XPD - Imparting Explainability to Parkinson's Disease Identification

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***Abstract*— Medicine has long reached an overwhelming consensus on the importance of detecting Parkinson's disease (a degenerative neurological disorder marked by decreased dopamine levels in the brain) in a timely manner. With the advent of the domain of HealthTech, Deep Learning approaches have generated State Of The Art performance in solving several problems in the medicinal arena. We propose the creation of a novel, explainable sequence learning problem that can detect Parkinson's Disease from voice recordings of characteristic vocal features and explain the reasoning for this inference. Our sequence learning architecture is modelled on the basis of a Recurrent Neural Network, and extends the architecture to provide interpretability to inferences. This would overcome the shortcomings of the traditional method of diagnosis where a physician is required to perform tedious analysis of a person's motor skills in various situations. Our model can serve as an effective non-invasive screening tool, promoting early detection. As deep learning continues to be adopted, the prominence of assistance and automated. decisions made by neural networks in high stake situations is an undeniable fact that stakeholders and academicians have to grapple with. An XAI model that detects PD leverages the performance of a neural network, while providing reasoning and accountability to inferences, reducing bias.**

***Keywords*— Explainability, Parkinson's Disease, Convolutional Neural Network, Time Series, Deep Learning.**

I. REVIEW OF LITERATURE

Various review works have been focused on the use of speech recognition in the problem of Parkinsons Disease prediction. In DeepVoice: A voiceprint-based mobile health framework for Parkinson's disease identification (H. Zang et al) [1] propose a voiceprint-based PD identification application that integrates deep learning and mobile health. They use a convolutional neural network (CNN) for the final identification. In Machine Learning using speech utterances for Parkinson Disease Detection (Ondřej Klempíř et al.)[10] , use changes in speech and articulation as significant biomarkers for detecting PD. They trained several recognition methods including AdaBoost, Bagged trees, Quadratic SVM and k-NN.

In Robust automated Parkinson disease detection based on voice signals with transfer learning [2] ,A Klempir et Al trained Convolutional neural networks (CNN) like SqueezeNet1_1, ResNet101, and DenseNet161 for automated PD identification based on biomarkers-derived voice signals. O Karaman et Al in Robust Feature Engineering for Parkinson Disease Diagnosis: New Machine Learning Techniques [3] used traditional ML technique of support vector machine and evaluated it with 10-fold cross-validation (CV), with stratification for balancing the number of patients and controls for each CV fold. In Detection of Parkinson Disease Using Variational Mode Decomposition of Speech Signal [4], M Yang et Al used variational mode decomposition (VMD) for extracting relevant information of speech signals and used various statistical features (mean, variance, skewness and kurtosis), energy and energy entropy for Parkinson disease detection.

Detecting Parkinson's disease with sustained phonation and speech signals using machine learning techniques [5], K Biswajit et al propose eighteen feature extraction techniques and four machine learning methods to classify PD data obtained from sustained phonation and speech tasks [6]. Their main contribution is speech signal processing: both traditional and novel speech signal processing technologies have been employed for feature engineering, which can automatically extract a few linear and nonlinear dysphonia features. [7]-[9].

II. BACKGROUND AND MOTIVATION

A. XAI can simply be described as aiming to make AI systems more understandable to humans."Black box" AI systems that give predictions without any explanation are problematic for numerous reasons, not only because of their lack of transparency but also because they hide potential biases within the system.

Speech is a complicated skill, and it's often affected by Parkinson's-associated motor changes. Between 60 and 80% of patients may experience reduced vocal loudness, harsh or breathy vocal quality and abnormal speaking rates.The early detection of Parkinson along with the anticipation of the start of treatment would have a relevant effect on both the quality of life of patients and the healthcare system.

III. PROBLEM FORMULATION

We propose to impart explainability to the black-box decision-making of the Deep Learning models. The problem of Parkinson's' disease classification is addressed to test our proposed XAI architecture. Considering sound waves as time-series data, we propose a novel architecture using the masking of chunks of the series at a time, to gauge their importance in decision making. Hence, a learned representation from the data of healthy individuals and Parkinson's' patients can potentially aid and provide insights for generalizing and understanding a healthy norm making way for the adoption of AI in medicine reliably.

IV. ARCHITECTURAL DESIGN OF THE PROPOSED SYSTEM

Sequence learning problems are problems in which the current output depends upon the previous inputs and the length(size) of the inputs is not necessarily fixed. Audio data is sequential in nature, and necessitates the use of a Sequence learning approach. We broach the problem statement with a two step approach - create a deep sequence model that accurately classifies an audio sample into the two relevant classes of Healthy control and Parkinsons's disease , and then proceed to add explainability by using our novel XAI algorithm.

In order to be able to extend our neural network to integrate interpretability, we also have to model our audio data in a novel manner. In our pipeline, audio data is converted to tensors using sampling. The sample rate is a hyperparameter to be tuned. After the audio is sampled, a tensor from every second of audio is collected, standardizing the representation of one second of audio. Our model can work with an audio of any given length, because of the aforementioned standardization. A multi-second audio file is simply treated as a collection of the one second standardizations. If an audio is not large enough to completely fill a chunk, zeros are padded at the trailing end to maintain the generalization. Each of the corresponding audio files is converted to model input using this pipeline.

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