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The Function of Computer Utilization in Educating and Researching Ocean Engineering Problems

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Abstract

Nowadays, the computational capability and graphical power based on PCs increase very rapidly every year. As a result, the complicated engineering or scientific problems that could have only been handled by supercomputers a couple of decades ago can now be routinely run on PCs. Besides, the PCs can be assembled in parallel to increase its computational capability theoretically without limitation. The Web-based interface and communication tools are also being enhanced very rapidly and the real-time distance learning (E-Learning) and project cooperation on web get increasing attention. Using the-state-of-the-art computational method, a number of complicated and computationally intensive problems are being solved by PCs. The results can be well demonstrated on screen by graphics and animation tools. Those examples include the simulations of fully nonlinear waves, their interactions with floating bodies, global-motion analysis of multi-unit floating production system including complicated mooring lines and risers. Several examples will be presented in this regard. Also, Web and java-applet based educational tools have been developed at Texas A&M University for better understanding of waves and wave-body interactions. The background and examples of such Web-based educational tools published in Kim et al. (2003) are briefly introduced here.

Keywords: Web-based computer simulation, Numerical wave tank, Ocean engineering problem, Educational tool

1 Introduction

Computer simulation techniques have become a significantly useful tool to demonstrate and understand complicated physics and solve difficult Ocean Engineering (OE) problems. In the present paper, two aspects of computer simulations applied in OE education and research are addressed; Web-based educational tools and state-of-the-art Numerical Wave Tank (NWT) simulations. The usefulness and effectiveness of the user-interactive Web-based teaching tools and the time domain simulations are briefly mentioned. The recent advancement of graphics technology in Internet enables students to access more effective visual dissemination and representation of complicated physics in remote places. On the other hand, computer simulations such as NWTs have become a valuable asset to design and analyze offshore and coastal structures. Computer simulations are particularly attractive when the optimum solution is sought through extensive parametric/sensitivity studies. Computer simulations have also benefit especially when physical tests are unavailable, significantly expensive, or cannot be properly scaled. Therefore, the role of computer simulation techniques and their utilization will be more important in OE field in near future.

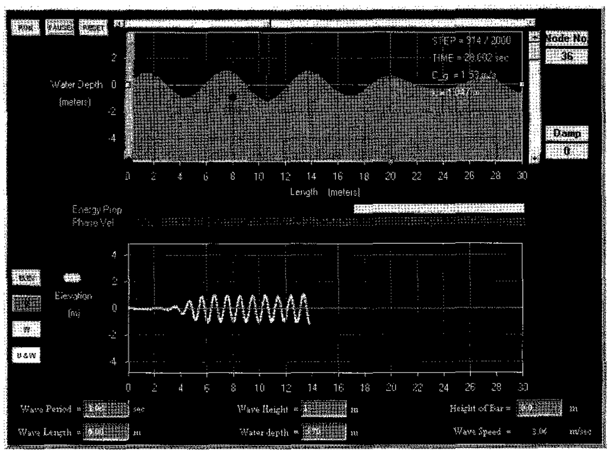

Figure 1: An example of Web-based computer simulation

2 Web-based computer simulations for OE education

The advantages of Web-based learning tools in disseminating knowledge to students in remote places may include anytime access, asynchronous communication to share information and collaborate with others in solving problems, computer platform independency, and flexibility in allowing students to control their learning pace (Haque, 2001). Aragon, et al. (2002) found that on-line learning can be as effective as face-to-face learning in many respects, even though students have different learning style preferences. In addition, some of the possible drawbacks of the traditional text-book and lecture style in dealing with ocean engineering include

- Difficulty in describing and understanding physics observed in nature through words
- Difficulty in parametric study
- Lack of visual representation

The Web-based teaching tools can overcome the deficiency of traditional teaching and can also provide a very exciting and vivid learning environment to the students even in remote places.

Ernest Page (1998) summarizes five areas of focus regarding potential impacts of web technologies on simulation: (1) simulation as hypermedia, (2) simulation research methodology, (3) Web-based access to simulation programs, (4) distributed modeling and simulation, and (5) simulation of the WWW. Regarding the first area, he writes: *The availability of simulation as a desktop, browser-based commodity has the potential to significantly alter current teaching and training methodologies, both for simulation as a technique, and for disciplines that apply simulation, like engineering, physics, and biology. Paradigms that focus on distance learning and interactive, simulation-based education and training are emerging.*

Judging from the above, Web-based simulation will increasingly benefit both research and education in the future. In this regard, more Web-based educational tools are expected to be employed in the ocean engineering field for collaborative learning and better cognitive benefit.

