

Study on Application of Pixelate in Architectural Internal Space Constitution

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Abstract—This paper starts from the study on the representation of two-dimensional pixels in three-dimensional space, and focuses on studying the internal space and combination form of commercial complex, using pixelated modular space to create infinite space in finite space. "Pixelate" is mostly applied to two-dimensional planes. The paper attempts to make the "pixels" three-dimensional, use equal "pixelate" to break traditional architectural design's confinement of starting from the plane, starts from three-dimensional design, and applies it to the representation of architectural space design. The form of "pixelated" space is selected for its shape uses the space most rationally and is the most easily realized. As land resource becomes less and less, the functions used cannot be directly proportional to it. Therefore, it is necessary to make rational use of space and maximize its use to achieve a higher level of spiritual consumption by users. The architecture of "pixelated" space has architectural ideas with distinct characteristics of times. The current thinking of space issues aims to save resources and diversify performances, and reflects the simplicity and functionality of modern design. To a large extent, it can solve the existing problems of space and sustainable development, and has certain practical significance.

Keywords—pixelate; space composition; architectural space

I. INTRODUCTION

With urban development, a lot of businesses emerge, and people's lifestyle has changed; they are no longer interested in ordinary consumption of living, but yearn for comprehensive experiential consumption for the purpose of seeking a certain experience. The functions are complex and the proportion of evening consumption increases. At this stage, the economy is running at a high speed, and almost all cities are conducting large-scale building activities, which makes architecture itself not pay attention to the internal structure any more. As a carrier, architecture is meant to meet human needs, and building space is its carrying content. Based on the needs of local people, the author regards pixelate as the basic point of architecture, and then takes it as a core of architecture to make planar pixels three-dimensional, to build multi-functional commercial complexes, thereby making full use of the space, effectively and rationally adjusting the use of the space, and achieving harmony and unity between people and architectural space, and between architectural spaces.

With the continuous development of modern science and technology, the urgent need for urban development and construction in the future, architectural form is no longer single, and multiple forms are constantly emerging. Diversified architectural forms are gradually being accepted by the public, and pixelated space is one of the representations of architectural space diversification, which is worth exploring and studying. In the pixelate architectural design, how to better deal with the constitution of "block" structure space and the overall building space is the study point of this project. In the future development of architecture, pixelated space is an inevitable development trend and another embodiment of space flexibility.

II. CONCEPTS RELATED TO PIXELATE IN ARCHITECTURAL INTERNAL SPACE CONSTITUTION

A. Pixelate

Literally, it is a basic representation of drawing an image point by point with "pixel" as a basic unit. After that, pixel art, a specific arrangement form that takes point as the basic unit is gradually formed under the premise of retaining the unitized visual attributes.¹

In terms the use of pixelate, Lego is outstanding in design. In the development and evolution of LEGO, each of its blocks is like a "pixel", and is arbitrarily combined and stacked into various forms as a unit. After "pixel" is made three-dimensional through Lego as a medium, the problems such as the interaction with people, interaction with the surroundings, and whether it's observable rise up. As a kind of representative element, there are many creative methods for "pixel", and the two most prominent methods are stacking and patchwork. The two methods seem to be very similar, but actually the expressive force of the two is very different. A lot of stacking methods focus on the overall shape of pixels, which is not the same as the expressive force of a few patchworks. Among a large number of stacking methods, mostly are inclined to the characteristics of pixels, such as geometry, flexibility and interactive variability, but

¹ Guo Xiaoyang, Liu Liwei, Wei Xiaodong. Pixelate Visual Performance in Environmental Art Design (in Chinese) [J]. Decoration. 2010(06)

the number of pixels actually used in patchwork still needs to be determined.²

B. Space Composition

Space is an objective form of material existence, expressed by length, width, and height. Space gives people a feeling of three-dimensional; it is people's cognition and experience of the surrounding things.

"Constitution" means forming and constituting in dictionary. It is a combination method formed by some means.

The conceptual composition is based on the meaning that people give to space and orientation; the substantial constitution is to distinguish and mark space by using the physical differences of the objects themselves.³ The space constitution here refers to the combination design of pixelated space from two-dimensional to three-dimensional.

