

TREMORSENSE – Parkinson’s Detection

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Abstract- *1 Parkinson's Disease (PD) is a progressive neurodegenerative disorder that primarily affects motor function. Early diagnosis is crucial for effective management, yet current methods can be invasive, costly, and time-consuming. This project, Tremorsense, presents a non-invasive, accessible, and efficient solution for the preliminary detection of Parkinson's disease using vocal biomarkers. The system is developed as a web application where users can record and upload a short voice sample. This sample is then processed to extract a range of acoustic features known to be affected by PD, such as jitter, shimmer, and fundamental frequency variations. A pre-trained Random Forest machine learning model analyzes these features to classify the sample and provide a risk assessment score. The methodology follows a standard data science workflow, including data preprocessing, feature extraction, and model training on a publicly available dataset of voice samples from healthy individuals and PD patients. The resulting web application provides an intuitive user interface, ensuring ease of use for individuals without technical expertise. The core technologies used are Python for the backend, the Scikit-learn library for the machine learning model, and HTML/CSS/JavaScript for the frontend. Black box testing was conducted to ensure functionality and usability. The research results in a functional prototype that can help individuals receive an early indication of risk, encouraging them to seek professional medical advice sooner and demonstrating the potential of machine learning in modern diagnostics.*

I. INTRODUCTION

Neurodegenerative diseases represent one of the most significant and rapidly growing challenges to global public health in the 21st century. Among these, Parkinson's Disease (PD) stands out due to its increasing prevalence and profound impact on the quality of life of millions of individuals and their families. Parkinson's is a progressive disorder of the central nervous system, primarily affecting the motor system, leading to symptoms such as tremors, rigidity, and bradykinesia (slowness of movement). The critical challenge in managing PD lies in its early and accurate diagnosis. Traditionally, a definitive diagnosis relies on the observation of motor symptoms, which often only manifest after a substantial loss of dopaminergic neurons has already occurred. This delay in detection limits the effectiveness of therapeutic

interventions that could slow disease progression and better manage symptoms. Consequently, there is an urgent and compelling need for accessible, non-invasive, and cost-effective screening tools that can identify potential risk factors in the very early stages of the disease.

Recent advancements in biomedical research have identified vocal impairment, or dysphonia, as one of the earliest and most common non-motor symptoms of Parkinson's Disease. Subtle changes in the voice, often imperceptible to the human ear, can precede the onset of classic motor symptoms by several years. These changes are quantifiable through the analysis of specific acoustic features known as vocal biomarkers. Key indicators such as jitter (variations in vocal frequency), shimmer (variations in vocal amplitude), and the harmonics-to-noise ratio (HNR) provide a measurable signature of the underlying neuropathology affecting laryngeal and respiratory control. The ability to computationally analyze these biomarkers presents a novel and promising avenue for early-stage screening.

In response to this opportunity, we have developed TremorSense, an innovative web-based platform designed to leverage the power of machine learning for the preliminary risk assessment of Parkinson's Disease through voice analysis. This project, undertaken as part of the seventh-semester curriculum for the B.E. Computer Science and Engineering programme at SNS College of Engineering, aims to bridge the gap between clinical research and practical application. TremorSense provides a user-friendly interface where an individual can upload a simple audio recording of a sustained vowel sound. This sample is then processed by a sophisticated machine learning model trained to detect the subtle vocal patterns associated with PD, delivering an instant, data-driven risk assessment.

The primary objective of this project was to design, develop, and deploy a functional prototype that demonstrates the viability of using vocal analysis as a preliminary screening tool. The scope of our work encompasses the entire development lifecycle, from data preprocessing and feature extraction using the Parselmouth library to the training and evaluation of a classification model and its subsequent integration into a secure, intuitive web application. It is crucial to emphasize that TremorSense is intended as a screening aid

to encourage further medical consultation and is not a substitute for a professional medical diagnosis.

