

3D-GIS Application in Information Management and Conservation Planning of Historic City

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Abstract:

Historic city is a particular type of cultural heritages with sustainable drive of development. It's a spatial vessel of people's activities shaped by regional environment, economical and social background. Actually, an integral city is not only meaning the town centers, but also the whole urban area. The massive information scattering on wide range of the urban area and changeeful adapting to sustainable living, are difficult collected and govern. GIS, no doubt, is the suitable solution.

In the conservation practice in Kuqa city, we promoted a 3D-GIS system to discuss the scientific way of conservation of historic city.

1. The specificity of the conservation and management in historic city

1.1. The specificity of history urban conservation

Historic city is a integrated carrier of human history activities, which has two property, "culture heritage" and "city". During the different historic stages, the city's department of natural environment conditions (as climate, hydrological, vegetation, and natural disasters) and social environment (as political, economic, and culture form) are totally different, the human activities, the construction demand, the construction way, and the space form are changing constantly, which have an impact on the natural environment and social environment of the city in turn.

From the 1980 of the 20th century, the complex urban issues and the deterioration of the ecological environment caused by rapid urbanization, which promote the perspective of the construction industry from house to settlement, from urban development to the region. Cities, towns, villages and other human population are considered as a whole, it will focus on the relationship between people and the environment. Conservation of cultural heritage will also change from the earlier focus on the preservation of heritage material ontology, turning on its bearing capacity of comprehensive historical information (which various historical stages, the surrounding environment patterns of the historical heritage, intangible cultural heritage, cultural and historical data and heritage related to ontology of physical substance, such as environmental and intangible cultural and social environment of integrity conservation). More and more importance to the concept of cultural landscapes and cultural lines, historical cities also began to break through the old city (pool, the ancient city of the ancient city area) limitations of the gradual expansion of the urban surrounding of the natural environment and all kinds of subsidiary heritage, considered as a complete system for conservation.

However, in the long historical process, because of the natural environment change and human development of construction, heritage has cannot reflect the historical panorama, and often appears as irrelevant, discrete or fracture state. It is very difficult to find without census. We can not repair the lack of historical framework between groups of cultural heritage, cultural heritage and natural environment, the intangible cultural heritage. Furthermore, we can not do a comprehensive, accurate, and comprehensive evaluation of the city's history and social value. It is possible that the spatio-temporal wrong on-line, Subjective speculation and one-sided emphasis misjudgment would happen, and affect the conservation measures formulation and effect.

In recent years, GIS (Geographic Information System) are being more and more widely used in archaeological and cultural heritage conservation areas as an important tools and techniques used for acquisition, arrangement, analysis and management of geographical spatial data. It is also used to realize archaeological and cultural heritage data management and storage, and establish archaeological and cultural heritage GIS database, which is one of the most popular application in archaeological and cultural heritage conservation field. Secondly, it is also applied in simple space analysis based on archaeological and cultural heritage GIS database. However, the existing research results are mostly stay in the simple spatial analysis of historical and cultural heritage information comprehensive management.

1.2. The particularity of management and supervision in historic city conservation

Heritage and historical environment is non-renewable. Any historical relic would lose the right historical information without it's original surrounding environment. The loss can not be made up, once the surrounding was damaged. So effective management and strict supervision is required in the historic city.

The conservation plan should formulate the high-level strategic measures at an overall urban height. It must be included in the overall urban planning, and linked up with the land use planning. It is a part of the urban economic and social development. According to the historical and cultural blocks such key conservation area, the regulatory detailed planning with the protective control index as the core is used as a conservation area planning control basis directly.

2. The historical cities conservation and management platform structure based on 3D_GIS

Based on the analysis of advantages and disadvantages of GIS system, combining with the particularity of historical cities, and the advantage of 3D analysis, we establish the 3D - GIS historical cities compiling and management system. The platform has query and spatial analysis function, not only can complete the investigation data input, storage, management, utilization status database query and draw status analysis picture, but also be able to apply algorithm to determine the conservation of historical cities. We use three-dimensional model to do the space analysis, the project contrast, in order to provide scientific basis for the correct conservation plan.

