Research on the Daily Travel Behavior Characteristics of the Elderly in New Urban Areas in China Based on GNSS Trajectory

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The Asian Conference on Aging & Gerontology 2024
Official Conference Proceedings

Abstract

The community living circle is the basic unit of urban community life. As one of the most active user groups, the elderly's daily travel behavior plays an important guiding role in the spatial layout planning of community facilities. This study uses the GNSS action tracking method, taking Binhu Century Community in new urban areas in Hefei, China as an example, to obtain 222 sets of valid daily travel action data of the elderly, and combines ArcGIS kernel density to analyze the facilities accessibility and select preferences of the elderly's daily travel, and explore the mobility characteristics and influencing factors of daily travel for the elderly in new urban areas through movement trajectories, walking distances and walking speeds. Then we explore the correlation between the layout of community facilities, the composition of surrounding space in the community and the travel behavior of the elderly. The study found that the travel behavior of the elderly in the new urban area is mainly concentrated on resting, shopping, etc., the travel distance is concentrated between 250-500 meters, and the trajectory lines are mainly concentrated along the walking space of urban roads. The study ultimately proposes improvement strategies and management measures to optimize the configuration of age-friendly community facilities and the community space environment.

Keywords: GNSS Trajectories, The Elderly, Daily Life Circles, Travel Behavior Characteristics, New Urban Areas

Introduction

The aging of the global population has become a trend, and the United Nations' "World Social Report 2023" proposed that the rights and well-being of the elderly should be given priority. As the largest developing country, China's population will enter a severely aging society, so it will actively respond to population aging into its national strategy. The "14th Five-Year Plan" National Aging Care Development and Elderly Care Service System Plan released in 2022 proposes to improve requirements include supporting community service facilities, optimizing the land layout of service facilities, promoting barrier-free and aging-friendly renovation of the public environment, and building a "quarter-of-an-hour" home care service circle. In the context of actively responding to aging, China's elderly care model needs to shift from institutional care to a new care model that combines community care and home care. Therefore, urban and rural communities, as the basic units of the elderly's lives, are important spatial carriers for the construction of community care systems. The community living circle is related to the living quality of community residents, especially how to optimize the construction of a living circle suitable for the elderly in the future is a topic that needs to be discussed now. Among them, the layout and spatial environment of community service facilities are important factors in the study of community aging. However, often due to lack of data and imperfect facility systems, scholars rarely explore the daily travel behavior characteristics of the elderly from the perspectives of community environment and community living circles.

In terms of research on the living circle and behavior of the elderly in the community, Huang Jianzhong (2019) identified the spatial characteristics of the elderly's daily life circle by analyzing the spatiotemporal behavioral characteristics of the elderly. Xu Leiqing et al. (2021) studied the form of age-friendly community living circles and highly pedestrian-friendly living circles from the perspective of scope. Research on the behavioral needs of the elderly mainly focuses on elderly care service facilities. For example, Tsang Zuyu (2011) used behavior setting theory to study the behavioral characteristics and activity mix behaviors of the elderly in day care service centers in Taiwan by tracking their behavioral content, interaction conditions and activity types. Li Bin et al. (2015) proposed a type segmentation plan for day care facilities based on the behavioral preferences of the elderly in choosing facility types, and found that the day care facility type element content combinations that the elderly most need are “nursing and health care services, walking within 15 minutes , care insurance, proximity to hospitals”. In addition, community aging-friendly renovation is also a practical exploration to deal with the aging of urban living space. Martin Lux and Peter Zunega (2014) analyzed sample data from eight European countries and concluded that the diversity and innovation of housing stock, housing policies, and choices are more conducive to the housing choices of the elderly under urban aging. Li Yuanyuan et al. (2022) took Beijing's Fatou Street as an example and proposed a full-factor, systematic aging-friendly community support system.

With the development of technological means, the use of positioning sensors, spatiotemporal big data, and artificial intelligence to obtain human behavior and movement trajectories has been further developed, allowing quantitative behavioral data to be combined with traditional qualitative questionnaire interviews to optimize travel behavior research. GNSS (Global Navigation Satellite System) can achieve precise positioning and has been widely used in various fields such as transportation, network, geological exploration, urban planning, etc., mainly including GPS, GLONASS, GALILEO and BDS. In the field of urban planning and architecture disciplines, Daisuke Matsushita (2010) used handheld GPS to measure the movement paths of hundreds of elementary school students after school, in Nagahama City, Japan, and studied the relationship between the movement areas of elementary school students and the characteristics of the school district. Li Zao (2008) used GPS to study the behavior of residents in waterscape spaces in residential areas in China, and quantitatively analyzed the correlation between residents' behavioral activities in waterfront spaces and site characteristics and landscape facilities. Zhou Suhong et al. (2016) analyzed the traffic generation and distribution characteristics of residential areas based on GPS start-end correlation through spatiotemporal mining of taxi GPS data during the commuting peak period, and studied the spatial relationship between urban employment and residence. Sun Xia (2016) used GPS technology to track and investigate the routes of primary school students in three primary schools in Hefei City, compared behavioral trajectory maps and action circle diagrams, and explored the planning layout, school zone divisions and service radius settings of urban primary schools. In addition, Qiu Zhiwei (2017), Xu Yishan (2019), and Yu Yifan (2021) respectively used GPS to collect and analyze data on the daily life activity trajectories of the elderly, and study the daily behaviors and living circles of the elderly in urban communities as well as the healthy community environment for the elderly. Wu Zhijian et al. (2019) analyzed the GPS activity trajectories of the elderly in Nanjing, used MATLAB spatiotemporal density trend surface visualization technology and GIS measurement spatial area analysis and compared the spatiotemporal characteristics of outdoor physical activities of the elderly in different communities in Nanjing, and explored community differentiation of spatiotemporal characteristics of the elderly outdoor physical activity in different communities.

