Low-Level Document: Alzheimer's Disease Predictor

1. System Architecture

The Alzheimer's Disease Predictor system processes MRI scans to predict the likelihood of Alzheimer's disease. It involves the following components:

1. **Data Ingestion:**
   - **Input: MRI images (DICOM or other image formats like PNG/JPEG).**
   - **Image Verification: Ensure that the images are in correct format, resolution, and orientation (e.g., axial, coronal, or sagittal slices).**
   - **Data Preprocessing:**
     - **Normalization: Normalize pixel values to a range of [0, 1] or [-1, 1].**
     - **Resizing: Resize images to a fixed dimension (e.g., 224x224 or 256x256) to fit the model's input.**
     - **Image Augmentation: Apply random transformations like rotation, flipping, zooming, and cropping to increase model robustness.**

2. Model Architecture

1. **Convolutional Neural Network (CNN):**
   - **Layer Composition:**
     - **Convolutional Layers (Conv2D): Extract low-level features (edges, textures) from MRI images.**

        - **MaxPooling Layers: Reduce spatial dimensions while preserving important features.**
        - **Fully Connected Layers (Dense): Flatten the feature maps and output a classification.**
        - **Dropout Layers: Prevent overfitting by randomly dropping neurons during training.**
    - **Model Example:**
        - **Input Layer: 224x224x3 image.**
        - **Conv2D Layer: 32 filters, 3x3 kernel, ReLU activation.**
        - **MaxPooling2D: 2x2 pool size.**
        - **Additional Conv2D and MaxPooling layers for deeper feature extraction.**
        - **Flatten and Dense layers for final classification.**
    - **Output: Single node representing the probability of Alzheimer's disease (e.g., 0 for no disease, 1 for disease).**
2. **Model Training:**
    - **Loss Function: Binary Cross-Entropy (for binary classification).**
    - **Optimizer: Adam optimizer with learning rate of 0.001.**
    - **Metrics: Accuracy, Precision, Recall, F1-score.**
    - **Epochs and Batch Size:**
        - **Epochs: 50**
        - **Batch Size: 32**

3. Data Flow and Processing Pipeline

1. **Data Ingestion:**
    - **The system receives MRI images as input (in DICOM, PNG, or JPEG format).**
    - **Image metadata (if applicable) is extracted (e.g., patient ID, scan date) but not used for prediction.**
2. **Preprocessing:**

- **Image Normalization: Pixel values are scaled to [0, 1] or [-1, 1].**
- **Resizing: Images are resized to a fixed size (224x224 or 256x256) to match the model's input shape.**
- **Augmentation: Random rotations, flips, and zooming are applied to enhance generalization.**

3. **Model Inference:**
   - **The preprocessed image is passed through the trained CNN model.**
   - **The model outputs a prediction score (probability) indicating the likelihood of Alzheimer's disease.**
4. **Post-processing:**
   - **A threshold (e.g., 0.5) is applied to the probability score to classify the image as either positive (Alzheimer's) or negative (no Alzheimer's).**
   - **Visualization of the MRI image alongside the prediction score might be displayed on the user interface.**

4. Deployment

- **Platform: The model is deployed on a cloud-based system (Render) or on-premise servers.**
- **API Integration: REST API endpoints for uploading MRI images and receiving predictions.**
- **User Interface: Simple web-based interface where healthcare professionals can upload MRI images and view predictions.**

5. Hyperparameters

- **Learning Rate: 0.001**
- **Batch Size: 32**
- **Epochs: 50**

- **Image Size: 224x224 (resized to fit model input)**
- **CNN Architecture: 3-5 convolutional layers followed by pooling and dense layers.**

6. Success Metrics

- **Accuracy: >90% on a test dataset.**
- **Processing Time: Predictions should be completed within 2-5 seconds per image.**
- **User Experience: Simple and intuitive user interface for easy image upload and result interpretation.**