VISUALIZATION SIMULATION SYSTEM IN COASTAL AND ESTUARINE AREAS

Wenjie Xin[1] and Xiaofeng Luo[2]

ABSTRACT

A complete numerical simulated system includes mould-building, needed data preparation, calculation and demonstration. The system compiles by Microsoft Visual C++, with friendly interface and is of easy operation. The system can carry out 2D and 3D current, salinity and sediment experiments. In the course of calculation, the real time change course of each physical quantity can be shown.

1. STUDY BACKGROUND AND MEANING

In recent years, along with the development of computer technology, the mathematic models of coast and estuary were developed from 1 dimensional models to 2 dimensional models, and to 3 dimensional models. It has become an important means of coastal project research. In 1990's, with computer technology's support, multi-media technology, large scale relation database technology, image handling technology and the GIS/GPS/RS technology, combined with new calculation technology, offer mathematical models a vast space of development space.

The mature foreign numerical simulation software includes MIKE series by DHI, Delft 3D by Dutch Delft hydraulic research institute. In addition, Wallingford HR hydraulic research institute and U.S. Waterway Experiment Station (WES) etc. which have been designed their own numerical simulation software.

In China, the main form is the wrapped software, which detaches the build mould, calculation mould and demonstration mould. Tianjin Research Institute for Water Transport Engineering has developed successful systematic software in demonstration, and its characteristic is transferring entire calculation digital information to direct image. According to the inattentive couple of system phenomenon of present domestic mathematical models, Ye Qinghua has developed an assembly type coastal mathematical model integrated system, and Xin Wenjie used assembly technology to develope wave, current and sediment mathematical model system of estuary.

A complete simulation system should include a build mould, a calculation mould and a demonstration mould. Among these three, the build mould is the course to prepare data information, the calculation mould is for calculation and saving compute result, and the demonstration mould expresses calculation result. All mathematic models can be completed through different methods,

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[1] Professor, River and Harbor Department, Nanjing Hydraulic Research Institute, No. 34 Hujuguan Rd., Nanjing, Jiangsu 210024, China. Phone: 86-25-85829320(O), 86-25-85829948(H) Fax: 86-25-85829333 Email: wjxin@njhri.edu.cn

[2] Engineer, River and Harbor Department, Nanjing Hydraulic Research Institute, No. 34 Hujuguan Rd., Nanjing, Jiangsu 210024, China. Phone: 86-25-85829377 Fax: 86-25-85829333 Email: xfluo@njhri.edu.cn

but the 3 above-mentioned steps must be involved. However, one problem is usually neglected——the visualization of calculating course, which is a shortage when compared with physical models. So how to integrate these 3 moulds to an organic system and realize the visualization of calculating course are the key problems.

2.   SYSTEMATIC PRINCIPLE AND FUNCTION

2.1   Principle

A system is an organic whole. As a complete system, it should combine organically with build, calculation and demonstration moulds. A build mould, usually called pre-treatment, prepares the data needed for calculating. Though calculation methods are varied, every method is to join the former input data and calculation result data. Demonstration solutes the expression of calculated result. According to the way of expressing, it can be divided into the demonstration of static demonstration (single pictures), and animate demonstration (continuous animation). If demonstration is needed after calculation, it is usually called post-treatment; it also can be demonstrated during the course of calculating (Real Time Observation).

For the continuity of function up grading and development, this system incorporates a build mould, a calculation mould and a demonstration mould into an independent object. Every object offers a general in/out function. The system joins every object through systematic application program organically, uses corresponding object according to different needs.

2.2   Develop Tools

Domestic calculation of simulation system is drawn up mainly with FORTRAN language; a few adopt C++, Visual Basic and Matlab and so on. The demonstration mould mainly uses a mature software, such as Surfer, Vis5D, Tecplot, and so on, but versatility is not good.

This system compiles by Microsoft VC++ (in the abbreviated as VC), which has the advantage of a few aspects: The application program of VC has inherited the window body interface style of Windows completely; the interface operates friendly and easily. VC has the efficiency ability of memory management, which can guarantee the stability and speed of calculation. VC offers powerful draw function.

2.3   Function

Fig.1 shows the interface of the numerical simulation system. Users can realize different functions by menu, tool strip, button, input frame and shortcut key, etc. This interface has following compositions: On the top is title and menu and tool strip. The left side bar of central section is a build mould and a verification tool. The right side of central section is a customer demonstration district. The bottom is calculated and demonstration tools.

The major function of build-mould is inputting original data and preparing needed data for calculation. Data needed for calculation can be divided into the followings: Model basic data, open boundary condition and initial condition, calculation parameters and so on.

