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STUDY ON A THREE DIMENSIONAL WAY TO PRESENT WAVE SIMULATIONS

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I.INTRODUCTION

Wave analyse is an important step in ports and harbors planning. To investigate this problem, engineers are using hydraulic models test and numerical simulations. These days, the numerical simulation is the most popular method because of recent innovations in computer possibilities, and because it can be done with a low cost and a real saving of time.

But numerical simulations raise some problems. Hydraulic model tests show the effect of the waves in a three dimension perspective, and provide a clear and immediate comprehension of the processes. But the usual output of numerical simulations are two or three dimensional wave field plots on the paper. So it is difficult to understand the field situation for the one who is not a professional in the hydraulic domain.

On this problem, authors tried to create a kind of EXPERT SYSTEM for wave analyses. This system aims to present clearly the waves situation to an audience of ordinary people, for example fishermen, with a 3-D wave animation. This animation is provide by a post processor added to the current wave calculation models.

The proposal method is using the AVS (Advanced Visualise System) capabilities, an easy-to-use tool running on workstation. With it , it is possible not only to create a classic 3-D birds eyes view, but also an animation with a moving view point, for example an observer standing in a moving boat.

II. PROCESS TO CREATE AN ANIMATION

a) Preprocess and input parameters

This system is proposing some wave models and equations :

* Short wave models : mild slope equation, small amplitude wave theory and energy balance equation.
* Long wave models : tsunami, storm surge, tide

Then the user can select the output format for the animation system.

The result of the calculation has to be set into a data file as the free surface elevation at each mesh and each time step. The plotting time step should satisfy the following condition:

$$dt \leq T/20 \quad \text{(where T is the incoming wave period)}$$

It means to have at least 20 frames for one wave to avoid discontinuity in the animation.

Other required datas are bathymetry model (land elevation related to mean sea level = 0m), and structures data (structure position in the model and shape: breakwater, jetty, quay.).

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Two other optional data files can be added :
- Landscape map giving some informations for each mesh of the model : beaches/rocks/vegetations(type, height). if no map file is given, the preprocessor can also generate a randomize landscape.
- Boat route datas : it contains the plan coordinates(x,y) of the way choose for the boat. The route is related to the origin point (0,0) of the model.Using these datas, and according to the boat speed, the preprocessor calculates the boat position for each time step. If no file is given, the default position of the boat is set in the center of the model.

The user has to input some parameters:
- type of boat : weight, size, speed
- display options :
  * season (winter,spring,summer,fall)
  * time of the day (daytime, night)
  * weather (clear,cloudy,stormy)

The video builder program will use the display parameters to select the color of the sea, the type and color of sky, and texture and color of vegetation and land.

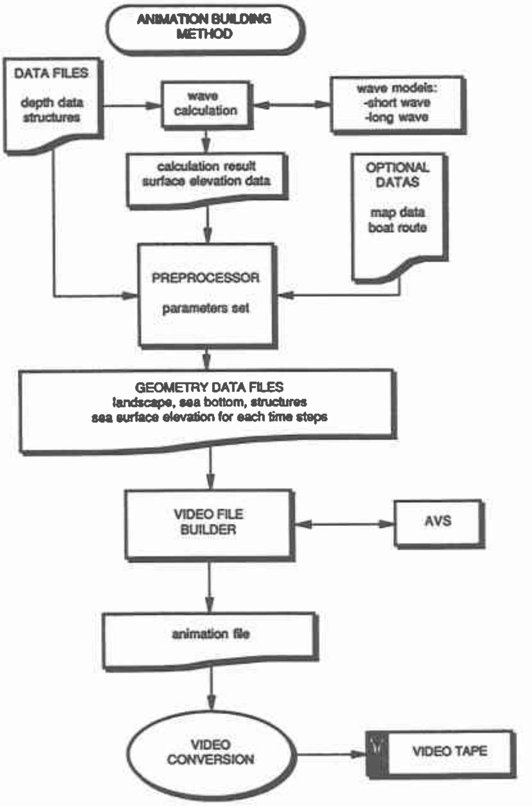


Fig.1 ANIMATION BUILDING METHOD

- type of animation :
  - ->fix point of view: spatial coordinates (x,y,z) should be entered. eye point is not moving and the camera is watching the boat position
  - -> bird eye view: coordinates should be entered, and the camera is looking at the center of the model, at a level z = 0 m
  - -> from boat : the eye point is set to the bridge of the boat. The camera follows the movement of the boat and looks at the front.
  - -> follow boat: the camera seems to be on a boat following and looking at the main one.

the process of data creation is completed within few minuts according to the size of the model and the required time step.

