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Original Contribution

REAL-TIME GIS FOR MONITORING AND SECURITY

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ABSTRACT: *Applications of geographic information systems in the security domain are diverse and cover various aspects such as crisis prevention and management, public safety, national security, critical infrastructure protection and military applications. Real-time GIS is essential for effective emergency response and management because it provides accurate information on the location and dynamics of events.*

KEY WORDS: *GIS technologies in real time, monitoring, security, crisis management, critical infrastructure protection.*

1. Introduction

Geographic Information Systems (GIS) are becoming increasingly important for monitoring and security, especially in the context of the growing need for rapid and effective crisis management.

The applications of GIS in the security domain are diverse and cover different aspects such as crisis prevention and management, public safety, national security, critical infrastructure protection and military applications. The effective application of GIS technologies for security improves preparedness for response and incident management, enhances the effectiveness of services and optimises resource allocation in crisis situations.

The purpose of this report is to present the fundamentals of real-time GIS, their monitoring and security applications, and the technologies that support them. Real-time data processing allows organizations to respond quickly, thereby reducing risks and improving safety.

2. Exposition

GIS is an integrated platform for the collection, storage, analysis and visualization of geospatial data. The main components of a GIS include hardware, software, data and expertise. Real-time data processing involves

obtaining and analyzing information as soon as it is collected. This feature is particularly useful for sectors that need rapid response, such as public safety, natural disasters, and transportation management.

Data sources for real-time GIS include satellite imagery, weather stations, ground sensors and GPS devices. They play a key role in monitoring a variety of processes and phenomena, providing data collection, analysis and visualisation capabilities that support resource management, forecasting and decision-making in a variety of situations. GIS platforms enable dynamic information updating and real-time visualization, which is essential for rapid recognition and response in critical situations.

The main applications of real-time GIS for monitoring are [2.5]:

• Monitoring of natural disasters - early warning systems, monitoring of floods, landslides and fires;

• Urban and transport monitoring - traffic and transport network monitoring, public transport management, infrastructure and construction project monitoring;

• Environment and natural resource management - monitoring air and water pollution, forest resource management and tracking changes in agricultural areas;

• Health and public health - tracking communicable diseases and epidemics, monitoring health services and resources;

• Energy and resource management - monitoring electricity distribution networks, managing water resources, monitoring renewable energy facilities.

Natural Disaster Monitoring. Real-time GIS is used to create early warning systems by collecting information from various sensors and satellites that monitor weather conditions and natural phenomena. This allows rapid prediction and prevention of potential disasters such as hurricanes, earthquakes, and volcanic eruptions [6].

GIS platforms combine satellite imagery, meteorological data and hydrological sensor data to visualise potential flood and landslide risks. By modelling water flows and tracking river levels in real time, evacuations can be coordinated and damage prevented.

In forest and agricultural areas, GIS is used to monitor fires using data from thermal imaging cameras and satellite imagery. This allows firefighters to receive up-to-date information on the direction and intensity of fires, which is essential for effective fire control.

Urban and transport monitoring. Real-time GIS can collect data from GPS devices, cameras and sensors located on roadways. This enables traffic congestion tracking, congestion identification and travel time analysis. Platforms such as Google Maps and Waze use real-time GIS to guide drivers along the most optimal routes [6,7].

GIS systems allow public transport operators to monitor the movement of buses, trams and trains in real time. This leads to improved coordination of the transport network by providing up-to-date information on arrival times and possible delays.

GIS is an important tool for monitoring infrastructure, such as road and building construction. The progress of construction projects can be monitored in real time and optimal use of resources and materials can be planned.

Environment and natural resource management. Real-time GIS uses air quality sensor data to monitor pollution levels in different areas. In this way, trends in air and water quality can be analyzed, which helps to take measures to improve the environmental situation.

GIS platforms can be used to track forest conditions, monitor illegal logging and assess ecosystem health. Based on this information, conservation measures can be planned and coordinated.

Real-time GIS also helps to monitor crop conditions, water resource use and the efficiency of farming practices. This is particularly useful for farmers and agricultural agencies in managing production and resource allocation.

Health and Public Health. Real-time GIS has been widely used to track epidemics and the spread of infectious diseases. Data on the location of infected individuals allows trends and outbreaks of infections to be tracked and control measures to be taken.

GIS helps to optimally allocate health services and resources, especially during crises. By tracking the occupancy of hospital beds, the availability of medical resources and the mobility of health teams, GIS helps to manage the health system more efficiently.

Energy and resource management. Real-time GIS is an indispensable tool for power grid management. Through sensors deployed at various points, GIS systems can monitor energy consumption, accidents and power outages, which supports rapid restoration of services.

GIS collects data on river, dam and reservoir levels, enabling forecasting and management of water resources. This is particularly important for preventing water crises and ensuring sustainable resource management.

GIS can monitor the performance and status of solar panels and wind turbines in real time, helping to maintain and optimise renewable energy systems

Role of real-time GIS for security

Geographic information systems play an important role in security by providing real-time data monitoring, analysis and visualisation capabilities. This supports rapid and effective response to a variety of threats and risks related to public safety, national security and critical infrastructure protection.