Acknowledging such aspects described above, a collaborative learning and Web-based simulation tool, *Electronic Classroom on Ocean Wave Theory* (or WOW: *Waves On Web*) have been developed by the joint effort of Texas A&M University (TAMU) and the University of Texas at Austin (UT) under the financial support of the National Science Foundation (Ryu, *et al.*, 2003a, http://otrc93.ce.utexas.edu/~waveroom/). The WOW includes many user interactive Java applets that can be directly used for solving wave-related ocean engineering problems including wave kinematics, multi-component waves, spectrum analysis, wave forces on a cylinder, Stokes wave, nonlinear wave kinematics, long and short wave interactions, 3-D multi-component waves, and wave-body interactions.

One simple form of NWT is shown in Figure 1. It is very similar to a physical 2D wave tank equipped with wave probe, pressure gage and velocimeter. Users can place the probes and gages at an arbitrary position and change water depth by dragging them. Then the corresponding time histories and statistics are shown on the screen corresponding to the given wave-maker motion. Users can also change the slopes of seabed to observe the general trend of shoaling phenomena i.e. increasing wave amplitude and decreasing wave length as water depth decreases. The absorption rate of the incident wave can be altered/controlled by the artificial damping factor to represent various wave absorber conditions. Theoretical and numerical background of the simple NWT can be found in Ryu, *et al.* (2003b).

The developed Web-based tools have been experimentally used by several universities for ocean engineering classes and the feedback is overwhelmingly positive. At TAMU and the UT, class term projects were assigned in wave related classes to solve certain problems using the Java interactive tools. The exit survey and students' comments show that the Web-based and Java interactive educational tools are significantly helpful to clearly understand and solve the given wave-related problems.

3 Computer simulations for OE research: state-of-the-art NWT simulations

Many OE problems can be studied through scale model testing in the physical wave tank. However, the physical model testing is usually expensive, takes long time to set up and collecting data, and is difficult to change parameters and tank dimension. Numerical wave tanks, on the other hand, have great advantage and flexibility in this regard. In particular, due to the rapid advancement of personal computers, the numerical tools are greatly enhanced and become more useful. As a

result, the complicated engineering problems that could have only been computed by supercomputers a couple of decades ago can now be routinely run on PCs.
One of such OE problems is fully nonlinear wave-body interaction simulation in a NWT in time domain. The full boundary value problem has to be solved at every time step, and thus it is extremely time consuming for long-time simulation. With the advance of computer power, it can now be routinely run on PCs.

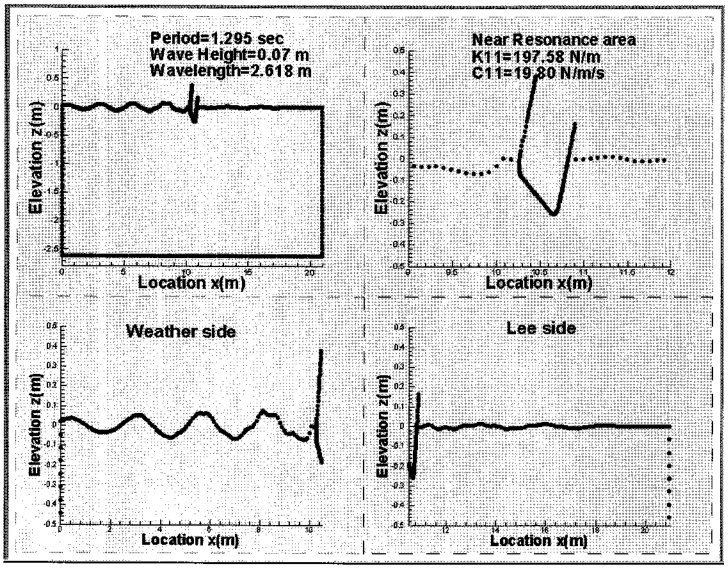

Figure 2: Freely floating body NWT simulation

Figure 2 shows the graphics illustration of such time-domain simulations (Koo and Kim, 2004). A boundary element method (BEM) was used with mixed Eulerian-Lagrangian (MEL) time-marching scheme. The treatment and updating of the free surface is extremely difficult since its position is not known a priori. A snap-shot of such animation shows both body motions and instantaneous free-surface profiles. It can be seen that the wave is highly nonlinear and greatly distorted compared to the linear sinusoidal wave. Various nonlinear phenomena, such as spontaneous generation of higher harmonics and parametric excitation/jump, can be clearly demonstrated using graphics and animation tools.

The second example (Figure 3) is the generation of nonlinear solitary waves by sub-sea land sliding (or generation of tsunami/solitary wave by underwater earthquake) (Koo and Kim, 2008). This kind of numerical prediction is very important in planning and designing coastal/near shore projects in an earthquake-prone environment. These NWT simulations have been verified through comparison with the available field measurement data and physical model testing. Finally, a viscous NWT (Tavassoli and Kim, 2001), which solves the full Navier-Stokes equation, has also been developed to investigate certain problems in which viscous effects play an important role. By comparing the potential-flow or viscous-flow simulations, the role of viscosity can be clearly demonstrated.

