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# Parkinson's Disease Prediction UsingConvolutional Neural Network

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**ABSTRACT**— Parkinson's disease is a neurodegenerative disorderthat affects the neurons that produce dopamine in a specific areaofthebraincalledsubstantianigrathiscauseshindranceinmotorandspeedskills.Forsuccessfultreatment ofParkinson'sdisease,itis essential to monitor the disease's progress. Voice changes at anearly stage before the brain cells are affected. Here we aim topredict if a person has Parkinson's disease using voice recordingdata set of patients by using a neural network. The voice of thepatientsisrecordedandthefeaturesareextractedthroughMFCC. The voice recordings are tested to predict if a person hasParkinson's diseaseandalsototelltheconditionofthedisease.

**Keywords:Parkinson'sdisease,dysphonia,MFCC ,Convolutionalneuralnetwork**

## I. INTRODUCTION

Parkinson's Disease (PD) affects the aged population, it is aprogressiveneurologicalcondition[1].Thepathophysiologicalhallmark of PD is a slow degeneration of the nigrostriataldopaminergic system. The widely accepted subcellular factorwhich underlies PD neuropathology is the presence of Lewybodieswithcharacteristicinclusionsofaggregatedalpha-synuclein.PD-specificpathologyextendsfarbeyondthenigrostriataldopaminergic system, affecting the widespread brain areas,includingtheolfactorysystem,autonomic,cerebralcortex,andgainsettingbrainstemnuclei.Motorsymptomssuchasakinesia, tremor at rest,postural instability and rigidity are the cardinal signs of PD.Therearealsomanynon-motorfeaturesofPDincludingbehavioralandpsychiatricproblemssuchasdementia,fatigue,anxiety and depression, autonomic dysfunction, addiction andcompulsion, psychosis, olfactory dysfunction, and cognitiveimpairment [2]. The UPDRS scale, known asthe UnifiedParkinson Disease Rating Scale, is a rating tool used to gaugethelevelofParkinson'sdiseaseinpatients.Thescalehasbeenmodifiedovertheyears withthehelpofseveralmedicalorganizationsandcontinuestobeoneofthebasesoftreatmentandresearchinPD clinics[3].Itisusedtofollowthelongitudinal course of Parkinson's disease. The UPD ratingscale is usedmostly in the clinical study of Parkinson's disease.ItincludesaseriesofratingsfortypicalParkinson'ssymptomsthatcoverallofthemovementhindrances ofParkinson'sdisease.Assessment based on UPDRS is tiring and time-consuming.The patients' physical presence is required in the clinic whichmakes its use difficult. Thus, giving rise to the need for anobjective,reliable,andeasy-to-usediagnosticmodality.Individualswith Parkinson'sdisease(PD)exhibit amotorspeechdisordercalledhypokineticdysarthriacausedbydamage to the basal ganglia control circuit. The symptomsrelatedtothevocalimpairmentofParkinson'sdiseasepatientsarecalleddysphonia[4].

Dysphonia can be recognized as the initial presenting speechfeature in Parkinson's, they exhibit mildly strained, tight, orwhispered voices. The dysphonia measure could be treated asan important and reliable tool in assessing the voice-relatedproblem and in monitoring it at different stages [5, 6, 7]. Herethefeatureselectionmethodisusedtoevaluatethecontributionoffeaturesintheassessmentofdiseasesatdifferentstagesforbetteraccuracy[8].TheproposedapproachhelpstodetectParkinson'sdiseasefromthevoiceattributesofpatients by using Convolutional Neural Networks[9]. Thepremotor stage of PD should be monitored carefully for earlydetection The premotor stage shows the symptoms like RapidEyeMovement(REM),SleepBehavior,andOlfactoryloss.Inthis work, a deep learning model is designed to discriminatebetweennormalindividualsandpatientsaffected byPD.