The popularization of GNSS equipment and the advancement of sensing technology allow researchers to continuously understand the use of community spaces. Therefore, this article uses a GNSS behavioral trajectory survey combined with a questionnaire survey to measure the longitude, latitude, speed and direction data of trajectory points, and uses quantitative and visual methods to analyze the daily travel behavior characteristics of the elderly and the use characteristics of community living space, and then grasp the correlation between the elderly's travel behavior and community space layout, and optimize the layout of community service facilities and space usage environment that are more in line with the daily use of the elderly.

Survey Summary and Data Processing

Survey Overview

Based on the preliminary inspection of community space, it was found that the community scale in new urban areas of Hefei is larger and the facilities are more concentrated. Therefore, this article selected the representative Binhu Century Community in new urban areas, Hefei as a sample to carry out experimental investigation and research.

Binhu Century Community is in the core start-up area of Binhu New District, Baohe District, Hefei. It is the first street-level community established in the reform of the street housing system in Hefei. It is a national model elderly-friendly community and a national model community for harmonious community construction. There are more than ten modern residential areas in the community, such as Binhu Harmony Garden and Binhu Holiday Fengdanyuan Community, as well as city-level facilities such as Binhu Hospital, Binhu International Convention and Exhibition Center, and Binhu International Shopping Center. In the community, there are Urban main roads, such as Huizhou Avenue, Luzhou Avenue, Jinxiu Avenue, Fangxing Avenue, and Ziyun Road, and urban secondary roads such as Guangxi Road, Tianshan Road, Zhongshan Road, Changsha Road, and Fuzhou Road form a checkerboard-like road network layout. Binhu Holiday Fengdanyuan Community has a large elderly population, a rich variety of surrounding living facilities, convenient urban parks and green spaces, and complete community living circle facilities.

The study started from the main pedestrian entrance of Binhu Holiday Fengdanyuan Community in Binhu Century Community and investigated the daily travel routes of elderly people over 60 years old. As shown in Table 1, the survey time was September 2022, the weather was clear, and the time was from 7:00 to 19:00, the investigators notified the subjects in advance and collected the travel trajectories of the elderly in an accompanying manner, and obtained a total of 222 sets of data (Figure 1). In addition, data on the walkers' basic attributes (such as gender, age, health, travel purpose, etc.) will be obtained through a questionnaire after the trial.

Attribute		Binhu Century Community	Attribute		Binhu Century Community
Survey Date		September, 2022	Survey Time		7:00-19:00
Weather		Sunny, 20-28℃	Active Survey Quantity		222（100.00%）
Gender	Male	102（45.95%）	Group Mode	Accompany	59（26.58%）
	Female	120（54.05%）		Alone	163（73.42%）
Age	60-64	88（39.64%）	Path Duration	0-5 Minutes	105（47.30%）
	65-74	112（50.45%）		5-10 Minutes	95（42.79%）
	75-84	22（9.91%）		10-15 Minutes	14（6.31%）
	≥85	0（0.00%）		≥15 Minutes	8（3.60%）

Table 1. GNSS Survey Attributes.

Fig. 1. Distribution of Daily Travel Trajectories for the Elderly.

Data Processing

The daily travel trajectory data of the elderly in this study were measured through a GNSS handheld instrument (UniStrong G659), which has the characteristics of high-precision positioning. The study imported the data obtained from the experiment into ArcGIS software, corrected the data, generated trajectory lines and trajectory points, and then completed spatial analysis such as kernel density analysis and OD analysis, and combined the urban vector map to combine the trajectory lines with the distribution of urban community service facilities and comparative analysis of community spaces. By studying the daily travel behavior characteristics of the elderly in new urban areas, we conduct quantitative analysis on the speed, distance, and travel time of the elderly's daily travel, and grasp the correlation between the elderly's daily travel trajectories and urban space.

The raw data collected by the UniStrong G659 handheld GNSS instrument is in the gmt task file format. The point data file in csv format and the point shape file in shp format are exported through the GIS Office software to obtain the spatial information of 28,405 data points, and the coordinates are matched Transform to form a trajectory point data set. Since the preset time difference between two adjacent trajectory points during the experiment is 3 seconds, by calculating the distance between adjacent trajectory points, the average speed of the two points within the time difference of 3 seconds can be obtained. Its expression is:

$$\Delta T_n = T_{n+1} - T_n = 3s \quad (1)$$

$$\Delta S_n = R * \arccos[\sin(\text{radians}\, A_{n'}) * \sin(\text{radians} A_{(n+1)'}) + \cos(\text{radians} A_{n'}) * \cos(\text{radians} A_{(n+1)'}) * \cos(\text{radians}(B_{(n+1)'} - B_{n'}))] \quad (2)$$

$$V_n = \frac{\Delta S_n}{\Delta T_n} \quad (3)$$

In the formula, R is the radius of the earth, taking 6371004 meters; $A_{n'}$、$B_{n'}$ are the latitude and longitude of the track point of M_n, $A_{(n+1)'}$、$B_{(n+1)'}$ are the latitude and longitude of adjacent trajectory points of M_{n+1}; ΔT_n is the time difference of 3 seconds between adjacent track points; ΔS_n is the distance between adjacent track points; V_n is the Average Speed between adjacent track points.

Number	$A_{n'}$	$B_{n'}$	ΔT_n(s)	ΔS_n(m)	V_n(m/s)
			……		
62	31.7364852	117.2866953	3	2.371484	0.7905
63	31.7364835	117.2866703	3	1.898707	0.6329
			……		
11350	31.7364402	117.2888849	3	2.101484	0.7005
11351	31.7364384	117.2889070	3	2.557975	0.8527
			……		

Table 2. The Processed Track Point Spatial Information Data.

The study imported the trajectory line data collected by GNSS instruments into GIS Office software to eliminate invalid data caused by satellite signals, objective environment, and the instability of the experimental equipment itself. Finally, 222 sets of valid data were obtained (Figure 1), and the valid experimental data reached 100.00%. Import the exported line graphics file in shp format of WGS84 coordinate system into ArcGIS Map, and convert the projected coordinate system so that the trajectory line matches the city vector map data.

