Spatial Decision Support Applications Based on Three Dimensional City Models

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Abstract:

With the increasing applications of three dimensional city models (here-form named 3DCM) in the urban planning, design and management. Based on 3DCM , spatial decision support is expected with great urgency. In this paper, the basic mathematic models and some typical analysis methods based on 3DCM are proposed and discussed, such as the statistic model, the time-serial model, the spatial dynamic model and so on. A few typical spatial decision making methods integrating the spatial analysis and the basic mathematical models are also introduced, for example, visual impact assessment, dispersion of noise immissions, base station plan for wireless communication, and etc. Also, a new idea of expectation of further applications and add-in-value service of 3DCM is promoted. As an example, sunshine analysis is studied and some helpful conclusions are drawn.

Keyword：3DCM, Spatial Decision Supporting, Mathematical Models

1 Introduction

Urban Geographic Information System (UGIS) is a kind of technology service system, which collects automatically the information about urban infrastructure, function and mechanism. It manages dynamic supervision by using high-tech means comprehensively, such as GIS, RS, remote surveying, network, multimedia and dummy simulate (Zhu Qing, Li Deren, Gong Jianya, 2001). This sort of analytical UGIS with multi-functions is the current key contents of digital earth, because（1）seeing from the whole, urban is the web node on the surface of earth;（2）seeing from the microcosmic, urban in each country is the center of politics, economy, culture, education, science and technology, population (Wang Dan, 2001);（3）from the view of systematic theory, urban is a self-organization system, with an opening, dynamic, multi-functional and dissipative structure. Compared with rural, urban is of a complicated structure and of obvious features of space-time continuum.

Urban GIS is the keynote which was investigated in many specialties. The foreign and domestic scholars have done many researches in spatial analysis and spatial planning of UGIS (Edmond and Shang, 1997; Monika and Gunther ,1997; Isabelle and Gaetan,1999; Theresa and Martin, 2001; Sivacoumar and Thanasekaran,1999; Peter, 1999; Tsuyoshi Horiguchi, Takehito Sakakibara,1998; Klungboonkrong and Taylor,1998; Yilmaz, et al, 2002; Liu Yaolin, Liu Yanfang, Liang Qinou,2001; Xu Zhaozhong, 2000; Zhang Wei, Gu Chaolin, 2000). However, many urban problems, for example electro-magnet radiation, air pollution, noise pollution, visibility, sunlight are of obvious space-time feature. However , these features are ignored by the above researches.

The main reasons is that ：（1）The present GIS technology can not meet the requirement of spatial analysis in building models needed by many fields. Thus, the city spatial analysis is no longer powerful；（2）Intercommunion between subjects lacks of depth, it maks the analytical GIS supply and demand channel not smooth, thus, influencing the research headway of 3DCM aided spatial decision support；（3）Lacking of basic mathematic models of 3DCMaided spatial decision supporting. For nearly ten years, the technology in building 3DCM and 3D visualization & virtual reality has got full advance, settled the technology foundation of application 3DCM aided spatial decision support. On the other hand, modern mathematical theory develops quickly in spatial statistics, operational research, chart theory, morphology, sub-shape geometry, fuzzy mathematics, mutation theory, systematical dynamics, supplying academic analysis tools for 3DCM aided spatial decision support.

3DCM is the basis of UGIS. With more and more digital city projects starting, add-value application of 3DCM will become the bottle-neck of limiting UGIS further advance. The intrinsic of 3DCM aided spatial decision support is the nesting applications of 3DCM such as DTM, 3D buildings and its feature model, Voronoi neighbor field model and 3D transverse section model and basic mathematic model, for example spatial statistics model, clustering analysis model and fuzzy analysis model etc., physical model such as wind fields model, electro-magnet wave model and sound wave spread model and flow model and so on. By building corresponding analysis mathematical model, simulate and forecast urban spatial growth in the course of macro -planning and conditional controlling.

