Research on the Unmanned Air Vehicle Team Intelligence Control System Based on Multi-agent

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Abstract. Unmanned Air Vehicle is a kind of flying intelligence robot with real-time reaction ability. Using the multi-agent idea in the exploitation of the unmanned air vehicle team Intelligence control system (UAVTICS) will enhance its intelligence degree greatly. The article introduces the design idea of Cruise Missile Weapon Control System, build the multi-agent frame of UAVTICS, and design the architecture of the fly-control agent and single unmanned air vehicle agent with "human-machine integration approach". And the model of unmanned air vehicle team agent is also described.

Keywords: Unmanned Air Vehicle Team, Multi-Agent, Intelligence Control.

1 Introduction

With the development of the computer and information technology, great progress has been achieved on the researcher of UAV. Compared with manned air vehicle, UAV has many advantages as a flying intelligence robot, such as low cost, low risk, good flexibility. And it has been widely used in reconnaissance, surveillance, attacking the target, and so on. Whereas, because of the complexity of the aerial warfare circumstance, a single UAV is no longer adequate for the tasks such as mission re-project and new attacking decision-making. So we pay our attention to UAV team.

Multi-Agent Systems(MAS) is an important part of distributed artificial intelligence, its main idea is dividing a complex system into some smaller agents which can communicate and cooperate with each other, and the complex system can accomplish its function by the cooperation of these smaller agents. It will be easier to study the cooperation of the single UAV agents by using the multi-Agent technology, and will enhance the Intelligence degree of the system greatly. The article combines the artificial intelligence with the machine intelligence with the direction of "human-machine integration approach" (the idea has been used successfully in the design of the Cruise Missile Weapon Control System in USA), brings forward a design project of the UAVTICS faced to the multi-Agent, and shows a way to build its architecture.

2 The MAS Architecture of UAVTICS

Architecture is the first sect to develop the UAVTICS, so we begin with the Architecture design. The theory and practice of intelligence control shows us: it is not enough to depend on high-autonomic intelligence system excessively; human intelligence can

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not be exchangeable. The "battle-axe" Cruise Missile is representative. The system adopts the "man in loop" technique, whose essential is adding a human-machine interaction system in the control loop. The "battle-axe" Cruise Missile weapon control system(CMWCS) can communicates with the flying missile though the secondary planet date chain, gives a series of orders to the missile such as: going around for the attacking chance; re-aiming in the flying course; scouting the information that missile transmit; evaluating the attacking effect. The CMWCS has the power to control the missile launch and program the mission on the launch platform, it make the cooperation of the missile team comes true [1]. Considering the comparability of CMWCS and UAVTICS, the article introduces the design idea of CMWCS to develop the architecture of UAVTICS.

2.1 The Design Object of UAVTICS

The object of the UAVTICS is: Command center agent binds the mission date on the unmanned air vehicle team on the ground. When there is no suddenness happened, every unmanned air vehicle keeps the real-time connection with Command center agent, unmanned air vehicle team executes the date pre-bonded and keeps auto-aviating though the cooperation among single unmanned air vehicles. When changes have taken place in warfare circumstance, including weather condition, equipments' conking out, and enemy's attacking, unmanned air vehicle team agent should take responses as below: making judgments on the new circumstance, making real-time re-projection and decision, supervising the execution course on the mission projection. At the same time, UAVTA transmit the information to Command center agent through Communication Module. Having finished evaluating the condition, command center agent make new decisions and give the UAVTA new order.

2.2 The Design of MAS Architecture

According to the object, the article builds the UAVTICS model based on MAS as Fig.1:

The function of every unit is introduced as below:

- Launch Control Agent (LC-A).UAV launch unit, its function is mainly about binding tracking date, original setting, detecting the UAV before launch, UAV launch control.
- Command and Surveillance Center Agent (CS-A). which includes: ① Command／launch surveillance agent (LSC-A): its function is supervise and accredit LC-A, communicate with superior and neighbor unit in behalf of UAVTICS, coordinate the agent's work in the surveillance center agent; ② Fly Control Agent (FC-A): its function is supervise the flying state of UAVT, identify the target, evaluate the target damage degree and give new order to UAVT according to the battlefield situation. ③ Mission re-Projects Agent (MrP-A):this unit mainly in charge the work as below: receiving and checkout attack plan and track program from the superior, making launch project, re-project or amend the plan according to the mission changing, transmitting the

mission date; ④ Communication Management Agent(CM-A): its function is mainly about managing the information from the superior, neighbor unit.