Kernel Density Estimation is a method proposed by Rosenblatt (1955) and Emanuel Parzen (1962) to estimate unknown density functions. It can directly use samples to estimate distribution characteristics without assuming the overall distribution. This method uses the kernel function to calculate the density contribution value of the sample point within a specified radius range. The closer the point within the search radius range is to the sample point, the greater the density contribution value of the sample point. The density values of all points are superimposed to form a kernel density map. The kernel function expression used in this study is:

$$\hat{f}(x,y) = \frac{3}{nh^2\pi}\sum_{i=1}^{n}\left[1 - \frac{(x-x_i)^2+(y-y_i)^2}{h^2}\right]^2 \tag{4}$$

In the formula, $\hat{f}(x,y)$ is the kernel density value of the trajectory point (x,y) to be estimated within the search radius; h is the search radius; x_i、 y_i are the coordinates of trajectory point i; n is the distance between (x,y) is less than or equal to the number of sample points in the search radius h.

$$h = 0.9 * min\left(SD, \sqrt{\frac{1}{\ln(2)}} * D_m\right) * n^{-0.2} \tag{5}$$

$$SD = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{X})^2}{n} + \frac{\sum_{i=1}^{n}(y_i - \bar{Y})^2}{n}} \tag{6}$$

In the formula, h is the search radius, that is, the bandwidth; SD is the standard distance; D_m is the median distance; x_i、 y_i are the trajectory point coordinates; $\bar{X}$、 $\bar{Y}$ are the average center point coordinates, and n is the number of trajectory points.

Travel Behavior and Trajectory Characteristics

Travel Behavior Characteristics

The study conducted statistical analysis on the attribute information of 222 sets of experimental data. As can be seen from Figure 2, the daily walking length of the elderly in Binhu Century Community is mainly concentrated within 1,000 meters, accounting for 95.05% of the total, of which 86.94% is within 500 meters; the median walking length of the elderly is 275.69 meters, the longest walking length is 2378.88 meters. Daily walking time is mainly concentrated within 10 minutes, accounting for 90.09% of the total, of which 47.30% is within 5 minutes. The median walking time of the elderly is 306 seconds, and the longest walking time is 2301 seconds. The daily walking length and walking time of the elderly in the new urban area are longer than those in the old urban area, and as age increases, the walking length shows a downward trend, which is related to the changes in the physiological functions of the elderly. In addition, the reason for the longer walking length and walking time of individual samples is that the elderly exercise in the form of walking.

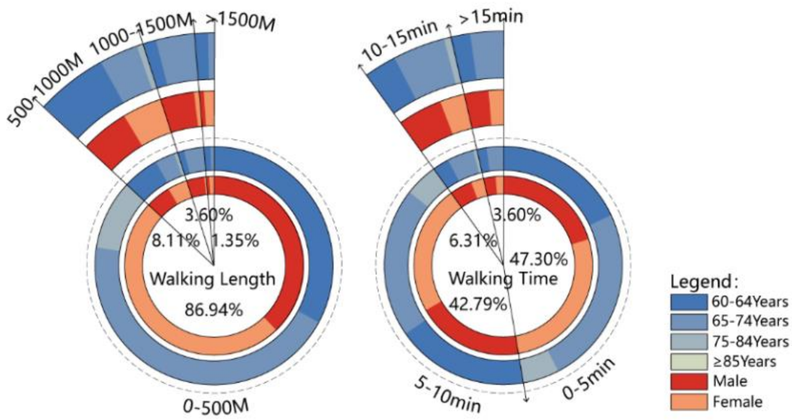

Fig. 2. Walking Length and Walking Time of the Elderly.

The daily travel purposes and facility selection preferences of the elderly in the community are important references for optimizing the facility layout and spatial environment of the community living circle. According to the daily travel trajectories and behavioral characteristics of the elderly, the study divided the elderly's daily travel purposes into life type, return type and commuting type. Among them, the life-type behavior mainly refers to going to various community service facilities, including purchasing, entertainment, rest, medical treatment, convenience, dining, picking up and dropping off grandchildren, etc.; the return-type behavior refers to walking in community public spaces and returning to residence; the commuting-type behavior refers to going to various places transportation service facilities, including subway stations, bus stations, etc. The study conducted statistics on the daily travel purposes of the elderly. It can be seen from Table 3 and Figure 3 that the daily travel purposes of the elderly in Binhu Century Community are mainly lifestyle behaviors, accounting for 82.88% of the total, among them, resting, purchasing, and picking up and dropping off accounted for the highest proportions, accounting for 28.83%, 19.82%, and 17.57% respectively. The main purposes of the elderly's daily travel are to rest in community public spaces, go to fresh food supermarkets and wet markets to buy food, and pick up and drop off their grandchildren.

Type		Proportion (%)	Type		Proportion (%)
Life Type	Purchase	19.82%	Life Type	Entertainment	1.80%
	Rest	28.83%		See Patient	5.40%
	Convenience	6.31%		Dining	3.15%
	Pick up	17.57%		Total	82.88%
Return Type		5.86%	Commuting Type		11.26%

Table 3. Proportion of types of daily travel purposes among the elderly

By comparing the travel behavior of elderly people of different genders and different age groups. It can be found that the travel behavior of male elderly people is mainly to rest, purchase, pick up and drop off, and commuting. Accounting for 31.37%, 18.63%, 15.68%, and 14.70% of the male sample respectively; the travel behavior of female elderly people is mainly to rest, purchase, and pick up and drop off. Accounting for 26.67%, 20.83% and 19.17% of the female sample respectively. In terms of age, the travel behaviors of the elderly aged 60-74 are mainly resting, shopping, picking up and commuting, etc. The travel behaviors of the elderly over 75 are mainly resting, purchasing, commuting, etc.

