A Modeling and Implementation Framework of Situation Deductive Information

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Abstract. This paper mainly studies the modeling and implementation framework of deductive information in large-scale situation scenarios. In view of the deficiencies of the current plotting systems in dynamic deduction, we achieve the dynamic modeling of situation information by applying deductive motions to military symbols. And we propose a dynamic adjustment strategy of situation layers. At the same time, through timing control, deduction control and script control, the situation deductive process can meet the actual combat needs, which is convenient for analysis and research. Finally, through practical development, it proves that our deduction method is feasible, and solve the key technology of situation information expression and realization in battlefield situation deduction.

1. Introduction

The most important thing in informationized warfare is the battlefield information. The battlefield information is constantly changing, the amount of data is huge, and the relationship between the data is also quite complicated[1]. How to use a variety of forms and means to accurately and comprehensively reflect the situation of the battlefield to make combat decisions correctly and timely is the hot issues of various countries competing for research. Traditional situation information refers to systematic information formed on the military map where military symbols are used to mark information containing combat planning, combat deployment, ship formation, firepower configuration, combat process, and military facilities. The situation map carrying rich situation information can enable commanders to understand the battlefield situation at a glance through human-computer interaction[2]. However, the current battlefield situation map drawn with military symbols can only represent the situation at a certain moment on the battlefield, or reflect the situation of the entire battlefield process. Its interaction is poor and it cannot accurately and vividly describe the complex battlefield situation environment. Therefore, situation deductive technology came into being. The situation deduction came into being.

The situational deduction visualization technology, which is derived from the situation deductive system, is an organic component of the battlefield information environment combat system. The central task of situational deduction visualization is to sequence and process the battlefield situation information[3], then show the development trend of the battlefield to the commanders in a deductive manner, it also provides many functions like creation, modification, storage, etc. of the situation deductive information, so that the commanders can infer the battlefield situation from various perspectives[4]. Therefore, this paper proposes a model and implementation framework of situation deductive
information to solve the dynamic expression problem in the deductive process and the performance problem in the deductive process.

2. Modeling of Situation Deductive Information

Considering that the situation information contains many different types of information, it is planned to divide situation deductive information from a logical level into three categories for modeling: map information, military symbols information, and deductive motion information. The modeling structure of the whole situation deductive information is shown in Figure 1:

![Model structure of situation deductive information.](image)

From Figure 1, we can see the entire situation deductive information is the root element of the model, which can be divided into three sub-elements at the logical level: map information, military symbols information, and deductive motion information. From the application level, situation deductive information can be divided into many different layers. A layer is a logical concept. When a map, multiple military symbols, and their corresponding deductive motions are added to the same layer, that means it belong to the same set at the application level. According to different upper layer applications, different layers may be created. Generally, there are several foundations for creating layers:

- If the duration of the battle is longer, the maps, military symbols, and their corresponding deductive motions of each stage can be grouped into the same layer according to different combat stages;
- If there are many war combatants in the battle, each layer corresponds to the situation deductive information of one combatant;
- If there are fewer combatants in a battle and the combat time is more concentrated, the information required to be displayed on the situation map is very large, and then the same type of military symbols on the situation map can be grouped into the same layer.

When there are multiple layers in the system, a manager is needed to record and manage the layer information. This manager is the situation layer manager. The logic level of the entire situation information model is very clear, which is a typical object-oriented design model. Through object-oriented design and modeling, the whole situational deductive information is like a tree. As long as the root of
the tree is found, it can be traced back to each leaf of the tree without returning. The contents of these parts will be discussed in detail below:

2.1. Map feature
The situation map is the carrier of the battlefield situation deduction, it is mainly composed of the base map and the drawing layer. In the information situation scene, it should be divided into military topographic maps, nautical charts, aeronautical charts and various military thematic maps by the practical purpose [5]. Military topographic maps are drawn with various terrain and feature elements such as mountains and plains, as well as plane rectangular coordinates and geographic coordinates. When the scale is large, the content is detailed and accurate. The angle, distance, slope, coordinates, elevation, and area can be measured from the map. It is the basic map used to study the terrain and organize the command of the troops. When the scale is small, it indicates the topography and geographical situation of a large area. It is mainly used by senior commanders and command organs to study and formulate strategies and battle plans, and to organize and command large-scale corps operations.

