MemoTag AI/ML Task Report: Voice-Based Cognitive Decline Detection

Submitted by – Ravinder Namdev (ravindernamdev151004@gmail.com)

1. Objective

To develop a proof-of-concept system that uses raw voice data to detect indicators of early cognitive impairment using speech and language features, NLP techniques, and unsupervised machine learning.

2. Features Extracted

Feature	Description
Pause Count	Number of detected silent pauses
Hesitation Words	Frequency of filler words like 'uh', 'um'
Speech Rate	Words spoken per second
Pitch Variability	Standard deviation of detected pitch
Incomplete Sentences	Ellipses or cut-off indicators
Jitter	Variability in pitch transitions
Articulation Rate	Words per second during active speech
Mean Pause Duration	Average duration of silent pauses
Filler Rate	Filler words per minute
Lexical Diversity	Ratio of unique to total words
Max/Min Pitch	Vocal range captured during speech

Most Insightful Features:

- Jitter & Pitch Variability: Indicate vocal instability common in stress or decline.

- Filler Rate & Hesitation Count: Strong markers of cognitive load.

- Lexical Diversity: Low variation may reflect word recall issues.

- Articulation Rate: Lower rate can indicate slowed thinking.

3. Machine Learning Methodology

Model Used: Isolation Forest (Unsupervised Anomaly Detection)

Why:
- No labels provided (unsupervised scenario)
- Detects outliers based on multiple input features
- Interpretable and fast for small datasets

How It Works:
- Each voice sample is converted into a feature vector.
- Isolation Forest assigns an anomaly score.
- High scores = higher likelihood of abnormality (potential cognitive decline)

4. Visualizations Included

- Bar plot of risk scores per file
- Correlation heatmap of extracted features
- Scatterplots (optional) for comparing key features (e.g., Jitter vs Risk)

5. Potential Clinical Improvements

- Use labeled clinical data for supervised learning.

- Include more structured language tasks (e.g., sentence completion, category fluency).

- Perform longitudinal monitoring (speech over time).

- Apply cross-language/generalizability validation.

- Consult speech pathologists and neurologists for feature relevance.

6. Deliverables

- Python Notebook: Fully functional, includes preprocessing, transcription, feature extraction, ML modeling, and visualizations.

- Visualizations: Risk trends, correlations.

- API Function: predict_cognitive_risk(file_path) returns risk score and transcript.

7. Conclusion

The system demonstrates a practical, lightweight pipeline to detect early indicators of cognitive decline using speech analysis. It is built with open-source tools and designed to be extensible with real-world clinical input.