Classification of Parkinson disease data with artificial neural networks

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Abstract. An artificial neural network system has been developed to detect Parkinson's Disease (PD). Three samples were taken from each patient and included in the system. The importance of the study is based on the development and use of a new subject-based ANN approach that takes into account the dependent nature of the data in a replicated measure-based design. In order to evaluate the performance of the proposed system, an audio replication-based experiment was performed to differentiate healthy people from PD patients. The UCI Experiment consisted of 80 subjects, half of whom were affected by PD. Although the proposed system has a reduced number of subjects, the system is able to distinguish people with PD from an acceptable degree of healthy people with an accuracy rate of 94.93% in an artificial neural network.

1. Introduction

Parkinson's disease is the second most common neurodegenerative disease affecting 2-3% of the human population at age 65 and older [1]. According to the Parkinson's Disease Foundation, 7-10 million people worldwide are infected with this disease [2]. As a result of the depletion of dopaminergic nigrostriatal neurons, deterioration occurs in movement (tremor, stiffness, slow movements, unstable posture...). Depending on the movement of the articulators, voice and speech may change. Non-dopaminergic changes may also affect language, cognition, and mood, which may affect communication [3]. Parkinson's Disease has symptoms such as tremors, loss of gestures while talking, slowing movements, not waving arms while walking, stiffness in one or more extremities, slow, small step or foot-dragging walking, soft and low voice or monotonous speech, oozing from mouth, difficulty swallowing, constipation, excessive sweating, drop in blood pressure, pain, and muscle spasms. The causes of Parkinson's disease (PD), the second most common neurodegenerative disease, are still unknown. The current idea is that parent gene mutations cause only a small proportion of all cases, and in most cases, non-genetic factors probably play a role in interacting with susceptibility genes. Numerous epidemiological studies have been conducted to identify such non-genetic risk factors [4]. For people with Parkinson's disease, voice and speech are also affected because voice and speech are dependent on laryngeal, respiratory and joint functions. Vocal disruption is assumed to be one of the earliest symptoms of the disease [5]. From the early stages of Parkinson's disease, there are abnormalities that prevent speech perception by listeners, but acoustic analysis of recorded speech signals can provide objective evaluation [6]. Our study was performed using Parkinson's Dataset with replicated acoustic features in the UCI Machine Learning database [7]. System was trained with artificial neural network and an estimation process was realized which decides whether the data belong to Parkinson's patient or not by taking data such as Credentials received from individuals, Registration number, Gender, Pitch local perturbation measures data: relative jitter (Jitter_rel), absolute jitter (Jitter_abs), relative average degradation (Jitter_RAP) and step perturbation coefficient (Jitter_PPQ), amplitude perturbation measure data: local Shimmer (Shim_loc),...
Shimmer in dB (Shim_dB), 3-point amplitude perturbation coefficient (Shim_APQ3), 5-point amplitude perturbation coefficient (Shim_APQ5) and 11-point amplitude perturbation coefficient (Shim_APQ11) and 3-point amplitude perturbation coefficient (Shim_APQ3), and 11-point amplitude perturbation coefficient (Shim_APQ5) and 11-point amplitude perturb. Harmonic-to-noise ratio criteria: 0-500 Hz (HNR05) in the frequency band 0-1500 Hz (HNR15), 0-2500 Hz (HNR25), 0-3500 in the range of harmonic-noise ratio Hz (HNR35) and 0-3800 Spectral measurements in Hz (HNR38) based on the Mel frequency cepstral coefficient of the range 0 to 12 (MFCC0, MFCC1, ..., MFCC12) and their derivatives (Delta0, Delta1, ..., Delta12), Density of recurrence period entropy RP (RPDE), degraded fluctuation analysis (DFA), Pitch period entropy (PPE), Glottal-to-noise excitation ratio (GNE).

Recently, artificial neural networks have been used as an important model in the classification of disease data.

2. Materials and Methods

Our study was performed using Parkinson's Dataset with replicated acoustic features in the UCI Machine Learning database [7].

2.1. Data set

A total of 80 people over the age of 50 participated in the creation of the data set. A total of 40 participants (22 males and 18 females) were healthy and 27 males and 13 females that form the remaining 40 participants were having Parkinson's disease. The mean (± standard deviation) age of the participants was 66.38 ± 8.38 for the control group and 69.58 ± 7.82 for people with Parkinson's disease.

