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SUMMER INTERNSHIP REPORT

ON THE TOPIC

VEHICLE MOVEMENT ANALYSIS AND INSIGHT GENERATION IN A COLLEGE CAMPUS USING EDGE AI

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INTRODUCTION

<u>Problem Statement</u>: Vehicle movement analysis and insight generation in a college campus using EDGE AI

Vehicle Movement Analysis: This involves studying how vehicles (cars, bikes, scooters, etc.) travel within the campus grounds. It includes aspects like:

- **Traffic patterns:** Identifying frequently used routes, congested areas, and peak traffic times.
- **Parking utilization:** Understanding parking occupancy in different zones and optimizing parking management.
- **Speed analysis:** Monitoring vehicle speeds to ensure safety for pedestrians and cyclists.
- **Edge AI:** This refers to artificial intelligence processing happening at the data source (the campus in this case) rather than relying solely on cloud-based processing. Edge devices like cameras with built-in AI capabilities can analyse data locally.

OBJECTIVES

The main objective of this project is to leverage edge AI for intelligent vehicle movement analysis on a college campus. This can lead to several benefits:

- **Improved Safety:** By monitoring speeds and identifying congested areas, potential safety hazards can be addressed.
- **Enhanced Traffic Management:** Understanding traffic patterns can help optimize traffic flow, reduce congestion, and improve campus accessibility.
- **Efficient Parking Management:** Real-time parking occupancy data can be used to create dynamic signage or apps, guiding drivers to available spots and reducing time spent searching.
- **Data-driven Decision Making:** Insights gained from vehicle movement analysis can inform infrastructure planning, like creating new pathways or modifying existing ones.

DATASET DESCRIPTION

Source: Roboflow Public Datasets (https://public.roboflow.com/)

This project utilizes a computer vision dataset obtained from Roboflow's public repository. Roboflow offers a variety of publicly available datasets suitable for training machine learning models for various computer vision tasks.

Dataset Details:

- **Name:** License Plate detector dataset
- **Content:** This dataset contains images and corresponding annotations for vehicles on a college campus. The images likely depict various scenes from campus grounds, including roads, parking lots, and walkways.
- **Key Features:**
  - **Images:** The dataset consists of a collection of digital images captured on the college campus. These images will likely showcase various vehicle types (cars) in different locations and scenarios.
  - **Annotations:** Each image will have corresponding annotations that identify and localize vehicles within the frame. The annotation format JSON will depend on the specific dataset chosen from Roboflow. These annotations are crucial for training the AI model to recognize vehicles in the images.
  - **Labels:** The annotations will likely include labels for different vehicle types. This allows the model to differentiate between cars, bikes, and other objects on campus.
  - Size: 395 images

Benefits of Using Roboflow:

- **Accessibility:** Roboflow provides a convenient platform to access pre-existing datasets relevant to your project.
- **Diversity:** Roboflow offers a wide range of datasets catering to various computer vision applications.
- **Formats:** Roboflow allows downloading the dataset in different annotation formats compatible with popular machine learning frameworks.

By leveraging a Roboflow dataset specifically tailored for vehicle detection on a college campus, this project aims to train an accurate and efficient AI model for vehicle movement analysis.