2.1. Platform characteristics

- 1) GIS data (digital elevation model and terrain analysis) auxiliary natural and cultural heritage space relation analysis
- 2) Data acquisition and deep processing of historical cultural relic data with the combination of GPS and RS
- 3) From the protective planning to the administration of the platform, achieving the real preparation to implementation management integration, avoiding the disjointed of establishment and staffing. Preparing resources must serve the management, in order to save resources and improve efficiency.
- 4) 3D GIS historical cities compiling and management system is based on the 3D space city model. It intuitive shows the city space, and does a 3D space analysis and operation on the current situation of urban spatial objects.
- 5) 3D GIS historical cities compiling and management system has not only foundation database, data analysis, and other functions. According to historical city special properties, it also develops a peculiar historical city with the related calculation model function.
- 6) Network system is applied in 3D GIS historical cities compiling and management system, which make a dynamic renewal of data and regulatory realize from the central to local seamless connection. Meanwhile, the establishment of the system supported a communication platform and media in city conservation planning and implementation process of the citizen participation.

2.2. platform framework

Platform is made up of database, conservation elements, special analysis, planning scheme, and planning management.



1) Database

Database includes GIS Data, GPS + RS, and urban data

● GIS data

DEM elevation data can be used for analysis, on the one hand, DEM and terrain analysis has played an important role in ancient roads, ancient water system distribution extraction and recovery. DEM analysis can auxiliary access the roads towards, the grading, the flow of rivers, and channel distribution etc. On the other hand, the formation of cultural relics and the surrounding terrain conditions are relevant. DEM terrain analysis makes auxiliary effective for interpretation of the distribution of cultural relic position, the attribute significance, the historical significance, and the deficiencies of remedying documents.

● The combination of GPS and RS of historical and cultural relic data collection

RS, GPS can be further integrated with 3D GIS. The historical geography, archaeology, sociological research method can be integrated in the urban development history research fields. We will connect history research, conservation planning, and urban development construction planning, to promote the historical cities, cultural heritage conservation planning scientific and technological. Such as data acquisition and data deep processing based on GPS and RS historical cultural relic combination; Sensing reading for ancient water system, old recovery analysis; Digital elevation model and terrain analysis of natural and cultural heritage space relation auxiliary analysis.

● Urban Data

Nine modules have been established in urban data including the general situation of architecture (construction era, building height, construction quality, construction application), the architectural features (construction structure, roof form, decorative materials, bay, deep, traditional elements), the household information (nation, the number over 60, the number under age 18, men quantity, women quantity, the total living population, economic sources, others), municipal utilities (with or without fluctuation, with or without toilets, heating methods), ancient and rare trees, streets and lanes (traditional streets, pavement, width), mountains and water system, intangible cultural heritage, affiliated cultural relics.

Large amounts of data such as text, graphs and images of architecture, land use, roads' pattern, population information, social economic can be stored and managed based on spatial orientation as the compile basis of historic city conservation planning.

2) Conservation elements

To determine the conservation elements and make it correct is the basis and the key problem of historic city conservation planning.

This function be set up on the platform is to support determine the conservation elements through the objective analysis of the database combining relevant information screening.

The platform has established seven conservation elements including city boundary, node, cultural relics, building conservation grades, conservation trees, intangible and historical memory.

3) Special analysis

(1) conservation zones

To determine the conservation zones is the core content of conservation control, different zones within different conservation efforts.

This platform finished defining the conservation zones through the peripheral environment analysis of cultural relics, architecture classification, the conservation elements, information superposition of the cultural relics units.

(2) Spatial analysis

To formulate the building heights in the conservation planning of historic cities should be based on the building height analysis within the historical urban areas and the visual corridor, the conservation area and the building height analysis within the conservation zone.

The spatial analysis function of the platform based on the based on 3D model realized the match of the real terrain elevation and the architectural model, achieved the real reappear of the real environment, guarantee the authenticity of the spatial analysis results.

Spatial analysis functions include height control analysis, vision analysis and visibility analysis.

