Introducing Space and Spatial Interactions in DISPAS: Demersal Fish Probabilistic Agent-based Simulator

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Demersal Fishing Stock Probabilistic Agent-based Simulator.

Overfishing is a rising marine ecosystem problem because of the immediate effect that it creates on the recovery of fish stocks. Currently, several projects are working to solve it with different approaches. Computational modeling is a useful approach to deal with the complexity that a biological systems shows. It is also a way to treat complex systems that can not be modeled in a suitable way using a classical mathematical methodology.

Demersal fishing Stock Probabilistic Agent-based Simulator (DISPAS) was developed with the aim of studying and supporting fish stock sustainability. It is based on Extended Probabilistic Discrete Timed Automata, a model of computation introduced to specify in an accurate way a probabilistic and timed behavior, suitable to represent the main events on a fish "life".

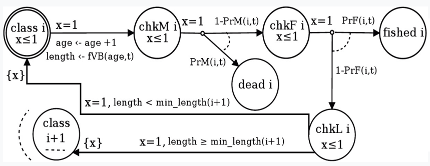

Fig. 1 EPDT Automaton

Fig. 2 Common Sole Fish

Data coming from the Italian project SoleMon are used to parametrize the simulator. The target species of interest of SoleMon is the common sole (Solea solea L.). From data we obtain and use: the number of individuals separated in age classes, the Fishing Mortality Probability and the Natural Mortality Probability. The mortality probabilities are monthly estimated, from 2005 to 2011. After 2011, the simulator predicts the number of agents that has to be added to the environment, basing on the previous three-year estimation.

In the DISPAS current version an average square kilometer is represented. This square kilometer is represented by a grid of hundred meters per hundred meters. Moreover, the von Bertalanffy growth equation, with growth rate K coming from data, is used to estimate the sole length, which determines the sole age class. The user of the simulator can easily create different simulation scenarios or tune the parameters of a simulation in order to reproduce observed results.

The simulation outcomes are the predicted quantities of agents in a month divided by age classes. They are saved in a plain text for off-line data analysis and also displayed in charts (like the ones in Figure 3) during the simulation execution.

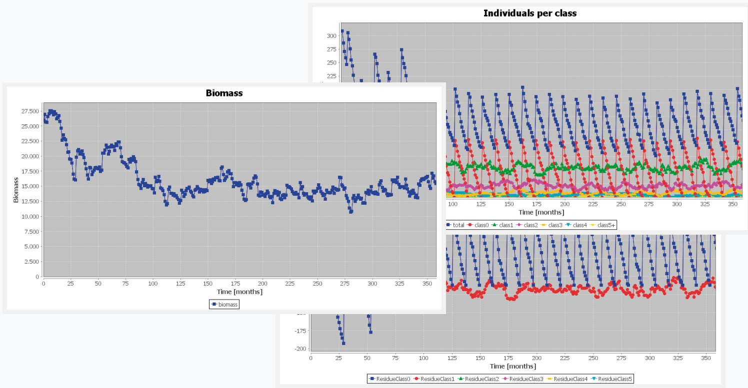

Fig. 3 Thirty years execution example

Interactions within Environment

Random walk is a mathematical model that describes a path that an individual performs. The individual chooses the next step regardless of the current or previous position. DISPAS has been enriched with the random walk feature for all the agents in the environment. Since the simulated kilometer square is in a plane, the agents perform their random walk in a two-dimensional grid. Each agent is placed in a cell of the grid and, at each time step, it creates the list of free cells in its neighborhood. The neighborhood is the von Newman one, i.e., the eight cells surrounding the agent. The cell where the agent moves is chosen randomly among the ones in the llist.

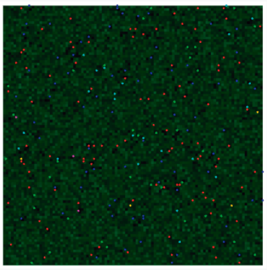

Fig. 4 DISPAS kilometer square

During the agent's random walk, the agent may consume an amount of food available in the cell at that moment; this is possible because **Food Generation** was introduced in the DISPAS model. The food generation is important because through it we can represent the carry capacity of the environment, which is determined by the available resources. These are related with the K parameter of the von Bertalanffy growth equation, which is used to estimate the agent's age classes. Through the addition of the above descripted spatial features, DISPAS is able to manage more simulation scenarios.

Micro - Macro Model

Another main aim of this research work is to model and simulate fish stocks, in particular the sole one, on the whole Adriatic Sea. For this reason, we propose an uncoupled multi-scale micro-macro model, where we introduce a new element in order to estimate the needed parameters. Fortunately, in the Northern part of the Adriatic Sea independent fishery surveys data are available (SoleMon). The data provided by SoleMon have been taken from 67 stations, placed in different parts of the sea. Since some areas of the sea could not be surveyed, we have to estimate the number of individuals in these areas by interpolation techniques. As a result, we expect to be able to reproduce, by the uncoupled simulation, an emergent behaviour observed by biologists, namely, the concentration of individuals of the same age class in specific geographic areas.

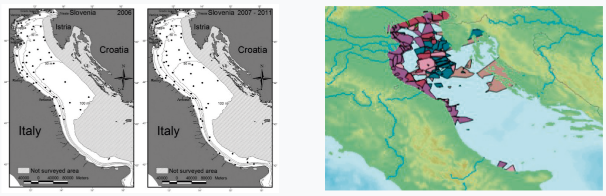

Fig. 5 SoleMon Data

Moreover, we intend to implement an agent-based Geography Information System (GIS), using the capability of Repast Simphony of handling shape-files, i.e., standardised files used in GIS for representing data such as coordinates or associated values. As a result, we expect to generate geographic projections of the data upon the Adriatic Sea.

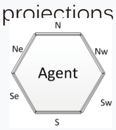

Fig. 6 Agent representation for the micro-macro Model

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