## II. LITERATURE REVIEW

In the year 2018 Diogo Braga et. al [10] suggested themethodologiesdetectParkinson'sinitsearlystage. Thebackgroundconditionwasuncontrolledandthenthefreespeechwasanalyzed.Theresultsportrayedthepotentialoftherandom forest method and Support Vector Mechanism (SVM). The system did an acousticspeechanalysisandtheenergywasusedtofeed aclassification-basedmachinelearningalgorithm.Theresultsshowedtheacoustic clues that are compatible with persons affected byParkinson's disease and also the healthy persons. The paperanalyzedtheproblemsofParkinson'sdiseaseand explainedthereasons behindit, alsoshowedthe importance of detectingParkinson's disease. The aspects like the screening techniquesand therapy with their costs were discussed. The neurologicalimplicationsinspeechproductionanditsdetectionandcoverageweredescribed. Themachinelearning approacheswere also mentioned with a brief discussion of the techniquesusedandtheadvantagesanddisadvantagesofusingthem.Withall these into account, a new approach was proposed in [10], and incomparisonwithothermethodologies,theirmethodologyexhibitedhighrobustnesstodisturbances.Italsohastheadvantageofnon-invasiveness,withlowcostandmuchcomfort.

In the year 2019 Salim Lahmiri and Amir Shmuel et. al[11]stateditasaneurodegenerative disorder that is due to the loss of dopamine-producing neurons. The symptomsthatwerecategorizedasmotorandnon-motor.Aneightpattern ranking technique that is coupled with a support vectormachine SVM to distinguish the healthy individuals and theParkinsonaffectedindividuals was utilized.Therankingpatterns of the voice and the features were ranked accordinglyand the ones with great accuracy specificity and sensitivity weredistributed for the study the wrapper technique based on theinductionalgorithmanalyzedthepatternsetstheirresultsshowedthattheSVMclassifierachievedthehighestclassificationaccuracyfortheclassificationofthefeatureswiththefirst14VoicepatternsidentifiedbyWilcoxonbasedpatternranking technique. They pointed out the need to explore themultimodalParkinson'sdiseasediagnosistechniquethatcanbeusedtoimprovetheperformancetoincrease theaccuracyinthefuture.

Athanasios Tsanas and Max A et. alin [12] mentioned about the unified Parkinson's diseaserating scale UPDRS. The verbalphonations that can be used to predict the Parkinson's diseasesymptoms were examined. A map between dysphonia measures andthe scale was observed. The motor and non-motor symptoms were analyzedwith the UPDRS which were similar to thatof clinician'sobservations. The algorithm was equivalent to a brute forcesearchwithallpossiblemeasurestofindthesmallestcombinationpossiblewhichisthepredictionmethod usedhere.

R Prashant et. Al [13] analysed the use of questionnaires to develop the predictivemodel for the Parkinson's disease detection.A predictive model was developed that has an accuracy that isgreater than 95 percent. The different strategiesusedtomanagethedisease were discussed.TheMDSUPDRSQuestionnairewasdevelopedfor the prediction models to classify the PD affected patients.The chine learning techniques that are used todetectthediseasesuchasboostedtrees,logicregressions,supportvectormachineandrandom,forest were also utilized.Allthesetechniqueshad high accuracy and high area under they are ROC curve.Among all these logic regression capabilities gives the best results.All these techniques help to analyze the initialevaluation of the patient but for more in-depth analysis SPECTimagingmustbeused.It was also provedthat a patient's self-questionnaire is a better tool for theanalysisofthemselves. It was stated in [13]thatcombiningboththeexisting questionnaires through machine learning will be analternatewaythathasabetterprobabilitytodetectPD subjects.

HakanGunduzin [15]stated thatPDhasmultiplemotorandnon-motorsymptomswiththefocalimpairmentshownatan earlystage.In this,twomethodsbased on CNN to identify the Parkinson's disease were introduced. Both themethods have similar frameworks but their combing mechanismfor the features are different. The first method combines a 9-layered CNN as input to the feature sets whilst the secondframework uses a parallel input layer that is connected to theCNN layer. It was on the UCI machine. This work isthefirsttoimplementthatmethodwithparallellayers with a datasetincluding3voicerecordings.It was statedthattheparallellayer network enables to use of different types of datasets thatcan be fed into the network inputs. This gives the multimodaldata analysis in PD classification.

