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

Objective

Detect early signs of cognitive stress or decline using short voice recordings, by extracting audio and NLP features, followed by unsupervised anomaly detection.

Most Insightful Features

- **Speech Rate (words/min):** Slower speech can indicate memory retrieval delays.

- **Hesitation Count (e.g., "uh", "um"):** Frequent hesitations may reflect word-finding difficulty.

- **Pauses per Sentence:** Increased pause frequency correlates with cognitive effort.

- **Pitch Variability:** Flat or erratic pitch may suggest reduced emotional or neurological responsiveness.

ML Method Used

Isolation Forest was used as the core unsupervised model for anomaly detection.
Justification:

- Does not require labeled data (suitable for early exploration).

- Robust to high-dimensional feature spaces.

- Produces interpretable anomaly/risk scores.

Model Evaluation

- Successfully identified outlier speech samples based on hesitation, pauses, and speech rate.

- Visualization of feature trends showed clear separation of anomalous speakers.

Next Steps for Clinical Robustness

- **Labeled Data:** Use clinical voice recordings from diagnosed patients.

- **Feature Enrichment:** Add linguistic complexity, vocabulary richness, and grammar patterns.

- **Task Design:** Include specific recall, naming, or association tasks to provoke target symptoms.

- **Expert Involvement:** Collaborate with neurologists and speech pathologists for feature validation.

- **Model Advancements:** Test interpretable temporal models (e.g., HMMs, Temporal CNNs).

- **Benchmarking:** Compare cognitive risk metrics against age-matched controls.

Deliverables Summary

- Python pipeline in Google Colab

- Audio + NLP feature extraction

- Unsupervised anomaly detection using Isolation Forest

- Risk score and visualization output