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| **Abstract:** | In most developing countries, where most of the basic health issues are not attended, it is very obvious that Parkinson's disease (PD) is not recognized and addressed properly. But the number of PD patients is increasing rapidly and the cost regarding their treatment is affecting the gross national income of a country. We are proposing a AI based mobile application which can help the patients with PD in developing countries where healthcare professionals and service are very limited or not available to support patients with PD. Any person having a smart phone with an internet connection can use AI based screening tools and check if he/she has PD or not and get basic information about PD management as well as guidance to connect with resources which includes detail information on various services on PD and PD specialists. |

# 1 Overview

We are representing an automated cloud based Parkinson's Disease detection system which can detect PD by identifying Dysphonia (voice or speech impairment) from voice samples of patients and Tremor (vibration of hands). The AI Based mobile App provides the option to record and save the speech sample and the vibration of a person and sends them to the cloud for screening. Then the speech and vibration records are stored in our central database under a user ID and sent for classification using a AI tools like, Feed forward Back-propagation based Artificial Neural Network (FBANN). The classifier classifies the person either as a PD patient or a Healthy Control. The classification results are stored in the DB. If the person is detected with PD, then a message is sent to the user along with a list of resources which includes PD specialists with their addresses, therapy centers etc. The system also provides some basic information about PD symptoms and PD management. A physician or specialist can use system too for patient diagnosis and monitoring as well as follow up. Doctors can insert diagnosis information in the patient file for regular PD monitoring. Data security including confidential patient information is maintained using ID based encryption.

# 2 Relevance

Parkinson's disease (PD) is the second most prevalent neurological disorder after stroke in developing countries. Therefore, it very important to work develop AI based tools to support people who need the most.

# 3 Impact

AI based mobile application which can easily detect and provide diagnosis for Parkinson's disease to people in developing countries with limited resources. It is noted that in developing countries, PD is the second most prevalent neurological disorder after stroke. However, there is very limited resource to service PD patients. Therefore, it is important to utilize digital services to support PD patients and improve their quality of life. With a simple and easily understandable user interface, our AI based mobile App can guide any user to cloud based system and get the proper screening and diagnosis, which can improve quality of life and make impact in the society.

# 4 Existing work

Parkinson's disease can be diagnosed in many different ways including invasive and non-invasive options. Though PD is not curable, early detection and diagnosis can delay the severity and effects of the disease. Different biomarkers can be used to detect and diagnose PD. Nanomaterial based sensors are used to sense alveolar breadth to detect PD [1] with 78% accuracy. Gene expression is used for PD detection with neural classifier approach [2]. Parkinson's disease can also be detected and diagnosed by analyzing the handwriting of a person with 88% accuracy and sensitivity [3].

Speech disorder is one of the most common symptom of Parkinson's disease. Several form of speech impairments can be used to detect PD. Vocal impairment level can be used as an early biomarker of PD and Sakar et al [4] used it to detect PD using the UCI data repository. 16 Dysphonia measurements were used as the feature set and fed into Support Vector Machines and K-Nearest Neighbor classifiers which were used as binary classifiers. Various motor Unified Parkinson's Disease Rating Scale (UPDRS) threshold values from 0 to 108 against the vocal impairment threshold value of 15 indicated the importance of speech in early detection of PD. UCI data repository was also used in [5] to classify PD patients from their voice impairment using 10 different classifiers and compared the results. Various voice samples were used in [6] for PD detection and SVM and k-NN classifiers were used on those voice samples. They used sustained vowels, words and short sentences and showed that sustained vowels can be a better measurement for PD and using mean and standard deviations of several voice samples of an individual can improve the classification results. Bolanos et al [7] used Teager energy operator and modified group delay functions to analyze low frequency speech to detect PD automatically by k nearest neighbor classifier. They experimented with five Spanish vowels and achieved almost 80% accuracy for vowels except /e/, for which 92% accuracy was achieved. A complex valued artificial neural network with minimum redundancy maximum relevance (mRMR)-based feature selection algorithm is used in [8] for PD detection using voice disorder. The system selected the most effective features for accurate diagnosis and compared their results with some existing methods and showed that their method outperformed others with accuracy of 98.12%. Frid et al [9] proposed a system which uses voice disorders to detect PD by extracting information from voice signals without any human intervention and also classified PD according to its severity using support vector machine as the classifier. They attained 81.8% accuracy on a dataset consists of voice signals from 43 patients with PD severity from grade 1 to 4 and the data was “Rainbow passage”. PSO algorithm [10] was used to filter the training data and parameters and naive Bayesian classifier was used to classify PD patients with voice impairments and the system was 97.95% accurate to classify patients. They stated that the output of any existing classifier can be improved by selecting the correct training dataset and proved their statement by experimenting with only 8 training data.

