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Optimization Strategy for the Spatiotemporal Layout of E-Bike Charging Piles from the Perspective of Sustainable Campus Planning: A Case Study of Zijingang Campus of Zhejiang University

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Abstract: With the expansion of Chinese university campuses, electric bikes (E-bikes) have become the most sustainable and effective commuting option because they are a flexible and energy-saving travel mode. Consequently, campus E-bike charging piles have become one of the most essential public service facilities on campuses. However, since most Chinese campuses are closed and independent, the principles of urban public service facilities cannot be simply applied to the layout and use of campus charging facilities. Thus, this study focuses on Zijingang Campus at Zhejiang University, and proposes an optimization strategy for the spatial and temporal layout of E-bike charging piles on the campus. First, trip chain demand models are constructed to examine the travel patterns of E-bike users on campus and the demands for charging areas and time. Second, a space location model is constructed to locate the charging piles in areas with high demand. Finally, according to the charging times of different users, user charging time is integrated into the strategy. This study enhances the layout and utilization system of campus E-bike charging facilities by considering both temporal and spatial dimensions. Overall, this study contributes to the advancement of sustainable transportation infrastructure planning on a campus-wide scale, offering theoretical insights for the design and utilization of functional facilities in large-scale, semi-enclosed environments (e.g., university campuses).

Keywords: e-bike charging piles; sustainable campus planning; trip chain model; space syntax; time guidance system

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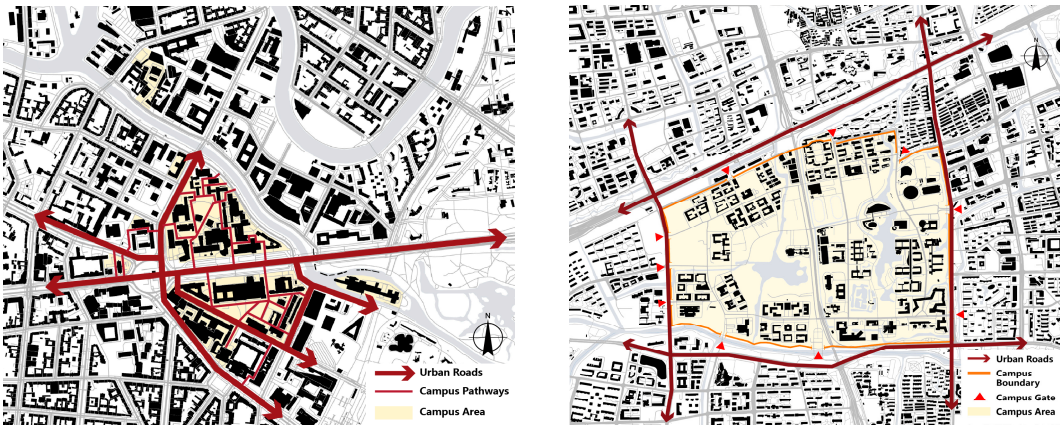
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1. Introduction

1.1. The Importance of E-Bike Charging Piles on Chinese University Campuses

After a long period of development, university campuses in developed countries, such as Europe and the United States, have broken out of the closed and independent campus model [1,2]. Meanwhile, campus buildings have been gradually integrated into their surrounding cities, forming a functional complementarity with urban public service facilities (Figure 1a). In contrast to the open campuses in Europe and the United States [3], Chinese university campuses tend to form small communities in which academic and research facilities, food, clothing, housing, and transportation are all offered within a central area [4]. In order to reduce students' living costs and facilitate management, Chinese campuses have adopted a centralized management model [5], with schools providing accommodation for students, and mandatory registration [6]. Especially after the COVID-19 outbreak, students' daily activities (e.g., studying, eating, and exercising) have been

mainly concentrated on campus in order to ensure that teachers' and students' work and lives are not disrupted [5].



(**a**) (**b**)

Figure 1. (**a**) The relationship between the campus of Technische Universität Berlin and the city; (**b**) the relationship between the Zijingang Campus of Zhejiang University and the city.

In general, Chinese university campuses are large-scale, with clearly defined boundaries. As for their public service facilities, they significantly differ from those on the outside. Additionally, the boundaries formed by the surrounding walls enclose each campus, creating "isolated islands" within their respective cities (Figure 1b). Since the beginning of the 21st century, the popularization of higher education has led to a dramatic increase in the number of students. In order to accommodate more learners, most Chinese universities have expanded their campuses or constructed new ones [7]. Specifically, to promote the reorganization, development, and utilization of higher education resources and public service facilities on campus [8,9], higher education complexes, called "university towns", have emerged in the suburbs of cities [10]. The campuses have also changed from the main place for students to study and carry out their daily life activities into diverse "micro-cities" that provide students and teachers with a wide array of industry/university/research services [4,11].

Public service facilities on Chinese campuses have been rarely oriented toward their respective cities, with the majority exclusively focusing on teachers, students, and staff [12]. Their configuration principles also significantly differ from those of urban public service facilities. For example, compared to the planning and coordinated construction of urban public service facilities, most facilities on campuses are incrementally added according to user demand, rather than following the comprehensive construction rules and regulations applied to urban areas.

Currently, campus planning in China tends to focus on the creation of large-scale physical spaces, with less attention being paid to small-scale activities centered around walking. Meanwhile, traditional production-oriented planning divides each campus into sections according to various functions such as research, teaching, accommodation, and living. Although campus commuting has some commonalities with social commuting, it often involves commuting across groups, unlike social commuting between the workplace and residence [12]. Campus commuting is also characterized by fast travel times and high frequency. However, with the increase in the number of people on campus and the gradual expansion of various functional groups, the "mega-campus" phenomenon has significantly increased commuting costs and demands within each campus. Moreover, although the long distances between planning areas and the lengthy traffic flow lines necessitate the use of transportation, the closed environment limits the development of urban transportation (e.g., subway and bus) within each campus. Especially under the influence of the COVID-19 pandemic, campuses are still subject to closures and control measures, prohibiting external

vehicles and personnel from entering. As for the students, cars are rarely chosen due to high costs, parking difficulties, and campus-restricted driving policies [13].

In this environment, campus-operated small cars, shuttle buses, and on-campus public transportation are not suitable for large-scale promotion, due to the nature of teacher and student travel, parking difficulties, and high costs. Therefore, electric bikes (E-bikes) have become the preferred choice for campus users due to their low cost, flexibility, and energy-efficient mode of travel, flourishing in university campuses across China [14]. E-bikes play an important role in alleviating traffic congestion, reducing air pollution, and meeting the demand for short-distance travel. They not only facilitate users' access to various functional locations but also improve travel efficiency and align with the concept of green transportation [4]. The Chinese government also encourages and supports the use of E-bikes for travel. However, with the increasing number of E-bikes, the government has also recognized the importance of safety and regulated management. Since 2019, China has issued the *Technical Specification for Safety of Electric Bikes,* which clarifies technical standards, maximum speed, battery quality, and other aspects [15]. Subsequently, numerous local regulations, such as the *Electric Bike Management Ordinance,* have further regulated usage times and other aspects. However, national policies and regulations regarding the production and use of E-bikes are still in the early stages. In the future, efforts need to be intensified in terms of regulation, maintenance, and other aspects. At the Zijingang Campus of Zhejiang University, the school has responded to the policies of Hangzhou, Zhejiang Province, by strengthening regulation through E-bike registration and implementing policies such as prohibiting charging at night and limiting the campus speed to 25 km/h. Due to potential issues such as overheating and short circuits during the charging of E-bike batteries, fires can occur [16]. Indoor fires can spread rapidly and may lead to explosions, releasing large amounts of toxic gases and posing significant threats to life and property safety [17]. Therefore, the Campus Security Department stipulates that E-bike charging must be conducted in open and outdoor environments (Figure 2). This makes outdoor E-bike charging piles on campus the most frequently used and essential public service facilities.



Figure 2. Current situation of E-bike charging pile on Zijingang campus of Zhejiang University.

1.2. Current Spatial and Temporal Distribution of E-Bike Charging Piles on Zijingang Campus

In the planning and layout of university campuses, the first consideration is functional zoning [18]. However, as the campuses continue to expand, the increasing distance between different functional zones has gradually affected the usage process of faculty and students within each campus. Thus, the research subject in this study is the Zijingang Campus at Zhejiang University, which is a typical large-scale, clustered, and functionally concentrated campus in China, covering an area of more than 1.2 million square meters [19]. Zijingang Campus, built during the peak of large-scale campus construction at the beginning of this century, is simply divided into teaching, residential, and public activity areas, resulting in large-scale blocks and excessively long travel distances within the campus [20]. For instance, the straight-line distance between the east and west gates of the campus is 4.5 km. Meanwhile, due to the layout of internal roads, landscape water systems, and other factors, the daily commuting distance is even more considerable. In this regard, the walking time

between the east and west gates can exceed one hour, which is a duration far beyond the comfortable walking distance for pedestrians (approximately 5 min for 400 m [21]). In order to facilitate rapid and convenient commuting within the campus, approximately 30,000 people use E-bikes on a daily basis. Among them, 85% utilize on-campus charging piles at least once a week.

The construction of Zijingang Campus began in 2001 with gradual zoning. E-bike charging piles, as an emerging phenomenon in the past five years, were not part of the comprehensive construction system during the campus planning phase. Currently, they are being incrementally added to address the shortage of charging facilities. According to preliminary statistics, more than 90% of users of on-campus E-bike charging piles believe that their layout is unreasonable, making it difficult to find suitable ones when necessary. At the spatial level, the layout of charging piles fully conforms to campus planning and they are placed within the "safe areas" of functional clusters on campus. Although the arrangement of charging piles considers the balance among teaching, research, and living, they still cause congestion (by obstructing main roads), they are located in remote/concealed areas, and they suffer from low utilization rates. There is also a contradiction between bottom-up charging demand and top-down charging pile configuration, with the latter making it difficult to cover users' needs.

At the temporal level, the general charging time for E-bikes is approximately 8 h per session. For safety reasons, the operating hours of campus charging piles are from 06:00 to 24:00. As for the users of campus charging piles, they consist of two main groups: students and staff. To ensure the charging rights of both groups, the university has established numerous dedicated charging piles for each category. However, there are differences in the typical charging times chosen by the different user groups. Consequently, the demand for charging piles exceeds the supply during peak hours, while a significant number of charging piles remain idle during off-peak hours, resulting in significant resource waste.

Presently, there are 1324 charging piles on Zijingang Campus (Table 1 and Figure 3), all of which are managed by the property management unit. On the one hand, due to the stabilization of the number of students and E-bikes on campus, it is not advisable to increase the number of charging piles for the sake of campus electrical safety. On the other hand, achieving breakthroughs in charging power at the technical level can be difficult. In this regard, maintaining the same number of charging piles, focusing on their rational layout and scheduling, and providing guidance on their usage can help solve the charging problem.

Table 1. Details of the charging piles on Zijingang Campus of Zhejiang University.

No.	Region	Quantity	Constructor	Responsible Entity	User Group	Available Time
1	Property Dormitory Area C	6	Property Management	Qiushi Property	Staff Only	6:00–24:00
2	The staff parking shed at the main cafeteria	138	Dining Center	Dining Center	Staff Only	
3	The staff parking shed at the takeout department	39	Dining Center	Dining Center	Staff Only	
4	The staff parking shed by the lake	20	Dining Center	Dining Center	Staff Only	
5	The East Wing International Student Dormitory	122	Neptune	International Education College	Students Only	
6	College of Animal Science	16	Neptune	College of Animal Science	Students Only (Designated College)	
7	South of Parking Lot East 4	53	Neptune	Security Office	Staff Only	
8	North of the West Side of the Chemistry Laboratory Building	10	Neptune	Department of Chemistry	Students Only (Designated College)	

Table 1. *Cont.*

No.	Region	Quantity	Constructor	Responsible Entity	User Group	Available Time
9	South of the West Side of the Chemistry Laboratory Building	14	Neptune	Logistics and Educational Services Center	Staff Only	
10	College of Pharmacy	51	Neptune	College of Pharmacy	Students Only (Designated College)	
11	Anzhong Building	60	Neptune	College of Civil Engineering	Students Only (Designated College)	
12	College of Agriculture	25	Neptune	College of Agriculture	Students Only (Designated College)	
13	College of Medicine (North side of the road)	99	Neptune	College of Medicine	Students Only	
14	College of Medicine (South side of the road)	132	Neptune	College of Medicine	Students Only	
15	Property Dormitory (West Academic Zone)	19	Neptune	Qiushi Property	Students Only	
16	West Wing International Student Dormitory	90	Neptune	International Education College	Students Only	
17	Within the Art Pavilion Compound	20	Neptune	the Art Pavilion Compound	Students Only	
18	Outside the east side of the Art Pavilion compound	50	Neptune	General Affairs Office Liaison and Construction	Students Only	
19	College of Life Sciences	26	Neptune	College of Life Sciences	Students Only	
20	Animal Hospital	24	Neptune	College of Animal Science	Students Only	
21	Yinquan Dormitory North	196	Neptune	Xinyu Property	Students Only	
22	Yuhu Dormitory	92	Neptune	Xinyu Property	Students Only	
	Total			1324		

In summary, the main issues with E-bike charging piles on Zijingang Campus include an unreasonable layout, the need to optimize charging locations, and low efficiency of use. In this study, adjustments will be made to the layout of campus charging piles and guidance will be provided on their usage, while maintaining the same number of charging facilities. This will not only allow for the reintegration of existing charging resources, but it will also maximize their efficiency. First, this study will start by conducting surveys of users' travel patterns and charging needs in order to select suitable areas for the construction of charging piles. Second, by using the space syntax accessibility measure to calculate road accessibility and traffic potential, suitable locations for the construction of charging stations will be selected within high-demand areas. Third, by considering the utilization time periods by different users, a guidance system will be established to address the issue of peak usage times for charging piles. The study's results establish a system for the layout of charging pile locations and guidance on usage times, providing a more convenient and effective solution for the use of E-bike charging piles at the Zijingang Campus of Zhejiang University. Additionally, it offers a theoretical basis and design references for the configuration of public service facilities in similar large-scale, closed environments such as institutional communities and enclosed training grounds.

