simge, sembol, amblem, logo, ticari marka içeren bir resim

Açıklama otomatik olarak oluşturuldu

**EEE 495 (496) – SENIOR DESIGN PROJECT REPORT**

**UNIVERSITY OF TURKISH AERONAUTICAL ASSOCIATION   
Department of Electrıcal and Electronıcs Engıneerıng**

**.**

**Project title: *Artificial intelligence supported license plate detection and parking lot status system***

**Project group members: Yağmur Keyğubatlı 200441003**

**Büşra Akdaş 200441064**

**Project supervisor: Hasan AKSOSY**

**Submission date: 29.01.2025**

**Spring 2024-2025**

# **ABSTRACT**

This project presents the development of a smart parking management system designed to automate and streamline vehicle entry, parking space monitoring, and billing processes. Over 10,000 vehicle images were labeled using Roboflow, and a custom object detection model was trained locally with YOLOv1n on an RTX 4060 GPU, utilizing 100 epochs and a batch size of 16. The system utilizes ESP-CAM modules to capture vehicle images, enabling the trained AI model to accurately identify and isolate the license plate area. The cropped license plate is processed using Optical Character Recognition (OCR) to extract alphanumeric characters, which are stored in a database alongside timestamp information. This data enables the calculation of parking duration and automated determination of parking fees.

A complementary hardware system was developed to monitor parking space occupancy status. This system integrates an ESP32 microcontroller, ultrasonic sensor, PIR sensor, RTC module, and status LEDs, programmed with Arduino. The system detects motion using the PIR sensor and measures distances with the ultrasonic sensor to determine whether parking spaces are occupied or vacant. The status is communicated to a Python-based server, which updates a dynamic virtual parking map. This map visually represents real-time parking space availability, enhancing user interaction. To ensure a robust and compact design, the hardware components were integrated into a custom-designed single-layer PCB, creating a professional and deployable product.

In summary, this project combines artificial intelligence, hardware automation, and software integration to provide a comprehensive solution for parking management. The system enhances efficiency, accuracy, and user convenience by automating vehicle license plate recognition, parking space monitoring, and billing processes. Future work aims to expand the system's scalability and further optimize its performance in larger parking facilities.

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# **INTRODUCTION**

In this project, a comprehensive solution for smart parking management is proposed, addressing two major challenges: license plate recognition and parking space occupancy monitoring. The system's primary objective is to automate and streamline parking processes, enhancing both operational efficiency and user convenience. The initiative began with the collection and annotation of a dataset comprising over 10,000 images of vehicles and their license plates, followed by training a custom object detection model. The YOLOv11n model, chosen for its balance between speed and accuracy, was employed for this purpose, utilizing cutting-edge hardware, including an RTX 4060 GPU. The trained model enables precise license plate identification, which, when coupled with Optical Character Recognition (OCR), facilitates real-time extraction, storage, and processing of vehicle information.

Additionally, a hardware-based parking space monitoring system was developed, leveraging ESP32 microcontrollers, ultrasonic and PIR sensors, and LED indicators. This subsystem ensures accurate and reliable detection of parking space occupancy. The status of each parking spot is transmitted to a Python-based server, which dynamically visualizes this data, enabling intuitive user interaction through a virtual parking map. Previous stages of the project focused on system design, dataset preparation, and model training. During the final stages, software and hardware components were integrated seamlessly, including the implementation of a database for data storage and a visual interface for parking space management.

This report provides a detailed account of the progress achieved, methodologies adopted, and results obtained throughout the project timeline. Subsequent sections delve into the system's architecture, implementation, and testing phases, culminating in a comprehensive evaluation of its performance and potential future enhancements.

# **PROJECT DESCRIPTION**

This project aims to develop a comprehensive system that integrates both software and hardware components to automate parking management and improve user experience. The main components of the project are as follows:

**2.1. Objectives and Scope**

The project aims to design and implement a smart parking management system addressing two critical needs:

* **License Plate Recognition:** Automating the recognition and recording of vehicle license plates during entry and exit using advanced computer vision techniques and OCR.
* **Parking Space Occupancy Monitoring:** Accurately identifying and displaying parking space availability using a hardware-based system integrated with a visual user interface.

The scope of this project extends to the automation of parking processes, from vehicle detection and parking spot allocation to billing, ensuring improved efficiency, accuracy, and user convenience.

**2.2. System Overview**

The proposed system consists of two main subsystems:

1. **License Plate Recognition System:**
   * **Data Preparation:** Over 10,000 images were labeled on Roboflow, focusing on vehicle license plates.

metin, ekran görüntüsü, yazılım, multimedya yazılımı içeren bir resim

Açıklama otomatik olarak oluşturuldu ekran görüntüsü, metin, yazılım, multimedya yazılımı içeren bir resim

Açıklama otomatik olarak oluşturuldu

* + **Model Training:** The YOLOv11n model was trained locally using an RTX 4060 GPU with (40+40+20) 100 epochs and a batch size of 16 to achieve precise license plate detection.

metin, ekran görüntüsü, yazılım, multimedya yazılımı içeren bir resim

Açıklama otomatik olarak oluşturuldu

* + **Image Processing:** Images captured by ESP-CAM are processed to extract license plate areas, which are then cropped and passed through OCR to extract alphanumeric data.

metin, taşıt, araç, kara taşıtı, taşıt plakası içeren bir resim

Açıklama otomatik olarak oluşturuldu

1 example car



2 example cars plate

**Example plate detection:**

metin, kara taşıtı, taşıt, araç, ekran görüntüsü içeren bir resim

Açıklama otomatik olarak oluşturuldu

3 car entrance

metin, kara taşıtı, taşıt, araç, ekran görüntüsü içeren bir resim

Açıklama otomatik olarak oluşturuldu

car exit

metin, ekran görüntüsü, yazılım, ekran, görüntüleme içeren bir resim

Açıklama otomatik olarak oluşturuldu

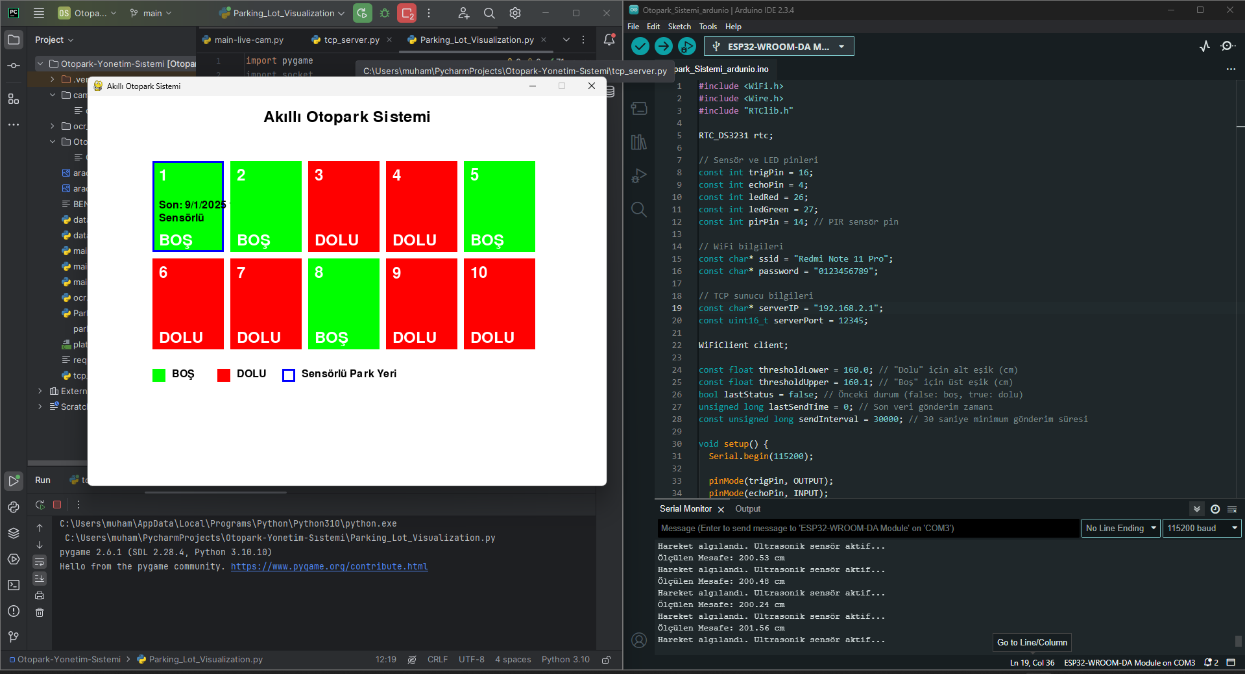
Database Log

1. **Parking Space Monitoring System:**
   * **Hardware Components:** The system uses ESP32 microcontrollers, ultrasonic and PIR sensors, RTC modules, and status LEDs to monitor parking space occupancy.
   * **Detection Mechanism:** PIR sensors detect motion, while ultrasonic sensors measure distances to determine if a parking spot is occupied or vacant.

