

Research on Design Update of Commercial Space in Community Street Based on Space Syntax

Taking Yulin Community of Chengdu as an Example*

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Abstract—Take Yulin community in Chengdu as research sample and collect POI big data about business condition. Relations between depth, integration, intelligibility and characteristics of commercial distribution are analyzed according to theory and technology of space syntax. Verify matching degree and analyze inconformity through theory and investigation, further analyze advantages and disadvantages of sample space via axis analysis results of space syntax, in order to propose more reasonable commercial layout for update design.

Keywords—update design; space syntax; POI; urban community; commercial layout; integration

I. INTRODUCTION

With the soaring development of urbanization, business districts in cities spring up like mushrooms after rain. In a sense, business district covers residence and construction in life and refers to one of the symbols of modern urbanization. With the appearance of business districts, small communities built at the close of last century without large-scale transformation will inevitably and rapidly decline. Commercial research on small communities in these cities is distinctly important for planning and update of old communities.

In the 1970s, space syntax theory was proposed by Bill Hillier who carry out abstract and modeling analysis on space relation with mathematical method through quantifying space elements. Bill Hillier believes the effectiveness of internal logic exists in things. In other words, people will choose more convenient and efficient ways in space system. He researches how social and economic factors gradually influence and form space. The effectiveness of this logic is verified.

Under the premise of update design of community, axis research method in space syntax theory is used to establish axis network diagram of object region, namely use axis to represent urban road. Topological relation exists between two connected axes. Variables in space syntax used in this paper include: depth, mean depth, integration and intelligibility, which can embody accessibility, throughput capacity and

spatial cognition of street space.

II. REGIONAL OVERVIEW AND RESEARCH METHOD

Yulin community of Chengdu city "Fig. 1" is old living quarter in modern times in the southwest of Chengdu city. It is surrounded by main traffic arteries, including South Renmin Road, Second Ring Road, Yongfeng Road and First-ring road. It is about 3km away from Tianfu Plaza in the center of Chengdu city. The community has residence and shops with street frontage and sound community configuration. The high street is about 7 to 12 meters and laneway is about 3 to 5 meters. The green belt centralizes in the southwest side. Catering mainly attracts consumption outside the community, with an area of about 1.9 km². The community has total population of about 150,000.



Fig. 1. The scope definition of Yulin and the position of metro station.

Yulin is a key area between first ring and second ring in the south of Chengdu. In recent years, three metro stations with rapid development exist around Yulin, including Yiguanmiao Station, Provincial Gym Station (transfer station) and Nijiaqiao Station. Besides, at present, there is a station under construction located in the intersection of Yulinxi Road and Fangcao Street. "Fig. 1"

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This research explores commerciality of Yulin district through big data POI (Point of Interest). It consists of four business types: catering, retailing, resident service,

entertainment and sports with corresponding commercial activities. "Table I"

TABLE I. DIVISION OF BUSINESS TYPE

Catering	Retailing		Resident service		Entertainment and sports
Hot pot restaurant	Supermarket	Building materials and hardware	Real estate medium	Copying and typewriting	KTV
Cafes	Shops of clothes, shoes and bags	Flower shop	Hotel	Pet service	Massage health
Rotisserie	Groceries and cake shops	Cosmetics and health care	Express and logistics	Household service	Tea house
Fast food restaurant	Convenience stores	Infant and mom	Hairdressing and beauty		Gym
Chinese restaurant	Vegetable shop	Press and book store	Primary school		Bar
Western food restaurant	Fruit market		Bank		Internet bar
	Drugstore		Kindergarten		Cinema
	Cigarette and wine shops		Clinic		Electronic game

In data statistics, thermodynamic diagram is used to mark business state and can better and more directly shows concentration and dispersion of business. The following is the thermodynamic distribution of the four business types.



Fig. 2. Thermodynamic diagram of catering.

