PRELIMINARY STUDY TOWARDS A CAPSIZING SIMULATOR

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ABSTRACT

A prototype of capsizing simulator is introduced as well as some historical review of computer graphics usage on the research of ship capsizing. Connecting two EWS/GWS's and a PC through LAN or serial communication line, real-time calculation and graphical presentation of ship motion of 6 degrees-of-freedom is realized. Displaying the graphical output on a video projector through a scan converter, a simple but powerful capsizing simulator is completed. As an example of the application, the verification of an operational guidance to avoid capsizing is shown.

INTRODUCTION

The new technology, especially that of computer hardware and software has brought us various benefits in almost all fields. In our laboratory, where we are dealing with various problems concerning ship manoeuvrability, motions and control, we had to and do always face to the front end in both theoretical and experimental approaches. In this paper, we will introduce an example from our experiences. It is on capsizing, one of the oldest, but at the same time the hottest topics in naval architecture.

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TIME-DOMAIN SIMULATION OF CAPSIZING IN WAVES

Capsizing in waves is a non-linear phenomenon. It is very difficult to treat it theoretically. Well-known strip theory itself is derived under the assumption that the wave height is much smaller than the wavelength, so it is not applicable to this problem. Hamamoto and others [1-11] have engaged in this problem for a long time and developed the equations of the motion applicable to severe motion of six degrees-of-freedom (Hamamoto et al. [9]). Time-domain simulation as well as free-running experiments thus become important except some simplified stability analysis (e.g. Hamamoto et al. [11]).

An example of such a time-domain simulation as well as the result of the corresponding experiment of a container ship, whose particulars and body plan are in Table 1 and Fig. 1 respectively, is shown in Fig. 2 (Hamamoto et al. [3]). It is a kind of way to explain the phenomenon. After a careful looking into the figure, one may understand the motion and find the model ship has capsized around 7 seconds after the start.

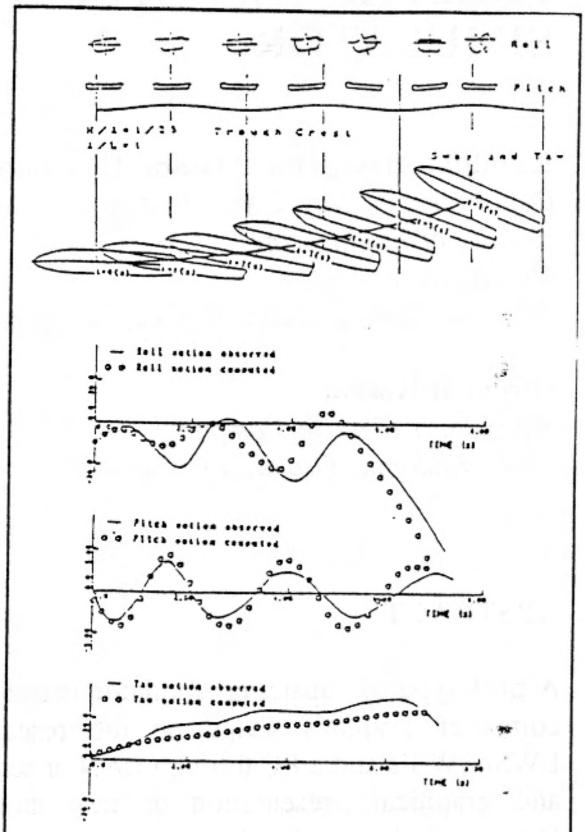

Figure 2. An example of time history of experiment and corresponding simulation

Table 1
Principal particulars of the ship and its model

	Ship	Model
L (m)	115.	2.5
B (m)	19.	.413
d (m)	6.4	.139
V (m^3)	9859.	.101
S (m^2)	2845.	1.345
C_b	.705	.705
C_w	.97	.97
B/d	2.97	2.97
L/B	6.05	6.05
	——	1/46

