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Organization of resource-intensive computational simulation in real time

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The concept of "virtual testbed"of real-time computational simulation is based on high-performance algorithms for modeling the physical phenomenon under study without losing the quality of reproducible processes. One of the most complicated and comprehensive areas of this nature is naval hydrodynamics, as it requires the integration of a sufficiently big number of heterogeneous models.
Application of stable implicit numerical schemes is not considered here, since practice shows uncontrolled smoothing of hydrodynamic processes in subareas with large gradients.
Cross-cutting and ubiquitous analysis of simulation results is allowed when using explicit numerical schemes. They allow hybrid rebuilding of physical models and mathematical algorithms directly in the process of interactive control of computational processes. Nevertheless, unfortunately, often in the formulation of computational simulation follows the conclusion about impossibility of simulation with the given engineering accuracy due to excessive demand of computational resources.The problems of naval hydromechanics in the general formulation are reduced to these insoluble problems, aggravated by the lack of effective models for non-stationary processes of hydromechanics as such. In particular, unsolvable difficulties in naval hydromechanics are caused both by criteria of stability in time and by criteria of approximation smoothness for difference representation and differentiation of high-frequency non-stationary physical fields.
Engineering approaches in naval hydrodynamics (as well as in any other complex technical field) traditionally bring any technical problem to an acceptable result, with adequate correspondence to theoretical, empirical or experimental results. In practice, such explorations are limited to private solutions and are often reduced to the author's "know-how", which is difficult to generalize and rather risky to apply in case of significant changes in the investigated objects.
Organization of expert systems based on high-performance computing systems allows to synthesize various theoretical approaches with engineering methods in naval hydromechanics. The purpose of such systems is to combine context-optimal modules for modeling, visualization and real-time data analysis.
The paper presents the idea of realizing such system in the current edition of the virtual testbed. Successive set of computational models are built from the simplest kinematic representations to complex modules requiring high-performance computing resources. The experience of specialists from researcher to navigator is formalized in the knowledge base of the expert system in the form of rules. According to these rules, based on the external conditions, the state of the object under study, the mode of motion and modeling objectives, the simplest but sufficient computational modules for adequate simulation of ship dynamics are selected in the distributed computing environment. In the future, they are integrated. It is possible on the basis of the concept of a virtual personal supercomputer.

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