OPTIMAL MODEL IN URBAN INFRASTRUCTURE BASED ON GIS

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Commission IV , Working Group 1

KEY WORDS: GIS , Urban, Optimal, Modeling, Thematic, Method

ABSTRACT

It maintains a balance beteen urban infrastructure such as water supply, sewage, electricity, gas (etc.) and block capacity. When some urban factors change, the balance may be destroyed. Optimizing urban infrastructure , supported by GIS platform, can rebuild the balance. This paper describes establishment of Optimal model in urban infrastructure in detail, then gives an example .

KURZFASSUNG

Ein dynamisches Gleichgewicht zwischen Infrastruktur der Stadt und Kapazität des Erdeblocks bewahrt sich . Wegen der Verănderung welcher Faktoren kann das Gleichgewicht zerstort werden . Mit Hilfe der GIS - Plattform zur Optimierung der Infrastruktur kann das Gleichgewicht erneut entstehen. In diserem Beitrag wird das optimierte Modell der Infrastruktur auf der GIS - Plattform ausführlicher diskutiert und ein entsprendes Beispiel gegeben.

1. PREFACE

Block capacity is an abstract concept, and especially points out the load capability of block. The urban development bring changes in many urban factors, such as population, economy, environment, land, and so on. This changes, reflecting finally on the blocks, can be called changes of block capacity. The changes of block capacity raise new requirement to urban infrastructure in certain. To maintain the dynamic balance between block capacity and urban infrastructure, it needs to establish each thematic optimal model of urban infrastructure to quantitative analysis. Through adjustment of pipe net, it can rebuild the balance.

2. PRESENT SITUATION ANALYSIS AND STRATEGY

In traditional approach of urban planning, optimization of infrastructure are always made manually , which is time consuming and complicated, and the precise only maintains a favorable level. When the number of nodes exceeds one hundred, even to one thousand, it would be very difficult to work out manually, and speed cannot be satisfied with the requirement.

It is possible to finish these programs quickly with optimal model of infrastructure based on GIS platform . In recent years, some thematic model have been developed world widely, which have acceptable speed and precise, but compared with those based on GIS platform, these model have some shortages. GIS has great advantages in four aspects described below:

2.1 Material Storage

Each time when a city revises its master plan, it is required to collect a lot of data and materials like report , investigation, map, image, captured data , historical reference, and so on. It creates new planning achievements from analyzing and arranging these materials and data , with the requirement to new urban master plan. GIS has more powerful function on data base management, it can put reference, map and image into classes and titles,then stores them. When next rang of master plan begin, these reference can be regarded as valuable historical data, because that urban plan always emphasize certain continuity .

2.2 Easy to Update

It is more convenient to achieve when existing infrastructure change, or some infrastructure need to change in the procedure of planning. GIS has the function on fusing spatial information like coordinate and non-spatial information like attribute, updating and maintaining easily, so it can keep data up to date, such as moving location of infrastructure , distributing adjustment of pipe net and updating attributes of infrastructure.

2 .3 Keeping Graphics and Texts on a Screen

Non-GIS thematic model always gives number to nodes and pipes manually, then inputs the attributes of those nodes and pipes to computer, by Which to achieve the strenuous calculating work . Some software ,which have been developed more deeply, also can create reports automatically with the given number and output map, but the preparing procedure are more difficult and strenuous . Even more , those operation are always not satisfied. on the contrary , GIS platform has good interface to support graphics and texts existing together on one screen, and it is very convenient to finish all the procedures, just like browse, query, statistics and output.

2.4 3D Viewing

It can create DEM by using separate elevation points or contours on GIS platform, then overlay the information of infrastructure on DEM. Now, users can observe and measure them from different viewpoints, so they can reduce some faults in the procedure of planning. for example, whether it needs add pressure on the scope with great changes of terrain. At the same time, GIS can return the information like coordinates of pipe net , elevation, length, overlay area and section area to user .
Users also can create 3D pressure model with elevation of infrastructure pressure, then overlay it onto existing DEM, view and query the pressure and coordinate information at any place. the effect is more novel and original.
Thus, GIS shows more powerful advantage on optimal urban infrastructure , and has very wide prospects. We'd like to solve the program through modeling of infrastructure based on GIS.