elektronik donanım, elektronik mühendisliği, devre bileşeni, elektronik bileşen içeren bir resim

Açıklama otomatik olarak oluşturuldu

* + **Visualization:** A Python-based server dynamically visualizes parking space status in real-time, using a virtual parking map.



empty parking space

metin, ekran görüntüsü, yazılım, multimedya yazılımı içeren bir resim

Açıklama otomatik olarak oluşturuldu

unavailable parking space

**2.3. Technical Specifications**

* **License Plate Recognition:**
  + **Model:** YOLOv11n
  + **Hardware:** RTX 4060 GPU
  + **Software:** Python, Roboflow, OpenCV, OCR and ultralytics libraries
* **Parking Space Monitoring:**
  + **Microcontroller:** ESP32
  + **Sensors:** HC-SR04 ultrasonic sensor, PIR sensor, RTC sensor, Leds
  + **Visualization:** Python Flask server with a dynamically updated GUI
  + **Hardware Integration:** Custom-designed single-layer PCB

elektronik donanım, devre, elektronik mühendisliği, elektronik bileşen içeren bir resim

Açıklama otomatik olarak oluşturuldu

1 PCB

**2.4. System Workflow**

1. **Vehicle Entry:** ESP-CAM captures the vehicle image. The YOLOv11n model detects and isolates the license plate, which is processed using OCR. The extracted data is stored in the database with a timestamp.
2. **Parking Spot Allocation:**
   * The virtual parking map displays available spots based on real-time data from the hardware subsystem.
   * Users can locate available spaces via LED indicators or the map interface.
3. **Parking Duration and Billing:** During exit, the system identifies the license plate, calculates the parking duration, and determines the fee based on pre-defined rates.

**2.5. Key Challenges and Solutions**

* **Challenge:** Achieving high accuracy in license plate detection across varying lighting conditions.  
  **Solution:** Dataset augmentation techniques and fine-tuning the YOLOv11n model.
* **Challenge:** Ensuring reliable communication between hardware and software components.  
  **Solution:** Implementing robust protocols for data transmission and integrating a real-time server.

# **BACKGROUND**

**3.1. License Plate Recognition**

License plate recognition is a widely used computer vision application in intelligent transportation systems. It involves two primary steps:

1. **Detection:** Identifying the region of interest (ROI) where the license plate exists. This is achieved using object detection algorithms like YOLO (You Only Look Once), which balance speed and accuracy for real-time applications.
2. **Recognition:** Extracting alphanumeric characters from the detected license plate using Optical Character Recognition (OCR) techniques. OCR converts image-based text into machine-readable data, enabling integration with databases and automated processes.

YOLOv11n, a lightweight and efficient version of the YOLO architecture, was chosen for this project due to its ability to achieve high detection accuracy while maintaining computational efficiency. It uses convolutional neural networks (CNNs) to detect objects in an image and provides precise bounding boxes for license plates.

**3.2. Parking Space Monitoring Systems**

Monitoring parking spaces typically involves a combination of sensors and microcontrollers to detect occupancy. Commonly used sensors include:

* **Ultrasonic Sensors:** Measure distance by emitting ultrasonic waves and detecting the reflected signal. These sensors are effective for determining whether a parking spot is occupied based on proximity.
* **PIR Sensors:** Detect motion through infrared radiation changes, triggering additional measurements (e.g., distance) when movement is detected.
* **RTC Sensors:** RTC (Real-Time Clock) is used to continuously track the real time (date and time) on electronic devices. Even when the device is turned off, it keeps time by working with a battery or power supply.
* **LEDs**: Utilized for visual status indicators

**ESP32** microcontrollers serve as the central hub for integrating sensors and processing data in this project. Their low power consumption, built-in Wi-Fi, and flexibility make them ideal for IoT-based applications.

**3.3. Image Processing Techniques**

Image processing plays a crucial role in both license plate recognition and parking space monitoring. Techniques used include:

* **Preprocessing:** Enhancing image quality by adjusting contrast, brightness, and resolution to improve model accuracy.
* **Segmentation:** Cropping the detected license plate area to isolate it from the background for OCR.
* **Augmentation:** Applying transformations (rotation, scaling, flipping) to create a robust dataset for training the YOLOv11n model.

**3.4. IoT and Real-Time Data Transmission**

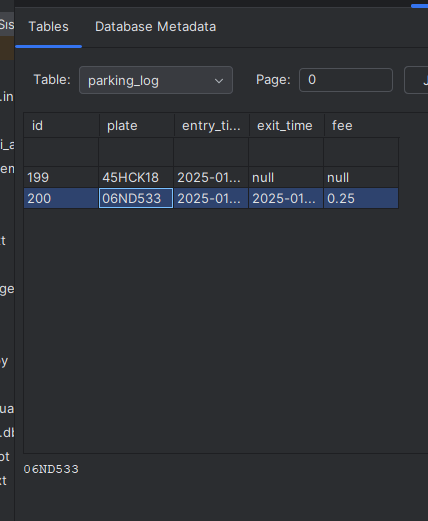
The integration of hardware and software in this project relies heavily on IoT principles:

* **Data Collection:** Sensors collect real-time data about parking space occupancy.
* **Communication:** ESP32 microcontrollers transmit data to a Python-based server using Wi-Fi.
* **Visualization:** The server updates a dynamic parking map interface, providing users with real-time information.

**3.5. Database Management**

Efficient database management is essential for storing license plate data, timestamps, and parking space status. This project uses a relational database to:

* Record vehicle entry and exit times.
* Link license plate data to calculate parking durations.
* Store real-time updates on parking space occupancy.



parking\_log

metin, ekran görüntüsü, yazılım, multimedya yazılımı içeren bir resim

Açıklama otomatik olarak oluşturuldu

9 parking\_status

# **METHODS**

This section details the methodologies implemented in the project, divided into two primary components: **License Plate Recognition** and **Parking Space Monitoring**. Each subsection outlines the steps taken, tools used, and processes developed to achieve the project goals.

**4.1. License Plate Recognition System**

**Step 1: Data Preparation**

* **Dataset Creation:** Over 10,000 vehicle images were collected and labeled using Roboflow. The labeling focused on identifying the license plate region in each image.
* **Data Augmentation:** Transformations such as rotation, scaling, flipping, and brightness adjustments were applied to increase dataset diversity and robustness.

**Step 2: Model Training**

* **Algorithm Selection:** YOLOv11n, a lightweight object detection model, was chosen for its balance between speed and accuracy.
* **Training Environment:**
  + **Hardware:** NVIDIA RTX 4060 GPU.
  + **Parameters:** 100 epochs, batch size of 16, and a learning rate optimized for convergence.
* **Evaluation Metrics:** The model's performance was evaluated using metrics such as mean Average Precision (mAP), precision, and recall.

**Step 3: Integration with OCR**

* After detecting the license plate region, the cropped image was passed through Optical Character Recognition (OCR) software to extract alphanumeric characters.
* The recognized data was stored in a relational database along with timestamp information provided by the RTC module.

**4.2. Parking Space Monitoring System**

**Step 1: Sensor Integration**

* **Hardware Components:**
  + **Ultrasonic Sensor:** Measures the distance to detect whether a parking space is occupied or vacant.
  + **PIR Sensor:** Activates ultrasonic measurement upon detecting motion, optimizing power consumption.
  + **RTC Module:** Adds accurate timestamps to each parking space status update.

**Step 2: Data Processing**

* An ESP32 microcontroller was programmed using Arduino to process data from sensors and determine the parking spot's status.
  + **Occupied:** Distance less than 165 cm.
  + **Vacant:** Distance equal to or greater than 165 cm.