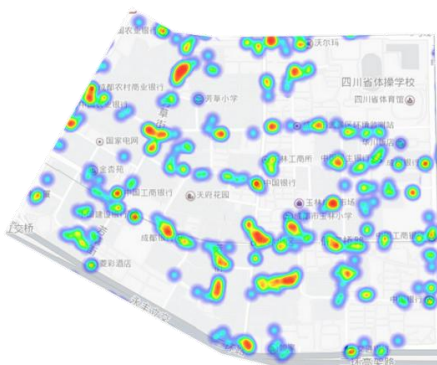


Fig. 3. Thermodynamic diagram of resident service.



Fig. 4. Thermodynamic diagram of retailing.

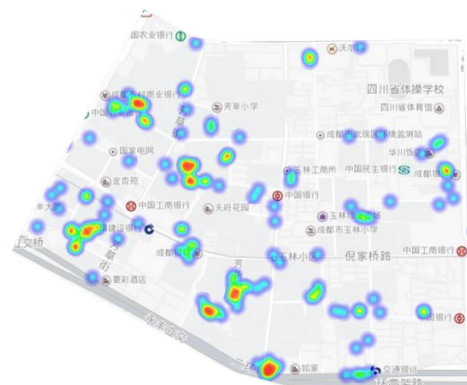


Fig. 5. Thermodynamic diagram of entertainment and sports.

Catering "Fig. 2" centralizes in four areas involving: western section of Yulinxi Road, northern section of Fangcao Street, Ruishengbei Street, Ruishengnan Street, Yulinzhong Road, middle section of Yulin Street, Yulinnan Street and southern section of Yulinnan Road. The distribution of resident service "Fig. 3" exists in an annular axis involving: Fangcao Street, Yulin Road, Fangcaodong Street, Nijiaqiao Road, Fanghua Street and Yujie Lane. It has dispersed commercial activities in lane of community near Reminnan Road. The distribution of retailing "Fig. 4" is even, extending from Fangcaodong Street to Nijiaqiao Road, from Yulinxi

Road to Yulindong Road, Fangcao section of First-ring Road and frontage of Second Ring Road. The distribution of entertainment and sports "Fig. 5" is most centralized, involving western section of Yulinxi Road, Lancao Road, Ruisheng Plaza and Fangcao Street. The commercial layout of Yulin district "Fig. 6-a" indicates it has "two longitudinal distributions and three lateral distributions" formed from Fangcao Street, Fangcaoxi Street to Nijiaqiao Road, from western section of Yulinxi Road to Yulindong Road, from Yulinbei Road to Yulinnan Road and Yulin Street. "Fig. 6-b"

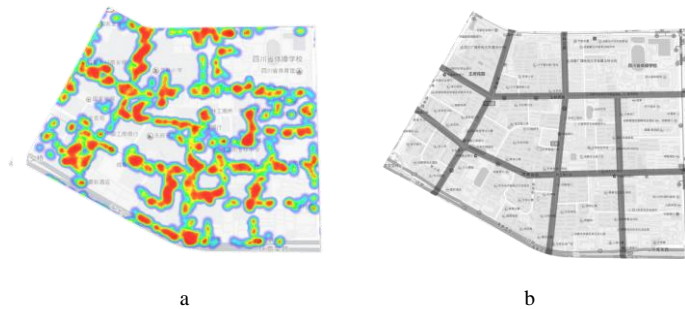


Fig. 6. Thermodynamic diagram of overall commercial layout.

