Research on the Application and Collaborative Mechanism of Distributed Simulation Technology in Cross - Regional Police Joint Tactical Drills

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Abstract: The social security situation is becoming increasingly complex, with frequent cross regional emergencies. The traditional police training methods are limited by cost, safety, and organizational difficulty, making it difficult to meet the needs of practical training. Distributed simulation technology, with its high flexibility, repeatability, and multi node collaboration capability, provides a new path for building a cross regional police joint exercise system. Distributed simulation technology is essentially a network-based approach for collaborative modeling and simulation of multiple systems. Its key lies in connecting multiple simulation nodes through a network to achieve real-time data interaction and state synchronization. This article discusses the application of distributed simulation technology in police joint exercises, analyzes its technical advantages and implementation path in multi regional collaborative operations. Distributed simulation technology can effectively improve the efficiency and practical experience of joint exercises, but its promotion still requires the coordinated promotion of systems, standards, and technologies.

1. Introduction

With the social security situation becoming more and more complicated, the cross-regional characteristics of emergencies become more and more prominent, and the traditional police drill mode has been difficult to meet the needs of modern actual combat. Especially when dealing with complex scenes such as terrorist attacks, mass incidents, and major natural disasters, the cross-regional and multi-departmental joint disposal ability has become a key indicator to measure the actual combat level of police [1]. It is difficult to organize large-scale and multi-scene joint drills frequently due to the limitations of venues, personnel, costs and security risks [2]. Therefore, exploring an efficient, economical and safe drill mode has become an important direction of the current police training reform.

Distributed simulation technology has gradually become an effective way to solve the problem of cross-regional joint exercise. This technology realizes real-time collaborative deduction of multi-location, multi-role and multi-system by building a virtual combat environment, which not only can simulate real scenes, but also has high flexibility and repeatability [3]. The purpose of this study is to explore the specific application path of distributed simulation technology in cross-regional police joint tactical drills, and to build a set of efficient and feasible cooperative mechanism model. By analyzing the limitations of the current drill mode and combining the characteristics of distributed simulation technology, this article puts forward a simulation platform architecture and collaborative mechanism design scheme suitable for police actual combat.

It should be noted that although the distributed simulation technology has obvious advantages, it still faces many challenges in the practical application process. For example, the heterogeneity between police systems in different regions, the guarantee of real-time and consistency of simulation data, the flexibility and adaptability of coordination mechanism, etc., all need to be further solved in the follow-up research [4]. In addition, the safety of simulation system, the adaptability of trainers and the evaluation system of drill results are also worthy of in-depth discussion.

Generally speaking, distributed simulation technology has brought new opportunities for improving the actual combat and intelligence level of police joint drills. Through systematic

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analysis and practical exploration, this study hopes to promote the deep application of this technology in the field of public security and help build a more scientific and efficient cross-regional cooperative combat system.

2. Application of distributed simulation technology in police joint exercise

With the increasing complexity of modern policing tasks, especially when dealing with cross-regional emergencies, mass incidents or major public safety incidents, the limitations of traditional drill methods in terms of cost, safety and flexibility are gradually emerging [5]. The appearance of distributed simulation technology has opened up a new technical path to solve these problems. This technology achieves multi-location and multi-role collaborative deduction by building a virtual exercise environment, which can not only simulate the real scene, but also effectively enhance the actual combat and repeatability of the exercise [6].

Distributed simulation technology is essentially a network-based collaborative modeling and simulation method for multi-systems, and its key lies in connecting multiple simulation nodes through the network to realize real-time data interaction and state synchronization [7]. In the police joint exercise, this technology can support the collaborative participation of multiple command centers, different police types and virtual combat units, and create a highly realistic virtual confrontation environment [8]. This model can not only break the geographical restrictions, but also allow multiple police forces to train in the same virtual space, and also greatly reduce the cost and security risks of the exercise.