This report provides a comprehensive overview of the TremorSense project, undertaken with the invaluable support and mentorship of our project guide, Ms. Nirmala D. It will detail the theoretical background, system architecture, methodology employed in model development, the implementation of the web platform, and an analysis of the results obtained. Finally, we will discuss the project's limitations and propose potential avenues for future enhancement and research.

II. IDENTIFY, RESEARCH AND COLLECT IDEA

Our empathy-driven research revealed that the problem was not merely technical but deeply emotional. We distilled our findings into three core insights:

1. **Anxiety is a Major Barrier:** Fear of a diagnosis, combined with the complexity of medical information, causes users to delay seeking help.
2. **Simplicity Builds Trust:** A complex interface is intimidating and can be perceived as untrustworthy, especially by older or anxious users.
3. **Guidance is More Valuable than Diagnosis:** Users are not looking for a definitive diagnosis from a web tool but rather a clear, gentle nudge towards professional medical care.

Developing Our Point of View (POV)

Based on these insights, we formulated a Point of View (POV) statement to anchor our efforts. The POV statement frames the problem from the user's perspective, combining their need with the insight we gained.

Our primary POV statement is:

A health-conscious but anxious individual needs a simple, private, and non-intimidating way to get a preliminary assessment of their vocal health because the current path to getting answers is often slow, confusing, and stressful, causing them to delay seeking professional help.

This statement became our North Star, ensuring we remained focused on solving the right problem for our specific user. It clarifies that we are not just building a prediction model, but a tool to reduce anxiety and bridge the gap to professional healthcare.

Framing "How Might We" (HMW) Questions

To transition from defining the problem to brainstorming solutions (the Ideate stage), we reframed our POV into a series of optimistic and open-ended "How Might We" (HMW) questions. These questions served as our creative launchpad.

The key HMW questions we generated were:

- How Might We design an analysis process that feels as simple and intuitive as using a basic mobile app?
- How Might We present the analysis results in a way that is clear and actionable, without causing unnecessary alarm or being misinterpreted as a final diagnosis?
- How Might We create a sense of security and privacy throughout the user journey, so users feel safe submitting a personal voice sample?
- How Might We empower users with the confidence to take the next step and consult a healthcare professional, using our tool as a catalyst for positive action?

The Defined Problem Statement

By synthesizing our POV and HMW questions, we arrived at our final, core problem statement for the TremorSense project:

To design and develop a trusted, web-based tool that provides a preliminary, data-driven vocal health screening. The platform must be radically simple, present results in a reassuring and understandable manner, and above all, empower users to move from a state of private concern to one of informed consultation with a medical professional.

III. WRITE DOWN YOUR STUDIES AND FINDINGS

Phase 1: Low-Fidelity Prototyping - Wireframes and User Flow

Our first step was to create low-fidelity prototypes in the form of paper sketches and digital wireframes. This rapid and inexpensive method allowed us to focus purely on the user journey and the structural layout of the application without being distracted by visual design elements like colors or fonts. We sketched the primary screens of the user experience:

1. **Registration and Login:** To map out the process of creating a secure and private user account.
2. **The Main Analysis Page:** We experimented with the placement of the instructions, the upload button, and the results panel to create the most intuitive layout.

3. The Results Dashboard: We created multiple layouts for the dashboard, exploring different ways to arrange the main prediction, confidence gauge, and biomarker details.

Key Learning: This low-fidelity process was invaluable. It quickly revealed that a single-page design for the main application was superior to a multi-step wizard, as it reduced clicks and simplified the user's cognitive load. It also helped us finalize the three-column grid layout for the results dashboard, which presented a balanced and digestible view of the information.

Phase 2: High-Fidelity Functional Prototype – The TremorSense Web Application

After validating our core layout and user flow with wireframes, we proceeded to build a high-fidelity, functional prototype. For this project, our high-fidelity prototype is the live, working version of the TremorSense web application itself. This prototype integrates the front-end user interface, the back-end server logic, and the trained machine learning model into a single, cohesive system.

