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The Theories and Methods of Military Operations Research in BD&AI Era

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***Abstract*—With the development of science and technology, human beings have entered the era of big data and artificial intelligence. How to play the role of fundamental subject has become a topic of concern in military operations research. In this paper, based on the changes of key element in the command and decision-making process derived by AI technology, the new characteristics of military operations research are analyzed, the new changes of the military operations research mechanisms are expounded, and the challenges faced by the operational core algorithm are pointed out. As a result, some suggestions military operations planning, command decision-making will be put forward in the future.**

Keywords—military operations; AI; mechanism; algorithm; theories and methods

I. INTRODUCTION

As everyone knows, the research breakthrough of Deep Learning Method opens a new era in Big Data (BD) and Artificial Intelligence (AI) technologies. In the military field, the application of AI technology is focus on Situation Awareness, Operation Research and Aided Decision-making. For example, in U.S, DARPA started an unmanned situational awareness platform. Meanwhile, the concept of Algorithmic Warfare was presented in 2017. On the basis of AI and Machine Learning technologies, massive information can be rapidly and effectively analyzed by using algorithm methods. In Military Operation Research field, DARPA developed a series software assistant project, such as Deep Green, Commander's Associate and Crystal Ball projects[1-2]. In Aided Decision-making field, some projects such as the Alpha series, Commander's Virtual Staff, and Compass projects were developed respectively.

All the developments of military theory are driven by two approaches. One is driven by practice on warfare; another is driven by science and technology. The development of Military Operation Research is no exception. In BD and AI era, as an important modified decision-making theory, what changes have taken place in Military Operation Research? There are three aspects as follow.

II. NEW FEATURES OF MILITARY OPERATIONS RESEARCH E

A. Fast Decision Making Becomes Highlights

Fast decision analysis method starts from the whole problem of decision-making, makes full use of the cognitive ability and empirical intuition of decision makers, and uses the method of logical reasoning to guide the decision-making process. In traditional fast decision-making, the first step is to clear the basic structure of decision-making problems, grasp key elements, and simplify problems. Then the decision trees, utility functions, probability calculations and other methods are used to make judgments and reasoning, so that decision analysis can quickly and effectively. In the information era, military fast decision-making, beyond experience support, modeling analysis, directly realize from data to decision-making, shorten the OODA cycle.

B. Simulation Still Dominates Operational Analysis

The era of artificial intelligence brought by big data, super-computing tools and algorithms, computer technology, artificial intelligence technology, distributed simulation technology, and virtual reality technology is embedded in the combat simulation engine. The traditional military operations research theory and methods are facing new challenges, the essence of information and intelligent warfare is confrontation between two or more combat system of systems. As an extension of systemic theory, simulation is the economically and effectively technical means, other technologies cannot be replaced, it breakthrough reductionism, suitable for studying military confrontation in complex battlefield environments. Practice has proved that as a new means of military operations analysis, simulation has accelerated the operations concept updating cycle and improving the comprehensive performance demonstration capability of the new generation of weapon systems, and has played an important role in reducing the number of tests, shortening the development cycle, saving development funds, and strengthening military training.

C. Collaborative Decision-making Becomes the Main Mode of Military Operations

With the development of science and technology, the scientificity of war has gradually replaced it's artistry, relying on the team's scientific decision-making, group decision-making to become the mainstream, the military experts is about to disappear, which has been proved by the war practice in the Gulf War, Kosovo, Iraq, Afghanistan, Libya, Syria, etc. . In big data era, the main elements of joint operations have become time collaborative, space collaborative and collaborative ways. The mission planning as the core of the operational planning works through the whole war process. Traditional decision-making based on personal experience cannot be available. Instead, the group decision-making highlights the group

advantage and the collective wisdom, as a concrete means of scientific decision-making, which relies on modern decision-making models and data support, has become the main method of modern military operations.

