A new generation framework for visual combat command system based on emergency map

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Abstract—**With the increasing requirements for power supply systems and the continuous improvement of emergency rescue command center system construction, the requirements for early warning emergency systems are constantly increasing. Improve strategic planning, decision-making, and operational command capabilities using charts, maps, and other visualization tools. Use map tools to provide the emergency command center with comprehensive on-site intelligence, quickly analyze terrain, disaster conditions, and the location of available resources, and conduct combat planning and on-site deployment. Based on the Geographic Information System (GIS) and related technologies, resource location and target information are visualized to optimize emergency resource scheduling and combat decisions. The location, movement trajectory and working status of combat units and command nodes are displayed through charts and maps, the visualization of command links and information exchange is established, and the efficiency of combat command is improved. The expansion of map combat capabilities combines advanced information technology with strategic needs and continuously explores and innovates new methods and tools to improve command decision-making efficiency, optimize combat effectiveness and ensure combat safety.**

Keywords—Emergency rescue command; Data Visualization; GIS; Resource Scheduling

I. INTRODUCTION

Based on the increasingly high requirements for power supply systems [1], the construction of the emergency rescue command center system is constantly improving. The new generation of emergency command system based on the correlation display of geographic information system (GIS)[2] has played a great role in handling emergency incidents such as the post-disaster repair of a tornado in Yancheng, Jiangsu, high-temperature power supply in Chengdu, Sichuan, heavy rain rescue in Zhuozhou, and power supply for Typhoon Dusurui, but it has also exposed several shortcomings. Incomplete display of information obtained from outside the system. It is impossible to accurately locate disasters and damage points such as earthquakes, wildfires, floods, collapsed towers, and broken wires on the map. It is impossible to support the convenience of information entry on these points. It is impossible to display the effective information of each business module in the system based on the geographical location information, such as the basic power grid, weather conditions, video equipment, team resources, equipment resources, material warehouses, vehicle resources and other information and distribution around the point. When the headquarters leaders were conducting operational commands, they were unable to highlight key information, were unable to command and coordinate operations efficiently, and lacked the means to assist in reviewing the command process.

The shortcomings above make situation analysis and strategic planning of early-warning emergencies impossible. They also need to meet the objective needs of command coordination and intelligence sharing and ultimately fail to effectively support early warning emergency response decisions. Therefore, providing a set of visual command links and information exchange systems is necessary to improve the efficiency of power supply combat command in emergencies.

II. OVERALL DESIGN

After an emergency warning incident, intelligence data is stored in the database and emergency operations are initiated. The system uses point analysis to view the distribution of various equipment resources within a radius of N kilometers from the incident point[3]. Map drawing can be performed based on the information obtained, and relevant event annotation, resource scheduling [4], etc., can be completed. The process is shown in Figure 1:

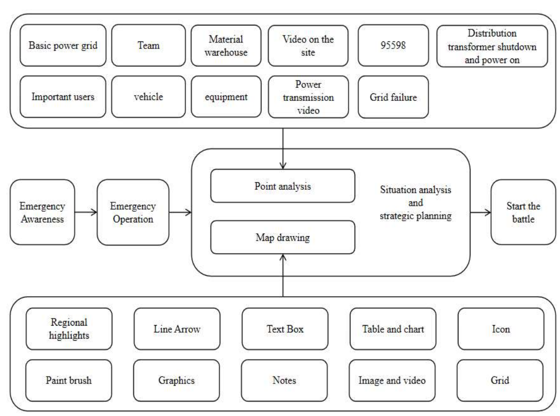

Fig. 1 Visualized combat command system overall process

A. *Ability to mark and analyze points on the map*

You can mark the location of the disaster or the location of the damage or failure on the map. You can classify and collect the points marked on the map, name them, and annotate the collected points. It supports the display and modification of favorite locations on the map. Actual meteorological conditions can be analyzed for the points marked on the map, and the distribution of basic power grids, essential users, disaster-damaged points, power transmission video equipment, in-station video equipment, team resources, vehicle resources, equipment resources, and material warehouses within a specified range around the marked points can be analyzed. It can summarize and display various analysis results, realize rapid preview of emergency command elements, and provide data support for emergency commands.

B. *Map drawing ability*

You can create plots based on GIS maps and use icons, lines, arrows, text and other plotting tools to perform combat command plots on maps. You can save the created drawings, edit and update the saved drawings, and create different versions by performing secondary operations based on the saved historical drawings. The saved historical plots can be displayed in the system, and the map scale and viewing angle can be adjusted. The created plots can also be saved to the server or exported to the local computer in the form of pictures to realize the printing and dissemination of the plots.

III. MAP MARKING AND POINT ANALYSIS

The on-map annotation and point analysis are based on GIS maps. After opening, select a point on the map, perform data analysis based on the selected point coordinates and the circled range selected by the user, display the results in a list and support viewing on the map[5].

A. *Point analysis content*

The statistical information of each analysis item around the point can be obtained according to the latitude and longitude of the marked point and the circled area. And it can be visualized on the map, so you can quickly understand the specific situation around it.