This functional prototype directly implements the core features selected during the Ideate stage:

- **Secure User Authentication:** A complete registration and login system was built using Flask and SQLAlchemy to address the critical user need for privacy and data security.
- **Minimalist User Interface:** The main analysis page was developed with a clean, uncluttered design, centered around a single, clear call-to-action (“Upload Audio File”), directly implementing the principle of radical simplicity.
- **Interactive and Graphical Dashboard:** The results panel was engineered to be a dynamic dashboard. We integrated the Chart.js library to create a visually intuitive gauge for the confidence score and animated bar graphs for the vocal biomarkers (Jitter, Shimmer, HNR), providing the rich, contextualized feedback we identified as a core user need.
- **Empathetic User Communication:** The language used throughout the prototype, from the recording instructions to the final recommendation, was carefully crafted to be reassuring, clear, and empowering, guiding the user towards professional consultation without causing alarm.

IV. IMPROVEMENT AS PER REVIEWER COMMENTS

While the current version of TremorSense is a robust and functional prototype, it represents the first step on a much longer journey. The platform has immense potential for growth, and we have identified several key areas for future work to enhance its capabilities, accuracy, and clinical relevance.

1. **Results History and Progression Tracking:** Based on direct user feedback from the Testing phase, the highest priority feature is the development of a "Results History" page. This would allow registered users to view all their past analyses on a single timeline. Such a feature would empower users and clinicians to track vocal biomarker progression over time, which could be a more powerful indicator of change than a single snapshot analysis.
2. **Machine Learning Model Enhancement:** The current model is effective, but it can be significantly improved. Future work should focus on retraining the model on a larger, more diverse dataset, incorporating samples from individuals of different ages, genders, accents, and native languages. This would enhance its generalizability and reduce potential biases. Furthermore, exploring longitudinal models that analyze an individual's vocal changes over months or years could yield even higher predictive accuracy.
3. **Mobile Application Development:** To further improve accessibility and ease of use, a dedicated mobile application for iOS and Android should be developed. A mobile app would provide a more seamless user experience by utilizing the smartphone's high-quality built-in microphone directly, eliminating the need for users to record and transfer .wav files. It would also enable features like scheduled reminders for users to submit a new sample.
4. **Integration of Multi-Modal Biomarkers:** Parkinson's affects more than just the voice. Future versions of TremorSense could evolve into a more holistic screening platform by integrating other digital biomarkers. This could include analyzing keyboard typing dynamics (keystroke speed and rhythm), simple motor skill tests conducted via the touchscreen, or even gait analysis using the phone's accelerometer.
5. **Clinical Validation and Collaboration:** The most critical next step for establishing the credibility of TremorSense is to pursue formal clinical validation. This involves partnering with neurologists, speech pathologists, and medical research institutions to conduct a structured clinical trial. Validating the platform's results against traditional diagnostic methods is essential for it to be

accepted as a legitimate tool in the medical community and to truly fulfill its potential in aiding early detection

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V. CONCLUSION

The rising prevalence of neurodegenerative disorders like Parkinson's Disease highlights a critical need for accessible, non-invasive, and early-stage screening tools. This project, TremorSense, was conceived to address this challenge by leveraging the power of machine learning and voice analysis. By adhering to a rigorous Design Thinking methodology, we moved beyond a purely technical implementation to create a solution that is deeply rooted in the needs and emotional journey of its potential users.

The project successfully achieved its primary objectives. We developed and integrated a machine learning model capable of classifying voice samples with a high degree of accuracy (92.0%), demonstrating the technical viability of the approach. More importantly, we translated this complex technology into a secure, intuitive, and user-centric web application. The final platform, with its minimalist interface and graphical results dashboard, effectively solves the problems of usability and accessibility that have limited the real-world impact of previous academic research. The TremorSense project stands as a successful proof-of-concept, demonstrating that student-led engineering initiatives can produce practical tools that address significant, real-world health challenges.

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