2 Models and Methods of 3DCM Aided Spatial Decision Supporting

2.1 Mathematical Models of Aided Spatial Decision Supporting

3DCM include DEM, 3D buildings and its attribute model , Voronoi adjacent field model and 3D section model . 3DCM are not only the main contents of Cyber-city , but also are of four-dimensional spatial models with time attribute and space attribute of the same time. The essence of 3DCM aided spatial decision support is supply with decision information , such as words, data , diagrams ,tables , images and knowledge for visibility decision under the virtual urban geographic environment. To obtain these information , the influences of 3DCM must be considered, and we should dig the vast spatial data for various information which is necessary for decision with the help of some mathematic rules. From the view of cognition, only when we adopt the exploring and empirical analysis mode of "investigating data—simulation—forecasting ", apply the statistic model, time-serials model, systematic dynamic model to the vast data that look like messy on appearance ,for example noise data, pollution data, electro-magnet distribution data and water erosion on hill-slopes data etc. , can we obtain the theoretical understanding about 3DCM'influences on the above data. According to above data, it is feasible and convenient to conduct spatial temporal simulation for the dynamic variations of city and extrapolate the developments and changes in city. Among the 3DCM aided spatial decision-making supporting applications for urban phenomena, selected mathematical model applied frequently are enumerated as below.

① Optimization and planning model: it contains linear planning, non-linear planning, multi-purpose planning, dynamic and static planning, cooperative-divided planning and so on. It is adopted on the district-selecting issue in urban planning and to the optimizing problem of shortest path, etc. The planning model is a mathematical support for optimization decision-making. For example, to select the spatial place of some buildings, and to consider many influence factor, the role of optimization model is to seek for optimum quality-price ratio by establishing multi-factor quantitative affection model.

②Spatial statistics model: The statistic model is a basic model for prediction support. It includes regression model, time series model, gray model GM (1,1), and etc. Its constructing means are classified into white-case approach, black-case approach, and gray-case approach. In the district-planning, prediction support tends to ask statistics model for help to solve such problems as population increasing, economy increasing, noise pollution, and etc. For instance, for some general influence rules of a certain factor such as noise or air pollution, because of the affection of 3DCM, there is no good analytic formula to describe them at present, we had to analyze and synthesize the spreading laws by building statistic models from vast observational data.

③Spatial dynamics model: it is a development based on systematical dynamics model. The spatial dynamics model is the mathematical analysis model constructed from the perspective of systematology after having introduced the non-linear dynamic theory, mutation theory, and etc. And it is use to analysis the behaviors of urban system. Spatial dynamic model could more completely describe the systematic urban features because of introducing spatial structural dynamics and individual spatial behavior into systematic dynamics. Spatial dynamic model will exert its full applications in the imitation and forecast of urban land-using increasing, urban air-pollution, urban economy increasing, ecological environment. In the urban system , any model of 3DCM is regard as individual behavior. Its increasing, decreasing and displacement will affect other factors in the system.

2.2 Typical Models of Aiding Spatial Decision Support

Decision-making and decision-making support are two different conceptions. Decision-making is a subjective and active course that decision-makers analyze and compare decision-making information according to effectiveness theory. Decision-making support (named DS) is an interactive, computer-based system designed to ***support*** a user or group of users in achieving a higher **effectiveness** of decision making while solving a **semi-structured spatial decision problem(**Jacek Malczewski,1995**)**. We must provide with abundant decision-making information such as words, diagram, image and data while solving a **semi-structured spatial decision problem** . Because space analysis problem concerned geometry space scale and form of terrain entity such as electromagnetic wave, yawp, air pollution and so on, we must study the affection rule about the above mentioned result from terrain model, architecture model etc. Before this time, people often use the modeling method of statistic regression analysis to study aided decision-making support under the frame of MIS and 2DGIS. Statistic regression analysis model depend much on the observation data, however, in practice, it is difficult to obtain a great deal of correlation data of some objects, and some matter have a great relationship with man-made factors, for example, the governmental policy may rapidly change the air pollution situation of a city. Wherefore, when studying 3DCM aided space decision-making support, we should combine multi-analysis methods with operational research method, statistics method, systematic theory method to improve the dependability of decision-making information.

2.2.1 Multi-Statistic Analysis Methods

Statistic analysis method can build the analysis model by taking full advantage of history data, and can make a relative exact extrapolate forecast to develop things in the future. Because of the complexity of things, we often see the following case: one reason has many results, or, one result has many reasons. For example, the factor affecting atmosphere pollution maybe multi-factors, however, among them, every factor can also produce other influence other than atmosphere pollution. In the case when we have not enough transcendental information about the causality of things, we always collect vastly the variable of reason and result. But, along with increasing of variable, it will bring about some practical difficult , Such as:（1）the capacity of calculate augment rapidly; （2） dimension curse; （3） the stability of statistic descending; （4） the normal nature of data descending (because of the relativity between variables); For multi-variable statistic analysis problem, some new methods have been found in theory, such as nerve-net method, projection-trace method, least square regression analysis method, principal component analysis method and so on.