C. Architectural Space

The architectural space is a kind of practical space, and an architectural form created by people using certain architectural means and combination methods according to the requirements of certain activities, which has an image. The constitution of architectural space is designed to rationally develop and utilize the natural space, and is a constitution way of dividing architectural space and natural space. The architectural space here refers to the architectural internal space.

III. THE APPLICATION OF PIXELATE IN ARCHITECTURAL INTERNAL SPACE CONSTITUTION

This chapter mainly studies the application of pixelate in architectural interior space constitution based on the characteristics and arrangement modes of three major constitution methods: repetitive constitution, aggregated constitution and dispersion. However, repetitive constitution is subdivided into four methods, which are also the most basic constitution methods.

Aggregated constitution is subdivided into three constitution methods: connected constitution, superposed constitution, and dispersed constitution. These three constitution methods belong to "addition" methods in constitution, and are used in architectural constitution for several times.

There are three basic constitution methods in decomposed constitution. Compared with aggregated constitution, decomposed constitution belongs to "subtraction" methods in constitution, and has a certain effect on the decomposition of large volumes in use.

These several design methods are very helpful to pixelated architectural interior space constitution.

² Li Qiudi. Pixel charm (in Chinese). [Master's thesis]. Central Academy of Fine Arts. April 2011

³ Pu Suwei, Cai Dongyan. Architectural Space Constitution Design (in Chinese). Xi'an Jiaotong University Press. February 2007

A. Method for Architectural Interior Space and Design Method

This part studies from the three major constitution methods, answers and enumerates spatial examples and graphics based on their rules. This paper takes the geometrical form of square as the prototype of "pixelate". Through the continuous understanding of geometrical form and data search, the following constitution methods are found.

1) *Repetitive constitution*: After several repetitions of the geometrical form, the space is closely connected to the whole, so that they are no longer single existence, but have certain significance. In the process of continuous repetition, the uncertainty of space gives people a lot of thinking. In order to adapt to the complexity and variety of space, the following basic forms are designed.

Such space constitution is characterized by linear arrangement after the change and reasonable form representation.

Repetitive constitution can be divided into four basic forms: translation, rotation, reflection and reverse.

a) *Translational constitution*: The geometry is linearly arranged in a simple manner after repetition. Through translation, the integrity of simple forms is weakened. The same space or body block will present full rhythm after a number of regular continuous translations. For example ("Fig. 1"), the continuous translation repeated in the space makes the space be linearly arranged, and such space is very convenient to use.

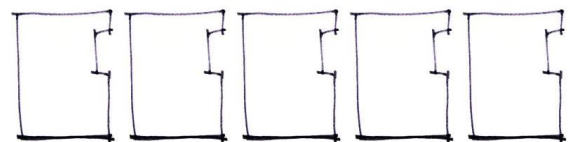


Fig. 1. Continuous translational constitution.

b) *Rotatory constitution*: The geometries are rotated and then linearly arranged after repetition. When people are not interested in continuous space, they can change slightly under normal circumstances. By rotating, they can make space more flexible, with a dynamic effect ("Fig. 2").

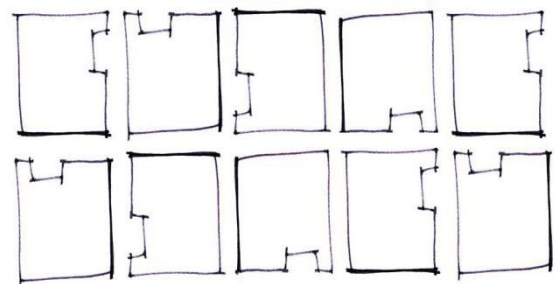


Fig. 2. Rotatory constitution.

c) *Reflective constitution*: Geometries are rotated symmetrically after repetition, and then linearly arranged. The principles of reflection and mirror are the same, both of which exist in a symmetrical form ("Fig. 3"). Such space will make small space no longer small, and the overall space looks transparent and harmonious.

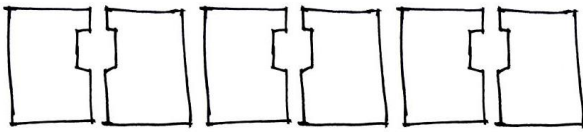


Fig. 3. Symmetrical constitution.

d) *Reverse constitution method*: Geometries are rotated symmetrically after repetition, and then arranged after rotating by 180 degrees ("Fig. 4"). Rotating on the basis of reflection creates a positive space effect between the various forms.