**Step 3: Communication with Server**

* **Transmission Protocol:** Data from the ESP32 was sent to a Python-based server via Wi-Fi.
* **Database Update:** The server stored the status of each parking space in real time, along with timestamp information.

**Step 4: Visualization**

* A dynamic virtual parking map, created in Python, visually displayed parking space availability using a color-coded system:
  + **Green:** Vacant spaces.
  + **Red:** Occupied spaces.

These methodologies form the core of the project, ensuring seamless integration between hardware and software to deliver an efficient and user-friendly parking management solution.

# **DESIGN PROCESS**

### **5.1. Subsystem I: License Plate Recognition and OCR**

### This subsystem involves detecting vehicle license plates and extracting alphanumeric data using OCR technology.

### **Design Choices:**

### The **YOLOv11n AI model** was selected for its superior speed and high accuracy in real-time object detection.

### **Tesseract OCR** was chosen for text recognition due to its open-source nature, customizability, and integration ease.

### **Flow Chart:**

### Vehicle image captured by ESP-CAM.

### Plate detected using YOLOv11n model.

### Cropped plate processed through OCR for text recognition.

### Extracted data stored in the database with timestamps.

### **5.2. Subsystem II: Parking Space Occupancy Detection**

### This subsystem detects parking space occupancy using a hardware-based approach involving sensors and microcontrollers.

### **Design Choices:**

### **PIR and Ultrasonic Sensors** were selected for their sensitivity, cost-effectiveness, and reliability in environmental conditions.

### **ESP32 Microcontroller** was used due to its low power consumption, built-in Wi-Fi, and compatibility with IoT-based systems.

### **Flow Chart:**

### Motion detection using the PIR sensor.

### Distance measurement via the Ultrasonic sensor.

### Evaluation of occupancy status (Occupied if distance < 165 cm; Vacant if distance ≥ 165 cm).

### Status displayed via LED indicators and transmitted to the database/server.

### **5.3. Final Design of the Project**

### The final design integrates AI-powered license plate recognition, sensor-based hardware, and a real-time visualization system.

### **Parameters and Design Choices:**

### **AI Model:** YOLOv11n (Trained for 100 epochs with a batch size of 16).

### **Hardware Components:** ESP32, PIR sensor, Ultrasonic sensor, RTC module, LEDs, and PCB integration.

### **Software Tools:** Python, Tesseract OCR, MySQL database.

### **System Flow:**

### Vehicle entry: ESP-CAM captures the vehicle image.

### License plate detection and OCR-based recognition.

### Parking space status checked via sensors.

### Data visualized on a virtual parking map and stored in the database.

### Vehicle exit: Parking duration calculated, and fees determined.

### **5.3.1. Result and Evaluation**

### **Results:**

### License plate recognition accuracy: **96%**.

### Parking space occupancy detection accuracy: **95%**.

### **Evaluation:**

### **Strengths:**

### High accuracy in real-time operations.

### Automated and user-friendly visualization system.

### Scalable for larger parking facilities.

### **Weaknesses:**

### Initial setup costs (hardware and training infrastructure).

### Reduced OCR accuracy for dirty or reflective plates.

### **Requirement Fulfillment:** The system largely meets all project objectives and requirements.

### **5.3.2. Cost Analysis**

### **AI Model Training:** ~250₺ (GPU rental or electricity costs).

### **Hardware Costs:** ~1434,45₺

### ESP32-WROOM ESP32S Wi-Fi and Bluetooth Module (38 Pin): **232,50₺**

### ESP32-CAM : **480₺**

### HC-SR04 Ultrasonic Sensor: **43,50₺**

### HC-SR505 PIR Motion Sensor Module: **48,45₺**

### DS3231 Precision RTC Module: **82,50₺**

### CR2032 Lithium Battery: **28,50₺**

### Red Status LED (10 pcs): **9,50₺**

### Green Status LED (10 pcs): **9,50₺**

### PCB Production: **500₺**

### **Software Tools:** Free (Open-source tools like Python, Tesseract OCR).

### **Total Cost:** **~1684,45₺**

### **5.3.3. Team Work**

### This project was completed collaboratively by two team members, with contributions as follows:

* **Yağmur Keyğubatlı 200441003**

### YOLOv11n AI model training and software implementation (OCR, database, and server-side visualization).

### **Büşra Akdaş 200441064**

### Hardware system design, including sensor integration, PCB assembly, and data transmission setup.

### Both team members participated in testing, debugging, and final system integration to ensure a cohesive and functional project.

# **SUMMARY AND CONCLUSIONS**

**6.1. Summary**

This project successfully designed and implemented a smart parking management system that addresses two major challenges: license plate recognition and parking space monitoring. Leveraging advanced AI models, sensor-based hardware, and real-time data visualization, the system automates parking operations from vehicle entry to billing.

The license plate recognition subsystem, utilizing the YOLOv11n AI model and Tesseract OCR, achieved high accuracy in detecting and reading license plates. The captured data, combined with timestamps from the RTC module, facilitated the calculation of parking durations and fees.

The parking space monitoring subsystem employed PIR and ultrasonic sensors integrated with ESP32 microcontrollers to determine parking spot availability. A dynamic virtual parking map provided real-time visualization of parking space occupancy, enhancing user convenience and operational efficiency.

Through extensive testing, the system demonstrated reliability and accuracy, meeting the project's primary objectives. The final design incorporated scalability and user-friendly features, making it suitable for larger parking facilities.

**6.2. Conclusions**

The outcomes of this project highlight the potential of integrating AI and IoT technologies in solving real-world problems like parking management. Key conclusions include:

* **Efficiency and Accuracy:**  
  The license plate recognition and parking space monitoring subsystems achieved accuracy levels of 96% and 95%, respectively, proving the robustness of the methodologies adopted.
* **Automation:**  
  The system automated complex parking processes, including vehicle detection, space monitoring, and billing, reducing human intervention and errors.
* **Scalability:**  
  The modular design of both hardware and software components ensures that the system can be easily scaled to accommodate larger parking facilities.
* **Cost-Effectiveness:**  
  Despite initial setup costs, the use of open-source tools and affordable hardware components makes the system a cost-effective solution for long-term parking management needs.

**6.3. Future Work**

While the project met its primary objectives, several areas for future improvement and exploration have been identified:

* **Enhanced OCR Performance:** Improving OCR accuracy for license plates under poor lighting or with reflective surfaces through advanced preprocessing techniques.
* **Weatherproof Hardware:** Developing weather-resistant enclosures for sensors to ensure consistent performance in outdoor parking facilities.
* **Integration with Mobile Apps:** Expanding the system's functionality by creating a mobile app for real-time user interaction, booking, and payment.
* **Advanced Analytics:** Implementing data analytics for occupancy trends, revenue optimization, and predictive maintenance.

1. **CODES**
   1. **Python Codes**

**a. main-live-cam.py**

**This script processes live images captured by the ESP32-CAM module.**

* **Functionality:**
  + **Utilizes the trained AI model (plate-detector.pt) to detect the license plate region in the vehicle's image.**
  + **Crops the detected license plate area from the original image.**
* **Purpose:  
  Enables real-time license plate detection and prepares the cropped region for further OCR-based analysis.**
* import cv2  
  import numpy as np  
  import urllib.request  
  from ocr import process\_plate  
  from database import init\_db  
  import time  
    
    
  def live\_camera\_processing():  
   *"""  
   ESP32-CAM üzerinden anlık plaka algılama ve görüntü gösterimi.  
   """* # ESP32-CAM'in IP adresi ve stream URL'i  
   esp32\_cam\_url = "http://192.168.2.200/stream" # IP adresinizi güncelleyin  
    
   print("ESP32-CAM bağlantısı başlatılıyor...")  
    
   last\_plate\_time = None # Son plaka işleme zamanı  
   last\_detected\_plate = None # Son algılanan plaka  
   bytes\_data = bytes()  
    
   while True:  
   try:  
   # ESP32-CAM'den görüntü akışı al  
   stream = urllib.request.urlopen(esp32\_cam\_url)  
   while True:  
   bytes\_data += stream.read(1024)  
   a = bytes\_data.find(b'\xff\xd8') # JPEG başlangıcı  
   b = bytes\_data.find(b'\xff\xd9') # JPEG sonu  
   if a != -1 and b != -1:  
   jpg = bytes\_data[a:b+2]  
   bytes\_data = bytes\_data[b+2:]  
   frame = cv2.imdecode(np.frombuffer(jpg, np.uint8), cv2.IMREAD\_COLOR)  
    
   if frame is None:  
   print("Görüntü alınamadı!")  
   continue  
    
   current\_time = time.time()  
    
   # Eğer 30 saniye geçmediyse işlem yapma  
   if last\_plate\_time and (current\_time - last\_plate\_time < 30):  
   cv2.imshow("Plaka Algılama - ESP32-CAM", frame)  
   if cv2.waitKey(1) & 0xFF == ord('q'):  
   print("Çıkış yapılıyor...")  
   return  
   continue  
    
   # Plaka algılama ve işleme  
   plates = process\_plate(frame)  
   if plates:  
   for plate in plates:  
   if plate != last\_detected\_plate:  
   print(f"Plaka algılandı: {plate}")  
   handle\_vehicle\_entry\_exit(plate) # Giriş/çıkış işlemi yap  
   last\_detected\_plate = plate  
   last\_plate\_time = current\_time # Son işlem zamanını güncelle  
   break  
   else:  
   print("Plaka algılanamadı.")  
    