2.2.2 Time-Serial Analysis Method

Time-serial analysis belongs to the category of statistic analysis, comparing with the regression-analysis that has been mentioned above, time-serial analysis does not consider affect –factor, and the method directly find the inherent rule of things changing according to the order and size of result-variable .This rule mainly includes trend rule and periodicity rule.

The time-serial data have two characteristics ① arranging by time-serial; ② between data which are border upon has a certain extent relativity.

Assume there is random serial$\{e_t, t\in T\}$, its mean function and self co-variance function are defined as follows respectively

$$\mu_t = Ee_t \qquad r_{t,s} = \mathrm{Cov.}(e_t, e_s) \qquad (1)$$

when $\mu_t=\mu=$Const., $r_{t,s}=r_{t-s}=r_k$, define $\{e_t\}$ as a non-strict smooth random serial. Standard form of auto-covariance function is called autocorrelation function, that is ${}_k=r_k/r_0$ ($k=0,\pm1, \pm2, \pm3,\ldots$). Nature of ρ_k, r_k is as follows：

(1) $\rho_0=1$, $r_0=\sigma^2=\mathrm{Var.}(e_t)$

(2) $|r_k|\leqslant r_0$, $|\rho_k|\leqslant 1$ (for all k)

(3) $\rho_k=\rho_{-k}$, $r_k=r_{-k}$ (for all k)

for smooth random serial$(e_t, e_{t+1}, \ldots, e_{t+m-1})^T$, its auto-covariance matrix Γ and autocorrelation matrix V are as follows respectively

$$\Gamma=\begin{pmatrix} r_0 & r_1 & \cdots & r_{m-1} \\ r_1 & r_0 & \cdots & r_{m-2} \\ \cdots & \cdots & \cdots & \cdots \\ r_{m-1} & r_{m-2} & \cdots & r_0 \end{pmatrix} \qquad V=\begin{pmatrix} 1 & \rho_1 & \cdots & \rho_{m-1} \\ \rho_1 & 1 & \cdots & \rho_{m-2} \\ \cdots & \cdots & \cdots & \cdots \\ \rho_{m-1} & \rho_{m-2} & \cdots & 1 \end{pmatrix}$$

But because the farther complications influence the results, it makes the time-serials to present some non-linear features. We can deal with that in two ways as the following

（1） Building models with Non-linear time-serial data

（2） Decomposing structure of nonlinear time-serials

The method to build non-linear time-serial model have three as black box way, grey box way and white box way. Decomposing structure of nonlinear time-serials may adopt the way of using parallel connection method and serial connection method. Information such as noise in some

spatial situation has relevant to the change of environment ， we may describe it in the time-serial model. Providing the environment planning with noise information by building corresponding analytical models. In the practice of building models, we should select the describing models according to that whether the fluctuation of data is in proportion to real value.
The time-serials models frequently used at present have MA(n), AR(n), ARMA(p, q), ARIMA(p, q, d)(An Zhihong, Chenmin,1998). The rules determining the terms of models have ①F-test rule；②AIC rule； ③BIC rule； ④ACH rule, AIC rule is widely used at present.

2.2.3 Spatial Dynamic Analysis Method

Spatial dynamics is used to research spatial information flow and spatial information feed-back in a complicated system. So the object being analyzed by spatial dynamics is the information feed-back system. Compared with statistics analysis, the spatial dynamic analysis method has many advantages as follows
①expressing the factors out or in the system and their relations；
②forecasting the dynamic advancing trends of the system；
③setting controlling factors of the system for decision analysis；
④combining quantitative analysis with qualitative analysis；
⑤dynamic emulation and analysis the system；
Therefore, we can use the spatial dynamics analysis for 3DCM aided spatial decision support to analyze dynamic changes of information, substance and energy. The basic thought of spatial dynamics analysis may demonstrate by water-tank storage chart. In Figure 1, assume the input water amount and output water amount are $R_1(t)$ and $R_2(t)$ respectively in a unit time. At time t, the water amount in water tank is L, if $R_1(t)$ and $R_2(t)$ are all continuous functions