4) Planning scheme

(1) Data analysis and summary

The compiling phase of the historic city conservation planning need to draw a lot of analysis graphs. The traditional method is to draw by AutoCAD and PhotoShop according to the present situation which is a big job. The platform based on database can generate the special graphs quickly and conveniently. Meanwhile it needs to undertake some special data analysis to determine the building density, cubage such as the building area, the land coverage and other data which will be not only complex but also bad to guarantee the accuracy by these data application of CAD.

After the establishment of 3d models, this platform can automatically calculate the data such as building base area, total construction area, the land coverage, the building density within the scope of land, etc. The platform sets and classifies the related numerical range according to relevant taxonomy and can generate building height map, architectural style diagram and so on many kinds of thematic mapping.

(2) Formulate the conservation drawings of historic precinct and buildings

Based on the classification of the building types within the historic precinct, the yard numbers in the database, the corresponding building density and the volume index to complete the renovation drawings which save much time on graphs and improve the efficiency of the conservation planning.

5) Planning management

Any construction must conform to the related requirements of conservation planning, any new construction projects require strict censorship. By switch among different schemes or different schemes in different browsing windows to compare schemes from every point of view. The more intuitive show different scheme in the city in history with historical environment effect, which make the result, the relationship between the schemes and the historic cities more intuitive to show better image for decision maker and avoid subjective mistakes In the assessment.

3. 3D-GIS Platform Application in Kuqa

Kuqa, which the ancient name is Qiuci, located in Tarim basin, the south of Xinjiang Uygur Autonomous Region (the "Western regions" in the history of our country); Kuqa is a famous OASIS city in the Silk Road, which has a long history of more than 2000 years and unique culture. It's 448km from Urumqi, the capital of the autonomous region, 753km highway mileage.

The domain area of kuqa is very broad, which is 193km max from the north to the south, 164km max from the east to the west, and it has a total area of 15,379 square kilometers. Uighurs kouzhan made up of the 88.15% of the total population. Within the County, it maintains a large number of precious cultural heritage: which has 7 national key cultural relics conservation units, 29 State-level cultural relic conservation unit, 60 county-level cultural relic conservation unit; of which Kizil Carhartt signal fine, Subash Buddhist temples is included in the declared world cultural heritage of the Silk Road project. It has 1 world class non-material cultural heritage, 7 provincial level of intangible cultural heritage, 37 intangible cultural heritage at the county level. In addition, qiuci unearthed a large number of documents and artifacts in more than 10 languane text, and qiuci ancient human skeletons, music and dance relics of qiuci box, Chinese turtle two-body five baht, and a large number of precious cultural relics.



Figure 1: location of kuqa basin in China;



Figure 2: location of kuqa in the Silk Road

According to the time series, the study on the conservation is divided as follows: census of Historical relics—research on the history development of the city--comprehensive evaluation-conservation planning; by space:-regional-county-history city-old town-the historical and cultural blocks – single building; by objects: cultural heritage--non-material cultural heritage_-natural heritage.

The city platform is applied to the conservation planning of historic city in kuqa, for building construction, thematic cartography, management of database and application analysis.

3.1. Fundamental Data

- 1) GIS data (digital elevation models and terrain analysis) assists the relations of natural and cultural heritage spatial

Digital elevation model is more applied to the analysis in the relationship between the cultural heritage and environment.

It can be clearly observed that the closely relationship between the cultural heritage and the landform, after the cultural heritage of Kuqa and circumjacent area added to the digital elevation model.

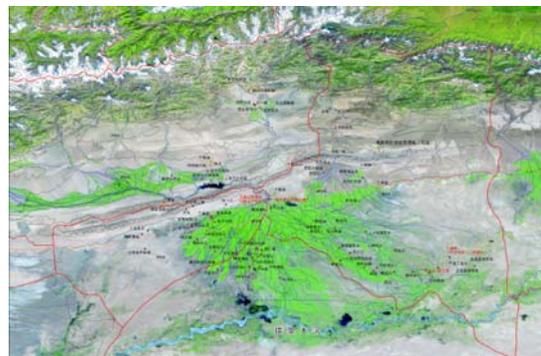


Figure 3: analysis of the relationship between historical cultural heritage and environment in kuqa

- 2) The acquisition and processing process of the historical and cultural legacy data combined with GPS and RS

In the investigations of historical and cultural relic in kuqa, GPS and RS technology will be used in data collection and site investigation job, and the data will be processed supported by GIS.

