ANP - ANP-D0449

DATA ANALYSIS USING PYTHON

PARKING SPACE UTILIZATION IN URBAN AREAS

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ABSTRACT:

Urban parking management has become an increasingly critical issue as cities grow and the number of vehicles on the road continues to rise. Efficient utilization of parking spaces can significantly reduce congestion, improve traffic flow, and enhance user experience.

This project aims to analyze the utilization of parking spaces within a parking facility using data from entry and exit logs, focusing on the calculation of parking durations, identification of peak parking hours, and assessment of parking spot utilization.

The dataset consists of vehicle entry and exit times along with the associated parking spot identifiers. By processing and analysing this data, we compute the total parking duration for each vehicle and determine the utilization rate of individual parking spots. Furthermore, the analysis identifies high-demand parking spots and peak hours of parking activity.

The key insights from this project can inform parking facility managers about usage patterns, helping to optimize the allocation of parking spaces, manage high-traffic periods, and improve the overall efficiency of parking operations. Visualizations such as bar charts and time-based heatmaps will be generated to clearly illustrate these patterns, providing actionable insights for decision-making. This project contributes to developing smarter, data-driven parking management strategies aimed at reducing inefficiencies and enhancing customer satisfaction in urban environments.

PROBLEM STATEMENT:

Objectives:
- **Calculate Parking Duration**: Determine the amount of time each vehicle spends in the parking facility.

- **Parking Spot Utilization:** Calculate the utilization rate for each parking spot to identify spots that are overused or underused.

- **Peak Parking Hours**: Identify peak hours of parking demand to help optimize staffing or pricing strategies.

- **High Usage Parking Spots**: Identify parking spots with high usage, where the total duration of parking exceeds a defined threshold.

SOLUTION STATEMENT:

The proposed solution aims to optimize parking space management and enhance decision-making for parking facility operators by analyzing the parking data to understand usage patterns and identify high-demand spots. By leveraging Python and its data analysis libraries **(such as Pandas and Matplotlib)**, the solution will involve the following steps:

1. **Data Cleaning and Preprocessing:** The dataset will be cleaned by handling missing or incomplete records, especially focusing on missing Entry_Time or Exit_Time.

2. **Calculation of Parking Duration:** The solution will calculate the total parking duration for each vehicle by subtracting Entry_Time from Exit_Time, yielding the time spent in the parking facility for each parking session.

3. **Parking Spot Utilization:** For each parking spot, the total duration it was occupied will be computed by summing the parking times of all vehicles using that spot. The utilization rate will then be expressed as a percentage of the total available time, allowing the identification of underused or overused parking spots.

4. **Peak Hour Analysis:** By grouping the data by hour of the day, the solution will identify peak hours of parking usage. This analysis will show when parking demand is highest, enabling better management of parking policies, staffing, or pricing strategies during these peak times.

5. **High Usage Identification:** The solution will highlight parking spots that have been used for more than a specified threshold (e.g., 10 hours) in total. Identifying these high-demand spots will help ensure that they are managed properly, potentially leading to improvements like maintenance schedules or reallocation strategies.

6. **Data Visualization:** Various visualizations (e.g., bar charts, line graphs, and heatmaps) will be created to represent parking spot utilization and peak parking hours. These visualizations will make the results more accessible and actionable for parking facility managers, helping them make informed decisions.

7. **Actionable Insights:** The ultimate outcome of the solution is to provide actionable insights for parking facility managers, such as identifying underused or high-demand spots, optimizing parking allocation strategies, and making data-driven decisions during peak usage hours to improve overall efficiency and customer satisfaction.

Source Code:

```python
import pandas as pd
# Loading the dataset
data = pd.read_csv("parking_data.csv", encoding="utf-8")
print(data.head(499))
#Converting date columns to datetime:
data['Entry_Time'] = pd.to_datetime(data['Entry_Time'])
data['Exit_Time'] = pd.to_datetime(data['Exit_Time'])
# Calculate the parking duration for each row
data['Duration'] = (data['Exit_Time'] - data['Entry_Time']).dt.total_seconds() /
3600  # duration in hours
# Displaying modified data
print(data.head(300))
#Calculating the average parking duration:
avg_duration = data['Duration'].mean()
print(f"Average Parking Duration: {avg_duration:.2f} hours")
# Utilization rate for each parking spot (percentage of time it was occupied)
parking_utilization = data.groupby('Parking_Spot_ID')['Duration'].sum() /
(data['Exit_Time'].max() - data['Entry_Time'].min()).total_seconds() * 100
print(parking_utilization)
# Peak hours of parking usage
data['Hour'] = data['Entry_Time'].dt.hour
peak_hours = data.groupby('Hour').size()
print("Peak Hours of Parking Usage:")
print(peak_hours)
data_cleaned = data.dropna(subset=['Entry_Time', 'Exit_Time'])
# Filter parking spots with high usage (e.g., spots that were used for more than
10 hours)
high_usage_spots = data.groupby('Parking_Spot_ID')['Duration'].sum()
high_usage_spots = high_usage_spots[high_usage_spots > 10]
print(f"Parking Spots with High Usage: {high_usage_spots}")
import matplotlib.pyplot as plt
# Plot parking utilization
plt.figure(figsize=(10, 6))
parking_utilization.plot(kind='bar')
plt.title('Parking Spot Utilization')
plt.xlabel('Parking Spot ID')
plt.ylabel('Utilization (%)')
plt.show()
# Plot peak usage hours
plt.figure(figsize=(10, 6))
peak_hours.plot(kind='bar')
```

```
plt.title('Peak Parking Usage by Hour')
plt.xlabel('Hour of Day')
plt.ylabel('Number of Cars')
plt.show()
```

