

Study on the Operation Mode of the Historic District of Cunha Street in Macao

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Abstract: The historic district of Cunha Street is a typical Portuguese commercial block in Macao. However, with the development of the city, the space forms of the districts in Cunha Street fail to update accordingly, resulting in the declining number of the tourists compared with that of the past. In view of this, by applying the method combining the Space Syntax, Traffic flow, and Poi business data, an analysis on the operation mode of the districts in Cunha Street is carried out, so as to explore the influences of space forms on the Choice of tourists and on the distribution of business forms in Cunha Street. Meanwhile, based on the aspects of optimizing space structure and bettering tourism experience for tourists, an evaluation system on the operation mode is constructed. In allusion to the analytic results, the suggestions of reconstruction strategy on the form distribution of businesses and space structure of roads are proposed.

Keywords: Operation mode; Space form; Space structure; Business form distribution; Reconstruction strategy

1. Introduction

1.1 Overview of the Cunha Street evolution

Since 1535, the Portuguese gradually began to set about their commercial and trade activities in Macao, and settled in Macao in 1557. The emergence of the hundred-year Eastern and Western cultures in Macao turned it into a city of consistent color and architectural style, and of color expression with clear regional and ethnic preferences^[1]. Located in Ilha da Taipa, Macao, the Cunha Street is a typical block merging with Chinese and Portuguese culture. Since ancient times, the street has been in a close relation with the development of commercial trade in evolution. In the past, the urban area of the Ilha da Taipa was not large. The Cunha Street officially named in 1884 was an important street running through it. At that time, many Portuguese people settled and fulfilled the area with Portuguese life. Huts and shops stood in great numbers on both sides of the street, mainly selling daily necessities such as fuel, rice, cooking oil and salt. The inconvenience of transportation leaving the island, the street, a place where residents often needed to come to buy supplies, was also the commercial center of Ilha da Taipa. Then the year 1983 witnessed Cunha Street being designated as the first special pedestrian only area in Macao. With Macao's return and the boom of tourism, Cunha Street has become a reborned tourist destination in Macao of time, as shown in Figure 1.

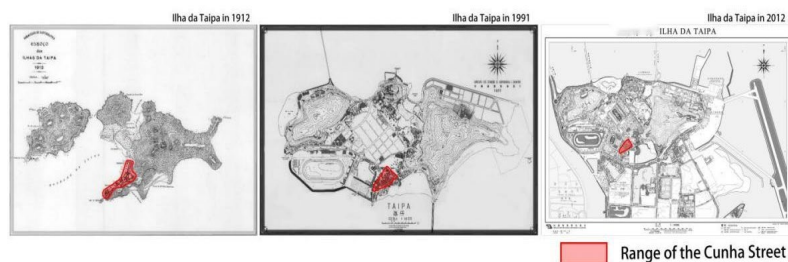


Figure 1: Location evolution of Cunha Street from 1912-2012

1.2 Constitution of the street space

The urban construction of Macao, both limited by the complex geographical environment and influenced by the concepts and techniques of urban planning and design in different periods, results in today's unique "collage" street network structure and urban form^[2]. The main roads of the historic district in the Cunha Street are composed of Cunha Street, Bunker Street, Rua Do Delegado, Correia da Silva Street and Governor Carlos Eugeino Street, with many alleys weaving in, thus forming the street space of the current historic district in the Cunha Street. Meanwhile, historical building are scattered around the street, such as Thean Hou Temple, Pak Tai Temple, Ilha da Taipa Carmo Hall, Museu da História da Taipa e Coloane, Carmo Church and others. The block is mainly composed of souvenir stores, snack shops and characteristic restaurants, which can meet the daily needs of tourists.

1.3 Research objective

The definition of commercial space is strongly linked to consumer culture, material culture and spiritual culture^[3]. Cunha Street, as a commercial historical district in Macao extensive Portuguese style, is a witness and carrier of Macao's history and culture. Exposed in the historic district, tourists will be unconsciously led into the mingled Chinese and Portuguese atmosphere of cultures, experience the distinct culture of Macao, and choose the route automatically. Studying the space form of the historic district in the Cunha Street is to study the two-dimensional street factors affecting tourists in selecting routes. This study hence conducts a joint analysis on the street syntactic indicators and business format distribution, so as to provide further improvement suggestions for the district.

