Applications of Brain-Inspired Intelligence in Intelligentization of Command and Control System

Shuangling Wang(✉), Chao Liu, Songhua Huang, and Kan Yi

Science and Technology on Information Systems Engineering Key Laboratory, Nanjing, Jiangsu 210007, China
wsltongxin@163.com

Abstract. In this paper, we analyze the development tendency of the intelligentization of command and control system and explore the application advantages of brain-inspired intelligence over traditional artificial intelligence methods in the intelligentization of command and control system. We also present a new approach through which general intelligence and system intelligence can be realized in command and control systems, and provide the evolution path of the invocation pattern of intelligent algorithms in command and control system.

Keywords: Command and control system · Brain-inspired intelligence · Military intelligence

1 Introduction

Recently, artificial intelligence (AI) and related techniques are penetrating into military applications step by step. AI is regarded as a representative technique that drives the organization of warfare forms to transform from data center and information center into cognition/action center. It will promote the evolution of command and control system from information-oriented to intelligence-oriented [1].

The discipline of AI origins from the vision that intelligent systems can think as humans do in the future [2]. After its first proposition in 1956, there have been two distinct comprehensions toward the discipline of AI, namely, the view of engineering and the view of science. The view of engineering considers AI as an important branch of computer science, aimed at enabling machines fulfill tasks which only human beings can do, by means of computer programming. The category of view of engineering ranges from the initial expert system to the recent fast-growing deep neural networks. In contrast, the view of science considers AI as part of cognition science. It emphasizes that AI must base on the cognition principles of human beings, or it cannot be termed as AI [3].

Inspired by the information processing mechanism of brains [4, 5], brain-inspired intelligence is a branch of AI which falls under the category of the view of science. Borrowing the experiences from cranial nerve mechanism and cognitive behavior mechanism, it achieves the effect of machine learning by investigating the biological

Q. Liang et al. (Eds.): *Artificial Intelligence in China*, LNEE 572, pp. 385–390, 2020.
https://doi.org/10.1007/978-981-15-0187-6_45

structure of brains, analyzing the mechanisms of biological processes of brains such as growing, learning and memorizing, and building models to simulate the structure and mechanism of brains [6–10].

Brain-inspired intelligence is featured by self-learning, self-adaption, collaborative cognition of multiple brain areas, etc. It provides a technical approach for command and control systems to borrow the experience from cognition processes of human brains, to achieve the intelligent operation of functional domains such as situation awareness, command, and decision-making, action control, support and guarantee, as well as collaborative operation between them.

2 Development Tendency of Intelligentization of Command and Control System

Military command and control system has been developing from the first generation, which is featured by single-arm and single-point, to the fourth generation under comprehensive construction nowadays, which is featured by inter-arm flat networking [11]. It has entered the stage of system of systems (SoS) construction. The command and control system will realize intelligent sharing across war zones in the future. This sharing will be knowledge sharing, rather than information sharing merely, thus facilitating advantages in decision-making and head start over the enemy.

In order to realize the knowledge sharing and ability evolution, the command and control system should achieve the transformation from specialized intelligence to general intelligence, and transformation from intelligence of point to intelligence of SoS [12].

(1) From specialized intelligence to general intelligence

At present several specialized AI modules have already been introduced into the command and control system, changing some kinds of information into knowledge, such as prediction of plane types and prediction of flight paths. These modules can only deal with specific issues and are not universal. Thus we call them specialized AI systems. With the complication of the environment of battlefield, command staffs may raise new intelligentized requirements at any time based on the actual situation, rendering the problem of exploding demands. This requires that AI systems be universal, in order to quickly understand knowledge in different forms, and quickly make decisions.

(2) From intelligence of point to intelligence of SoS

Now AI modules are especially aiming at single domains and providing local intelligent services such as activity pattern analysis, target identification, intelligent issues, study and judgment of situations, etc. The intelligence ability of SoS have still not formed. In the future, faced with combat between SoS, we will develop intelligence abilities such as operational planning based on swarm intelligence, feedback learning based on combat effects, manned and unmanned autonomous collaborated engagement, etc.

3 Application Advantages of Brain-Inspired Intelligence

Brain-inspired intelligence shows quasi-man features in the matter of adaptation. It provides a new technique path for the formation of general intelligence and intelligence of SoS, as well as for the development of military intelligence.

