# GalaxyALPR

Automatic License Plate Recognition

# Back-End Documentation

OPENTHEGATE HACK
BSS PARKING
06-25

# Galaxy ALPR Backend

A comprehensive backend platform for **Automatic License Plate Recognition (ALPR)**, enabling real-time vehicle and plate detection using AI/ML, robust database integration, and seamless communication with a modern frontend. This system is designed for smart parking management, security, and analytics in enterprise and public environments.

## 📖 Table of Contents



---

## 📝 Project Overview

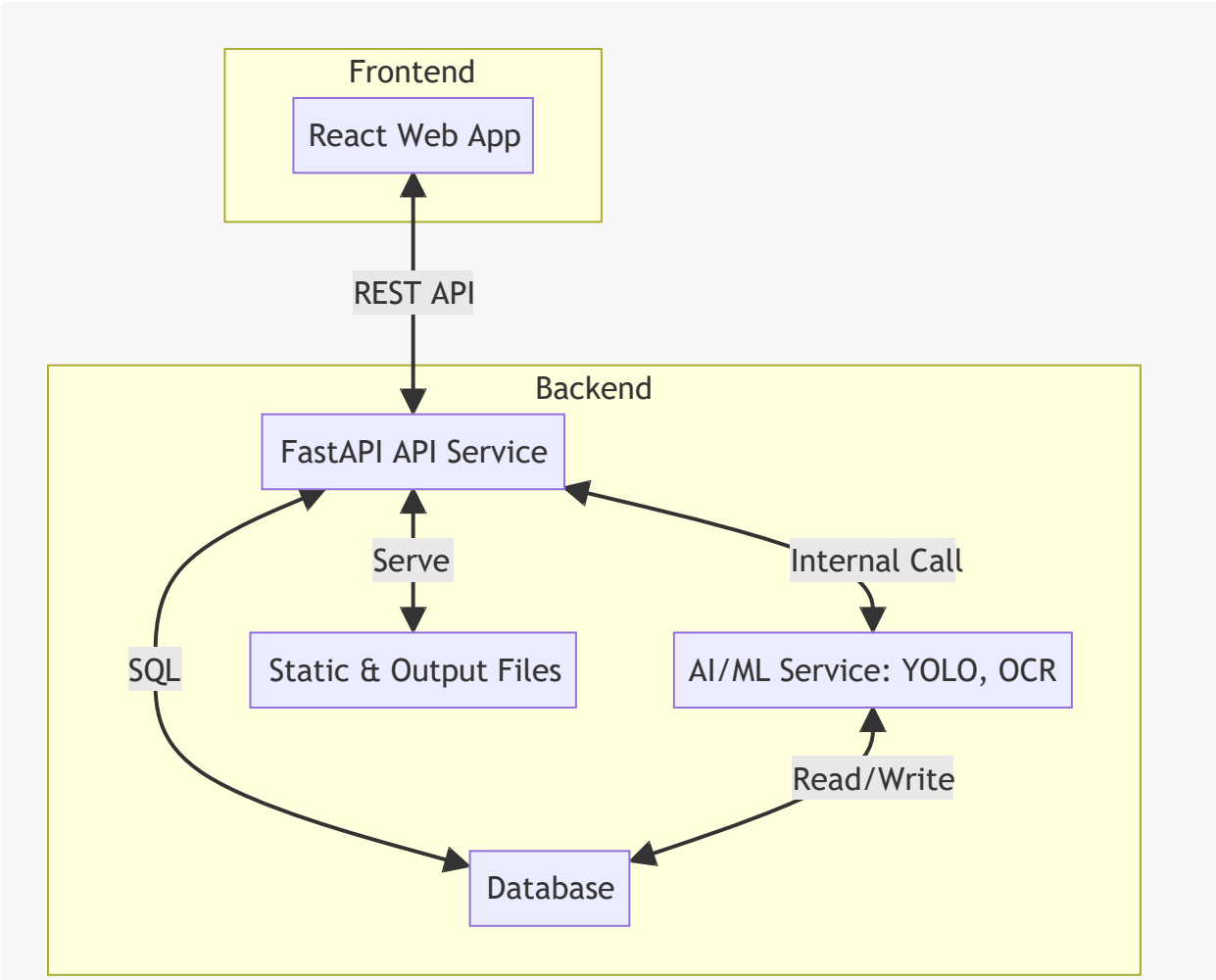
**Galaxy ALPR Backend** provides:

- **RESTful API** for vehicle and license plate detection, querying, and statistics.
- **AI/ML Service** for high-accuracy detection using YOLO and OCR models.
- **Database Integration** for storing detection events, user sessions, and analytics.
- **Static & Output File Serving** for detected images and results.
- **Frontend Communication** for real-time dashboards and management.

This backend is designed to be modular, scalable, and easy to extend for new detection types, analytics, or integrations.

---

# 🏗️ Architecture




- **Frontend**: Sends HTTP requests to the API for detection, history, and analytics.
- **API Service**: Handles requests, triggers AI/ML inference, and manages data.
- **AI/ML Service**: Performs detection and recognition, returns structured results.
- **Database**: Stores all detection events, user data, and statistics.
- **Static/Output Files**: Served via FastAPI for detected images and artifacts.