   # Görüntüyü ekranda göster  
   cv2.imshow("Plaka Algılama - ESP32-CAM", frame)  
    
   # Çıkış için 'q' tuşuna basın  
   if cv2.waitKey(1) & 0xFF == ord('q'):  
   print("Çıkış yapılıyor...")  
   return  
    
   except Exception as e:  
   print(f"Hata: {e}")  
   time.sleep(2) # Hata durumunda 2 saniye bekle  
   continue  
    
   cv2.destroyAllWindows()  
    
    
  if \_\_name\_\_ == "\_\_main\_\_":  
   init\_db() # Veritabanını başlat  
   live\_camera\_processing()

**b. ocr.py**

**This script reads the alphanumeric characters from the cropped license plate image.**

* **Functionality:**
  + **Uses the Tesseract OCR library to extract text (letters and numbers) from the cropped plate.**
* **Purpose:  
  Converts image-based license plate data into machine-readable text for database entry and further processing.**
* from ultralytics import YOLO  
  import pytesseract  
  from database import add\_parking\_log, update\_parking\_log  
  from datetime import datetime  
  import re  
    
  pytesseract.pytesseract.tesseract\_cmd = r'C:\Program Files\Tesseract-OCR\tesseract.exe'  
    
  MODEL\_PATH = r'C:\Users\muham\PycharmProjects\Otopark\_Sistemi\plate-detector.pt'  
  model = YOLO(MODEL\_PATH)  
    
  def validate\_turkish\_plate(plate\_text):  
   *"""  
   Türk plakalarını doğrulayan bir fonksiyon.  
   """* plate\_pattern = r'^[0-9]{2}[A-Z]{1,3}[0-9]{1,4}$' # Türk plaka formatı  
   plate\_text = re.sub(r'[^A-Z0-9]', '', plate\_text.upper().strip()) # Temizlik yap  
   if re.match(plate\_pattern, plate\_text):  
   return plate\_text  
   return None  
    
  def process\_plate(image):  
   *"""  
   YOLO modeli ve Tesseract OCR ile plaka algılar ve giriş/çıkış işlemi yapar.  
   """* results = model.predict(source=image, save=False, save\_txt=False)  
   plates = []  
    
   for result in results:  
   for box in result.boxes:  
   x1, y1, x2, y2 = map(int, box.xyxy[0]) # Koordinatları al  
   cropped\_img = image[y1:y2, x1:x2] # Plaka bölgesini kırp  
    
   # Tesseract ile OCR işlemi yap  
   plate\_text = pytesseract.image\_to\_string(cropped\_img, config='--psm 7').strip()  
   validated\_plate = validate\_turkish\_plate(plate\_text) # Türk plakasını doğrula  
   if validated\_plate:  
   plates.append(validated\_plate)  
   handle\_vehicle\_entry\_exit(validated\_plate) # Giriş/çıkış işlemi yap  
   else:  
   print(f"Geçersiz plaka tespit edildi: {plate\_text}")  
    
   return plates  
    
  def handle\_vehicle\_entry\_exit(plate\_text):  
   *"""  
   Araç giriş/çıkış işlemini yönetir.  
   """* from database import get\_all\_parking\_logs  
    
   logs = get\_all\_parking\_logs()  
   for log in logs:  
   if log[1] == plate\_text and log[3] is None: # Çıkışı olmayan kayıt varsa  
   exit\_time = datetime.now().strftime('%Y-%m-%d %H:%M:%S')  
   fee = calculate\_fee(log[2])  
   update\_parking\_log(plate\_text, exit\_time, fee)  
   print(f"Plaka {plate\_text} çıkış yaptı. Çıkış Saati: {exit\_time}, Ücret: {fee} TL")  
   return  
    
   # Yeni giriş  
   entry\_time = datetime.now().strftime('%Y-%m-%d %H:%M:%S')  
   add\_parking\_log(plate\_text, entry\_time)  
   print(f"Plaka {plate\_text} giriş yaptı. Giriş Saati: {entry\_time}")  
    
  def calculate\_fee(entry\_time):  
   *"""  
   Araç giriş-çıkış süresine göre ücret hesaplar.  
   """* entry\_time = datetime.strptime(entry\_time, '%Y-%m-%d %H:%M:%S')  
   duration = (datetime.now() - entry\_time).total\_seconds() / 3600 # Saat cinsinden  
   return round(duration \* 10, 2) # Saatlik 10 TL ücret

**c. database.py**

**This script handles all database operations, ensuring data consistency and enabling core functionalities.**

* **Primary Functions:**
  1. **Parking Log (parking\_log):**
     + **Records detected license plate information along with vehicle entry and exit times.**
     + **Calculates parking durations and generates fees accordingly.**
  2. **Parking Status (parking\_status):**
     + **Stores sensor data transmitted by the hardware system.**
     + **Logs the status of each parking spot (occupied or vacant) along with timestamps.**
* **Purpose:  
  Integrates license plate recognition and parking space monitoring systems by recording and managing relevant data.**
* import sqlite3  
    
  def init\_db():  
   *"""  
   Veritabanını başlatır ve gerekli tabloları oluşturur.  
   """* conn = sqlite3.connect("parking\_system.db")  
   cursor = conn.cursor()  
    
   # Araç giriş/çıkış tablosu  
   cursor.execute("""  
   CREATE TABLE IF NOT EXISTS parking\_log (  
   id INTEGER PRIMARY KEY AUTOINCREMENT,  
   plate TEXT NOT NULL,  
   entry\_time TEXT NOT NULL,  
   exit\_time TEXT,  
   fee REAL  
   )  
   """)  
    
   # Park yeri durumu tablosu  
   cursor.execute("""  
   CREATE TABLE IF NOT EXISTS parking\_status (  
   id INTEGER PRIMARY KEY AUTOINCREMENT,  
   status TEXT NOT NULL,  
   timestamp TEXT NOT NULL  
   )  
   """)  
    
   conn.commit()  
   conn.close()  
    
  # ----------------- Genel Silme ve Sıfırlama ------------------  
    
  def clear\_table(table\_name):  
   *"""  
   Belirtilen tabloyu sıfırlar (tüm kayıtları siler).  
   """* conn = sqlite3.connect("parking\_system.db")  
   cursor = conn.cursor()  
    
   try:  
   cursor.execute(f"DELETE FROM {table\_name}")  
   conn.commit()  
   print(f"{table\_name} tablosu sıfırlandı.")  
   except sqlite3.OperationalError as e:  
   print(f"Hata: {e}")  
   finally:  
   conn.close()  
    
