

# Parking simulation

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# Introduction

- ① Zhixue station mostly serve both local residents and NDHU students.
- ② Due to a lack of planning, the parking lot has reached its capacity.
- ③ This study focuses on Zhixue station's parking space.



Figure 1: Zhixue station.

## Motivation and Background

- ① Park without ride problem  $\Rightarrow$  Occupied the spaces  
 $\Rightarrow$  Parking space shortage  $\Rightarrow$  Passenger unable to park.
- ② Demand  $>$  Supply  $\Rightarrow$  Reach the maximum capacity
- ③ Lack of parking space no efficiently utilize the space
- ④ Does expanding works? To evaluate the long term effect.



Figure 2: Zhixue station parking lot.

# Objectives and Scope

- ① To understand the comprehensive vehicle flows model.
- ② Simulate pre- and post-renovation parking space to simulate the parking shortage.
- ③ Identify the key contribution to parking shortage.
- ④ Recommend and improve the capacity of parking lot of the station.

# Methodology

- ① Prepare Google form for data collection.
- ② Observe the flow of passenger enter and exits.
- ③ Identify the variables and modeling.
- ④ Setting experiments via simulation code.

# Questionnaire and data collection

We collect our data from Tuesday and Wednesday.

Period of time from 6:00 AM to 8:00 AM and from 6:00 PM to 7:00 PM.

Our questionnaire consists following questions:

- ① Enter or exit.
- ② Type of vehicles park at the station.
- ③ Prefer which type of mode of vehicles.
- ④ Willingness to pay parking fee.

# State Variables

- ① Time variables
- ② Number of passengers
- ③ Parking spaces
- ④ Vehicles parked

# Type of Events

- ① Update event
- ② Bicycles and vehicles parking event
- ③ Bicycles and vehicles leaving event

# Flowcharts

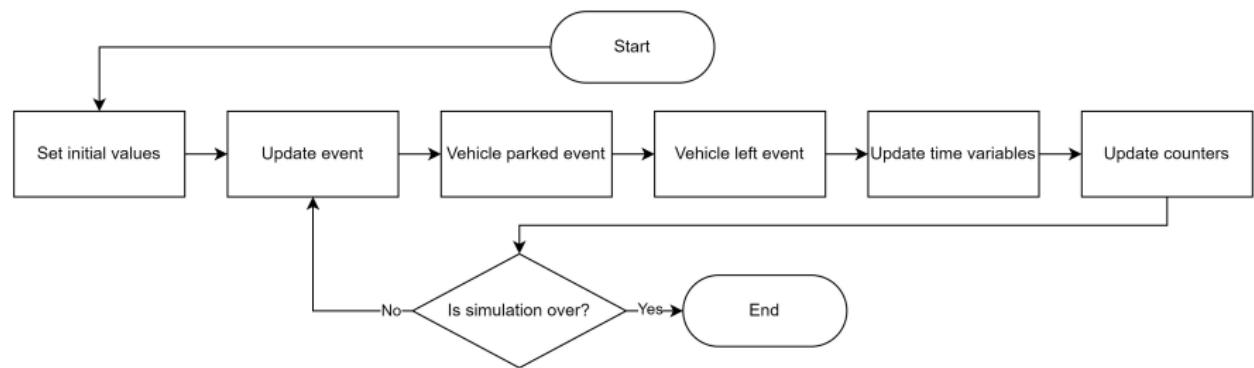


Figure 3: The parking system flowchart.

# The three simulations

## Scenario 1: Unlimited parking space

- ① No restrictions on parking capacity.
- ② Number of people entering and exiting determine by system per hour.
- ③ Calculate the resulting number of vehicles parked by observed at the station per hour.

# The three simulations

## Scenario 2: Pre-renovation parking lot

- ① Based on the existing number of parking spaces.
- ② To determine the exact capacity of the current parking infrastructure and its ability to meet demand.