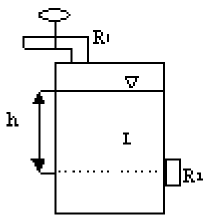


Figure 1 water tank storing water

The formula should be as following

$$DL =[R_1(t) - R_2(t)]dt \qquad (2)$$

When $\triangle t \to 0$, regarding $R_1(t) - R_2(t)$ as constant, we have

$$\triangle L==[R_1(t) - R_2(t)]\triangle t \qquad (3)$$

Assume $\triangle t=t_2-t_1$, time t_1 correspond to storage water L_1, time t_2 correspond to storage water L_2. Then

$$\triangle L=L_2-L_1 \qquad (4)$$

combine (4) with（3）, we have

$$L_2= L_1+[R_1- R_2]\triangle t \qquad (5)$$

Formula（5）is the basic function for systematic dynamics analysis.

3 Typical Application of 3DCM Aided Spatial Decision Supporting

Combining 3DCM geometry spatial data with spatial decision support to establish the decision support mathematic model. The actual form of this kind of model depends on the content of the decision, and the solution of the model always need to nest professional physical model, geographic model, biological model and so on. In this section, we only discuss the typical application of 3DCM aided spatial decision support.

3.1 Considering 3DCM's spatial inter-visibility model

The spatial inter-visibility is widely used in urban planning. For example, China Telecommunication launch tower, television launch tower, wireless calling station, wireless launching pad, sunlight analysis, shadow analysis, the plane of city's traveling sites and so on will all take spatial inter-visibility into consideration. We will discuss the basic analysis model from the corner of mathematics.

Assume there is point light source A, its elevation is H_A; B is the top of buildings, its elevation is H_B; C is the view point, its elevation is H_C; the elevation of A, B, C are h_A, h_B, h_C respectively The three parameters stated above may be obtained directly from 3D models data. See figure 2

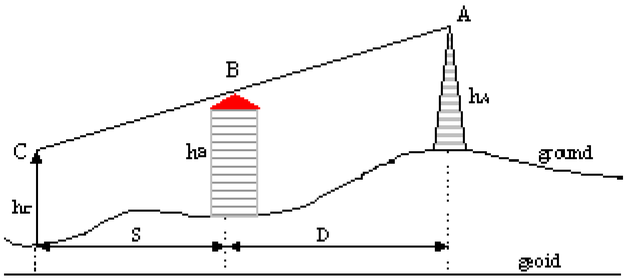


Figure 2 inter-visibility analysis considering DEM

Assume height of B is a constant W; heights of C and A are both of variable, their values are T and Q respectively; then invisible distance S is as follows

$$S=D[(h_B+W)-(h_C+T)]\div[(Q+h_A)-(W+h_B)] \qquad (6)$$

The invisible area P is as follows

$$P=[\pi S^2+2\pi DS] \div\cos[tg^{-1}\{ h_B - h_C \}/S] \qquad (7)$$

The invisible volume V is as follows

$$V=[\pi S \{(H_B - h_C)^2+(H_B - h_C)T+T^2\}- \pi S(h_B - h_C)^2] \div 3 \qquad (8)$$

Obviously, formulas (6), (7) and (8) are all basic mathematical models. we should apply the above models according to different purposes. For example, we should adjust the height of base-station e when evaluating the coverage of electro-magnet wave. We should pay more attention to the auto-turn and omni-turn of the earth when imitating shadow of sunlight.

3.2 Considering 3DCM's model of polluted atmosphere

Before discussing the model of city's polluted atmosphere, we must study several questions in order to help understand pollution model.

●The problem of polluted atmosphere

The main air pollution source in cities are: 1.industrial production pollution, most of them is point pollution, 2.traffic and transportation pollution, most of them is linear pollution; 3.living stove pollution, most of them is plane pollution.

●Influence of the gravities on the polluted surface

because of the influence of gravities, pollution dust may easily nest on the inter-surface of atmosphere and ground;

