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Mathematical Modeling for Forecasting the State of Coastal Ecosystems Based on Satellite Images

Abstract: The biotic, biological and anthropogenic factors are permanently affecting the coastal ecosystems in the south of Russia. Thus, there arises a need to develop the non-stationary spatially-heterogeneous interrelated mathematical models to simulate the various scenarios of biological and geophysical process development within the coastal ecosystems. The practical application of the mathematical models is hindered by the problem of provision the real input data (boundary conditions, initial conditions) and the information about the source functions. This information can be received from the spacecrafts. Therefore, there arises a problem of identifying the phytoplankton populations on the water body images, which have, as a rule, a speckle pattern with low contrast relative to the background, as well as determining their boundaries.

The paper presents a developed software-algorithmic toolkit for space image recognition based on a combination of methods — local binary patterns (LBP) and neural network technologies designated for the subsequent insertion of the obtained initial conditions of the phytoplankton dynamics problem to a mathematical model. During the research, the satellite images, which enable getting the highly accurate information about the state of coastal ecosystems, have been referred to, the initial conditions have been inserted into the mathematical (computer) model. The model have analyzed the satellite image data and determined the levels of "pollution," formation of fish-kill zones and other factors threatening the nature. Using this model, possible changes in the coastal ecosystems can be forecasted and strategies for protecting thereof can be developed. The results obtained make it possible to significantly reduce the time of forecast calculations (by 20–30%) and increase the probability of early detection of unfavourable and hazardous phenomena, such as intense "blooming" of the aquatic environment and formation of fish-kill zones in the coastal ecosystems.