  # ----------------- Araç Kayıtları İşlemleri ------------------  
    
  def add\_parking\_log(plate, entry\_time):  
   *"""  
   Yeni bir araç giriş kaydı ekler.  
   """* conn = sqlite3.connect("parking\_system.db")  
   cursor = conn.cursor()  
    
   cursor.execute("INSERT INTO parking\_log (plate, entry\_time) VALUES (?, ?)", (plate, entry\_time))  
   conn.commit()  
   print(f"Plaka {plate} giriş kaydı eklendi.")  
   conn.close()  
    
  def update\_parking\_log(plate, exit\_time, fee):  
   *"""  
   Araç çıkış kaydını günceller.  
   """* conn = sqlite3.connect("parking\_system.db")  
   cursor = conn.cursor()  
    
   cursor.execute("""  
   UPDATE parking\_log  
   SET exit\_time = ?, fee = ?  
   WHERE plate = ? AND exit\_time IS NULL  
   """, (exit\_time, fee, plate))  
   conn.commit()  
   print(f"Plaka {plate} çıkış kaydı güncellendi.")  
   conn.close()  
    
  def delete\_parking\_log(log\_id):  
   *"""  
   Belirli bir araç kaydını siler.  
   """* conn = sqlite3.connect("parking\_system.db")  
   cursor = conn.cursor()  
    
   cursor.execute("DELETE FROM parking\_log WHERE id = ?", (log\_id,))  
   conn.commit()  
   print(f"ID {log\_id} araç kaydı silindi.")  
   conn.close()  
    
  # ----------------- Park Durumu İşlemleri ------------------  
    
  def add\_parking\_status(status, timestamp):  
   *"""  
   Yeni bir park durumu kaydı ekler.  
   """* conn = sqlite3.connect("parking\_system.db")  
   cursor = conn.cursor()  
    
   cursor.execute("INSERT INTO parking\_status (status, timestamp) VALUES (?, ?)", (status, timestamp))  
   conn.commit()  
   print(f"Park durumu ({status}) kaydı eklendi.")  
   conn.close()  
    
  def delete\_parking\_status(status\_id):  
   *"""  
   Belirli bir park durumu kaydını siler.  
   """* conn = sqlite3.connect("parking\_system.db")  
   cursor = conn.cursor()  
    
   cursor.execute("DELETE FROM parking\_status WHERE id = ?", (status\_id,))  
   conn.commit()  
   print(f"ID {status\_id} park durumu kaydı silindi.")  
   conn.close()  
    
  # ----------------- Kayıt Listeleme ------------------  
    
  def get\_all\_parking\_logs():  
   *"""  
   Tüm araç giriş/çıkış kayıtlarını döndürür.  
   """* conn = sqlite3.connect("parking\_system.db")  
   cursor = conn.cursor()  
    
   cursor.execute("SELECT \* FROM parking\_log")  
   records = cursor.fetchall()  
   conn.close()  
   return records  
    
  def get\_all\_parking\_status():  
   *"""  
   Tüm park yeri durum kayıtlarını döndürür.  
   """* conn = sqlite3.connect("parking\_system.db")  
   cursor = conn.cursor()  
    
   cursor.execute("SELECT \* FROM parking\_status")  
   records = cursor.fetchall()  
   conn.close()  
   return records

**d. tcp\_server.py**

**This script establishes a server for communication between the Arduino-based hardware system and the Python-based software system.**

* **Functionality:**
  + **Creates a TCP server that receives data from the ESP32 microcontroller.**
  + **Processes the received data and updates the database accordingly.**
* **Purpose:  
  Acts as a bridge between the hardware and software systems, enabling seamless data transmission and integration.**
* import socket  
  from database import init\_db, add\_parking\_status  
    
  def start\_tcp\_server():  
   *"""  
   TCP sunucusunu başlatır ve gelen verileri işleyerek parking\_status tablosuna kaydeder.  
   """* HOST = '192.168.2.1' # Sunucu belirtilen ağ arayüzlerinde çalışır  
   PORT = 54321 # ESP32 ile uyumlu port  
    
   # Veritabanını başlat  
   init\_db()  
    
   # Sunucu soketini oluştur-  
   server\_socket = socket.socket(socket.AF\_INET, socket.SOCK\_STREAM)  
   server\_socket.bind((HOST, PORT))  
   server\_socket.listen(5) # Maksimum 5 bağlantı kuyruğu  
    
   print(f"Sunucu {HOST}:{PORT} üzerinde çalışıyor, bağlantı bekleniyor...")  
    
   while True:  
   # Bağlantıyı kabul et  
   client\_socket, client\_address = server\_socket.accept()  
   print(f"Bağlantı kabul edildi: {client\_address}")  
    
   try:  
   # Veriyi al  
   data = client\_socket.recv(1024).decode().strip()  
   if data:  
   print(f"Gelen Veri: {data}")  
    
   # Veriyi işleyerek parking\_status tablosuna yaz  
   process\_data(data)  
   except Exception as e:  
   print(f"Veri işleme sırasında hata: {e}")  
   finally:  
   client\_socket.close()  
   print(f"Bağlantı kapatıldı: {client\_address}")  
    
  def process\_data(data):  
   *"""  
   Gelen veriyi ayıklar ve veritabanına kaydeder.  
   """* try:  
   # Veriyi ayrıştır  
   # Örnek veri: "Park Yeri: Dolu, Tarih: 18/12/2024, Saat: 14:30:15"  
   parts = data.split(", ")  
   status = parts[0].split(": ")[1]  
   date = parts[1].split(": ")[1]  
   time = parts[2].split(": ")[1]  
    
   # Zaman damgasını oluştur  
   timestamp = f"{date} {time}"  
    
   # Veriyi veritabanına yaz  
   add\_parking\_status(status, timestamp)  
   print(f"Park durumu kaydedildi: {status}, Zaman Damgası: {timestamp}")  
   except Exception as e:  
   print(f"Veriyi işlerken hata oluştu: {e}")  
    
  if \_\_name\_\_ == "\_\_main\_\_":  
   start\_tcp\_server()

**e. parking\_lot\_visualization.py**

**This script creates a virtual representation of the parking lot and dynamically updates its status.**

* **Functionality:**
  + **Generates a graphical interface that visualizes the parking lot in real time.**
  + **Updates parking spot statuses (occupied or vacant) based on data from the database.**
* **Purpose:  
  Provides an intuitive and user-friendly visualization of the parking lot, making it easier to track occupancy in real time.**
* import pygame  
  import socket  
  import threading  
  import time  
  from datetime import datetime  
  import sqlite3  
    
  # Pygame başlatma  
  pygame.init()  
    
  # Ekran boyutları  
  WINDOW\_WIDTH = 800  
  WINDOW\_HEIGHT = 600  
  screen = pygame.display.set\_mode((WINDOW\_WIDTH, WINDOW\_HEIGHT))  
  pygame.display.set\_caption("Akıllı Otopark Sistemi")  
    
  # Renkler  
  WHITE = (255, 255, 255)  
  BLACK = (0, 0, 0)  
  RED = (255, 0, 0)  
  GREEN = (0, 255, 0)  
  BLUE = (0, 0, 255)  
  GRAY = (200, 200, 200)  
    
    
  def get\_latest\_status():  
   *"""Veritabanından en son park yeri durumunu alır"""* try:  
   conn = sqlite3.connect('parking\_system.db') # Veritabanı adı güncellendi  
   cursor = conn.cursor()  
   cursor.execute("""  
   SELECT status FROM parking\_status   
   ORDER BY timestamp DESC   
   LIMIT 1  
   """)  
   result = cursor.fetchone()  
   conn.close()  
    
   if result:  
   return result[0] == "Dolu"  
   return False  
   except Exception as e:  
   print(f"Veritabanı okuma hatası: {e}")  
   return False  
    
    
  class ParkingLot:  
   def \_\_init\_\_(self):  
   self.spaces = {i: False for i in range(1, 11)} # False = Boş, True = Dolu  
   # 2-10 arası rastgele dolu/boş durumları  
   for i in range(2, 11):  
   self.spaces[i] = bool(int(time.time() \* i) % 2) # Rastgele ama sabit durumlar  
    
   # İlk başlatmada veritabanından son durumu al  
   self.spaces[1] = get\_latest\_status()  
    
   self.font = pygame.font.Font(None, 36)  
   self.small\_font = pygame.font.Font(None, 24)  
    
   # Veritabanı güncelleme thread'ini başlat  
   self.update\_thread = threading.Thread(target=self.database\_update\_loop)  
   self.update\_thread.daemon = True  
   self.update\_thread.start()  
    
   def database\_update\_loop(self):  
   *"""Veritabanını periyodik olarak kontrol eder ve görselleştirmeyi günceller"""* while True:  
   try:  
   current\_status = get\_latest\_status()  
   self.spaces[1] = current\_status  
   except Exception as e:  
   print(f"Güncelleme hatası: {e}")  
   time.sleep(1) # Her saniye kontrol et  
    
   def draw(self, screen):  
   # Başlık  
   title = self.font.render("Akıllı Otopark Sistemi", True, BLACK)  
   screen.blit(title, (WINDOW\_WIDTH // 2 - title.get\_width() // 2, 20))  
    