●Special climate effect in urban

Because of the density of population and industries, it makes the urban atmosphere lie on nearly a level. People are living under the urban layer.
Assume there is urban area A, height of over-layer is H, total drainage from living stove and auto-mobile tail gas is M, industrial drainage is amount to Q. Neglecting the influence of wind, assume the polluted air distribute evenly in space V, here V is as follows

$$V=A\times H \quad (9)$$

When density of polluted gases is ρ, according to gases function, we should have the following equation

$$V\times\rho=A\times H\times\rho=M+Q \quad (10)$$

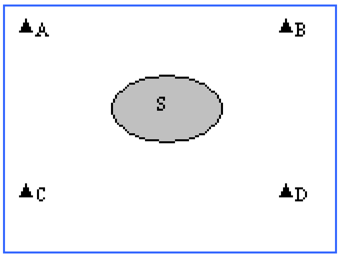
The parameters in formula (9), (10) may be obtained from environment protection branch. There are terrace and terrestrial objects in area A, occupying space V_1 (coming from 3D GIS data), having

$$(V-V_1)\times\rho=(A\times H-V_1)\times\rho_1=M+Q \quad (11)$$

here ρ_1 is the quantity of polluted mater in the unit space, which also is called the polluted index.

3.3 Considering 3DCM's noise polluting model

With the development of industry and traffic transportation, noise is doing great harm to the normal life of people, affecting the health of human beings, and becoming one of the main factors that are polluting the nature environment. In modern cities, noise comes mainly from three: ① traffic transportation; ②industry; ③public action. Noise spread in the way of wave, besides,it has features of direction and power decreasing. Figure 3, assume the spatial distance between the center of S and point sound source A, B, C, D is d_1, d_2, d_3, d_4 respectively



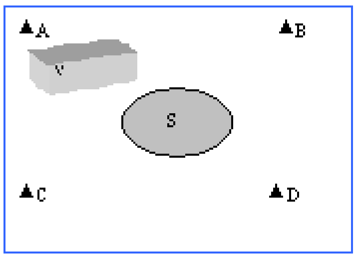


Figure 3 point noise pollution distribution Figure 4 influence from 3DCM on noise spread

Assume sound intensity from sound source A, B, C, D are P_A, P_B, P_C, P_D respectively, then the sound intensity in center S may be obtained according to the overlapping principle of wave

$$P_S=\frac{P_A}{k\bullet d_1}+\frac{P_B}{k\bullet d_2}+\frac{P_C}{k\bullet d_3}+\frac{P_D}{k\bullet d_4} \quad (12)$$

Here k is a constant factor. If there is a block V in the middle of A and S, see figure 3, the absorb efficiency of V to sound is m, then (12) may be written as

$$P_S=\frac{(1-m)P_A}{k\bullet d_1}+\frac{P_B}{k\bullet d_2}+\frac{P_C}{k\bullet d_3}+\frac{P_D}{k\bullet d_4} \quad (13)$$

Then judge the polluted extent in some area by a given index, and deal with it in an appropriate way. The noise polluting index may be affected by many factors, such as DEM, insulation sound wall, buildings, bridges, streets and height of railway, height of vegetation, surface structure of wall, etc. Figure 5 shows the power changes of spreading noise being sheltered.

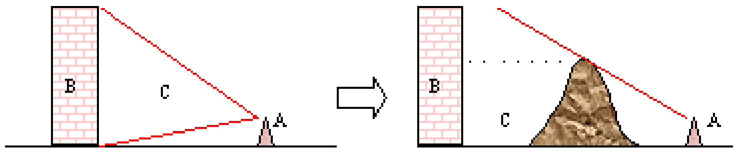


Figure5.1 noise spreading before being sheltered   Figure5.2 noise spreading before being sheltered

Sound spread in the form of wave. Figure 5.1 shows C is intensive sound area. Figure 5.2 shows C is weak sound area.

3.4 Considering 3DCM's sunlight model

Sunlight time has a great influence on human health and environment compatibility. Meanwhile, sunlight analysis and shadow analysis are important means by which we evaluate installation layout of buildings. Not only with the moving speed of the earth and the sun sunlight analysis has connection, but also with season and geographical situation of objects. Here discussing the general sunlight analysis model in two levels：（1）area level；（2）object level. Assume there are three blocks A, B, C. Simulating movement of sun, we can attain the sunlight time per day when block B was sun-shined as shown in figure 6.

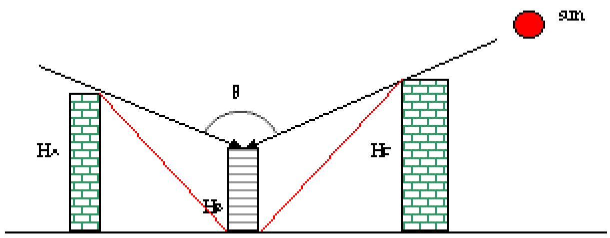


Figure 6 simplify model of sunlight

According to Figure 6, the time T when building B is sun-shined satisfied with following

$$T = \theta / \omega \qquad (14)$$

Here ω is the revolution speed of earth. Sunlight time and the heat radiation amount calculation of some concrete floors will be discussed in special papers. Sunlight analysis will do great help to plan the distance between two buildings, design face-direction of buildings, plan orientation and width of streets, plan distribution of building blocks. Figure 7 is the simulating shadows of 3DCM.