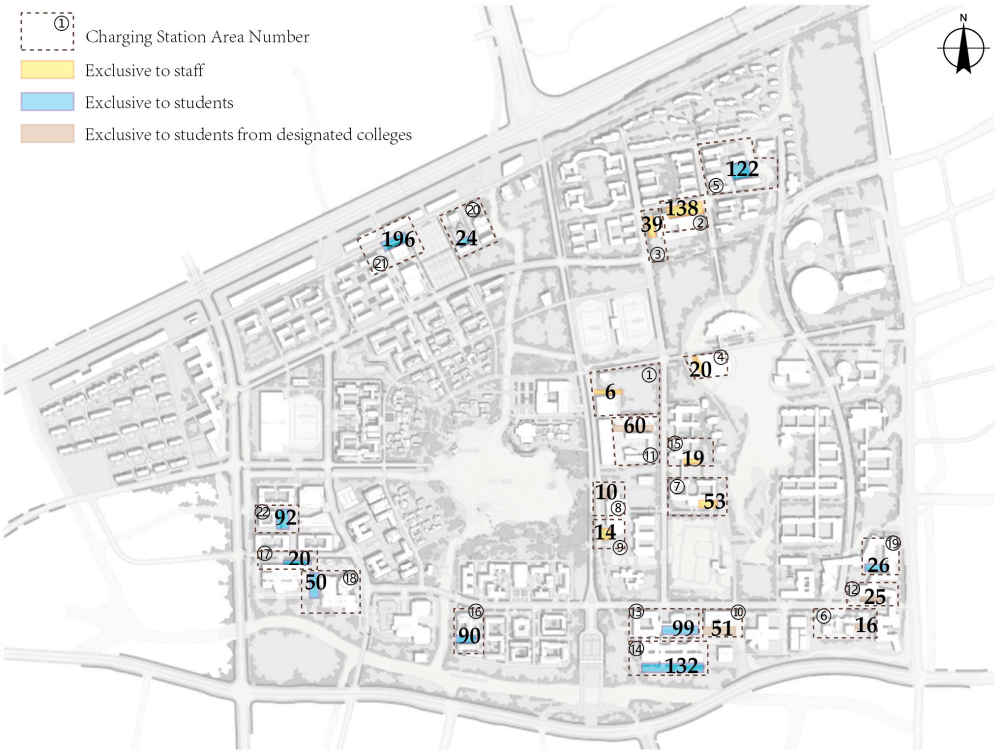


Figure 3. Distribution map of the charging piles' locations on Zijingang Campus of Zhejiang University.

2. Literature Review

2.1. Campus Planning and Transportation Systems

The modern concept of universities originated in the Middle Ages, evolving from early theological institutions. Universities initially exhibited a closed, courtyard-style layout or they were concentrated within a single building [22]. As for student activities, they were mainly confined to courtyards or buildings. Then, the concept of "residential colleges", originating from Western universities, was introduced to facilitate academic exchange and management. Prominent examples include Cambridge University and Oxford University [23].

Over time, the "collegiate system" emerged, which consolidated residential and academic areas, and expanded students' living to college clusters. In modern times, university education shifted from elitism to massification, after which campuses evolved from traditional courtyard styles to open layouts. In fact, many newly built European university campuses have broken the boundaries between campuses and their respective cities, allowing campus buildings to be freely scattered throughout the urban landscape [24]. Renowned American planner Richard Dober classified campus functions into three categories: teaching, service, and activities, in his works *Campus Planning* [25] (1963), *Campus Design* [26] (1992), *Campus Architecture* [27] (1996), and *Campus Landscape* [28] (2000). He also established functionalism as the core direction for campus planning and construction, advocating for a campus planning approach that centers on productive spaces and functional clusters. Since then, Western campuses have transitioned from the "quadrangle style" to the "collegiate system" and eventually to the "functional cluster", gradually expanding the boundaries of campuses and continuously enlarging the scope of students' campus life.

Meanwhile, Chinese university campus planning has lagged behind the West and has continually learned from Western campus planning models, implementing significant measures such as the abolition of church schools [29], departmental adjustments, institutional mergers, and the adoption of the Western "collegiate system" reforms. Until now, Chinese university campuses have generally adopted a layout that integrates multiple functions into a large, enclosed campus [30]. With the further expansion of urbanization

and the increasing demand for talent in society, educational land in cities has become more centralized, and the scale of Chinese university campuses continues to move towards further expansion. Most campus planning still adopts the "functional clustering" layout, integrating teaching, service, and activity functions. More reasonable and mature campus planning layouts have yet to emerge. This has led to the continuous expansion of student activity areas within Chinese university campuses, thus increasing the cost of accessing surrounding public services.

It is important to note that the traditional layout pattern of university campuses has generated usage issues, prompting reflection within the academic community on the "people-oriented" design philosophy. Traditional campuses coordinate the relationship between teaching, living, and logistics through the clear delineation and division of the campus functional system. This method is suitable for construction-oriented planning measured in meters. However, in the construction of large-scale campuses covering thousands of acres, it can lead to distortions in the scale of pedestrian spaces [31]. This is also one of the main reasons why students have had to shift from walking to relying on E-bikes and other transportation modes. Consequently, campus transportation systems have shifted from traditional pedestrian-oriented modes to complex mixed traffic modes involving both pedestrians and vehicles.

While shared transportation has become increasingly popular in cities, with a significant number of shared bikes and cars being available, the initial framework of a shared transportation system has been established in urban areas. As a result, theories of sustainable urban mobility and user behavior analysis have also become hot topics in academic discussions [32]. The goals of sustainable mobility primarily include more efficient use of transportation vehicles, reducing emissions and resource consumption, and advocating for energy-efficient and environmentally friendly modes of green travel [33]. Pereira et al. assessed urban mobility through a Sustainable Urban Mobility Index to enhance the quality of urban life [34]. Brcic et al. addressed global transportation issues by enhancing traffic mobility and considering spatial, energy, environmental, and financial aspects comprehensively [35]. Damidavicius et al. analyzed various European models of sustainable urban transportation plans to evaluate their effectiveness [36]. Such studies explore sustainable urban transportation methods, but research into urban mobility primarily focuses on larger-scale, open urban spaces with evenly distributed shared transportation. Campuses, being relatively enclosed, face challenges in providing comprehensive coverage for shared mobility within their boundaries. Campus travel exhibits tidal characteristics, often experiencing peak demand periods where supply may fall short, while off-peak times may see underutilization. Therefore, theories of sustainable urban mobility and the construction of shared transportation systems applicable in urban settings are challenging to implement in campus environments. Students tend to prefer private E-bikes for convenience, making E-bike charging stations indispensable on campuses. Hence, this study explores methods to optimize the spatial and temporal layout of E-bike charging stations on a campus.

2.2. Campus Public Service Facilities Layout

In traditional production-oriented planning, the layout of campus public service facilities is similar to that of traditional urban public service facilities. Both are designed to provide services to users by establishing a "service circle", with the facilities as the core and service scope radius [37]. With the advancement of humanistic thought, academia has been extensively considering the daily needs of users in the layout of urban public service facilities. In this regard, various theories and methods, such as "activity space" and "time geography", have been employed to assist in facility allocation. Compared to urban public service facilities, the layout of campus public service facilities often focuses on the grouping of functions, which may not fully address the actual usage needs of faculty members and students. In fact, with the expansion and transformation of modern university campuses, campus public service facilities tend to be comprehensive, diverse, and varied [38]. Additionally, the spatial layout is more adaptable to the development

of various functional needs on campus. However, this layout is gradually departing from urban methods, such as maximum coverage and hierarchical configuration based on indicators, and beginning to construct new layout principles based on the daily behaviors of faculty members and students.

As for the "people-oriented" perspective, many scholars have applied the theory of "activity space" to optimize campus public service facilities [39]. For example, Liu proposed humanized design principles based on the behavioral characteristics of university students [40], while Stessens developed a spatiotemporal accessibility measurement model based on individual needs [41]. In the latter, through the analysis of students' activities and behaviors, they established daily activity circles to optimize the layout of public service facilities. In related research, Fang delineated the scope of usage through "temporal circles" and further improved functional configuration by using the space syntax accessibility measure [31]. Although these scholars have considered the logic of faculty members' and students' use of campus public service facilities and the scope of "living circles" from a bottom-up perspective, and focused their research on user behavior patterns, the results have not transcended the traditional methods of macro configuration. They still evaluate the rationality of public service facility configurations using rigid indicators such as service radius [42]. Moreover, most studies have only considered the living spaces of faculty members and students, neglecting office spaces, which also serve as long-term stay areas. Both living and office spaces should be comprehensively considered to delineate a "commuting circle" that better aligns with the travel patterns of campus users. This study will adopt a micro-level perspective of user needs and attempt to reconstruct the principles for configuring campus public service facilities based on the "commuting circle". This approach aims to provide theoretical support to issues related to campus travel and planning.

2.3. Optimization Model for the Layout of Charging Facilities

In their study on the configuration of electric vehicle charging stations at the urban scale, Ma et al. proposed that the layout problem of charging facilities can be decomposed into three sub-problems: (1) predicting the spatiotemporal distribution of charging demand; (2) establishing an optimization model for the layout of charging facilities; and (3) solving the multiobjective optimization model [43]. This is analogous to the core problem addressed in our study, in which the layout optimization model constitutes a key focus of our investigation.

Currently, academic research on optimization layout models for charging facilities mainly begins with charging efficiency. Building on the uneven distribution of traditional optimization configuration models, it utilizes various parameters, such as charging demand, average charging time, average range, and service capacity [44–46], to constrain the fairness of their allocation [47]. To date, optimization configuration models applicable to urban public service facilities include the Location Set Covering Problem (LCSP) [48], which minimizes the number of service facilities within limited distance and time, while maximizing coverage or meeting demand; the Maximum Covering Location Problem (MCLP) [49,50], which maximizes coverage under expected distance or access time constraints; the P-Center model [51], which optimizes spatial locations, while minimizing access costs from the demand points to the farthest facility point within the area; and the multifactor constrained P-median model [52,53], which focuses on travel efficiency and service capacity. Most of these models adopt a dual perspective of equity and efficiency. While they optimize the traditional charging facility configuration results based on metrics to some extent, they still follow a centralized approach and fail to adequately respond to user needs. Such models are more suitable for large-scale, unbounded, complex urban public service facility configuration issues and are difficult to apply to the configuration of charging facilities in small-scale, enclosed campus areas. This study addresses the issue of configuring public service facilities in campus environments, attempting to establish principles for the placement of E-bike charging piles that balance equity, efficiency, and user needs from the user perspective.

In recent years, the "people-oriented" urban development concept has replaced the traditional pursuit of fairness and efficiency in maximum coverage construction and design. In this regard, public service facility allocation has been focusing on users' daily living activities, with the "community life circle" becoming the fundamental unit of urban construction [54]. For example, the "activity space" theory originating from Japan has helped delineate spatial boundaries, achieve optimized resource allocation, and create favorable community support services. Liu et al. evaluated community public service facilities within living circles to assess the quality of community life [55]. Wang et al. used GIS and GPS data to track and investigate the delineation of neighborhood living circles and the utilization of internal spaces, proposing methods for facility configuration and planning [56]. Based on this concept, some scholars have utilized distance-based methods to calculate the accessibility of abstract road networks and optimize the placement of charging facilities. Scholars have also employed optimization methods, such as the whale optimization algorithm [57], the gravity model, the topological network model, etc., to optimize the layout of urban charging facilities. Wang et al. employed mathematical model analysis, ArcGIS spatial analysis, field investigation, questionnaire measurement, and hierarchical analysis methods to study the spatial layout and evaluation of electric vehicle charging facilities in downtown Chongqing [58]. Rane et al. considered thirteen parameters and determined the weights of Multi Influencing Factors to identify the optimal locations for new electric vehicle charging stations [59]. While these methods consider user needs, they predominantly approach the placement of electric vehicle charging stations from economic, power supply capacity, and environmental harm reduction perspectives, abstracting the users of charging stations as a rational group. However, they are not suitable for the diverse user base and complex demands within a campus environment.

