STRATEGY AND DEVELOPMENT OF MAS AGENTS IN MULTIFACTORIAL CLASSES

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Abstract. The paper considers the issues of behavioral control of reactive MAS agents for multifactorial classes. The applicability of MAS technologies for a large data flow of different nature characteristic of classes of complex problems is substantiated. The conceptual MAS model and the architecture of the COVID-19 intelligent information system on its basis are proposed. The structure, behavior, choice of strategy, and functionality of the reactive agent are investigated.

Keywords: multi-agent system, reactive agent, distributed artificial intelligence, action strategy

The latest developments of modern information technology are distributed artificial intelligence and multi-agent systems. An intelligent system is required to behave like human intelligence, and information technology is becoming a tool to achieve this goal. The most important fields here are:

- Knowledge engineering and knowledge-based judgments;
- Processing of fuzzy information and fuzzy inference;
- Information processing in neural networks and neurocomputers;
- Distributed artificial intelligence and multi-agent systems.

The field of distributed artificial intelligence and multi-agent systems has only recently begun to take shape in the early 1990s and is therefore considered to be the latest of the existing areas of modern information technology. It began to emerge from the demand for data processing speed, and its main focus was the parallelization of search and processing [1].

The use of multi-agent systems is very appropriate when considering a multifactorial problem, as these problems belong to a class of complex problems and it is impossible to investigate them only in one aspect: being multiparametric and multifactorial, they require large-scale processing of data from different media and by different methods. The requirements and criteria for these problems vary. For instance, in medical problems, the media include surveys, examinations, functional tests, computerized tomography, etc., each with its own processing methods. Since it is impossible to process all data by the same method, it is appropriate to make such a system distributed.

In this paper, COVID-19, a current relevant problem, has been chosen as the area of application. The issue under consideration is the development of a centralized intelligent information system in a pandemic situation. As mentioned above, a successful solution to such problems can be implemented with MAS technologies. Thus, in the problem under consideration, a MAS model observes the time span from infection to recovery, all information being collected in one center. To do this, the process is divided into stages and communication between them is carried out through agents. The paper focuses on reactive agents, exploring their abilities, functional loads, reception/transmission capabilities. To solve the problem, it is necessary to fulfill the following sub-tasks:

- Correctness of the problem statement;
- Conceptual model of the multi-agent system;
- Functionalities of the reactive agent;
- Reactive agent coding and programming.

A *multi-agent system* is a system in which several agents interact, sharing certain information with each other, thus solving a problem. The study of multi-agent systems is associated with the solution of artificial intelligence problems. When building a conceptual model, it is clear that the system requires agents with different functionalities (Fig. 1).

Fig.1. Conceptual model of the multi-agent system

Strong, intelligent, reactive agents can be noted among them. As can be seen, the planner interacts with all components in the system. The planner must combine in itself all the information about the system, as well as ensure lossless data transmission. The functions performed by the planner in the system are:

- Distribution to objects ($A_1, A_2, \dots, A_n$)
- Selection agents and assignment of functions;
- P_1 – patient databank, P_2 – databank of vaccinated patients.

The components $A_1, A_2, A_3, \dots, A_n$ in the diagram are distributed systems and distributed databases. There may be two-way or one-way communication between these distributed systems and distributed databases, or there may be no communication between some components.

Fig. 2. The structure of the COVID-19 multi-agent system

Based on the conceptual model, we propose a version of the COVID-19 multi-agent system (Fig. 2). In our opinion, the system can be operated at the level of a district, a township, or a city. It is implied that there is a polyclinic, a hospital and an ambulance station available in the selected area. It is also possible to set up a mobile hospital in the area in case the number of patients exceeds the norm.

Reactive agents do not understand the relationship between environmental and individual behavior. These agents cannot understand the overall behavior either. To create such reactive agents that can understand these behaviors is a challenging task. Moreover, the methodology to create such agents does not exist. Reactive agents sense and act through various means, i.e., they respond to the current state of the environment in which they are located.

