Flying like a School of Fish: Discovering Flocking Formations in an Agent-Based Model with Analogical Reasoning

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In agent-based modeling, the modeler defines behaviors for individual agents, then explores the possible aggregate system level behaviors that can emerge from different agent behaviors. This approach allows researchers to flexibly simulate a variety of complex systems. However, due to the complex aggregate level behavior inherent in many of these systems, classic quantitative approaches are often insufficient for analyzing the results of models of these systems. Analogical reasoning involves comparing and identifying similarities between multiple structured representations. Analogical generalization systems have been created that both identify similarity and generalize instances into more abstract representations. We applied analogical generalization to identify aggregate level structures in an agent-based model.

We tasked an analogical generalization system with the goal of learning to recognize flocking formations in a classic flocking model. The generalization system was presented with instances of qualitative encodings of the flocking model state generated by repeated runs of the model. We used an equal number of instances showing flocking formations and non-flocking formations. The system then applied an unsupervised hierarchical clustering technique to the instances, using the analogical generalization system to identify similar instances and to generalize those instances into categories. This resulted in a tree of categories, with specific instances as leaves of the tree. The generalization system correctly clustered all and only instances of flocking within the same subtree of the hierarchy. Thus, the analogical generalization system was able to generate a generalization representing flocking that matched human judgment perfectly in all test cases.