AiteXhaiet. alin [16] discussed a methodthat is based on machine learning to rate the PD severity fromgaitanalysiswiththehelpoffootsensors,theyused spatiotemporalpatternsofgaitdata.Adeeplearningarchitecture and a two-channel network on LSTM and CNNused were for modeling the gait data over a period of time. Thepreviousmodelprovidedonlybinarydetection,but theproposedmodelhastheabilitytoperformmulti-categoryclassification thatenablesustounderstandtheseverityofPD.from gait sensors. However, this work only enables to thefinding of the severity of PD. Also, VGRF gait data is hard toobtain as the patients have difficulty walking because of theseverity of the disease. It was claimed that in future works fusedfeatures can be used to achieve greater accuracy.The LSTMalso is advantageous as it can include more data types. Theseapproaches provide a baseline for future works and also inspireto makemorecomputer-aidedapplications.

In the work by Laura Silveira Moriyammaet. al [17], thesmell ofidentificationtestshasbeenusedforthedetectionofPD.HyposomaiscommoninPDpatientsandcanbeutilizedforPDidentification. The study had 221 patients with PD and 207without. The Queen Square Brain Bank Criteria was satisfiedforthediagnosis.TheDaTSCAN dataset was used. The smelltest showed good accuracy this helps to know about the nasalfluctuations and the analysis of the respiratory tract. It was alsostated that dopamine transporter scan is hard to find and areexpensive, and also has the chance of misinterpretations.

Theworksuggeststhatodortestsarecheaperandaremoreavailable.

In[18], GaetanoValenza et. al states that PD affects a person in many ways and they aim for acomprehensivecomputationalassessmentofheartbeatdynamics as PD has spontaneous cardiovascular oscillations.They are computed at 600s obtained for 29 healthy people and30 PD patients. The variance was in the Lyapunov exponent.ANS-related HRV metrics were employed for the PD analysis.Theplethysmographicsignalswererecorded andthedifferencewas analyzed. The instantaneous linear and non-linear cardiovascular dynamics in PD was calculated and the featuresofbothPD-affectedandhealthysubjects were analyzed.Themodelingtechnique was based on the thetheoryinhomogeneousnous pointprocess.ThestatisticalPDanalysiswasdoneandfoundthattheinter-subjectvariabilityreducedthegroupdifferencesincardiovascular dynamics. The accuracy obtained was 70.83%.They only need the ECG as it has cardiovascular dynamicswhich is easier these days and also portable. The parameteroptimization forSVMcanbeimproved intheir futuremodels.

Thefeatureextractionclassificationwasdiscussedby Suleyman Bilgin in [19]. They studied Parkinson’sdisease which is a nervous system disorder and Huntington’sdiseasewhichishereditarycausingnerve celldegeneration.Thegate dynamics were also disrupted due to the NDD, the earlydiagnosisisveryimportant.Thestudywasdoneby 60withone-minuterecordingsoftheCFSsignalthatistakenfrom13 ALS,15 PD, 20 HD, and 16 healthy persons were included in thestudy.TheCFSistakenfromtheleftandrightfoodofthepatientduringeachgaitcycle wearedonethroughgaitsensors.The CFS is then transformed for the determination of features.Theanalysisisdonebyelectromyogramorbloodtests,allthesemethods are time-consuming and may have misinterpretationswavelet analysis is done to investigate the signal in both thetime domain and the frequency domain.The wavelets had thebest performance compared to others their comparison had LDAandNBCmeanvaluesandfastalgorithmsforALS discrimination study were created but they needed more timeforthecompetitiveanalysisofthegatesignals.The studyprovided solutions to the signal parameter changes thatareobtained from the patient they are done by the usage of anartificial intelligence algorithm. The ALS can be discriminatedfromothergroupsbytheobservationoftheD5 Band.

## III. METHODOLOGY

The flowchart represents the proposed PD detection procedure.This study proposes a deep learning [20] framework for theearly detection ofPDDetection andisdonein twostagesnamely the testing stage and the training stage. It is illustratedinFig1.

