequence used in this cross-validation method.

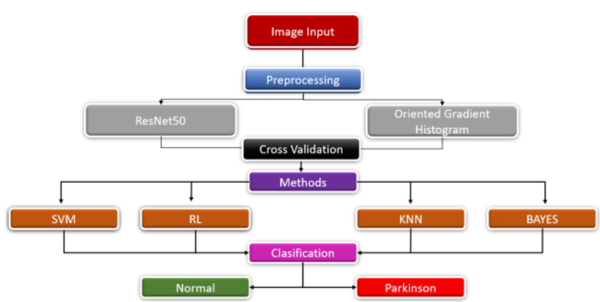


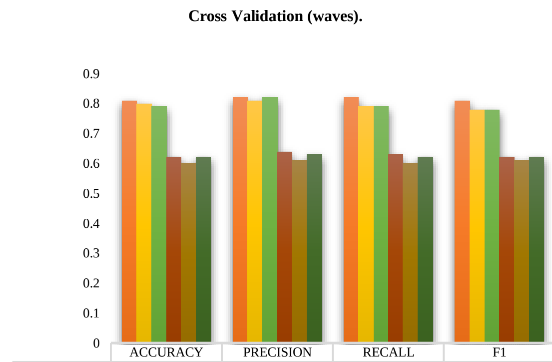
Figure 4 Diagram for Cross Validation

4. Results

The following evaluation metrics were measured for each ranking scenario:

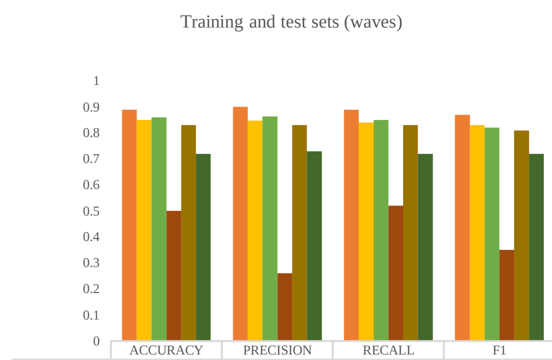
– Accuracy
– Recall
– Accuracy
– F1

The following tables show the results for each database (Wavelets and Spirals), the results obtained with the ResNet50 neural network and the Oriented Gradient Histogram.



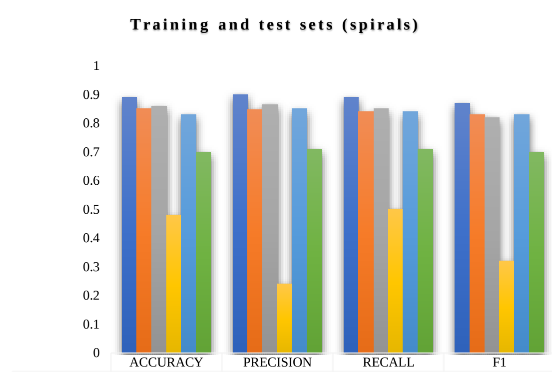
	ACCURACY	PRECISION	RECALL	F1
SVM (Resnet)	0.81	0.82	0.82	0.81
RL(Resnet)	0.8	0.81	0.79	0.78
KNN (Resnet)	0.79	0.82	0.79	0.78
SVM (HOG)	0.62	0.64	0.63	0.62
RL(HOG)	0.6	0.61	0.6	0.61
KNN (HOG)	0.62	0.63	0.62	0.62

Graph 1 Results for waves using Training and Test Set



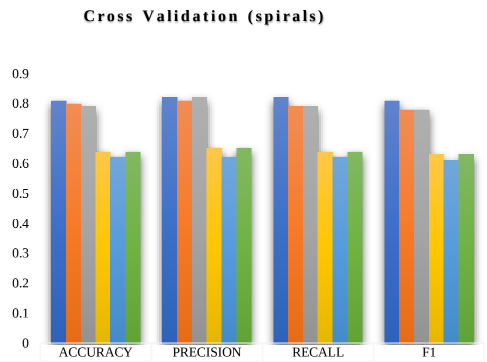
	ACCURACY	PRECISION	RECALL	F1
SVM (Resnet)	0.89	0.9	0.89	0.87
RL(Resnet)	0.85	0.848	0.84	0.83
KNN (Resnet)	0.86	0.864	0.85	0.82
SVM (HOG)	0.5	0.26	0.52	0.35
RL(HOG)	0.83	0.83	0.83	0.81
KNN (HOG)	0.72	0.73	0.72	0.72

Graph 2 Results for waves using Cross Validation



	ACCURACY	PRECISION	RECALL	F1
SVM (Resnet)	0.89	0.9	0.89	0.87
RL(Resnet)	0.85	0.848	0.84	0.83
KNN (Resnet)	0.86	0.864	0.85	0.82
SVM (HOG)	0.48	0.24	0.5	0.32
RL(HOG)	0.83	0.85	0.84	0.83
KNN (HOG)	0.7	0.71	0.71	0.7

Graph 3 Results for spirals using Training and Test Set



	ACCURACY	PRECISION	RECALL	F1
SVM (Resnet)	0.81	0.82	0.82	0.81
RL(Resnet)	0.8	0.81	0.79	0.78
KNN (Resnet)	0.79	0.82	0.79	0.78
SVM (HOG)	0.64	0.65	0.64	0.63
RL(HOG)	0.62	0.62	0.62	0.61
KNN (HOG)	0.64	0.65	0.64	0.63

SVM (Resnet) RL(Resnet) KNN (Resnet) SVM (HOG) RL(HOG) KNN (HOG)

Graph 4 Results for spirals using Cross Validation

Showing as a result that the best classification scenario obtained is the training and test sets in the ResNet50 neural network compared to the Oriented Gradient Histogram having a performance of almost 90% accuracy in the drawings of spirals and waves respectively and having Support Vector Machine as the best classifier in both scenarios because the test set never visualizes the training set avoiding any influence on the assignment of categories in the images for the classification in the detection of Parkinson's disease.

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ISSN 2523-6849