Figure 4: Satellite image of pre-renovation Zhixue station.

# The three simulations

## Scenario 3: Post-renovation parking lot

- ① Explored the potential benefits of increasing the parking capacity.
- ② The expansion was expected to alleviate the pressure caused by the lack of parking spaces and improve overall accessibility.



Figure 5: Top view of Zhixue Station parking lot renovation.

# The Three Simulations

Item	Value
<b>Simulation Time</b>	
Max Simulation Time (hours)	8760 (a year)
<b>Number of Spaces Parked</b>	
Cars Parked	15
Motorcycles Parked	120
Bicycles Parked	120
<b>Number of Vehicles Occupied Long Term</b>	
Cars (Long-term)	8
Motorcycles (Long-term)	34
Bicycles (Long-term)	40
<b>Other Parameters</b>	
Max Bicycles Parked in a Motorcycle Space	2

## Scenario 1: Unlimited Parking Spaces

To understand the parking demand of passengers and residents, we set the maximum capacity for all vehicle types to unlimited in Scenario 1 and conducted a simulation.

Item	Scenario 1
Car parking space	Infinity(Not use)
Motor parking space	Infinity(Not use)
Bicycle parking space	Infinity (Not use)
Bicycle parked in motorcycle space	2

Table 1: Scenario 1 Simulation Details

# Scenario 1: Unlimited Parking Spaces

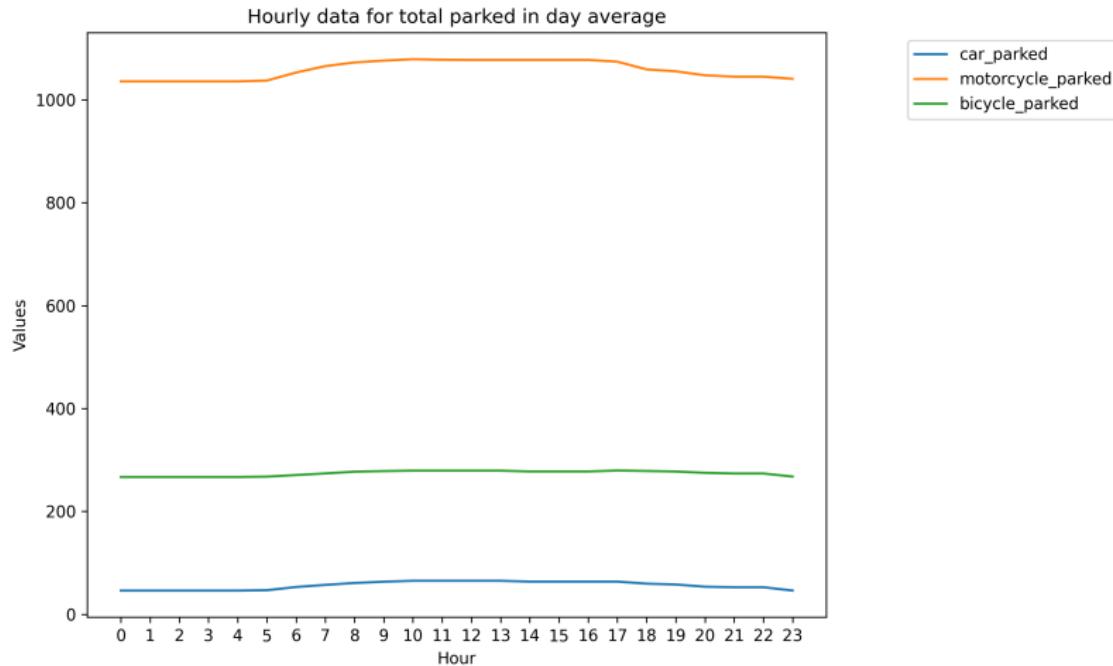


Figure 6: The average hourly parking status in Scenario 1.

