**Journal of Computing and Electronic Information Management**
ISSN: 2413-1660 | Vol. 15, No. 3, 2024

# Analysis of spatiotemporal changes in bicycle rental demand: Taking New York as an example

**Guanbo Wang**

Tianjin University of Technology and Education, Tianjin Municipality, 300000, China

**Abstract:** In order to optimize the rental patterns of public bicycles and the allocation plan, the temporal and spatial movement laws of public bicycles should be obtained. Propose a distribution model and time trend model for public bicycles at different time points and rental locations. Take New York city as an example, based on the public bicycle travel data in New York City, a reference plan for the allocation of rental points was proposed using the moving average time model, kernel density method, and decision tree regression model.

**Keywords:** Rental; Shared bike; Moving average time model; Kernel density method; Decision tree regression model.

## 1. Introduction

In recent years, environmental issues and traffic congestion have become increasingly prominent, and the national government has also realized the potential harm and actively taken measures to vigorously promote low-carbon transportation modes. Shared bicycles have become a new way of transportation for people under low-carbon advocacy suggestions. Public bicycles are an emerging green mode of transportation, which not only solves the "last mile" of people's travel, but also plays an immeasurable role in improving urban traffic conditions and optimizing road management. The site selection layout of public bicycle rental points often takes into account the frequent travel areas of the entire city. In these areas, reasonable rental point locks and corresponding bicycle quantities are set up according to actual needs. However, there is still an issue of uneven distribution in the allocation of bicycles, with some peak populations experiencing no available bicycles. The aim of this study is to optimize the allocation of bicycles at each rental point based on time and space, so that everyone with a need can have a bike available.

For the allocation of shared bicycles at various rental points based on time and space, China started earlier as an emerging public transportation system. Although there is some research on the public bicycle system in China, there is still a significant gap, and there is a lack of relevant experience and theoretical research results; Although the public bicycle system in foreign countries started earlier, the overall quantity and scale are relatively small, and there are significant differences in the usage environment of public bicycles compared to China. There are few experiences and theoretical achievements that can be learned from. Therefore, the optimization of the number of public bicycles at each rental point in terms of time studied in this article is of great significance.

## 2. Literature review

Domestic and foreign scholars have made some achievements in understanding the spatiotemporal changes in bicycle rental demand. At present, in China, Zhang Bingqi introduced the concept and background of public bicycles, and proposed a mathematical model based on queuing theory to solve the optimization problem of vehicle allocation at public bicycle rental points. In addition, the article also introduces how to quantify indicators such as service intensity, idle probability, and average waiting time of public bicycle systems, and simulates and analyzes data from Beijing and Hangzhou as examples; Jiao Yuntao established a demand model for public bicycle rental station scheduling with the goal of achieving the strongest overall stability and the latest scheduling start time during peak hours, and delayed the scheduling start time during peak hours;Zhang Yongge uses clustering metho to analyze the travel habits and preferences of urban residents, uses historical data of bicycle rental, and predicts the future demand for public bicycles based on time series algorithms. This can achieve accurate deployment of public bicycles, greatly reducing the number of idle public bicycles and thus lowering the service costs of public bicycle providers. Guo Xiaohui, Wei Ming, and Sun Rong constructed a model for the allocation of public bicycles, which considers multiple demand points, the number of bicycles, and traffic flow constraints, with the goal of minimizing the distribution path. Liu Dongx u analyzed the spatial distribution characteristics, temporal evolution characteristics, and OD correlation characteristics of bicycle rental and return behavior at typical service points to obtain the travel patterns of public bicycle system users and the macro/micro operation patterns of each service point. He also conducted field research using Hangzhou as an example. Zhang Dandan elaborated on the advantages of using public bicycles as a method to solve urban traffic congestion, environmental pollution, and resource waste problems, and provided optimization plans for the layout and configuration of public bicycle rental points in Chuzhou City, as well as research methods, analysis, and conclusions. The main content includes the basic situation of Chuzhou City, the current situation and problems faced by public bicycles, as well as optimization config uration plans. Cheng Long addressed the issue of uneven use of the public bicycle system, taking Nanjing as an example, exploring the usage characteristics of the existing public bicycle system, analyzing the functional positioning of the public bicycle system, and conducting a combined weighting analysis of the evaluation of the location selection plan for public bicycle rental points. Chen wendong used Nanjing as an example to quantitatively analyze the relationships between various

factors.