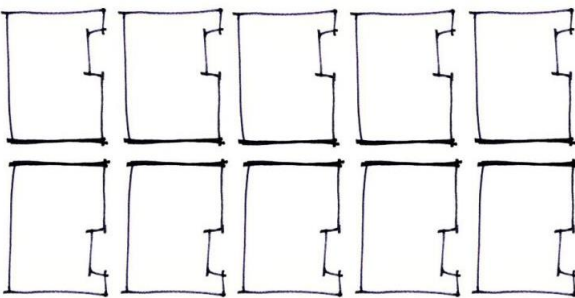


Fig. 4. Reverse constitution.

2) *Aggregate constitution*: Aggregation is to add up multiple identical geometries, which belongs to "additional" constitution method. Aggregation method is extremely widely used in design, and it is a combined constitution method.

Aggregated constitution can be divided into three methods: connection, superposition and dispersion.

a) *Connected constitution*: Repetition is the basic unit of separation. Connection it to connect all of the relatively independent basic units used in some way. This kind of constitution is inevitable, and there is connection from no matter which aspect.

b) *Superposition constitution*: Superposition is a constitution method that combines and overlaps multiple geometries. In this method, it is recommended to note that each geometry should be combined under the premise of maintaining its original contour and expressive force, so as to express spaces with a variety of meanings and abundant contents. Superposition constitution is subdivided into two forms: the one is like stacking Lego bricks, among which layered stacking is the most stable way of building composition; the other is to stack disorderly stack. These two methods are mostly reflected in architecture.

c) *Dispersed constitution*: A number of identical or different geometries separated from each other are aggregated into one, and an abundant gap, namely negative space⁴, is generated between the separated geometries; the dispersion of geometries is a constitution form of negative space. In such negative space, it is appropriate to add interesting little things or greening to adjust the negative sense of space. The negative space here is the outer space around the building.

3) *Decomposed constitution*: Decomposition is to decompose a complete geometric from the inside while keeping the basic integrity of the external form as much as possible.⁵ That means differentiating in a complete space. Its differentiation may be the differentiation of functions or the differentiation that needs to use a certain space.

Decomposed constitution can be divided into three methods: of division, penetrating and cutting.

a) *Dividing constitution*: Most of the connections are represented by the appearance of geometries. In contrast, division is to divide into several small geometries inside a complete and simple geometry, which is a typical "subtraction" constitution.⁶ A complete space is divided into multiple small spaces and then re-combined. This makes the space extremely malleable and reasonably arranged for use.

For example, "Sumiyoshi Residence" ("Fig. 5") is divided into two directions, three parts in each direction, which naturally forms a layout of squared figure. The method of division is extremely common in architectural space. The space formed by division maintains the most primitive form as a whole, while the interior of the space is variable.

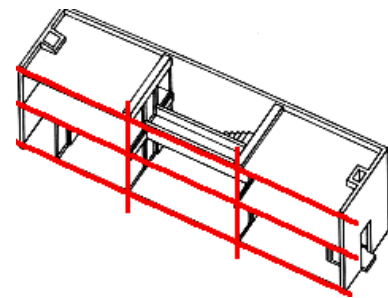


Fig. 5. Layout of squared figure.

b) *Penetrating constitution*: Penetrating means completely nesting the gradually narrowed geometries into a same form within a geometry and carrying out multiple combinations⁷.

⁴ [Japan] Awara Yoshishin. External Space Design. China Building Industry Press. March 1983.

⁵ Pu Suwei, Cai Dongyan. Architectural Space Constitution Design (in Chinese). Xi'an Jiaotong University Press. February 2007.

⁶ Pu Suwei, Cai Dongyan. Architectural Space Constitution Design (in Chinese). Xi'an Jiaotong University Press. February 2007.

⁷ Pu Suwei, Cai Dongyan. Architectural Space Constitution Design (in Chinese). Xi'an Jiaotong University Press. February 2007.

When penetrating, it is recommended to note that the external and internal geometries are in the same shape, which is characterized by obvious structure and effect when penetrating, but different shapes can also achieve different effects. Such spatial processing between external and internal geometries is very important. For example, Kiko Mozuna's "reverse residence" is designed by penetrating ("Fig. 6").