## Scenario 1: Unlimited Parking Spaces

- ① All three different line are steady.
- ② On average, there are above 1000 motorcycle parked in the station.
- ③ Whereas, there are between average of 200 to 250 bicycle parked in the station hourly.
- ④ However, there are estimate below 200 cars averagely parked in the station hourly.

## Scenario 2: Pre-Renovation Parking Lot

In this scenario, we set the parking spaces as follows to simulate the changes in vehicle numbers under the weekday conditions before the parking lot renovation.

Item	Scenario 2
Car parking space	22
Motor parking space	339
Bicycle parking space	Infinity(Not use)
Bicycle parked in motorcycle space	2

Table 2: Scenario 2 Simulation Details

## Scenario 2: Pre-Renovation Parking Lot

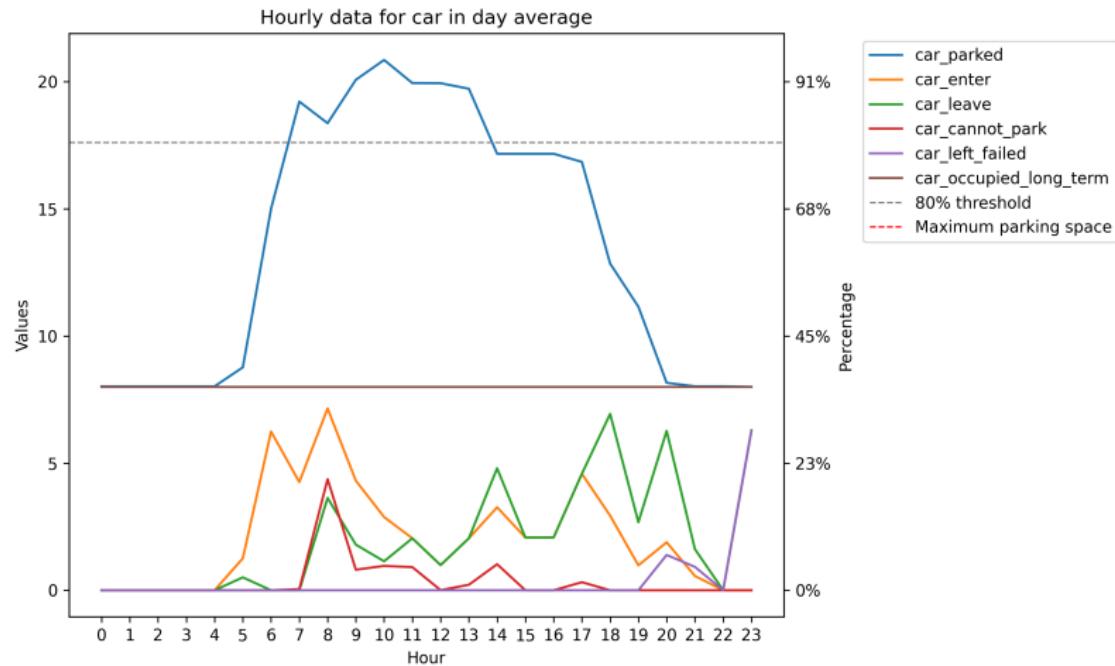


Figure 7: Average number of cars parked per day before the parking lot renovation.