# 3. Data and methodology

## 3.1. Data

New York is a highly developed city with diverse modes of transportation. The types of travel are also one of the most complete cities in the world. The bike sharing market in New York City has gradually emerged since the end of 2013 with the rise of China's sharing economy. Initially dominated by brands such as ofo and Mobike from China, followed by brands such as LimeBike and Jump from the United States. As of 2021, the number of shared bicycles in New York City has exceeded 10000, distributed in multiple areas such as Brooklyn, Queens, and Manhattan, becoming a green space for both citizens and tourists.

Color and convenient transportation are important choices. New York shared bicycle market in the city is in a rapid development stage, with the market size constantly expanding, technological applications constantly upgrading, and policy support continuously strengthening. Shared bicycles provide convenient and green modes of transportation for citizens and tourists, solving the ”last mile” travel problem and promoting sustainable urban development. About 140000 shared bicycle rental data, including spatial and temporal distribution, were selected in New York, which can fully guarantee the reliability and accuracy of the research

## 3.2. Methodology

### 3.2.1. Literature research method

By reviewing domestic and international papers on time and space management methods for public bicycle rental, summarize the methods and patterns used, identify shortcomings, and improve.

### 3.2.2. Qualitative analysis method

Qualitatively classify data, conduct "qualitative" analysis, use induction and deduction, analyze synthesis, and abstract and generalized methods to process the obtained data through thinking.

### 3.2.3. Quantitative analysis method

Quantitatively calculating preprocessed data to obtain patterns of change, enabling people to have a clearer understanding of the distribution of data from a temporal and spatial perspective, and providing theoretical support for drawing conclusions. This study adopts two methods:

1)Moving Average Time Model

The moving average method runs sequentially based on time series data, calculating a certain number of time series averages each time, and using a set of averages to reflect long-term trends.

2)Kernel density function analysis method

$$f(x,y) = \frac{1}{n * h^2} \sum_{i=1}^{n} pop_i \, K_0(\frac{dist_i}{h})$$

Among them, pop2 is the given weight field. If it does not contain this field, the value is 1, and n is the number of POI points.

$$d = 0.9 * \min(A, \sqrt{\frac{1}{\ln(2)}} * D_m) * n^{-0.2}$$

Parameter explanation:

Average center: refers to the average center of n POI points, where longitude and latitude are averaged separately.

Weighted average center; refers to the weighted average center of n POI points

Standard distance calculation formula:

$$SD = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{X})^2}{n}} + \sqrt{\frac{\sum_{i=1}^{n}(y_i - \bar{Y})^2}{n}} + \sqrt{\frac{\sum_{i=1}^{n}(z_i - \bar{Z})^2}{n}}$$

Among them, $x_i, y_i, z_i$ is the coordinate of POI; X. Y and Z represent the average center; n is the total number of POIs

Weighted standard distance calculation formula:

$$SD_w = \sqrt{\frac{\sum_{i=1}^{n} w_i(x_i - \overline{X_w})^2}{\sum_{i=1}^{n} w_i}} + \sqrt{\frac{\sum_{i=1}^{n} w_i(y_i - \overline{Y_w})^2}{\sum_{i=1}^{n} w_i}} + \sqrt{\frac{\sum_{i=1}^{n} w_i(z_i - \overline{Z_w})^2}{\sum_{i=1}^{n} w_i}}$$

Where w is the weight of element i; $X_w, Y_w, Z_w$ represent weighted average centers; n is the total number of POIs.

If the POI point does not contain a weight field, then, $D_m$ is the media n distance to the average center, n is the number of POI points, and A is the standard distance.

