**Tanish Arora**
**23BCE1924**

Project Title:

# AI-Based Dementia Screening & Counseling System

## ❖ Overview:

Dementia, including Alzheimer's disease, affects millions worldwide, and early detection is critical for improving patient outcomes and life quality. However, subtle cognitive decline often goes unnoticed until it reaches advanced stages, limiting treatment effectiveness. This project aims to develop an **AI-powered system** to screen for early signs of dementia using **cognitive tests and speech analysis**, providing **risk scores, stage prediction**, and **recommendations for counseling or clinical referral**.

The system integrates **machine learning**, a **user-friendly web dashboard**, and **optional recommendation features** to guide patients and caregivers. By leveraging AI, the system can support **early interventions**, reduce the burden on healthcare systems, and empower educators and doctors with data-driven insights.

## ❖ Project Aim:

To create an **accessible, low-cost AI system** that detects early signs of dementia.

- To **analyze cognitive test performance and speech patterns** for prediction.
- To provide a **risk score and stage classification** (very mild, mild, moderate).
- To generate **recommendations for consultation with specialized doctors**.
- To build a **user-friendly web interface** for patients, caregivers, and healthcare providers.
- To support **multi-language input** and ensure usability for diverse populations.

## ❖ Objectives

1. Collect and preprocess data from cognitive tests and speech input.
2. Extract features from speech and cognitive responses to identify patterns indicative of dementia.
3. Develop a **machine learning model** for:
    - Dementia detection (binary: yes/no)
    - Risk scoring (0–100%)
    - Optional stage prediction (very mild, mild, moderate)
4. Build a **web-based dashboard** to display results and recommendations.

5. Integrate **doctor recommendation system** using APIs like Google Maps for location-based guidance.
6. Provide **alerts or notifications** to patients, caregivers, or doctors.
7. Ensure **data security and privacy** for all patient inputs and results.

## ❖ Motivation / Problem Statement

- Dementia often goes **undiagnosed in the early stages**, delaying interventions.
- Early detection can **slow progression**, improve quality of life, and extend life expectancy.
- Cognitive tests alone can be **subjective and error-prone**, while speech patterns provide additional insight.
- There is a **lack of low-cost, accessible AI-based tools** for early dementia detection.
- By combining **speech analysis and cognitive testing**, this system allows **early-stage detection**, empowering patients and caregivers to take timely action.

## ❖ Input Data And Sources

The AI-Based Dementia Screening & Counseling System relies on **two main categories of inputs**: **cognitive test data** and **speech data**. Optionally, you can include demographic or behavioral data to improve prediction. Below is a detailed breakdown:

### 1. Cognitive Test Inputs

**Source**

- Directly from **users/patients** via the **web application**.
- Administered as **interactive forms or quizzes** in the dashboard.

**Data Collected**

1. **Memory Tasks**
    - Recall sequences of numbers, words, or images.
    - Measures short-term and working memory.
2. **Attention Tasks**
    - Focus-based tests, e.g., spotting differences or selecting correct sequences.
    - Measures sustained attention and concentration.

3. **Problem-Solving Tasks**
    - Simple logic, pattern recognition, or arithmetic questions.
    - Measures executive function.
4. **Reaction Time / Response Metrics**
    - Time taken to answer each question.
    - Number of correct vs. incorrect responses.

**Format**

- Usually tabular: each row = one user/session, columns = features (score, time, accuracy).
- Stored in the **database** after preprocessing.

## 2. Speech Inputs

**Source**

- Recorded **voice samples** during the test, e.g., reading a passage, describing a picture, or answering questions.
- Users record directly via **web microphone interface** or mobile device.

## Data Collected

1. **Speech Patterns**
    - Pause frequency and duration
    - Hesitations, repetitions
    - Speech rate (words per minute)
2. **Acoustic Features**
    - Pitch, tone, volume
    - Voice modulation
3. **Optional Text Transcription**
    - Speech-to-text conversion for analyzing grammar, word choice, and sentence structure.
4. **Optional Behavioral Markers**

- Word-finding difficulties
- Incoherent sentences or tangential speech

**Format**

- Raw audio files (.wav, .mp3) → preprocessed features (numerical vectors) for ML model.
- Speech features stored in **database** after extraction.