D. Big Data Correlation Analysis Leading Operational Results

It is difficult to trace causality in a big data environment. However, it's easier to find the relationship between various factors. Correlation analysis is to find correlations in a large number of data sets, which describes the rules and patterns of the simultaneous occurrence attributes. As the big data era, facing massive, heterogeneous, and complex operation experimental data, it is necessary to use big data analysis and mining techniques to analyze the correlation between operational elements, meanwhile to expand the understanding of causal relationships through correlation analysis. "Outside of coups victory away" which relies on military experience and intellectual factors has been out of date. The military operations in the big data era are to use data to analyze operational results, use technology to mine key nodes, and use patterns to explore operational rules.

E. Accurate Decision Making Becoming Possible

In traditional military decision-making, commanders are accustomed to making decisions based on their own experience, intuition, and savvy. If there are multiple plans, multi-attribute decision-making methods are used to analyze the plans. The results are always ambiguous, plausible, that is to say when someone make decisions they always make mistakes. The emergence of big data technology and tools has enabled people to find a new way of decision analysis. Big data abandons traditional experience and intuition, emphasizes dependence on data and analysis, not only makes decision-making results more scientific, and alleviates the tremendous mental stress that decision makers are exposed to. Under AI conditions, scientific decision-making has encountered new challenges, that decision-making realizes subversive changes from big data to action. Intelligent decision-making will completely bid farewell to human experience and intuition, bypassing the mistakes that human decision-making can make, and achieving accurate and fast decision making.

III. NEW CHANGES IN THE OPERATION MECHANISM

As a discipline for studying military activities, military operations research focuses on the 3+1 theoretical systems, namely, the game theory, programming theory, queuing theory, and Lanchester equation. Under the conditions of big data, these theoretical mechanisms have changed.

A. Countermeasure Theory Mechanism

Countermeasure theory is an important part of operations research, which is a strict uncertainty decision. The countermeasure theory is a mathematical theory and method for studying the phenomenon of confrontation or competition. The traditional countermeasure theory mechanism forms a countermeasure matrix by studying the possible strategies against both sides, and then takes the saddle point of the matrix as the optimal strategy. In big data era, the mechanism of countermeasure theory has changed, the opposing parties can use the data of confrontation experience and decision makers' preferences as samples to conduct deep learning, predict the opponent's strategy, and give their own optimal strategy. Accuracy and speed of the decision-making are greatly improved.

In recent years, with the wide application of information technology, the combination of game theory and information has opened up a new perspective for us to study military countermeasures. Researchers can obtain Nash equilibrium points by studying the strength of opponents and possible strategies. Thus, eliminate the fog of war, meanwhile improving the scientific and feasibility of scientific research results.

B. Programming Theory Mechanism

The traditional programming theory mechanism is mainly based on linear programming and nonlinear programming, which is used for static target allocation and task assignment. It uses genetic algorithm and ant colony algorithm for nonlinear programming problems, which belongs to computational intelligence. The extensive use of big data, artificial intelligence, mobile internet and cloud computing makes the traditional programming theory and method gradually become intelligent. The programming process is intelligent, its theoretical methods involve knowledge expression, knowledge reasoning, scenario calculus, human-computer interaction and knowledge mining, etc., especially in the expression of knowledge, should seek to adapt to the description language of the era of big data, and effectively exploit the knowledge contained in data under the premise of making full use of explicit knowledge [3-5]. At present, in military planning, traditional static planning is gradually transformed into nonlinear planning, combined planning, stochastic planning, multi-objective planning, and large-scale dynamic real-time intelligent mission planning.

C. Queuing Theory Mechanism

The queuing theory mainly used for the target allocation problem in air defense areas. Traditional queuing theory is always based on the assumption of negative exponential distribution, and the Poisson distribution model, which drive allocation strategy from model. In big data era, data can be used to discover the use value and directly construct real-time distribution models, so data directly drives the target allocation.

