DEVELOPMENT AND APPLICATION OF A VISUALIZED SYSTEM FOR 2-D MATHEMATIC MODEL OF LOWER YELLOW RIVER BASED ON GIS

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ABSTRACT

Progress of the GIS has made strong support for the treatment of the huge amount of geographical information in the development of the visualized system for the 2-D mathematic model of the Lower Yellow River. The principle and method of design of the components in the visualized system based on GIS are introduced in this paper. Method of creating the topography of the main channel by means of the measured transverse cross sections in the range survey and the map of flow pattern and the position of main currents is developed. Based on these and incorporated with the GIS,the elevations of all the mesh points in the network can be computed that can be used in the 2-D model. The coupled integration of the 2-D mathematic model with the GIS is realized. On the basis of integration a visualized system for the 2-D mathematic model is developed. Special features and capabilities of the visualized system and its application for the 2-D model are also described in the paper.

1. PRESENT STATUS OF THE DEVELOPMENT OF VISUALIZED SYSTEM

In recent years, powerful around processing mathematic models were developed very fast. Most outstanding development of visualized system had developed by Delft Hydraulics in the Netherlands, Wallingford in U.K. and Mike in Denmark. In the specialized software of the visualized system, senior modules were inserted in the mathematic model with which either the original data or the computed results can be displayed through colorful and clear animated cartoon drawings. It has provides the following features: (1) friendly user interface easy for mutual exchange; (2) import /export interface with some GIS software is made available so that data resource can be easily shared and exchanged; (3)installed with a powerful around processing capability; (4) integrated coupling of the simulation techniques with the visualized system.

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2. OBJECTIVE OF DEVELOPMENT OF THE VISUALIZED SYSTEM

Objectives of development of the visualized system for the 2D mathematic model used in the Lower Yellow River based on GIS are as follows: (1) integrated coupling of the mathematic model with the GIS. i.e. conform the resource in GIS according to the simulation requirements of the mathematic model, such that the visualized system may be formulated with the model storehouse as its center; (2) Based on the visualization capability of the GIS, in addition to the modern development of the visualization techniques, the around processed visualized system is constructed and the computed results and the mutual response can be displayed on real time basis. Finally, an unified high-efficient platform for the simulation of whole process of the Lower Yellow River can be established on the basis of the GIS system.

3. DESIGN OF THE OVERALL STRUCTURE OF THE VISUALIZED SYSTEM

The flow chart of the design of visualized system for the mathematic model of Lower Yellow River based on GIS is shown in Fig.1.

(1) User interface: it is composed of multi-file interface, menu, toolbar. The menu system is an integrated logic organization that has all the capability of the system.

(2) Data input and output system: It includes the collection, recording, retrieval, storage, management, inquiry, display and charting of vast spatial information in the field of hydrology, sedimentation and river morphology. It also includes the import/export interface in connection with the software of GIS.