Figure 7 Simulating Shadows of 3DCM

3.5 Considering 3DCM's electro-magnet radiation model

Buildings in cities are very density. If hoping receive electro-magnet signal in every corner, we should take many measures such as decreasing wane, leading waves and so on. We know that electro-magnet spread in the form of wave, the spreading distance has a relationship with emitting power, in the meantime, after the wave reach a buildings or other materials, it will reflect and transmit. So if we want to establish such a service system as location based service (LBS) in the cities, we must analyse the spatial distribution of electro-magnet in cities. Figure 8, assume A is the source of electro-magnet, B is a building, on the back of B, there is a man C. If power of electro-magnet is E, distance between A and B is Z, then the power of electro-magnet after reached to B is as the following equation

$$E' = E - (1 - 2kZ) \tag{15}$$

Here k is wane factor. E´ produces two components after reaching B:（1)reflecting component;（2）transmit component; the power that could be reflected and transmitted has a relationship with the material of B.

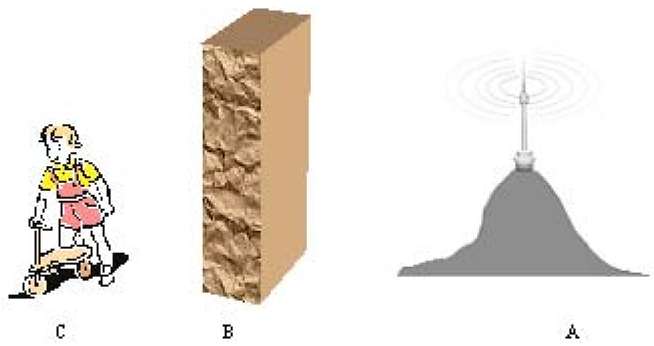


Figure 8 Simulating Radiation of Electro-magnetic Wave

Assume transmitted intensity is E_t, reflected intensity is G_t, neglecting of the distance between C and B, then the intensity in place C may state as the following

$$E_t = E' - G_t = E - (1 - 2kZ) - G_t \tag{16}$$

Here what should be emphasized is that the electro-magnet emit in the three dimensional space, thus,the spread of electro-magnet was limited by the height of buildings. When analyzing the coverage of electro-magnet and distribution of field intensity, apart from the power and frequency of station, the following affecting factors should be added

(1) Distance between base station and moving platform
(2) Antenna height of base station
(3) Height of moving antenna
(4) Typical heights of buildings
(5) Distance between one side of buildings in street and moveable station
(6) The included angle from street strike and moving station to emission direction of base station

4 Sunshine Analysis Considering Geometric 3DCM

3DCM aided spatial decision support is the depth application of 3D spatial data and its models. During forty years,， vast researches on DSS(Decision Support System) models have been done， but most of them focus on the transition from structural decision to semi- structural decision， and connection model house to data-base。With 2DGIS,espetially 3DGIS appearance， it makes the spatial analysis involve in geometric spatial features of objects. 3DCM aides spatial sunlight analysis by building shadow analysis models combining 3DCM with sun's moving track， providing decision proof for city spatial planning. 3DCM aiding spatial planning decision covers two facts：(1)aided analysis of locating and orientating cities；(2)aided analysis of optimizing and configuring spatial buildings。But there are at least three difficulties to obtain these decision proofs （1）display various of shadows；（2）calculating sunshine times；（3）calculating sunshine interval.

4.1 display various of shadows

Shadow of buildings come from two aspects: one is produced by other building's shading, the other is produced by itself shading。There are two ways of shadow analysis ：（1）shadow superimposition[Zhang Ziping,2002] ； (2) project transform[TongJi University and ChongQing Architecture Engineering College]. Buildings are all 3 dimensional， transform cubic objects into two dimensional plane by projecting the buildings to ground along direction of sun ray. In the course of projection, we should have a transformation， that is to say ,we must transform a three-equation group in which the three equations are all independent each other into a two-equation group in which the two equations are all independent each other. So we may design a 4*4 shadow matrix. With the matrix times present perspective environment from right, we can obtain the shadow polygon formed on the ground by buildings. Single building shadow experiment see figure 7.

