MULTI-AGENT SYSTEMS

Abstract

It has only been less than 20 years since Distributed Artificial Intelligence (DAI) emerged as a separate subject of AI. Systems with numerous independent entities interacting inside a domain are what DAI is concerned with. DAI has traditionally been divided into Distributed Problem Solving (DPS) and Multiagent Systems (MAS), two sub-disciplines. MAS deals with controlling the behavior of groups of various agents or independent entities. Agent-based applications are becoming commonplace thanks to the current technological advancements in a wide range of industries, including e-commerce, supply chain administration, logistics, telecommunications, medical care, and production. Another reason why multi-agent systems are so well-liked is because they are thought of as an innovation and a tool which encourage the development of new theories and models for massively distributed systems or systems that are centered on people.

Keywords: multi-agent systems; agent methodologies; single-agent system; MAS Learning

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I. INTRODUCTION

The strength and complexity of AI techniques have grown significantly during the last few years. Using the ALVINN system, a car recently drove itself more than 95% of the way across the United States, to name just one of the numerous thrilling accomplishments [Pormerleau, 1993]. The topic of artificial intelligence called "multiagent systems" (MAS) is still in its infancy, but it tries to provide both concepts for building multiagent complex systems and mechanisms for coordinating the actions of autonomous agents [1]. One variety type distributed system is the multi-agent system, and what makes them unique is that each component is autonomous, self-interested, and focused on achieving its own goals. These systems also stand out because they lack a centralized design and are open systems [2]. The primary subject of this study, multi-agent systems (MAS), is made up of self-sufficient individuals known as agents.. Agents collaborate to complete tasks similarly to computing entities in DPS, but they provide additional flexibility because they have the innate capacity to learn and take independent decisions. In order to do the task assigned to them, agents make decisions and take actions on the environment [3]. To build MAS, a variety of complicated issues must be addressed, including agent coordination [4], learning, and security [5].

II. SINGLE-AGENT VS. MULTIAGENT SYSTEMS

We must first think about MAS' most obvious rival: centralized, single-agent systems, before we can analyze and classify MAS. In centralized systems, one agent is in charge of all decision-making, with the others serving as distant slaves. A "single-agent system" should be viewed for the purposes of this survey as a centralized system in a domain that also supports a multiage approach.

Even with only one agent, a system may have various entities, such as numerous actuators or even robots. The central process is the lone agent, nevertheless, if every creature transmits its observations to it and receives its commands from it. Each entity is modeled by the central agent as a single "self." In this section, the single-agent and multi-agent strategies are contrasted.

1. **Single-Agent System:** In a single-agent system, the agent typically simulates the environment, itself, and the interactions between the three. However, for the purposes of this article, agents are also regarded to have extra-environmental components even though the agent itself is obviously a part of the environment. They are autonomous beings with their own objectives, courses of action, and knowledge. In a single-agent system, the agent does not recognize any further similar entities. Therefore, If there are additional agents, they are not depicted as having objectives or anything else; instead, they are only seen as a component of the environment. Although agents are a component of their environment, it is important to note that they are explicitly described as having their own objectives, course of action, and domain knowledge (see figure 1).

A.A Pros

- Distributed sensing
- Communication content

A.B Cons

- Reactive vs. deliberative agents
- Local or global perspective
- Modeling of other agents' states
- How to affect others

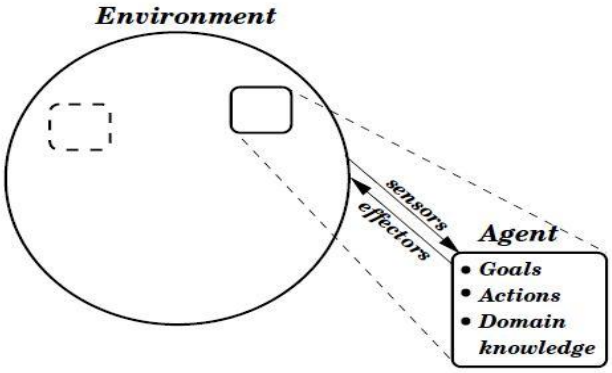

Figure 1: Single-Agent System

2. **Multi-Agent System:** From the perspective of a single agent, the major distinction between single-agent and multi-agent systems is that the dynamics of the environment can be affected by other agents. Other agents purposefully alter the environment in unpredictable ways, in addition to any inherent uncertainty in the domain. Thus, it is possible to consider the environments of all multiagent systems as dynamic. Figure 2 demonstrates the idea that each agent is both modeled as a separate entity and a component of the ecosystem.