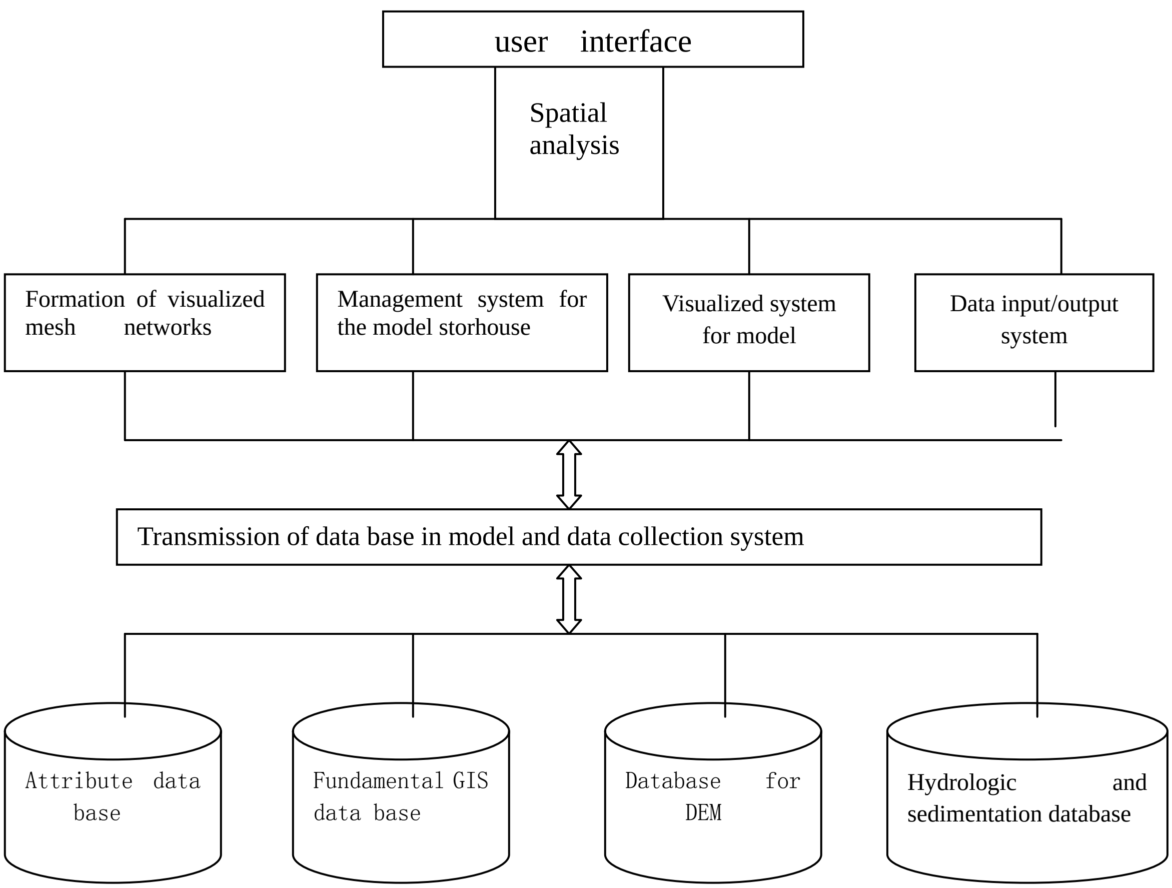

Fig.1 Flow chart of structural design of the visualized system

(3) Formation of the visualized mesh network: It includes the automatic formation of the meshes in the network for computation with the 2D model; self-adjustment of the mesh in the visualized system; automatic numbering and withdrawal of the ordinates of the knot points; formation of topography of the river course from the measured cross section data and elevation and its modification by visualized system; Automatic formation and revision of the original data of knot points: formation , display and revision of divisions of the parameters.

(4) Around processing system, i.e. first and post processing for the model visualized system. Formation and display of the graphs required in the first processing such as the composite hydrologic graphs and topographic maps of the river, etc; and isograms, isosurfaces, flow-lines, curved surfaces produced automatically by knot data; three dimensional graphs developed through figure drawings; and display on real time basis of the computed results and the intervention of the computation;

(5) Management of the model storehouse. A model is an abstract description of the objective things. Complicated problems may be better understood and properly treated by means of modeling. It is a common practice to use a model as an aid in decision-making. The model storehouse is to organize various models into a composite unit and effectively managed through the model storehouse management system. Similar to other data base, it is also shared by users. Besides the mathematic model, it includes also the data treatment programs or models, a program library, graphic models, image treatment programs, an intelligence model and programs for printing etc;

(6) Data base in the model and transfer of data: The data base in the model is established by means of digitalized Yellow River in conformity with the special feature of the mathematic model. It includes the spatial data base, attribute data base, parameters storehouse used in the mathematic models, and relevant data in the model storehouse; Data transfer programs are used for transferring data between digitalized Yellow River and the model data base;

4. AUTOMATIC FORMATION OF TOPOGRAPHY OF THE RIVER CHANNEL

Topography of the main channel of the Lower Yellow River is one of the pre-requisite indispensable data for the 2D mathematic model. It relates directly to the accuracy and reliability of the computed results of the model. It is also the fundamental data for the two-dimensional flow field, flood inundation, sedimentation processes and variation of the flow patterns as well as the visualization of these things. In fact, erosion and deposition take place incessantly in the Lower Yellow River. Drastic and rapid changes may be observed in the main channel. In order to monitor the variation of the river morphology, range surveys are carried out twice a year, prior and after a flood season, on the pre-set transverse cross-sections along the entire Lower Yellow River. However, the longitudinal distance between two cross-sections is too large to define the topography.

At present, there are only two ways to obtain such a topographical data. One is to take field topographic survey with aid of satellite images or other remote sensing data. Another is to use the range survey data and intermediate data interpolated through stage-discharge relationship. However, topographic survey is rather expensive, time-consuming, and sometimes, the underwater data is missing, so it can hardly fulfill the requirement of 2D mathematic model. The second approach is also labor and time-consuming. In our work, the topography of the main channel is automatically formulated through programs developed by the author with aid of GIS system on the basis of the observed range survey data, maps of flow pattern and trace maps of main currents and thalweg charts.

Sketches of the path of main currents, flow pattern charts, position of thalweg, stage discharge relationships together with the range survey data are also required in the generalization of the channel topography. In case the position of river regulation structures and the vulnerable spots may have influence on the channel topography, the ordinates of these engineering structures should also be provided.

Generalization of the topography is accomplished in two steps: the following five sets of data should be made available, i.e. water edge line, thalweg line, range survey data, stage-discharge relationship and secondary range data. In the software program named as **RGTOOLS**, developed by the author for management of range survey data of the Lower Yellow River and also of the reservoir, ranges are formulated in conformity with the topography, perpendicular to the main flow line and maybe interpolated into the system. Elevations, areas and widths of the interpolated ranges can be computed through the observed upstream and downstream ranges and stage discharge relationships. Irregular TIN topography can be formed by the elevation of the interpolated ranges and the GIS system. Elevation of any points in the main channel can be withdrawn through these works in preparation.