Tsanas et al [11] implemented a PD mobile phone technology based tele-monitoring process using speech disorder recognition with standard 2G or 3G networks. A patient can record some vowel phonations with his phone and transmit the data and the receiver extracts the features from the speech and classifies the voice using Random Forests and Support Vector Machines. The UPDRS level is predicted with only 3.5 points different than the clinical assessment. RF and SVM were again used in [12] achieving almost 99% accuracy in distinguishing PD patients and healthy people using only 10 Dysphonia measures. A novel system which uses subject based Bayesian classifier to detect PD using voice samples was introduced in [13] with 80 subjects which could detect PD in women more accurately than in men. Yang et al [14] used sequential forward selection (SFS) and kernel principal component analysis (KPCA) to reduce the dimensions of voice sample features and then classified the features with MAP decision rule having a better accuracy rate 91.8% compared with FLDA and SVM classifiers. A comparison between Random Tree (RT), Support Vector Machine (SVM) and Feed forward Back-propagation based Artificial Neural Network (FBANN) to detect PD using Dysphonia was performed in [15] where FBANN had 97.37% detection accuracy. German, Spanish and Czech, speech from three languages were used in PD detection [16] and the accuracy level varied from 84% to 99%. They classified patient voice with soft margin SVM. Nonlinear dynamics (NLD) [17] was used to classify PD patients using five Spanish vowels and acquired 76.81% accuracy for only the vowel /i/. Bocklet et al [18] used a German dataset of 176 speakers, 88 with PD and 88 healthy people using four recognition systems- Acoustic, Prosodic, Glottal Excitation and openSMILE. A maximum accuracy of 100% in classifying PD patients from voice signals was achieved by Hariharan et al in [19] using a hybrid intelligent system. The system was comprised of Model-based clustering for pre-processing of features, principal component analysis (PCA), linear discriminant analysis (LDA), sequential forward selection (SFS) and sequential backward selection (SBS) for feature selection, and least-square support vector machine (LS-SVM), probabilistic neural network (PNN) and general regression neural network (GRNN) as classifiers. Performances of SVM and Fuzzy KNN in PD detection from speech were compared in [20] with FKNN having better results. Naive Bayes and KNN were compared and the first one outperformed by 93.3% accuracy in PD detection using speech samples [21]. SVM, Majority and kNN (Bayes Net, Naive Bayes, Logistic, Simple Logistic, KStar, DTree, J48, LMT and Random Forest) classifiers were implemented and tested to detect PD from voice recordings in [22]. We also developed an algorithm to detect PD and avail to achieve 96.6% accuracy in the cloud environment for detecting PD using FBANN classifier.

Another important symptom of PD detection is tremor or shaking. It has been analyzed and used in Parkinson's disease diagnosis for a long time. Some sensors were placed on the patient's wrists, chest and waist to record tremor in different postures and then classified the patient according to the tremor records [23]. Wile et al [24] experimented on 41 patients with tremor using a smart watch which could record the tremor from the shaking of hand in three to six minutes and could accurately classify PD patients and ET patients from tremor. They compared the accuracy of the system with a simultaneous experiment with analog accelerometer on 10 patients and showed that both devices had analyzed almost the same peak frequencies and proportional harmonic power.

# 5 Feasibility

It is feasible and in Bangladesh we are developing a AI based screening tool called PVDoctor: Cloud based Virtual Doctor for Parkinson's Disease Screening and Monitoring. In the beginning of 2020 we will start do clinical trails to the clinical validation.

# 6 Data availability

There is open data set available in UCI repository but that data is very limited. We are working to create big data set for our clinical validation and have plan to make it open by satisfying regulatory guidelines.

# 7 Data quality

Assessment of data quality need to be evaluated and also we need to design a guideline for capturing good quality of data in the future.

# 8 Annotation/label quality

We need to consider it in topic group discussion.

# 9 Data provenance

This will consider before data set development.

# 10 Benchmarking

This will consider for AI model optimization and clinical validation.

# 11 Organizer

Advanced Intelligent Multidisciplinary Systems Lab (AIMS Lab), United International University focuses on theoretical aspects and applications of the areas of machine learning and data mining, intelligent systems, computational intelligence, biomedical engineering, bioinformatics and embedded systems in healthcare and disabilities. This lab is driven by a multidisciplinary team of highly qualified researchers in their respective fields and aiming to maximizing possibilities for computer science research in healthcare in Bangladesh. In addition, it is also working to establish collaborations between academia and industry as well as to do collaborative research with foreign renowned research centers. The vision of its research is to investigate problems and develop innovative technological solutions that could potentially make an impact in the society, improve quality of life, and more importantly make a significant contribution in the scientific arena. Number of research outcomes of AIMS Lab are commercialized and serving people of Bangladesh, which include CMED Health (IoT enable AI driven Cloud based Primary and Preventive Healthcare Platform and currently serving 1.6 million rural people in Bangladesh) and Bolte Chai (Tools for enhancing Communications for non-verbal children).

In AIMS Lab, we are working to develop an AI based tool called PVDoctor: Cloud based Virtual Doctor for Parkinson's Disease Screening and Monitoring with clinical validation to serve people in Bangladesh and other resource limited countries.

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