Using the VC++ pointer, dynamic array technology, etc., the calculation has a high efficiency. If close the real time visualization, the calculated speed by this system is more rapid than the program by FORTRAN. The calculation mould has 2 dimensional and 3 dimensional patterns. It is necessary to decide before calculating that which content needs to be simulated, whether a movable boundary is to be considered, and whether real time visualization should be selected. During the course of calculating, each arbitrary physical quantity of current unit, calculation information, etc

can be inquired. After calculation, the system can automatically preserve initial condition, verification data and preserves the information of all field according to the time-interval of needs.
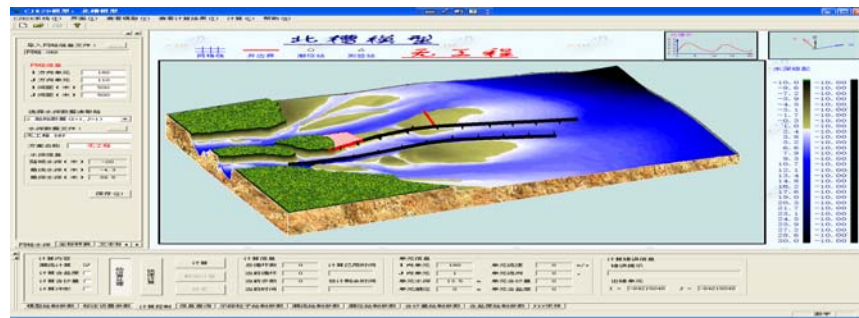

Fig.1 Interface of Simulation System

Since the cycle time of the salinity simulation is much and the time is longer, the regular routine is examining the result after calculation finished. During the course of calculating, whether the calculation is right is known. For instance, in simulating three-dimensional salinity, it distribution needs several days, if according to before practice, can only export the information of designated unit on screen during the course of calculating, but the information of full-field can not be seen, only after the computing finished can we look over the result. Since the calculating information is great, we can not see detailed intermediate course, the debug work has great obstacle. Therefore, real time visualization during computing is introduced in this system.

Demonstration has a variety of expression: Curves, model pictures, profile and model animation. Curves are used to show verification of water level, current velocity, current direction and salinity, etc. Model pictures include topography, water level field, tidal current and salinity field. Topography can be expressed by isoclines, 3d grid lines and depth render, etc. The salinity and water level field have two expression forms: isoclines or color-filled graphs. Flow field shows usually by current vectors, also can convert the Enler field to trail particle based on Lagrange field. A model is completely three-dimensional, support zoom in or out, a model also can be rotated in an arbitrary angle and arbitrary position. At the same time, the above graphs can also overlay to realize three-dimensional show. A section profile graph is to show the three-dimensional calculation result of each section.

3.   KEY TECHNOLOGY

3.1   Data Structure

From an entire system process, data is the linkage connecting every module. The build mould handles data, the calculation mould gets result data, and the demonstration mould expresses data. How to establish a strict data structure is very important for demonstration. In the mathematical model of estuary, the variables have two kinds: Scalar and vector, both are multidimensional physical variables. A system   referred to 5 dimension concept data set in meteorology study. According to definition, a 5 dimension dataset is used to describe time and space distribution of many physical variables. Compared with a 4 dimension dataset, the difference contains many physical variables. Therefore a 5 dimension dataset needs to express the relation between physical variables. For example, the salinity field of entire simulated area for all times, since relatively stratification is adopt, each vertical layer's actual depth is related with the water surface.

3.2   Graph Handling

All graphs are related with the data field. If fill colors according to every unit, the efficiency will be very low when the data bulk is great, and affects the demonstration effect. The full information can be divided into levels by contours, then fill color and render the graph. This method has greatly raised the drawing efficiency. VC is a programming language with object, the data structure can be encapsulated into isoclines classes, then the isoclines data of each site or each time can be tracked, finally a vector picture can be drawn which can be edited.

Color palette adopts Windows RGB (Red, Green, and Blue) pattern, in which every item values from 0 to 255. So a 24 bit real color pattern can be obtained. There are two methods to fill the isoclines. One is to fill according to different levels of isoclines values, such image shows apparent effect. Another method is fillint with stepless gradual change, joined with tendency surface imitation, and then fill the color according to the value. The image visual effect of principle is reality, but the speed of generation is comparatively slow.