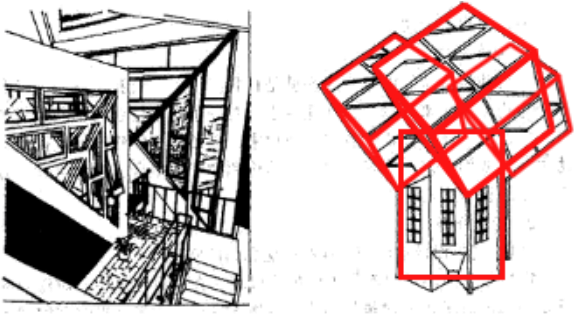


Fig. 6. Cube penetrating process.

c) *Cutting constitution*: Cutting is to cut off or cut into smaller geometries from a complete geometry. The cut part can be once again connected with the overall space; it pursues spatial changes, so that people can better enjoy the space.

B. The Method for Pixelate in Architectural Internal Space Constitution

This part combines the three cases analyzed in Chapter II and three methods for architectural internal space constitution to illustrate which constitution way(s) is used in the case, and how pixelate is constituted inside the architectural internal space. According to the understanding of the above construction space, the constitution method applied in the case and design and its significance are analyzed.

1) *Aggregating form*: The aggregating form of pixelated space is basically the same as the architectural internal space constitution above. It is dominated by one space, and other spaces gather around it and move closer together. Pixelated spaces are dominated by superimposed constitution, supplemented by spatial connection.

2) *Linear combination*: A path is used to link various space combinations. Linear combination is also a one-line layout, and a repeating means. It can be used continuously in pixelated space to maximize the use of space ("Fig. 7").



Fig. 7. Linear space form.

3) *Radiation*: Radiation is to center on one space, and spread other spaces along the radiation route ("Fig. 8"). Although each independent functional space is scattered, it is still a whole. In the pixelated spatial constitution, it is diverged around with a center as the benchmark, and the whole space is connected to each other. The space can be used alone to save energy.



Fig. 8. Space radiation form.

4) *Surrounding*: The path forms a loop outside a certain space, and the commercial space is distributed along the loop. The combination of pixelated space and spatial nodes forms an abundant rich spatial form ("Fig. 9").

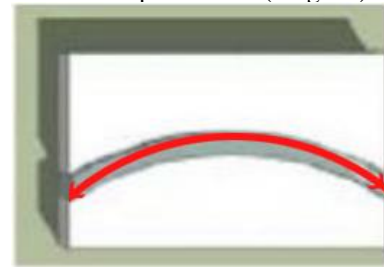


Fig. 9. Space surrounding form.

5) *Paralleling*: In few space or space combination ("Fig. 10"), there is no obvious primary and secondary feature, which is evenly distributed in the building; the connection path is not long, and is not strengthened; this is the combination of annular space mentioned abroad. In a pixelated space, combinations are variable and can stand out in the function of large commercial buildings.

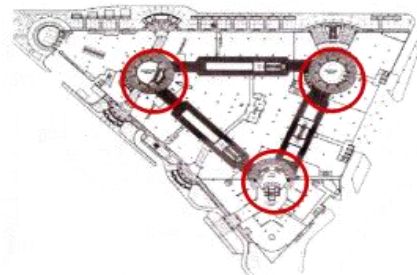


Fig. 10. Parallel space.

6) *Grid*: When the space is paralleled too much, grid form is the best expression. This method is similar to

penetrating, both of which use different combinations to form such grid-shaped space. In the pixelated space, the spatial function is complex and versatile; when processing with grid space, it makes the space mixed but not confused, and the function is clear. For example, the museum designed by designers H Casanova and J. Hernandez (“Fig. 11”) simultaneously performs the same spatial grid division in both horizontal and vertical directions to form a regular internal space.



Fig. 11. Grid space, Source: Graduation thesis.

