Neurological Disorder Detection System using Gemini AI and Hybrid Image Analysis Techniques

# Abstract

This project presents a Neurological Disorder Detection System capable of analyzing brain CT scans to detect signs of neurodegenerative disorders, including Alzheimer's disease, using a hybrid approach that combines artificial intelligence, rule-based analysis, and reference image comparison. The system leverages Google Gemini AI for deep learning-based radiological interpretation, custom rules-based algorithms for pattern detection, and reference databases for comparative similarity scoring.  
  
Designed with an intuitive Tkinter-based graphical user interface (GUI), the application allows users to load CT images, perform enhanced image preprocessing, analyze them through multiple methods, and view comprehensive diagnostic insights, including confidence levels, disease progression stages, and recommendations. Users can also calibrate the rules engine, visualize anatomical differences, and save or extend the reference dataset for future improvements.  
  
Disclaimer: This tool is for educational and experimental purposes only. It does not guarantee 100% accuracy and should not be used for medical diagnosis without expert verification.

# Use Case

- Assists radiologists and researchers in preliminary screening of neurological disorders.  
- Helps educators and students understand CT-based neurodegenerative markers.  
- Useful in AI research for medical image analysis and clinical decision support system development.

# Key Features / Uses

- Load and display CT brain images.  
- Pre-process images with advanced neuro-enhancement techniques.  
- Analyze using:  
 - Gemini AI for deep learning detection.  
 - Rule-based logic calibrated from known scans.  
 - Reference matching against stored normal/abnormal examples.  
 - Hybrid mode combining all methods with weighted logic.  
- Visualize disease progression and affected brain regions.  
- Save results as structured JSON.  
- Continuously update the system with new reference data.

# Advantages

- Multi-method approach reduces the risk of false positives/negatives.  
- Highly customizable and extensible for different disorders or imaging types.  
- Integrated visualization and reporting improves interpretability.  
- Enhances learning and experimentation with real-world medical imaging datasets.

# Python Packages & Their Roles

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| Package | Use |
| Tkinter | Builds the GUI for user interaction and layout. |
| PIL (Pillow) | Loads and resizes CT images for display. |
| OpenCV (cv2) | Performs image enhancement (CLAHE, edge detection, ventricle analysis). |
| Google Generative AI | Uses the Gemini 1.5 model for intelligent image-based diagnosis. |
| NumPy | Handles image data manipulation. |
| Matplotlib | Visualizes disease progression as bar charts or gauges. |
| Threading | Keeps the UI responsive by running analysis tasks in background threads. |
| JSON | Handles saving and loading structured result data. |
| Datetime / OS | Manages file I/O and timestamps for saved results. |
| Webbrowser | Opens visualization files for inspection. |
| Custom Modules | Includes reference\_database.py and ct\_rules\_analyzer.py for specialized logic. |