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Modeling Minority Game Problem using Holonic MACS

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Minority Game problem solution using Holonic organizational cooperation over XCS based autonomous agents.

1. Introduction

In this paper, HMACS - a holonic organization infrastructure for intelligent multiagents is proposed for social modeling on the Minority Game(MG) problem. The multiagent system utilizes learning classification system XCS. Holonic multiagent system (HMAS) provides terminology and theory for the realization of dynamically organizing agents.

The operational autonomy in this particular case of study, is provided by learning classification system, XCS. The holonic organization is implemented by providing modularity and recursion to the XCS agent paradigm. In the resulting Holonic multiagent classification system (MACS), an agent that appears as a single entity to the outside world may in fact be composed of many sub-agents (MACS) and conversely sub-agents may decide that it is advantageous to join in to the coherent structure of a super-agent and thus act as a single entity.

2. Brief Description on Minority Game

MG was introduced and first studied by Challet and Zhang (1997), as a means to evaluate a simple model where agents compete through adaptation for finite resources. MG is a mathematical representation from El Farol Bar problem introduced by Arthur (1994), providing an example of inductive reasoning in scenarios of bounded rationality. Two parameters i.e. comfort threshold (θ_f)) and number of total agent that make an event place enjoyable are defined. If the event (Bar) has a capacity of 60 seats and 100 customer agents, each of the agents are rewarded when it (1) decides to go to the bar and the comfort threshold is no exceeded or (2) decides to stay at home and the comfort threshold exceeded. For abstraction in MG it is decided to be the comfort threshold θ_f=0.5 and the agents are rewarded if they are in the group with less number of agents. Each of the agent predicts the total number of agents who will attend the event(bar), based on history data i.e. last two or three weeks attendance. If this prediction is below the comfort threshold θ_f then the agent considers to attend the event. At a discrete time step t of the game an agent i takes an action either 1 or -1. Agents taking the minority action win, whereas the majority looses. After a round, the total action is calculated as A(t) = $\sum_{1}^{N} a_i(t)$.

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3. Reward Distribution

In this paper co-operative reward distribution schemes is used. The cooperative reward scheme was introduced as, if the bar is overcrowded none of the agents are rewarded, otherwise every agent is rewarded with a scalar value proportional to the attendance with a maximum of 1000.

4. Holonic Multiagent System

Holonic MAS organization consists of Holons(H_n), Agents(A_n) and Mediator Agent(M_A). Super Holon(H_0) consists of Holons($H_1, H_2, H_3..., H_n$). Similarly consists of Agents($A_1, A_2, A_3, ..., A_n$). For a MAS consisting of the set A_t of agents, the set H_t of all holons at time is defined recursively:

- for each $a \in A_t$, h=(a, a, ϕ) $\in$H,i.e. every instantiated agent constitutes an atomic holon, $h = (Head, Subholons, C)$ $\in$H and
- where $Subholons \in 2^H \setminus \phi$ is the set of holons that participate in h, $Head \subseteq Subholons$ is the non-empty set of holons that represent the holon to the environment and are responsible for coordinating the actions inside the holon. $C \subseteq Commitments$ defines the relationship inside the holon and is agreed on by all holons $h' \in Subholons$ at the time of joining the $holon, h$.

5. HMACS: A Holonic Multiagent System that learns using XCS

In the multiagent system each of the agents is implemented with the common characteristics of agent and XCS. The Holonic organization is implemented to limit the activities of the MACS(Multiagent Classification System).

6. XCS implementation of the Agent

- Partial representation of the environment represents the Classifier database.
- Perception of the environment is represented by detectors.

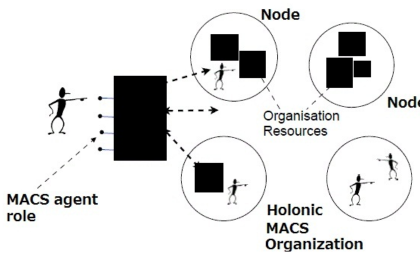

Figure 1: Holonic MACS infrastructure

- Skill to evaluate its own performance indicates the accuracy measures.
- Behavior toward satisfying its objectives is represented by reinforcement component.
- Autonomy, not directed by commands indicates the environmental interaction.
- Capacity to alter its environment indicates the action posting.

7. Holonic abstraction of the Environment

Organizational hierarchy and taking over positions by mutation.

8. Experiments

Ten agents have been used for the experiment. To simplify the control of the system as a whole, all the agents explore or exploit all together. Here each of the XCS agents can evaluate the simple value good(1) or not(0) and have a memory capability of 5 weeks (M=5). The system can only see the correct answer for each of those weeks, i.e. a 0 if the bar was overcrowded and a 1 if it was good to attend. The system has been extensively tested using cooperative reward schemes with the whole range of possible comfort thresholds. $(\theta_f = 0, \theta_f = 0.1, \theta_f = 0.2, \theta_f = 0.3, \theta_f = 0.4, \theta_f = 0.5, \theta_f = 0.6, \theta_f = 0.7, \theta_f = 0.8, \theta_f = 0.9, \theta_f = 1)$.The following parameters have been used for the experiment: probability= 0.333, explore/exploit-rate= 0.5, crossover-rate(χ) = 0.8, mutation-rate(μ) = 0.02, $\theta_g a = 25$, minimum-error($\in_0$) = 0.01 and learning-rate(β) = 0.2.

9. Results and Discussions

The result represent a single run of 5000 time steps. It has been found that the behavior of the agents is very extreme when the θ_f values are close to 0 and 1. Due to the threshold value, they either go or not go. A more interesting behavior of the population as a whole can be observed for the thresholds in the central interval($\theta_f = [0.3, 0.7]$). All the possible values were tested in 10 different experiments for each type of reward. MACS solved all the problems correctly. After analyzing all the results, those obtained for the θ_f =0.0, 0.3, 0.6, 1.0 values have been chosen. The behavior observed for these values are representative of the system's performance.

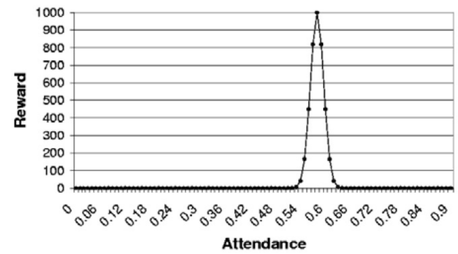

Figure 2: For threshold value 0.6 maximum reward achieved

From a population extract, agents seem to pay attention to what happened 3 weeks ago. Most of the agents have a rule with the -1-11-1-1 or -1-10-1-1 condition, this means that the agents are learning to go every third week. Another point to note is that two rules with condition -1-1-1-1-1 (one for each action) appear in all the populations, despite having high numerosity, they don't take over the population in the end.

10. Conclusions

In this paper XCS based MAS is employed to evolve under the Holonic organization cooperation. The MG is experimented using Holonic MACS framework to determine the comfort threshold θ_f.

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