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AGENT BASED MODEL OF FISHER BEHAVIOR AS A DYNAMIC CONSTRAINT RESOLUTION PROBLEM

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ABSTRACT

An agent-based approach for modelling fisher behavior as a dynamic constraint resolution problem is proposed. The fishers are modeled as agents tasked with optimizing different multi-objective utility functions over a search space subjected to ecological, social, and political constraints derived from existing ecological and social models. The agents search for a satisfactory strategy by using a guided local search algorithm modified to allow for competition or cooperation in varying degrees, and the utility function is modified to mimic perfect rationality, as well as to include well-known behavioral strategies such as repetition, imitation, and social comparison. The goal of the model is to allow analysis and comparison of fisher strategies and their impact on the environment under different ecological limitations, fishing policies and assumptions of rationality on the part of the fishers.

1 INTRODUCTION

Fisher behavior is an important aspect of fishery models, and one of the more difficult to model due to its complexity. Policies aimed at maintaining the sustainability of fish stocks often fail to properly account for the many ways in which human behavior eschews perfect rationality or compliance to the rules, and the complexity of human behavior in general, and of fishers in particular, makes it difficult to anticipate how fishers will react to changes in policy (Fulton et al., 2010; Schlueter et al., 2012). The fact that fishers´ actions feedback into the system further compounds the problem.

Our proposed attempt to account for issues of human behavior is to model fisher strategies as solutions to a dynamic constraint resolution problem, and the fishers as agents tasked with finding these solutions by way of a modified local guided search algorithm (Barbucha, 2012), in which a number of agents cooperate to dynamically evolve a population of solutions. By using existing ecological and social models instead of raw or statistical data to determine the constraints, we allow the constraint model to evolve in time and in response to fisher strategies. In order to avoid overgeneralized results, which could prove difficult to interpret and of questionable utility, the model will be limited to Icelandic fisheries data.

2 BASIS OF MODEL CONSTRAINTS

The strategies of the agents will take into account such variables as available stock (both allowable within current policies and existing within the ecosystem), number of stock species, composition of stock species, exploitation capacity of the agent, cost of exploitation for the agent, risks incurred by breaking policy rules, pressures from other fishers, market fluctuations etc. The constraints imposed on the search space defined by these variables will be derived from existing ecological and social models. The ecological constraints will be derived from the output of the Gadget (Begley and Howell, 2004) and the Atlantis (Fulton et al., 2004) models, which are currently being parametrized for Icelandic fisheries data as part of the MareFrame project. The outputs of these models include: total biomass, biomass by age, length, area, time step, and stock component, catches and landings, predation, recruitment, mortality, stock proportion, profit by fishery etc. Economic constrains, such as operation and production costs, relative competitiveness of fleet types and comparison with other sectors, impacts of changing market conditions, will be derived from results obtained from the PrimeFish project. The social constraints and the cognitive biases of the agents will be

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derived from the results obtained within the SAF21 project, which focuses on research concerning the social aspects of fisheries. Policy constraints will be determined based on fishing regulations currently governing Icelandic fisheries. While ecological constraints are rooted in real-world data, policy constraints can be modified in order to see how the agents will behave under different regulations.

Regardless of the scenario, the strategies of the fishers will feedback into the constraint models and affect the evolution of the constraints over time, and thus the future strategies of the fishers.

3 GUIDED LOCAL SEARCH ALGORITHM MODIFICATION

By modifying the guided local search algorithm to allow communication only between certain agents, we can model aspects of the formation and behavior of fishing communities, as well as competitive or cooperative trends among the fishers. The agents will attempt to optimize profit and effort, and the utility function can be modified in order to obtain either perfectly rational agents or cognitively biased agents. In the latter case, an additional criteria to be optimized will be cognitive effort, which can be mitigated through strategies such as repetition of previously satisfactory behavior or imitation of similar agents´ strategies (as opposed to recalculating the current strategy).

4 DISCUSSION

We expect to obtain a number of evolving locally optimal solutions rather than a globally optimal solution to the constraint resolution problem, meaning we expect to obtain a number of advantageous alternative/co-existing fishing strategies rather than a universally optimal behavior.

Special care will be needed when interpreting the results. In this setup, the model aims only to identify types of advantageous behavior for the fishers under a number of competition/cooperation and rationality assumptions given a constrained search space without explicitly addressing the underlying causes or mechanisms. As such, the strategies found by the agents may be sound, but the way they arrived at the solution may have nothing in common with the way fishers arrive at similar solutions.

The quality of the results depends heavily on the quality of the input data for both the constraint model and the biasing of the utility functions. As such, the success of the model hinges on the interdisciplinary cooperation between fishing, social and computer scientists.

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