A distributed simulation system is generally composed of several functional modules, including command and control nodes, tactical deduction nodes, virtual role modeling modules, situational awareness and visualization modules [9]. In the actual exercise process, distributed simulation technology presents the following advantages: First, it strengthens the realism and immersion of the exercise, and enhances the actual combat experience of the participants through high-precision modeling and dynamic behavior simulation; Secondly, the flexibility of the drill is improved, and scenes and rules can be quickly reconstructed according to different task requirements; Thirdly, the collaborative efficiency is enhanced, and multi-department and multi-region information sharing and collaborative decision-making are realized by relying on a unified platform; Fourthly, it reduces the cost and risk of the drill and avoids the possible casualties and waste of resources in the real drill.

3. Cross-regional police cooperation mechanism

With the increasing complexity of social security situation, the trend of cross-regional communication of emergencies is becoming more and more obvious, which puts forward higher requirements for the rapid response and cooperative combat ability of public security system. The traditional regional independent combat mode has been difficult to deal with complex scenes such as major mass incidents, cross-regional terrorist attacks, major natural disasters, etc., and it is urgent to build an efficient, flexible and extensible cross-regional police coordination mechanism [10]. The introduction of distributed simulation technology provides technical support for the construction of collaborative mechanism, making it possible for multi-regional and multi-departmental joint exercises and collaborative decision-making.

The core of cross-regional police coordination mechanism lies in the efficient unification of information sharing, resource scheduling and command coordination. In practice, the mechanism should cover multiple dimensions, including organizational structure, communication protocol, decision-making process, resource allocation and so on. In order to better understand and design this mechanism, we can systematically analyze it from three levels: collaboration level, collaboration mode and collaboration process.

Table 1 shows the three main levels of cross-regional police coordination mechanism and their corresponding coordination objects and functions. There are significant differences between different levels of collaborative goals and participants. High-level collaboration pays more attention

to strategic decision-making and resource allocation, while low-level collaboration pays more attention to tactical execution and on-site command.

Table 1 Hierarchical Structure of Cross-Regional Police Coordination Mechanism

Coordination Level	Coordinating Entities	Coordination Content	Coordination Method	Information Requirements
Strategic Level (National/Provincial)	Provincial Public Security Bureaus, Emergency Management Agencies	Policy formulation, resource allocation, emergency command	Joint meetings, remote command systems	Macro-level data, resource distribution, policy documents
Operational Level (Municipal)	Municipal Public Security Bureaus, Armed Police, Fire Services	Action deployment, task assignment, joint command	Video conferencing, joint command platform	Tactical intelligence, mission status, personnel deployment
Tactical Level (District/On-site)	SWAT, Traffic Police, Local Police Stations	On-site handling, personnel control, information feedback	Radios, mobile terminals	Real-time situation, personnel location, incident progress

In the design of collaborative mechanism, besides hierarchical division, the choice of collaborative mode should also be considered. According to the relationship between collaborative subjects and the way of information interaction, collaborative modes can be divided into three types: centralized collaboration, distributed collaboration and hybrid collaboration. Table 2 compares and analyzes these three modes, and evaluates them from the aspects of response speed, flexibility, system complexity and applicable scenarios.

Table 2 Comparative Analysis of Cross-Regional Coordination Models

Coordination Model	Response Speed	Flexibility	System Complexity	Applicable Scenarios	Advantages	Disadvantages
Centralized Coordination	Fast	Low	Medium	Large-scale incidents, centralized command	Unified command, strong coordination	Relies on central node, potential bottleneck
Decentralized Coordination	Medium	High	High	Multi-region independent operations, local conflicts	Strong autonomy, good fault tolerance	Decentralized decision-making, coordination difficulty
Hybrid Coordination	Fast-Medium	High	High	Comprehensive tasks, multi-level coordination	Combines efficiency and flexibility	Complex system structure, difficult management

As can be seen from Table 2, centralized collaboration is suitable for scenarios requiring unified scheduling and rapid response, such as major terrorist attacks; However, distributed cooperation is more suitable for multi-regional independent operations or local conflict scenarios, such as joint border patrols or regional public security rectification actions; Hybrid collaboration combines the advantages of the former two, which is suitable for complex and changeable task environment, but its system structure and management difficulty are relatively high.