## ❖ Technical Stack:

| Layer | Technologies / Tools | Purpose |
|---|---|---|
| **Frontend** | Streamlit / HTML5 / CSS / Bootstrap | Web dashboard, cognitive test interface, speech input UI |
| **Backend / API** | Python (Flask / FastAPI) | Handle requests, run ML predictions, manage user sessions |
| **Database** | SQLite / MongoDB / PostgreSQL | Store patient data, test responses, risk scores, session history |
| **Machine Learning** | scikit-learn, XGBoost, TensorFlow / PyTorch (optional) | Classification, risk scoring, stage prediction |
| **Speech Processing** | OpenAI Whisper, Vosk, librosa | Audio preprocessing, feature extraction (pauses, speech rate, hesitations) |
| **Visualization** | Plotly, Matplotlib, Seaborn | Graphical dashboards, risk heatmaps, trends over time |
| **APIs / External Services** | Google Maps API | Recommend nearby specialized doctors based on user location |
| **Environment** | Python 3.x, virtualenv | Isolated development environment for reproducibility |
| **Version Control** | Git / GitHub | Track project code and collaborative development |

## ❖ System Architecture

**1. User Layer:**

- Patients or caregivers access the system through a **web app or mobile-friendly dashboard**.
- Inputs include cognitive test responses and speech recordings.

**2. Frontend Layer:**

- Handles **UI/UX** for cognitive tests, speech recording, results display, and recommendations.
- Uses **Streamlit** for rapid deployment of interactive dashboards.

**3. Data Preprocessing Layer:**

- **Cognitive data:** Normalization, feature extraction (accuracy, response time, errors).
- **Speech data:** Noise reduction, feature extraction (speech rate, pauses, repetition, pitch), optional speech-to-text conversion.

**4. Machine Learning Layer:**

- Features from cognitive and speech data are **fused into a single dataset**.
- ML model predicts **dementia risk**, optionally classifies **stage**.
- Algorithms: Random Forest, XGBoost, Logistic Regression, or Neural Networks.
- Evaluation metrics: Accuracy, F1-score, precision, recall.

**5. Backend Layer / API:**

- Receives preprocessed data from frontend, runs ML model, returns predictions.
- Handles storage and retrieval of historical results.

**6. Database / Storage Layer:**

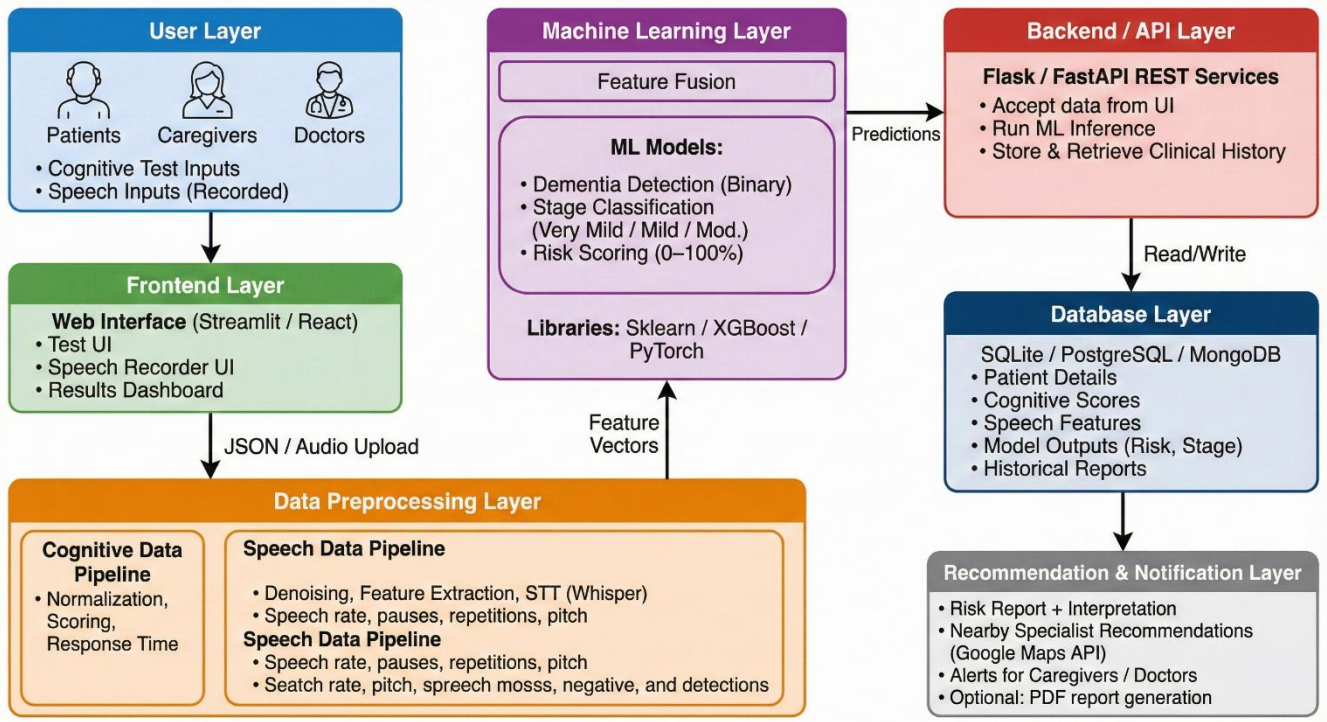
- Stores patient information, cognitive responses, speech features, risk scores, timestamps.
- Database choice can vary: SQLite for small deployments, MongoDB/PostgreSQL for larger projects.