2. Methodology

2.1 Research methodology

Space Syntax, proposed by an English scholar Bill Hillier in the 1970s, is a mathematical method used to describe and analyze spatial relations^[4], with a basic principle to use the relationship of mathematical topology to describe the quantitative relationship of space after space segmentation, and to explore the relationship between human activity behavior and space form in space with it. In this dissertation, it is applied to analyze the influence and its degree of the spatial form of the Cunha Street on the spatial behavior of tourists.

Space form, the shape characteristics reflected by space and its constituent elements, includes both the connotation of space and the connotation of object form^[5]. Based on the space syntax theory, the operation mode of the historical and cultural district of the Cunha Street in Macao is studied while the ArcGIS is used to classify the commercial poi data of the district for commercial analysis^[6], and the tourist activity statistics is accomplished by virtue of the Cross-Section Flow Statistics method^[7], thus preliminarily exploring the business format distribution and the relationship between tourist aggregation and space form in Cunha Street^[8].

When other conditions are consistent, the network space structure of urban streets itself will exert a systematic influence on the distribution pattern of people flow^[9]. Integration, one of the important indicators in syntax, can measure the potential of a space to attract traffic. The higher the integration is, the easier it is for people to reach it^[10]. In a manner of speaking, due to the inherent inequality in the space structure of roads in tourist blocks, the roads with high integration will be visited by more tourists, while the roads with low integration will have few tourists, which will directly affect the planning of commercial areas and the site selection of different types of businesses. When the rational operation of syntax can provide reference for planning and location, regional planning and business location can be in accordance with the business properties and business positioning required. For example, FMCG businesses are more suitable for areas with high rent but high integration, while businesses providing slow services besem area with low rent and low integration. The support of syntax operation ration can greatly increase the scientific nature of site selection and reduce the waste of resources caused by the mismatch between commercial attributes and site selection. Besides, the syntactic-based improvement strategy can optimize the matching degree of space and commercial attributes and enhance the overall vitality of commercial space.

2.2 Research scope

The Cunha Street stretches from the front of Macao Fire Department in the west to the intersection of the Correia da Silva Street and Governor Carlos Eugeino Street in the southeast. The total length is 121 meters and the width is 5 meters. It is named after the 81st governor-general. Together with the several streets around, it forms a historic district with unique Portuguese style. As shown in Figure 2, the research scope in this study involves the area stretching from the Bunker Street in the north, to the Rua Do Delegado in the east, and Correia da Silva Street and Governor Carlos Eugeino Street in the south. Regarding the uncertainty existing in the boundaries of the quantitative analysis in integration and choice, the scope is extended outwardly to map the range of road network studied, taking the road net east from Ilha da Taipa Carmo Sports field, west from Road Governador Nobre de Carvalho, south from Olympic Avenue and north from Estrada da Baía de Nossa Senhora da Esperança, so as to reduce the impact of boundary effects on the space analysis.

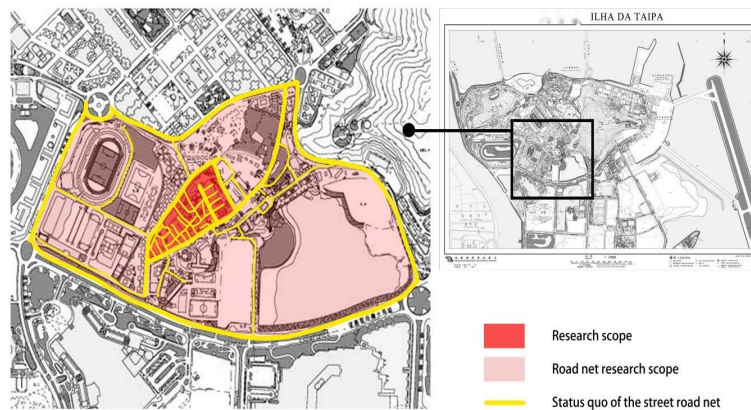


Figure 2: Research scope, road net research scope and status quo of the street road net in Cunha Street

3. Analysis on the base of space syntax

The research scope of the road network of the historic district in Cunha Street is taken as the base map to map the roads, so as to briefly summarize the space structure of Cunha Street block. Besides, the axis map is imported into Depthmap for the quantitative analysis on the integration and choice of the historic district in Cunha Street.