Live weather conditions: analyze the live weather information around the marked longitude and latitude.

Basic power grid: obtain information on substations and transmission lines of 500kV and above around the point.

Important users: Get the important users' information about the power grid around the point. This information can be displayed as a heat map.

Teams, Vehicles, Material Warehouses, Equipment: Get information about emergency teams, emergency vehicles, material warehouses, and emergency equipment around the location. You can aggregate scattered location information on the map.

Surrounding Video: Get the video of the power transmission lines around the point and the video information inside the station, locate the video on the map, and display the number of video devices in the form of corner marks.

Power grid failure: Obtain information on unrestored power grid failures around the point and count the substation, transmission, and distribution line failures separately.

Distribution transformer power outage and power on: Obtain the distribution transformer power outage and power on fault information around the point.

95598 power outage work order: Get the current 95598 power outage work order information around the point.

B. *Point Analysis Data Acquisition*

The point analysis data comes from 5 different platforms and is summarized and displayed in this system, making it easy to understand the specific situation of the current location at a glance, view the important data information of concern, and better formulate command plans.

The four resource data elements are obtained from the material platform, including teams, vehicles, warehouses, and equipment. Real-time weather information data is obtained from Nari Hydropower, and the weather information of the current point is displayed in real-time. Data from important users and 95598 power outage work orders from the data center. Video and business center equipment data are retrieved from the unified video platform. The power grid resource business center obtains the equipment ledger and fault data. The process is shown in Figure 2:

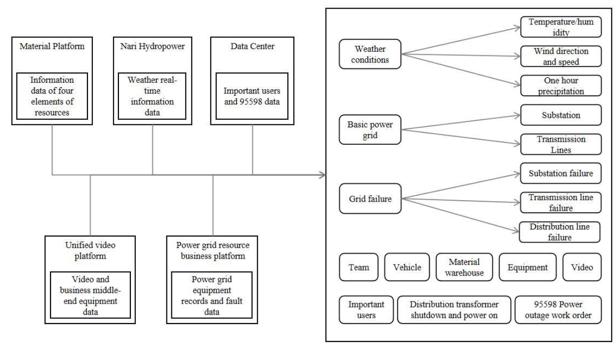

Fig. 2 Point analysis data source

C. *Point analysis algorithm*

Point analysis uses geospatial gridding algorithms[6]. By dividing the geographic space into a series of regular grid cells containing a certain geographic area and data, geographic data can be stored, queried, analyzed, and visualized more efficiently.

First, different grid division standards are set according to different application scenarios and data requirements to analyze the required data more accurately. Then, the original geospatial data is cleaned, converted and formatted to obtain a data format that meets the grid division requirements. After data preprocessing, grid division is performed, and the geographic space is divided into a series of grid cells according to the grid division standards set for the current type of data. Then, a unique code is assigned to each grid cell, and an index is established to support fast retrieval and positioning. Finally, the gridded data is used for spatial analysis, statistical analysis and visualization.

IV. MAP DRAWING

Create plots based on GIS maps and use lines, arrows, text, icons, charts and other plotting tools to plot operations on the map. Highlight some areas, mark disasters, dispatch resources, and arrange routes. The process is shown in Figure 3.

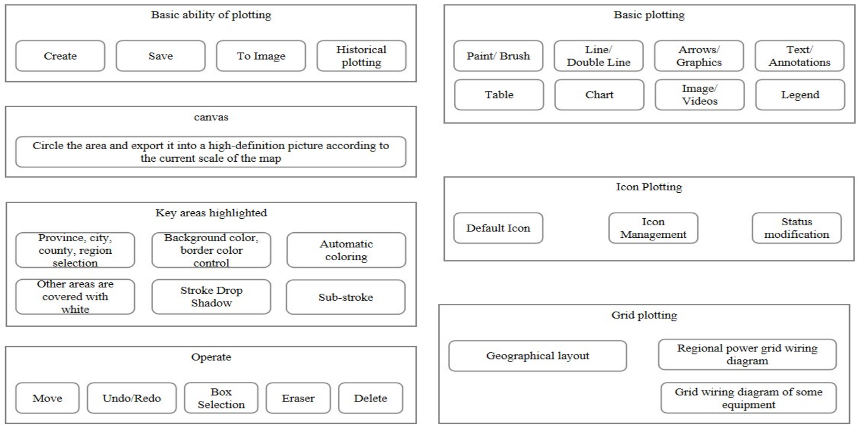

Fig. 3 Map drawing function design

A. *Basic Abilities*

Map drawing supports basic creation and saving.

It supports mapping. After the mapping editing, many manually added marks, text annotations, and other mappings help analyze the map. One can perform the mapping operation and convert the current map display into a picture for saving and downloading, which is convenient for subsequent offline use.

It supports viewing historically saved plots, and it can only view the images generated by plotting during the editing process of the corresponding plot. Historical plots can be copied as new plots for version control. It supports associating specific emergency events, which facilitates viewing plots for specific events.