The nautical chart emphasizes the geographical elements such as the nature of the coast, the seabed geomorphology, and the bottom quality, and the navigational elements such as navigation obstacles and navigation aids. Aeronautical charts are various maps used for air navigation and ground navigation. The map focuses on geographical elements such as residence, roads, and water systems related to air navigation, and aviation elements such as airports and vertical obstacles. In addition, the military thematic map is a map that focuses on displaying one or several thematic contents to meet certain military needs, such as military traffic maps and military engineering geological maps [6].

2.2. Military symbol element
The military symbol is a graphic language for marking military conditions, and it is a graphic symbol for marking troops, institutions, weapons, equipment, and military operations. Any complex military symbol can be regarded as a combination of several simple figures, and these simple figures are called basic primitive objects. Primitives are some basic geometric figures, such as lines, circles, rectangles, triangles, etc. They are composed of: points, polylines, line segments, rectangles, circles, arcs, ellipses, sectors, curves, text, etc. According to the geometric characteristics of military symbols, military symbols can be divided into punctate military symbols, linear military symbols, surface military symbols and text military symbols. The punctate military symbols mainly represent the punctate military entity in the battlefield situation, such as weapon equipment, combatants, etc.; the linear military standard mainly represents the military situation information extending in a certain direction, such as the direction of the army's attack, the battle defense line, etc.; Planar military symbols mainly represent military entities with a certain range, such as assembly positions and combat ambush areas; text military symbols are mainly some textual information used to help explain the situation information [7].

According to the data characteristics of military symbols, the static attributes of military symbols are divided into six categories: public attributes, geometric attributes, display attributes, annotation attributes, avoidance attributes, and time attributes [8]. The public attributes mainly include information such as the type of military symbols, the internal code of the military symbols, and the layer to which the military symbols belong. The geometric attributes mainly include the coordinates of the basic and positioning points of the military symbols, and the coordinates of the control points of the military symbols. The display attributes mainly include the color, size, line type, line width, gradient step size, fill style and other information of the military symbol. By setting the display attributes for the military symbol, there can be more forms and richer means to express the battlefield situation information, such as the color of military symbols can indicate the attributes of the enemy and us. All military symbols that represent the situation information of our army use red, and all military symbols that represent the situation information of the enemy use blue. The annotation attribute is to add descriptive text to the military symbol to express a specific meaning. The attribute mainly includes information such as the font, color, height, width, and background color of the annotation. The avoidance attribute means that when the local layer level changes or military symbols overlap during deduction, some
points do not need to be drawn temporarily according to the importance and priority of the military symbols. The time attribute is mainly used to describe the deductive motions that a military symbol needs to perform within a certain period of time.

2.3. Information of deductive motions
The deductive motions of military symbols mainly include path motions, growth motions, blinking motions, zooming motions, explicit and implicit motions, attribute motions, and military symbols change [9]. The current correspondence between military symbols and motion types is shown in Figure 2:

![Figure 2. Deductive motions corresponding to military symbols.](image)

Each of the military standard symbol motions can set the start and end time of the motion execution. The main control parameters of the military symbol movement are shown in Table 1.

| Type of motion                  | Control parameters                        |
|---------------------------------|-------------------------------------------|
| Path motion                     | track point coordinates, time             |
| Growth motion                   | control point coordinates, time           |
| Blinking motion                 | motion cycle, motion number               |
| Zooming motion                  | zoom factor, centerpoint coordinates, time|
| Explicit and implicit motion    | time                                      |
| Attribute motion                | Color, serif, time                        |
| Military symbols change         | id of military symbol, time               |

During the course of battlefield situation deduction, as time goes by, the positions of some military symbols need to move to represent certain military operations of combat entities in the real battlefield, such as the movement of troops in the battle, and combat forces such as tanks and aircraft to the target location perform tasks, etc. This position movement can be reflected by setting the path motion of the military symbol.