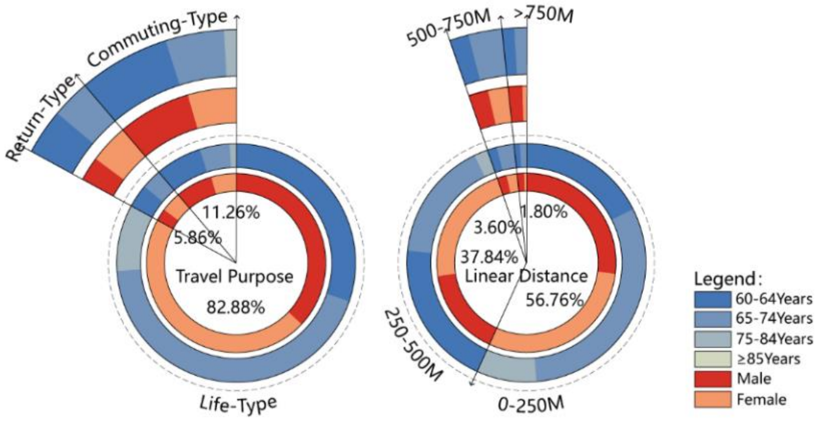

Fig. 3. Travel Purpose and Linear Distance of the Elderly.

The study uses ArcGIS to generate an OD map (Origin-destination) of the elderly's daily travel trajectories (Figure 4), and combines it with statistical analysis (Figure 3). It can be found that 100.00% of the elderly's daily trips are within 1,000 meters in a straight line, of which 94.59% are within 500 meters. The median straight-line distance of the elderly's daily trips is 213.22 meters, and the longest straight-line distance is 913.63 meters. Since the community living facilities in new urban areas are relatively concentrated and basic living needs can be met within a 500-meter living circle, the daily travel behavior of the elderly in new urban areas has obvious directionality, and community parks, farmers' markets, primary schools, kindergartens, and community health service centers etc. are concentrated in the core area of the community. This area provides daily basic needs for the elderly, that is, the inner circle of the living circle, including rest, shopping, pick-up and medical treatment, etc.; and along the extension of urban arterial roads such as Dongtinghu Road, Guangxi Road, Zhongshan Road, Luzhou Avenues, which are the outer layer of the living circle, is reflected in the elderly's need to obtain urban public services, including urban parks, city-level tertiary hospitals, commercial centers, rail transit stations and other facilities. Therefore, the daily living needs of the elderly in Binhu Century Community can be basically met within a range of 1,000 meters.

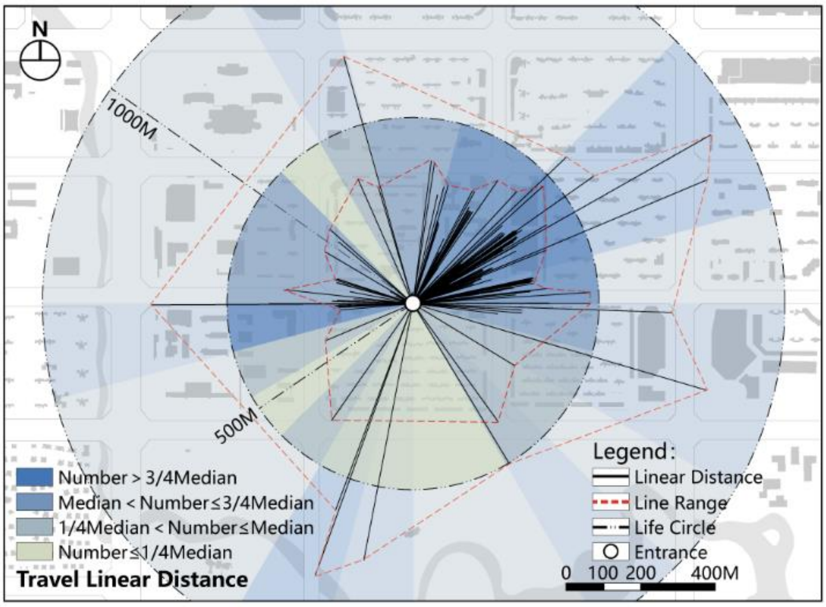

Fig. 4. Travel Linear Distance of the Elderly.

Trajectory Line Distribution Characteristics

Binhu Holiday Fontaineyuan Community is in the south of Binhu Century Community, and the main pedestrian entrance and exit of the community is in the north of the community. It can be seen from Figure 5 that the trajectory evacuation direction starts from the pedestrian entrance and exit of the community, and disperses along Dongtinghu Road from east to west, Tianshan Road and Guangxi Road to the north, and urban roads around the community. The density of trajectory lines is the highest in the northeast direction of the community entrance, because there are community parks, community health service centers, primary schools, and kindergartens; in addition, the trajectory lines in the northeast direction of the community entrance appear detours and circuitous phenomena, because there are many community parks facilities such as fitness equipment and seats gather more elderly people, and community interaction and stay behaviors under a network of acquaintances are more likely to occur. There are many trajectory lines along the east-west Dongtinghu Road, and they are scattered along Tianshan Road, Guangxi Road, Luzhou Avenue, Huizhou Avenue, and other intersections. Urban secondary roads have a guiding role in the travel behavior of the elderly, because the lower grade urban roads have more comfortable and safer street environment.