**7. Recommendation / Notification Layer:**

- Generates **risk reports**, doctor suggestions (via Google Maps API), and optional alerts.
- Optionally creates **PDF reports** for medical consultation.

**8. Optional Extensions:**

- Multi-language support for cognitive tests and speech.
- Visualization dashboards to show trends over time.
- Integration with wearable devices for behavioral data.
- Telemedicine or chat interface for remote guidance.




## ❖ Machine Learning Pipeline

1. **Feature Extraction:**
    - Cognitive test metrics (accuracy, speed, errors)
    - Speech metrics (rate, pauses, word repetitions, pitch)
2. **Feature Fusion:**
    - Combine all features into a **single structured dataset**
3. **Model Selection:**
    - Logistic Regression / Random Forest / XGBoost
    - Optional: Neural Network (MLP)
4. **Training & Validation:**
    - Dataset: synthetic or anonymized real data
    - Cross-validation, hyperparameter tuning
    - Metrics: Accuracy, Precision, Recall, F1-score
5. **Prediction:**
    - Binary classification: Dementia / No Dementia
    - Risk score (0–100%)

- Optional stage classification

6. **Deployment:**
    - Model exposed via API → Frontend consumes prediction

## ❖ 10. Expected Outcomes

- **Early-stage dementia detection** before severe cognitive decline.
- **Risk score and stage prediction** available in real-time.
- **Dashboard for patients, caregivers, and doctors**.
- **Recommendations for nearby specialized doctors**.
- Improved **life expectancy and quality of life** through early intervention.
- Demonstrates **AI/ML applied to healthcare** in a real-world scenario.

## ❖ Challenges & Mitigation

| Challenge | Mitigation |
|---|---|
| Lack of real patient data | Use **synthetic datasets** or anonymized open-source datasets |
| Speech data variability | Preprocess with **noise reduction** and normalization |
| Feature fusion complexity | Start with **simpler cognitive + speech features**, extend later |
| Multi-language support | Use **speech-to-text models** supporting vernacular languages |
| Model evaluation | Perform **cross-validation** and report standard metrics |
| Privacy concerns | Store anonymized data and ensure **secure database practices** |

## ❖ Future Enhancements

- Add **MRI/CT image integration** for clinical confirmation (optional advanced extension).
- Multi-language speech recognition for **regional accessibility**.
- Telemedicine integration for **remote consultation**.
- Longitudinal tracking of patients for **progress monitoring**.
- Integration with **wearables** for behavioral analysis (sleep, activity, etc.).

## ❖ Conclusion

This project presents a **practical, scalable AI system** to detect dementia early using cognitive testing and speech analysis. It combines **machine learning, frontend dashboards, and recommendation systems** to provide a **comprehensive tool for patients, caregivers, and doctors**. The project demonstrates **real-world AI application, social impact, and technical depth**, making it **resume-worthy and suitable for college-level implementation**.

**Git hub Porfile Link** ( vit email address ):
https://github.com/tanish-arora2023