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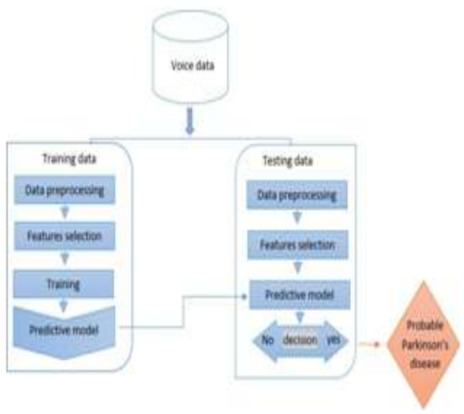


Fig1.Flowchartoftheproposedmodel

**TRAININGDATA**

Thetrainingprocessconsistsof4stages,

- Datapreprocessing
- Featureselection
- Training
- Predictivemodel

➢ **DataPreprocessing**

Thedatapreprocessingisusedtopreparetherawrecords ofdatato make them suitable for the application in machine

datasetcontainanymissingdata,itcouldcreateahugeproblemfor the machine learning model. Then the categorical data isencoded.Andthenthedatasetissplitintotrainandtest data,

x ·[k]=∑x[n]℮xp(−j
N
n=0

kn)

learning.Thedatapreprocesshelpstoimprovetheefficiencyand accuracy of the machine learning model. The raw real worldgenerally has many missing values, and noises and also can bein an unusable format that cannot be used directly for machinelearningpurposes.

Thefirststepindatapreprocessingistoobtain the dataset. The dataset is converted into CSV(Comma Separated File) file. The python libraries have to beimportedinordertoperformthepreprocessinginpython.Numpy library and Matplotlib is a used for this purpose. Thenthe datasets have to be imported, the "read_csv()" function isusedforthis.Next,themissingdatahavetobehandled. Ifthe IntheMFCCfeatureselection whichisillustratedinFig.3,thefirst step is A/D conversion. Now, the audio is sampled andconverted from analog to digital, they'll be in discrete forms.Next, the pre-emphasis is done to boost the energy in higherfrequencies, it is done by a filter. Then, windowing is done byslicing the audio waveforms into sliding frames. Then DFT isapplied to extract information in the frequency domain by theequationshownbelow.

N−1
2π

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whichisillustrated inFig.2.

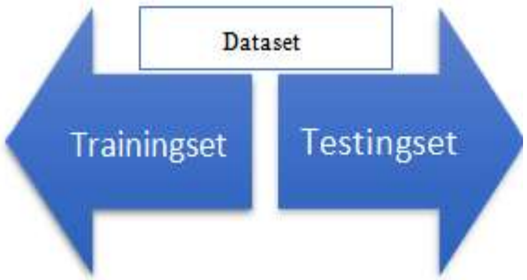


Fig2. Data set

The training set is the subset of the dataset to train the machinelearning model.Here theoutputisalreadyknown.

➢ **Featureselection**

Machinelearningextractsthefeaturesformingadenserepresentation of the model. To obtain the audio features, anacoustic model is created. To extract the audio files, a 25mswide sliding window is used. The features extracted have to beindependent, for this many models have been created, and weuseteMel-FrequencyCepstralCoefficients(MFCC).Itconsistsof 39 features, 12 of which are related to the amplitude offrequencies.

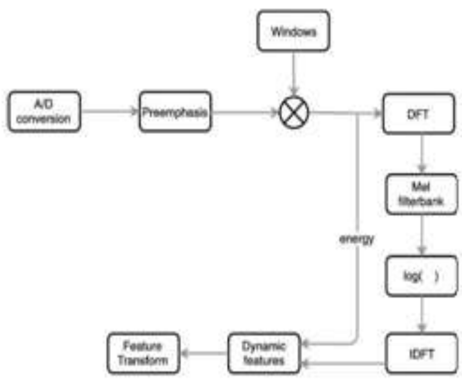


Fig3.FlowofextractingMFCCfeatures

TheoutputoftheDFTissquaredto ($x[k]^2$),itiscalledtheDFTpower spectrum, here the Mel-scale filter banks are applied totransform it into a Mel-scale power spectrum. The log is thentakenfromtheoutputoftheMelfilterbank.TheInverseDiscrete Fourier Transform (IDFT) is done to transform thepitchinformation.Thedynamicfeaturesarecomposedofthe39MFCCfeatures.