If the POI point contains a weight field, then $D_m$ is the media n distance to the weighted average center, n is the sum of the POI point weight field values, and A is the weighted standard distance

3) Decision tree regression equation

Here is the decision tree regression equation code.

```
dummy_hour = pd.get_dummies(train['hour'],prefix='hour')
dummy_weather = pd.get_dummies(train['weather'],prefix='weather')
from sklearn.cross_validation import train_test_split
x_train,x_test,y_train,y_test = train_test_split(x,y,random_state=5)
from sklearn.linear_model import LinearRegression
linreg = LinearRegression()
linreg.fit(x_train,y_train)
y_pred = linreg.predict(x_test)
y_pred = list(map(lambda x: x if x >= 0 else 0, y_pred))
def score(y_pred,y_test):
    return np.sqrt(sum((np.array(y_test) - np.array(y_pred))**2)/len(y_pred))
score(y_pred,y_test)
```

# 4. Conclusions

Bike-sharing has experienced a rapid growth around the world, providing new options for transport as a main mode of travel and/or supportive to public transport. It encourages people to make themodal shift from other sustainable transport (i.e., bus, tram, train, walking) and motorized transport (i.e., car, taxi and carsharing).This study focuses on the modal shift behavior influenced by threeshared mobility modes. More specifically, this paper aims to answer three research questions, which have been mentioned in Section.

Figure 1 shows a stratified plot of the number of 24-hour public bicycle rentals in a certain area of New York City. It is evident that the residential and commercial areas have the highest number of public bicycle rentals.

Figure 2 shows the distribution trend of shared bicycles in New York for 24 hours a day. As shown in the figure, there are two peaks in the rental quantity between 7-9 hours and 17-19 hours, indicating that there is a high demand during working and off hours, with the maximum rental quantity

exceeding 40000 vehicles per hour.

Based on Figure 1 and Figure 2, it can be seen that the traffic flow changes with the flow of people. During the morning rush hour, the direction of traffic flow is from residential areas to commercial areas, and during the evening rush hour, it is from commercial areas to residential areas, indicating that the concentrated user group is young people who are working. And from 11:00 to 13:00, the number of public bicycles flowing in the commercial area is also higher compared to other time periods.

