Research on Networked Operations Mental Model Modeling Method Based on Agent Technology

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Abstract. This paper uses Agent to model the network combat unit. Through the research shows that Agent can accurately describe the role of the mental model in the network of operations, the effective realization of the combat mission simulation. The research of this paper lays a good foundation for the further study of the role of mental model in networked operations.

Introduction

Networked operations are a new type of combat method for networked connection of decentralized combat units, which has been widely used in combat. Due to the complex structure of networked operations, the research is carried out by using the simulation model. The combat model, complex network and motif are used to simulate the network combat process. The networked operations system has the characteristics of fast rhythm, large amount of information and randomness, which makes the networked combat system more complex the traditional combat simulation method is difficult to accurately describe the command process [1]. The human factors in networked operations have important influence on the system performance. Whether the combatants can understand the battlefield situation accurately and make accurate decision-making determines the level of system combat effectiveness. Most of the simulation methods currently regard the combat unit as a functional node, without considering the cognitive ability of the combatants, and the awareness of the combatants is the key to determine the outcome of the network which makes the previous combat model cannot be effective simulation of networked operations. In order to solve this problem, this paper uses Agent technology to model the networked operations unit. Agent modeling can be divided into complex systems that are compatible with the inherent attributes of individuals in their systems. Each Agent has its own data structure, model and interface, etc. Agent unit model is limited by practical application, has a specific structure and function, and cannot be applied to the general combat simulation. This paper presents a modeling method based on the mental model of the combat unit. This method combines the OODA command process to divide the agent cognition process into two stages: situational awareness and decision making. In this paper, the Endsley situation awareness model is used to describe the mental model orient stage [2].It is shown that the model can be used to simulate the combat process of networked operations unit, and it has certain promotion value.

Networked operations units Agent function

The networked operations agent realizes the simulation of its cognitive process by simulating the unit mental model in real combat. The networked operations system uses decentralized command, through the power to the edge to achieve the combat unit autonomy. There are no command units in the collection of the same operational tasks. The units develop operational plans through their own information and their own mental models, with flexible command and control to achieve autonomous collaborative operations. Agent entity in the simulation process according to the battlefield changes in the dynamic completion of combat mission planning. Battlefield network to ensure that the unit has the same level of intention, communication and collaboration can make the unit to form combat teams, the common implementation of independent units cannot complete the complex combat missions.

The command relationship between the networked operations agent unit can be shown in Figure 1 below.

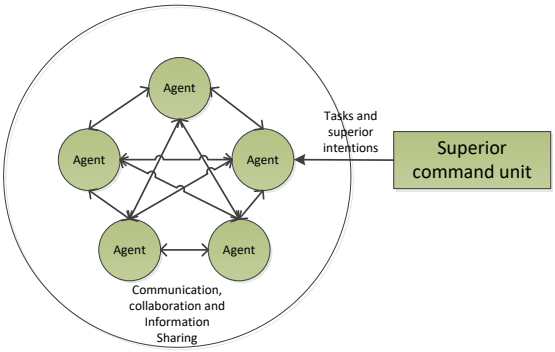

Fig. 1 networked operations unit agent command relationship diagram

Networked operations units Agent architecture

Rouse and Morris argue that the mental model is a psychological mechanism by which people describe the system goals and forms, interpret system functions, observe system status, and predict the future state of the system [3]. Johnson-Laird argues that the mental model allows people to dynamically speculate and understand real-time capabilities and to act accordingly [4]. Bedny and Meister argue that situational awareness encompasses logical concepts and imagination, awareness and unconsciousness so that individuals can form mental models of external events [5]. The mental model regards situation awareness as part of the information processing chain and provides perceptual support for subsequent decision making and execution.

The mental model of the combat unit agent obtained the battlefield situation from the outside environment and judged it, and formed the battle plan and executed after the decision. The combat unit Agent forms the combat team to complete the combat mission, which not only relates to the operational coordination mode between the combat units, but also the architecture of the agent itself. Agent architecture design must consider the combat unit characteristics and its relationship with other units. The networked operations unit has the characteristics of complex combat tasks, equal team structure, fast combat pace and high timeliness. Hybrid architectures include modules such as sensing, communication, execution, knowledge base, decision making, and response. Awareness module can be formed by the battlefield situation to understand the battlefield and projection, and according to the task needs to be sent to a different module processing. The communication module realizes the communication and information sharing between agents. The decision-making module makes use of the set of programs and rule sets in the knowledge base to develop operational plans based on projection and other unit information. The response module can react quickly on the basis of projection to achieve rapid action. The implementation module makes the plan work in the external environment, affecting the future development of the environment. The networked operations agent architecture shown in Figure 2, which can more accurately and effectively describe the reality of combat unit cognitive behavior.

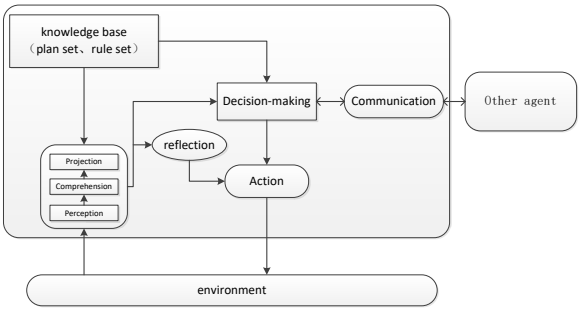

Fig. 2 Networked operations unit Agent model

Networked operations Agent mental model processing

The networked operations unit agent mental model includes two parts of situational awareness and decision-making. The situational awareness of the battlefield environment information is screened, understood and projected, and the decision-making process is based on the formation of the projection combined with the knowledge base to form the operational plan. The process can be shown in Figure 3 below.