In recent years, many studies have focused on urban charging facilities and electric vehicle travel, with less attention on campus environments [4]. However, such environments are markedly different from urban settings, with relatively smaller scales and fewer users of charging facilities exhibiting similar travel times and paths. This specificity of small-scale, multi-user entities and travel patterns means that the layout of campus charging facilities cannot be simply extrapolated from models designed for urban contexts. Instead, it requires a layout tailored toward users' travel, clustering characteristics, and demands.

2.4. The Principles of Functional Facility Siting Based on Spatio-Temporal Accessibility

Spatial accessibility refers to users' ability to reach a destination/amenity, reflecting the convenience level of the facility [60,61]. Such measurements are commonly used to evaluate the rationality and fairness of the layout of public service facilities. Previous research has applied various methods, such as the spatial impedance model [62], the potential model [63], the opportunity accumulation model [64], and the two-step floating catchment area (2SFCA) model, to quantitatively analyze and measure the spatial accessibility of public service facilities. However, such methods typically focus on areas without boundaries and are generally applicable to research at an unbounded urban scale, such as schools, bus stations, and hospitals. Specifically, these facilities have relatively low location requirements in terms of layout, often resulting in similar travel times for users, regardless of their locations. Similar to parking lots, pharmacies, and parks [65], E-bike charging piles are common and indispensable public service facilities in daily life [66]. These facilities are function-driven and numerous in quantity, with a high degree of substitutability.

Currently, academia has been extensively employing the space syntax accessibility measure as a basis for determining the spatial accessibility of such facilities [67]. Based on topology, this measure elucidates the interaction relationships between various nodes in spatial networks. It has also been widely applied in the literature to explore the spatial structure of specific areas and to quantitatively analyze pedestrians' usage and perception of space [68]. For instance, Zhang calculated the spatial accessibility of primary schools in the central urban area of Fuzhou [69], while Zhao evaluated the accessibility and service status of parks and green spaces in the central urban area of Guangzhou by applying this

measure [70]. In related research, Zhang et al. evaluated the spatial accessibility of urban fire stations and proposed various optimization strategies [67]. Existing research generally suggests that function-dominated public service facilities should be located in areas with high levels of spatial accessibility within cities. However, most studies remain at the stage of model construction and principle explanation. There are relatively few studies that place space syntax results in real-world locations, and most do not compare them with actual road conditions or perform site corrections. In studies where this measure was applied to the layout of charging piles, Ge argued that, to avoid causing traffic congestion, it is preferable to select road segments with good accessibility, rather than those with the best accessibility [71]. Currently, the academic application of the space syntax accessibility measure in studying the layout of charging facilities is still in its infancy, mainly focusing on urban charging infrastructure and electric vehicle charging stations. Moreover, it has yet to provide guidance for optimizing the layout of E-bike charging piles on university campuses. Therefore, this study attempts to establish location principles for functional facilities using space syntax. Taking Zhejiang University's Zijingang Campus as an example, the study compares space syntax results with actual road conditions for site correction, resulting in a comprehensive layout plan for E-bike charging piles.

Traditionally, the selection of public service facility locations has been generally based on spatial distance. However, with the accelerating pace of modern life, "time accessibility" has become an important criterion for determining the location of such facilities [72]. Measuring accessibility in terms of spatiotemporal characteristics is also an intuitive way to express individual activities. This is based on the "time geography" theory proposed by Swedish scholar Torsten Hagerstrand [73], which has been widely applied in various disciplines, including urban planning [74,75], road traffic [76,77], and land use [61,78]. Specifically, time geography has led to a shift in the methodological approach to urban planning from supply-driven to demand-driven and from a macroscopic to a microscopic perspective, offering new solutions for examining individuals' daily time utilization. Li et al. believe that, with the emergence of geospatial artificial intelligence, artificial intelligence and machine learning technologies are also transforming the methods used for spatial analysis, making temporal accessibility increasingly important [79]. Therefore, spatiotemporal accessibility has become a critical criterion for assessing the rationality of the layout of public service facilities. In the following section, this study (based on actual users' needs) will arrange the placement of E-bike charging piles by using spatiotemporal accessibility as a basis.

3. Methods

In order to explore the layout principles of public service facilities within closed campuses, this study takes Zijingang Campus at Zhejiang University as an example. Specifically, it statistically analyzes the usage of E-bike charging piles on the campus and adjusts their spatial layout to improve their efficiency, while maintaining the same number of charging stations. The challenges of this study include statistically analyzing the usage of E-bike charging piles on campus through questionnaire surveys; dividing the demand areas for the charging piles based on users' travel patterns; and selecting the locations of the charging piles based on their spatiotemporal accessibility.

3.1. A Survey on the Current Usage of E-Bike Charging Piles on Campus

Zijingang Campus follows a typical functional clustering and production-oriented campus planning model. Thus, this study categorizes the layout of the campus into four types: Residential place (Rp), Work–office place (Wop), Work–teaching place (Wtp), and Consumption place (Cp). These functional clusters are coded for ease of statistical analysis in the subsequent research phase (Figure 4). To obtain information on the usage of E-bike charging piles on campus, a questionnaire survey was conducted in this study. The study has been approved by the Security Department of Zhejiang University and the Institute of Architectural Design and Theory at the College of Civil Engineering and Architecture,

Zhejiang University; ethical approval was not needed. The informed consent form can be found in Appendix A. The 30,000 people using E-bikes on campus daily can be categorized into four types based on their status and usage of different campus functions, namely undergraduates, master's students, doctoral students, and staff, with approximate ratios of 5:6:3:2. In this case, a total of 207 users, including 63 undergraduate students, 74 master's students, 44 doctoral students, and 26 staff members, responded to the survey, representing a distribution that closely aligns with the demographics of the total number of users on campus. Therefore, the data are typical and representative.



Figure 4. Zijingang Campus of Zhejiang University Planning Zoning Code.

Further analysis of users' charging needs reveals that out of the 207 participants, 197 find the current E-bike charging piles on campus inadequate to meet their charging needs. Among them, 158 users believe the main reason is the unreasonable layout of charging piles locations. Based on the findings, the users generally preferred to charge their E-bikes in areas where they spend longer periods of time. Users also considered the maximum acceptable walking distance to their next destination. In this case, it was an average of 380 m (Appendix B). According to the presurvey of E-bike charging pile users, and after combining their current usage patterns and charging demands, the locations of E-bike charging piles on Zijingang Campus do not align with the areas where users spend most of their time on a daily basis, which goes against their expectations.

To further ascertain the users' demands regarding the locations of E-bike charging piles, it is necessary to quantitatively study their maximum durations and locations as well as their commuting processes, i.e., their travel patterns. Therefore, this study conducted a campus commuting survey among the 207 users, further developing a travel model for E-bike charging pile users.

3.2. Classification of E-Bike Charging Pile Users Based on Travel Patterns

Conducting a comprehensive commuting survey is one of the most efficient ways to understand the commuting needs, preferences, and current practices of E-bike users [12]. It can also help guide decisions on campus transportation operations, planning, design, and infrastructure layout. Thus, this study utilizes trip chain demand models to examine the

travel processes of E-bike users. This concept originated in the 1960s and is commonly used to describe the ordered movements of travelers in spatial locations. It was first mentioned by Hagerstrand in his article "What About People in Regional Science?" presented at the European Regional Science Association conference in 1970 [73]. It is commonly used to describe the ordered movements of travelers in spatial locations. Based on the basic functional zoning of the campus, commuting on campus can be divided into several stages, such as "Rp-Wop/Wtp-Cp-Rp", which represents a complete trip chain. The trip chain not only contains spatial information but also includes temporal information, exhibiting coupling in both time and space dimensions (Figure 5).

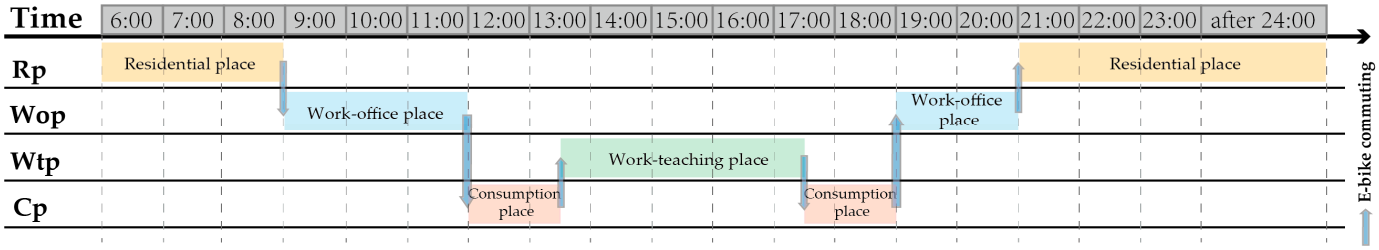


Figure 5. Typical schematic of the "Trip chain model".

In Chinese university campuses, students have a fixed timetable for classes and spend a significant amount of time traveling between classrooms and work/office locations. On the other hand, commutes to recreational areas are random, and activities, such as dining, exercising, and shopping, typically involve shorter stays than work or study-related engagements. As for the staff, they often commute between the campus gate and workplace by solely using E-bikes, resulting in a relatively straightforward travel pattern.

Overall, campus commuting exhibits strong regularity, with students from the same college/year sharing similar travel times and destinations. Meanwhile, staff members working in similar roles also follow comparable travel patterns. Hence, E-bike commutes on campus can be clustered into several trip chain types, based on the departure times and the different travel processes to and from destinations. However, in order to balance the charging needs of students and staff and maximize their satisfaction, further research is necessary to develop an effective guidance and control system for determining the construction and usage times of E-bike charging piles.

3.3. Charging Station Location Layout Based on Spatio-Temporal Accessibility

This study examines the spatiotemporal accessibility of E-bike charging piles on campus, while ensuring that these piles are actively chosen for use and do not impede the current traffic flow. In terms of spatiotemporal accessibility, this study quantitatively calculates the integration and choice of roads within the campus, thus dividing the hierarchy of road accessibility and traffic potential. This also enables the rational selection of E-bike charging pile locations.

As stated earlier, the space syntax is a method used to analyze and understand spatial configurations and their social effects. It can be used to quantitatively analyze the relationships between various spatial elements through the structure of human habitats, thereby uncovering the structure and spatial characteristics. It is commonly used in research on spatial accessibility, structural organization, and human activities [80]. It provides a series of tools and algorithms to assess spatial accessibility and betweenness. This study selects two variables, i.e., integration and choice, which, respectively, reflect the convenience of space relative to the overall system and the potential of space to attract traffic flow. Spatial accessibility is assessed using global integration, which calculates the shortest path length (in steps) from one node to all other nodes in the network. In this case, the higher the integration value, the greater the convenience of the space within the system, indicating higher accessibility. Spatial betweenness is assessed using choice, which calculates the total number of shortest paths that pass through a node. The higher the spatial choice value,

the greater the potential of the space to attract traffic flow within the system. In this study, the median values of integration and choice are used as thresholds to divide the levels of accessibility and traffic potential. Compared to the mean, the median can better distinguish the hierarchical relationships and prevent the extreme values of integration and choice on certain roads from affecting the calculations.

Therefore, this study codes the road network of Zijingang Campus and calculates the integration and choice of each road. For public service facilities, such as E-bike charging piles, it is advisable to select locations with high levels of accessibility but a relatively low traffic potential to ensure that they are both accessible to the majority of the users and do not disrupt current traffic conditions. This study uses DepthmapX for space syntax calculation and analysis. A metric distance of R = 380 m (based on the maximum acceptable walking distance after charging for Zijingang Campus users) is adopted to measure the road network of Zijingang Campus, obtaining the integration and choice of the roads (Figure 6). Based on the findings of Ge et al., this study suggests that E-bike charging piles should be placed in locations that are easily accessible and do not obstruct regular traffic flow [71]. However, the locations with the highest integration scores are often on both sides of main roads, which are not suitable for the placement of charging facilities. Thus, this study selects roads with integration at the second-highest level and choice at the lowest level for the placement of charging piles.



(**a**) (**b**)

Figure 6. (**a**) Integration of roads in Zijingang campus; (**b**) choice of roads in Zijingang campus.

In terms of spatiotemporal accessibility, if the charging piles are located far from areas where users stay for extended periods of time, then fewer users will be willing to spend a long time or travel long distances back to these areas after charging, leading to resource waste. Hence, when selecting locations, they should be placed within a walking distance of 380 m from areas where users stay for long time periods (Figure 7), increasing the likelihood that the charging piles will be selected by more users.

Based on the research methodology and survey findings, a series of trip chain demand models and a space location model are constructed in this study to select suitable locations for E-bike charging piles on Zijingang Campus. These selections are then compared and adjusted to suit campus planning and actual road conditions, resulting in the final layout of charging pile locations. Moreover, a user charging time model is constructed to explore the use of E-bike charging piles in different time periods, thus forming a guidance system for enhancing their efficiency. The study framework is presented in the following diagram (Figure 8).