Intelligentization of command and control system is faced with such special conditions and requirements: (1) Limited data resources. Compared with applications in Civil Internet, the sample capacity available in military activities is quite limited, since military activities are accidental and less frequent. Thus it is often very hard to collect thousands of or tens of thousands of samples for one kind of weapon. (2) Lots of low-quality samples. Because of the confidentiality of military activities, there are lots of samples with unclear features. (3) Exploding battlefield requirements. With the dynamic change of the situation of battlefield, command staffs and warfighters may raise new intelligentized requirements at any time according to the current situation.

However, at present, the AI techniques are faced with such bottlenecks: (1) Huge demand for data. The learning process relies on huge amount of sample data. (2) Strict requirement for data quality. There is strict requirement for the sample articulation, sample integrity, and label accuracy. (3) Strong dependency on models. The accuracy of models strongly depends on the source and quality of sample data, and these models are only suited for specific issues.

Brain-inspired intelligence is precisely a kind of adaptable AI, whose characteristics of learning with small samples, anti-noise ability, and general intelligence can serve the command and control system with a new way to solve the above problems. (1) Learning with small samples. While human beings can draw inferences about other cases from one instance, machines are still seeking hard for the similarity between new instances and what they have seen before even after training with tens of thousands of examples. Machines often can hardly identify the ships/planes if there are a small amount of training examples. In contrast, brain-inspired intelligence provides machines with the ability of drawing inferences like human brains, by multi-modal awareness and learning processes with synergy of multiple brain areas [6]. (2) Anti-noise ability. Human beings can identify the planes and ships in a photo taken in the rain or in the mist, as well as capture the essence from fragmentary pictures. However, machines are usually lost in excessive concern with local features. Therefore the rate of identification seriously drops when the pictures are noisy or fragmentary. By comparison, brain-inspired intelligence reproduces the magical operating mechanism of human brains by introducing neuron models with the ability of excitation and inhibition, making machines capable of self-adaptive denoising [7]. (3) General intelligence. Under control of brains, human beings have the skills of reading, thinking, learning, etc. However, AI at present is often only capable of doing a single job, for example prediction of plane types or flight paths. Although in some recent studies, deployment of algorithms as required is realized through construction of algorithm libraries, improving the problem of fixed algorithm function to some degree, it is still quite less flexible compared with humans. In contrast, based on the synergy mechanism between brain areas, brain-inspired intelligence performs self-learning and knowledge reasoning by constructing pulse neural network, making machines capable of carrying out multiple tasks [8].

4 Evolution Path of the Invocation Pattern of Intelligent Algorithms in Command and Control System

According to the trend of intelligentization, the invocation pattern of intelligent algorithms in command and control systems can evolve through three stages: specialized invocation of specialized algorithms, invocation of general algorithms as required, and dynamic adaption based on brain-inspired software architectures. Then the intelligent service under general intelligence and intelligence of SoS can be gradually realized.

The first stage is specialized algorithms directed at specific tasks for specialized invocations. In this stage, the intelligent supporting environment which provides support for development, operation, train, and services can be constructed based on existing cloud platforms, as shown in Fig. 1a. Thereinto, in the intelligent data management layer, data is accumulated by construction of basic model libraries, specialized model libraries, mapping knowledge domains and so on; in the intelligent computation framework layer, computation engines as well as specialized intelligent algorithms, such as object identification and graphic searching, are deployed to provide service framework for intelligent computation; in the intelligent service supporting layer, services like planning and reasoning, intelligent detection, etc. are formed, providing services and operating environment for typical applications such as situation awareness, command and decision, so as to realize specialized invocation of specialized algorithms.

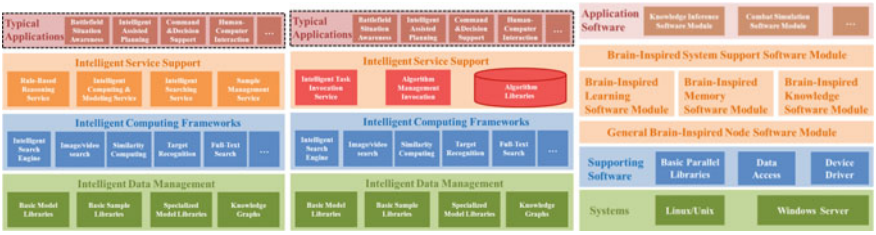

Fig. 1. Evolution diagram of the invocation pattern of intelligent algorithms in command and control system: **a** specialized invocation of specialized algorithms (left), **b** invocation of general algorithms as required (middle), and **c** dynamic adaption based on brain-inspired software architectures (right).

