

# **Cognitive Speech Anomaly Detection - Project Report**

**Project Title:** Cognitive Speech Anomaly Detection using Machine Learning

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## **1. Introduction**

Cognitive disorders like Alzheimer's disease can often be detected through subtle changes in speech patterns. This project aims to develop a lightweight anomaly detection system that analyzes audio recordings of speech and identifies potential indicators of cognitive decline, using acoustic features and unsupervised learning techniques.

## **2. Objectives**

- To extract key audio features indicative of cognitive changes.
- To apply unsupervised anomaly detection to identify at-risk samples.
- To visualize and interpret feature-based differences.

## **3. Dataset**

- **Total audio files analyzed:** 9
- **Format:** WAV
- **Source:** Custom/test dataset manually compiled

**Files analyzed:**

- astronaut-says-game-over-73039.wav
- counting-2-139468.wav
- didyouhearthatiseverybodythere-61210.wav
- maybe-next-time-huh.wav
- nice-work.wav
- seriously-right.wav
- thats-the-loveliest-thing.wav
- this-is-sc-v1-106448.wav
- youll-see-very-soon.wav

## 4. Methodology

### 4.1 Feature Extraction

Extracted features include:

- **Pauses per second**
- **Average pause duration**
- **Pitch standard deviation**
- **Speech density** (voiced vs unvoiced segments)

Tools used:

- Librosa (audio analysis)
- NumPy, Pandas
- scikit-learn (modeling)
- Seaborn (visualization)

### 4.2 Anomaly Detection

- **Model:** Isolation Forest

- **Reason:** Works well for high-dimensional data and unsupervised anomaly detection

## 5. Results

**Anomalies Detected:** 2 out of 9 files

Filename	Anomaly Score
thats-the-loveliest-thing.wav	-0.075420
astronaut-says-game-over-73039.wav	-0.020644

## Key Feature Differences

Feature	Normal (mean)	Anomalous (mean)
Pauses per sec	0.926	0.419
Avg pause duration	0.76 sec	1.45 sec
Pitch std	83.07	71.42
Speech density	0.75	0.64

## 6. Visualizations

- Boxplot generated for pitch standard deviation to visually distinguish between normal and anomalous

samples.

- FutureWarning regarding `sns.boxplot()` was encountered but did not affect results.

## **7. Conclusion**

This project successfully demonstrates a proof-of-concept anomaly detection system for speech-based cognitive assessment. The tool identified 2 potential at-risk recordings based on speech irregularities.

## **8. Future Work**

- Apply on larger, clinical datasets
- Incorporate semantic/NLP features
- Build an interactive dashboard (e.g., Streamlit or Gradio)
- Improve model robustness with additional classifiers

## **9. Files Included**

- `index.py` - Main script
- `cognitive_analysis_results.csv` - Output results
- Audio files (9 WAV samples)
- Visualizations folder (optional)