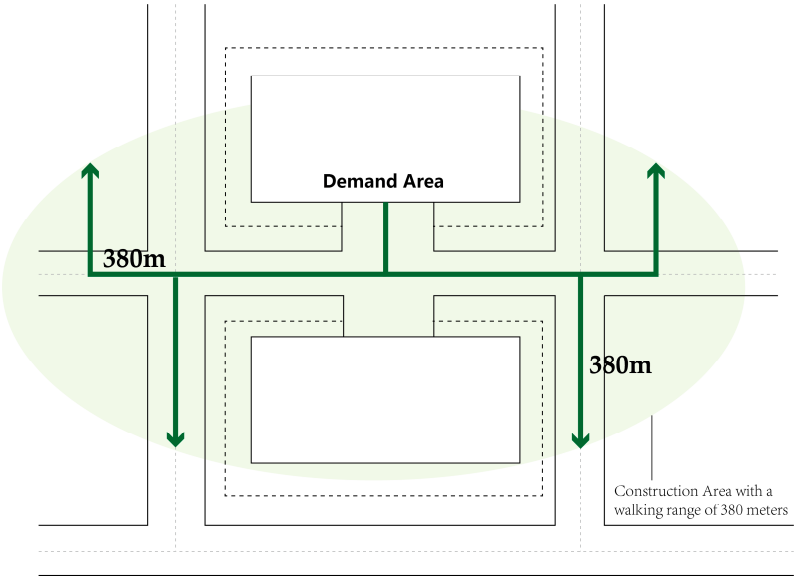


Figure 7. The construction scope of the "380 m walking circle" to meet temporal accessibility.

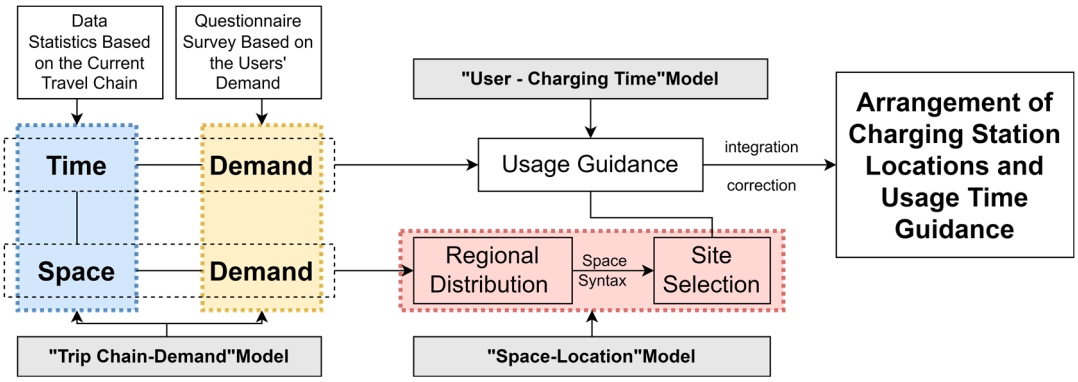


Figure 8. The conceptual framework of the study.

4. Results

4.1. Trip Chain Demand Analysis

This study analyzed the commuting processes of 207 E-bike charging pile users during regular weekdays into a series of trip-chain demand models. Based on the frequency of their regular trips on E-bikes and their usage time, our analysis resulted in four typical models: Type 1: "Morning–Noon–Evening Commute"; Type 2: "Noon–Evening Commute"; Type 3: "Morning–Noon Commute"; and Type 4: "Noon Commute" (Figure 9). According to the results, the student population was generally associated with Types 1, 2, and 3, with the majority spending more than 6 h at both office and residential locations. Conversely, the staff was predominantly associated with Type 4, with the majority spending more than 6 h in consumption areas. Both groups spent the longest time at their respective workplace locations, with nearly identical time periods. The main difference between the trip chain demand models was the different locations of their workplaces. In this regard, the frequency of selecting a location and the duration of stay at that location determined the users' demand for installing charging piles there, providing a basis for constructing more charging piles at various locations.

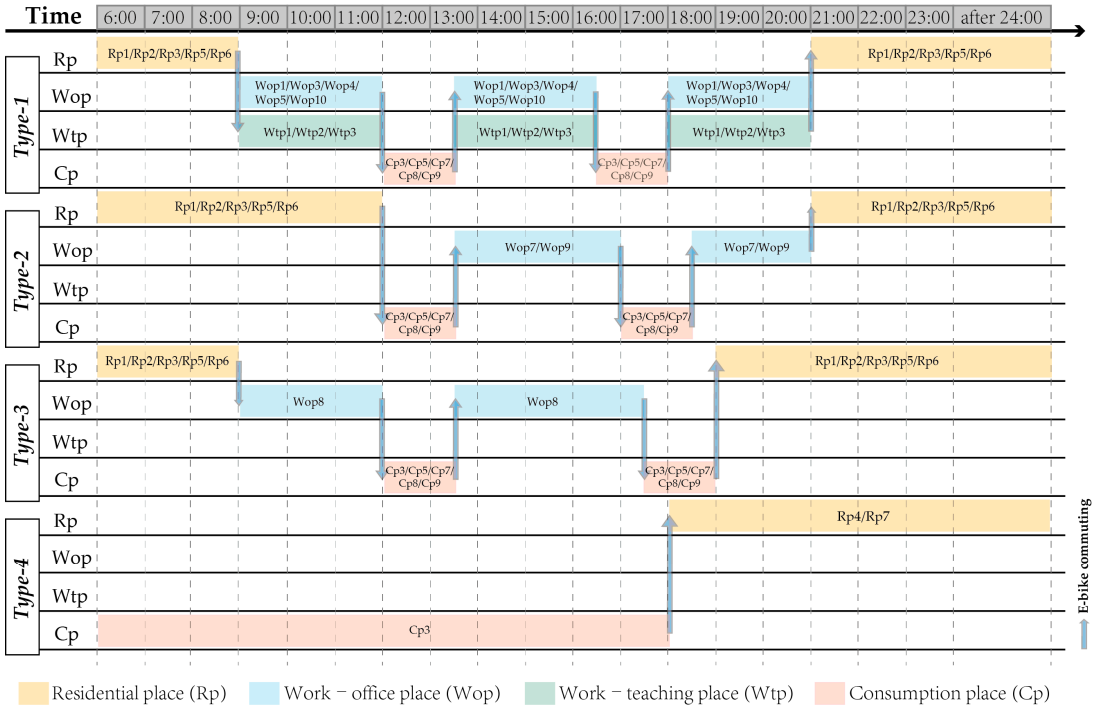


Figure 9. Four typical "Trip chain" models in the Zijingang Campus.

In order to adjust the layout of charging facilities at a minimum cost, without changing the current number of charging piles, this study constructed a demand-level model using "duration of stay" and "frequency of location selection" as variables (Figure 10). In other words, this model categorized the urgency of constructing charging stations at various locations. According to the results, the students spent the most frequent and longest durations at office locations such as Wop1 and Wop8 (teaching buildings, department classrooms, laboratories, etc.). Since the demand for charging facilities at these locations was the most pronounced, such facilities should be prioritized for construction. Charging facilities should also be installed at Cp3, since staff members spent a considerable amount of time there. Since office locations, such as Wop11 and Wtp3, are occasionally used by students, they should be considered a second level priority for the construction of charging piles. Meanwhile, Cp5 and Cp9 in the consumption area are frequently selected for stops, but the duration of stay is short. Consequently, only a small number of emergency charging stations should be constructed. Finally, Cp1 and Wop2 (hospitals and sports stadiums) have relatively short durations of stay and are selected for stops less frequently than other areas. Accordingly, they may not need to be considered for construction. These results provide a wide range of priority levels for the construction of E-bike charging piles on Zijingang Campus (Figure 11).

4.2. Space Location Analysis

This study categorizes the roads of Zijingang Campus based on the integration and choice values obtained from the encoding and space syntax analysis of the road network in Section 3.3. The calculation formula for road integration is as follows:

$$R_i = \frac{2\left(\sum_{j=1}^{n-1} d_{ij}\right)}{n-2}$$

d_{ij} is the shortest path length from node i to node j, and n is the total number of nodes. The calculation formula for choice is as follows:

$$C_i = \sum_{s \neq i \neq t} \frac{\sigma_{st}(i)}{\sigma_{st}}$$

σ_{st} is the total number of shortest paths from node s to node t. $\sigma_{st}(i)$ is the number of shortest paths from node s to node t that pass through node i.

After calculation, the highest integration value for all of the roads on the campus was 0.733, the lowest was 0.648, and the median was 0.692, while the highest choice value for the roads was 0.793, the lowest was 0, and the median was 0.003. By using the median as the dividing line, this study selected road sections with high levels of accessibility but low traffic potential as the locations for E-bike charging piles, ensuring that they are chosen by more users, without obstructing normal road traffic (Figure 12). In related research, Ge et al. mentioned that, in order to avoid causing traffic congestion, road sections with good levels of accessibility (second level integration) should be selected, rather than those with the best accessibility [71]. Therefore, the road sections selected in this study, as shown in Figure 13, should have charging piles installed in areas where accessibility is at the second level and traffic potential is low.

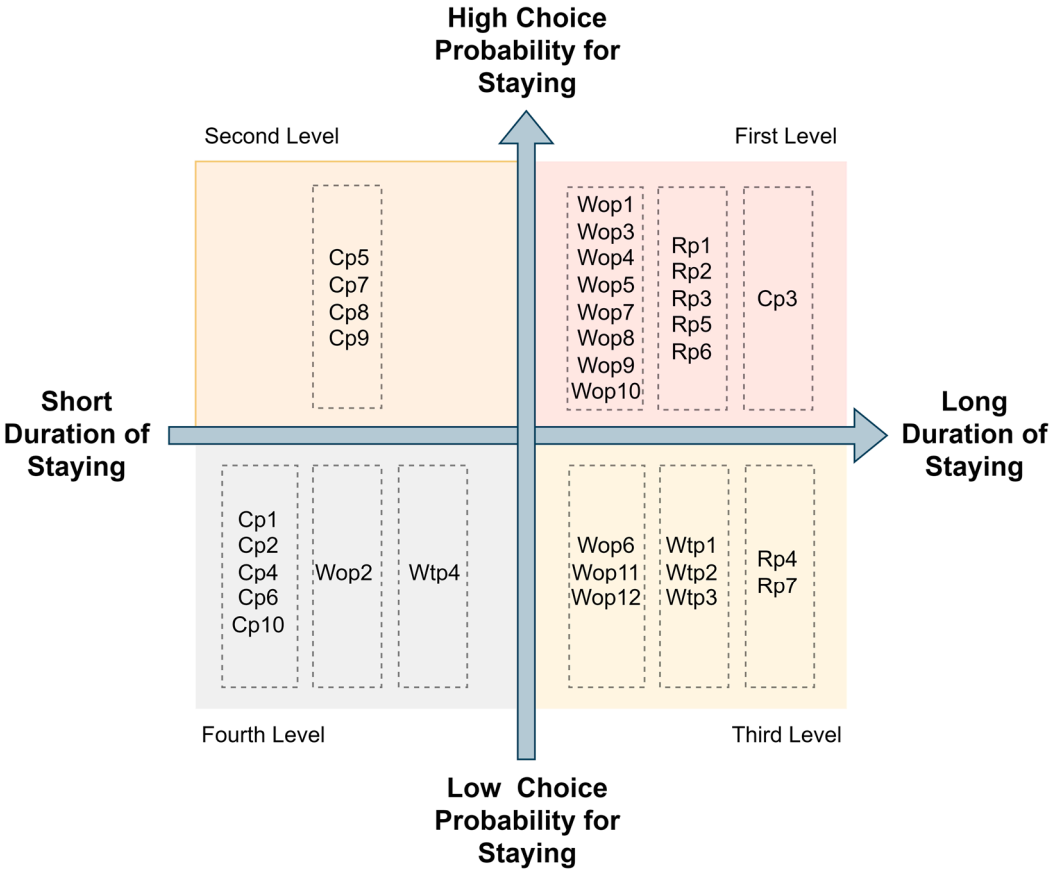


Figure 10. Model of the levels of demand for the construction of E-bike charging piles.