## Scenario 2: Pre-Renovation Parking Lot

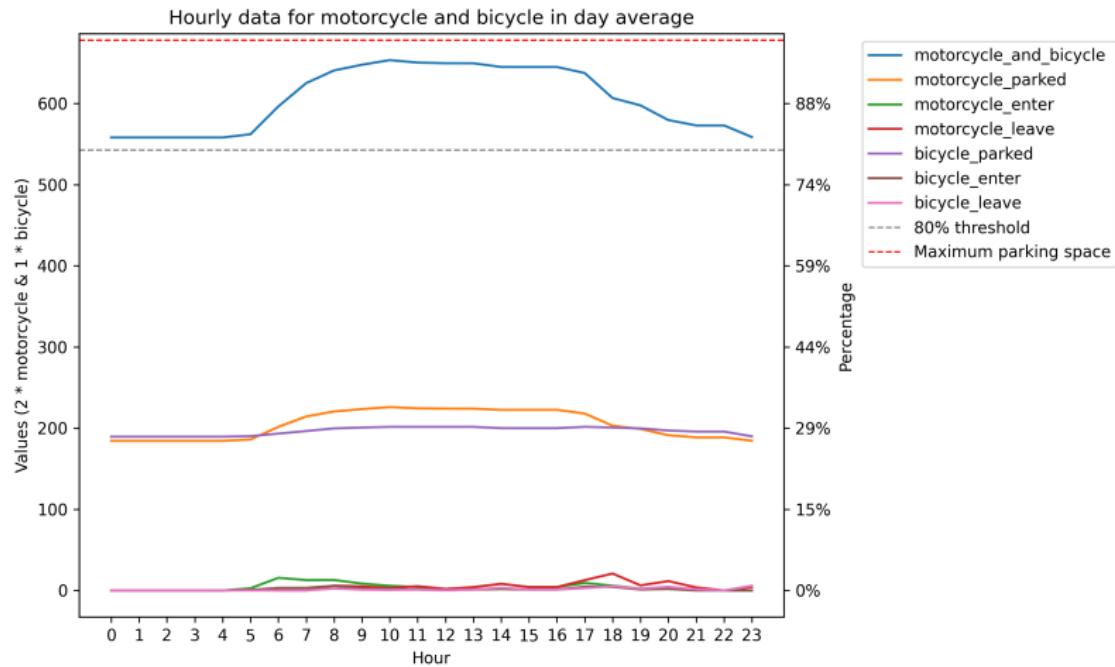


Figure 8: Average number of motorcycles and bicycles parked per day before the parking lot renovation.

## Scenario 2: Pre-Renovation Parking Lot

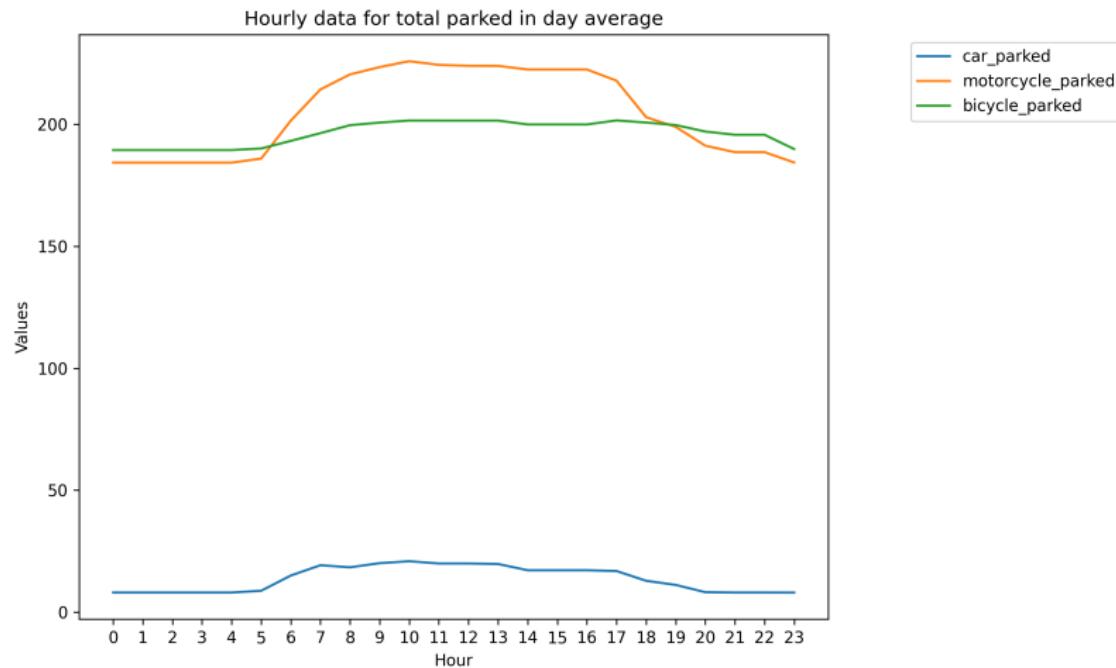


Figure 9: The average hourly parking status in Scenario 2 before the renovation.