- UAVT Agent (UT-A). The agent is composed of some single UAV agents. Every single agent communicates and cooperates with each other according to some stated rules, and keeps the real-time connection with Communication Management Agent. UT-A is the direct unit to carry out the mission, it carry out its work according to the pre-bonded date and make decisions accordingly. Its decision level is lower than MrP-A's in LSC-A.
- Communication Module Agent (CM-A). This unit is mainly composed of secondary planet and signal receiving station on the ground. Its job is the communication between CS-A and UT-A.

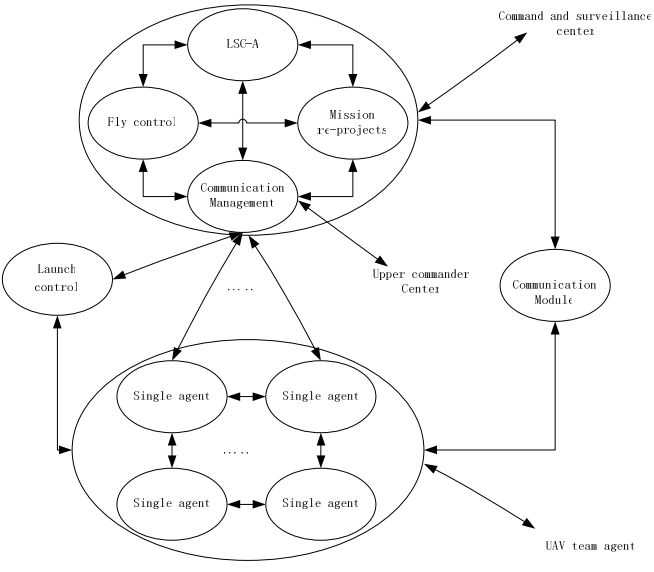

Fig. 1. The UAVTICS model based on MAS

3 The Communication and Cooperation Rule of UAVTICS

Excepting for the voice communication between the human-machine integration Agent, FIPA ACL format (an Agent communication language in intelligence physical fund organization) is used widely by the information transmitted in date form. The content and ontology of FIPA ACL message uses XML (eXtensible Markup Language) code. Communication among the Agents obeys FIPA communication [2]. The agent in CS-A communication though LAN; different kinds of wireless and lineate method is used among CS-A, LC-A and superior command system; CS-A connects with ground station of secondary planet and communicate with UAVT through the secondary planet date-line.

3.1 Cooperation Based on Organization Architecture

Organization architecture defines the rule, function and relationship of single agents. LSC-A plays a governor and controller role compared with LC-A, FC-A and UAVT. LSC-A, FC-A and MrP-A Cooperate equally with each other on the whole in the Command and surveillance center. Single UAV agents cooperate with each other though FC-A. The content of UAV cooperation includes time cooperation and attack direction cooperation, the method is composed of using attack project and track program planned before launch, plan regulation by LSC-A during the launch cause, remote control by FC-A to aero-UAV[3-4-5].

3.2 Cooperation Based on Promises

All agents promise to finish their conjunct work and obey the rules as below: ① Every Agent should keep the promise except for finding that the mission has been finished or the mission is impossible or unnecessary. ② When agents receive new order or the modificatory information of promised mission, they should execute new mission or actualize update as quickly as possible. ③ One agent must notify the other agents concerned when it has finished, abandoned or changed its promise…[2-3].

3.3 Cooperation Based on Shared Plan

All agents obey a shared plan to achieve dynamic combination and cooperation in the group. The plan contains all the detail and approach in the mission, single agent or agent group participate part of the plan. If the plan can not be abided, the surveillance center will take real-time adjustment to the shared plan and actualize control on it.