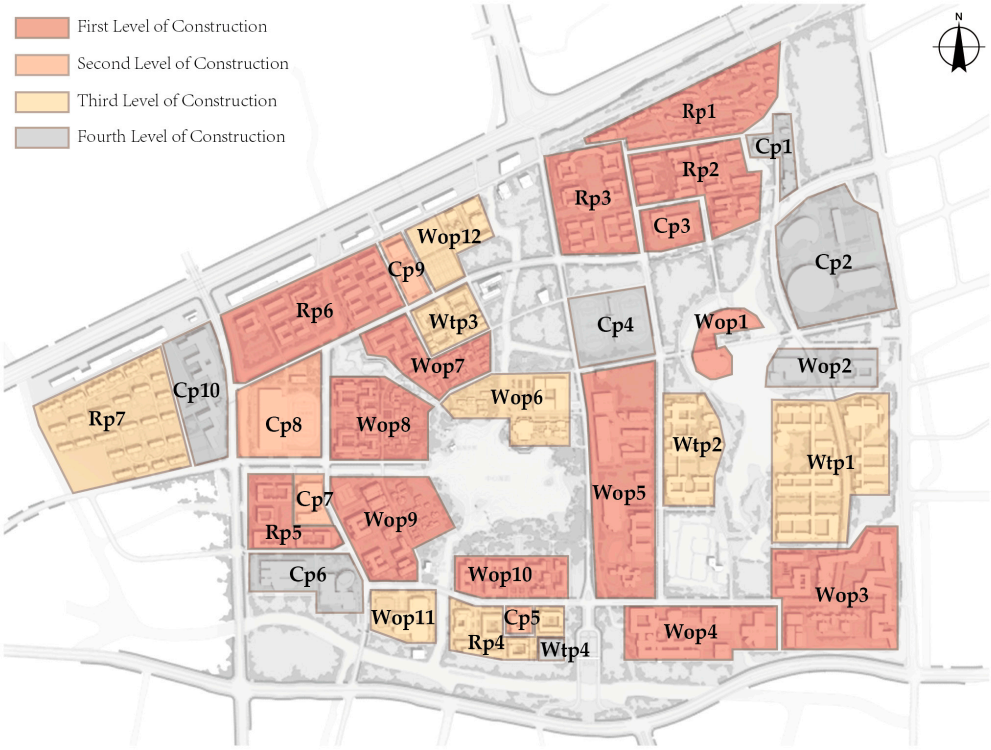


Figure 11. The range of construction priority levels for E-bike charging piles.

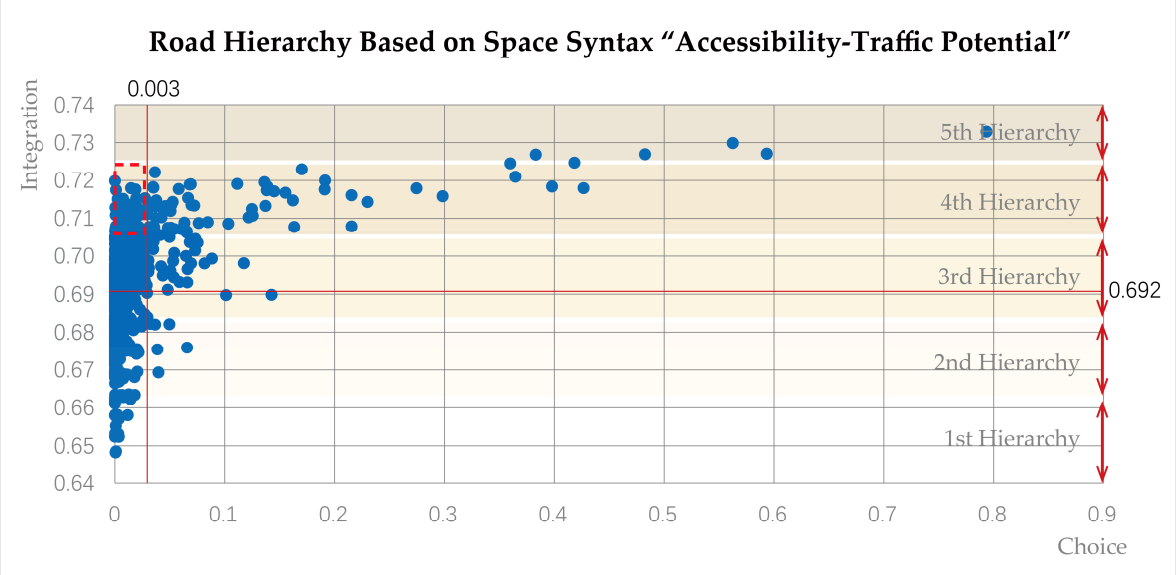


Figure 12. The grading of accessibility and traffic potential of roads in Zijingang Campus.

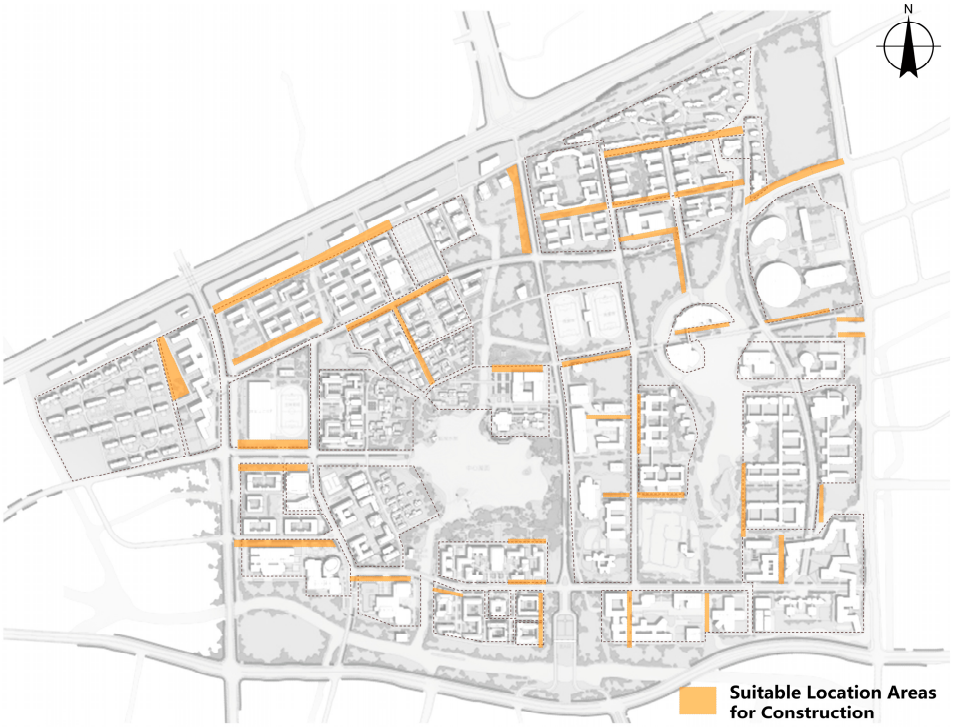


Figure 13. The suitable road areas for constructing charging piles in Zijingang Campus.

After selecting roads that meet the accessibility and traffic potential criteria through space syntax, the study will further delineate suitable construction areas for charging piles based on the demand construction hierarchy obtained in Section 4.1, using a 380 m walking circle.

5. Discussion

5.1. Placement Considering the Actual Demands of the User Groups

This study obtained the actual demands of each user group on Zijingang Campus (based on the trip chain demand models), distinguished the demand levels, and balanced the number of charging stations in each area, while keeping the total number of E-bike charging piles unchanged at 1324. According to the demand levels, the first level should have a sufficient number of charging piles to meet general demand, the second level should have fewer charging piles to accommodate some users, the third level should only include a small number of charging piles to meet emergency needs, and the fourth level should not include charging piles, since there was no demand from users.

Currently, existing charging piles in areas, such as Cp3, Wop3, and Wop4, which belong to the first level of construction demand, should remain unchanged. However, charging piles in areas such as Wtp2 and Wtp3 which currently have charging piles, but belong to the second and third levels of construction demand, should be partially relocated to areas belonging to the first level. Considering the estimated number of actual users, a higher number of charging piles should be installed in densely populated residential areas, while fewer charging piles should be set up in office and consumption areas. In this regard, the optimal layout and quantity of charging piles based on the balance of multiple user demands is shown in Figure 14.

This method of selecting public service facility sites based on the diverse needs of multiple stakeholders and the hierarchy of demands has also been confirmed by many scholars. For example, Thomas et al. established a model for the layout of ground-penetrating radar facilities based on the diverse needs of stakeholders in the Mapping the Underworld Project [81], while Rey integrated considerations from multiple stakeholders and criteria to comprehensively determine the siting of special waste storage facilities, along

with the necessary upgrades for both technical and non-technical decision making [82]. In related research, Achmad elucidated how systemic facilities can successfully enhance the tourism industry and quantified their performance by considering the needs of stakeholders and the dynamic environmental impacts [83], while Janssen assessed the preferences of three types of stakeholders (i.e., property developers, retail organizations, and local governments) toward surrounding retail planning schemes as well as their adaptation behaviors. According to these findings, facility siting based on demand balancing and hierarchical division can more accurately serve users, maximizing the satisfaction of their needs within the constraints of limited overall resources.

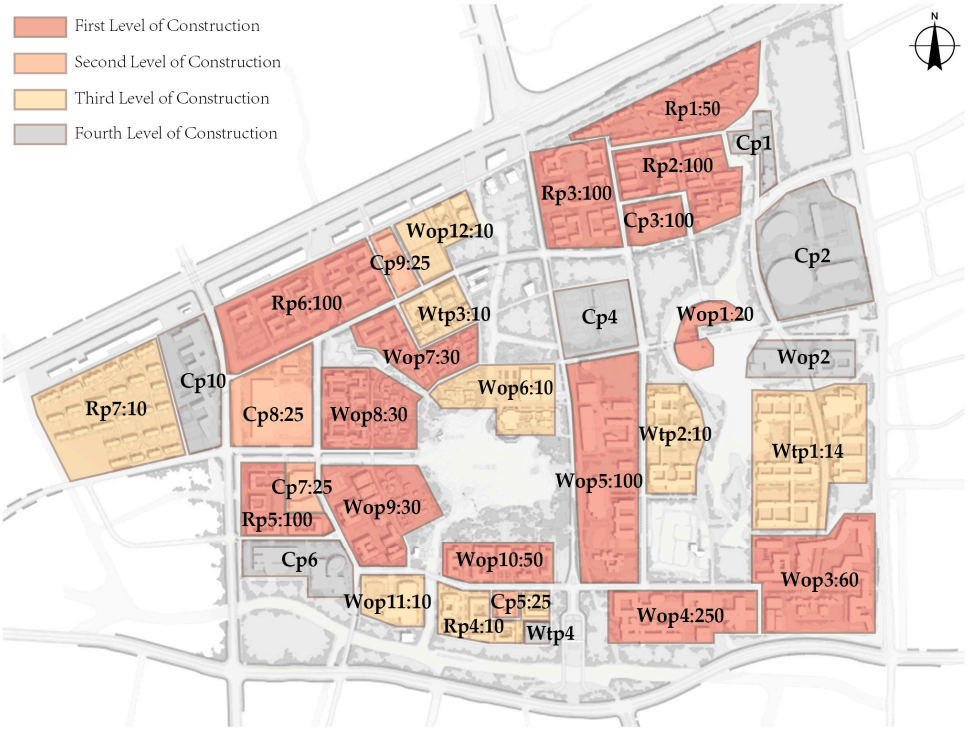


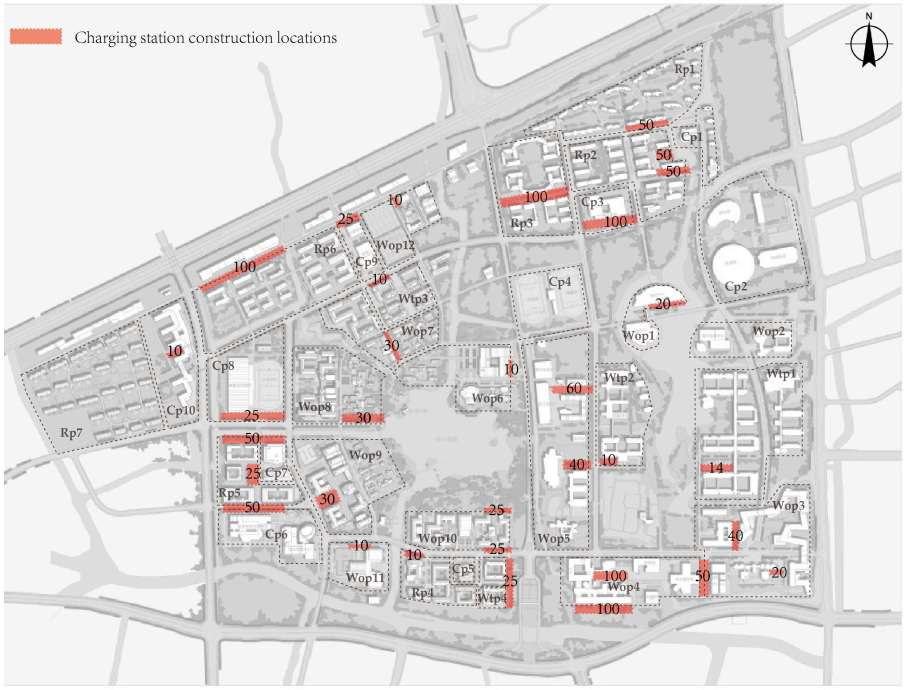
Figure 14. The number of charging piles in each area according to the demand.