## Scenario 2: pre-renovation parking lot

- ① For daily data, all three vehicles have shown a diminishing in between 10-17 hours, then decrease eventually.
- ② Car enter and exits fluctuate dynamically, and follow a certain distribution.

## Scenario 3: Post-Renovation Parking Lot

In this scenario, we set the parking spaces as follows to simulate the changes in vehicle numbers under the weekday conditions after the parking lot renovation.

Item	Scenario 3
Car parking space	90
Motor parking space	627
Bicycle parking space	Infinity(Not use)
Bicycle parked in motorcycle space	2

Table 3: Scenario 3 Simulation Details

## Scenario 3: Post-Renovation Parking Lot

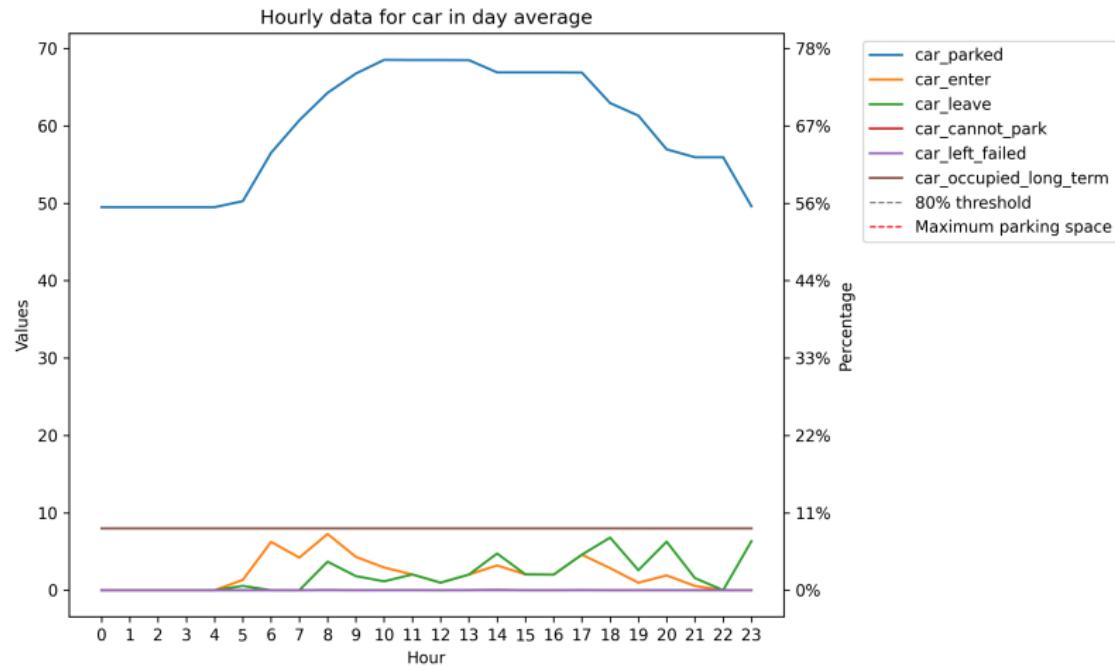


Figure 10: Average number of cars parked per day after the parking lot renovation.