The growth motion is mainly to express the development of military entities by changing the stretched shape of the linear graphic symbol. For example, the growth motion of the arrow type military symbol can show the attacking situation of the army, and the growth motion of the barbed wire
type military symbol can show certain construction process of engineering equipment and facilities\[^{[10]}\]. Among them, the growth motion of the arrow-type military standard is most widely used in the process of situation deduction, which contains the most important and rich situation information, and has great research significance. The motion is mainly iteratively calculated through certain control points on the central axis of the arrow-like military symbol, and the military symbol calculated in each frame is rendered on the map according to the timing information, so as to achieve the deduction of the growth motion.

The blinking motion is used to highlight important military entities. In the situation map, in order to highlight the importance of some military symbols, it is necessary to set blinking motions for them during the deductive process, such as the commanding heights of the two sides in the military exercise. The zooming motion is mainly to highlight the changes of certain military entities or military operations by periodically zooming in and out of the military symbol, such as the expansion or contraction of the military assembly place during the operation. Explicit and implicit motions can be used to represent military entities that show or hide at a certain time or period of time, such as the construction of trenches and field fortifications on the battlefield, and the destruction of artillery and combat vehicles can be expressed more intuitively with explicit and implicit motions. The attribute motion is mainly to change the color of the military symbol or the serif of the linear military symbol to reflect the change of the attribute of the military entity. For example, when our army occupy the enemy assembly area or intelligence reconnaissance facility, the color of the military symbol should change from blue to blue.

Military symbols changes are mainly used to change a certain military symbol to other specific military symbol when the deductive process is carried out to a certain moment to explain the change of situation information.

3. Implementation framework of situation deductive system

In order to realize the unified organization and management of situation information, we adopt the way of situation layers to organize, manage and schedule situation information. Meanwhile, in order to improve the scalability of the architecture, the auxiliary functions are designed in the form of a global layer service\[^{[11]}\][\[^{[12]}\]. Figure 3 is implementation framework of the system:

![Implementation framework of situation deductive system](image)

Among them, the situation layer manager is the core of the entire situation deductive system, which is responsible for organizing and maintaining the logical relationship between all managers. The situational information manager is responsible for maintaining the situational information factory and cre-
ating a situational information management instance. The situation layer service manager is responsible for maintaining the creation and management of situation layer service factories and instances, and provides a unified interface for acquiring situation layer services. Situation layer is a container of all situation information, which gathers all the expressed situation information. It creates, organizes, and maintains all situation information through situation information manager. Meanwhile, by referring to the situation layer service manager to obtain the extended functions required by the situation layer. The situation layer service follows a unified service interface standard, and can expand required functions according to the interface standard, thereby providing a way for flexible expansion of system functions [13]. Similarly, situation information manager also stipulates a unified management interface standard, which can flexibly design the organization structure of situation information, such as array structure, linked list structure, tree structure, graph structure, etc., according to application needs.

3.1. Dynamic adjustment strategy of layer manager

It can be seen from the above introduction that a dynamic situation deductive map is composed of many different situation layers. Different layers represent different upper-layer applications. The system can create different layers according to different needs. During the deductive process, some derivation motions may cause military symbols to exceed the current display range, or when the scale of the map changes, some layers need to be hidden. At this time, the layer manager needs to dynamically adjust the layers to satisfy the complete expression of the deductive information. The specific strategy is shown in Figure 4:

![Dynamic adjustment strategy of layer manager](image)

Figure 4. Dynamic adjustment strategy of layer manager.

The detailed steps of the dynamic adjustment strategy in Figure 4 are as follows:
• For the picture of the current frame, the situation layer manager judges the positional relationship between the layer and the center of the window, and if there is an offset, shifts the center point of the layer to the center point of the window;
• Determine the relationship between the size of the outsourcing frame and the window of all military symbols in the layer. If the outsourcing frame is too small, enlarge the scale of the map to make the outsourcing frame fit the size of the window;
• If the outsourcing frame exceeds the display range of the window, we need to zoom out the scale of the map to make the outsourcing frame fit the size of the window. Then determine whether there is a problem of overlapping military symbols in the reduced layer. If there is, then hide some of the military symbols or some points of the military symbols according to the avoidance attribute of the military symbols.
• Determine whether the deductive process is over. If not, repeat the above process until the deduction is over.