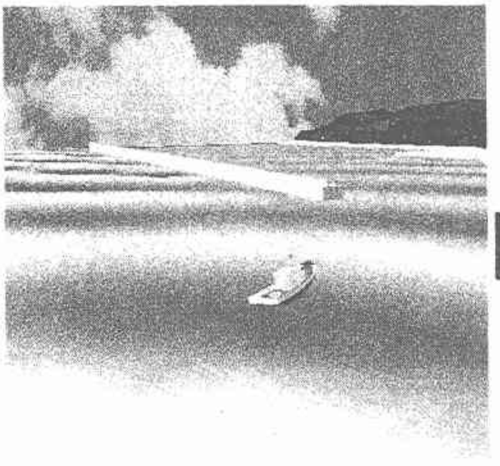


Fig.2a VIEW FROM FIX POINT

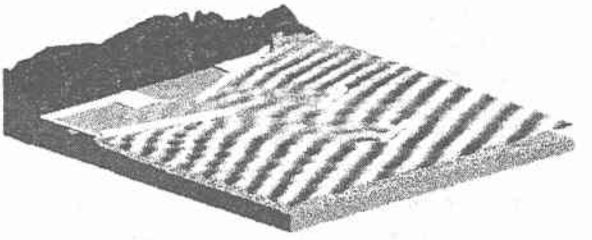


Fig.2b BIRD EYES VIEW

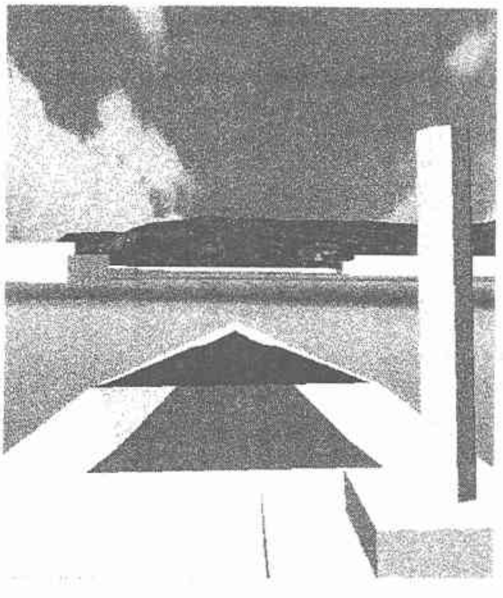


Fig.2c VIEW FROM BOAT

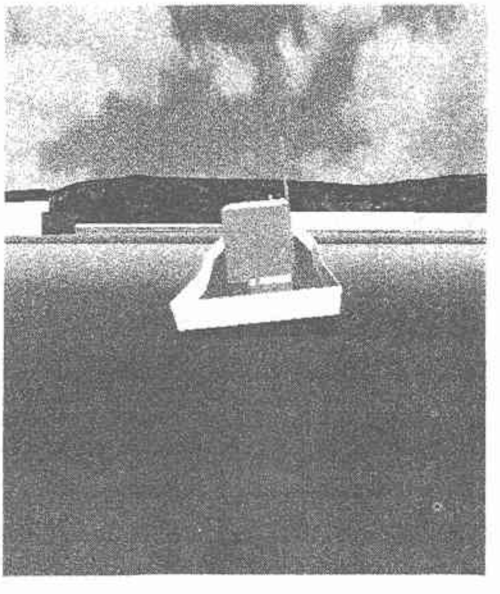
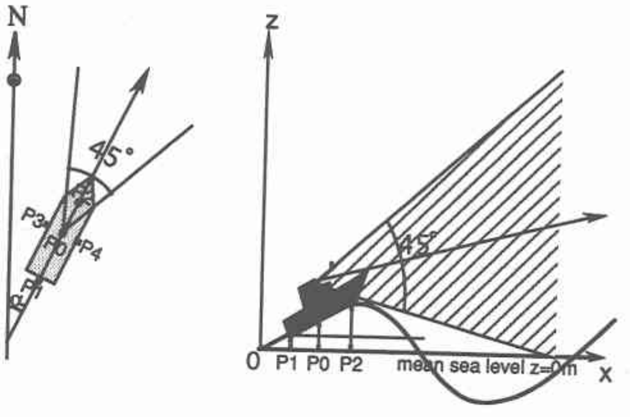


Fig.2d VIEW FOLLOW BOAT

b) boat and camera position calculation

(x0,y0) coordinates of point P0 are given by the boat route according to the boat speed.
Sea surface elevation is read from result file for the points P1(back), P2(front), P3 (left) and P4 (right).
The camera looks at the front of the boat with an angle of view of 4 5 degrees.
The boat and the camera angles are given by the difference of P1 and P2 (pitching), and P3 and P4 (rolling).



upper view side view

Fig,3 BOAT POSITION AND ANGLE OF VIEW

c) animation builder

After preprocessing the datas, the system creates the views by using the input parameters.
One image is a combination of several geometries, e.g. 3 - D objects :

1. land; textured with vegetations photography,
2. sea bottom and beaches; textured with sand photography,
3. structures; sea port, wave breakwaters,
4. sea surface water colorised from the dark color(through of waves) to the clear color (crest of waves),
5. boat.