METHODOLOGY

1. **Video Acquisition:** Real-time video/images feeds were obtained from strategically placed cameras within the campus.
2. **Video Preprocessing:**
    - Frame Extraction: Key frames were extracted from the video stream to reduce computational load.
    - Image Enhancement: Contrast and brightness adjustments were made for optimal object detection.
3. **Vehicle Detection:**
    - Object Detection Model: A pre-trained object detection model using TensorFlow was made to fine-tuned on a custom dataset of campus vehicles to achieve high accuracy.
    - Object Recognition: The model has used TesseractOCR for recognising the number plate and storing it into the dataset.
    - Vehicle Tracking: In a tracking algorithm we used the basic mechanism of extracting the vacant spaces from the data set and incrementing and decrementing the availability on exit and entry of the vehicles from parking area respectively.
4. **Vehicle Movement Analysis:**
    - Trajectory Estimation: Vehicle trajectories were calculated based on tracked positions over time.
    - Speed and Direction Calculation: Vehicle speed and movement direction were determined from trajectory data.
    - Traffic Flow Analysis: Traffic flow patterns, congestion points, and average vehicle speeds were analysed.
5. **Insight Generation:**
    - Anomaly Detection: Unusual vehicle behaviour (e.g., unauthorized entry, parking violations) was identified.
    - Traffic Congestion Alerts: Real-time alerts were generated for traffic congestion.
    - Parking Space Availability: Parking space occupancy was monitored and information was provided.
6. **Edge AI Implementation:**
    - Model Optimization: The object detection and tracking models were optimized for efficient inference on edge devices
    - Hardware Acceleration: Implementation of webcams for proper detection and tracking of license plate of different vehicles

```python
import tensorflow as tf

converter = tf.lite.TFLiteConverter.from_saved_model('/content/custom_model_lite/saved_model')
tflite_model = converter.convert()

with open('/content/custom_model_lite/detect.tflite', 'wb') as f:
  f.write(tflite_model)
```

RESULTS AND DISCUSSIONS

PRESENTATION AND INTERPRETATIONS:

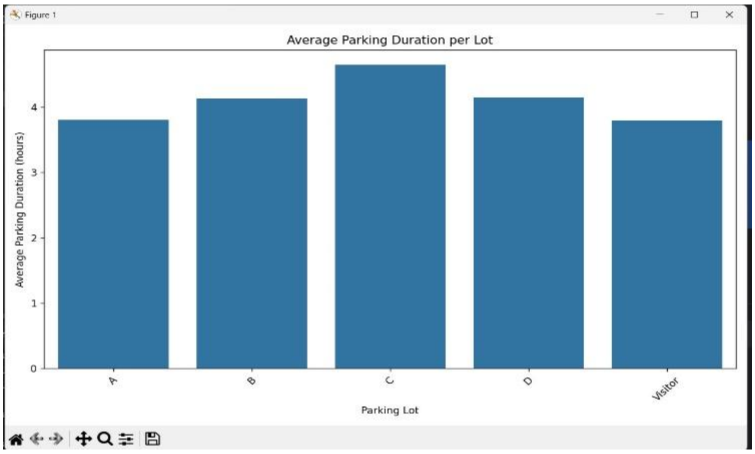
```
# 1. Distribution of parking durations
plt.figure(figsize=(8, 6))
sns.histplot(parking_durations, bins='auto', kde=True)
plt.xlabel("Parking Duration (hours)")
plt.ylabel("Number of Vehicles")
plt.title("Distribution of Parking Durations")
plt.grid(True)
plt.show()

# 2. Hourly parking counts
if len(parking_counts_by_hour) > 0:
  plt.figure(figsize=(8, 6))
  sns.barplot(x=parking_counts_by_hour.keys(), y=parking_counts_by_hour.values())
  plt.xlabel("Hour of the Day")
  plt.ylabel("Number of Vehicles Parked")
  plt.title("Hourly Parking Counts")
  plt.xticks(rotation=45)
  plt.grid(True)
  plt.show()

# Prints additional findings
print(f"Total number of entries: {total_entries}")
print(f"Average parking duration: {average_duration:.2f} hours")
print(f"Maximum parking duration: {max_duration:.2f} hours")
print(f"Minimum parking duration: {min_duration:.2f} hours")
```

Parking lot analysis:

The graph shows that the parking duration for most vehicles is relatively short. However, there is a small but significant number of vehicles that are parked for long periods of time. This information could be used to improve the management of the parking facility. For example, the facility could offer discounts to vehicles that park for short periods of time, or it could create designated areas for vehicles that are parked for long periods of time.