B. *Plotting Canvas*

It supports delimiting an area and exporting it into a high-definition image according to the current scale of the map. Delimit an area in the middle of the map with the aspect ratio of A4 paper and drag to adjust the size and horizontal and vertical directions. After confirmation, obtain the coordinates of the four vertices. After that, no matter how the map is zoomed in or out, the final exported image will use the surface connected by these four vertices as the export surface to export a large-scale map at the community level.

C. *Key areas highlighted*

The user can select provincial, municipal, and county regions. After selection, the region will be drawn with a borderline, and a default background colour will be added. The color can be modified. The borderline supports modifying the line width and colour and supports stroke projection to highlight the borderline. A lower-level stroke switch can draw the borderline of the current level and the next level according to the province, city, and county for easy viewing.

After selecting an area, it supports white masking, which adds a layer of white mask to other areas on the map except the selected area to highlight it. It also supports automatic coloring, which can fill the lower-level areas with 4 colors and use 4 non-adjacent colors to fill the entire selected area

D. *Basic plotting*

The brush tool is used to drag on the map to draw corresponding irregular lines. The color and thickness can be adjusted.

The line and double-line tools allow users to select points on the map. It supports connecting solid lines, dotted lines, solid double lines, dotted double lines, dotted and solid lines, etc., between the selected points. Users can adjust the color and thickness.

The arrow tool connects the points clicked on the map into arrows. It supports line arrows, surface arrows, and curved arrows. It also supports thickness and color control.

With the graphics tool, user can click and drag on the map to generate the selected graphics, which support rectangles, circles, ellipses, and custom polygons after selecting the type. We can also modify the border color and thickness of the graphics, modify the fill color, and support gradient color filling.

The text tool can generate a text box anywhere on the map for text input. The annotation tool supports generating a text box with connecting lines, which can be bound to a location. After selecting a text, you can set different styles, such as font, font size, font color, background color, bold, italic, underline, etc.

The table tool supports generating a dynamic table on the map, and the table content and style can be manually controlled.

The chart tool supports the generation of bar charts, line charts, pie charts and ring charts, which can be placed on the map. The position can be modified by dragging.

The picture and video tool supports displaying a picture or video at a selected location. It can upload local resources and also supports selecting remote video library resources.

The legend tool supports the dynamic generation of legends based on the content marked on the map, making it easier for users to view.

E. *Icon Plotting*

Users can drag and drop icons from the toolbar onto the map. By default, there are four icons: resources, disaster damage, security, and power grid facilities. Icons can be uploaded and configured on the map icon management page. Icons have different states, and different states correspond to different colors. After selecting an icon, you can switch the state directly without reinserting it.

F. Grid plotting

Supports geographic layout, regional power grid wiring diagram, and equipment power grid wiring diagram. In the geographic layout, search for substations, transmission lines, and distribution lines, and then select them to draw the geographic grid of the equipment on the map. In the regional wiring diagram, select the area and voltage level, and then display all the equipment with the voltage level in the area. This line is straight, showing the relationship between the equipment. The equipment wiring diagram is the wiring diagram of a single device. After selecting it, only the device is displayed.

These three types of grid mapping make it convenient for users to mark key affected equipment on the map to conduct combat commands more clearly.

G. Operate

All plots can be moved as a whole after selecting a frame. Undo and redo operations are supported. An eraser can partially erase some plots. All plots can be deleted and copied.

V. Relation with earlier related studies

UAV aerial survey technology and quasi-real-time 3D restoration are increasingly applied for emergency rescue.[7] Mixed reality, an improvement of Virtual Reality known as MR, allows users to interact with virtual and real objects. [8] Chen et al. [9] described the construction of numerical models, the rainstorm rule calculation method and the visual maps of the emergency rescue for urban flooding. Tang et al. presented the problems in applying electric UAV visual detection and navigation technology in urban emergency rescue environments. The multiple maneuver of a group of cooperating units proposed by Nohel et al. [11] is a tactical information system to support decision-making in an emergency.

Many studies provided models and results but needed to provide a complete framework and architecture for building a total visual combat command system. This work outlines a comprehensive visual combat system for emergency operations. This work has created a framework and only large disaster management systems can apply in practice.

VI. Summary

Given the problems in the early stage of the new generation of emergency command systems, such as the incomplete display of information obtained from outside the system, the inability to aggregate and display effective information of various business modules in the system based on geographic location information, the inability to highlight key information during combat command, efficient command and coordination of operations, and the lack of means to assist in the review of the command process, this system uses charts and maps to display the location, movement trajectory and working status of combat units and command nodes, establish visualization of command links and information exchange, and improve combat command efficiency. Use map tools to provide comprehensive on-site intelligence for the emergency command center, quickly analyze terrain, disaster conditions and the location of available resources, and conduct combat planning and on-site deployment. Use charts and graphical interfaces to display on-site changes, resource scheduling and emergency response effects, monitor combat progress, and promptly make command decisions and adjustments. Based on geographic information systems (GIS) and related technologies, resource locations and target information are visualized to optimize emergency resource scheduling and combat decisions, thereby improving emergency command and combat of power supply services.

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