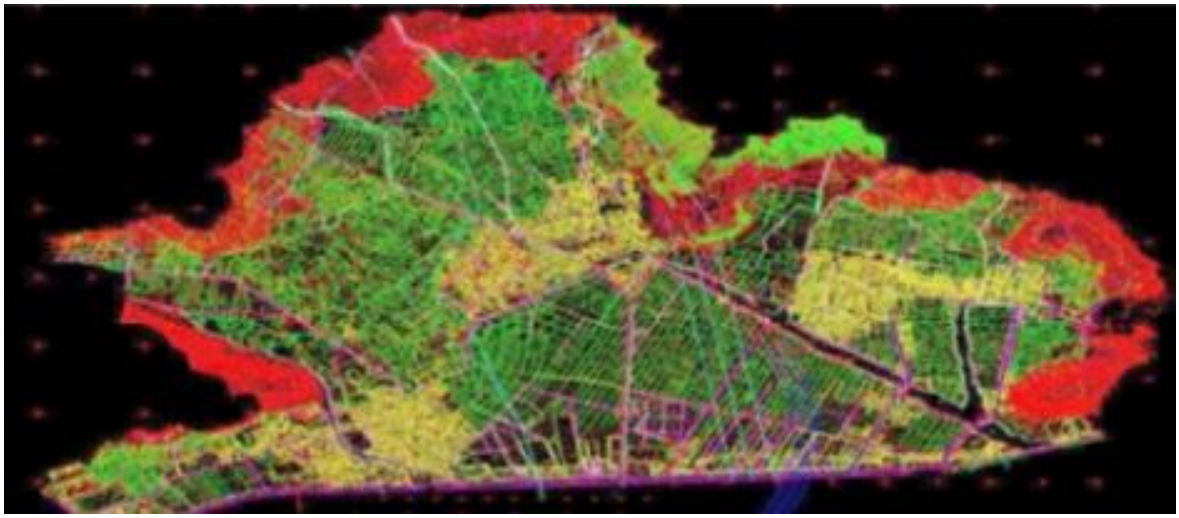

**Figure 1.** Time Map of Public Bicycle Area in a Certain District of New York

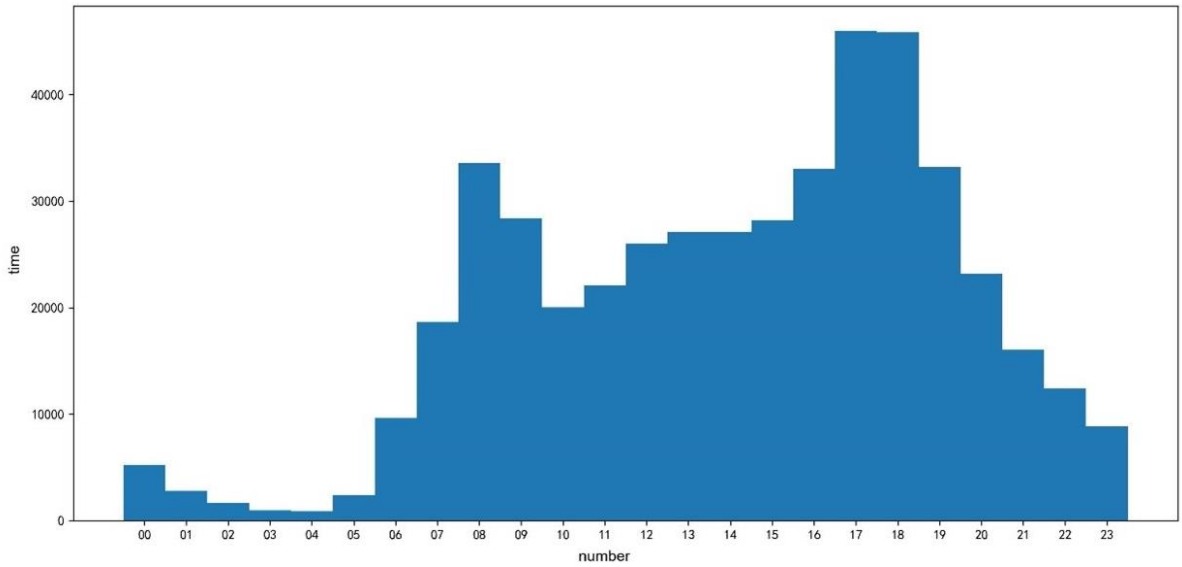


**Figure 2.** Change in the Number of Shared bike Rentals in New York over time

Overall, there is a significant overlap between the trend in the number of public bicycle rentals in New York City and the lifestyle patterns of young people. It is recommended for urban planning to transfer public bicycles from commercial areas to residential areas at night to ensure the daily needs of residents for work the next day, and to deliver scattered public bicycles to the commercial area at noon. Set up as many rental points as possible in commercial and residential areas, especially downstairs from companies and at the entrance of residential areas, in order to maximize the scale and solve the problem of not being able to rent shared bicycles for travel. Ensure the convenience and feasibility of citizens' travel.

# References


[1] Genikomsakis K N , Galatoulas N F , Ioakimidis C S .Towards the development of a hotel-based e-bike rental service: Results from a stated preference survey and techno-economic analysis[J].Energy, 2021, 215(1):119052.

DOI:10.1016/j.energy.2020.119052.

[2] Lenfers U A , Ahmady-Moghaddam N , Glake D ,et al.Improving Model Predictions—Integration of Real-Time Sensor Data into a Running Simulation of an Agent-Based Model[J].Sustainability, 2021, 13.

DOI:10.3390/su13137000.

[3] B X M A , B Y Y , B N V O ,et al.Bike-sharing systems' impact on modal shift: A case study in Delft, the Netherlands - ScienceDirect[J].Journal of Cleaner Production, 259[2024-01-29].

DOI:10.1016/j.jclepro.2020.120846.

[4] Glass C , Appiah-Opoku S , Weber J ,et al.Role of Bikeshare Programs in Transit-Oriented Development: Case of Birmingham, Alabama[J].Journal of urban planning and development, 2020(2).

DOI:10.1061/(asce)up.1943-5444.0000567.

[5] Wenhuan N .The Research of Development Countermeasure on Urban Public Bike System[J].Weifang Higher Vocational Education, 2017.

[6] Kim,Kyoungok.Investigation on the effects of weather and calendar events on bike-sharing according to the trip patterns of bike rentals of stations[J].Journal of transport geography, 2018.

[7] Deepak K. Meteorological barriers to bike rental demands: A case of Washington D.C. using NCA approach [J]. Case Studies on Transport Policy, 2021, 9 (2): 830-841.