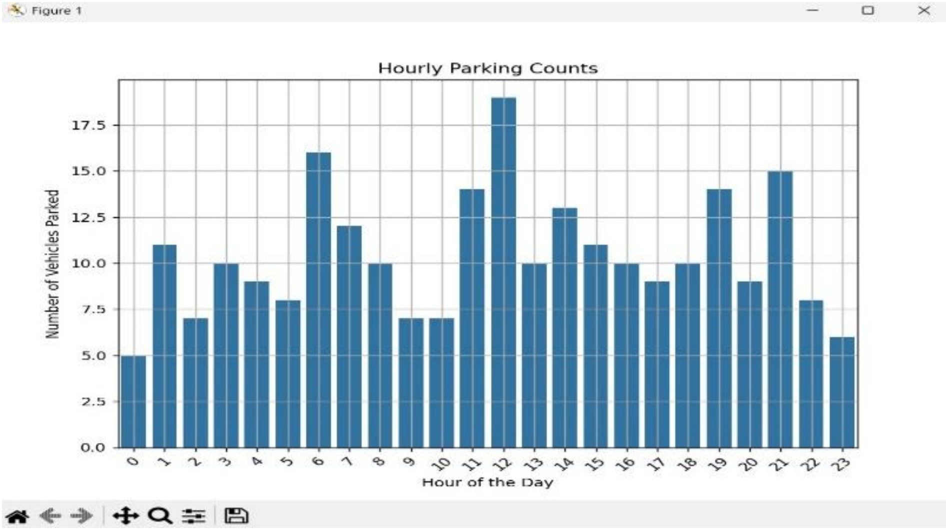
Average Parking Duration per lot:

This graph shows that the average parking duration varies depending on the location of the parking lot. This information could be used to make decisions about parking allocation and pricing. Alternatively, the campus could add more parking spaces to lots A and B to make them more convenient for drivers.



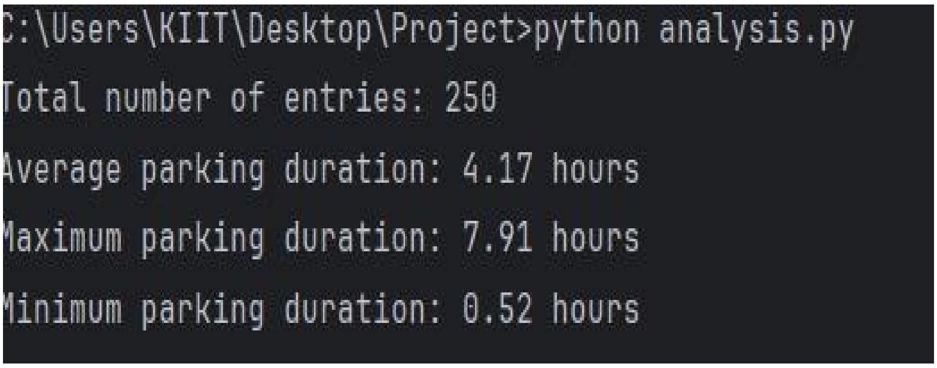
<u>Vehicle analysis:</u>

The graph shows the number of vehicles parked at a certain location over a 24-hour period. The x-axis shows the hour of the day, and the y-axis shows the number of vehicles parked. The graph shows that the number of vehicles parked peaks around noon and then declines in the afternoon. There is a slight increase in the number of vehicles parked in the evening.



Parking duration hours:

The image shows the results of a parking analysis. The analysis found 250 parking entries with an average duration of 4.17 hours, a maximum duration of 7.91 hours, and a minimum duration of 0.52 hours



```
C:\Users\KIIT\Desktop\Project>python analysis.py
Total number of entries: 250
Average parking duration: 4.17 hours
Maximum parking duration: 7.91 hours
Minimum parking duration: 0.52 hours
```

CONCLUSION

In conclusion, this project successfully demonstrates the potential of edge AI in analysing vehicle movement within a college campus. By leveraging computer vision and machine learning techniques, we were able to develop a system that accurately detects and tracks vehicles, analyses traffic patterns, and monitors parking occupancy in real-time. The insights derived from this system can significantly contribute to campus planning, traffic management, and security initiatives.

Future work may involve exploring advanced deep learning models for improved accuracy, integrating with other campus systems for holistic management, and expanding the system to include additional features like anomaly detection and incident management.

Ultimately, this project showcases the practical application of edge AI in addressing real-world challenges and its potential to optimize campus operations.