4 The Architecture Design of FC-A

FC-A is the core of UAVTICS on the ground and the key of system development. Considering FC-A's function is very complexity and the design idea of "battle-axe" Cruise Missile has been proved successfully, the article uses the idea for reference to enhance the intelligence degree of FC-A. Its main idea is "human-machine integration approach" [6]:it consider the agent as a whole consists of human, intelligence machine agent and common machine that help human acquire and transmit the information(such as telephone, fax). In the whole agent, human is the core, intelligence machine agent (IMA) is the assistant, they cooperate with each other to make decisions and carry out the mission. On the base of analysis to the mission feature, human characteristic and function demand, the key elements of the design includes: distribute the function of human and machine rationally; design the human-machine interface of IMA in order to best the human beings' ability to cognize the information and short the time that FC-A need to respond to the decision and action which might change with the situation [7]. The structure graph of FC-A was shown as Fig.2 [4-7]:

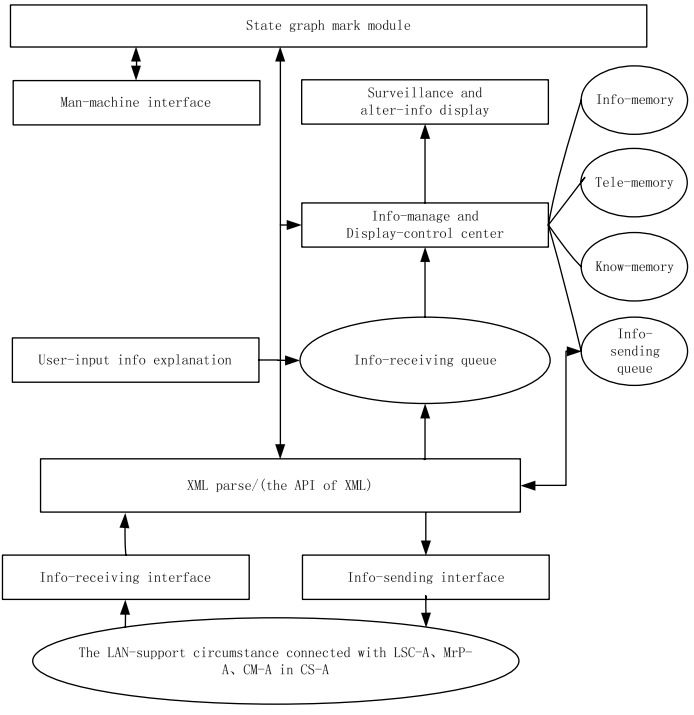

Fig. 2. The structure graph of FC-A

In Fig.2, the hardware of IMA consists of a workstation with a keyboard, a mouse and two link-monitors. Its main part includes:

(1) State graph mark module. It is consists of several parts: the army tab memory contains plot function which can create military standard; geography and map memory provides us date map and geography attribute of the battlefield; application program interface(API) contains the interface function provided for the display and operation of surveillance software; the program for the situation mark and control is in charge dealing with the information from human and API, read the date in database, command the bottom graph control program to mark on the map, store and manage map , turn human's operation into input affair to the command center then induce the corresponding action[7].

(2) Man-machine interface. this unit includes two parts: state graph surveillance machine and date surveillance machine. Their functions are both provide human with the information of the battlefield. We can conclude the difference between them, that is, the one shows graph and the other shows date.

(3) Info-manage and Display-control center. It is the intelligence core of IMA, its job is cognizing, responding to and disposing the information. In this way, IMA can communicate with human and other agents. XML parse machine analyses FIPA ACL message with XML code and puts the result in Info-receiving queue. Command center deals with the information according to the communication agreement, Info-memory

stores the date of faith aggregate for the display and decision; Tele-memory stores date and cyclostyle of Tele-message; Know-memory stores the preparative knowledge of IMA as arithmetic, consequence rules, communication knowledge. XML format is used in all the three above.

5 Structure Design of Unmanned Air Vehicle Team Agent

Because of the complexity of the aerial warfare circumstance, it is insufficient in actual combat with a single Unmanned Air Vehicle executing mission. Building an Unmanned Air Vehicle Team is essential. We construct a multi-agent system which can accomplish its mission by cooperating with every sub-agent. Firstly a single Unmanned Air Vehicle Agent's structure is given.

5.1 Structure Design of Single Unmanned Air Vehicle Agent

When we select method of Agent structure design, structure BDI was taken into account. Because structure BDI uses observe-think-act executing manner, which can obviously express Agent's Beliefs, Desires, Intentions and Programming. Furthermore structure BDI has perfect theory, flexibility and response. So we design the structure of single Unmanned Air Vehicle Agent based on the BDI.