III. ANALYSIS ON SPACE SYNTAX

The current road net in Yulin district is turned into axes, to avoid the influence of "boundary effect". First, extend the axes beyond the research scope in axis figure. Besides, there inevitably will be vague roads in drawing the axis figure, so the axes of roads that extend to even run through community are deleted, and only axes of community road and above are kept. "Fig. 7"

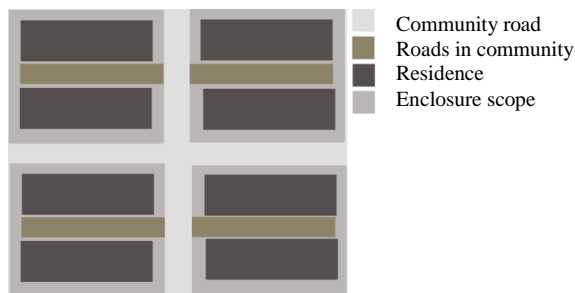


Fig. 7. Schematic diagram of community.

A. Mean Depth

In mean depth figure, the mean depth value of blue axes is the lowest, so people will pass through less space to reach these places. "Fig. 8" indicates mean depth value from Fangcaoxi Road to Fangcaodong Road, Nijiaqiao Road and Yulin Road is the lowest. These places have convenient transportation and large pedestrian volume. Mean depth value from green to red axes is high, which means people have to pass through more space to reach these places. By comparison, most areas conform to thermodynamic diagram. However, the mean depth value of pedestrian street area (Ruishengnan Road, Ruishengbei Road) of Ruisheng Plaza and Fanghua Street is greatly different from actual business condition. Mean depth

values of the two areas all reach above 4.0. Mean depth value of Fanghua Street is about two times larger than that of Yulindong Road and Nijiaqiao Road.

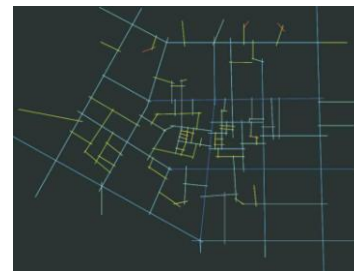


Fig. 8. Axis figure of mean value.

B. Integration

The integration "Table II" indicates the area with the highest integration is Yulin Road, namely the intersection of Yulinxi Road, Yulindong Road, Yulinbei Road and Yulinnan Road "Fig. 9".



Fig. 9. Axis figure of integration.

(Left figure is overall integration, and right figure is 3R integration)

TABLE II. STATISTICAL TABLE OF INTEGRATION

Street name	Overall integrity	3R integrity
Western section of Yulinxi Road	1.92462	2.27613
Yulinxi Road to Yulindong Road	2.75279	3.09663
Northern section of Fangcao Street	2.06459	2.4291
Southern section of Fangcao Street	1.8769	2.4209
Fangcao Western Second Street	1.9494	2.56304
Eastern section of Fangcao Street to Nijiaqiao Road	2.42894	2.76014
Yulinbei Road	2.20491	2.52141
Yulinzhong Road to Yulinnan Road	2.87475	3.05335
Yulinbei Street	2.01872	2.52211
Yulin Street	2.29399	2.87993
Ruishengbei Road	1.31275	1.5469
Ruishengnan Road	1.31275	1.5469
Fanghua Street	1.33766	1.4228
Yulinshang Lane	2.22652	2.66258
Yujie Lane	1.78823	2.04132

Places with high integration are more accessible. The integration of Ruisheng district formed by Pedestrian Street of Ruisheng Plaza, Ruishengnan Road and Ruishengbei Road is low. But the thermodynamic diagram shows catering, retailing, service and entertainment gather in this area. The axis integration is different from physical truth. Through field research, the pedestrian street of Ruisheng Plaza is surrounded

by four communities with commercial residential buildings including Mudanyu Garden, Ruisheng Garden, Mingren Garden and Jinxing Garden. It differs from the form of old residence built in the 1980s to 1990s in Yulin center, "one access with one building on each side respectively". Communities around Ruisheng Plaza conform to planning mode of development for modern communities and were built during 2000 and 2005. Four communities with commercial residential buildings surround one pedestrian plaza, so pedestrian volume on the plaza and business conditions are good.