2.2. Speech recordings

At this stage, the vocal task of the participants was to make as constant a voice as loud and as loud as possible. This phonation was held for at least 5 seconds in one breath. This task was repeated three times per person, all of which were regarded as copies, creating 240 data sets for a total of 80 participants. Speech data collected from the participants was recorded using a portable computer with an external sound card (TASCAM US322) and a headband microphone (AKG 520) with a cardiogram pattern. The resulting digital audio recordings were performed at a frequency of 44.1 KHz and 16 bit / sample resolution using Audacity software (version 2.0.5). Different data fields were created according to the different characteristics of the obtained voice recordings [2].

2.3. Artificial neural network

Artificial neural network is a model inspired by biological neural networks used to predict a function connected to multiple inputs. Basically; ANN was inspired by a biological neural network consisting of a large network of interconnected neurons. These links are weighted based on past experience; Thus; it is an adaptive network and is capable of learning [8]. The general structure of artificial neural networks is shown in Fig.1. Artificial neural networks are widely used in pattern recognition and classification problems. During the training of ANN, the most appropriate algorithm should be chosen for the correct conclusion of the problem. The most widely used approaches used in the training phase of multilayer networks are batch back propagation (BBP), uintessential propagation (QP), conjugate gradient descent (CGD) and Levenberg-Marquardt (LM) training algorithms. In our study, classification process with LM algorithm was preferred. The Levenberg - Marquardt (LM) algorithm, developed by Kenneth Levenberg and Donald Marquardt, is a combination of gradient descent characteristics and Newton's method in back propagation [9]. It is a nonlinear optimization algorithm based on the use of second order derivatives. The weight calculation equation used in the training algorithms is shown in eq. (1) [10].

\[ W = (J^T J + \mu U)^{-1} J^T e, \]  

where J is Jacobian matrix, which is composed of derivatives of errors at each weight, \( \mu \) is a scalar; U unit matrix; and e represents the error vector of the network.
3. Result and discussion
The study is based on gender and 44 acoustic characteristics that can be divided into five categories. These include: noise characteristics, local perturbation measurements, amplitude local perturbation measurements, nonlinear measurements and spectral envelope measurements. Neural Network Pattern Recognition tool (nprtool) was used in MATLAB to perform the classification process [11]. Using this tool, input values of 45 properties whose entries are defined and classified in 1 output category, ie Parkinson’s Disease or Not. The data were randomly divided into 3 sample groups of artificial neural networks. These are:
- Training: 80% random data (192) from the data set is given to the network during the training and the network is trained accordingly.
- Validation: Random 5% data from the data set (12) was used to terminate training when generalization stopped the development of the network.
- Test: 15% random data (36 pieces) from the data set were used to measure the performance parameters of the network during training and verification procedures. Figure 2 shows the customized view of ANN.

When the ANN is run according to Levenberg-Marquardt algorithm, the regression graph of the training data set is shown in figure 3. Figure 4 shows the regression graph of the validation dataset.

Figure 1. General Structure of Artificial Neural Network.

Figure 2. Customization of ANN

Figure 3. Training Regression.

Figure 4. Validation Regression.
Figure 5 shows the regression graph of the test data set. The regression graph of our entire data set is shown in figure 6.

![Figure 5. Test Regression.](image1)

![Figure 6. All Dataset Regression.](image2)

After the completion of ANN operation, the output and the graph of the target output are shown in figure 7.

![Figure 7. Target-Output Graph](image3)

Figure 8 shows the error histogram graph of the Training, Validation and Test data set. In figure 9, the error histogram graph of the whole data set is given.

![Figure 8. The error histogram graph of the Training, Validation and Test data set.](image4)

![Figure 9. The error histogram graph of the whole data set.](image5)
The MATLAB program is used for executing the process. The model uses the trainlm by Levenberg – Marquardt function for training. The MATLAB program randomly divides input variables and target variables into three sets. 80% of the samples are assigned to the training set, 5% to the validation set, and 15% to the test set. It is predicted that it can produce better results with machine learning methods that can be done on classification methods and data used and it is thought that these studies will be done in the future.

4. Conclusion
Artificial neural networks have been shown to exhibit good classification performance of the dataset [7]. In our study, an accuracy of 94.93% was obtained for the whole data set. MATLAB is one of the most widely used software for this purpose. Nowadays, research studies in this area are developing and various classification techniques are applied in order to obtain more accuracy.

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