Design and implementation of forecast and early warning system for offshore platform based on GIS

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Abstract. A forecast and early warning system for offshore platform was developed to reduce security risks of offshore operations. The tool uses an ArcGIS Server as electronic chart display and system platform, in combination with Silverlight, WCF Service and AIS. The system incorporates management of offshore platforms, subsea pipelines and warning zones, as well as real-time monitoring and early warning for typhoon and ships around the platform. This system has been put into use on offshore platforms, and the system's powerful early warning capabilities, excellent experience and performance have been recognized by the user.

1. Introduction

Ship and oil platform collision accidents occur around the world with a high frequency. In the event of such an accident, the resulting casualties, property damage and environmental damage are staggering. With the continuous increase of China's marine development, various offshore oil production platforms, land terminal treatment plants and oil refining companies are also growing and growing. Poor meteorological environment, frequent typhoons make it difficult to develop deep water oil and gas resources in the South China Sea.

Many offshore oil production platforms have built early warning systems such as large column tension and compass data, single point positioning to reduce safety production risks. SHEN in [1] has discussed the use of ArcGIS as a GIS display platform, and described the key technologies, system functions and architecture used by the integrated marine early warning platform; XIA in [2] used a comprehensive management system consisting of computer network technology, information processing technology, geographic information technology and other advanced systems to predict and evaluate the security risks of offshore platforms; SUN et al. in [3] have developed a channel management platform based on the AIS system to display the static and dynamic information of the ship on the electronic chart, and achieved good results; SHAO et al. in [4] have used MapX control to construct a GPS/GIS/GPRS integrated information processing platform, which realized functions such as chart production, ship positioning and navigation track recording, providing remote monitoring and security control for offshore oilfield operations and shipping; FENG et al. in [5] have developed a ship integrated information service system based on electronic chart display and information system and AIS, which realized real-time AIS information collection, real-time display of charts, flexible query of related information, statistical analysis, trend prediction and other functions; HE et al. in [6] used the improved analytic hierarchy process to conduct safety risk assessment of risk factors for offshore
drilling platforms and obtain quantitative warning results; SHENG et al. in [7] proposed the problems and countermeasures for the typhoon emergency procedures based on the implementation of the typhoon emergency procedures for a deep-water drilling platform in the South China Sea, and pointed out that the main factor to be considered in the typhoon emergency procedures is time.

Due to the inconsistent construction pace of each operation area of each offshore oil production platform, and only the safety risks of the oil production platform are evaluated during the construction process, the common factors affecting the safety of the platform, such as ship collision and typhoon, are not comprehensively evaluated, and the first stage of the oil production platform cannot be realized. To this end, this paper uses ArcGIS as a GIS display platform to study the factors affecting the safety of offshore oil production platforms, and to achieve safety risk prediction and early warning.

2. Offshore oil production platform disaster prediction and early warning

The factors affecting the safety of platform oil and gas operations are multi-faceted and generally divided into natural disasters and non-natural disasters. The factors affecting the safety of offshore oil production platforms are shown in Figure 1. This paper selects the more common and serious hazard factors: typhoon and ship collision for prediction and early warning.

![Figure 1. Factors affecting the safety operation of offshore oil platforms.](image)

2.1. Typhoon disaster

A typhoon is a highly destructive low-pressure vortex that occurs on tropical oceans. Typhoons are easily formed in the Pacific Northwest and the South China Sea in the summer and autumn. China's offshore oil and gas fields are basically affected by typhoons, but the extent and scope of the impact is different.

The wind speed of the typhoon can reach more than 60m/s, and the strong wind pressure acts on the structures such as platforms and ships, which can cause great damage. Not only can the platform derricks on the sea be blown down, the ship can be overturned, and the collision between the ship and the platform can be caused, resulting in huge economic losses. Timely and accurate prediction of typhoon path and typhoon impact range can effectively mitigate the damage caused by typhoon to the platform. Meteorological stations such as the Central Meteorological Observatory and the Japan Meteorological Agency provide global typhoon path forecasting messages with high accuracy. In this paper, the typhoon message of the above station is used to forecast the impact range of the typhoon.

| Table 1. Typhoon impact radius prediction. |
|-------------------------------------------|
| Prediction time (h) | 24 | 48 | 72 | 96 |
| Influence radius (km) | 150 | 210 | 240 | 270 |

The typhoon influence radius can be predicted by using the typhoon influence radius (as show in Table 1), as shown in Figure 2 (the slash area is the typhoon warning area).
2.2. **Ship collision**

With the increasing number of offshore platforms, accidents involving collisions between ships and platforms often occur and may cause serious consequences. Therefore, research on collision problems of ships has attracted people's attention. In recent years, the use of the ship's AIS system has provided accurate position information for preventing ship collision platforms.

AIS is a new type of digital navigation aid system integrating network technology, modern communication technology, computer technology and electronic information display technology. It consists of shore-based (base station) facilities and ship borne equipment. AIS establishes a navigation data exchange between the ship and some other ships and coast stations through a broadcast communication system. It is a radio data link system consisting of two or more stations operating on one or more channels. The device can be a mobile station or a base station. The offshore platform monitors the platform and the ships around the sea pipe in real time through the AIS system. When the ship is anchored above the sea pipe or enters the platform early warning zone, the system issues an early warning signal and the staff takes corresponding emergency measures.