By means of mesh networks formation programs a 2D triangular or quadrangle mesh network can be formed which can be superimposed on the TIN topography and the elevation of any knot points can be withdrawn. The initial topographical map used in the 2D mathematic model is obtained as illustrated in Fig.2.

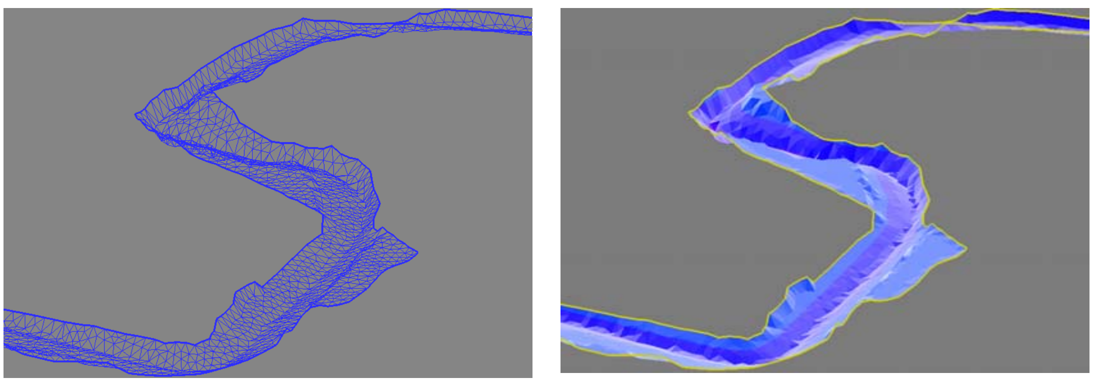

Fig.2 triangular mesh networks and formation of the main channel topography

5. MAJOR FUNCTIONS OF THE VISUALIZED SYSTEM

The visualized system for the mathematic models used in the Lower Yellow River is built up on the basis of the spatial geographic information such as the topographic maps of the river, maps of the layout of river training structures, flood inundation maps and social economic data. Expressing all these data in pictures or graphs will make the readers feeling as if he is personally on the scene. Different impacts on the river by alternatives of reservoir operation schemes can be easily compared with 2D dynamic imitation techniques. Use of the visualized system in mathematic models will be helpful in understanding the computation results of the user and is a good help in the improvement of the decision-making.

The first and post processing in the visualized system include mainly the following items:

(1) Graphic man-machine interaction interface. Users may easily exchange information with the machine using the menu and keyboards such as data input and output. First processing of the computed area can be made with aid of GIS graphics such as the initial topography of the river channel and also the control of the inlet and exit boundary conditions, etc.

(2) Formation of the required data of the model by means of GIS, such as the generalization of the topography of the channel based on a digitized river channel or a reservoir. Geographic data and attribute data required in the mathematic models may be made available by means of GIS and TIN modules.

(3) Development of the model can be illustrated in a certain degree by graphics. Contents of

the model will be easily made understandable to the user. The model may be modified by the user such as the parameters in the parameter storehouse of the model, dictionary of the model, etc.

(4) Processes of imitation such as flood routing and fluvial process can be displayed in 2D or 3D graphics, users or managers may have a clear, visual display of the impact of reservoir dispatch, and the water and sediment movement that will improve the effectiveness of decision-making.

6. REALIZATION OF THE SYSTEM

The visualized system of the 2D mathematic model of the Lower Yellow River is mainly developed on Visual Basic 6.0 and Oracle 9i Data Base and GIS software. Computation of hydraulics, sediment transport and fluvial processes are realized by using Fortran 90 dynamic storehouse. Graphics storehouse available in Windows and GIS are used through programs by Visual Basic; Data storage is realized by using Oracle 9i. Connection and updating of data-base are performed by using ActiveX and ADO; Interface of operation and main program are directly created through Visual Basic; Different modules are dispatched by the notice received from the main program. Data-base of mathematic model and basic geographic data-base of the river can also be dispatched. The computed data can also be converted into geometric data. After completion of all these steps, the result of computation is made visualized and can be shown on the computer screen. The visualization can be shown also on local networks. The operation platform used for the system is Windows XP.

7. CONCLUSIONS

(1) The visualized system of 2D mathematic model based on GIS is not only a change in the digital simulation methods,but also provides a prospective way for the study and application of 2D mathematic models. It further promotes deep understanding of the fluvial processes and sediment transport mechanics.

(2) Programming of the components is used in the visualization system that can be put into full ontrol of the user. It provides also a frame-work with strong flexibility that it can be further improved and perfected along with the future development of the model.

(3) Study of the visualizazed system for the present model will be helpful in the development of similar system in other fields of study of the Yellow River

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