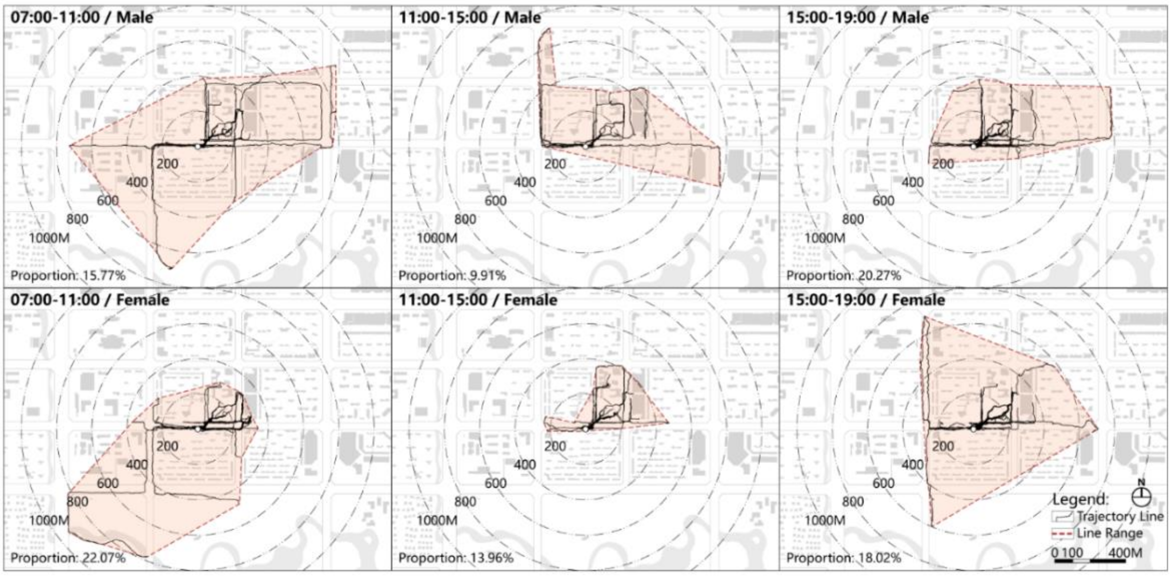

Fig. 5. Trajectory Lines in Different Time Periods.

The daily travel trajectories of the elderly also show different spatial distribution characteristics in different time periods. The study divided travel time into three time periods: morning (7:00-11:00), noon (11.00-15.00), and afternoon (15.00-19.00) for statistical analysis (Figure 5). In the morning, the activity range of the elderly is the widest, showing multi-directional dispersion characteristics, concentrated in the 1000-meter living circle, and the activity range of male elderly people is wider than that of female elderly people; at noon, the activity range of the elderly is the smallest, mainly along the northeast direction of the pedestrian entrance shows the characteristics of extension and dispersion; in the afternoon, the activity scope of the elderly is concentrated within the 1000-meter living circle. It can be concluded that the morning and afternoon are the time periods when the elderly travel extensively. The trajectories are concentrated to the east and north, and to the south they mainly take walks along the Tangxi River Park.

Relation Between Travel Behavior and Community Space

Kernel Density Analysis of Action Paths

The study compared the kernel density of the elderly's daily travel trajectory points in different time periods and different spaces (Figure 6). It can be concluded that the trajectory points are mainly concentrated at the entrance of the community, community parks, community facility entrances and road intersections; the entrance of the community shows spatial characteristics that are highly concentrated and extend to the road and sidewalks, such as TH-01, AH-01, NH-01, PH-01; community parks present spatial features that extend linearly along the park paths, such as TH-02, AH-02, NH-02, and PM-02; entrances to community facilities present spatial features that are concentrated in points, such as AH-03, NM-01; road spaces are concentrated in low-level living street spaces, such as PM-01; in addition, they also exist in spaces such as street intersections (TM-06, AM-01, NM-07) and farmers' market entrances (AM-04) Areas with higher density values.

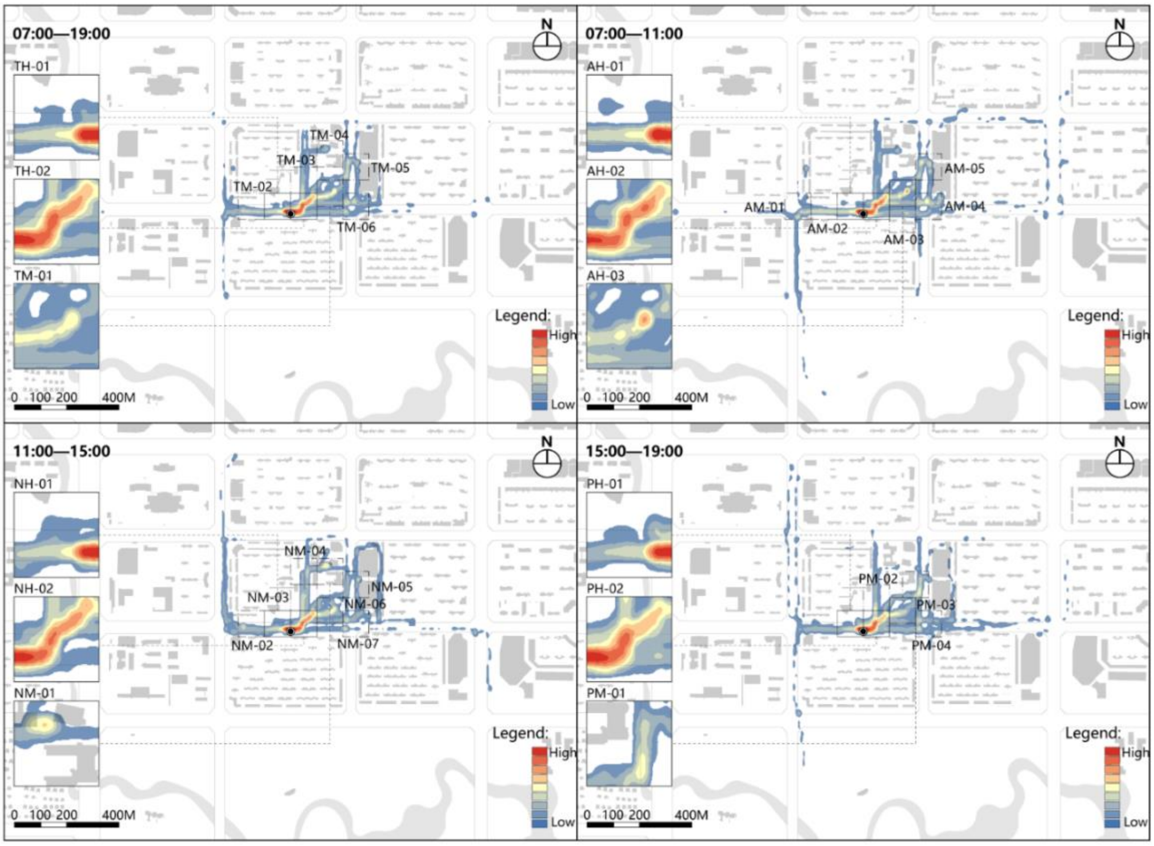

Fig. 6. Trajectory Point Density in Different Time Periods.