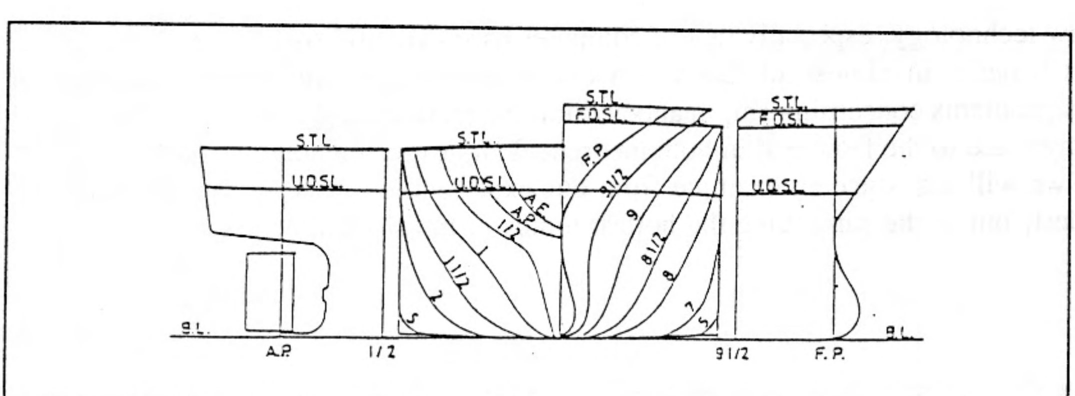

Figure 1. Body plan of the ship

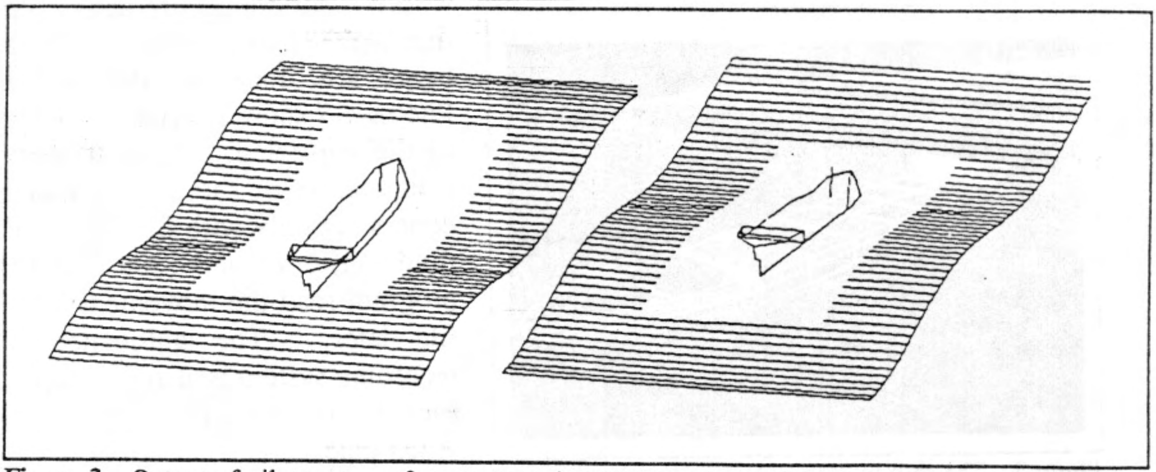

Figure 3. Output of pilot system of computer animation on ship capsizing

COMPUTER ANIMATION FOR CAPSIZING MOTION

The advanced technology in computer graphics will make it more intuitive, when it is prepared in animated motion. The first author has tried to apply it from the early stage of the research. Fig. 3 is such an example done in 1988. At that time wire-frame model using a mini-computer (HP1000) was only available in their laboratory and it took about 5 seconds to make one picture. Besides, wave surface around the ship was omitted to avoid time-consuming calculation for hidden lines. However, it was really impressive to see the dynamic movement of the ship up to capsizing.

