MULTI-AGENT SYSTEM FOR SIMULATION AND VALIDATION OF SCENARIOS

João Pedro Correia dos Reis

Project/Dissertation developed under supervising of Professor Gil Manuel Magalhães de Andrade Gonçalves

in Faculty of Engineering, University of Porto

1. Motivation

Simulation aims in real world replication regarding interactions and environment, in which tests and simulacrums could be avoided that incur in huge costs. This project has a major motivation of aiding in decision-making process regarding the production of configuration and strategies defense for the harbor surveillance and protection. The usage of simulation processes is intended to avoid costs as well as life-threatening in real world environment. This is an important factor for simulation development due to scarce validation means for the number and type of maritime forces along with its strategies.

The multi-agent usage is also a motivation for the project development. The latest emergence in agent-based platforms for simulation processes independent from its context represents a strong motivation for the development of a new approach in military domain, being the agent an approximation of individual entities that could be perhaps vehicles or soldiers.

2. Main Goals

This platform was developed in the scope of SAFEPORT project proposed by NATO, in which it represents a module of the whole project. The platform is intended to establish a bi-directional communication with the decision-support system, receiving a certain defense configuration with its strategies and vehicles to use, and sending the results of simulation. The result is a defense configuration validation, in which statistics are calculated according to the simulation execution and agent interaction.

The usage of an agent-based architecture for the simulation of hostile environments is a goal to the project's implementation. For the multi-agent architecture development, interaction between its entities to recreate the real world dynamics and modeling agents as a single individual and not a group should be taken into account.

3. Work Description

As previously said, the developed platform has a bi-directional communication, allowing the information exchange with the decision support system. this modular communication is achieved using XML-based files the specifies the configuration being tested in the simulator, as well as the validation results that were obtained along the execution.

Regarding the different functions and purposes that simulation could represent using an agent-based architecture, being simulation the implementation of a model through time, and a multi-agent system a way for representing behaviors, interaction and adaptation, the developed platform has the purpose of using those two components for military replication and representation, as a validation. For the multi-agent implementation, JADE framework was used, which provides simple tools for communication and behaviors effective implementation.

As the interaction representation of environment conditions, a simple interface was developed as integrated part of the simulation platform. Interface has also the central goal of visually validate the implemented behaviors and the modeled interactions.

The validation of defense configuration file is accomplished using the all the modeled areas (land and sea) along with a protected area, being agents responsible for its effective and efficient surveillance, recurring to strike vehicles capture. Taking into account the interactions replications and effectors appliance in the simulation process, it should be executed with the purpose of providing a metric of its performance, for being included in the decision-support system next execution.

3.1. Multi-agent System

The agent-based architecture has the main objective to define agent hierarchies and interactions, as well as the environment in which agent would be inserted in. The implemented multi-agent system does not represent an open system, being external entities not allowed to join and execute, making an integral part of the environment.

For the multi-agent system implementation, an architecture presented by *Shapiro*, *Shukiar* and *Hall* in 1985 was used. The usage of this architecture with more than 20 years is due to the correct representation and appropriate for the platform goal, not being relevant its creating date, being an independent from the technology used for its development. The architecture is based on different agent implementations: team agent that represents a vehicle of a team; environment that represents the environment dynamics; force agent is responsible for the simulation execution.

For the communication process between agents, the FIPA standard was used which defines a set of

parameters for the message exchange. The definition of ontologies was defined for an easier message representation and understanding, knowing an agent always what should receive in an information transaction from one another.

For the hosting of plans and its consequent execution, a data dictionary was created were the information about all the agents' plan is maintained updated along the simulation execution. Every time an agent wants to change its plan, it simply needs to send it to the dictionary for further simulation execution and impact in the environment.

3.2. Agent

For the behavior modeling of agents, parameters like team, goal, speed, and perception radius were implemented. Most of set parameters of agent's interaction control and environments are defined in the configuration file provided by the decision-support system. The concept of plan of created for the definition of agent's behavior, in which it is composed by tasks. A single task is simply a displacement through the environment that could be a route between two different points, or a predefined survey behavior.

3.3. Simulation

For the minimum simulation reliability, few aspects of real world dynamics should be taken into account. One of them refers to the displacement through environment, being the obstacle avoidance a problem to be solved. For the avoidance of vehicles crossing land regions taking the shortest path, an algorithm was created, using information from the mapped area in the configuration file, which is composed by a set of points that defines the land region in a clockwise order.

A XML-based file used created for the behavior's implementation regarding the agent's architecture. The strategy file has firstly the purpose of creating a communication protocol between agents, and secondly the association of actions to the reception or dispatch of messages.

Each step of the simulation represents one second in the real world, and a certain mapped cell refers to 20 meters, being the maximum vehicle speed 40 knots – 70 meters per second.

3.4. Interface

For the interface implementation was used two different technologies: Processing and Java SWING. The SWING component was used for the user's interaction construction, like buttons and search boxes, and Processing component was used for environment dynamics animation.

The painting of mapped region was developed using the implementation of two different algorithms: Flood Fill (recurring to Queue) and Ray Casting. The combination of those two approaches allowed a correct implementation of any shaped area in the configuration file, with a set a points in its proper order.

4. Conclusions

Is expected this project contributes to the simulation of maritime means being used in the final decision support, framed in the scope of SAFEPORT project.

With the approach used in this project, is possible to conclude that an agent-based architecture is capable of replicate a military warfare, in which a single agent represents a vehicle or other individual entity. The interaction capability of both entities and environment allows the creation of a complex dynamic system that represents a, not fully, well real word approximation.

It could be also concluded that the usage of Processing for animation purposes in simulation environments is a good approach, being a simple and very efficient implementation even when integrated with other interface implementation technologies.

Finally, it can be concluded that validation is achieved through the agent's behavior analysis, as an entry in a harbor protected area, or the capture of strike vehicles. This analysis provides feedback for the decision support system, in which it could be capable of improve the configuration file generation.