**Service Architecture**

This Flask-based backend service implements an AI-powered brain tumor detection and medical reporting system designed for MRI image analysis. The service integrates multiple deep learning models to provide automated tumor detection with comprehensive medical report generation.

**Core Functionality**

**1. Image Processing Pipeline**

* Accepts multiple brain MRI images (PNG, JPG, JPEG formats, max 16MB)
* Processes images through a YOLOv8-based detection model
* Identifies four tumor classes: Glioma, Meningioma, Pituitary tumors, and No Tumor
* Calculates bounding boxes, confidence scores, and dimensional measurements

**2. AI Model Integration**

* **YOLO Model**: Custom-trained YOLOv8 model ([yolov8\_model.pt](vscode-file://vscode-app/c:/Users/zamza/AppData/Local/Programs/Microsoft%20VS%20Code/resources/app/out/vs/code/electron-sandbox/workbench/workbench.html)) for brain tumor detection
* **LLM Integration**: Multiple language model options (TinyLlama, DialoGPT, Microsoft Phi-2) for medical report generation
* **Fallback System**: Template-based report generation when LLM models are unavailable

**3. Medical Report Generation**

* Generates professional radiological reports following standard medical format
* Includes sections: Clinical History, Technique, Findings, Impression, and Recommendations
* Calculates tumor dimensions, locations, and confidence metrics
* Provides clinical context and urgency recommendations based on findings

**API Endpoints**

**Health Check (GET /health)**

* Returns service status and model loading information
* Monitors YOLO and LLM model availability

**Image Analysis (POST /analyze)**

* Processes uploaded MRI images
* Returns comprehensive PDF report with:
  + Visual detection results with bounding boxes
  + Detailed medical analysis
  + Clinical recommendations
  + Professional radiological formatting

**JSON Analysis (POST /analyze-json)**

* Alternative endpoint returning structured JSON data
* Includes detection coordinates, confidence scores, and text-based medical report
* Suitable for programmatic integration

**Technical Features**

**Performance Optimizations**

* Models loaded once at startup to minimize response time
* GPU/CPU automatic detection and optimization
* Memory-efficient processing with cleanup routines
* Configurable generation parameters for speed vs. quality balance

**Report Generation System**

* **Template-based Reports**: Structured medical reports with standardized clinical language
* **LLM-enhanced Reports**: AI-generated narrative reports using advanced language models
* **PDF Visualization**: Matplotlib-generated images with tumor highlighting and annotations

**File Management**

* Secure filename handling and temporary file cleanup
* Configurable upload directory with automatic creation
* CORS enabled for web frontend integration

**Medical Report Structure**

The system generates comprehensive medical reports including:

1. **Clinical History**: Context about the examination purpose
2. **Technique**: Description of AI-based analysis methodology
3. **Findings**: Detailed analysis of each image with:
   * Tumor location and dimensions
   * Confidence levels and measurement accuracy
   * Anatomical relationship descriptions
4. **Impression**: Clinical interpretation and diagnostic conclusions
5. **Recommendations**: Specific next steps based on findings severity

**Quality Assurance**

* Multiple fallback mechanisms ensure report generation even with model failures
* Comprehensive error handling and logging throughout the pipeline
* Professional disclaimer emphasizing the need for radiologist verification
* Standardized medical terminology and formatting compliance

**Integration Capabilities**

* RESTful API design for easy integration with web applications
* Multi-format support (PDF for clinical use, JSON for system integration)
* Health monitoring endpoints for system status verification
* Frontend compatibility with drag-and-drop file upload interface

This backend service represents a complete medical AI pipeline, combining state-of-the-art computer vision for tumor detection with natural language processing for clinical report generation, suitable for deployment in healthcare environments requiring automated MRI screening assistance.