Integration and Functionalization of Spatial Boundaries

-A Case Study of Macau University of Science of Technology

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Abstract—**As a defining element between spaces, boundary is defined by spatial extent and attributes. This paper discusses the feasibility of dealing with spatial images and background relationship by analyzing concepts, effects and forms of existing spatial boundaries and combining the relationship of graphics and background in Gestalt Psychology. Taking the campus boundary of Macao University of Science and Technology as a case, boundary extensions and functional implantations are analyzed to explore the diversity of spatial boundary forms. The case studies of marginalized spatial boundary can serve as a place where numerous information and functions converge, not just as an element of defining spaces.**

Keywords—Boundary; Integration; Forms; Functionalization

I. INTRODUCTION

Literally, boundary is understood as the end of certain space or field, or beginning of other space or field. However, all those bounds in reality between objects or spaces call boundary, including national border between countries, interfaces between architectural spaces, and even psychological defensive lines in human interaction [1-2]. Usually, boundaries exist in the form of a line called a boundary line.

II. CONCEPT AND MEANING OF BOUNDARY

Boundary begins as the way to understand space. The space in our daily experience is limited in a certain scope, and its attributes are determined by restricting elements that form different boundaries. In indoor spaces, partition walls are the boundary defining different functional areas to turn the whole indoor space into varied independent spaces. As the boundary between interior and exterior space, an external wall defines both the nature of indoor and outdoor space. In an outdoor space, boundary exists between housing estates most often in the form of a green belt, between schools and the road most often in the form of fence or wall [3-5]. Lynch.K, from the US, considers that as a linear component which is not regarded as passageway, boundary identifies different spaces.

All boundaries play similar roles although differing in materials. Firstly, they are for protection, as shown in Fig.1. The massive city wall in a city-state ancient China was made to protect people from intruders. In modern life, the wall is used to divide spaces into multiple ones, with the ultimate purpose of protecting safety of life and property in the defined space. These use a variety of materials such as brick-concrete structure, balustrade construction, or vegetation type [6-8]. The second purpose is to decorate as shown in Fig.2. Wall play an essential role in a Chinese classical garden. Architects have made great efforts on selecting materials and decorative ways to present diversified walls. Nowadays, with the creation of advanced security technology and equipments, constructors of the residential quarters pay more and more attention on cultural and decorative attributes. Therefore, a lot of walls have more distinct decorative nature but less protective function.

Fig. 1 Ancient city wall in Xi'an

Fig.2 Wall with cultural and decorative attributes

III. Connotation and Extension of Boundaries

A boundary wall in architecture means directional spatial partition structures to enclose, divide or protect certain areas usually around building walls, which are the boundary in an absolute sense for protection and decoration. The area rounded by a wall become interior space, which is occupied and protected by animals to keep their necessary resources such as food, nest or spouses [9]. Occupants of an area can be an individual, a pair of spouses or animal community. This is how boundaries divide space, protect areas and decorate environment.

In daily life, spatial boundaries are usually understood by physical and psychological aspects. Some are seen by people and others depend on human senses. Moreover, there is a kind of boundary with no wall or other material objects. Fig.3 shows a site for praying to God, a ceremony with four erected bamboo hang straw string on the ground, applied with white sand. Thus, divine realms take shape within the field circled by straw string, which symbolically represents the boundary between sacred and impure areas. Although there is no actual wall, external and interior area can be clearly distinguished from concepts. When we spread a mat on a piece of lawn, the mat edge turns into boundary. The mat becomes our interior part and all area except the mat is external area. There is security boundary between people. You'll feel a sense of oppression and tension when a stranger stays 1.5 meters away from you, while a circle with 1.5 meters radius against you in a center becomes your security boundary.

Fig.3 Divine space within straw string

Under the circumstances of accelerating urbanization, advancing to dismantle walls, share resources and ease traffic pressure is important [10]. This essay reflects on and discusses how to deal with boundaries among each functional area in order to serve citizens better.