3D fully nonlinear potential and viscous NWTs are also being developed by the authors. However, it is computationally so entensive that it is not practical yet.

Considering the rapid progress of PC computational capacity, the 3D NWTs can also be routinely run on PCs in the coming years.

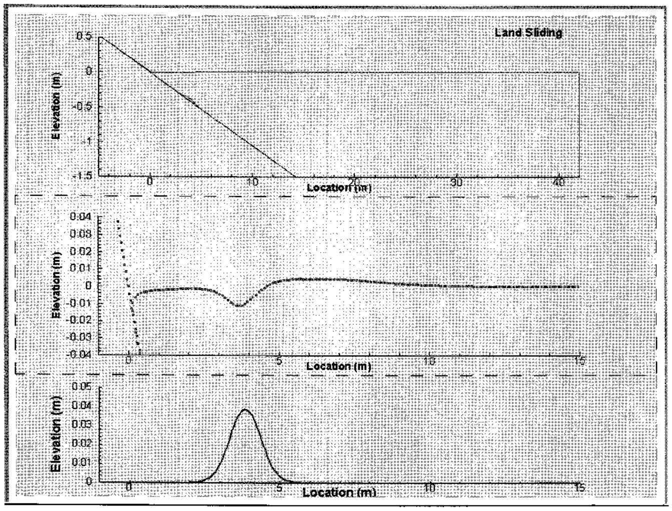

Figure 3: Generation of solitary wave by land sliding simulation

4 Concluding remarks

In this study, Web-based educational tools and state-of-the-art NWTs are briefly introduced to address the role of computer simulations in OE education and research. Web-based interactive tools can be a significantly important medium which connects physical experiment and numerical simulation to distant researchers/learners over the Internet. The effectiveness of learning wave-related physics through Java interactive tools has been demonstrated through WOW project. Web-based classroom and distance learning are expected to be more popular in the coming years.

The fully nonlinear NWTs are useful tools to investigate various linear and nonlinear OE problems. However, it is so computationally intensive that has been rarely used in practical applications. Thanks to the rapid progress of PC computational capacity during the past decade, the 2D NWT can now be routinely run on PCs. Such numerical simulation tools can rapidly provide reliable solutions as a relatively cost-saving approach compared to physical facility tests. Computer simulations are also favored especially when physical model tests are unavailable, significantly expensive, or cannot be properly scaled. Therefore, the role of computer simulations will become more important in the OE field in the coming years.

References

Aragon, S.R., S.D. Johnson and N. Shaik. 2002. The Influence of Learning Style Preferences on Student Success in Online Versus Face-to-Face Environments. American Journal of Distance Education, **16**, **4**, 227-244.

Haque, M.E. 2001. Web-based Visualization Techniques for Structural Design Education. American Society for Engineering Education, ASEE Annual Conference Proceedings, Session 2793.

Kim, M.H., S. Ryu and W.C. Koo. 2003. The Role of Computer Simulations in Educating and Solving Ocean & Coastal Engineering Problems. US-Korea Conference on Science, Technology and Entrepreneurship, UKC2003, Pasadena, CA.

Koo, W.C. and M.H. Kim. 2004. Freely floating-body simulation by a 2D fully nonlinear numerical wave tank. Ocean Engineering, **31, 16**, 2011-2046.

Koo, W.C. and M.H. Kim. 2008. Numerical modeling and analysis of waves induced by submerged and aerial/sub-aerial landslides. Journal of Civil Engineering, KSCE**, 12, 2**, 77-83.

Page, E.H. 1998. The Rise of Web-based Simulation: Implications for the High Level Architecture. Proceedings of the 1998 Winter Simulation Conference, 1663-1668.

Ryu, S., M.H. Kim and P.J. Lynett. 2003a. Fully Nonlinear Wave-current Interactions and Kinematics by a BEM-Based Numerical Wave Tank. Computational Mechanics, in press.

Ryu, S., M.H. Kim, S.A. Kinnas and J.H. Kang. 2003. Development of Web-based Numerical Wave Tank and Java Applets as an Advanced Tool for Teaching Wave Mechanics. American Society for Engineering Education, ASEE Annual Conference Proceedings, Session 1478, 2003b.

Tavassoli, A. and M.H. Kim. 2001. Interactions of fully nonlinear waves with submerged bodies by a 2D viscous NWT. Proceedings of 11th International Offshore and Polar Engineering Conference, ISOPE, Stavanger, Norway, **3**, 348-354.