Thermal analysis figure shows business condition of Fanghua Street, in which retailing, service and entertainment industries gather. According to the axis analysis result of integration in space syntax, we find the integration of Fanghua Street is low. Field research proves tearooms and health clubs in this street are more than that of other streets. Although old residences with "one access with one building on each side respectively" exist on both sides of the road, the roads are wider, and the widths of two-lane and each sidewalk are about 5 meters and about 4 meters respectively. Compared with most areas of Yulin Community, the road width is more advantageous in commercial development. Moreover, as a community road, Fanghua Street connects Fangcaodong Street, Yulinnan Street and Second Ring Road "Fig. 10", and alleviates the pressure of traffic flow in Yulin Community with narrow roads. However, after all, Fanghua Street is a community road, so there are not so much catering here.



Fig. 10. Schematic diagram of Fanghua Street at the ends

The analysis on axis integration in space syntax indicates the integration of Yulinshang Lane is high, but the thermodynamic diagram shows the business condition is very poor actually. Two main problems are found in field research: first, the road in Yulinshang Lane is narrow. Only two vehicles can pass through western section of the road and only one vehicle can pass through eastern section. Second, there are few stores and most parts of both sides are walls. The absence of business and narrow road fail to embody the advantages of commercial integration.

In the southern section of Yulin Road, Yujie Lane is perpendicular to it. The thermodynamic diagram indicates service industry gathers here. The integration value is not good but the service industry has high degree of concentration. Similar to areas of Ruisheng Plaza, Yujie Lane is surrounded by several large residential areas including Yulinjia Garden,

Youth Island Community, Tianfu South Garden. Yujie Lane gathers retailing and service industries and the areas of stores are within 10 m². Although the road of Yujie Lane is not wide, it meets needs of residents in the communities. The investigation shows Yujixi Road is wider and has parking area, so more large-scale catering services gather on Yujixi Road. Besides, Yujixi Road is L-shaped and connects Nijiaqiao Road and Yulinnan Road. Like Fanghua Street, Yujixi Road alleviates the pressure of traffic flow in the area.

Except for the above areas that big differences exist between thermal situation and axis integration, other areas have matched integration of space syntax and actual business condition. The area in Yulin district with the highest commercial integration includes: two longitudinal distributions and two lateral distributions. Yulin district has some open communities, in which the roads connect with external road nets and most allows the passage of vehicle. But buildings exist on both sides of the road so there is no room for business. The average width of road is:

In general, the integration of Yulin district coincides with physical truth. Some areas have different business flow, and the reasons include:

- 1: Some roads in areas with high community enclosure degree and high concentration degree must be convenient for the people.
- 2: Roads are built early and have no room for stores because of narrow road and small reserved space.
- 3: The ends of some roads connect trunk road, which alleviates pressure of traffic flow in Yulin area with narrow road.

C. Intelligibility

Intelligibility is shown in regression line and scatter diagram, including X coordinate of integration and Y coordinate of integration R3. When R2 (R refer to the value of regression line) is below 0.5, it proves horizontal axis is irrelevant to vertical axis. When R2 is larger than 0.5, the horizontal and vertical axes are relevant. When R2 is larger than 0.7, the horizontal and vertical axes are significantly correlated.

The function regression relation of overall and local integration indicates its correlation R2=0.89, forming excellent linear regression relation "Fig.11". It shows space users can relatively easily infer overall space from local space and have obvious advantages in spatial cognition.

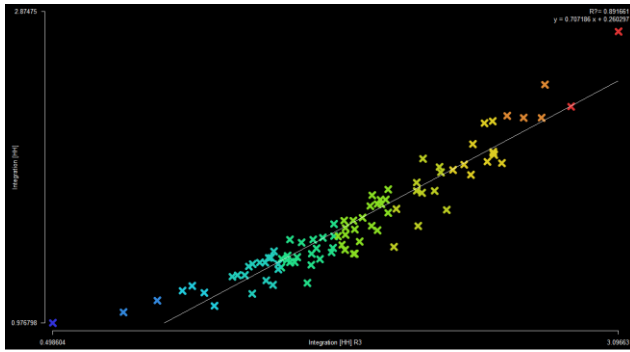


Fig. 11. Regression line and scatter diagram.

