APPLICATION OF CASE-BASED METHODS AND INFORMATION TECHNOLOGY IN URBAN DESIGN

The Renewal Design of the urban region around Roma Railway Station

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Abstract. The research explores the application of the case-based design methods and information technology in urban design by processing OpenStreetMap (OSM) database. Taking the renewal design of the area around the Roma Termini Railway Station as an example, the research has following two purposes. One is to update the abandoned area from the point of view of building function, the other is to design the flyovers connecting the railway station with the pedestrian path simulation. Both of them aim at exploring new methods of urban renewal design by using map information data and providing reference cases for designers.

Keywords. Urban Design; Generative Design; Case Base; Procedural Modeling.

1. Introduction

This research is based on a course of urban design that has set up an area to be renewed for exploring new methods. The area to be renewed is located in the northeast corner of the ancient city of Rome, with a total planning area of about 20 hectares. This area not only preserves the historical remains of ancient Rome, but also reorganizes and adjusts the structure of several Roman cities in the 19th, 20th and 21st centuries, as well as the coexistence of abandoned or urban degradation. Large-span time periods, rich building types, and collisions of different cultures have put forward higher requirements for the revival and development of this area.

There are two reasons leading to the abandonment of these areas. One is the unreasonable building function settings, the other is the huge scale of the railway station, which divides the main urban area into two parts, resulting in traffic disruption on both sides. Therefore, this research uses digital technology to analyze urban city map data and complex urban renewal problems. The design is divided into two parts, the urban space on both sides of the railway station and the pedestrian flyover design across the railway station.
2. Previous Research

At present, in the application of Geographic Information System (GIS), most of the research results are about the measurement and acquisition of geographic information. However, the data compilation and application of information are relatively few. Traditional spatial data analysis methods mainly include spatial data-based analysis operations, joint operations based on spatial data and non-spatial data, etc. Later, they gradually developed into the simulation of spatial decision-making process and the simulation and prediction of complex multi-factor spatial systems.

Abundant geographic information data is used to explore new methods of urban design, which makes urban design more large-scale, diversified and high-speed. Through the graphical visualization of data, multiple aspects of information integration are integrated, such as road information, peripheral facilities, important historical nodes and etc. Moreover, the stored information is not limited to the block size shape and the architectural space form, but also includes the block functional information and the surrounding neighborhood relationship. The multi-faceted weights make the search results closer to the architect’s goals, which in turn allows feedback to be compared to the results before and after the update.
3. Data & Methods

The data from OSM includes not only physical information, but also building function, construction history and other related attributes. The convenience is that the selected area map can be exported as a vector file. The information in the map is recorded by points and polylines having multiple layers of distribution, and after extracting and sorting them, the corresponding data can be conveniently calculated and judged. Different data contained in the map will play different roles in subsequent applications, such as the number and location of public facilities in the map will affect the design of pedestrian flyover.

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<th>Table 1. Data Collection.</th>
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- **Road information** includes quantity, rating, and name. The road centerline is represented by a polyline. According to the grade, it is divided into walking roads, urban roads, urban expressways and highways.
- **Building information** includes building outlines, building heights, and building densities. The building outline information in the map is represented by a closed polygon, where the building within the parcel is determined by the inclusion relationship of the parcel polygon and the architectural polygon. The topological relationship of polygons is more complex and can be implemented by a professional graphical computing toolkit (such as the JTS toolkit for vivid-solution). The occupied area of each building is represented by polygonal contour lines. Combined with the building height information available in the map, a three-dimensional model can be built and stored (Figure 2).
- **Functional information** includes public service facilities such as restaurants, hotels, parks, plazas, and special architectural or regional functions, all recorded in points with coordinates (Figure 3). These information can serve as a basic reference for the general situation of block functions. For example, information about public facilities accessible in adjacent neighborhoods or within a certain range can be used as a basis for convenience of neighborhoods.
Figure 2. Three-dimensional Case Base.

Figure 3. Data Visualization. Different color markers represent the locations of various public facilities distributed within the area.
All information is stored and debugged in the database. When performing urban design, the search is performed in the case library according to the design goal, and the qualified case can be obtained as a reference. According to the city’s information, other information can be derived, such as the degree of public openness and accessibility of different areas of the city. Select ten test points on both sides of the railway station, which is the intersection of the road and the railway station to detect the flow density, as shown in Figure 4. In such a circle, one block is used as a radius, and the distribution of pedestrians is calculated according to the functions of buildings and public facilities. The calculated results can be used to guide the design of the pedestrian flyover across the railway station.