3.1 Analysis on integration

Integration refers to the degree of agglomeration or dispersion between one element and other elements in a space system^[11]. In this study, the integration is to measure the transportation capacity of Cunha Street as a tourist destination to attract tourists, reflecting the transportation centralization of the core location of the block. Integration and accessibility are directly proportional to them, so do the centrality and the aggregation of tourists^[12]. In this dissertation, the axis map is imported into Depthmap, and the (R3) local integration is used to measure the data of each street, thus obtaining the local integration (R3) of the historic district in Cunha Street, as shown in Figure 3, and the correlation map of the street global integration and local integration (R3) data is presented as Figure 4. The warmer the axis, the higher the integration, and the colder the color, the lower the integration.

According to the analysis results of Figure 3, the relative ratio of the five main streets under the (R3) local integration is: Cunha Street (1.38) > Correia da Silva Street (1.34) > Governor Carlos Eugeino Street (1.25) > Bunker Street (1.08) > Rua Do Delegado (1.00). Actually, Cunha Street, Correia da Silva Street and Governor Carlos Eugeino Street are the most dense areas of FMCG shops with the highest flow in the block, which is consistent with the analytical results of the space syntax.

In (R3) local integration analysis, roads with low local integration such as Anle Street (1.06), Xinxiang (1.13) :Rua Ho Lin Vong (1.11), and Shuiya Street (1.14) mainly lanes and roads connecting the arterial road. These are also low-grade road in the block, with thin contact with the outside world, which is not conducive to gathering tourists. Thus the general rent is low. So do the centrality and accessibility.

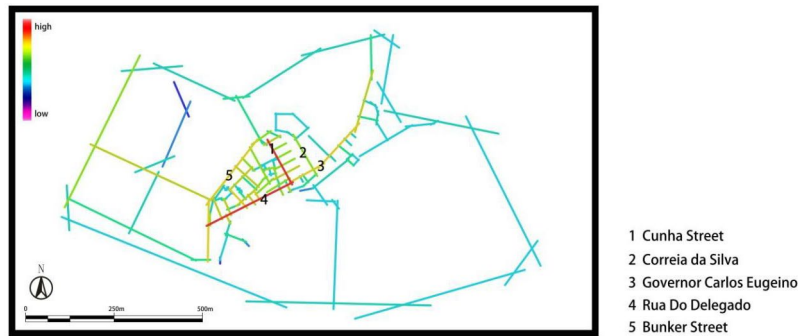


Figure 3: Regional integration (R3) Depthmap analysis chart of the historic district in Cunha Street

Figure 4 shows the degree to which the global integration (R_n) is associated with the regional integration (R3) of Cunha Street, and the determination coefficient R^2 is 0.76404. When the determination coefficient is > 0.7 , it means that the independent variable and the dependent variable are strongly correlated, so the global integration of the street has a high correlation with the regional integration (R3), that is, tourists can walk through a small space in this block and understand the overall spatial form of the block [13]. This study can make better use of the local space to reflect the overall spatial system.

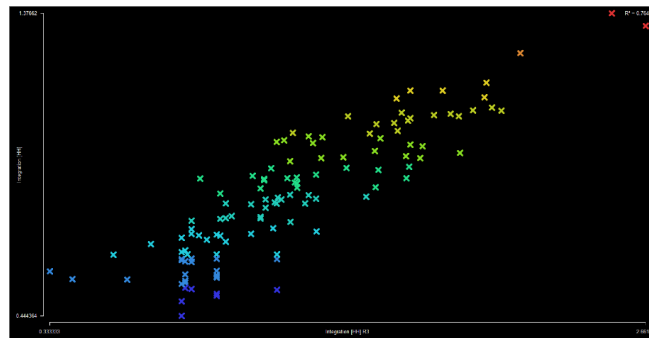


Figure 4: Association diagram of global integration and regional integration (R3) of the historic district in Cunha Street

3.2 Analysis on choice

Choice refers to the frequency of an element in the space system as the shortest topological distance between two nodes. It examines the advantages of space units as the shortest travel path, and reflects the possibility of space being traveled [14]. The higher the choice in Cunha Street, the easier it is to be traveled by tourists, and the higher the road activity.

In studying the suitable walking distance threshold for community residents, the suitable walking distance of 787m is obtained under 10% utilization rate, which has a good reference value for vigorously promoting slow traffic [15]. In this study, R800 value is taken as the walking distance radius to draw the historic district choice diagram in Cunha Street. A total of six selected locations are: ① south of the Cunha Street, ② north of the Cunha Street, ③ east of the Bunker Street, ④ east of the Rua Do Delegado, ⑤ west of the Governor Carlos Eugeino Street, ⑥ and middle of the Correia da Silva Street. A total of six points are the reference points of choice data, as shown in Figure 5.