IV. Thinking Boundary under Gestalt Psychology

In Gestalt psychology, there is a famous "cup map" of Edgar Rubin. From the cup in the picture, the white part on both sides is called the non-graphic space. If the white part is taken for the silhouette of two people standing opposite to each other, the black part of the cup becomes Non-graphic space. In the figure, the cup and the faces become graphics and background and are converted to each other. The basis for their mutual transformation is the boundary line they share. When viewed as a cup, border is the outer contour of the cup. When viewed as two faces, the boundary becomes the outline of the face. When studying streets of Italy, Awara Yoshito used the graphics-background relationship between street and building to study its aesthetic value. In his view, the beauty of the Italian street lies in the fact that it's along the outer contour of the building. Relations between street and building reflect how the graphic relates with the background.

In China's urban construction, there is often a lot of unoccupied space between buildings and streets. Boundary divides how the land is used, it is difficult to form a relationship between a structure and background between building and boundary. Boundary basically exists in the form of a line. As shown in Fig. 4, the two spaces form boundary. The relationship between the figure and the background cannot be formed. That is to say, the space on both sides of the boundary does not produce an aesthetic sense of form, nor in-depth thinking of design with space and boundary, nor even a functional processing combined with the actual needs of users on both sides of the boundary. The boundary's connotation and extension has not been expanded and improved. An effective solution is to use the relationship

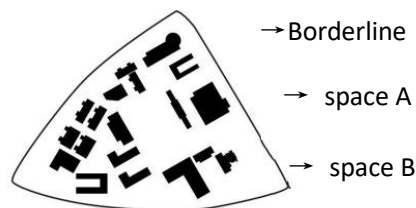between graphics and background to deal with the boundaries of space.

Fig.4 Relationship between space and borderline

V. ANALYSIS OF THE STATUS QUO OF CAMPUS BORDER OF MACAO UNIVERSITY OF SCIENCE AND TECHNOLOGY

Located in the Macao Special Administrative Region, Macau University of Science and Technology is situated in Taipa, Macau. The school plan is triangular shaped as shown in Fig.5. Tai Tam Shan and an urban main road are on the northwest side, only one road away from the Macau airport on the southeast. And this is one of the most prosperous areas of Macau's business on the south side, near to high-end hotels and casinos such as City of Dreams, Wynn, Venetian, Sheraton Hotel, and Studio City. The school gate is located on the side of Taitan Mountain, with two small entrances on the other two sides of the school, which is convenient for vehicles and pedestrians entering into the school from different roads. In addition to the school, Macao University of Science and Technology Hospital is in the northeast corner and the international school is in the south, with major bus stops and pedestrians on both sides of the school, as shown in Fig.5.

Facing the main traffic trunk
(focus image, function, symbol)

Facing main gaming and hotels (focus difference, function, technology)

Facing the main aviation hub
(focus function, technology)

Fig.5 Plan of Macao University Campus and surroundings

The entirety of walls of the school are bounded by iron-net railings with pierced green metal cutouts, covered with shrubs as a protective layer inside, municipal roads and sidewalks are outside the boundary. Near the border of the campus on the northwest, the density of the bushes is less, there are just iron nets, no bushes somewhere, while, the thickness reaches 3-6 meters on the southeast and south borders. The latter thickness provides efficient use of the site and more possibilities for bound treatment.

From the perspective of people of different orientations and industrial forms of the university, it should be considered more actual needs in regards to guests and pedestrians entering and leaving the airport for border treatment of southeastern airport. It should be combined with the bus station and functional integration. Being close to hotels and the gaming industry on the south, treatment of the border should focus on school differences, pay more attention to functionality of the border and the technical characteristics of the school. Because the main passage in and out of the school is on northwest gate, an overall image of the college should be fully considered, in addition to bus station and school gate, emphasizing representativeness as well functionality.

VI. BOUNDARY BLURRING, FUSION AND FUNCTIONAL PROCESSING

Through analysis of the campus boundary of Macao University of Science and Technology, combined with the relationship between graphics and background in Gestalt psychology, we'll analyze how to effectively deal with boundary through the relationship between graphics and background. The campus plan of Macau University of Science and Technology is presented in black and white to express their relationship, campus buildings are represented with black blocks, white areas for roads, playgrounds, greenery and other parts. The campus boundary line is marked with a black line as shown in Fig. 6, from which, the relationship between background and graphics is lost, being segmented by boundary lines. Figure 7 shows black and white effect after breaking the boundary lines, relationship between the graphic and the background becomes more obvious. The graphics with boundaries looks constrained and tense because of the existence of the boundary. In the graph without borders, more connections and integrations are established between interior and exterior of the campus.
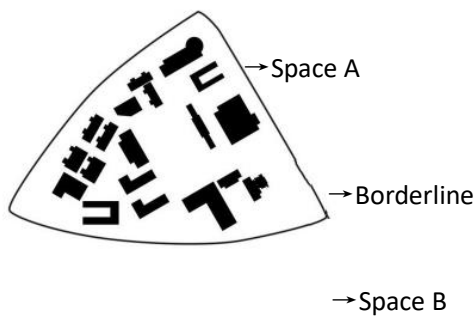
Fig.6 Campus plan in black and white (with boundary)