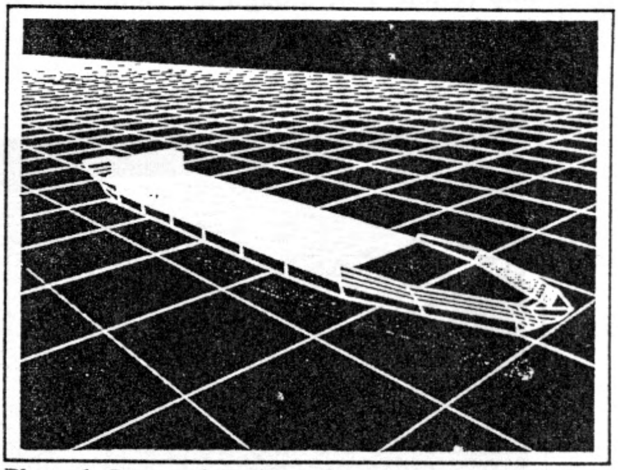

Photo 1. Perspective view of the ship

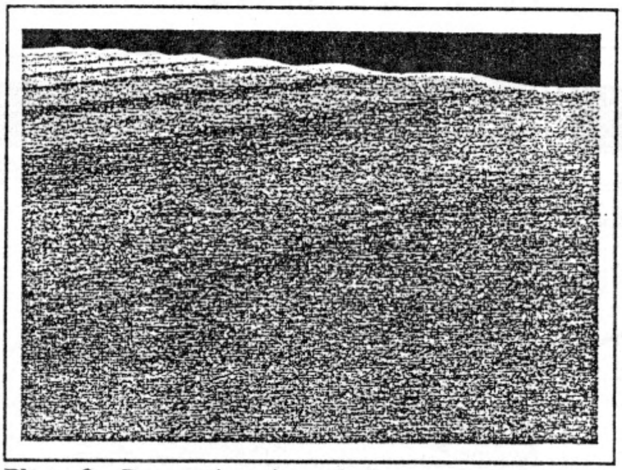

Photo 2. Perspective view of 2D wave

The pilot system thus developed has encouraged us to proceed to the next step. We were lucky to be granted a project in which we could buy an EWS (Engineering Workstation). The calculation ability was not so different, but the speed, tools and output quality of graphics were overwhelmingly improved. It did not take much time to implement the program onto the EWS (Hasegawa [12]). Photo 1 shows the perspective view of the ship with grids of coordinates and Photo 2 shows that of 2D wave. Photo 3 is the resultant view of the ship in wave,

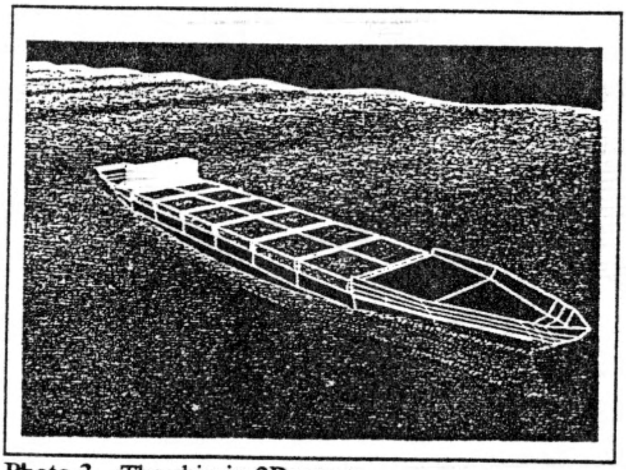

Photo 3. The ship in 2D wave

where hidden surfaces, half-transparency or ambient diffuse of lights are done by the hardware. Photos 4-7 show a series of motion up to the capsizing. At that time the computation of the ship motion was done separately with file output of the time history and the animation program read the movement from the file later. The automated VTR recording system is also developed, so each display output is captured into a video tape.

The system is quite effective to know the phenomena, the difference between calculation and experiment etc. As it is easy to set the camera point at any place such as shown in Photo 8 or even beneath the waterplane (Photo 9). Finally, it is also possible to set the camera in the bridge of the ship (Photo 10), though the camera didn't rotate. This suggests to us the possibility to develop a capsizing simulator.