3. ESTABLISHMENT OF MODEL

Optimal model of urban infrastructure includes mainly four aspects described below:

3.1 Assessment and Forecast of Requirement to Infrastructure

Assessment of requirement is often derived from uses, for example living use, industry use,fire fighting, afforecast (etc.). The part of living use can be got by requirement per one person multiplying the total population. The part of industry use can be derived by expending quantity per ten thousand output value multiplying the total quantities of bigger user. The part of fire fighting and afforecast is always got from the statistics number per one minus.

Forecast for development of requirement always needs to consider comprehensively with economy, population, environment , and so on. Generally , there are some methods like below:

3.1.1 Method of Regression

In the ordinary way, it appears one-variable linear relation between GNP and the quantity of requirement. Putting historical data into formula :

$$Y = a + b * X$$

to calculate variable a, b , then we can get the mathematics model of regression forecast . In the formula, X is GNP;

Y is the quantity of requirement.

3.1.2 Method of Expending Quantity per Output Value

The formula of expending quantity per output value just likes:

$$Q = A * B * C$$

in the formula,

A is the gross value of industrial output in the period of planning ;

B is the expending quantity per output valu;

C is the proportion in the total quantity of requirement;

So, it is more important to assess rightly the three variables.

3.1.3 Methods of Satistics and Analysis

It appears certain regularity of variation among the continue years, and the result can be got from formula:

$$Q = Q_0 * [1 + p / 100]^t .$$

In the formula,

Q_0 is the quantity of requirement in the datum year;

P is varying progressively rate;

t is the total number of statistics years.

3.2 To Calculate the Pressure of Nodes, Flow of Pipes, Maintaining Current Situation

This function can be used by government to control and manage the pipe net system, and also used to update and maintain the facilities.

3.3 When Capacity of One Block or Some Blocks Change, to Calculate the Optimal Planning Pipe

Here is the program of establishment of refining water pipe net system (figure 1.).

3.3.1 Data Preparation

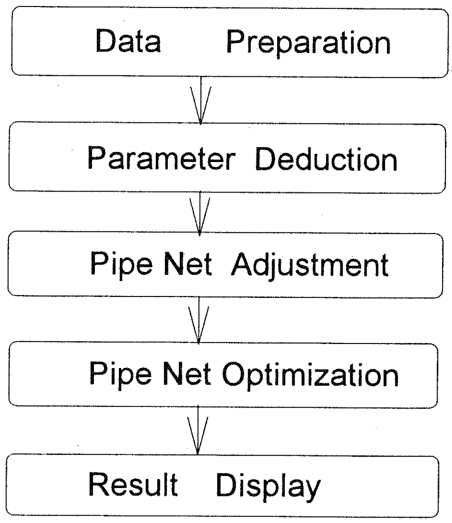
This procedure is used to edit and arrange data, and to supply basic data for next procedure. It includes mainly some aspects:

* To input water pipe map to computer, edit them, and create topology relation of pipes.

* To add information such as diameter and flow of pipes to Arc Attribute Table (AAT), and elevation of nodes to Node Attribute Table (NAT);

* To determine location and water pressure of water factory, tower, pump.

* To determine the big consumers' consumption and the nodes them belong to.



(Figure 1. Establishment of optimal model in urban infrastructure)

3.3.2 Parameter Deduction

It needs to deduce some medium parameters from formulas after data preparation. These parameters include: overall length of pipe line, total water consumption of big consumers, flow of each node, and so on, then system distributes preliminary flow and calculates the economical speed of flow.