IV. GUIDANCE ON UPDATE DESIGN

A. Maintain Main Commercial Space Layout and Preferentially Develop Metro Stations and Traffic Nodes

On the whole, physical truth of Yulin district matches with analysis result of integration. The area with “two longitudinal distributions and two lateral distributions” with the highest integration from Yulinxi Road to Yulindong Road, Yulinbei Road to Yulinnan Road, Fangcao Street, Fangcaoxi Road and Nijiaqiao Road should serve as main commercial section. But the space syntax analysis and development situation of Yulin indicate the area from Yulinxi Road to Nijiaqiao Road has low depth value and high integration value, and two metro stations including Yulinxi Road Station (metro line 8 is under construction) and Nijiaqiao Road Station. Metro stations will drive development of radiation area and gather and distribute pedestrian volume. Besides, the two stations are on the same section. The area from Yulinxi Road to Nijiaqiao Road should be taken as the commercial center of Yulin district. Nijiaqiao Road directly connects with Tianfu Avenue and is adjacent to Laifushi Plaza, not suitable for the establishment of large-scale business. However, the intersection of Yulinxi Road and Fangcao Street has mature community environment and is adjacent to Yongfeng interchange. Located in Second Ring Road connecting Chengdu-Ya’an Expressway, Yongfeng interchange is key traffic node in the southwestward of Chengdu and points directly at downtown northwards and is close to Shenxianshu community cluster. At present, commercial complex in third ring of Chengdu develops rapidly and the commercial class in downtown is backward. The intersection of Yulinxi Road and Fangcao Street has great commercial potential.

B. Spatial Layout of Community Is Relatively Balanced; the Update Should Be under the Premise of Improving Business Convenience of Life Community

Yulin district consists of small communities, which constitute of micro communities. Substantially, it belongs to large life community. Planning and transformation should focus on the lives of residents. Space syntax analysis indicates data of Ruisheng Plaza, Fanghua Street and Yujie Lane deviate from reality, because these areas meet commercial demand of residents and are in southern part of Yulin. The result of space syntax indicates the section from Yulinxi Road

to Yulindong Road in northern part of Yulin has the lowest depth value and the highest overall integration. Local integration is highest (3.09663) in Yulin district, indicating the street (axis) is the most accessible in the scope of three depths. Therefore, the section from Yulinxi Road to Yulindong Road should focus on business for the convenience of the people in northern part of Yulin, in order to change the imbalance between the north and the south. Wangfu Garden Community cluster in western section of Yulinxi Road gathers catering which develops well, and eastern section of Yulindong Road has Sichuan Gymnasium occupying large area, so business area should gather in the intersections between this road and Fangcao Street and Yulin Street. The area has many micro communities in the north and south sides and is close to two schools (Fangcao Primary School and Yulin School), more suitable for business for the convenience of the people.

Yulin district has several small communities formed by micro communities. After years of self-organization, large scale roads and business conditions will be transformed. In linear regression analysis simulated by space syntax software, the value of high intelligibility $R^2 = 0.89$, indicating road axes in these communities are not chaotic. People can easily infer overall space from local space. Therefore, according to the analysis on commercial radiation range, it is reasonable to establish small scale centralized business for the convenience of the people.

V. CONCLUSION

The research on update design of commercial space in community streets carries out axis simulation and comparison for researched areas via space syntax theory and big data POI. Data calculated through axis figure of space syntax and POI data are compared and analyzed, verifying the high pedestrian volume in commercial streets in community can be explained through space syntax. Besides, inconformity is researched and explained. Suggestions are proposed for update design of commercial streets in community. There are varied factors that influence pedestrian volume in commercial area in reality, so the design about the combination of space syntax and POI needs further exploration.

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