As analyzed above, these constitution methods also exist abroad, and they are also called one-line, curved shape, T-shape, pinwheel shape, L-shape, ring shape, etc.; although the shapes and forms are different, the essence is the same (“Fig. 12”). [14]

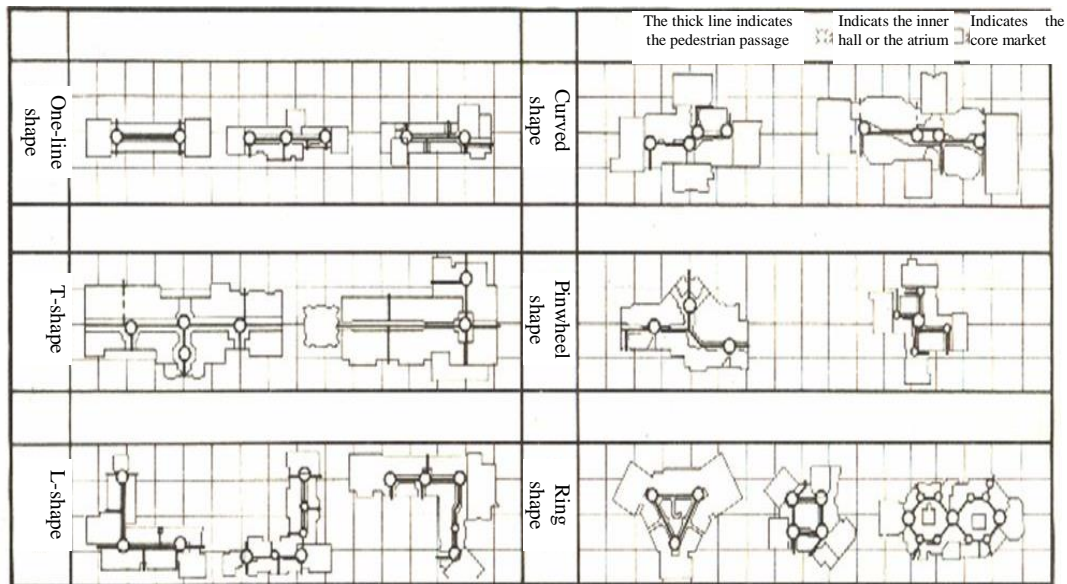


Fig. 12. Commonly used combination forms in foreign shopping centers, Source: Graduation thesis.

C. Summary

In this chapter, readers have learned about the constitution methods for pixelated internal spaces, and their application forms in design. Pixelated space is basically the same as other spaces, except that pixelate is equal and regular. It is inseparable from the architectural form. The form of combined constitution is varied. No matter which constitution method is adopted, design must respect and refer to the needs of users, and create and innovate space according to their ideas. Pixelated spatial combination has a great impact on the use, environment, and layout of space.

IV. APPLICATION PRACTICE OF PIXELATE IN ARCHITECTURAL INTERNAL SPACE CONSTITUTION

According to the previous research, this chapter seeks the design method, and uses the previous method of pixelate in

architectural internal space constitution, to plan the actual plan, and apply the research content.

A. Overview of the Project Review of Pixelated Space Constitution

The design project is located at the intersection of Hebei Street and Santiaoshi Street in Hebei District, Tianjin. Through the understanding, research and questionnaires of the design site selection, it is determined that the program focuses on young people aged 20-40, and meets the basic radiation range of 3-5 km. The purpose is to meet the basic needs of local people on the premise of innovative experiential consumption, to promote the development of the region and enhance the charm of the region. In the entire commercial complex, shopping accounts for 40%, catering accounts for 15%, and the remaining is leisure, entertainment and cultural innovation zones, in which the proportion of experiential consumption is large. It is an experiential

commercial complex that integrates business, catering, leisure, entertainment, and cultural life.

It starts from architectural space, focuses on pixelated space, takes unitized small space as the design concept, and carries out diversified pixelated space design. The pixelated unit space area is set at 100m².

Pixelated design emphasizes pure structure, flexibility and regularity. Although space design is static, designers can make use of various spatial changes and imaginations. The use of space is variable, enabling space-saving sustainable development.

B. Conceptual Program for Pixelated Space Constitution

The program uses the most basic geometries and the most traditional layered stacking form to pursue the stability of pixelated space. The shape of foundation is used to organize the space shaping (“Fig. 13 and “Fig. 14”). With the organic combination of the terrain and the space, it echoes the terrain in space. The author draws out the extra blocks in the cuboid and adds modules at the appropriate locations or misplaces (“Fig. 15”), achieving the effect by using a stacking method. In the internal space, the pixel block is taken as the basic

element, and the space combined by continuously copying, superimposing and connecting, to enhance the overall harmony and unity, and rationally arrange the entire space. The block structure is continuously reflected in the space, which forms the effect of pixel, and makes the space not boring but practical.