# 📂 Folder Structure

```
backend/
│
├── app.py                # Main FastAPI application and entry point
├── endpoints/            # Modular API endpoint definitions
│   ├── detect_image.py
│   ├── latest_detection.py
```

```
│   ├── detections.py
│   ├── plate_regions.py
│   ├── plate_queries.py
│   ├── vehicle_queries.py
│   ├── statistics.py
│   ├── plate_status.py
│   ├── session_queries.py
│   └── location_routes.py
│
├── PlateDetector.py       # AI/ML logic for plate and vehicle detection
├── database.py            # Database connection and ORM logic
├── requirements.txt       # Python dependencies
│
├── outputs/               # Output images, crops, and detection artifacts
│   ├── vehicles/
│   ├── plates/
│   ├── uploaded/
│   └── ...
├── uploads/               # Temporary storage for uploaded images
├── static/                # Static assets served by the API
│
└── README.md              # This documentation
```

## 📂 Folder/Service Breakdown

| File / Folder | Description |
|---|---|
| `app.py` | Main FastAPI app, server entry point, and configuration. |
| `endpoints/` | All API route definitions, organized by feature. |
| `PlateDetector.py` | AI/ML detection logic (YOLO, OCR, OpenCV, etc.). |
| `database.py` | Database models, schema, and connection logic. |
| `outputs/` | Stores detection results, vehicle/plate crops, and uploaded files. |
| `uploads/` | Temporary storage for user-uploaded images. |
| `static/` | Static files (docs, UI assets, etc.) served by FastAPI. |
| `requirements.txt` | Python dependencies for backend and AI/ML. |

---

## 🛠️ Tech Stack

### 🔷 API Service

- Python 3.10+
- FastAPI (web framework)
- Uvicorn (ASGI server)
- CORS Middleware

### 🔷 AI/ML Service

- YOLOv8/YOLOv11 (PyTorch)
- OCR (Tesseract, Gemini, or custom)
- OpenCV, NumPy

### 🔷 Database

- SQLite (default, easy dev setup, offline)
- SQLAlchemy (ORM)

### 🔷 Frontend

- React + TypeScript (see `frontend/README.md`)

### 🔷 Utilities

- Logging via Python `logging` module
- File serving via FastAPI

---

## ⚡ Setup & Installation

### 1. Clone the Repository

```
git clone https://github.com/your-org/galaxy-alpr-backend.git
cd galaxy-alpr-backend
```

### 2. Python Environment

Create and activate a virtual environment:

```
python -m venv venv
source venv/bin/activate  # On Windows: venv\Scripts\activate
```

Install dependencies:

```
pip install -r requirements.txt
```

## 3. Directory Preparation

The backend auto-creates `outputs/`, `uploads/`, and `static/` on startup. Create manually if needed:

```
mkdir -p outputs/ uploads/ static/
```

## 4. Run the API Service

```
uvicorn app:app --reload
```

API will be available at: http://localhost:8000

## 5. Configuration

- **CORS**: Default allows `localhost:5173`, `localhost:3000`, and all origins (`*`). Change in `app.py`.
- **Database**: Uses SQLite by default. For MySQL, edit connection string in `database.py`.

---

# 🔗 Service Communication

| From | To | Protocol / Method |
| --- | --- | --- |
| Frontend | API | RESTful HTTP (CORS) |
| API | AI/ML | Internal call or REST |

| From | To | Protocol / Method |
|---|---|---|
| API | Database | SQLAlchemy ORM |
| AI/ML | Database | Direct read/write |
| API | File Store | FastAPI static routes |

---

# 📡 API Overview

## 🔑 Key Endpoints

| Method | Endpoint | Description |
|---|---|---|
| POST | `/detect_image` | Upload an image for vehicle/plate detection |
| GET | `/latest_detection` | Fetch the most recent detection result |
| GET | `/detections` | List all detection events |
| GET | `/plate_regions` | Get plate regions in a specific image |
| GET | `/plate_queries` | Query plate detection history |
| GET | `/vehicle_queries` | Query vehicle detection history |
| GET | `/statistics` | Retrieve analytics and stats |
| GET | `/plate_status` | Check status of a specific plate |
| GET | `/api/locations` | Manage/query location data |
| GET | `/outputs/{path}` | Download detection result artifacts |
| GET | `/static/{path}` | Download static files |

---

# 👨‍💻 Development & Contribution

1. Fork and branch from `main`
2. Follow PEP8 and internal code style
3. Add or modify routes in `endpoints/`

4. Include/update tests if available
5. Use clear commit messages and submit PRs

## Code Quality

- Modular endpoint architecture
- Logging for key operations and errors
- Auto-creates required folders on first run

---

# Subfolder Documentation

- `backend/README.md` — API and backend logic
- `backend/endpoints/README.md` — API endpoint documentation
- `backend/PlateDetector.py` — ML model logic and image processing
- `backend/database.py` — Database models and setup

---

# License

This backend system is developed and maintained by **@GalaxyDeveloper**.

---

# Citation

If you use **Galaxy ALPR Backend** in your research, academic paper, or production system, please cite:

```
Galaxy ALPR Backend - Modular Backend for AI-Powered License Plate Recognition
Developed by @GalaxyDeveloper (2025)
Includes FastAPI, YOLOv11n, OCR, and SQLite Integration
```

---

**Galaxy ALPR Backend** – Modular, scalable backend for intelligent vehicle and plate detection. *Powered by FastAPI, YOLOv11n, OCR, and SQLite*

**Developed by @GalaxyDeveloper — 2025**

---