![Figure 4. Data Visualization of Pedestrian Accessibility. The ring represents the range of one block radius of the test point. The deeper the color, the higher the reachability.](image)

4. Results

The results of the update are described in two parts. One part is the renovation of an abandoned block, hoping that the renewal of this area will bring vitality to the city along the railway station. The other part is the design of the pedestrian flyover on the railway station, which combines the important nodes around the station to simulate the path to design the streamline of the flyover.
4.1. CASE-BASED DESIGN OF THE BUILDING

In urban renewal design, multiple conditions can be set up to search the case base. The retrieval conditions can include block area, the shape of the block to be renewed, the function of the building, the volume ratio and so on. Figure 6 shows an automatic detection of case similarity. In any block within the city, another block with the closest area and shape can be found. This technology realizes that when users input certain conditions, the library can give a case that meets the conditions, including the number, area, aspect ratio and volume ratio of the case. Case-based graphics retrieval method can not only provide architects with information efficiently, but also make use of map data in many ways.

A deserted area around Roma Railway Station is selected to try to update it. The first step is to divide the plot according to the surrounding urban texture, such as the area with too large area and low accessibility, using multi-agent algorithm. The second step is to search for cases of geometric rules based on the area and shape of the block. Different cases can be obtained by changing the weights and quantity of control conditions. In the process of case base screening, matching cases can be searched according to the shape, area, aspect ratio of the blocks to be updated, and other conditions including building area and volume ratio can be
added to make the final results more satisfying. The third step is to adjust the final conditions to the plots (Figure 7). The results of case retrieval can be arranged according to the similarity of the stored cases. Architects can adjust the results manually after previewing the retrieval results. They can also determine that a certain spatial feature can be adjusted by computer. The core of the case-based method is to help architects quickly retrieve the original urban space by means of the network and make the design process more rational and efficient.

Figure 7. Application of Database Updating the Local Area.

After the case is put into the target block, the geographic information around it can be constantly updated and stored with cases. According to the designer’s design objectives, information comparison is carried out, and the updated blocks are evaluated and fed back, so as to provide the designer with the closest case to the goal. In the detailed design, the advantages of multi-dimensional information synthesis can be further brought into play, and the deep design can be extended to parking lot, building elevation design, landscape design and so on, providing more possibilities for design.

4.2. GENERATION DESIGN OF THE FLYOVER

Due to the huge scale of the railway station relative to the surrounding neighborhoods, the roads on both sides of the station are blocked, which also causes the traffic pressure around the station to become larger. The purpose of the bridge design is to reconnect the traffic that has been cut off by the railway station. On the one hand, it can make the neighborhood more integrated, and on the other hand, it provides a pedestrian leisure platform for the citizens.
Figure 8. Generation Step.

Figure 9. The Result of Generation under Different Parameters.
Steps of design and generation are shown in Figure 8. The first step is to record the pedestrian density of ten intersections mentioned above in figure 4, each of which has different weights as the starting point of the path. In the second step, the railway station plane is meshed according to the structural column. Considering the orbit at the top of the railway station, the landing point of footbridge must avoid the train track. Therefore, mesh density can be adjusted as a parameter. Figure 9 is the result of different density. The third step uses the A-Star algorithm to calculate the shortest path between points. From one point on one side of the railway station to another point on the other side, the path between the two points is the shortest along the grid. When there are multiple points on each side, the weight focus will have an impact on the path. Points with a strong weight will be attractive, and the greater the weight, the greater the appeal. Conversely, a point with a small weight will generate thrust and the force will be smaller. The fourth step is to get the shape of the pedestrian path of the generated bridge. The shape will change according to different conditions. For example, when the function of a nearby building changes, the shape of the pedestrian path and the bridge will change. Designers can set up a resting landscape platform in conjunction with walking distance.

5. Conclusion

The research uses network data to obtain urban spatial information and attempts to solve many problems in urban design. In the architectural renewal design, the urban 3D model library was established and its application was explored. In the future, the model can be placed in combination with conditions such as sunshine calculation, which is more in line with local geographical conditions. In the flyover generation design, the A-Star algorithm was tried to get the pedestrian path. I tried new ways of applying digital technology in architectural design.

With the advancement of information technology, there will be more possibilities, such as the combination of artificial intelligence technology to enable the instance library itself to be continuously expanded and optimized. The combination of case-based method and information technology will become the development trend of computational urban design in the future.

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