## Scenario 3: Post-Renovation Parking Lot

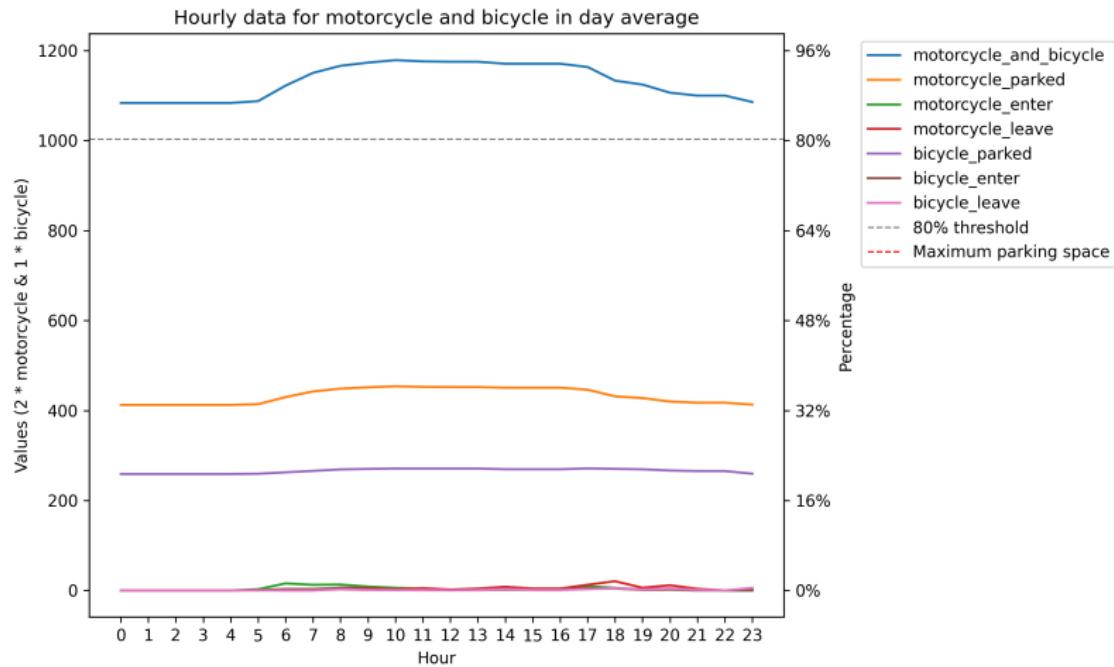


Figure 11: Average number of motorcycles and bicycles parked per day after the parking lot renovation.