Referred to Open GL paste picture technology, in three-dimensional graph, the model boundary and land region in three-dimensional effect can be pasted. Fig.2 shows the expression of 3d terrain.
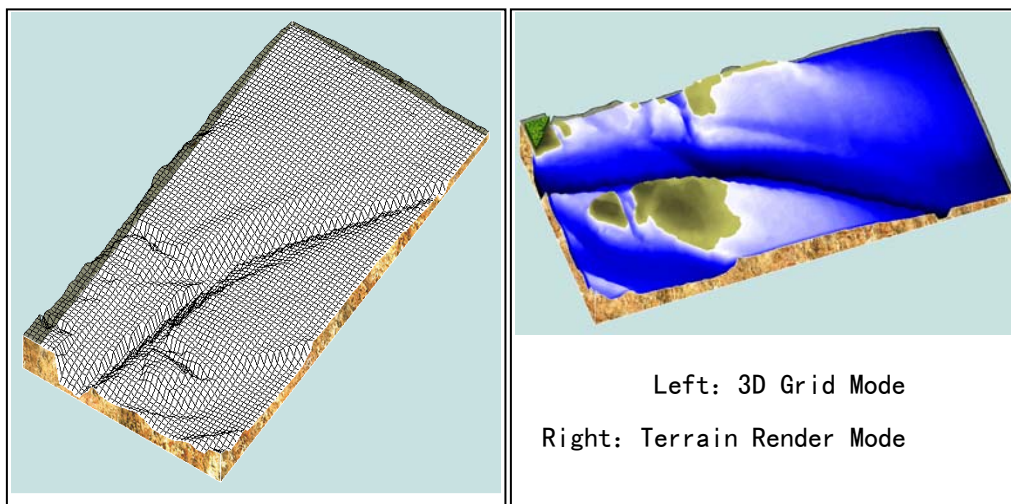

Left: 3D Grid Mode

Right: Terrain Render Mode

Fig.2 Expression of 3D topography

3.3   Animation Demonstration

A physical model can directly demonstrate the course of water level and salinity field change, but a mathematic model must rely on animation demonstration. In the past, the adopted method was to preserve the site picture of every time, then use related software connecting a sequence position pictures to carry out continuous play. The shortcoming is great workload. If reduce the picture quantity, the continuity of animation will be bad.

This system uses the powerful function of VC to generate instant pictures of a vector field, generating in a proper order when playing animation according to time sequence. In demonstration, when the grid unit quantity is great, the frame can have obvious twinkle phenomenon. Refresh screen speed can not go up because the needed memory is too big. To avoid this kind of phenomenon, buffer swap technologies in Open GL is adopted in this system. Buffer swap technology carries out draw code in the memory of computer and can store complex images, then put it to screen by exchanging order of produce animation. Use buffer swap technology, when an

image at a certain time is put to the screen, another image is carried out simultaneously in the memory buffer besides the screen, so there is no twinkle phenomenon on the screen.

3.4 Printing

Proceeding describe is the demonstration technology that how to demoed on the computer screen. What we most care for is printing graphs on paper. VC supports to print, but if directly use the print support offered by VC, the printed quality is rough. The major reason is the default pattern offered by VC is MM_TEXT, which is relatively low than the resolution capacity of a printer.

This system rewrites the On Print function of VC, and chooses MM_ISOTROPIC pattern, whose minimum resolution capacity is 0.001 mm. So, high quality vector pictures can be printed by setting the scope and proportion.

4.   CONCLUSIONS

4.1 Characteristic

The System has the following characteristics:

1．The system adopts the window body style as MS Windows, an interface fairly friendly and convenient.

2．The System can carry out 2 dimensional and 3-dimensional current and salinity simulation, and realize 2d to 2d and 2d to 3d offering nest boundary.

3．The System can observe the real time physical quantity in the course of calculation, which is not so dull, at the same time can pause the calculation easily in time to carry out parameter adjustment.

4．Demonstration operation is simple and convenient; it can be played continuously and also can be looked over each time, and support prints current graph.

5．Upgrading of system function is easy. Along with the development of calculation method, different calculation methods can be easily inlaid into this system by maintaining the consistency of data structure, and will not affect the continuity of entire system. Since every function of this system is completed by modules, the systematic environment that a user needs can easily be set through the assembly of increase and decrease.

4.2 systematic limitation and prospect

The major shortcoming of the system is only support rectangle calculating grid, and calculation adopts the mature methods.

The core of a mathematical model is the computational method. The calculation method and analog precision are an important standard to appraise the system. The power conditions of an estuary are fairly complex, storm waves, current, salinity and sediment interaction, and each physical quantity is complex multidimensional course. Along with the development of computational method, this system needs to develop on the diversified method and analog precision.

Along with the high speed development of computer, application of GIS and OpenGL and other technology is already more and more extensive in the numerical simulation of estuaries and coasts. How to combine the existing characteristic of this system refers to processing technique and the experience of other application technology, perfects the demonstration of this system, and accomplishes the digital model on genuine meaning.

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