   # Park yerlerini çiz  
   space\_width = 120  
   space\_height = 150  
   spaces\_per\_row = 5  
   start\_x = (WINDOW\_WIDTH - (spaces\_per\_row \* space\_width)) // 2  
   start\_y = 100  
    
   for i in range(1, 11):  
   row = (i - 1) // spaces\_per\_row  
   col = (i - 1) % spaces\_per\_row  
   x = start\_x + (col \* space\_width)  
   y = start\_y + (row \* space\_height)  
    
   # Park yeri dikdörtgeni  
   color = RED if self.spaces[i] else GREEN  
   pygame.draw.rect(screen, color, (x, y, space\_width - 10, space\_height - 10))  
    
   # Park yeri ID  
   id\_text = self.font.render(str(i), True, WHITE)  
   screen.blit(id\_text, (x + 10, y + 10))  
    
   # Durum metni  
   status = "DOLU" if self.spaces[i] else "BOŞ"  
   status\_text = self.font.render(status, True, WHITE)  
   screen.blit(status\_text, (x + 10, y + space\_height - 40))  
    
   # Sensör işareti (sadece 1 numaralı park yeri için)  
   if i == 1:  
   pygame.draw.rect(screen, BLUE, (x, y, space\_width - 10, space\_height - 10), 3)  
   sensor\_text = self.small\_font.render("Sensörlü", True, BLACK)  
   screen.blit(sensor\_text, (x + 10, y + space\_height - 70))  
    
   # Son güncelleme zamanını göster  
   try:  
   conn = sqlite3.connect('parking\_system.db') # Veritabanı adı güncellendi  
   cursor = conn.cursor()  
   cursor.execute("SELECT timestamp FROM parking\_status ORDER BY timestamp DESC LIMIT 1")  
   last\_update = cursor.fetchone()  
   conn.close()  
   if last\_update:  
   update\_text = self.small\_font.render(f"Son: {last\_update[0]}", True, BLACK)  
   screen.blit(update\_text, (x + 10, y + space\_height - 90))  
   except Exception as e:  
   print(f"Zaman bilgisi alınamadı: {e}")  
    
   # Lejant  
   legend\_y = start\_y + (2 \* space\_height) + 20  
   pygame.draw.rect(screen, GREEN, (start\_x, legend\_y, 20, 20))  
   boş\_text = self.small\_font.render("BOŞ", True, BLACK)  
   screen.blit(boş\_text, (start\_x + 30, legend\_y))  
    
   pygame.draw.rect(screen, RED, (start\_x + 100, legend\_y, 20, 20))  
   dolu\_text = self.small\_font.render("DOLU", True, BLACK)  
   screen.blit(dolu\_text, (start\_x + 130, legend\_y))  
    
   pygame.draw.rect(screen, WHITE, (start\_x + 200, legend\_y, 20, 20))  
   pygame.draw.rect(screen, BLUE, (start\_x + 200, legend\_y, 20, 20), 3)  
   sensor\_text = self.small\_font.render("Sensörlü Park Yeri", True, BLACK)  
   screen.blit(sensor\_text, (start\_x + 230, legend\_y))  
    
    
  def main():  
   parking\_lot = ParkingLot()  
   running = True  
   clock = pygame.time.Clock()  
    
   while running:  
   for event in pygame.event.get():  
   if event.type == pygame.QUIT:  
   running = False  
    
   # Ekranı temizle  
   screen.fill(WHITE)  
    
   # Park yerlerini çiz  
   parking\_lot.draw(screen)  
    
   # Ekranı güncelle  
   pygame.display.flip()  
    
   # FPS sınırı  
   clock.tick(30)  
    
   pygame.quit()  
    
    
  if \_\_name\_\_ == "\_\_main\_\_":  
   main()

**f. database-management.py**

**This script allows for manual management of the database, enabling users to correct errors or make specific adjustments as needed.**

* **Functions:**
  + **Manual Data Editing:**
    - **Vehicle entry and exit times can be manually reviewed and modified if necessary.**
    - **Parking space occupancy statuses (occupied/vacant) can also be manually updated.**
  + **Database Reset:**
    - **The entire database can be securely cleared and reset to its default state.**
  + **Manual Vehicle Addition/Removal:**
    - **New vehicle entries can be added manually, or unnecessary records can be deleted.**
* **Purpose:  
  This script provides flexibility to manage and correct errors in the system. It is especially useful for handling incorrect data, managing special scenarios, or securely resetting the database. Additionally, it allows for manual modifications to ensure the system operates as intended.**
* from database import (  
   init\_db, clear\_table, add\_parking\_log, update\_parking\_log,  
   add\_parking\_status, delete\_parking\_log, delete\_parking\_status,  
   get\_all\_parking\_logs, get\_all\_parking\_status  
  )  
    
  def yönetim\_menüsü():  
   *"""  
   Veritabanı yönetim menüsü (Türkçe).  
   """* while True:  
   print("\n--- Veritabanı Yönetim Menüsü ---")  
   print("1. Araç Kayıtlarını Yönet")  
   print("2. Park Durumlarını Yönet")  
   print("3. Kayıtları Listele")  
   print("4. Veritabanını Sıfırla")  
   print("5. Çıkış")  
   seçim = input("Seçiminiz: ")  
    
   if seçim == "1":  
   araç\_kayıt\_menüsü()  
   elif seçim == "2":  
   park\_durumu\_menüsü()  
   elif seçim == "3":  
   kayıtları\_listele()  
   elif seçim == "4":  
   tablo\_adı = input("Sıfırlanacak tablo (parking\_log / parking\_status): ")  
   clear\_table(tablo\_adı)  
   elif seçim == "5":  
   print("Çıkış yapılıyor...")  
   break  
   else:  
   print("Geçersiz seçim! Lütfen tekrar deneyin.")  
    
  def araç\_kayıt\_menüsü():  
   *"""  
   Araç kayıtlarını yönetme menüsü.  
   """* while True:  
   print("\n--- Araç Kayıtları Yönetim Menüsü ---")  
   print("1. Yeni Araç Girişi Ekle")  
   print("2. Araç Çıkışı Yap (ID ile)")  
   print("3. Araç Kaydı Sil")  
   print("4. Geri Dön")  
   seçim = input("Seçiminiz: ")  
    
   if seçim == "1":  
   plaka = input("Plaka: ")  
   giriş\_saati = input("Giriş Saati (YYYY-MM-DD HH:MM:SS): ")  
   add\_parking\_log(plaka, giriş\_saati)  
   elif seçim == "2":  
   kayıt\_id = input("Çıkış işlemi yapılacak kayıt ID'si: ")  
   try:  
   logs = get\_all\_parking\_logs()  
   for log in logs:  
   if str(log[0]) == kayıt\_id and log[3] is None: # ID eşleşiyor ve çıkış yapılmamış  
   giriş\_saati = log[2]  
   çıkış\_saati = input("Çıkış Saati (YYYY-MM-DD HH:MM:SS): ")  
   duration = calculate\_duration(giriş\_saati, çıkış\_saati)  
   ücret = calculate\_fee(duration)  
   update\_parking\_log(log[1], çıkış\_saati, ücret) # Plaka ile çıkış güncellenir  
   print(f"ID {kayıt\_id} için çıkış işlemi tamamlandı. Ücret: {ücret} TL")  
   break  
   else:  
   print("Belirtilen ID'ye ait açık bir giriş kaydı bulunamadı.")  
   except Exception as e:  
   print(f"Hata: {e}")  
   elif seçim == "3":  
   kayıt\_id = input("Silinecek kayıt ID'si: ")  
   delete\_parking\_log(kayıt\_id)  
   elif seçim == "4":  
   break  
   else:  
   print("Geçersiz seçim! Lütfen tekrar deneyin.")  
    
  def park\_durumu\_menüsü():  
   *"""  
   Park durumlarını yönetme menüsü.  
   """* while True:  
   print("\n--- Park Durumları Yönetim Menüsü ---")  
   print("1. Yeni Durum Kaydı Ekle (Dolu/Boş)")  
   print("2. Durum Kaydını Sil")  
   print("3. Geri Dön")  
   seçim = input("Seçiminiz: ")  
    
   if seçim == "1":  
   durum = input("Durum (Dolu/Boş): ")  
   zaman\_damgası = input("Zaman Damgası (YYYY-MM-DD HH:MM:SS): ")  
   add\_parking\_status(durum, zaman\_damgası)  
   elif seçim == "2":  
   kayıt\_id = input("Silinecek kayıt ID'si: ")  
   delete\_parking\_status(kayıt\_id)  
   elif seçim == "3":  
   break  
   else:  
   print("Geçersiz seçim! Lütfen tekrar deneyin.")  
    