## Scenario 3: Post-Renovation Parking Lot

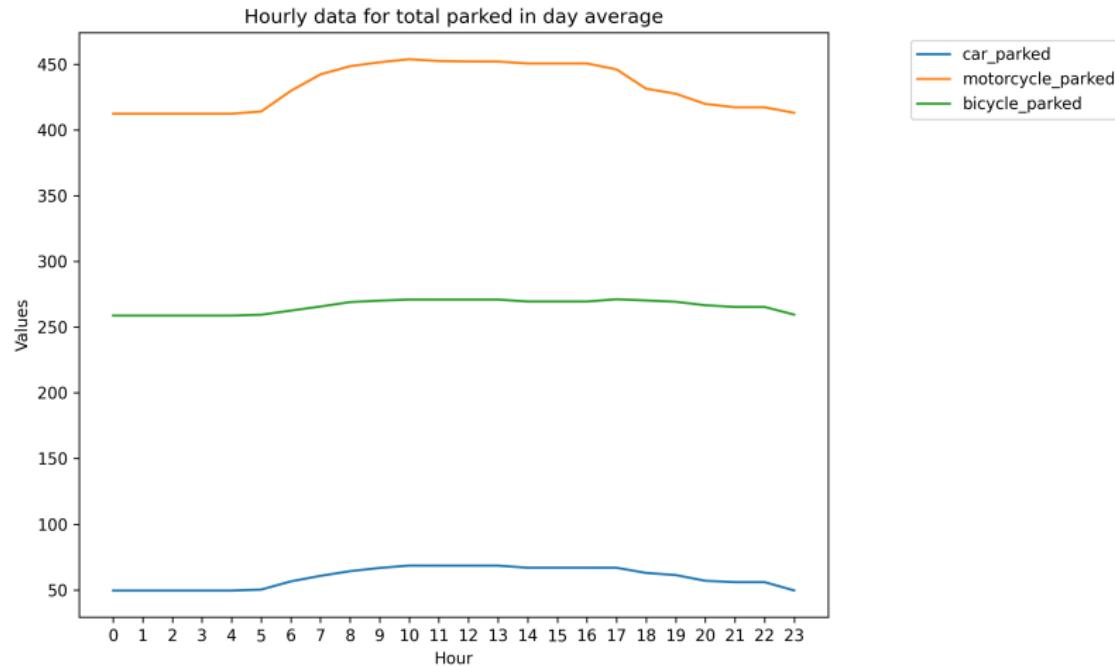


Figure 12: The average hourly parking status in Scenario 3 after the renovation.

## Scenario 3: Post-renovation Parking Lot

Based on the graph show that the post-renovated parking has increase its capacity to park more vehicles. We can see that the post-renovation parking lot has the capacity to park motorcycle and bicycle about 1000 to 1200. and able to park 60-70 cars.

# Conclusions and Discussions

- ① We conduct survey to collect the data.
- ② post-renovation has increase its capability to meet the demand of parking.
- ③ long-term parked is the key contribution to lack of parking space.

