Analyze My Voice:
A Smartphone App for Parkinsonian Dysphonic Screening and Monitoring

Alice Rueda, Sri Krishnan
Dept of Electrical and Computer Engineering, Ryerson University

Problem Description: With the growing ageing population, there is a need for low-cost accessible screening and monitoring processes for age-related neurodegenerative disorders such as Parkinson's disease (PD). The current diagnostic process is long and complicated. In addition to providing quality care, the healthcare system will be burdened with providing screening and continuous monitoring functions.

PD affects 1% of the senior population age over 65 and more than 80% will eventually develop into PD dementia [1]. There is no known cure and no known prevention. Early detection is crucial to start disease management and to slow down disease progression. PD voice treatment can improve a PD voice from 65 dB to the normal level (70-74 dB). However, sever cases with <55 dB will not be possible to get back to normal.

A person's voice can provide a lot of information. Since the 1970s, Darley has introduced the concept of differentiating dysarthria for neurological diseases [2]. Each type of disease has a set of specific auditory-perceptual characteristics. The qualitative perceptual characteristics can be represented by quantitative acoustic characteristics. It is possible to use an individual's voice to determine the probability of the existence of PD. An early warning indication can be provided to the individual to initiate the diagnostic process. Changes in voice quality can provide monitoring on PD voice treatment effectiveness.

Design Solution: We are proposing to develop a simple, intuitive, easy-to-use Smartphone app based on changes of an individual's voice quality to provide early warning indication. The data collected from the app can also provide supplementary information for clinicians. The application will provide the following functions:

1. Voice validation check: Unlike offline analysis, there will not be a data analyst to validate the voice recordings. This function has to be built-in to the system. Lessons learned from mPower's PD iPhone recordings have resulted in a set of software requirements for voice validation check. These requirements include recording validation, background noise validation, and volume validation.
2. Real-time noise estimation and removal: Audio noise is inherent in Smartphone recordings. A real-time noise removal will be used to remove background noise if the recording has passed the noise validation.
3. Feature extraction: A set of acoustic features/data will be extracted from a validated voice for analysis.
4. Data analytics and indications: The changes in the acoustic features will be used to provide necessary warning indications.

Design Rationale and Explanation: Currently, there are no voice-based applications for PD screening and/or monitoring. A few PD voice collection projects have been initiated and completed. These projects include Parkinson's Voice Initiative and Sage Bionetworks' mPower. However, none of them are equipped with analytics to provide warning indications and monitoring.

Smartphones are readily available and a Smartphone app is easy to develop. The processors on a Smartphone can easily perform the required computations. The storage space is large enough to store the required data. Smartphones are becoming popular among seniors. According to 2016 US statistics, 59% of age 65-69 owns a Smartphone and about half for age 70-74. The overall percentage is 42% for age 65+ [3].

Application: Using mPower recordings as a proof-of-concept, we were able to identify 5 functional requirements for voice validity check and identified some differentiating features. Figure 1 illustrates the changes of a healthy voice to dysphonia voice, specifically hoarse and lack of resonance. To capture the change in the voice quality, 85 features were studied. However, most of the features do not provide insight to voice change and will not be implemented.

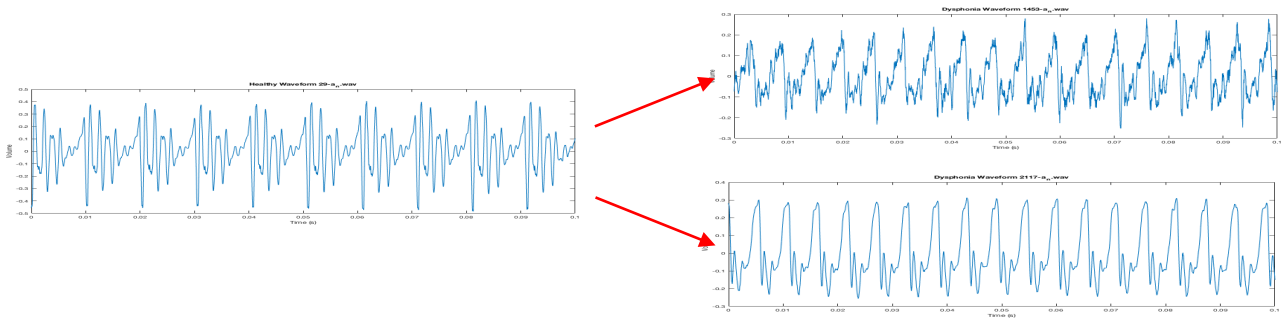

Figure 1: Healthy voice to dysphonia voice with hoarse voice on top and lack of resonance at the bottom.

Implementation: There is still much research to be done to make the app robust to different noisy environments. This can be replaced by more rigid noise validation check. Since this is a new project, it will take a few months to develop. The sequence of activities required for implementation is provided below:

Activity	Description	Estimated Time
1	Determine differentiating features	1 month
2	Functional and non-functional requirement specifications	1 month
3	UI/UX design with PD HCI principles	2 months
4	Implementation (UI)	1 month
5	Implementation (Engine)	1 month
6	Quality Assurance (Software validating and verification)	2 months
	Total required time	*8 months*

References:

[1] S. M. K. Farhan *et al.*, "The Ontario Neurodegenerative Disease Research Initiative (ONDRI)," *Can. J. Neurol. Sci. / J. Can. des Sci. Neurol.*, vol. 44, no. 2, pp. 196–202, 2017.

[2] J. R. Duffy and R. D. Kent, "Darley's contributions to the understanding, differential diagnosis, and scientific study of the dysarthrias," *Aphasiology*, vol. 15, no. 3, pp. 275–289, 2001.

[3] https://www.statista.com/statistics/733811/us-percentage-of-senior-smartphone-and-cell-phone-owners-by-age-group/