Texture mapping is the mapping of a 2-dimensional image to the surfaces of a 3-dimensional object.
each frame is stored in sequence in an animation file. A large amount of disk memory space is needed since one frame has a size of nearly 60Kbytes and a common animation includes sometime until 500 frames.

d) video

When the building of the animation file is completed, AVS has a tool to replay it on screen at the required speed. Then a video converter is connected with the workstation console to record on videotape the animation.

III. EXAMPLE CASE

The following example was choosen to illustrate the possibilities of 3-D animation presentation :
* the model size is 800 m * 900 m, including a port. The mesh size for wave calculation was 5m.
* Incoming waves have an Height of 2.6m, a period of 7.6s and a direction of 30 degrees related to the shore line.

Selected model is a short wave model using the mild slope equation with regular unidirectional waves. Simulation is done for two configurations of breakwaters.The calculation runs until the model becomes stable, then a sequence of 20 sea surface elevation results are set in the output file with a time step of 0.38s. These 2 0 frames corresponds to one wave cycle.

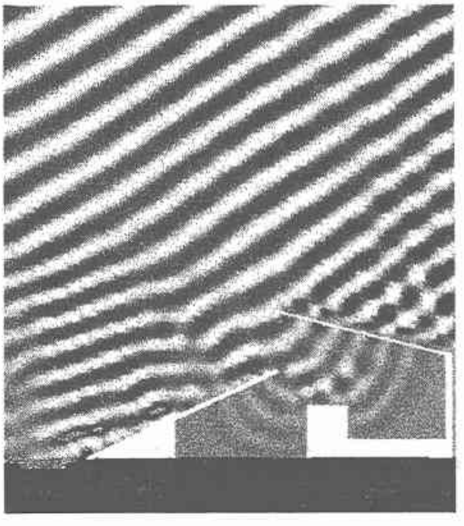


Fig.4a CASE 0 , no offshore breakwaters

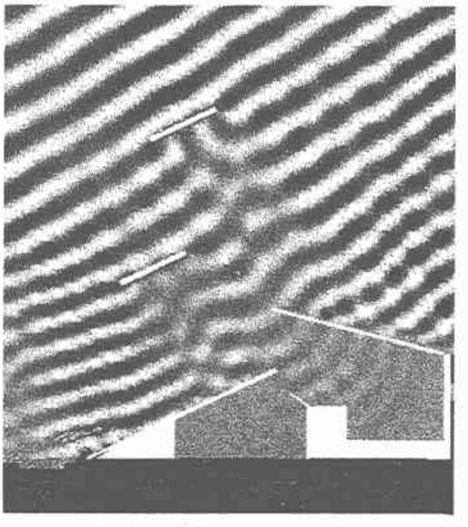


Fig.4b CASE 1 , 2 offshore breakwaters

One major feature of this 3-D animation is the possibility to link the wave motion with a boat motion. With a basic calculation for the boat movement (rolling, pitching and vertical displacement), and also for a camera located on the bridge of this boat, the system can generate a virtual animation of the boat motion for the 2 test cases.

boat characteristics :

fishing boat 7 tons
length = 1 2 m
speed = 7 nautics (1 2.9km/h)

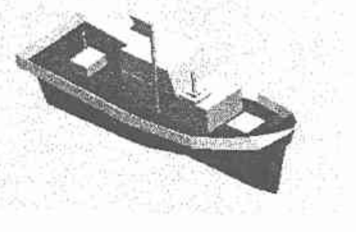


Fig.5 BOAT GEOMETRY

It is then possible with the animation to understand the effect of the breakwaters. In the case 0, the waves are very high until the boat enters the sea port, while in the case 1, the sea is quite calm behind the breakwaters. It is illustrated by the amplitude of the boat movement.

IV.CONCLUSIONS

To include a boat motion into a wave model is an easy and efficient way to understand a wave field. In the near future, the authors intend to add to this system the possibility to build a 3-D animation for sea bed sediment evolution. It will provide an efficient tool to understand the dynamics of the phenomenon of accretion and erosion over a large time scale (e.g. years).Next developments will also include a 3 dimension dynamic vector plotting to illustrate the nearshore current fields. In the age of multimedia, the use of 3-D in engineering will be ever more a necessity.