Judging from the core density of the trajectory point distribution in different time periods, the high-density value areas in the morning and noon show a multimodal distribution, and the high-density value areas in the afternoon show a unimodal distribution, indicating that the elderly are more active in travel activities in the morning and noon. In the afternoon, it is weaker and concentrated in the community park at the entrance of the community. Judging from the kernel density of trajectory point distribution in different community spaces. The entrance of the community selected TH-01, AH-01, NH-01 and PH-01 for horizontal comparison. It can be found that the trajectory lines and trajectory points in the space at the entrance of the community are the densest and the degree of aggregation is the highest. The density core in the morning shifts further to the west. Because there are many elderly people going to the city park in the south of the community for morning exercises. Community parks selected TH-02, AH-02, NH-02 and PH-02 for horizontal comparison. It can be found that the density core in the morning is more dispersed, indicating that the activities in community parks are more active, and community parks provide more convenience for the elderly to rest, and at the same time, the morning is the main time for the elderly to obtain their daily needs. AM-05 and PM-01 were selected for horizontal comparison of street and alley spaces. It can be found that the density core is stronger in the morning and afternoon because there is a school on the west side of the road, and some elderly people are responsible for picking up their grandchildren from school.

Speed of Motion Path

The study further explores the relationship between trajectory point speed, community space and the daily travel behavior of the elderly. The study calculated a total of 28,405 track point velocities. Considering the errors in the experiment, the positioning points with a track point speed higher than 3.2m/s (the average running speed of the elderly is about 3-5 times the average walking speed) were eliminated to obtain effective trajectories. 28,396 points, 99.97% effective.

Combined with previous studies on the normal walking speed of the elderly, this study defines trajectory points with an average speed of less than or equal to 0.60 m/s as slow points, which reflect the slow speed of the elderly walking or the occurrence of dwell or detour behaviors in a certain spatial range; define trajectory points with an average speed between 0.60m/s and 1.0m/s as medium speed points, which reflect the normal walking behavior of the elderly; define trajectory points with a speed greater than or equal to 1.0m/s as fast point, which reflects the elderly walking or jogging quickly through a certain space. The median speed of daily travel for the elderly in Binhu Century Community is 0.96 m/s, and the average speed is 0.94 m/s.

Attributes	Quantity
Total Number of Track Points	28405
Valid Track Point	28396
Speed≤0.6m/s	6117个（21.54%）
0.6m/s < Speed < 1.0m/s	9208个（32.43%）
Speed≥1.0m/s	13080个（46.06%）
Average Speed	0.9426m/s

Table 4. Track Point Velocity Attribute

The distribution range of slow-speed points (speed ≤ 0.6m/s) is smaller than the distribution range of the overall trajectory points, showing the spatial characteristics of discrete distribution of multiple peaks. They are mostly gathered at the entrance of the community, cross-street sidewalks, community park open space, etc. to form cluster-shaped point blocks, such as TSH-01, TSH-02 and TSH-03. In the morning, the most densely packed track points are at the entrance to the community and inside Tianshan Park, such as ASH-01 and ASH-03; at noon, the most densely populated track points are at the square at the community entrance and in the community service center, such as NSH-01 and NSH-03; in the afternoon, the densest concentration of trajectory points is at the entrance of the community and extends toward the community park in the northwest, such as PSH-02. In addition, slow speed points are also distributed at the entrance of the school (ASM-05), the entrance of the farmer's market (TSM-06), etc.