Parking Spot Utilization

Peak Parking Usage by Hour
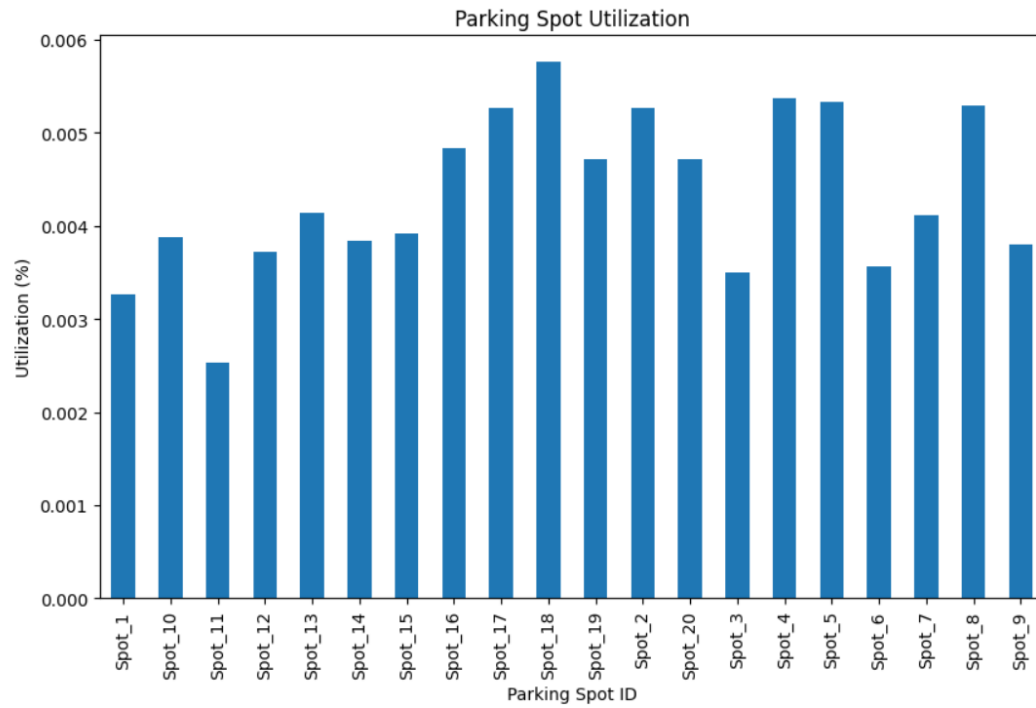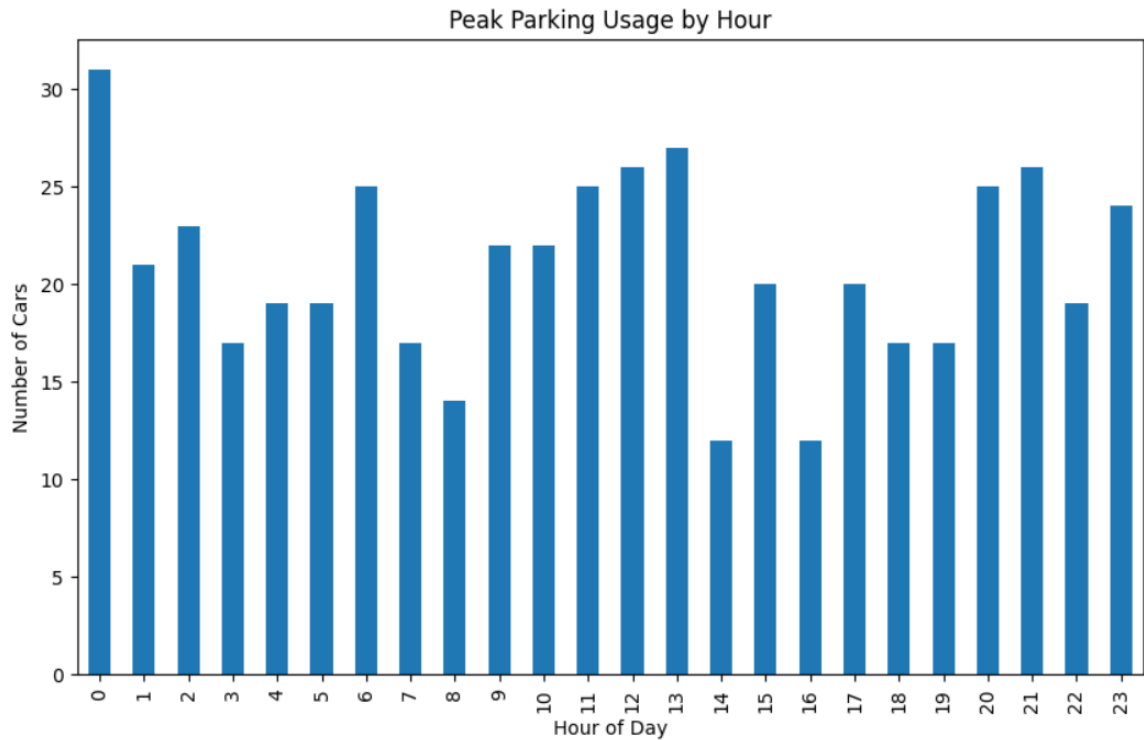
In this project highlights the importance of leveraging data analysis for improving parking space utilization in urban environments. The use of Python for processing and visualizing the data has provided clear, actionable insights that can aid in the development of smarter, more efficient parking management systems. By using these insights, parking facility operators can make informed decisions that lead to better resource management, reduced congestion, and an improved overall parking experience for users.