**Predicting Alzheimer's disease Progression Using Neuroimaging Data**

**Problem Statement:**

Alzheimer's disease (AD) is a progressive neurodegenerative disorder that leads to severe cognitive decline and loss of functional independence. Early prediction and tracking of the disease's progression are crucial for timely intervention and management. Traditional methods rely heavily on clinical assessments and subjective evaluations, which may not capture the disease's subtle changes. Neuroimaging data, including MRI and PET scans, offers objective and detailed insights into brain structure and function, potentially enhancing prediction accuracy. This project aims to develop a robust algorithm to predict the progression of Alzheimer's disease by analyzing neuroimaging data.

**Algorithm:**

1. **Data Pre-processing:**
   * **Normalization**: Standardize imaging data to a common scale.
   * **Noise Reduction**: Apply filtering techniques to reduce artifacts in the images.
   * **Segmentation**: Identify and isolate regions of interest (e.g., hippocampus, cortical regions) using segmentation algorithms.
2. **Feature Extraction:**
   * **Voxel-Based Morphometry (VBM)**: Extract voxel-wise brain features to capture structural changes.
   * **Texture Analysis**: Assess texture patterns in brain tissues that may indicate progression.
   * **Region of Interest (ROI) Analysis**: Quantify changes in specific brain regions linked to Alzheimer's.
3. **Model Development:**
   * **Machine Learning Algorithms**: Train models such as Support Vector Machines (SVM), Random Forests, or Convolutional Neural Networks (CNN) on the extracted features.
   * **Cross-Validation**: Implement k-fold cross-validation to assess model performance and generalizability.
4. **Prediction and Evaluation:**
   * **Progression Prediction**: Use the trained model to predict future disease stages based on current imaging data.
   * **Performance Metrics**: Evaluate model performance using metrics like accuracy, precision, recall, and Area Under the ROC Curve (AUC-ROC).

**Dataset:**

* **Dataset Source**: Alzheimer’s Disease Neuroimaging Initiative (ADNI) or similar publicly available neuroimaging datasets.
* **Description**: Includes MRI and PET scans from participants with varying stages of Alzheimer’s disease, as well as healthy controls. Accompanied by clinical assessments and cognitive test scores.
* **Authentication**: Ensure dataset access complies with licensing agreements and ethical guidelines. Properly anonymize and handle personal data to adhere to privacy regulations.

**Expected Output:**

* **Prediction Accuracy**: High accuracy in predicting Alzheimer's progression stages (e.g., Mild Cognitive Impairment, Moderate AD, Severe AD) based on neuroimaging features.
* **Progression Insights**: Detailed analysis of brain regions most affected by disease progression.
* **Visualization**: Graphs and heatmaps showing predicted progression trends and model performance.
* **Clinical Application**: Provide actionable insights for clinicians to enhance early diagnosis and tailor patient-specific treatment plans.
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