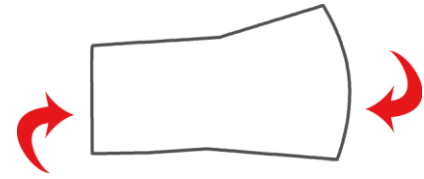


Fig. 13. Base deformation and height change.



Fig. 14. Base shape change.



Fig. 15. Repeat pixel module evolution process.

C. Establishment and Practice of Conceptual Program for Pixelated Space Constitution

The program mainly starts from the unit space, takes pixel block as the basic element, and rationally allocates and utilizes the space by continuously superimposing, copying and extracting. The shape of the building is decomposed into cube modules, and each pixel is equally large, 10m * 10m * 5m, forming a pixel-like architectural appearance (“Fig. 16”), which helps dissipate large buildings. The pixelated space and its overall effect have a strong visual impact.

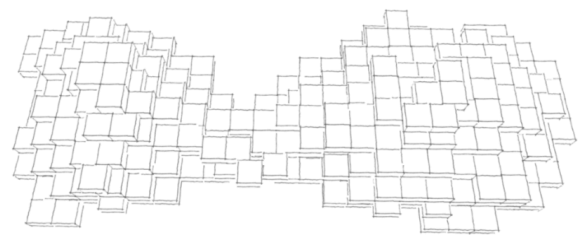


Fig. 16. Pixel-like building appearance.

In the internal space, according to the size of pixel blocks and the required space, modules are randomly combined by repeating, superimposing, and extracting (“Fig. 17”). The flexibility and variability of space is reflected in this combination.

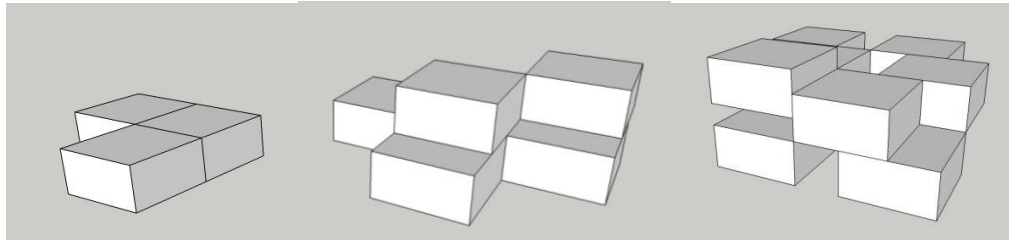


Fig. 17. Repeating, superimposing, and extracting.

The overall building area in the design program is 6,3700 m², including two floors underground and six floors above ground. It is an experiential commercial complex that integrates business, catering, entertainment and cultural life. In terms of cultural the life, the content is presented in the form of traditional hand workshops, so that people can better experience life better and enjoy the fun.

The second floor underground of the building is an underground parking lot of the commercial complex (“Fig. 18”). The number of parking lots, the population flow and the building area are determined according to the data (“Table I”)⁸; the parking lot can provide 600 underground parking spaces for the convenience of people. On the ground floor, there is a large supermarket and indoor sports to meet the living needs of residents in the area.

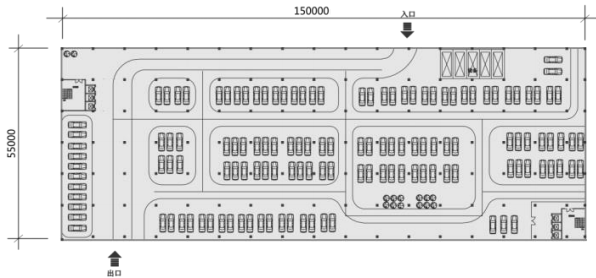


Fig. 18. Parking lot on the second floor underground.