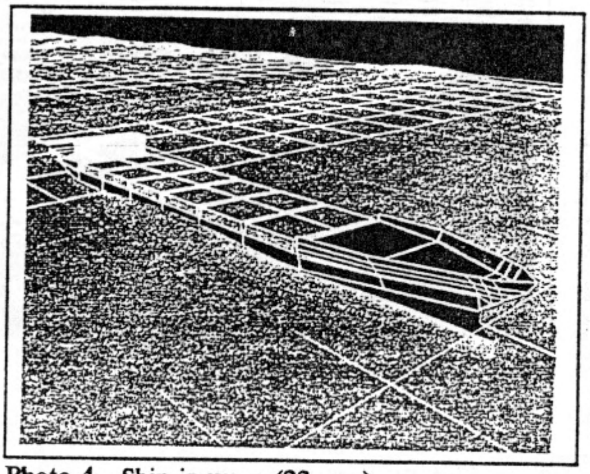

Photo 4. Ship in wave (23 sec.)

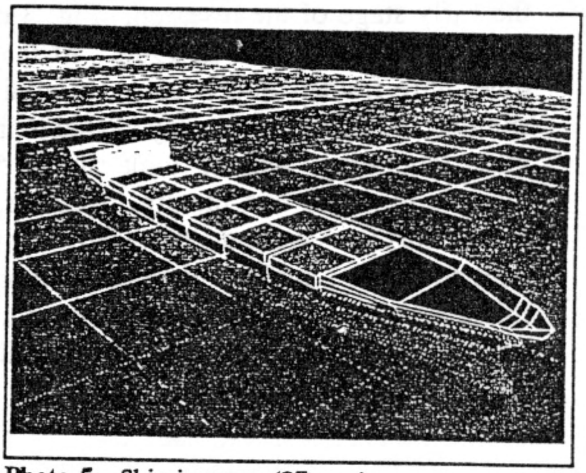

Photo 5. Ship in wave (27 sec.)

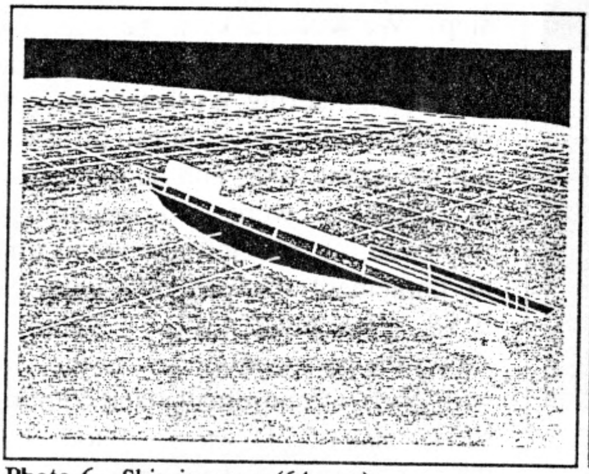

Photo 6. Ship in wave (64 sec.)

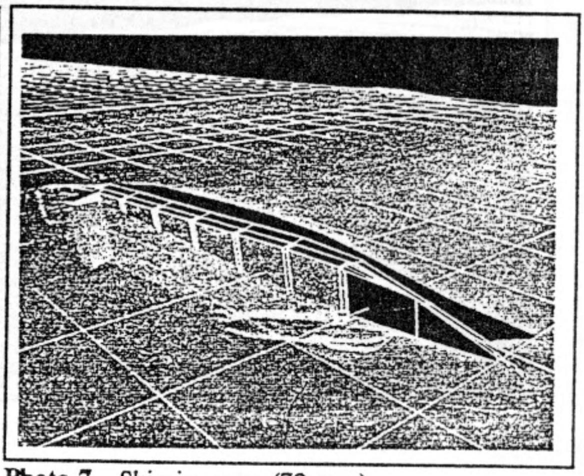

Photo 7. Ship in wave (72 sec.)