4.2 calculating sunshine times

Sunshine times got by a building depends greatly on other objects around it. when we investigate the sunshine time of a building, we should combine the theory of sun's moving with the shadow coverage and times that topography and objects all round reflect on the buildings investigated， theoretical sunshine times minus shadow times equal to real sunshine times. Sunshine time has a connection with season ,longitude ,latitude and analysis height of building。Having known the geometric data of geo-objects， we may work out shadow polygon on the definite height plane in accordance with shadow project matrix ，by judgment of crossing or non-crossing the polygon(2D) of building bottom with shadow polygon(2D) of around buildings，we may know if the building is shaded by other geo-objects around it。Starting from sunrise ,every piece of moment, repeating above judgment ，accumulating sunshine time until sunset，the total times accumulated is the real sunshine times during a certain day when the building get from sunlight。Sunrise moment and sunset moment may supposed to be the earliest and the latest values respectively. Figure 9 shows the experiment analysis results of sunshine time under condition of the above given parameters.

Figure 9 sunshine times analysis result

4.3 calculating sunshine interval

Calculating sunshine interval should consider people's demands for sunshine hours of buildings. Firstly calculating the beginning shade time， according to the sun's position angle at this time and direction angle parameters of two buildings ,calculating the sunshine interval factor ， sunshine interval factor times the height of one building which lies in the eastern to another building，then we may get the reasonable sunshine interval between two buildings ,which may satisfy the special demands。Calculating result see Figure 10 .

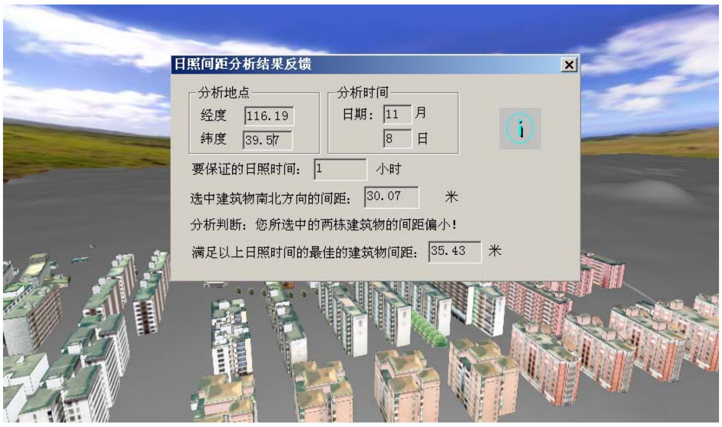


Figure 10 sunshine interval analysis result

5 Conclusion and Prospect

3DCM aided spatial decision support need to mine the relevant decision supporting proofs by way of three dimensional spatial analysis of GIS. In this paper, the basic mathematic models of 3DCM aided spatial decision support such as spatial statistic model, dynamic analysis model, and planning model have been investigated, also studied the nesting applications of 3DCM, mathematic model and professional application models .Compared with the present spatial analysis, this paper has given full consideration of the main contents of cyber-city, named 3DCM, from the corner of decision support proofs, investigating the nesting of 3DCM with sun moving equation, discussing the way of obtaining necessary decision proofs for urban spatial planning. These show that

(1)3DCM aided spatial decision support is widely applied. Further advanced UGIS must realize the increasing value application of 3DCM;

(2)3DCM aided spatial decision support emphasis “decision support”, proofs support is the key content of 3DCM aided spatial decision support. Obtaining the decision support proofs involves the nesting application of mathematical models, 3DCM and professional application models.
(3)3DCM aided spatial decision supporting must build some basic spatial mathematical analytical models. Spatial statistics model ,spatial dynamic models and spatial optimized model and planning model are all basic mathematical models;
(4)sunshine times analysis of buildings is a typical added-values application of 3DCM aided spatial decision supporting;
(5)The nesting application of 3DCM with sun radiation equation may calculate accurately the shadow coverage of buildings and sunshine times, providing urban planning and design with more decision support proofs than 2D spatial analysis.
(6)This paper only gives some exploring idea. The concrete way of building model aimed at specialized question, decision supporting way in space of decision supporting models are all remained further studied;

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