In terms of collaborative process, cross-regional police collaborative mechanism should include six stages: information collection, situation awareness, decision-making, task allocation, implementation feedback and effect evaluation. Among them, information collection and situation awareness are the basis of collaboration, decision-making and task allocation are the core of collaboration, and implementation feedback and effect evaluation are the key to continuous optimization of collaboration mechanism. With the support of distributed simulation system, these processes can be highly automated and intelligent, thus improving the overall collaborative efficiency.

4. Problem analysis and optimization proposal

Distributed simulation technology has a good application prospect in cross-regional police joint drills, but it still faces many challenges in the process of actual promotion and landing. These problems cover system compatibility, data synchronization and security at the technical level, as well as organization and coordination at the management level, personnel adaptability and lack of standards.

From the technical point of view, the distributed simulation system is still in the initial application period in the public security field, and the problem of system heterogeneity is particularly obvious. The simulation platforms used by different regions and different police types are often based on different technical architectures and communication protocols, which makes it difficult to achieve efficient interconnection and data interoperability between systems. In addition, the real-time and consistency of simulation data are also lacking, especially in large-scale and multi-node cooperative drills, information delay and state asynchronization occur frequently, which affects the realism and cooperative efficiency of drills. At the same time, the problem of data security should not be underestimated. Because the simulation system involves a lot of sensitive information such as police deployment and tactical flow, once it encounters data leakage or network attack, it may lead to serious consequences.

At the management level, the organization and implementation of collaborative mechanism are still lack of unified norms. At present, cross-regional police cooperative drills are mostly temporary tasks, lacking normalization mechanism and institutional guarantee. During the drill, the division of command authority between public security organs in different regions is unclear, and the information sharing mechanism is not perfect, so it is easy to have a situation of "going their own way". In addition, the drill evaluation system is not yet perfect, and how to scientifically measure the drill effect and improve the training quality is still an urgent problem to be solved. On the other hand, some front-line police officers have a low degree of acceptance of the simulation exercise, and feel that there is a gap between it and the actual operation, which affects the participation enthusiasm and training effect of the exercise to a certain extent.

In view of the above problems, the following optimization proposals are put forward: First, relevant departments should speed up the construction of a unified simulation platform standard to promote the interconnection between systems. Relevant departments can refer to the international common standards such as HLA/RTI (High-level Architecture/Operation Support System) and combine the actual needs of public security to formulate the interface specification of simulation system suitable for China's national conditions. Second, public security departments should strengthen data management and security mechanisms and actively introduce new technologies such as blockchain and edge computing; At the same time, the public security department needs to establish a strict access control and authority management system to prevent information leakage and abuse. Thirdly, the government and the public security system should improve the system design of the coordination mechanism, and promote the cross-regional police coordination exercise to be normalized and institutionalized. All localities can set up regional joint exercise coordination institutions, which are responsible for the unified allocation of resources, standardized processes, and the establishment of information sharing and joint evaluation mechanisms. Fourthly, public security training institutions should strengthen the training and adaptive guidance for police officers, and enhance the acceptance and participation of frontline police officers in simulation drills through the combination of simulation and actual combat.

5. Conclusions

This article analyzes the feasibility and advantages of this technology in simulating complex scenes and improving collaborative efficiency. Distributed simulation technology can effectively make up for the shortcomings of traditional exercises in terms of cost, safety and flexibility, and also provide technical support for building a multi-regional and multi-departmental joint exercise system. Through the construction of simulation platform and the design of cooperation mechanism,

the organic unity of information sharing, resource scheduling and command coordination is realized.

In practical application, although this technology shows a good application prospect, there are still some practical problems, such as system heterogeneity, data synchronization delay, imperfect security mechanism and lack of organization and coordination mechanism. These problems restrict the in-depth application of technology, and also put forward higher requirements for the information construction and management mechanism of public security system. Therefore, the future development direction should focus on platform standardization, intelligent data management, institutionalization of collaborative mechanism and other aspects. On the one hand, we should promote the unification of simulation system interfaces and enhance the compatibility and expansibility between systems; On the other hand, it is necessary to strengthen the data security protection system and improve the stability and reliability of the drill system.

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