3. **System implementation**

3.1. **Key technologies**

3.1.1. **Silverlight**. Silverlight is a cross-browser, cross-platform plugin that brings a .NET Framework-based media experience and rich interactive applications to the web. It not only combines the advantages of Client/Server mode and Browser/Server mode, but also combines the advantages of fast response and strong interaction of desktop applications. The Silverlight technology that implements the RIA application uses the XAML language to describe the multimedia interface, implements rendering logic on the client, and communicates with the Web services distributed over the Internet through the network to obtain data resources.

Silverlight provides a flexible programming model that can be easily integrated into existing web applications. For mainstream browsers running on Macintosh and Windows, Silverlight provides a unified and rich user experience, with Silverlight plug-ins, video, interactive content, and other
applications that fit together. Silverlight’s powerful vector graphics technology, rich animation effects and perspective 3D effects, as well as the unique Deep Zoom technology enhance the user experience.

Silverlight supports multiple development languages and can easily integrate and interact with existing websites. Developers can use the familiar Visual Studio to create business logic. Designers can use the Microsoft Expression design interface, which is the first choice for business application development. Silverlight combines video, interactive content, and other formats to integrate powerful image and layer technologies to seamlessly integrate images of any size and add buttons, titles, or other interactive content to images.

3.1.2. ArcGIS API for Silverlight. The ArcGIS API for Silverlight is a set of programming interfaces for developing WebGIS applications on the Silverlight platform from Esri, USA. The ArcGIS API for Silverlight accesses ArcGIS Server's published map services, image services, geometry services, geoprocessing services, network services, etc. through the REST interface, as well as access to OGC-standard WMS, WFS, and WCS services.

The ArcGIS API for Silverlight provides powerful GIS capabilities for map development, such as spatial data presentation, graphics rendering, symbol rendering, geoprocessing, network analysis, online editing, temporal awareness, image processing, and map output. Online editing allows users to efficiently manage spatial data such as platforms and sea pipes.

3.1.3. WCF service. WCF (Windows Communication Foundation) is a service-oriented distributed layered architecture proposed by Microsoft. It integrates all the technologies related to distributed systems under the .Net platform and provides a solution for developing distributed systems in various environments. A unified and efficient method. WCF is a framework product based on the .Net platform launched by SOA (Service Oriented Architecture). It represents a development direction of software architecture design and development, and also plays a very important role in Microsoft's strategic plan. WCF is a unified framework for building and running Service Oriented applications using managed code, enabling developers to build a cross-platform, secure, transactional, transactional solution that works with existing systems.

The combination of Silverlight and WCF services is in line with the development trend of web applications. Silverlight is a client-side execution environment that does not work directly with ASP.NET. WCF services provide framework components, tools, and services to enable Silverlight clients to share application logic with the server.

3.2. System implementation

On the basis of meeting the basic needs of map operations, the offshore platform forecasting and early warning system also provides chart management, ship information management, early warning area management, meteorological information management, typhoon information management, regional location management, system management, etc. As shown in Figure 3.

3.2.1. Ship information management. Ship information management mainly includes ship inquiry, ship real-time trajectory tracking, ship track playback, alarm mode setting, sending messages, etc.

Ship queries are divided into attribute queries and spatial queries. Attribute query refers to the ship that can be maritime navigation within the current map and can be received by AIS equipment by ship name, MMSI number, IMO number, ship status, ship type, etc. The spatial query is to draw a point, line, and surface to generate a buffer on the map, and query the ship within the current buffer range.

The alarm mode refers to the type of alarm when the ship enters the early warning area. The user can set the method as “flashing prompt”, “color change prompt”, “voice prompt”, etc., and send a short message to the ship. Ship real-time trajectory tracking refers to the location of the ship's real-time location through AIS and displays the location on the map. Ship track playback is a function to realize the playback of the ship's historical track.
3.2.2. Typhoon information management. Typhoon information management includes live typhoons and historical typhoons. The live typhoon displays the currently active typhoon information and forecasts the extent of the typhoon (Figure 4) to reduce the impact of the typhoon on the platform and the surrounding heading vessels, minimizing losses.

The historical typhoon query is to query the typhoon that has occurred in the database according to the query conditions, and display its trajectory on the map.

![Figure 4. Real-time typhoon management.](image)

3.2.3. Early warning area management. The early warning area management is an early warning area established to ensure the safety of the platform and the sea pipe. After the ship enters the early warning area, it will give an alarm prompt to provide a basis for the safety decision of the management personnel.
3.2.4. **System Management.** System management enables the management of organizational members and the allocation of permissions. The system strictly controls the operation authority and display content according to different usage requirements to ensure the security and confidentiality of the system data.

4. **Conclusions**

Based on the analysis of the factors affecting the safety of oil and gas development on offshore platforms, this paper selects the more common typhoon disasters and ship collisions for disaster warning, and develops a GIS-based offshore platform forecasting and early warning system to realize chart management, ship information management and early warning area management, meteorological typhoon information management, regional location management, system management, etc. The system has been put into operation on the offshore platform of China National Petroleum Corporation. The system adopts B/S architecture, which is easy to install, deploy, upgrade and maintain, and has strong scalability. The centralized storage management of data makes the data more real-time, secure, unified and complete, and the superior performance of the system is recognized. However, there are many factors affecting the safety of offshore platforms. In addition to typhoon disasters and ship collisions, there are sea ice, earthquakes, and oil spills. Therefore, the GIS offshore platform forecasting and early warning system must also be continuously upgraded and improved, and expand its disaster warning range to make it truly a comprehensive disaster prediction and warning system.

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