Handheld GPS is combined with “The third relics census” used in the collection of majority of cultural relics geographical position of the county. We have collected a variety of resolution satellite image material, and matched the ruins point and satellite image map in Spatial treatment (Bird Quick 0.61 meters resolution or CBERS - 2B 2.36 meters resolution HR data), to obtain the remote sensing planar distribution and basic data sets of the ruins point.

After the space processing of the historical relics data, we will import it to the geographic information system processing software, such as Mapinfo etc, than superpose and analyze the images, mapping figure in different periods. Combined with geographic information data (water system, terrain, settlement, etc.), each relic based information (age, remains, etc.) and types of archaeological records for nearly 100 years (mainly since the late 19th century, western explorers, and the exploration and mining taken by Chinese

archaeological scholar__ Wenbi Huang, from 1920s to 1950s in the tarim basin), we will dig and process the deep data, and complete all those spatial distribution information which has disappear.

3) Establish the based database in kuqa old town

We did a comprehensive survey of the old town, including architecture, land use, roads, population information, social economy and so on. We conducted household survey in each house, which including seven categories of 30 events, 12,000 buildings, and more than 6,000 households.

In the investigation process, we will obtain a lot of text, graphics and image data, which has positioning properties, belonging to the category of spatial information. 3DGIS historical city system is applied in the survey of data storage and management.

We use AutoCAD to processing topographic map, and make the building into one layer. Than we divide land border through the present situation, and set to the land layer. We import the land and construction layer to citymaker, establish 3d model in building layer. Land information is imported into the system, each building property is imported into 3D model, and the road property is imported into relative layer. Through the model building and related properties, we have established the kuqa historical city database.

Therefore, through the methods of household survey, interview, questionnaire, and the mapping, we have fully censused more than 6000 families, 12000 buildings, intangible cultural heritage, and famous trees in 3.5 square kilometers of kuqa. According to the measured topographic map (1:500) and high-resolution remote sensing data, we use city maker to establish the old City 3d model.

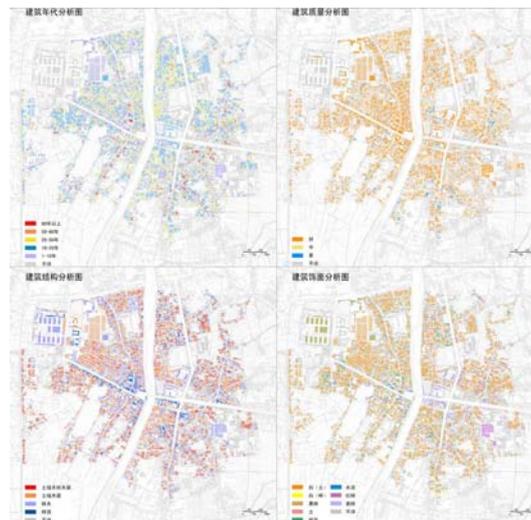


Figure 4: Building database of old town

3.2. 3DGIS application in protecting planning

1) Definition of conservation districts

Digital terrain analysis is applied in the analysis of kuqa cultural heritages conservation district. It can be used to simulate arbitrary angle space vision of cultural heritage circumjacent environment, determine each cultural heritage conservation boundaries, and precisely coordinate localization



Figure 5: analysis picture of conservation districts space vision in Soubachi protective districts

2) Building hierarchies

Based on the fully investigate on the present building, we do a comprehensive judgment and value of the present building, and put forward the hierarchy of old buildings. We weight the influence factors of architectural level judgment, do an analysis on architectural value, so as to determine the old buildings level.