Through the above-mentioned dynamic adjustment strategy of the situation layer manager, we can achieve intelligent zooming of the situation layer and automatic avoidance of the military symbols during the zooming process. This strategy helps the commander to observe the overall situation information and provides powerful decision support for the commander.

3.2. Interaction of Situation deductive system

3.2.1. Timing control. In the large-scale situation scenario deduction, the time axis of the situation deduction is a time comparison table between the deductive time and the actual time, which can reflect the situation in the real scene, so that the commander can perform situation analysis and combat assessment. For example, the starting point of a deductive process is \( t_0 \), and perform path motions in the \((t_0, t_0 + T_0)\) interval. Suppose that the time for a military entity to pass through a trajectory point in reality is \( t_1, t_2, ..., t_n \), then the actual time required for the motion is \( T = \sum_{i=1}^{n} t_i \), usually \( T_0 < T \). In order to correspond the time in the deductive process with the real time, this paper introduces the concept of time axis in the situation deductive model.

At the same time, because the performance process is based on the time axis, so that the same deductive motion of a military symbol in different time periods cannot overlap on the time axis, and different deductive motions in the same time period can overlap on the time axis. By setting multiple motions or even multiple identical motions for military symbols, more battlefield situation information can be expressed.

3.2.2. Deduction control. The deductive system needs to provide interactive control of the demonstration process to realize the interaction between situation deduction and the commander. The deduction control module includes global control and local control of situation deduction. Among them, the global control includes the start and end of the performance process, and the local control includes the pause and playback of the performance process. The start and end of the thread is the control of the whole situation deduction life cycle. The local control is to control the behavior of the deduced elements of the situation[14].

At the same time, the progress of the show can be controlled by designing the show control command; the play setting command can set the playback speed and the frame rate of the show during the whole process; the play progress bar can reflect the proportion of the show and the current show time. In addition, you can view the battlefield situation at different times by dragging the progress bar without playing.
3.2.3. Script control. The script control in the deductive process can provide more flexible control for the deduction in the deductive process and enrich the expressiveness of the deductive data. The main commands controlled by the script include the play scene command, play speed command, jump command, and pause reservation command, each of which has a specific execution time $T$, and other parameters of each command are shown in Table 2.

| Script command             | Control parameters               |
|----------------------------|---------------------------------|
| Play scene command         | map scale, map center point     |
| Play speed command         | play speed ratio                |
| Jump command               | jump moment                     |
| Pause reservation command  | pause time, pause duration      |

In the process of deduction, in order to highlight the situation of a local area or cooperate with reflecting the movement of the entity, sometimes it is necessary to change the range and scale of the plot display in the window to adjust the display content of the plot, highlight the local situation, this paper by setting the play scene command to achieve this function. The playback speed command is mainly used to set the playback speed in different time periods. By setting this command, you can play at different speeds in different time periods during the playback process. Play it at a slow speed for important situations and play it at a fast speed for unimportant situations.

In the battlefield situation deductive process, we may only need a certain period of situation content. In this case, you can set a jump command for the deductive process to skip unnecessary periods and directly play the situation information of the important period later. The pause appointment command can automatically pause the performance without manual intervention. The length of the pause can be set arbitrarily, which is conducive to the commander or staff to observe and analyze the situation at a certain moment, or to discuss and study the situation on the battlefield.

4. Experimental results
This paper is based on a prototype system of a high-performance geographic computing platform, which provides spatial data management services, spatial analysis services, map mapping, map icon drawing and other services. On this basis, the modeling of the above situation deductive information and the realization of the situation deductive system are completed, which verifies the feasibility and practicability of deductive system. The combat process simulated by the system is shown in Figure 5:

Figure 5: Fight process map of a battle.
5. Conclusion
The modeling and implementation framework of situation deductive information proposed in this paper can represent the changing process of battlefield situation with time. Meanwhile, this method is used to design and implement a situation deductive system on the existing platform, which can reflect the battlefield environment and reflect the motions of combatants. It shows the trend of battle, provides intuitive and rich battlefield situation expression and orderly situation deductive process, helps commanders quickly formulate battle plans, win combat opportunities, and has a profound impact on the victory of the battle.

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