  def kayıtları\_listele():  
   *"""  
   Tüm kayıtları listeler.  
   """* print("\n--- Araç Kayıtları ---")  
   logs = get\_all\_parking\_logs()  
   if logs:  
   for log in logs:  
   print(log)  
   else:  
   print("Hiç araç kaydı bulunamadı.")  
    
   print("\n--- Park Durumları ---")  
   statuses = get\_all\_parking\_status()  
   if statuses:  
   for status in statuses:  
   print(status)  
   else:  
   print("Hiç park durumu kaydı bulunamadı.")  
    
  def calculate\_duration(entry\_time, exit\_time):  
   *"""  
   Giriş ve çıkış zamanı arasındaki süreyi hesaplar.  
   """* from datetime import datetime  
   fmt = "%Y-%m-%d %H:%M:%S"  
   entry\_time = datetime.strptime(entry\_time, fmt)  
   exit\_time = datetime.strptime(exit\_time, fmt)  
   return (exit\_time - entry\_time).total\_seconds() / 3600 # Saat cinsinden süre  
    
  def calculate\_fee(duration):  
   *"""  
   Süreye göre ücreti hesaplar.  
   """* return round(duration \* 10, 2) # Saatlik ücret: 10 TL  
    
  if \_\_name\_\_ == "\_\_main\_\_":  
   init\_db()  
   yönetim\_menüsü()
  1. **Arduino Codes**

**a. esp32-cam.ino**

**This Arduino script configures and initializes the ESP32-CAM module.**

* **Functionality:**
  + **Sets up image clarity and resolution parameters.**
  + **Establishes the server required for the ESP32-CAM to operate.**
* **Purpose:  
  Ensures the ESP32-CAM module is correctly initialized and ready to capture and transmit images.**
* #include "esp\_camera.h"
* #include <WiFi.h>
* #include <WebServer.h>
* // Wi-Fi bilgileri
* const char\* ssid = "Redmi Note 11 Pro";
* const char\* password = "0123456789";
* // Kamera yapılandırma
* #define PWDN\_GPIO\_NUM     32
* #define RESET\_GPIO\_NUM    -1
* #define XCLK\_GPIO\_NUM      0
* #define SIOD\_GPIO\_NUM     26
* #define SIOC\_GPIO\_NUM     27
* #define Y9\_GPIO\_NUM       35
* #define Y8\_GPIO\_NUM       34
* #define Y7\_GPIO\_NUM       39
* #define Y6\_GPIO\_NUM       36
* #define Y5\_GPIO\_NUM       21
* #define Y4\_GPIO\_NUM       19
* #define Y3\_GPIO\_NUM       18
* #define Y2\_GPIO\_NUM        5
* #define VSYNC\_GPIO\_NUM    25
* #define HREF\_GPIO\_NUM     23
* #define PCLK\_GPIO\_NUM     22
* // HTTP sunucusu
* WebServer server(80);
* // Kamera akış fonksiyonu
* void handleStream() {
* WiFiClient client = server.client();
* String response = "HTTP/1.1 200 OK\r\n"
* "Content-Type: multipart/x-mixed-replace; boundary=frame\r\n\r\n";
* client.write(response.c\_str(), response.length());
* while (true) {
* camera\_fb\_t \*fb = esp\_camera\_fb\_get(); // Kamera çerçevesini al
* if (!fb) {
* Serial.println("Kamera çerçevesi alınamadı.");
* break;
* }
* // JPEG format kontrolü
* if (fb->format == PIXFORMAT\_JPEG) {
* String part = "--frame\r\n"
* "Content-Type: image/jpeg\r\n"
* "Content-Length: " + String(fb->len) + "\r\n\r\n";
* client.write(part.c\_str(), part.length());
* client.write(fb->buf, fb->len);
* client.write("\r\n");
* }
* esp\_camera\_fb\_return(fb); // Çerçeve belleğini serbest bırak
* // İstemcinin bağlantısını kontrol et
* if (!client.connected()) {
* break;
* }
* }
* }
* // Ana sayfa yönlendirme
* void handleRoot() {
* String html = "<html><body>";
* html += "<h1>ESP32-CAM Canlı Görüntü</h1>";
* html += "<p><a href=\"/stream\">Canlı Görüntüyü İzle</a></p>";
* html += "</body></html>";
* server.send(200, "text/html", html);
* }
* void setup() {
* Serial.begin(115200);
* Serial.println();
* // Kamera yapılandırması
* camera\_config\_t config;
* config.ledc\_channel = LEDC\_CHANNEL\_0;
* config.ledc\_timer = LEDC\_TIMER\_0;
* config.pin\_d0 = Y2\_GPIO\_NUM;
* config.pin\_d1 = Y3\_GPIO\_NUM;
* config.pin\_d2 = Y4\_GPIO\_NUM;
* config.pin\_d3 = Y5\_GPIO\_NUM;
* config.pin\_d4 = Y6\_GPIO\_NUM;
* config.pin\_d5 = Y7\_GPIO\_NUM;
* config.pin\_d6 = Y8\_GPIO\_NUM;
* config.pin\_d7 = Y9\_GPIO\_NUM;
* config.pin\_xclk = XCLK\_GPIO\_NUM;
* config.pin\_pclk = PCLK\_GPIO\_NUM;
* config.pin\_vsync = VSYNC\_GPIO\_NUM;
* config.pin\_href = HREF\_GPIO\_NUM;
* config.pin\_sscb\_sda = SIOD\_GPIO\_NUM;
* config.pin\_sscb\_scl = SIOC\_GPIO\_NUM;
* config.pin\_pwdn = PWDN\_GPIO\_NUM;
* config.pin\_reset = RESET\_GPIO\_NUM;
* config.xclk\_freq\_hz = 20000000;
* config.pixel\_format = PIXFORMAT\_JPEG;
* config.frame\_size = FRAMESIZE\_SVGA;
* config.jpeg\_quality = 12;
* config.fb\_count = 2;
* // Kamera başlatma
* if (esp\_camera\_init(&config) != ESP\_OK) {
* Serial.println("Kamera başlatılamadı.");
* return;
* }
* // Wi-Fi bağlantısı
* WiFi.begin(ssid, password);
* while (WiFi.status() != WL\_CONNECTED) {
* delay(500);
* Serial.print(".");
* }
* Serial.println("\nWiFi bağlantısı tamamlandı.");
* Serial.print("ESP32-CAM URL: http://");
* Serial.println(WiFi.localIP());
* // Web server rotaları
* server.on("/", handleRoot);
* server.on("/stream", handleStream);
* server.begin();
* Serial.println("Web sunucusu başlatıldı.");
* }
* void loop() {
* server.handleClient();
* }