D. Lanchester Equation Mechanism

The Lanchester equation is a differential equation that describes the relationship between the forces of the two sides during the engagement, also known as combat theory or combat dynamics theory. The Lanchester equation based on strict preconditions, and is often used in the cold weapon era or in modern times using guns for fighting. The mechanism of the Lanchester equation is the dynamic change of the loss rate of both parties with time. When loss rate reaches a certain threshold, it is failure. In information age the Lanchester equation considers the changes of the elements of the command automation system and the morale of the person, but the basic

form of the equation and the mechanism of winning and losing have not changed. In big data era, the linear law and the square law of the Lanchester equation may no longer exist. The damage rate of both sides can be directly analyzed by the big data technology so that to dynamic prediction.

IV. Operational Algorithms Face New Challenges

From mathematical point of view, military operations research is a discipline that optimizes military action strategies, and its core is to design processes for algorithmic principles and algorithmic optimization. Under the conditions of big data, the algorithm of military operations research will focus on the depth algorithm and carry out deep learning with data as samples.

A. "Algorithmic Warfare" Becomes Possible

The information explosion has expanded to the operational domains of land, sea, air, sky, electricity, and the Internet. Facing the large amount of data generated by intelligence surveillance and reconnaissance, the general algorithm is powerless. At the same time, the non-linear, cross-domain and network features of the battlefield put forward extremely high requirements for decision-making, command and coordination in terms of time and space, element types and action rhythm. Therefore, we must apply artificial intelligence, machine learning, and data mining and deep learning techniques to develop depth algorithms. First, the depth algorithm can effectively deal with the massive data processing pressure, using historical and real-time data at an unprecedented speed. Second, the depth algorithm can shorten the time interval between task planning and task execution, and achieve re-planning ability during task execution, thereby speed up the combat rhythm and enhance combat flexibility. Third, the depth algorithm can realize intelligent decision-making support and improve the efficiency and accuracy of decision [6-8].

B. Violence Algorithms Becomes Normalcy

The emergence and development of supercomputing and cloud computing technologies have greatly improved the computing power, making violent algorithms possible. When using military operations to solve certain problems, the violent algorithm will bring unexpected effect. In particular, math and computer programming problems will be greatly simplified. The disadvantage of the violence algorithm is its inefficiency, while the advantage is that the coding complexity is low, almost no thinking and mistakes. Therefore, in a certain sense, depth-first search and breadth-first search can also be called violence algorithms.

C. Intelligent Optimization Becomes the Mainstream

Optimization is the goal of the military operations research theoretical approach, which is usually greatly or minimizes a function with multivariate in the condition of some equality or inequality constraints. The traditional simple optimization problem, the operation algorithm is easy to obtain the optimal solution of the function, but for the complex function and combination problem of nonlinear, multi-extreme and other characteristics, the classical algorithm is often powerless. The intelligent optimization algorithm is based on the mechanism of computational intelligence. Through the knowledge of relevant actions, experiences, rules and mechanisms in the field of military systems, it reveals the design principle of optimization algorithms, refines the corresponding feature models, and designs intelligent iterative search optimization algorithms, including natural evolutionary algorithms, bionic algorithms, artificial search algorithms, and artificial neural network algorithms [9-10].

D. The Basic Theory of Operations Research Has Great Potential

There are many ideas of how does the basic theory of operations play important role in big data and artificial intelligence era. In fact, the mathematical basis of machine learning is fitting, and fitting itself is a kind of learning. Therefore, deep learning relies on operational planning theory to be more compact, so the basic theory of operations will become more and more important. For example, convex optimization is a kind of special optimization, which refers to a kind of optimization problem in which the objective function of finding the minimum value is a convex function. The optimization problem in which the objective function is a convex function and the domain is a convex set is called unconstrained convex. The optimization problem, while the objective function and the inequality constraint function are convex functions, the equality constraint function is an affine function, and the optimization problem for the domain convex set is the constrained optimization problem. If the deep learning algorithm does not meet the conditions of convex optimization, many algorithms cannot be designed, and data cannot be analyzed.

V. Conclusions

Human beings have entered the era of big data and artificial intelligence, the theories and methods of military operations research have presented new features, new changes have taken place in the mechanism of military operations, and operational algorithms are facing new challenges. The above is a little experience in studying military operations research. If it is inappropriate, please criticize and correct.

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