The structure of single Agent was shown as Fig.3:

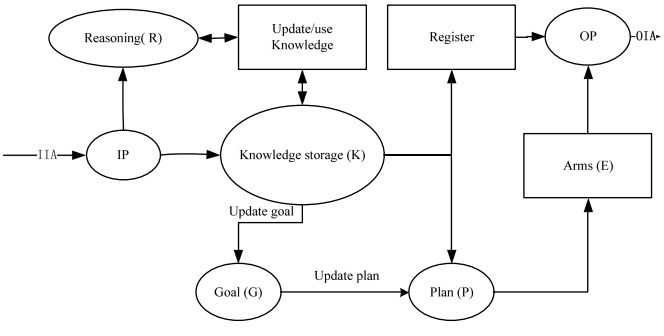

Fig. 3. The structure of single Agent

In the model BDI=(R,K,G,P,E,IP,OP,T,F,ILA,OLA,E).
Thereinto:

- R,K,G,P,E are abstract databases, they can be gauged by different mission.
- Reasoning(R) shows the reasoning and decision-making course of Unmanned Air Vehicle. During this course, Unmanned Air Vehicle makes decisions according to the information of its own, information offered by other Unmanned Air Vehicles and existing knowledge storage.
- Knowledge storage (K) is the finite set of database, which corresponds with the Beliefs of BDI. It shows the war field circumstance and the information of

other Unmanned Air Vehicle Agents (such as the number and position of goal and companion, the forecast of mobile intention).

- Goal (G) corresponds with the Desires of BDI, it shows Unmanned air vehicle Agent's motivation and final goals (such as air holding up, air convoy and air recovery), at last battle plan is set up on the battle intention.
- Plan (P) corresponds with the Intentions of BDI, it shows the action of Unmanned Air Vehicle Agent when it locks goal. Decision-making information which is set up by goal is input into corresponding control organization.
- Arms (E) is the implement organization of Unmanned Air Vehicle Agent, including flight control system, weapon control system and electro-war system [8].
- IP and OP are databases which contains input and output message.
- IIA and OIA show input and output interface of system model independently, they mainly describe communicating information and communicating behavior between agents and other sets. They are the service single UAV can get or provide, which can be exchanged with circumstance or other UAV. It is pivotal in the course of Multi-UAV agent cooperating with each other.
- Registration module shows that interrelated information must be registered or deleted when a new UAV joined in or exit the system.

When UAV agent firstly acquired war field situation by itself or accepted message from other agents, the message will be sent to the reasoning module(R) of agent, reasoning war field situation or mission on the base of knowledge storage, updating Agent's knowledge storage module (K), goal module (G) and programming module (P). If the similar message was accepted next time, it will be directly sent to knowledge storage, and agent will go ahead by former experience.

5.2 Cooperation Process among Unmanned Air Vehicle Team Agent

A lead plane agent, a wing plane agent and command center agent are included in a simple multi-UAV intelligent command control system structure model. UAV agent model can be gauged by Fig.3. In the process of aerial warfare, the attacking action of UAV Team is an action under the command of lead plane agent. UAV agents observe the war field situation by its sensors, and broadcast what it had to other UAV agents through communication module. Lead plane agent fuses the whole information based on the mission ordered by command center, information detected by itself and other wing planes, then makes out the whole aerial warfare situation, resets cooperating tactics, and redistributes wing plane agent mission. Under the lead plane agent's command, the wing plane agent makes an attack on goals according to programming and mobile tactics [9]. At last lead plane agent and wing plane agent transfer the actual state of mission to the command center agent by communications module. Having evaluated the attacking effect and our expenses, the command center agent reassigns lead plane agent by the existing troops.

6 Conclusions

The article introduces the multi-agent idea in the design of UAVICS, constructs the structure of MAS, and demonstrates its responsibility assignment, configuration, communications and cooperation. On the base of Cruise Missile Weapon Control System, we designed the control center—the architecture of the Fly-Control Agent and Single Unmanned Air vehicle Agent according to BDI model. And the cooperation process of Unmanned Air Vehicle Team Agent is also described. Reference [10] indicates that introducing the multi-agent idea to the design of UAVICS can exert high autonomy, response and intelligence of UAV. The article has just discussed the structure design of UAVICS, in the future we will research on the cooperating algorithms and project applications of Unmanned Air Vehicle Team Agent.

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