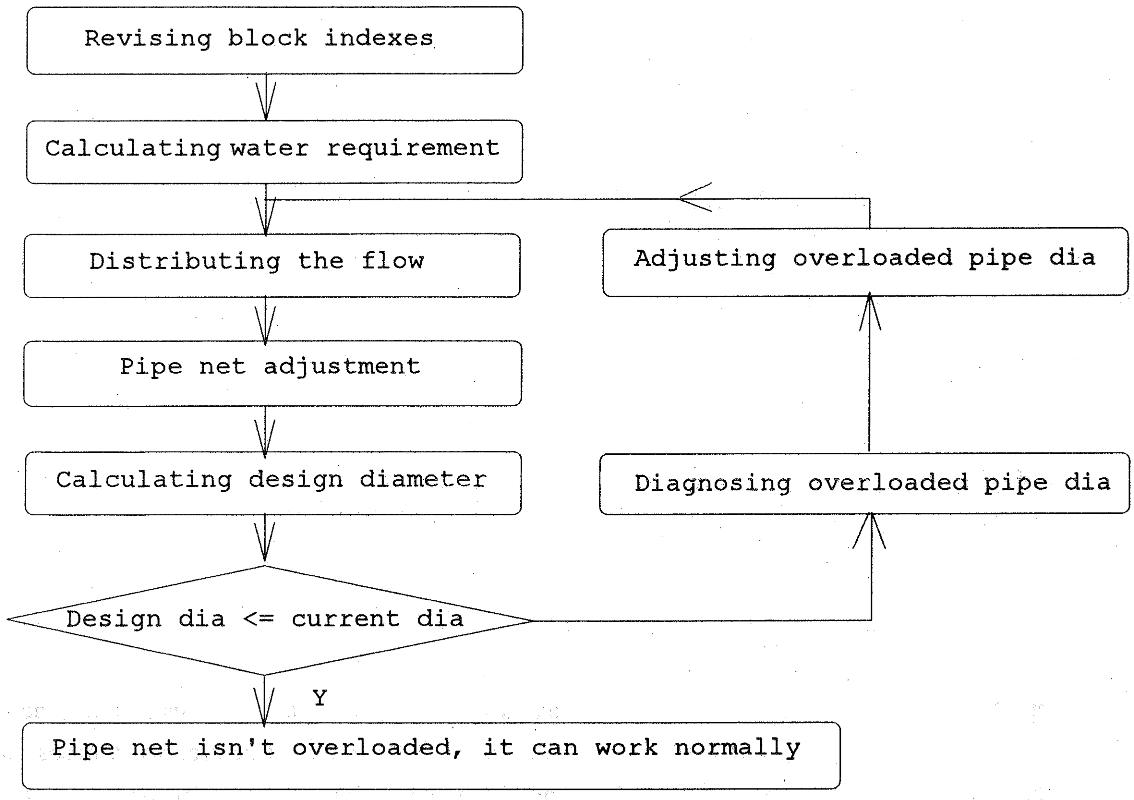
3.3.3 Pipe Net Adjustment

Determined the position of water factory, water tower, water pump, and given out the most unfavorable point or the lest pressure of water, system derives the loss of water pressure from the parameters matrix and calculates the flow of pipe section. granting system a threshold (for example 0.0001), when the maximal difference of the pipe section flow which is obtained after twice adjustment less than the threshold, it finishes the procedure of repeated adjustment.

3.3.4 Pipe Net Optimization

Changes of block factors must bring new requirement to the infrastructure, so it needs to rebuild dynamic balance. The following figure is a flow chart of pipe net optimization, it describes the whole procedure of pipe net optimization in detail (figure 2.).

When factors of some blocks change, such as Floor Area Ratio, population, building density (etc.), updating the indexes of blocks directly on the computer, deriving the volume of water, and distributing it to the relative nodes, system can calculate the optimal diameter of pipe through pipe adjustment now. Comparing the diameter of the designed pipe and the current pipe, system diagnoses results automatically : if the diameter of designed pipe is less than or equal to the current one, it shows that the pipe can still satisfy the requirements when block capacity has changed, otherwise, it shows the pipe has been overloaded and need to be renewed into a designed pipe with bigger diameter. System also prompts user to update with red flash. After updating the pipe diameter, system repeats the procedures described upon , until it satisfies the balance between block capacity and the amount of water in the water pipe system at last.



(Figure. 2 Flow chart of pipe net Optimization)