B.A Pros

- Understanding each other
- Planning communicative acts
- Benevolence vs. competitiveness
- Negotiation
- Resource management (schedule coordination)
- Commitment/decommitment
- Collaborative localization
- Changing shape and size

B.B Cons

- Benevolence vs. competitiveness
- Stable vs. evolving agents (arms race, credit assignment)
- Modeling of others' goals, actions, and knowledge
- Resource management (interdependent actions)
- Social conventions
- Roles

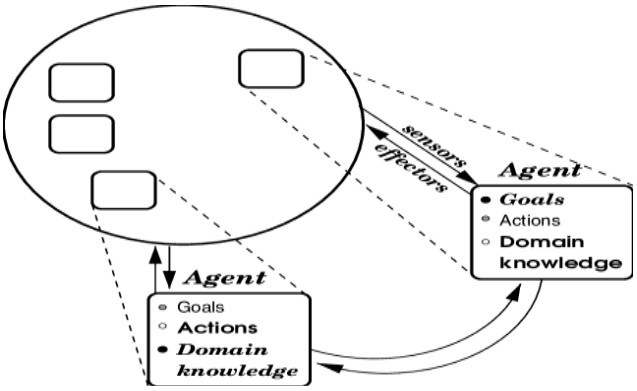

Figure 2: Multi-Agent System

III. MAS AND METHODOLOGIES

In recent years, a number of articles have appeared in an effort to provide innovative processes and methodologies for the development of multi-agent systems. Concurrent programming to address task coordination carried out on various machines with various scheduling policies, software engineering techniques to organize the development process, artificial intelligence techniques to give systems the ability to handle unforeseen circumstances and make decisions, all of these technologies are integrated into the construction of MAS [6]. This Paper contains three pieces of work related to agent-oriented programming.

1. **Accountability:** Accountability is a well-known critical resource in human organizations. Additionally, it is suggested that agent systems be created with accountability as a quality that is by design assured. To demonstrate how to build agents and the organizations to which they belong while being mutually accountable, the ADOPT, JaCaMo interaction protocol might be used. [7].

2. **Development Methodology:** Agent Modeling Language with Semantic Web Support, a domain-specific modeling language, can be used to create MAS that operate in semantic web contexts.

3. **Agent Development Framework:** The framework's support for linked data is the primary contribution. Linked data support is the ability to supply the agent's beliefs from the connected data environment and apply those beliefs during the planning process.

IV. MAS LEARNING

Agents may have to learn since they don't fully understand their environment or are unaware of how other agents behave. The context in which the learning takes place might be either cooperative, where we also want the agents to share what they have learned, or competitive, where we want them to outperform one another. We propose analysis and learning algorithms for these distinct environments' learning agents.

1. **Cooperative Learning:** Several agents work together in cooperative multi-agent systems to try and solve problems or maximize value through their interactions. Multi-agent problem complexity can increase quickly with agent count or behavioral sophistication due to interactions among the agents.

2. **Competitive Learning:** Two or more agents are pitted against one another in competitive learning, hopefully starting an advantageous "arms race" between them. For instance, it could be preferable for two agents to learn to play chess at roughly the same rate, resulting in a gradual increase in difficulty.

V. CONCLUSION

The analysis done on the accepted articles has allowed us to see that MAS research continues to offer technological solutions in a wide range of fields. Researchers at MAS make new discoveries that enable the creation of stronger, more adaptable, and systems that can forecast a successful future.

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