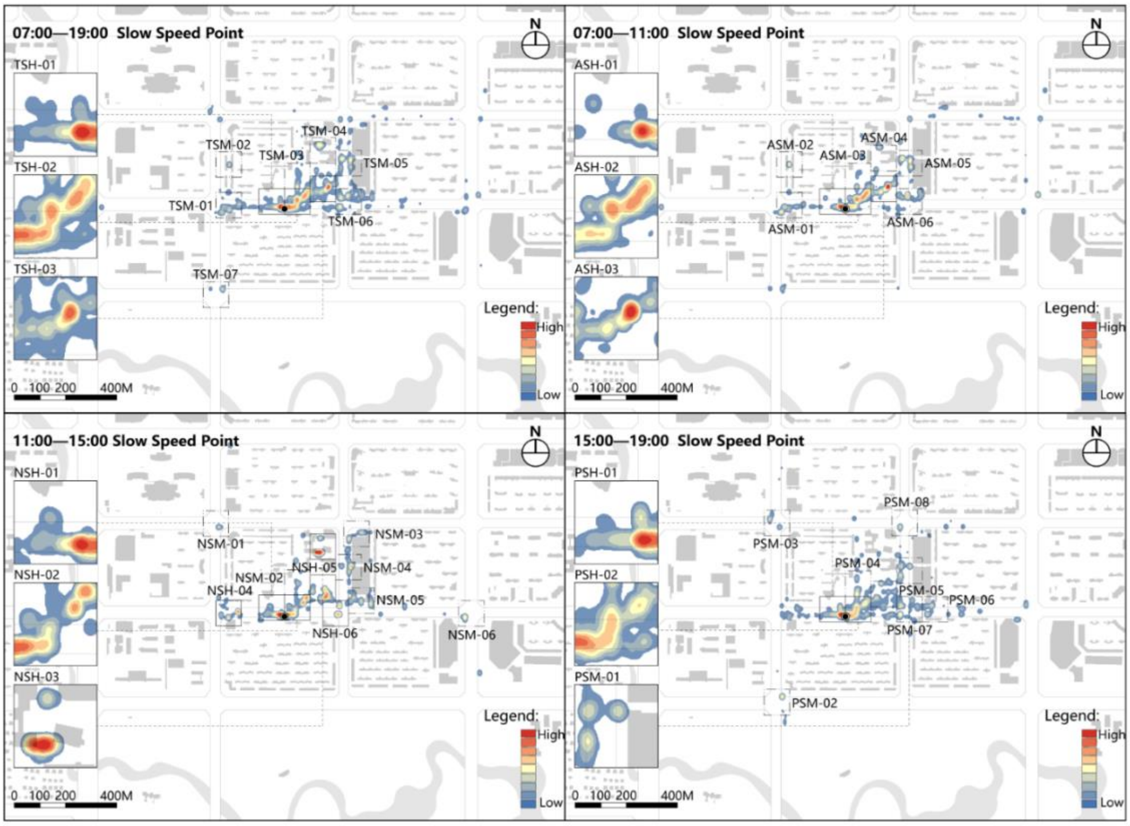

Fig. 7. Kernel density of travel slow speed point distribution.

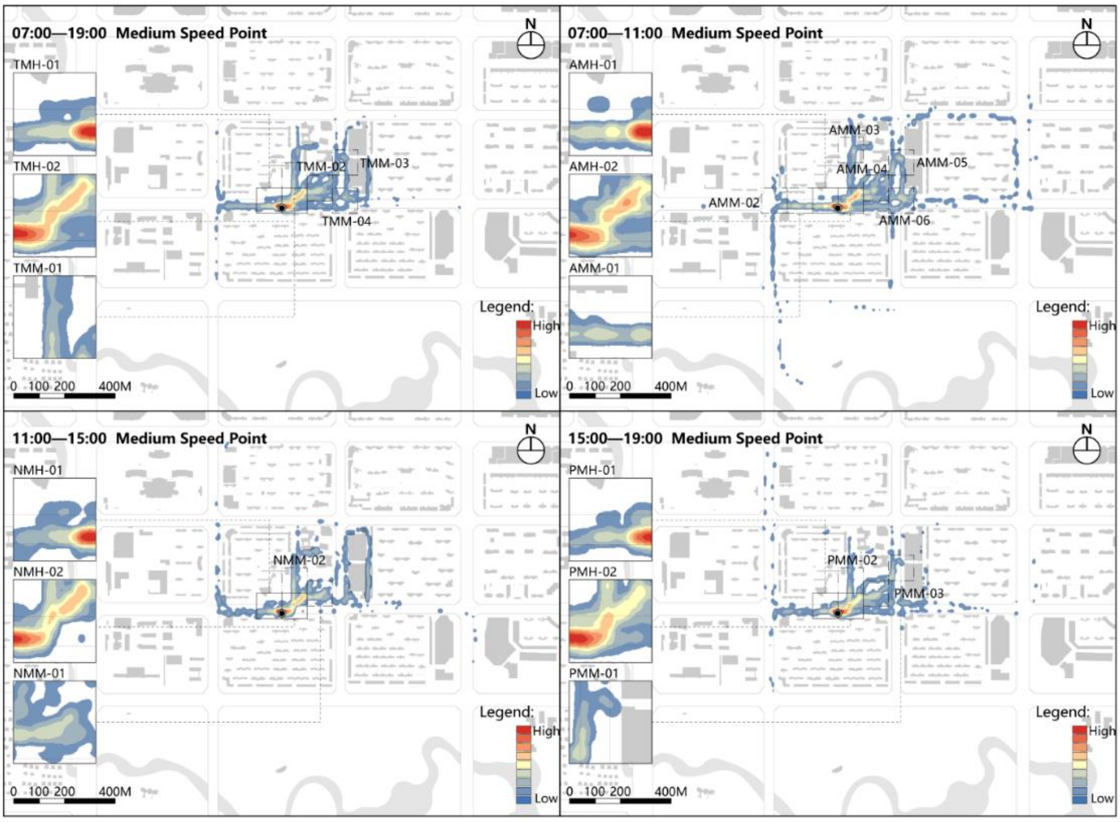

Fig. 8. Kernel density of travel medium speed point distribution.

Medium-speed points (0.6m/s＜speed＜1.0m/s) present the spatial characteristics of a single wave crest radiating and extending, mainly forming density along urban sub-level streets such as Dongtinghu Road, Tianshan Road, Tianshan Branch Road, and Tianshan Park. In the concentrated area, the medium speed points are more widely distributed in the morning, followed by the afternoon, which shows that the travel behavior of the elderly in the new urban area is more active in the morning and afternoon.

The distribution range of fast points (speed ≥1.0m/s) is close to the distribution range of the overall trajectory points, showing the spatial characteristics of linear distribution of multiple peaks. They are mostly clustered in front of residential areas, road intersections, and both sides of urban roads, such as TQH-01, TQH -02 and TQM-01. The densest locations of track points are located at the entrances of communities and Tianshan Park, such as AQH-02, NQH-02, and PQH-02. Crowds and vehicles gather at road intersections, causing the elderly to walk faster across the road. In addition, express points are basically distributed along the street direction and are relatively uniform, and are clustered along urban arterial roads (TQM-01, AQM-03, NQM-03), road intersections (AQM-09, NQM-02) and other spaces.