TABLE I. REFERENCE FOR PARKING LOT STANDARD

Building Category		Calculating Unit	Standard Parking Space	
			Small car	Bicycle
Shop	Class I	Per 1000m ²	2.5	40
	Class II	Building area	2	40

The first and second floors of the building are mainly for shopping. The shopping space not only meets the material needs of users, but also meets their spiritual needs; diverse spaces should be attractive and different from other complexes. The shopping space is part of the main content of commercial complex, and the internal-external connections are very close. On the first floor, there are multi-functional

⁸ Note: ① This table is taken from Parking Lot Standard for Large and Medium-sized Public Buildings in Beijing.

② Class I refers to shops with a building capacity of more than 10000 m², and Class II refers to small ones

open shops on the right side, which can accept different functional requirements. For example, this area can accept some small exhibitions, merchandise discounts, etc. Each space can be used alone or in combination. The third floor is mainly for catering, and the fourth, fifth and sixth floors are mainly for leisure, entertainment and cultural life. Due to the further improvement of catering and entertainment consumption, the mobility of people is large and profitable, it is recommended to design good position and circulation in the space. The flexibility of space is enhanced by combining different functional space blocks.

In the inner space, unit modules of the same size in different combinations are used; different composition methods make the entire space form an overall pixelated space, with clear function and clear circulation. Externally, the formation of pixelated space makes the overall building have an undulating vision, which is an inside-out pixelated building.

V. CONCLUSION

With development of the times, the problems of space are constantly being concerned. Designers are required to continuously improve their level in terms of space use and space saving, which is also a challenge to the future space. In the future, space must be forward-looking and automatically adjustable, which requires designers to pursue. The development trend of pixelated space is also limitless. "Pixelate" is a spatial overall effect formed by unit modules through different composition methods, that is, pixelated space. Although a lot of materials and cases are referenced, and they are helpful for studying pixelate, the author's ability is limited, and cannot think comprehensively in many aspects, and needs careful study in the future. From two-dimensional to three-dimensional, from Lego toys to architectural art, the charm of pixelate design is everywhere. Pixelate has considerable operability and practicality, and has a broader design space. It is hoped that pixelated space will be more used in public space and real life, contributing to humans. It is more worthy of relevant art workers to study, practice and explore, to reflect its artistic value.

REFERENCES

[1] Guo Xiaoyang. Application of Pixelate Design Method in Environmental Art Design[J]. Literature & Art Studies.2011 (12). (in Chinese)

- [2] Shen Yuan. The Overall System — The Rules Of Geometric Constitution of Architectural Space Form. [PhD thesis]. Tianjin University. December 2010. (in Chinese)
- [3] Zhang Shangzhi. On Spatial Combination Design and Energy Saving from Space Experience. [Master's thesis]. Qingdao University of Technology. June 2012. (in Chinese)
- [4] Wang Wei. Study on Application of Modular Strategy in Architectural Optimization Design. [PhD thesis]. Hunan University. June 2012. (in Chinese)
- [5] Cheng Shaowei. Architectural Space Constitution[J]. Huazhong Architecture. March 20, 1999. (in Chinese)
- [6] Cai Yingying. Study on the Application of Pixel Art in Two-Dimensional Animation. Education Teaching Forum [J]. Donghua University. 2011(18). (in Chinese)
- [7] Fu Chunyou. Measures for the Design and Optimization of Architectural Space Structure under the New Situation [J]. Architecture and Planning and Design. 2014(02). (in Chinese)
- [8] Ren Lengyuan. Quantitative Research on Urbanization Space in Building Complex. [Master's thesis]. Shandong Jianzhu University. May 2014. (in Chinese)
- [9] Editorial Board of Architectural Design Data Collection. Architectural Design Data Collection (Second Edition) Volume 5. China Building Industry Press. 1994. (in Chinese)
- [10] Peng Yigang. Space Combination Theory [M]. China Building Industry Press. 1998. (in Chinese)
- [11] Pixels Go Mad-The Celebration of Pixel Art. smashing magazine .
- [12] Adele Goldberg,Robert Flegal."ACM president's letter:Pixel Art". Communications of the ACM. 1982.
- [13] Kenneth Frampton. Modern Architecture:a Creitical History [M]. (New York: Thames&Hudson. 1990.
- [14] Wang Hualing. Experience humanized commercial space (in Chinese). [Master's thesis]. School of Architecture, Tianjin University. June 2006.