# Conclusions and Discussions

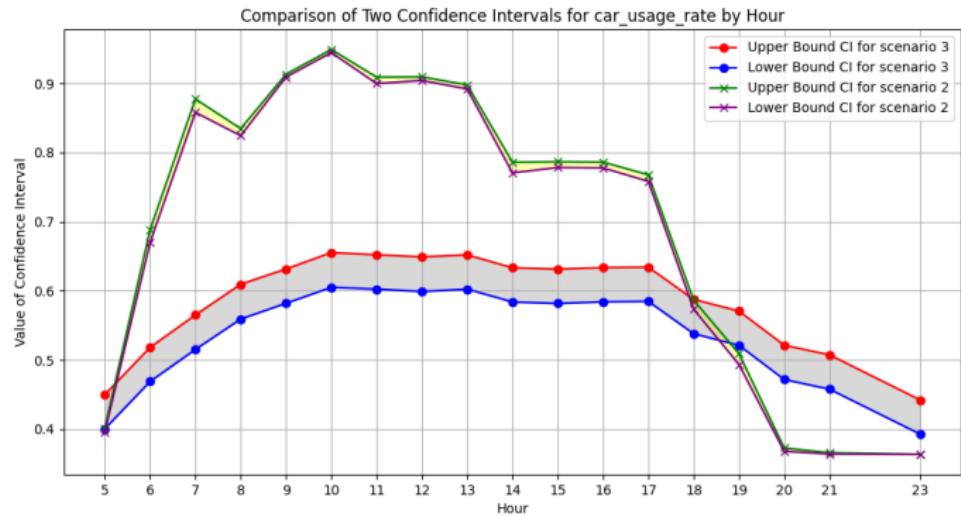


Figure 13: Parking space usage rate of car

# Conclusions and Discussions

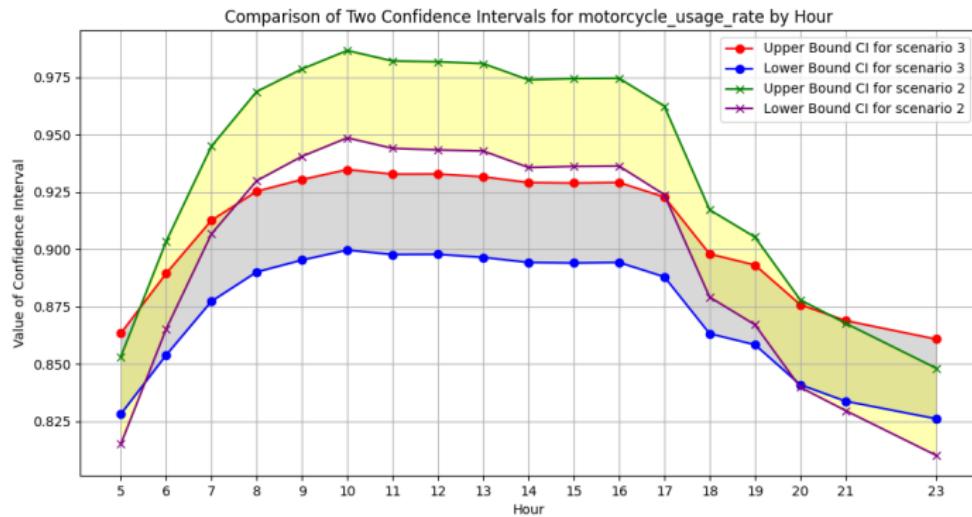


Figure 14: Parking space usage rate of motorcycle and bike

# Conclusions and Discussions

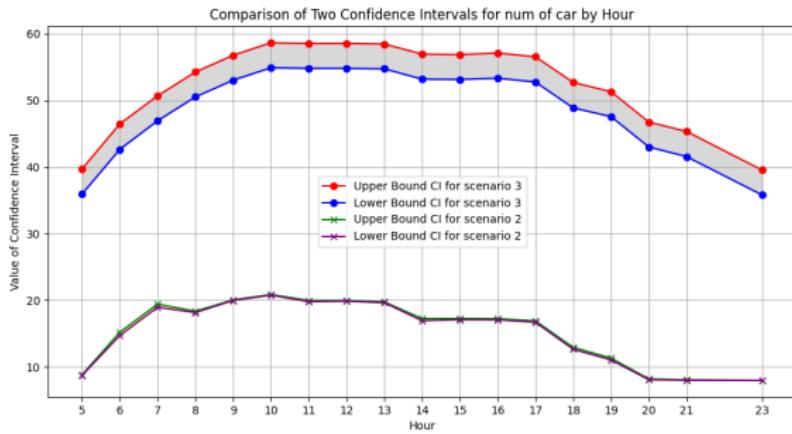


Figure 15: num car

# Conclusions and Discussions

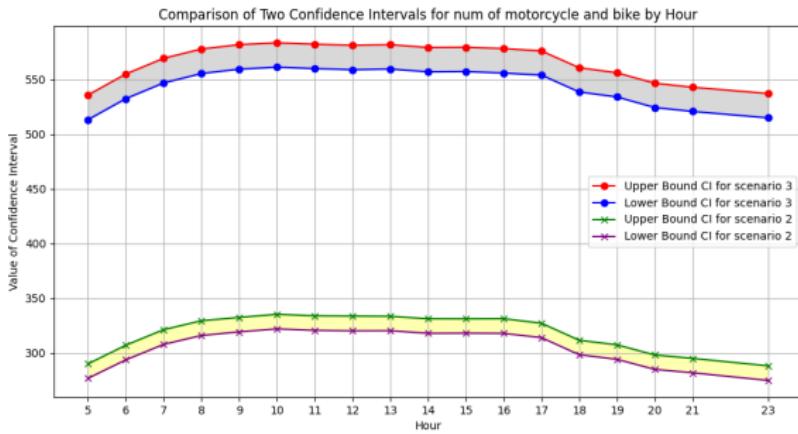


Figure 16: num motorcycle and bike

## Future Works

- ① Capture weekend and holiday trend of passenger and vehicle flow.
- ② Integrate with other factor, such as weather, special event, etc.
- ③ Collaborate with local authorities.
- ④ Study the impact of parking fee.

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