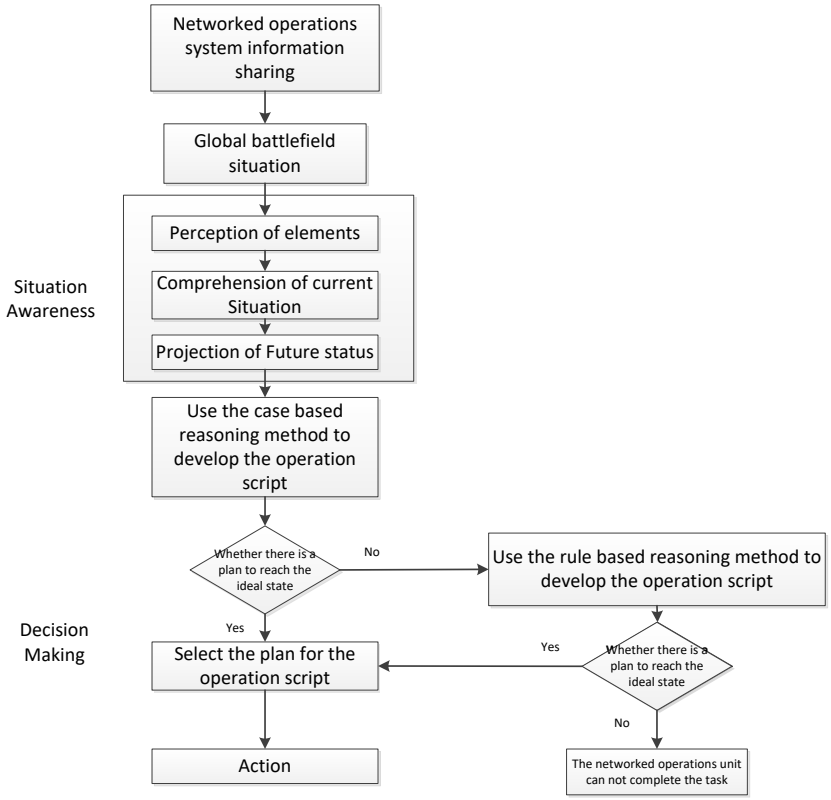

Fig. 3 Networked operations unit Agent situational awareness process

Set the input situation to perceive the battlefield environment information element set I_A, which contains the information elements that can be used to describe the battlefield as shown in $\{I_1, \cdots, I_n\}$. The first layer filters the input information set, sets the set of task requirements elements to S_r, and selects the element sets I_p and I_p that meet the demand attributes in I_A according to S_r. The demand information will be input to the next layer. After the second layer has obtained the I_p, the rule set R_s executes the rule based reasoning to form the battlefield attribute set, the rule set contains the rules such as$\{r_1, \cdots, r_n\}$, Rules for the connection information elements and battlefield properties of the mapping, set the model to understand the property t_i its role as follows:

$$s_i \times r_i \rightarrow t_i$$

The battlefield information element $i_i$is formed by mapping the rule element r_i to form an understanding element t_i. The awareness module forms an understanding set T after traversing the elements in the set of S_r and R_s, which is the understanding of the formation of the awareness unit, including the understanding elements $\{t_1, \cdots, t_n\}$. It is worth mentioning that the set of responses should be analyzed to eliminate possible contradictions. The awareness module projection layer will understand the set T and the projection rule R_p to be mapped to form the battlefield future development projection p_j, which can be represented by the following equation:

$$t_i \times r_i \rightarrow p_i$$

The traversal understanding of the set T and the projection rule set R_p can form the battlefield future projection set P. Combining the other unit information obtained by the communication module and eliminating the contradiction, the projection set P is input to the decision module.

The decision-making module adopts the rule based reasoning combined with the case based reasoning to form the operational script. First, we use the case based reasoning to match the projection set P with the plan set in the knowledge base to see whether the projection t_i can reach the target after matching with the plan set, that is, the ideal state. If there is a plan that achieves a goal in the set, the plan is selected as a combat script. If there is no plan to achieve the goal after traversing the program set, the rule based reasoning is used to form the operational script. Rule based reasoning searches for a sequence of actions that can reach the target by matching the projection set P with the decision rule Rd. If the task is achieved by rule based reasoning, the action sequence formed by the reasoning is selected as the operational script. Such as after reasoning cannot be achieved through the action sequence to achieve the task objectives, then the network at this time cannot achieve the combat unit combat mission, the task failed.

It can be seen that the actual combat process can be simulated by Agent modeling of the networked operations unit mental model. When the networked operations unit Agent to obtain the overall situation, the awareness module can filter the information and the formation of understanding and projection. The decision-making unit through the reasoning and rule-based reasoning on the projection reasoning to form a combat plan to complete the entire combat unit cognitive process description. It can be seen that Agent modeling can effectively describe the mental model of networked combat unit, and describe the cognitive process of networked combat in detail.

Summary

In this paper, the mental model of networked operations unit is modeled by Agent t, and the situation awareness and decision process in the mental model are simulated by means of combination of case based reasoning and rule based reasoning. Through the research we can see that Agent modeling can accurately describe the cognitive process of each unit in networked operations, and it lays the foundation for further research on the mental model of networked combat.

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