5.2. Adjustment of Site Placement in Combination with Actual Road Attributes

This study selected suitable locations for constructing E-bike charging piles by using a coupled model of accessibility and traffic potential, and integrating them with the functions and planning of campus locations for the adjustment of site placement. Based on the results in Sections 4.2 and 5.1, and considering the 380 m "time accessibility" walking radius that meets users' comfort, preliminary areas for constructing E-bike charging piles can be selected. However, charging E-bikes poses significant safety hazards, and campus regulations stipulate that they must maintain a safe distance from buildings (i.e., no less than 9 m from office buildings and no less than 14 m from residential buildings). Meanwhile, existing landscaped areas on campus cannot be disrupted, and E-bike charging piles should be placed in open squares or along roadsides to ensure the uniformity of the campus landscape environment. Thus, after comparing these stipulations with the actual road conditions, the layout of E-bike charging piles was adjusted. The final construction plan is shown in Figure 15.

Altintasi et al. developed a multi-criteria decision support model by using a geographic information system, which integrated the location of E-bike charging piles with existing public transportation systems and points of interest to determine the optimal road network for placement. This model was replicated in other studies to achieve more environmentally sustainable and more operationally efficient charging systems [84]. For example, Larsen et al. objectively determined the optimal locations for new bicycle facilities

based on existing traffic data sources, and suggested enhancements/additions to the city's bicycle infrastructure [85], while Guo et al. proposed a principle for siting urban charging stations based on spatial semantics and individual activities. This method considered various factors, such as population density, current traffic network conditions, and existing charging infrastructure, to generate siting solutions with multi-party considerations [86]. In related research, Jordan et al. refined initial optimal configuration locations by overlaying social network activities and mobile information data, and utilizing genetic algorithms to optimize charging facility placement [87]. In sum, the selection of charging facilities for E-bikes requires careful consideration of multiple influencing factors. Furthermore, based on the theoretical models and data calculations, it is necessary to overlay the existing actual road network conditions and accessibility requirements to integrate the optimal deployment plan on Zijingang Campus.



Area	Current	Plan
Rp1	0	50
Rp2	122	100
Rp3	0	100
Rp4	90	10
Rp5	112	100
Rp6	0	100
Rp7	0	0
Cp1	0	0
Cp2	0	0
Cp3	177	100
Cp4	0	0
Cp5	0	25
Cp6	50	0
Cp7	0	25
Cp8	0	25
Cp9	196	25
Cp10	0	10
Wop1	20	20
Wop2	0	0
Wop3	67	60
Wop4	282	250
Wop5	90	100
Wop6	0	10
Wop7	0	30
Wop8	0	30
Wop9	0	30
Wop10	0	50
Wop11	0	10
Wop12	24	10
Wtp1	0	14
Wtp2	72	10
Wtp3	0	10
Wtp4	0	0

Figure 15. The adjusted number and layout of charging piles in Zijingang Campus.

5.3. Usage Guide of Charging Piles for Enhanced Sustainability and Efficiency

Based on the statistical analysis of the trip chain demand models, this study found significant differences in charging times between the students and staff. Specifically, the students generally chose to use charging piles after 14:00, while the staff tended to use them around 6:00, reflecting the concentrated working hours of these two groups. Currently, the 289 charging piles designated for the staff are largely idle after 16:00, whereas the 1013 charging piles designated for the students remain unused between 6:00 and 12:00, with high demand after 12:00. This disparity in charging times has led to the underutilization of dedicated charging piles on campus, resulting in the inefficient use of charging infrastructure resources. Thus, this study proposes a "time-based usage" charging pile utilization model, allowing charging piles typically reserved for the staff to be accessible to the students during certain time periods. For instance, the students can use the charging piles designated for the staff after 16:00, significantly improving the operational efficiency of existing charging piles and alleviating the current shortage of charging facilities on campus. The implementation of the usage guidance plan is shown in Figure 16.



Figure 16. Guidance scheme for campus E-bike charging piles utilization.

Currently, there is insufficient research on facility-based, time-of-use methods. However, some studies use algorithm models to optimize the usage balance and improve efficiency, thereby enhancing the sustainability of the system. Among the few studies, Park et al. aimed to reduce summer electricity burdens by enhancing the utilization of power facilities and balancing energy consumption by redistributing power loads when electrical infrastructure capacity is limited [88], while Khattak et al. utilized a discrete event simulation method based on phase-type distribution to evaluate performance and optimize the configuration of subway station service facilities [89]. Xu et al. constructed a dynamic shared system for dockless E-bikes using the Markov decision process and evaluated the performance of different operational service schemes through the dueling double deep Q-network reinforcement learning method, thereby optimizing usage schemes and improving system efficiency [90]. Jia et al. used a model-free intelligent scheduling approach based on the deep Q-learning method to intelligently coordinate variables such as available bicycles, bicycle locations, and user travel times, achieving a balance in the bike-sharing system and improving average utilization and customer satisfaction [91]. These findings indicate that combining the principle of facility utilization in different time periods based on users' demand can significantly enhance the utilization rate of the charging facilities, increase their efficiency, and promote sustainable development.

This study still discusses the optimization of E-bike charging piles layouts under ideal conditions. In reality, the layout of the charging piles at the Zijingang Campus of Zhejiang University has not yet been adjusted according to the experimental results. The optimization and renovation of E-bike charging piles on campus involve balancing funds, project approvals, and coordination among multiple parties, making it a complex process that cannot be completed overnight. Therefore, the results of this study are still at the stage of theoretical exploration, and the actual usage cannot yet be used to verify the research findings. However, the findings of this study have already gained the attention and recognition of the interviewed students, the school's security department, and the E-bike charging piles construction department. Moving forward, the optimization of charging facilities will be achieved through layout adjustments and time-based usage, thereby improving the efficiency of campus E-bike charging piles and user satisfaction.

6. Conclusions

In the context of the "mega-campus" concept, E-bikes have gradually become sustainable modes of transportation for campus commuting, making E-bike charging piles essential public service facilities on campus. This study integrated emerging public service facilities (e.g., E-bike charging piles) into pre-planned locations on campus in order to ensure their efficient and sustainable operation. For this purpose, this study explored the layout principles and methods of E-bike charging piles on campus through the construction of trip-chain demand models and the space location model. By proposing a user charging time guidance scheme, this study introduced a usage pattern for charging facilities based on different time slots in order to maximize the efficiency of existing resources. Additionally, this study addressed the layout issues affecting charging facilities within this large-scale campus by examining the relationship between spatiotemporal behavior and demand. It also refined the method for selecting sites for function-driven facilities within enclosed areas. The findings not only provide theoretical foundations and practical references for the layout and site selection of functional public service facilities within closed large-scale university campuses, but they also supplement the planning principles of public service facilities from the perspective of time geography theory.

Based on the current closed environment of the campus and the assumption of a same total number of E-bike charging piles, this study examined Zijingang Campus as an "isolated island", disregarding existing charging stations in surrounding residential areas, office districts, and other areas. However, future research should integrate the surrounding areas. Specifically, the perspective on charging station placement can be extended by considering the development of campus public service facilities in surrounding residential areas. For campuses under construction or in the planning stages, E-bike charging piles should be incorporated as essential public service facilities into the campus development framework. This integration should be coupled with adherence to safety standards, thus enhancing the construction principles and requirements. At the same time, as sustainable development becomes a major topic of our era and new technologies evolve rapidly, using "green and clean" energy is becoming a more suitable approach for modern societal development. In the future, when constructing new campus charging piles, emerging "green" charging piles using solar and wind power should be fully utilized. This will not only enhance the low-carbon and environmentally friendly effects of E-bike use but also increase the safety and stability of charging, avoiding potential hazards [92].

Finally, it should be noted that this study overlooked the inherent characteristics of E-bike charging piles and potential issues that may arise during their use. For example, it was assumed that charging piles can be immediately available for use when idle, resulting in a somewhat idealized spatiotemporal distribution pattern. However, in reality, E-bikes are often difficult to remove immediately after charging, indicating that charging piles may not become immediately available after use. Thus, to improve the utilization of E-bike charging piles on campus, policies regarding parking turnover and other measures are necessary. Furthermore, in order to simplify this model, this study homogenized the inherent attributes of E-bike charging piles such as charging power, ease of charging operation, and charging area safety. As a result, the conclusions may deviate from real-world operations. In this regard, to derive more accurate and comprehensive principles for E-bike charging pile layout and usage schemes, future research should consider various factors, including the inherent attributes of charging piles and users' tolerance for battery levels.

Author Contributions: Conceptualization, S.W. and H.X.; methodology, S.W. and H.X.; software, S.W. and H.X.; validation, S.W., H.X., B.Y., and X.P.; formal analysis, S.W. and H.X.; investigation, S.W., H.X., B.Y., X.P., and Z.Q.; resources, S.W., H.X., and Z.Q.; data curation, S.W.; writing—original draft preparation, S.W. and H.X.; writing—review and editing, S.W. and Z.Q.; visualization, S.W., H.X., B.Y., and X.P.; supervision, Z.Q.; project administration, Z.Q.; funding acquisition, Z.Q. All authors have read and agreed to the published version of the manuscript.

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Institutional Review Board Statement: This study does not involve any physiological data related to life sciences or medicine concerning human subjects. According to the document "Notice on Issuing the Measures for Ethical Review of Life Sciences and Medical Research Involving Humans" (Guo Wei Ke Jiao Fa [2023] No. 4, website: https://www.gov.cn/zhengce/zhengceku/2023-02/28/content_5743658.htm, accessed on 30 May 2024), this study does not require ethical approval.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: Data supporting reported results can be found at https://pan.zju.edu.cn/share/f1ae03505912267b386ebd7b0e (accessed on 23 May 2024).

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Conflicts of Interest: Authors Su Wang, Haihui Xie and Binwei Yun were employed by the company The Architectural Design and Research Institute of Zhejiang University Co., Ltd. The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest. The authors have no conflict of interest to declare. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

Appendix A

Informed Consent Form

This experiment has received approval from the Security Department of Zhejiang University and the Ethics Committee of the Institute of Architectural Design and Theory at the College of Civil Engineering and Architecture, Zhejiang University.

The experiment involves the collection of personal information data, including but not limited to personal details, daily commute data, and daily stopover data. We pledge that the collected data will only be used for relevant academic research and will be kept strictly confidential within the legal framework. Your name will not appear in any research summaries, articles, or public publications; only the identification number assigned to you in the experiment will be used.

Please participate in the experiment voluntarily according to your own willingness; you can withdraw at any time during the experiment.

If you have any comments or suggestions regarding this experiment, please contact the Institute of Architectural Design and Theory at the College of Civil Engineering and Architecture, Zhejiang University.

Contact person: Su Wang

Participant: Participation Date:

Appendix B

I. **Basic information**

1. What is your gender? A. Male B. Female
2. What is your affiliation at Zijingang Campus?
   A. Undergraduate student B. Master's student C. Ph.D. student D. Teacher E. School staff
3. Which is your residential area? Select from Rp1-Rp7 in Figure A1.
4. During which time slots do you stay in the residential area? (Multiple selections allowed)
   A. 6a.m.–7a.m. in the morning B. 8a.m.–9a.m. in the morning C. 10a.m.–11a.m. at noon D. 12a.m.–1p.m. at noon E. 2p.m.–3p.m. in the afternoon F. 4p.m.–5p.m. in the afternoon G. 6p.m.–7p.m. in the evening H. 8p.m.–9p.m. at night I. 10 p.m. at night-the next day J. Never
5. Which area is your affiliated college located in? Select from Wop1–Wop12; Wtp1–Wtp4 in Figure A1.
6. During which time slots do you stay in the affiliated college? (Multiple selections allowed)

A. 6a.m.–7a.m. in the morning B. 8a.m.–9a.m. in the morning C. 10a.m.–11a.m. at noon D. 12a.m.–1p.m. at noon E. 2p.m.–3p.m. in the afternoon F. 4p.m.–5p.m. in the afternoon G. 6p.m.–7p.m. in the evening H. 8p.m.–9p.m. at night I. 10 p.m. at night-the next day J. Never

7. Which area do you work or attend classes on a daily basis? Select from Wop1–Wop12; Wtp1-Wtp4 in Figure A1.
8. During which time slots do you work or attend classes on a daily basis? (Multiple selections allowed)
   A. 6a.m.–7a.m. in the morning B. 8a.m.–9a.m. in the morning C. 10a.m.–11a.m. at noon D. 12a.m.–1p.m. at noon E. 2p.m.–3p.m. in the afternoon F. 4p.m.–5p.m. in the afternoon G. 6p.m.–7p.m. in the evening H. 8p.m.–9p.m. at night I. 10 p.m. at night-the next day J. Never
9. Which area is the consumer venues you frequently visit located in? Select from Cp1–Cp10 in Figure A1.
10. During which time slots do you frequently visit the consumer venues? (Multiple selections allowed)
    A. 6a.m.–7a.m. in the morning B. 8a.m.–9a.m. in the morning C. 10a.m.–11a.m. at noon D. 12a.m.–1p.m. at noon E. 2p.m.–3p.m. in the afternoon F. 4p.m.–5p.m. in the afternoon G. 6p.m.–7p.m. in the evening H. 8p.m.–9p.m. at night I. 10 p.m. at night-the next day J. Never
11. Which area do you spend most of your time during the day? (Fill in examples such as Rp1, Wop1, etc. You can fill in multiple options.)



Figure A1. Zijingang Campus of Zhejiang University Functional Zoning Code.