The role of real-time GIS for security can be divided into several main areas [2]:

• Public safety and criminal analysis - crime analysis and prevention, patrol monitoring;
• Crisis management and disaster response - coordination of emergency services, disaster tracking and evacuation organisation, early warning and forecasting systems;
• Border control and national security protection - border monitoring, situational awareness in national security, prevention of terrorist threats;
• Critical infrastructure protection - monitoring of strategic facilities, risk analysis.

Public safety and criminal analysis. Real-time GIS is used to analyze crime areas and to visualize crimes on maps. Through this data, law enforcement can identify crime trends and patterns and allocate resources in an efficient manner. For example, predicting areas at higher risk of crime allows for rapid response and preventative action.

Real-time GIS systems allow law enforcement to track the position of patrol vehicles and coordinate their movements. This is particularly useful in emergencies where rapid deployment of teams to critical areas is required. GIS platforms optimize the response of law enforcement officers by providing a dynamic map of resources and available teams.

Crisis management and disaster response. Real-time GIS supports the coordination between the Fire and Rescue Service, the Ministry of Interior, the Central Emergency Response Centre and rescue teams. For example, in the event of earthquakes or floods, GIS provides a detailed visualisation of the affected areas and the distribution of emergency resources, which is key to a rapid response.

GIS platforms use satellite and aerial imagery to track fires, hurricanes and floods. They provide information on the evolution of disasters, which supports informed decision-making for evacuation and rescue operations.

Real-time GIS can collect data from weather stations and other sensors to enable forecasting and rapid response to natural disasters and emergencies. GIS-based early warning systems inform local authorities and the public of impending hazards.

Border control and national security protection. Real-time GIS is used to monitor border areas through integrated sensors, cameras and drones. This allows tracking of illegal border crossings and other suspicious activities. For example, GIS can be used to set up an alert system for violations and to dispatch security teams on the spot. The European Border and Coast Guard Agency (Frontex) uses GIS to monitor borders and detect illegal crossings and human trafficking.

Military structures use GIS for real-time operational planning and coordination. GIS provides accurate information on the terrain and force

positions, which is essential for the effective conduct of military operations and national security.

GIS assists in analyzing data on terrorist activities and vulnerabilities such as critical infrastructure sites. Security organizations can use GIS to map potential risk points and plan countermeasures.

Critical Infrastructure Protection. Real-time GIS helps monitor sites such as power plants, water supply facilities and transportation networks. GIS systems collect data on the condition and vulnerability of infrastructure, allowing timely intervention in the event of accidents and security breaches.

GIS systems provide data on various risk factors around critical infrastructure. This allows organisations to identify vulnerabilities and implement protection measures. For example, GIS can be used to analyse areas with a higher probability of natural disasters and take measures to strengthen facilities in these areas.

GIS can be used to track the movement of vehicles carrying dangerous goods such as gas and chemicals. This allows security services to monitor the risks associated with transporting hazardous substances and take safety measures.

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Cybersecurity and data protection. Real-time GIS helps to visualize the origin of cyber attacks by providing information on the locations of attacking IP addresses and the locations targeted by the attack. This allows cybersecurity teams to locate the sources of attacks and take measures to protect networks.

GIS systems used for national security and public safety process sensitive information. Therefore, they need secure data access and encryption protocols to prevent unauthorized access and cyber attacks on critical data.

Technologies used for real-time GIS monitoring and security [1,3,4,8]:

- Satellite imagery and aerial photography: enables rapid mapping of areas and monitoring of threats in remote and inaccessible areas, as well as offering up-to-date information on large geographical areas and supporting monitoring of natural and anthropogenic changes.
- Sensors, cameras, IoT and GIS technologies: collect data on movement and activity around strategic sites and border areas, providing real-time security information. By measuring parameters such as temperature, humidity, air quality, water levels, traffic movement and the location of citizens in risk situations, the devices provide important data for GIS platforms. IoT and GPS are indispensable in real-time data collection.
- Drones and UAVs: Provide aerial monitoring of special access areas such as borders and critical infrastructure.

• GNSS technology: Global Navigation Satellite Systems (GNSS) provide the precise geographical coordinates needed to locate and track objects in real time.

• Cloud platforms and network infrastructure: cloud services enable real-time storage and processing of large volumes of data, providing rapid access to geospatial information for multiple users and organisations.

3. Conclusion

Real-time geographic information systems are becoming a powerful monitoring and security tool, finding applications in a wide range of sectors such as public safety, disaster management, transportation and environmental protection. Through the integration of various technologies such as sensors, GPS, IoT devices and cloud platforms, real-time GIS enables dynamic spatial data collection, processing and analysis, greatly improving management efficiency and decision-making.

In the security domain, GIS provides capabilities for criminal analysis and crime prevention, crisis coordination, border surveillance and critical infrastructure protection. Real-time data enables rapid response and better allocation of resources, especially in emergency situations. GIS platforms are also used to predict and control disasters through early warning systems that collect information on natural and meteorological conditions.

Despite the benefits, real-time GIS faces challenges related to handling large volumes of data, ensuring network connectivity, protecting personal information, and cybersecurity. In addition, organizational and legal constraints, such as data protection regulations and the need for trained personnel, require significant resources and a well-coordinated effort to use these systems effectively.

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And in the future, real-time GIS will play a critical role in modern security management and monitoring. With the continuous development of technologies such as artificial intelligence and 5G, and the response to the challenges of data collection and protection, GIS will continue to contribute to creating a more secure and sustainable environment.

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