The second stage is management and invocation of algorithm resources according to tasks, directed at the problem that different task environments have different requirements for intelligent algorithms. Based on the first stage, in this stage algorithm libraries are constructed in the intelligent service supporting layer of the intelligent supporting environment. As shown in Fig. 1b, algorithms are integrated and encapsulated into services which can be directly oriented to special applications, thus realizing invocation of general algorithms as required.

In the third stage, the general intelligence ability of command and control system is generated gradually, through the adoption of brain-inspired intelligence techniques.

The brain-inspired software architecture will be built as shown in Fig. 1c. Supported by common operating systems such as Linux/Unix or Window Server, software modules corresponding to various nodes are realized, such as general brain-inspired nodes, brain-inspired learning nodes, brain-inspired memory nodes, and brain-inspired knowledge nodes. By interconnection of brain-inspired nodes, the mechanisms and functions of processes like learning and memory of super-brain network system are achieved, supporting the command and control system for the brain-inspired cognitive pattern, providing dynamic adaptive intelligent services for the fight.

From the above evolution path, we can see that the dynamic adaption based on brain-inspired software architecture is the advanced stage of the invocation pattern of intelligence algorithms in command and control systems. Based on brain-inspired software architecture, combined with brain-inspired algorithms such as autonomous reinforcement learning, the construction of super-brain network system can achieve general intelligence ability for command and control system to some degree, in ways of speech recognition, image analysis, knowledge reasoning, augmented reality, natural language processing, etc. Moreover, it provides intelligent support for domains such as situation awareness, command and decision, action control, support and guarantee, etc., thus achieving fast awareness of battlefield situation, scientific command and decision-making, agile control of actions as the occasion requires, and real-time guarantee of material support, gaining the ability of SoS intelligence.

5 Conclusion

In this paper we analyze the development tendency of intelligentization in military command and control system, which will be from specialized intelligence to general intelligence, and from intelligence of point to intelligence of SoS. The advantages of brain-inspired intelligence in learning with small samples, anti-noising, and general intelligence, contribute to promoting general intelligence and SoS intelligence in command and control system. Besides, the evolution path of invocation pattern of intelligent algorithms in command and control system can be divided into three stages: specialized invocation of specialized algorithms, invocation of general algorithms as required and dynamic adaption based on brain-inspired software architectures.

References

1. U.S. DoD Defense Science Board, (2016) Summer study on autonomy. http://autonomousweapons.org/department-of-defense-science-board-summer-study-on-autonmy/
2. Turing AM (1950) Computing machinery and intelligence. Mind 49:433–460
3. Wilson R, Keil F (1999) The MIT encyclopedia of the cognitive sciences. MIT, Cambridge, MA
4. Maass W (1997) Networks of spiking neurons: the third generation of neural network models. Neural Netw 10(9):1659–1671
5. Dayan P, Abbott LF (2003) Computational and mathematical modeling of neural systems: Model neurons I: Neuroelectronic. MIT Press, Cambridge

6. Zhao F, Zeng Y, Xu B (2018) A brain-inspired decision-making spiking neural network and its application in unmanned aerial vehicle. Front Neurorobotics 12(56)
7. Zeng Y, Liu C-L, TAN T-N (2016) Retrospect and outlook of brain-inspired intelligence research. Chin J Comput 39(1):212–222
8. Zeng Y, Wang G, Xu B (2016) A basal ganglia network centric reinforcement learning model and its application in unmanned aerial vehicle. IEEE Trans Cognit Dev Syst, 1–15
9. Eliasmith C (2013) How to build a brain. Reprint edition. Oxford Press, New York
10. Eliasmith C, Stewart TC, Choo X, Bekolay T, DeWolf T, Tang Y et al (2012) A large-scale model of the functioning brain. Science 338(6111):1202–1205
11. Wang H, Zhang J, Guo C, Duanmu Z, Yi K (2017) Network operation method for C∼4ISR system based on collaboration mechanism of system resources. Command Inf Syst Technol 8(1):15–21
12. Wang S, Huang S, Yi K, Mao X, Zhang Z (2018) Brain-inspired intelligence and applications in next generation command and control systems. Command Inf Syst Technol 9 (5):25–30