II. Daily travel conditions

12. What is the frequency of your e-bike usage?
    A. 1–3 days per week B. 4–6 days per week C. Every day of the week D. Do not use E-bike for travel
13. During which time slots do you frequently use your E-bike? (Multiple selections allowed)
    A. 6a.m.–7a.m. in the morning B. 8a.m.–9a.m. in the morning C. 10a.m.–11a.m. at noon D. 12a.m.–1p.m. at noon E. 2p.m.–3p.m. in the afternoon F. 4p.m.–5p.m. in the afternoon G. 6p.m.–7p.m. in the evening H. 8p.m.–9p.m. at night I. 10 p.m. at night-the next day
14. What kind of trip do you usually take on your E-bike within the campus? (Multiple selections allowed)

A. Residential place (Rp)—Work-office place (Wop)
B. Residential place (Rp)—Consumption place (Cp, like cafeteria, gym)
C. Residential place (Rp)—Work-teaching place (Wtp)
D. Work-office place (Wop)—Work-teaching place (Wtp)
E. Work-office place (Wop)—Consumption place (Cp)
F. Work-teaching place (Wtp)—Consumption place (Cp)

III. **Usage of charging piles**

15. What is the frequency of you using the E-bike charging piles at Zijingang Campus?
A. Completely unused B. Once a week C. 2–3 times a week D. 4–5 times a week E. Use anytime during free time
16. During which time slots do you frequently use the E-bike charging piles?
A. 6a.m.–10a.m. B. 10a.m.–14p.m. C. 14p.m.–18p.m. D. 18p.m.–24p.m. E. Use anytime during free time
17. What is the charging piles location you usually use?

No.	Region
1	Property Dormitory Area C
2	The staff parking shed at the main cafeteria
3	The staff parking shed at the takeout department
4	The staff parking shed by the lake
5	The East Wing International Student Dormitory
6	College of Animal Science
7	South of Parking Lot East 4
8	North of the West Side of the Chemistry Laboratory Building
9	South of the West Side of the Chemistry Laboratory Building
10	College of Pharmacy
11	Anzhong Building
12	College of Agriculture
13	College of Medicine (North side of the road)
14	College of Medicine (South side of the road)
15	Property Dormitory (West Academic Zone)
16	West Wing International Student Dormitory
17	Within the Art Pavilion Compound
18	Outside the east side of the Art Pavilion compound
19	College of Life Sciences
20	Animal Hospital
21	Yinquan Dormitory North
22	Yuhu Dormitory

IV. **Demand for charging piles**

18. Do you think the current number of charging piles in the school is sufficient?
A. Yes B. No
19. Do you think the current arrangement of charging piles in schools is reasonable?
A. Yes B. No
20. Can you quickly find a suitable charging pile when you need to charge?
A. Yes B. No
21. From the perspective of your own convenience, which area on campus do you think should be equipped with charging piles? (Multiple options are available,

with a maximum of 4 options to choose from)
Select from Rp1–Rp7; Cp1–Cp10; Wop1–Wop12; Wtp1–Wtp4 in Figure A1.

22. What is the acceptable walking distance after charging? Select from 200/300/400/500/600/700/800m.

References

1. Göçer, Ö.; Göçer, K.; Başol, A.M.; Kıraç, M.F.; Özbil, A.; Bakovic, M.; Siddiqui, F.P.; Özcan, B. Introduction of a Spatio-Temporal Mapping Based POE Method for Outdoor Spaces: Suburban University Campus as a Case Study. *Build. Environ.* **2018**, *145*, 125–139. [CrossRef]
2. Maciel de Brito Soares, I.; Yamu, C.; Weitkamp, G. Space Syntax and Volunteered Geographic Information for University Campus Planning and Design: 12th International Space Syntax Symposium, SSS 2019. In Proceedings of the 12th International Space Syntax Symposium, Beijing, China, 8–13 July 2019; pp. 134.1–134.15.
3. Brockliss, L. Gown and Town: The University and the City in Europe, 1200–2000. *Minerva* **2000**, *38*, 147–170. [CrossRef]
4. Jiageng, N.; Lanlan, Z.; Xianghong, L. A Study on the Trip Behavior of Shared Bicycles and Shared Electric Bikes in Chinese Universities Based on NL Model—Henan Polytechnic University as an Example. *Phys. A Stat. Mech. Its Appl.* **2022**, *604*, 127855. [CrossRef]
5. Zhan, G.; Yan, X.; Zhu, S.; Wang, Y. Using Hierarchical Tree-Based Regression Model to Examine University Student Travel Frequency and Mode Choice Patterns in China. *Transp. Policy* **2016**, *45*, 55–65. [CrossRef]
6. He, S. Consuming Urban Living in 'Villages in the City': Studentification in Guangzhou, China. *Urban Stud.* **2015**, *52*, 2849–2873. [CrossRef]
7. Göçer, Ö.; Göçer, K.; Özcan, B.; Bakovic, M.; Kıraç, M.F. Pedestrian Tracking in Outdoor Spaces of a Suburban University Campus for the Investigation of Occupancy Patterns. *Sustain. Cities Soc.* **2019**, *45*, 131–142. [CrossRef]
8. Goddard, J.; Vallance, P. *The University and the City*; Routledge: London, UK, 2013; ISBN 978-0-203-06836-6.
9. Hall, P. The University and the City. *GeoJournal* **1997**, *41*, 301–309. [CrossRef]
10. Freestone, R.; Pullan, N. Evolution of Spatial Planning Strategies at Australian University Campuses 1945–2017. *Int. Plan. Hist. Soc. Proc.* **2018**, *18*, 800–810. [CrossRef]
11. Tan, H.; Chen, S.; Shi, Q.; Wang, L. Development of Green Campus in China. *J. Clean. Prod.* **2014**, *64*, 646–653. [CrossRef]
12. Unveiling the Commuting Experience of an Urban University Community—ProQuest. Available online: https://www.proquest.com/openview/cd5bb9099383c8c09d981a78230a1cbd/1?pq-origsite=gscholar&cbl=18750&diss=y (accessed on 24 May 2024).
13. Samsuddin, M.F.; Ahmad, S.N.A.; Ahmad, S.N. Sustainable Transport in Campus Area: E-Bike. In Proceedings of the 3rd International Conference on Business and Economics, Selangor, Malaysia, 21–23 September 2016; pp. 100–107.
14. Jia, X.; Cheng, P.; Chen, J. A Data Analysis and Visualization System for Large-Scale e-Bike Data. In Proceedings of the 2016 IEEE International Conference on Big Data (Big Data), Washington, DC, USA, 5–8 December 2016; pp. 3998–4000.
15. Technical Specification for Safety of Electric Bikes. Available online: https://baike.baidu.hk/item/%E7%94%B5%E5%8A%A8%E8%87%AA%E8%A1%8C%E8%BD%A6%E5%AE%89%E5%85%A8%E6%8A%80%E6%9C%AF%E8%A7%84%E8%8C%83/22342722 (accessed on 26 June 2024).
16. Yuan, L.; Dubaniewicz, T.; Zlochower, I.; Thomas, R.; Rayyan, N. Experimental Study on Thermal Runaway and Vented Gases of Lithium-Ion Cells. *Process Saf. Environ. Protect.* **2020**, *144*, 186–192. [CrossRef]
17. Liu, Z.; Guo, X.; Meng, N.; Yu, Z.; Yang, H. Study of Thermal Runaway and the Combustion Behavior of Lithium-Ion Batteries Overcharged with High Current Rates. *Thermochim. Acta* **2022**, *715*, 179276. [CrossRef]
18. Yerli, O.; Ozdede, S. Design Process of a Campus Plan: A Case Study of Duzce University Konuralp Campus. *Int. J. Eng. Res. Appl.* **2017**, *07*, 50–59. [CrossRef]
19. Mu, T.; Lao, Y. A Study on the Walkability of Zijingang East Campus of Zhejiang University: Based on Network Distance Walk Score. *Sustainability* **2022**, *14*, 11108. [CrossRef]
20. Conception of Planning Scheme of Zijingang West Campus of Zhejiang University—ProQuest. Available online: https://www.proquest.com/openview/66ae25c5b7ed9c92997f03abe1ccba1f/1?pq-origsite=gscholar&cbl=1596366 (accessed on 24 May 2024).
21. Wang, F.; Gong, C.; Wu, K. Operational Analysis of an Intelligent Traffic Management System on the Zijingang Campus of Zhejiang University. In Proceedings of the CICTP 2015, Beijing, China, 24–27 July 2015; pp. 466–475. [CrossRef]
22. Filippakou, O.; Tapper, T. Founding the New Universities of the 1960s: Interpreting the UGC's Strategy. In *Creating the Future? the 1960s New English Universities*; Filippakou, O., Tapper, T., Eds.; Springer International Publishing: Cham, Switzerland, 2019; pp. 17–29. ISBN 978-3-030-06091-6.
23. Lane, J.C. The Yale Report of 1828 and Liberal Education: A Neorepublican Manifesto. *Hist. Educ. Q.* **1987**, *27*, 325–338. [CrossRef]
24. Whitton, P.D. The New University: Space, Place and Identity. Doctoral Thesis, Manchester Metropolitan University, Manchester, UK, 2018.
25. Dober, R.P. *Campus Planning*; SCUP: Ann Arbor, MI, USA, 1996; ISBN 978-0-9601608-1-5.
26. Dober, R.P. *Campus Design*; J. Wiley: New York, NY, USA, 1992; ISBN 978-0-471-54258-2.
27. Dober, R.P. *Campus Architecture: Building in the Groves of Academe*; McGraw-Hill: New York, NY, USA, 1996; ISBN 978-0-07-017185-5.
28. Dober, R.P. *Campus Landscape: Functions, Forms, Features*; John Wiley & Sons: Hoboken, NJ, USA, 2000; ISBN 978-0-471-35356-0.