Fig.7 Campus plan in black and white (without boundary)

In a city, the existence of private space cannot be avoided. However, interface between private space and public space, the boundary should be designed from the perspective of the city and from the perspective of the publicity as well as openness. This can not only improve the overall quality of the urban environment, but also contribute to the vitality of the space itself. Through the analysis of the figure above, we find that the boundary exists in a linear way. From the perspective of the form of the picture, it will directly affect the relationship between the figure and the background. From a practical point of view, it will also block the communication and integration between Spaces. The existence of a long boundary around the school is essentially the greatest waste of a limited space. The boundary is changed from linear to planar to form a graph, and the relationship between the figure and background is established. Then the shape of the boundary is processed and designed based on the relationship between the figure and background. We summarize its form in the following ways:

A. *Take the straight line as the boundary and extend the function to both sides of the boundary*

Taking straight line as a boundary is a commonly used boundary treatment method in the separation of functional areas in the current urban construction. Some do this with metal or wooden railings as a boundary composition; Some do both. No matter which material is used as the boundary, the linear shape of the boundary itself does not change.

If we make some proper adjustments in the linear boundary as shown in FIG. 8, to make the space on either side of the line penetrate their functions between space A and space B, then the space can be divided, and the forms and functions of the boundary can be enriched. The original simple linear boundary can be transformed into a morphologically rich block boundary. Surface on both sides of the boundary can be adjusted and designed formally to form a rich plane shape. This can effectively alleviate the single form of boundary and enrich the function of boundary through the intervention of practical functions, such as plants, fixtures, chairs, and publicity boards.

From the perspective of the relationship between figure and background, the boundary after fusion and functionalization forms the relationship between the figure and the background, and the black and white forms the figure or background of each other. It is precisely why this relationship between the architecture and the street in Rome, Italy, that the street has great attraction to the gathering of people.

Fig.8 Formal chart with straight line as boundary

B. *Function on both sides of the boundary with the broken line as the boundary*

The boundary treatment with polyline breaks the conventional boundary treatment with straight line as the main boundary line. In most cases, the planning red line will be used to mark a plan land to divide different land space or functional areas. However, on both sides of the planning red line, there is a certain space between the red line and the building. This provides enough space and possibility for the boundary of the polyline form. See figure 9.
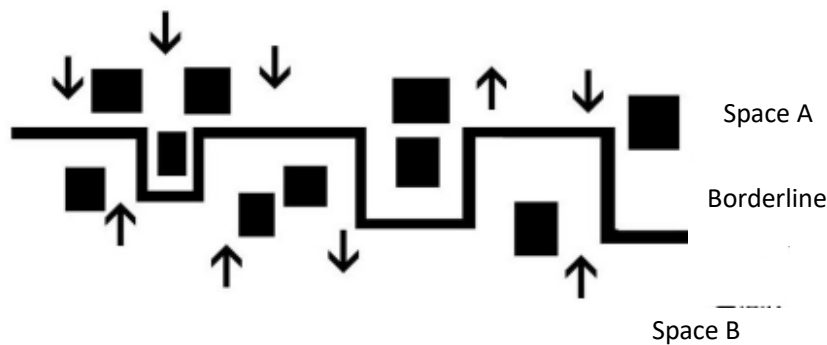
Fig.9 Formal chart with broken line as boundary

In FIG. 9, the boundary line divides space A and space B in the form of polylines. In the process of repeated convex and concave forms of polylines, space A and space B form a spatial fusion. This convergence is formal, and the planning red line has not changed as a result. In the concave-convex shape formed by space A and space B, the functional setting can be carried out by combining the spatial attributes on both sides of the boundary with the actual needs. In this case study, if the boundary form is placed on the border to the northwest, space A will be the campus space, while space B will be the municipal sidewalk. Considering the actual site conditions, since space B is located on the main traffic trunk and is the main boundary of the campus, municipal public facilities, such as public seats, shared bikes and small public artworks, can be considered in the concave and convex form of space B. In space A, public seats, decorative plants and installation works in the campus can also be considered. Therefore, the boundary treatment of polyline form breaks the single boundary form, enriches the form and function of the boundary, and is an effective way of boundary treatment.