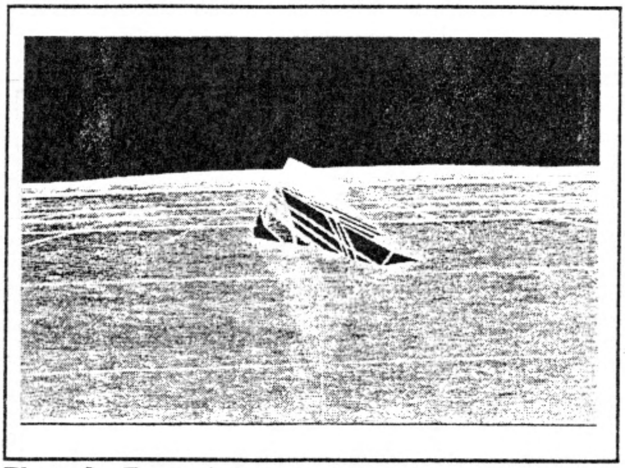

Photo 8. Front view

Through these experiences on theoretical and experimental approaches, and computer graphics, the prototype of a capsizing simulator was developed. The system graded up to the network distributed computation. A RISC-type high performance EWS calculates the motion every 1/4 second. The output is piped to another GWS (Graphics Workstation) through Ethernet, where graphic display is updated before the next calculation output reaches. The inputs of rudder and engine orders are supplied by a PC and transmitted to the EWS through RS-232C communication line. As the GWS has a real-time scan converter, the display output is projected onto a 100' screen. Though the hard copy of the screen is not so clear as to reproduce here, the movie video shall be shown at the presentation.

This kind of simulator will be useful for providing the guidance of operation in severe seas. Fig. 4 shows an example to demonstrate how this simulator will be used. There are several proposals on operational manuals in IMO (International Maritime Organization). Some are theoretical, some are experimental and the other are statistical ones. We can check the proposals using this simulator.

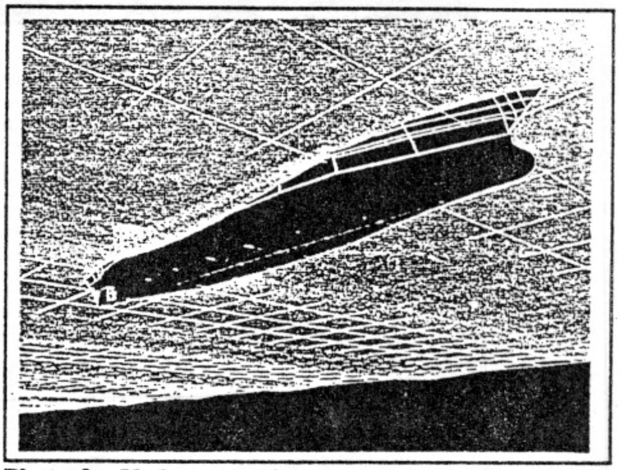

Photo 9. Underwater view

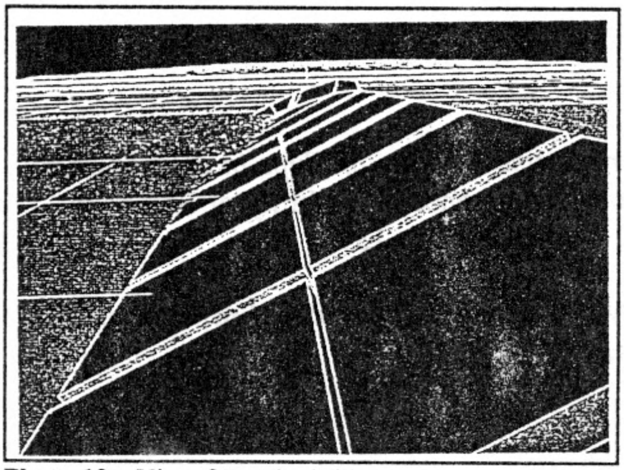

Photo 10. View from the bridge

CONCLUSION

As an example of the impact of new technology on marine industries, a prototype capsizing simulator is introduced. More attention should be paid to theoretical considerations on the equations of motion governing severe ship motion up to capsizing, confidence to build up a capsizing simulator is obtained.

Remaining works concerning the improvements on graphics and interfaces, may be easily done by commercial base, but new technology, especially software tools should be constantly monitored.