According to Figure 6, in the analysis on the historic district of Cunha Street: ① south of the Cunha Street (9715), ② north of the Cunha Street (1563), ③ east of the Bunker Street (1880), ④ east of the Rua Do Delegado (11075), ⑤ west of the Governor Carlos Eugeino Street (12340), ⑥ and middle of the Correia da Silva Street (1239). In the actual situation, the flow of people is large on the south side of Cunha Street, the east of the Rua Do Delegado and the west of the Governor Carlos Eugeino Street, which is consistent with the spatial syntactic analysis results. However, the value on the north side of Cunha Street is low, but the actual flow of people is not. The first reason is that many tourists come to the main road of Cunha Street and the whole view of the road is short. And the second reason is the attraction of many famous shops, which leads to the large difference between the choice degree and the actual situation.

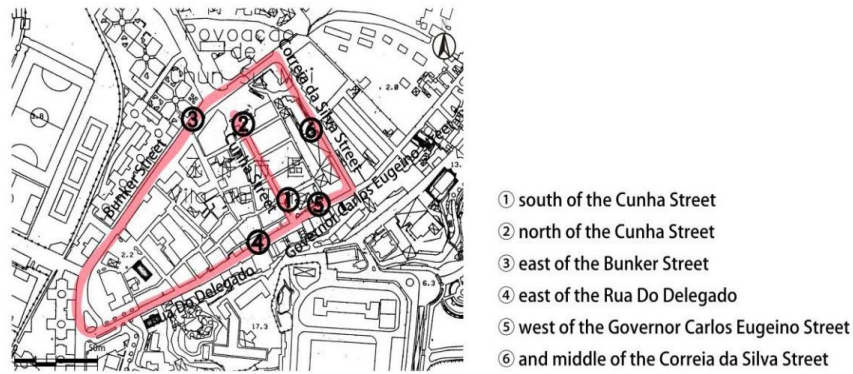


Figure 5: Reference point of the selection degree of the historic district in Cunha Street

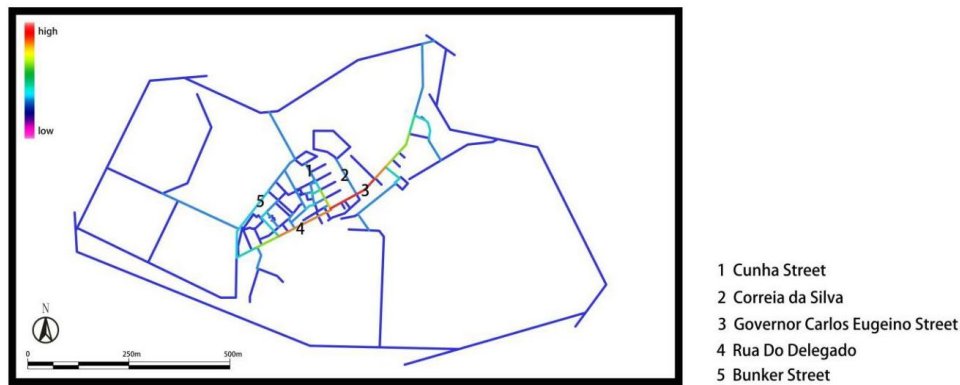


Figure 6: Choice (R800m) Depthmap analysis diagram of the historic district in Cunha Street

4. Results and discussion

The choice and judgment of the movement of people affect the spatial structure of the urban street and lane network to some extent^[16]. In space syntax, the potential of space being traveled is described by choice. In this study, the data of street section traffic are counted and analyzed to obtain the influence of space form on tourist activities in the historic district of Cunha Street. The flow mapping statistics at the same location as the reference point of the choice data is carried out, as shown in Figure 5, and the field flow data are calculated as shown in Figure 7. The number of people passing through the section per hour is recorded in ten working days and non-working days, with each interval for 1 hour, as shown in Table 1. To avoid extreme situations, this study uses the flow situation of $\frac{\text{The median holiday} \times 2 + \text{Median of working days} \times 5}{7}$ flow of people.