C. With the curve as the boundary, functional implantation on both sides of the boundary

In addition to the previously mentioned boundary treatment of lines and polylines, there is another form of boundary processing--curve. The boundary processing of the curve has certain similarities with the polyline, breaking the existed boundary form of a straight line. The difference is that the boundary of the curve is softer than the fold line, and its form and function are more diverse.

From Fig. 10, the boundary line in the form of a curve divides space A and space B, but in fact, similar to the boundary shape of the polyline, space A and space B produce a form of complementarity and fusion. Combined with the actual position of the boundaries of the Macau University of Science and Technology, this form can also be placed on the side close to the gate, or on the south side of the school, close to the hotel and the gaming industry. The boundaries of these two sides can better reflect the characteristics of the school, and maintain the differentiation

of functional and spatial attributes. Combined with the circular crossover bridge in the middle of the road, good visual effects can be created.
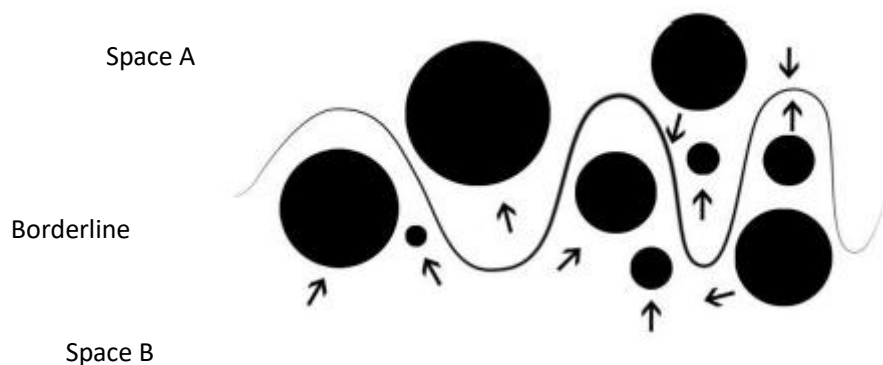

Fig.10 Formal chart with curve as boundary

VII. RECONSTRUCTION OF THE MEANING OF THE BORDER

The boundary has a defining and enclosing effect, and as long as there is a defined need, it can appear, separating the object or space from the object or space. A boundary is a closed relationship that is a condition for a region or domain to maintain its integrity. Without boundaries, the field disappears [9]. On the other hand, while the boundary is in the field of confined space, the boundary itself has an aggregation effect. According to the ecological principle: "In general, the boundary, which has spatial heterogeneity, is where many information is gathered, where changes occur and is prone to special phenomena and concerned by people. This is known as the boundary effect [10].

From a dialectical point of view, while the boundary plays a role in defining space and is ignored by the public, it is inherently characterized by being a visual focus. This feature is easily overlooked. We must make full use of this feature, combine with the attributes of the boundary space and the

actual needs to meet the design of the boundary form. We can change the shape of the boundary, and combine the space on both sides of the boundary through the combination of function setting and information collection, so often marginalized boundary can be re-appreciated and used to make it truly rejuvenate.

VIII. CONCLUSION

The boundary is both a restriction on space and an obstacle to communication between space and space, people and people. Today, when urban space is diversified, we do not oppose the existence of private space. To effectively deal with the relationship between private space and public space, we cannot proceed from the perspective of their own space, but should stand in the perspective of urban operation and management, and eliminate the adverse effects of the boundary.

The fusion and functional design of the boundary is a new idea for the design of existing boundaries. However, except this, we expect more from the perspective of the publicity and openness of urban space to break the boundary and eliminate the boundary. Perhaps at that time, while breaking the border, we are actually a kind of tolerance and acceptance to the outside world. It will not only affect the space, but will enhance the vitality of the space and enhance the vitality of the city.

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