➢ **Training**

A training model is used to train the data, consisting of sampleoutput data and parallel sets of input data. The learning rate forthe iteration process is set to 0.00001 with 80 steps in eachtraining iteration. Class is set as with Parkinson's and withoutParkinson's, the X and Y classes respectively are split intotrainX, testX, trainY, and testY. Then the train data and trainlabel is printed. The tflearn is the tensor flow which is a platformforthe neural network.

Long Short-term Memory (LSTM) is a feedback network for thetraining.Thetrainingisdonethroughasupervisedmodelusinganoptimizationalgorithmcombinedwithbackpropagationthroughtime.

➢ **Predictivemodel**

Thepredictivemodelisamodelinmachinelearningthatisusedtopredictthelikelyoutcomesbyanalyzingthepresentandpastdata. Here the model show if the given data is Parkinson'spositiveornegative.

**TESTINGDATA**

Theprocessoftestingdatais alsodonein4 stages,

- Datapreprocessing
- Featureselection
- Predictivemodel
- Decision

The first 3 steps in data testing are done similarly as is in thetraining process. The data is split as testX and testY and theMFCCfeaturesareextractedandcomparedwiththemodelandthenthe decisionismade.

Thedecision-makingprocessisdonethroughthevariablesthatareacquiredthroughthetrainingprocess.TheyfinalizewhetherParkinson's disease ispresentor not.

## IV. RESULT AND DISCUSSIONS

Inthissection,theexperimentalresultsanddiscussions ofourproposedCNNarchitecture is explained.Theskitlearningtechnique is used to analyze the accuracy of the training andtesting stages. SK-learn is a free software machine learninglibrary for the Python programming language and is also usedto split training and testing data. SK-learn is written in PythonandusesNumPyextensivelyforhigh-performancelinearalgebraandarrayoperations.

Fig. 4 gives the confusion matrix gives the performance of the model forthe provided test data.

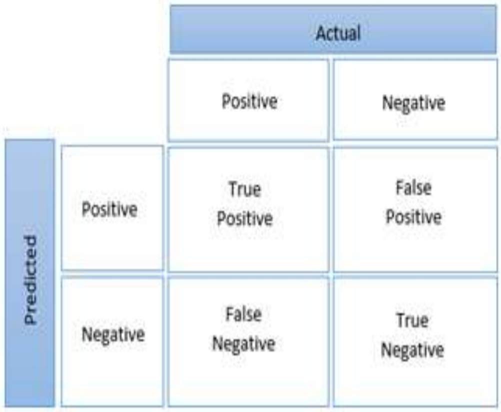


Fig4.ConfusionMatrix

Toevaluatetheperformanceofmachinemethodsfordiscriminating Parkinson's patients, the followingcriteria was employed:

- Accuracy= $\frac{TP+TN}{TP+FP+TN+FN}$

where TP is the number of true positives, FP is the number offalsepositives,TNisthenumberoftruenegativesand FNisthenumber of false negatives.

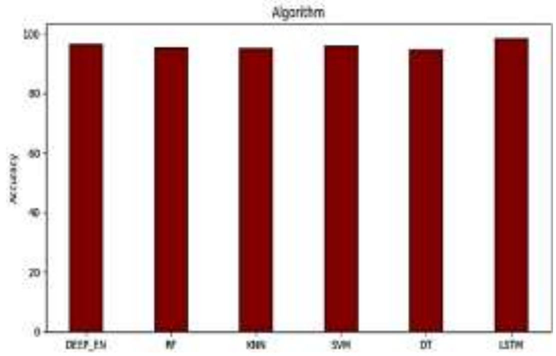


Fig5.Accuracycomparisonofthemodels

With a learning rate of 0.00001 and 80 steps in each iteration,weobtainedanaccuracyof98.41%,thisgives usamoreaccuratepredictionthanthepreviouslydoneworks.Fig5.showstheaccuracycomparisonofthemodels.Theearlydetection of Parkinson's disease can be of great use in reducingtheimpact,thatthediseasehasinstore.TheCNNisadvantageous as it reduces the human help at most, and thetrainingprocesshelpsthesystemto learnthe processes.

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