According to the analysis of the use of the section, the road reaches 1,074 people per hour on the south side of Cunha Street. The road itself has a high grade, high selectivity and accessibility, and the road is also the tourist sign of the block. In the case of low selection between the north side of Cunha Street and the east side of Bunker Street, the flow of people is still high. According to the research results, the old businesses on the north side of Cunha Street attract a group of tourists. Bunker Street, as an important route connecting the center of Ilha da Taipa, the flow of people is still not weaker than that of other roads. Although the integration of Governor Carlos Eugeino Street is high, the east side of the street is low, the actual flow of people is not ideal, and the space needs to experience more turning points. In real life, although the actual distance of such roads is shorter, the road twists and turns, often not chosen by tourists. As the road with the highest integration in the block, the actual human circulation does not reach the ideal state. The reason is that the selection degree of the west side of the road is low. In the actual investigation, there is no business planning on the south side of the road, resulting in the obvious trend of tourists. The accessibility, selection degree and excessive human circulation of Correia da Silva Street are relatively low, so the use as a traffic function is more in line with the positioning of low-grade roads.

Table 1: Statistics of traffic flow of the historic district in Cunha Street

Traffic flow mapping of the historic district in Cunha Street (unit: person)																		
No.	Time Location	9:00-10:00	10:00-11:00	11:00-12:00	12:00-13:00	13:00-14:00	14:00-15:00	15:00-16:00	16:00-17:00	17:00-18:00	18:00-19:00	Mean	Standard deviation	Median	Coefficient of variation	Choice (r800m)	Regional integration (R3)	Flow of people
		①	South side of Cunha Street (Workday)	643	871	938	988	920	864	943	1322	1443	1668	1060	313.825854	940.5	0.19	9715
South side of Cunha Street (Festival and holiday)	916		1178	1422	1483	1390	980	1379	1772	1983	2011	1451.4	379.0380221	1406	0.26			
②	North side of Cunha Street (Workday)	466	560	788	855	703	688	691	1012	1294	1321	837.8	289.1158169	745.5	0.35	1563		820.8
	North side of Cunha Street (Festival and holiday)	550	672	830	1039	989	937	1029	1401	1583	1720	1075	381.2663111	1009	0.35			
③	East side of Bunker Street (Workday)	329	371	523	589	504	420	537	602	696	730	530.1	131.1389848	530	0.25	1880	1.08	565.7
	East side of Bunker Street (Festival and holiday)	413	530	598	701	623	618	687	834	976	1265	724.5	245.3683173	655	0.34			
④	East side of Rua Do Delegado (Workday)	368	370	412	490	439	401	467	520	550	569	458.6	72.4955171	453	0.16	11075	1.34	471.9
	East side of Rua Do Delegado (Festival and holiday)	397	410	521	560	517	462	510	587	689	803	545.6	124.2257801	519	0.23			
⑤	West of the Governor Carlos Eugeino Street (Workday)	421	459	470	545	521	460	587	659	734	790	564.6	125.9904758	533	0.22	12340	1.25	569.3
	West of the Governor Carlos Eugeino Street (Festival and holiday)	410	480	616	691	629	610	770	831	910	1017	696.4	188.354984	660	0.27			
⑥	middle of the Correia da Silva Street (Workday)	58	62	97	114	80	71	61	92	118	137	89	27.32926799	86	0.26	1239	1	87
	middle of the Correia da Silva Street (Festival and holiday)	68	71	94	128	85	81	69	96	138	150	98	30.09614224	89.5	0.32			

5. Cross-analysis of space syntax and cross-section flow and commercial Poi data

5.1 Analysis of block Poi and cross-section flow data

In this study, the map vector download version V6.0 is used to download commercial Poi data, which include two items, shopping services and catering services, including 88 names and geographical location information of Poi facilities located in five streets, as shown in Figure 7.

According to the flow data in Table 1, the CAD map measures the total area of the historic district streets and surrounding shops, and Figure 7 summarizes the Poi data, which is shown in Table 2. The catering service facilities and shopping service facilities in Cunha Street are the most in the block, matching the composition of the main road. Bunker Street and Governor Carlos Eugeino Street have the most catering service facilities, belonging to the obvious catering streets. The number of catering service facilities and shopping service facilities in Rua Do Delegado is relatively even and Correia da Silva Street's catering service facilities are slightly more than shopping service facilities.