29. Tong, Q.; Tang, L.; Li, Q. Analysis of New Campus Planning for Wuhan University in the Early Republic of China (1929-1937). *J. Asian Archit. Build. Eng.* **2022**, *21*, 34–47. [CrossRef]
30. Gown and Town: University Spatial Development and Urban Transformation in the Knowledge Society. The Case of Shanghai. Available online: https://www.politesi.polimi.it/handle/10589/75104 (accessed on 24 May 2024).
31. Liu, Y.; Liu, C.; Wang, X.; Zhang, J.; Yang, Y.; Wang, Y. Exploring the Layout Optimization of Commercial Service Space Affecting Energy Consumption in Communities Using Machine Learning. *Buildings* **2024**, *14*, 108. [CrossRef]
32. Systemadmin_Umwelt Nachhaltige Mobilität. Available online: https://www.umweltbundesamt.de/themen/verkehr/nachhaltige-mobilitaet (accessed on 26 June 2024).
33. Nachhaltige Mobilität—Neue Technologien für die Verkehrswende—Fraunhofer ISE. Available online: https://www.ise.fraunhofer.de/de/nachhaltige-mobilitaet.html (accessed on 26 June 2024).
34. Pereira, R.C.; Branchi, B.A.; Lombardo Ferreira, D.H. Sustainable Urban Mobility Diagnosis: Applicability of a Composite Index. *J. Innov. Sustain. RISUS* **2021**, *12*, 16–29. [CrossRef]
35. Brcic, D.; Sostaric, M.; Sojat, D. Sustainable Urban Mobility Plans. In *Proceedings of the Road and Rail Infrastructure IV*; Lakusic, S., Ed.; University of Zagreb, Faculty of Civil Engineering: Zagreb, Republika Hrvatska, 2016; pp. 373–377.
36. Damidavicius, J.; Burinskiene, M.; Uspalyte-Vitkuniene, R. A Monitoring System for Sustainable Urban Mobility Plans. *Balt. J. Road. Bridge. Eng.* **2019**, *14*, 158–177. [CrossRef]
37. Shi, J.; Guo, Q.; Lv, Q.; Zhao, X. From Accessibility of Traffic to Accessibility of Service: The Spatial Analysis of N-Minute Service Circle of Urban Park System. *J. Asian Archit. Build. Eng.* **2023**, *22*, 3680–3702. [CrossRef]
38. Mei, W.; Symaco, L.P. Higher Education for Development: The Role of University Towns in China. *Sage Open* **2021**, *11*, 21582440211046586. [CrossRef]
39. Jiang, J.; Gong, L.; Li, Y. Establishment and Empirical Analysis of Evaluation Index System for Basic Public Service Level of Transportation. *MATEC Web Conf.* **2017**, *124*, 01004. [CrossRef]
40. Liu, H. Public Facilities Design around South River of Shenyang Aerospace University. Doctoral Thesis, Shenyang Aerospace University, Shenyang, China, 2015.
41. Stessens, P.; Khan, A.Z.; Huysmans, M.; Canters, F. Analysing Urban Green Space Accessibility and Quality: A GIS-Based Model as Spatial Decision Support for Urban Ecosystem Services in Brussels. *Ecosyst. Serv.* **2017**, *28*, 328–340. [CrossRef]
42. Li, C.; Xia, W.; Chai, Y. Delineation of an Urban Community Life Circle Based on a Machine-Learning Estimation of Spatiotemporal Behavioral Demand. *Chin. Geogr. Sci.* **2021**, *31*, 27–40. [CrossRef]
43. Ma, Q. Optimization of Charging Station Layout Based on Spatiotemporaldistribution Forecast Charging Load and Research on Orderly Chargingand Discharging Strategies of Electric Vehicles. Doctoral Thesis, Xi'an University of Technology, Xi'an, China, 2024.
44. Quddus, M.A.; Shahvari, O.; Marufuzzaman, M.; Ekşioğlu, S.D.; Castillo-Villar, K.K. Designing a Reliable Electric Vehicle Charging Station Expansion under Uncertainty. *Int. J. Prod. Econ.* **2021**, *236*, 108132. [CrossRef]
45. Zhu, Z.-H.; Gao, Z.-Y.; Zheng, J.-F.; Du, H.-M. Charging Station Location Problem of Plug-in Electric Vehicles. *J. Transp. Geogr.* **2016**, *52*, 11–22. [CrossRef]
46. Zhou, G.; Zhu, Z.; Luo, S. Location Optimization of Electric Vehicle Charging Stations: Based on Cost Model and Genetic Algorithm. *Energy* **2022**, *247*, 123437. [CrossRef]
47. Yagcitekin, B.; Uzunoglu, M. A Double-Layer Smart Charging Strategy of Electric Vehicles Taking Routing and Charge Scheduling into Account. *Appl. Energy* **2016**, *167*, 407–419. [CrossRef]
48. Murad, A.; Faruque, F.; Naji, A.; Tiwari, A.; Qurnfulah, E.; Rahman, M.; Dewan, A. Optimizing Health Service Location in a Highly Urbanized City: Multi Criteria Decision Making and P-Median Problem Models for Public Hospitals in Jeddah City, KSA. *PLoS ONE* **2024**, *19*, e0294819. [CrossRef]
49. Wang, F. Measurement, Optimization, and Impact of Health Care Accessibility: A Methodological Review. *Ann. Assoc. Am. Geogr.* **2012**, *102*, 1104–1112. [CrossRef]
50. Murray, A.T. Maximal Coverage Location Problem: Impacts, Significance, and Evolution. *Int. Reg. Sci. Rev.* **2016**, *39*, 5–27. [CrossRef]
51. Xifeng, T.; Ji, Z.; Peng, X. A Multi-Objective Optimization Model for Sustainable Logistics Facility Location. *Transp. Res. Part D Transp. Environ.* **2013**, *22*, 45–48. [CrossRef]
52. Ashibani, Y.; Mahmoud, Q.H. A Behavior-Based Proactive User Authentication Model Utilizing Mobile Application Usage Patterns. In *Proceedings of the Advances in Artificial Intelligence*; Meurs, M.-J., Rudzicz, F., Eds.; Springer International Publishing: Cham, Switzerland, 2019; pp. 284–295.
53. Hakimi, S.L. Optimum Locations of Switching Centers and the Absolute Centers and Medians of a Graph. *Oper. Res.* **1964**, *12*, 450–459. [CrossRef]
54. Yao, Y.; Zhou, C. Study on the Correlation between User Emotional Benefits and Their Perception of Campus Outdoor Spaces—Take Longquan Campus of Yunnan University of Finance and Economics as an Example. *J. Innov. Dev.* **2023**, *4*, 76–82. [CrossRef]
55. Liu, S.; Guo, H.; Su, L. Evaluation of Quality of Life in Urban Life Circles from a Composite Perspective of Subjective Needs and the Supply of Public Amenities: A Case Study of Changbai Island, Shenyang. *Sustainability* **2023**, *15*, 10095. [CrossRef]
56. Wang, J.; Zhang, X.; Chai, Y.; Kwan, M.-P. A Context-Based Approach for Neighbourhood Life Circle Delineation and Internal Spatial Utilization Analysis Based on GIS and GPS Tracking Data. *Appl. Spat. Anal. Policy* **2023**, *16*, 1493–1515. [CrossRef]

57. Zhang, H.; Tang, L.; Yang, C.; Lan, S. Locating Electric Vehicle Charging Stations with Service Capacity Using the Improved Whale Optimization Algorithm. *Adv. Eng. Inform.* **2019**, *41*, 100901. [CrossRef]
58. Wang, Z.; Yang, Q.; Wang, C.; Wang, L. Spatial Layout Analysis and Evaluation of Electric Vehicle Charging Infrastructure in Chongqing. *Land* **2023**, *12*, 868. [CrossRef]
59. Rane, N.L.; Achari, A.; Saha, A.; Poddar, I.; Rane, J.; Pande, C.B.; Roy, R. An Integrated GIS, MIF, and TOPSIS Approach for Appraising Electric Vehicle Charging Station Suitability Zones in Mumbai, India. *Sustain. Cities Soc.* **2023**, *97*, 104717. [CrossRef]
60. Hansen, W.G. How Accessibility Shapes Land Use. *J. Am. Inst. Plan.* **1959**, *25*, 73–76. [CrossRef]
61. Anderson, P.; Levinson, D.; Parthasarathi, P. Accessibility Futures. *Trans. GIS* **2013**, *17*, 683–705. [CrossRef]
62. Ingram, D.R. The Concept of Accessibility: A Search for an Operational Form. *Reg. Stud.* **1971**, *5*, 101–107. [CrossRef]
63. Yan, J. Study on Evaluation Method of Spatial Accessibility of Urban Public Service Facilities. Doctoral Thesis, Southeast University, Dhaka, Bangladesh, 2017.
64. Wachs, M.; Kumagai, T.G. Physical Accessibility as a Social Indicator. *Socio-Econ. Plan. Sci.* **1973**, *7*, 437–456. [CrossRef]
65. Zhang, Z.; Ma, G.; Lin, X.; Dai, H. Accessibility in a Multiple Transport Mode Urban Park Based on the "D-D" Model: A Case Study in Park City, Chengdu. *Cities* **2023**, *134*, 104191. [CrossRef]
66. Liu, H. Study on Location, Capacity and Operation Decision of Electric Vehicle Charging Station Considering Multi-Subject Interests. Doctoral Thesis, Northeast Electric Power University, Jilin, China, 2024.
67. Zhang, L.; Tian, F.; Zheng, X.; Sun, Z. Spatial Configuration of Fire Protection for Historical Streets in China Using Space Syntax. *J. Cult. Herit.* **2023**, *59*, 140–150. [CrossRef]
68. Qanazi, S.; Hijazi, I.H.; Shahrour, I.; Meouche, R.E. Exploring Urban Service Location Suitability: Mapping Social Behavior Dynamics with Space Syntax Theory. *Land* **2024**, *13*, 609. [CrossRef]
69. Zhang, S. Spatial Accessibility Analysis of Primary schools Based on Geographical Conditions Monitoring Results: Take the Main Urban Area of Fuzhou as an Example. *Geomat. Spat. Inf. Technol.* **2022**, *45*, 147–150+153.
70. Zhao, Y.; Qin, M.; Shi, Q. The Accessibility Analysis of Urban Park Green Space Based on spatial syntax: Taking the Central City of Guangzhou as an Example. *J. Spatio-Temporal Inf.* **2022**, *29*, 40–45.
71. Ge, Y.; Li, J. Research on Layout Planning of Automobile Charging Pile Based on Nuclear Density Analysis and Space Syntax—A Case of Wuhan in Hubei. *Urban. Archit.* **2019**, *16*, 41–45. [CrossRef]
72. Dodge, S.; Nelson, T.A. A Framework for Modern Time Geography: Emphasizing Diverse Constraints on Accessibility. *J. Geogr. Syst.* **2023**, *25*, 357–375. [CrossRef]
73. Hägerstrand, T. Reflections on "What about People in Regional Science"? In *Papers of the Regional Science Association*; Springer: Berlin/Heidelberg, Germany, 1989; Volume 66, pp. 1–6. [CrossRef]
74. Chen, B.Y.; Yuan, H.; Li, Q.; Wang, D.; Shaw, S.-L.; Chen, H.-P.; Lam, W.H.K. Measuring Place-Based Accessibility under Travel Time Uncertainty. *Int. J. Geogr. Inf. Sci.* **2017**, *31*, 783–804. [CrossRef]
75. Kibambe Lubamba, J.-P.; Radoux, J.; Defourny, P. Multimodal Accessibility Modeling from Coarse Transportation Networks in Africa. *Int. J. Geogr. Inf. Sci.* **2013**, *27*, 1005–1022. [CrossRef]
76. Benenson, I.; Ben-Elia, E.; Rofé, Y.; Geyzersky, D. The Benefits of a High-Resolution Analysis of Transit Accessibility. *Int. J. Geogr. Inf. Sci.* **2017**, *31*, 213–236. [CrossRef]
77. Li, Q.; Zhang, T.; Wang, H.; Zeng, Z. Dynamic Accessibility Mapping Using Floating Car Data: A Network-Constrained Density Estimation Approach. *J. Transp. Geogr.* **2011**, *19*, 379–393. [CrossRef]
78. Levinson, D.; Marion, B.; Owen, A.; Cui, M. The City Is Flatter: Changing Patterns of Job and Labor Access. *Cities* **2017**, *60*, 124–138. [CrossRef]
79. Li, W.; Hsu, C.-Y. GeoAI for Large-Scale Image Analysis and Machine Vision: Recent Progress of Artificial Intelligence in Geography. *ISPRS Int. J. Geo-Inf.* **2022**, *11*, 385. [CrossRef]
80. Alkamali, N.; Alhadhrami, N.; Alalouch, C. Muscat City Expansion and Accessibility to the Historical Core: Space Syntax Analysis. *Energy Procedia* **2017**, *115*, 480–486. [CrossRef]
81. Thomas, A.M.; Rogers, C.D.F.; Metje, N.; Chapman, D.N. A Stakeholder Led Accuracy Assessment System for Utility Location. In Proceedings of the 2007 4th International Workshop on, Advanced Ground Penetrating Radar, Naples, Italy, 27–29 June 2007; pp. 272–277.
82. Rey, M.; Soriano, P.; Stampfli, E. La Localisation D'Une Installation De Stockage De Dechets Stabilises: Le Cas De La Suisse Romande. *INFOR Inf. Syst. Oper. Res.* **1995**, *33*, 50–62. [CrossRef]
83. Achmad, F.; Prambudia, Y.; Rumanti, A.A. Improving Tourism Industry Performance through Support System Facilities and Stakeholders: The Role of Environmental Dynamism. *Sustainability* **2023**, *15*, 4103. [CrossRef]
84. Altintasi, O.; Yalcinkaya, S. Siting Charging Stations and Identifying Safe and Convenient Routes for Environmentally Sustainable E-Scooter Systems. *Sustain. Cities Soc.* **2022**, *84*, 104020. [CrossRef]
85. Larsen, J.; Patterson, Z.; El-Geneidy, A. Build It. But Where? The Use of Geographic Information Systems in Identifying Locations for New Cycling Infrastructure. *Int. J. Sustain. Transp.* **2013**, *7*, 299–317. [CrossRef]
86. Guo, M.; Zhang, Y.; Zhao, L. Electric Vehicle Charging Station Siting Method Based on Spatial Semantics and Individual Activities. *J. Comput. Appl.* **2023**, *43*, 2819. [CrossRef]
87. Jordán, J.; Palanca, J.; del Val, E.; Julian, V.; Botti, V. Localization of Charging Stations for Electric Vehicles Using Genetic Algorithms. *Neurocomputing* **2021**, *452*, 416–423. [CrossRef]

88. Park, J.; Park, S.; Ok, C. Optimal Factory Operation Planning Using Electrical Load Shifting under Time-Based Electric Rates. *J. Adv. Mech. Des. Syst. Manuf.* **2016**, *10*, JAMDSM0085. [CrossRef]
89. Khattak, A.; Yangsheng, J.; Abid, M.M. Optimal Configuration of the Metro Rail Transit Station Service Facilities by Integrated Simulation-Optimization Method Using Passengers' Flow Fluctuation. *Arab. J. Sci. Eng.* **2018**, *43*, 5499–5516. [CrossRef]
90. Xu, M.; Di, Y.; Zhu, Z.; Yang, H.; Chen, X. Designing Van-Based Mobile Battery Swapping and Rebalancing Services for Dockless Ebike-Sharing Systems Based on the Dueling Double Deep Q-Network. *Transp. Res. Pt. C-Emerg. Technol.* **2022**, *138*, 103620. [CrossRef]
91. Jia, L.; Yang, D.; Ren, Y.; Feng, Q.; Sun, B.; Qian, C.; Li, Z.; Zeng, C. An Electric Fence-Based Intelligent Scheduling Method for Rebalancing Dockless Bike Sharing Systems. *Appl. Sci.* **2022**, *12*, 5031. [CrossRef]
92. Huang, X.; Xu, C.; Wang, P.; Liu, H. LNSC: A Security Model for Electric Vehicle and Charging Pile Management Based on Blockchain Ecosystem. *IEEE Access* **2018**, *6*, 13565–13574. [CrossRef]

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