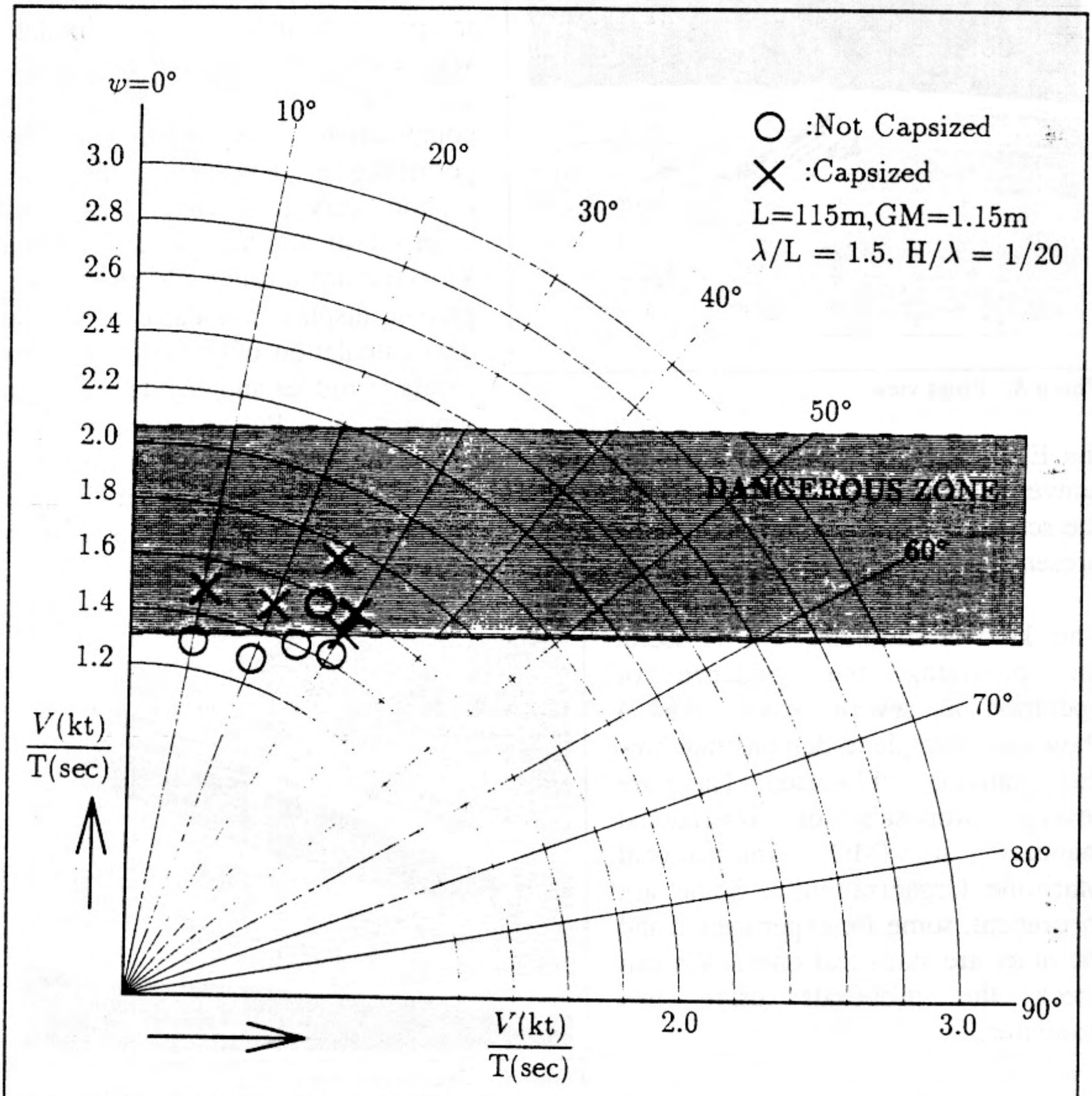

Figure 4. Dangerous zone and its verificated result using the capsize simulator

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