Figure 7: Poi facility diagram of the historic district in Cunha Street

Table 2: Vitality matching degree data of street space facilities of the historic district in Cunha Street

Vitality matching degree data of street space facilities of the historic district in Cunha Street				
Street	Pop (Total number of people gathered within one hour) (unit / person)	Area (Total area of historic district streets and surrounding shops) (unit / m ²)	Num (Total number of Poi facilities) (units / per)	Num (Total number of catering service Poi facilities) (unit / per)
Cunha Street	947	1478	9	23
Bunker Street	566	2952	4	15
Rua Do Delegado	472	2482	7	7
Governor Carlos Eugeino Street	569	2797	4	12
Correia da Silva Street	87	1329	2	5

5.2 Space syntax cross-over analysis

In this study, the following formula and the data obtained in Table 2 will be used to obtain the vitality matching degree of space facilities in the two directions of shopping service and catering service to conduct cross-analysis.

$$A = \frac{\text{Pop/Area}}{\text{Num}}$$

A represents the vitality matching degree of spatial facilities in historic districts, Pop represents the total number of people gathering within an hour, Area is the total area of the historic district streets and surrounding shops, and Num represents the total number of facilities of POI of a certain type. The higher the vitality matching degree of spatial facilities in historical blocks, the better the matching degree of the vitality of human flow and facility construction within the scope, and the stronger the spatial vitality, as shown in Table 3.

Table 3: Vitality matching degree of street space facilities of the historic district in Cunha Street

Vitality matching degree of street space facilities of the historic district in Cunha Street		
Street	A (Matching degree of shopping service space)	A (Matching degree of space catering service)
Cunha Street	0.07	0.03
Bunker Street	0.05	0.01
Rua Do Delegado	0.03	0.03
Governor Carlos Eugeino Street	0.05	0.02
Correia da Silva Street	0.03	0.01

In the matching degree of shopping service space: Cunha Street (0.07)> Bunker Street (0.05), Governor Carlos Eugeino Street (0.05)> Rua Do Delegado (0.03), Correia da Silva Street(0.03). In the matching degree of catering service space: Cunha Street (0.03), Rua Do Delegado (0.03)> Governor Carlos Eugeino Street (0.02)> Bunker Street (0.01), Correia da Silva Street (0.01).

Among them, Cunha Street has the highest matching degree in both shopping service space and catering space, indicating that the matching degree of people flow vitality and facility construction in Cunha Street is the best among all streets. The matching degree of shopping service vitality between Bunker Street and Governor Carlos Eugeino Street is obviously stronger than that of catering service vitality, indicating that the catering poi facilities are more intensive. The matching degree of the vitality of shopping facilities and catering service facilities is relatively average, which is a balanced street. Correia da Silva Street itself is a low-grade road, and the vitality of the two facilities is low, in line with its own traffic function.

6. Conclusion

This study uses the axis analysis of space syntax to analyze the integration and choice of the streets in the historic district of Cunha Street to explore the influence of its space form on tourist agglomeration. Combined with the statistics of the tourist flow and the distribution of the commercial business forms, the in-depth analysis of the operation mode is conducted to further explore the influence of the space form on its operation mode.

The results reveal that the overall space of the historic district of Cunha Street is distinct from inside to outside, and the shape of the district is coordinated, presenting the "Gong" shaped road skeleton and "Leaf Vein" shaped street space. As the main road, Cunha Street plays a leading role in the integration, choice and commercial business distribution, and together with many streets, it forms the road structure of the block, which is conducive to the evacuation of tourists. As the road with the highest degree of integration, the commercial distribution of the south side of the Rua Do Delegado can be appropriately increased to the south side, so that the road resources can be fully used. As an important road connecting the city center of Taipa, Bunker Street has a low degree of integration and choice, which can appropriately increase the traffic connection with Cunha Street to enhance the accessibility of the road. The integration degree of the Governor Carlos Eugeino Street and the distribution of business forms are good, but the choice is low due to the twists of roads, so guidance facilities can be appropriately added to guide tourists.

It is both necessary to protect the original historical features of historic districts, and protect and update them according to the scientific planning to maintain the prosperity and development of the districts. In the future, more analytical methods will be added for in-depth research to provide a more comprehensive understanding of the protection and development strategies of historic districts.

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Sources of the tables and figures

Figure 1, 2 and 5, prepared by the authors according to the information from the Cultural Affairs Bureau of the Macao Special Administrative Region (Distribution map of the assessed real property and buffer zones).

Figure 3, 4 and 6, prepared by the authors according to the Macao map data with Depthmap software.

Figure 7, prepared by the authors with GIS software according to map Map vector loader V6.0 downloaded commercial Poi data.

Table 1, prepared by the authors based on the on-site investigation data of the block in the Cunha Street.

Table 2, prepared by the authors according to map Map vector loader V6.0 downloaded commercial Poi data and block map data.

Table 3, prepared by the authors base on the calculation and collocation of the data in Table 2 with the formula $A=(Pop/Area)/Num$.

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