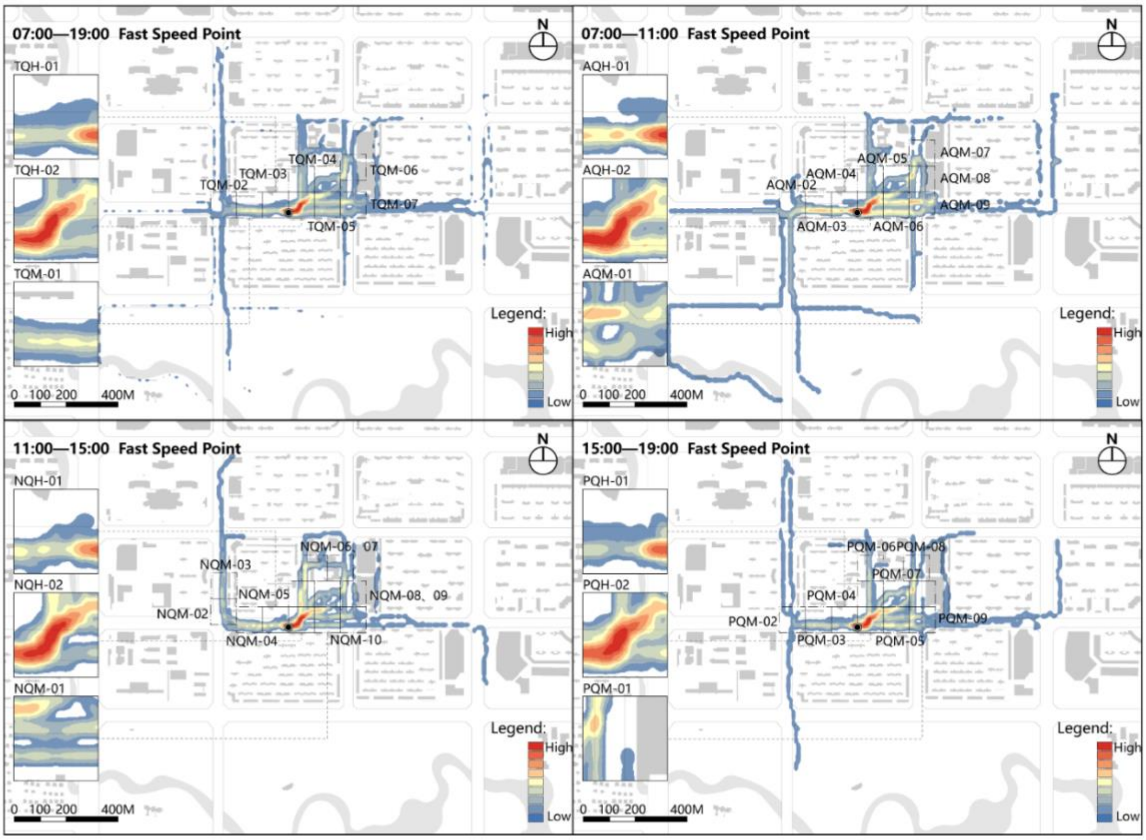

Fig. 9. Kernel density of travel fast speed point distribution.

Relationship Between Action Paths and Community Space

By tracking the daily travel paths of the elderly, the study compared travel action trajectories and trajectory point kernel densities with community spaces, and reflected the characteristics of the elderly's travel behavior in community spaces by screening the different speeds of trajectory points.

The trajectory line radiates along urban roads with the community entrance as the center, and has many branches in sub-level streets. The entrance space of the community is a necessary place for the elderly to pass through in their daily travels. The spatial richness in the community space plays a positive role in the daily travels of the elderly. Open spaces such as community parks are important spaces that attract the elderly for daily travel, and their distribution and openness affect the degree of trajectory aggregation. Traffic nodes such as road intersections also affect the distribution of the elderly's trajectories. Road traffic safety is also an issue that the elderly in the community need to pay attention to during their daily travel.

The number of slow points (speed ≤0.6m/s) in the travel trajectories of the elderly in Binhu Century Community is less than that of fast points (speed ≥1.0m/s), and the latter are distributed in a wider range, indicating that the urban traffic environment in the new urban area dangerous degree is higher. Slow points reflect the elderly passing through or staying in a certain space slowly and engaging in various behaviors; fast points reflect the elderly passing through a certain space quickly and with strong purpose. The slow points exhibit the characteristics of discrete distribution of multiple peaks; the fast points exhibit the characteristics of linear distribution of multiple peaks.

Conclusion

The study uses GNSS motion tracking measurement and GIS spatial analysis methods to analyze the daily travel behavior characteristics of the elderly in Binhu Century Community, to explore the correlation between the daily travel behavior of the elderly and the spatial layout of the community in new urban areas, Hefei City.

Research shows that: 1) The walking length of the elderly in Binhu Century Community is concentrated within 1,000 meters, and the walking time is concentrated within 10 minutes; the purpose of the elderly’s daily trips is mainly lifestyle activities, such as going to community parks to relax and market purchases. 2) The daily needs of the elderly in Binhu Century Community are basically met within 1,000 meters, and centralized community service facilities provide the elderly with basic daily needs; 3) The daily travel trajectory of the elderly starts from the pedestrian entrance and exit of the community. The radiation is scattered along Dongtinghu Road from east to west, Tianshan Branch Road to the north and urban roads, and the range of travel trajectories in different time periods is different; 4) The daily travel trajectory points of the elderly are mainly concentrated at the entrance of the community, community parks and road intersections etc., the slow points show the characteristics of discrete distribution of multiple peaks, and the fast points show the characteristics of linear distribution of multiple peaks.

Based on the research results, the layout of the "five-minute living circle" and "ten-minute living circle" service facilities in new urban communities should be improved, and the aging-friendly renewal and renovation of sub-level urban streets should be strengthened. The entrance space of residential areas should be combined with landscape leisure facilities to set up evacuation sites, and the community Streets should have a reasonable layout of living service facilities and rest seats. At road intersections, attention should be paid to the safety of the elderly crossing the street, and to improve the quality, age-appropriateness, and safety of the community environment. By analyzing the daily travel trajectories of the elderly in the new urban area of Hefei City, the study aims to provide references and suggestions for community living circle planning and community environment optimization in the new urban area of the city. In the future, the relationship between the community environment and the physiological perception of the elderly will also be further explored.

Acknowledgements

This research was supported by Urban Renewal and Transportation Joint Laboratory of Anhui Provinc, Anhui Provincial Engineering Research Center for Regional Environmental Health and Spatial Intelligent Perception, China Scholarship Fund (202206690039), Anhui Province University Outstanding Scientific Research and Innovation Team (2022AH010021), Anhui Province Graduate Academic Innovation Project (2022XSCX017).

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