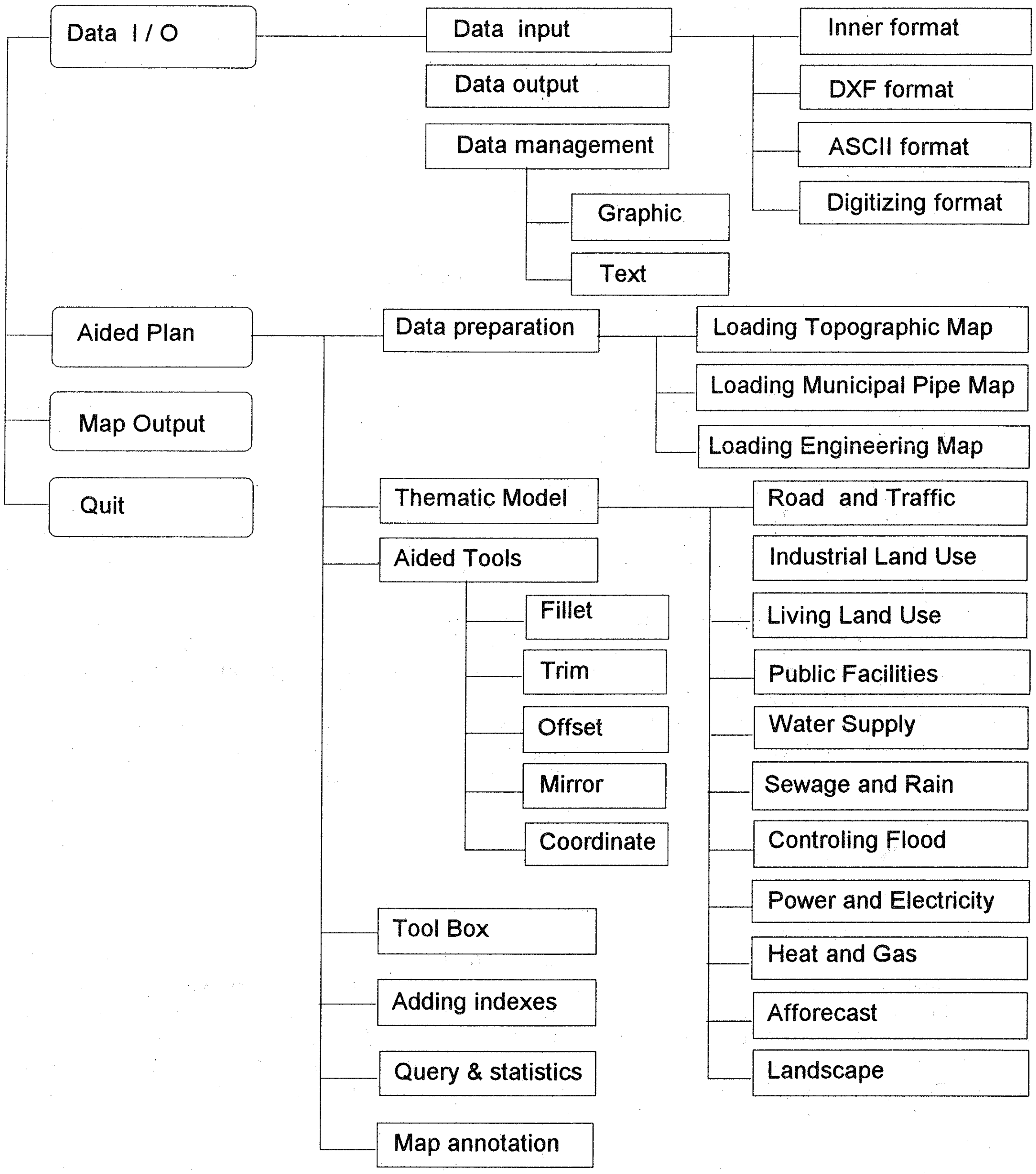
3.3.5 Result Display

After repeated optimizations of pipe net and adjustment of pipe diameter , system rebuilds the balance between block capacity and water pipe net . System produces the parameter report tables and prints it. At the same time, system can annotate the information such as diameter, length, flow , and the loss of pressure of water pipes (etc.) on the graphics, then output it.

4. CASE STUDY

The rapid development of economic construction and city scope in Qingdao makes the original master plan unable to completely satisfy the requirement of the urban construction and management, thus it is necessary to have a new range of revision of urban master plan. School of remote sensing and informatics in WTUSM developed a CAD system based on GIS platform to support the comprehensive plan in Qingdao, a very beautiful beach city .Urban infrastructure is part of it, including water, drain, rain, power, electricity, heat, gas (etc.) seven themes. The system frame is shown in figure 3.

The CAD system can support most of the daily businesses from the master plan, distinct plan, to detailed plan. Moreover, it has advantages such as good communication, easy operation, fast updating and the precise maintaining at a quite high level. Taking the data of industry area of Qingdao as an example, the procedure of plan, optimization, graphic of each thematic infrastructure need about one day's time to be finished, the efficiency is raised greatly.



(Figure. 3 The System Frame)