Thus, reactive agents follow simple behavioral patterns that can be easily programmed, which is why they are also called *behavior-based agents*. One of the main properties of these agents is their relative simplicity and basic interaction with other agents. The most interesting aspect of the use of reactive agents is not in one agent's behavior mode, but in the simple interaction with other agents that can create global complex patterns of action (Fig. 3).

Fig. 3. Interaction between an agent and the environment

Unlike other traditional agents, these agents are defined only by a certain behavioral complex, because they are behavior-based. There is *no need for memory* because the behavior of reactive agents responds to stimuli from the external environment. A simple example of a reactive agent is the automatic mail filter that many email systems now possess [2].

Reactive agents must meet a number of requirements [3]:

- They must moderate the pace and frequency of their requests to some server;
- They must limit their searches to appropriate servers;
- They must share information with others;
- They must respect the authority placed on them by server operators;
- An agent's services must be accurate and up-to-date.

Note the following main properties of reactive agents [4]:

- Behavior-based action: reactivity is a behavior-based model of activity. Reactive agents cannot plan ahead what they will do. They do not take past events into account and cannot foresee the future. Their actions are based on what is happening now and their response to the situations. Fault tolerance and robustness are one of the key properties of reactive agent systems.

- Importance of topological structures: the structure of the space in which agents exist (live) is of great importance for organizing an environment, because spatial differences become social differentiation of agents.

- Traditional Simulation Techniques: Traditional techniques of simulation are based on mathematical or stochastic models, usually differential equations that relate different parameters and explain the dynamics of the systems. They examine cause-and-effect relationships during simulation by relating output variables to input ones.

- Multi-agent simulation: The life of an individual can be characterized by its behavior, where the term behavior refers to the set of actions an agent performs in response to its environmental conditions and internal states.

- The chosen strategy takes a special place in the behavior of the agent. $A = \{a_1, a_2, \dots, a_v, \dots, a_n\}$ is the set of possible events, 0_v is the information the agent possesses at the instant v , the selection of the optimal action at time t requires the use of all information 0_v and the activity information until time t . The function $\pi(0_1, 0_2, \dots, 0_t) = a_t$ is the agent's strategy. The simplest (one-step) functionality of the reactive agent [5] and the coding algorithm are given below:

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if status = Inquiry return Answer
else if location = A then return Enter the table
else if location = B then return Find a line
  
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else if location= C then return Take a line
Reactive agent in the "Covid-19" system
from pade.misc.utility import display_message, start_loop
from pade.core.agent import Agent
from pade.acl.aid import AID
from pade.behaviours.protocols import TimedBehaviour
from sys import argv
class ComportTemporal(TimedBehaviour):
def __init__(self, agent, time):
super(ComportTemporal, self).__init__(agent, time)
def on_time(self):
super(ComportTemporal, self).on_time()
display_message(self.agent.aid.localname, 'The agents message')
class Agent_mess(Agent):
def __init__(self, aid):
super(Agent_mess, self).__init__(aid=aid, debug=False)
comp_temp = ComportTemporal(self, 1.0)
self.behaviours.append(comp_temp)
if __name__ == '__main__':
agents_per_process = 2
c = 0
agents = list()
for i in range(agents_per_process):
port = int(argv[1]) + c
agent_name = 'agent_message_{ }@localhost:{ }'.format(port, port)
agente_message = Agent_mess(AID(name=agent_name))
agents.append(agente_message)
c += 1000
start_loop(agents)
#Reactive agent that transmits time parameter message

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There are several reactive agents in the system. For instance, the role of the agent in the resuscitation (oxygenation) department: the pattern is determined based on the request, the information on patient's latest condition is obtained and transmitted to the appropriate point.

Conclusion. A class of problems with distributed parameters has been considered, for the solution of which an intelligent information system based on multi-agent systems has been proposed. Agents with different functionalities have been investigated with a particular emphasis on reactive agents. A conceptual model and architecture of the "Covid-19" MAS as an information-intelligent system and an algorithm for coding a reactive agent operating in the system have been given as an example.

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