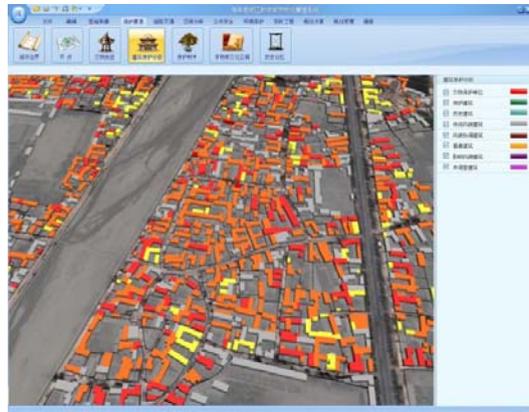


Figure 6: Building hierarchies

3) Building conservation and renovation in historical precinct

Based on the division of building level in old town, We should do meticulous division of the protective and regulation in Historical precinct, so as to determine the way of the historical precinct construction protecting and renovating. According to the relative calculation method, the buildings are divided into 9 classes except cultural relics in historical precinct.

Based on the above standards, we determine the score range of each building, and determine the class of historical precinct at last.

Spatial analysis

Based on the extraction of surveying and mapping figure terrain data, the system can automatically generate 3d terrain model. Through the match with previous architecture underside data, we can build old town model of whole kuqa. Through the analysis of the historical and cultural space factor, to determine the kuqa mosque as the commanding height of the ole town, and the mosques in each community as the second commanding heights in old town. The surrounding of the commanding height is building highly controlled area. We must control the building height of the surrounding area of traditional alleyways and other important attractions.

We use the system to do the real visible analysis on Kuqa Temple and the community mosque to confirm the real control district. As for the traditional alleyways and the important landscape point, model is applied in the scale of the alleyways and the view of corridor analysis.

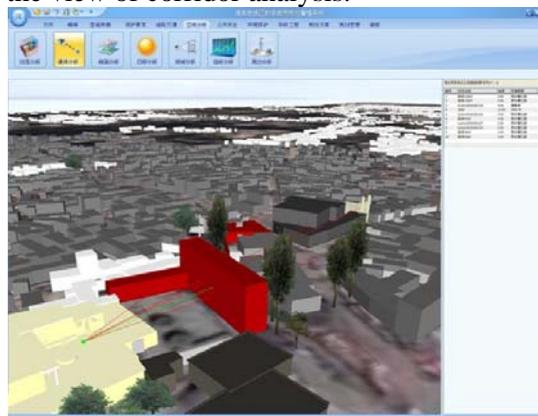


Figure 7: spatial analysis

We use the system to analyze the reliable old building height and the view corridors, in order to avoid the subjective interpretation about the two dimension space, and improve the accuracy of conservation plan.

4) Scheme Contrast

In the plan of historical and cultural blocks, using the platform to contrast, with the comparing of the same angle and the same time on different schemes. In order to avoid the unnecessary mistake in the plan.

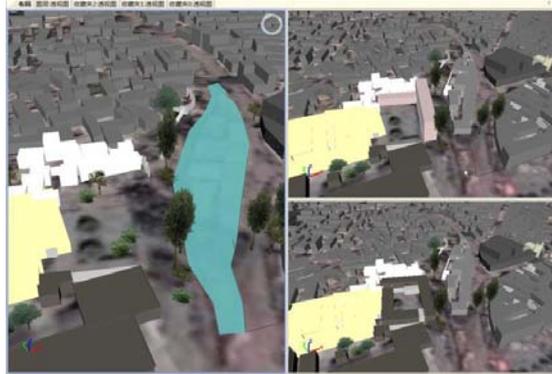


Figure 8: Scheme Contrast

4. Summary

In the above study, 3S technology is used as an effective assistance method, applied in cultural relic data acquisition analysis, data mining and deep processing, data management, relevant space analysis of natural environment and humane environment, protected areas define and database construction and management, etc. On this basis, we combed and compare the city history from the view of urban history, culture communication history and life again, and make a comprehensive, accurate, and systematic evaluation of the city.

Our research results obtained experts praise. Our job proves that the 3S technology applied in cultural heritage and historical cities conservation can effectively increase the scientific, reasonable and efficiency of the planning in historical city, cultural heritage conservation planning and urban development planning. This technology has a broad application prospect, and it will become one of the most important historical city conservation technologies.

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