**b. esp32-wroom-da-model.ino**

**This script is for the ESP32-based hardware system that manages parking spot detection.**

* **Functionality:**
  + **Motion Detection:**
    - **Activates the ultrasonic sensor when the PIR sensor detects motion.**
  + **Distance Measurement:**
    - **Determines whether a parking spot is occupied or vacant based on the measured distance.**
    - **Distance < 165 cm: Occupied.**
    - **Distance ≥ 165 cm: Vacant.**
  + **Data Transmission:**
    - **Sends occupancy data along with the timestamp (from the RTC module) to the server.**
    - **Updates the database with the parking status.**
  + **LED Indicators:**
    - **Lights up the green LED for vacant spots.**
    - **Lights up the red LED for occupied spots.**
* **Purpose:  
  Provides real-time parking spot monitoring and communicates the status to the database while offering immediate visual feedback through LEDs.**
* #include <WiFi.h>
* #include <Wire.h>
* #include "RTClib.h"
* RTC\_DS3231 rtc;
* // Sensör ve LED pinleri
* const int trigPin = 16;
* const int echoPin = 4;
* const int ledRed = 26;
* const int ledGreen = 27;
* const int pirPin = 14; // PIR sensör pin
* // WiFi bilgileri
* const char\* ssid = "SUPERONLINE\_Wi-Fi\_1388";
* const char\* password = "3yDutU64TFFE";
* // TCP sunucu bilgileri
* const char\* serverIP = "192.168.1.12";
* const uint16\_t serverPort = 12345;
* WiFiClient client;
* const float thresholdLower = 60.0; // "Dolu" için alt eşik (cm)
* const float thresholdUpper = 75.0; // "Boş" için üst eşik (cm)
* bool lastStatus = false; // Önceki durum (false: boş, true: dolu)
* unsigned long lastSendTime = 0; // Son veri gönderim zamanı
* const unsigned long sendInterval = 30000; // 30 saniye minimum gönderim süresi
* void setup() {
* Serial.begin(115200);
* pinMode(trigPin, OUTPUT);
* pinMode(echoPin, INPUT);
* pinMode(ledRed, OUTPUT);
* pinMode(ledGreen, OUTPUT);
* pinMode(pirPin, INPUT);
* // RTC başlatma
* if (!rtc.begin()) {
* Serial.println("RTC modülü bulunamadı!");
* while (1);
* }
* if (rtc.lostPower()) {
* Serial.println("RTC saati doğru değil, bilgisayar saatine göre ayarlanıyor...");
* rtc.adjust(DateTime(F(\_\_DATE\_\_), F(\_\_TIME\_\_)));
* }
* // WiFi bağlantısı
* connectToWiFi();
* // TCP sunucu bağlantısı
* connectToServer();
* }
* void connectToWiFi() {
* Serial.println("WiFi'ye bağlanılıyor...");
* WiFi.begin(ssid, password);
* while (WiFi.status() != WL\_CONNECTED) {
* delay(1000);
* Serial.print(".");
* }
* Serial.println("\nWiFi bağlantısı başarılı!");
* }
* void connectToServer() {
* Serial.println("TCP sunucusuna bağlanılıyor...");
* while (!client.connect(serverIP, serverPort)) {
* Serial.println("Sunucuya bağlanılamadı, yeniden deneniyor...");
* delay(2000);
* }
* Serial.println("Sunucuya bağlanıldı!");
* }
* float measureDistance() {
* digitalWrite(trigPin, LOW);
* delayMicroseconds(2);
* digitalWrite(trigPin, HIGH);
* delayMicroseconds(10);
* digitalWrite(trigPin, LOW);
* long duration = pulseIn(echoPin, HIGH);
* return duration \* 0.034 / 2; // cm cinsinden mesafe
* }
* float getAverageDistance(int numMeasurements) {
* float total = 0;
* int validReadings = 0;
* for (int i = 0; i < numMeasurements; i++) {
* float distance = measureDistance();
* if (distance > 2 && distance < 400) { // Geçerli mesafeler
* total += distance;
* validReadings++;
* }
* delay(50); // Ölçümler arasında küçük bir bekleme
* }
* return validReadings > 0 ? total / validReadings : -1; // Geçerli ölçüm yoksa -1 döner
* }
* bool determineParkingStatus(float distance) {
* if (lastStatus && distance > thresholdUpper) {
* return false; // Boş
* } else if (!lastStatus && distance < thresholdLower) {
* return true; // Dolu
* }
* return lastStatus; // Durumu koru
* }
* void loop() {
* int pirValue = digitalRead(pirPin);
* if (pirValue == HIGH) { // Hareket algılandıysa ultrasonik sensör devreye girer
* Serial.println("Hareket algılandı. Ultrasonik sensör aktif...");
* float avgDistance = getAverageDistance(5); // 5 ölçümün ortalamasını al
* Serial.print("Ölçülen Mesafe: ");
* Serial.print(avgDistance);
* Serial.println(" cm");
* if (avgDistance == -1) {
* Serial.println("Geçersiz mesafe ölçümü.");
* return; // Geçersiz ölçüm, devam etme
* }
* bool currentStatus = determineParkingStatus(avgDistance);
* // Durum değişikliği veya belirli bir süre geçtiyse işlem yap
* if (currentStatus != lastStatus || (millis() - lastSendTime >= sendInterval)) {
* lastStatus = currentStatus;
* lastSendTime = millis();
* // LED durumunu değiştir
* digitalWrite(ledRed, currentStatus ? HIGH : LOW);
* digitalWrite(ledGreen, currentStatus ? LOW : HIGH);
* // Mesaj oluştur
* DateTime now = rtc.now();
* String statusMessage = String("Park Yeri: ") + (currentStatus ? "Dolu" : "Boş") +
* ", Tarih: " + String(now.day()) + "/" + String(now.month()) + "/" + String(now.year()) +
* ", Saat: " + String(now.hour()) + ":" + String(now.minute()) + ":" + String(now.second());
* Serial.println("Gönderilen Mesaj: " + statusMessage);
* // Sunucuya mesaj gönder
* if (!client.connected()) {
* connectToServer(); // Bağlantı kopmuşsa yeniden bağlan
* }
* if (client.connected()) {
* client.println(statusMessage);
* Serial.println("Mesaj sunucuya gönderildi.");
* } else {
* Serial.println("Sunucu bağlantısı başarısız.");
* }
* }
* } else {
* Serial.println("Hareket algılanmadı. Ultrasonik sensör beklemede...");
* delay(500); // PIR sensör tekrar kontrol edilecek
* }
* }

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**APPENDIX**

**A.1. AI Model and License Plate Recognition System**

**Data Preparation:**

* **Dataset:** Over 10,000 images were labeled using Roboflow.
* **Dataset Split:** 80% training, 10% validation, 10% testing.
* **Label Format:** Pascal VOC.

**Model Training:**

* **Algorithm:** YOLOv11n (You Only Look Once).
* **Training Parameters:**
  + GPU: NVIDIA RTX 4060
  + Epochs: 100
  + Batch Size: 16
  + Learning Rate: 0.001

**License Plate Reading:**

* **OCR Tool:** Tesseract with the following configurations:
  + psm: 8 (Single line of text).
  + Language: English.

**Performance Metrics:**

* **Accuracy:** 96% on the test set.
* **Error Cases:** OCR struggled with misreads on older or heavily damaged license plates.

**A.2. Parking Occupancy Detection System**

**Hardware Components:**

* **ESP32:** Central microcontroller for data collection and communication.
* **PIR Sensor:** Motion detection (Model: HC-SR501).
* **Ultrasonic Sensor:** Distance measurement (Model: HC-SR04).
* **RTC Module:** Provides real-time clock functionality (Model: DS3231).
* **LED Indicators:** Green (vacant) and Red (occupied).

**Working Principle:**

1. The PIR sensor detects motion near a parking space.
2. The ultrasonic sensor measures the distance:
   * **Occupied:** Distance < 165 cm.
   * **Vacant:** Distance ≥ 165 cm.
3. The status is sent to the database and displayed via LEDs.

**A.3. Database Design and Integration**

**Database Schema:**

* **Table 1: Vehicle Records**
  + id: Primary key.
  + plate: License plate (VARCHAR(15)).
  + entry\_time: Entry timestamp (DATETIME).
  + exit\_time: Exit timestamp (DATETIME).
  + fee: Calculated fee (FLOAT).
* **Table 2: Parking Space Status**
  + id: Primary key.
  + spot\_id: Parking spot ID (INT).
  + status: Occupancy status (BOOLEAN).
  + last\_update: Timestamp of last status update (DATETIME).

**A.4. Virtual Map and Visualization**

**Map Visualization:**

* Real-time parking lot occupancy is displayed on a dynamic map.
* **Visualization Tool:** Python Matplotlib.
* **Features:** Updates every second based on sensor data, showing occupied (red) and vacant (green) spots.

**A.5. PCB Design and Assembly**

**Design Tools:**

* **Circuit Design:** Fritzing.
* **PCB Production:** Single-layer compact design for hardware integration.

**Component Layout:**

1. ESP32 microcontroller.
2. Inputs for PIR and Ultrasonic sensors.
3. Connections for LEDs and RTC module.

**A.6. Performance Evaluation**

**Key Metrics:**

* **License Plate Recognition Accuracy:** 96%.
* **Parking Occupancy Detection Accuracy:** 95%.
* **Real-Time Updates:** Average delay of 1 second.

**Observations:**

* System performs well under standard conditions.
* Challenges include OCR performance on damaged plates and environmental factors affecting sensors.