Research on WebGL-based 3D Visualization Platform for Earthquake Rapid Reporting

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Abstract. In the era of big data, after the devastating earthquake, the amount of information required for earthquake emergency has increased geometrically. In order to display various geological, environmental and meteorological information more intuitively, network 3D visualization has become the Core technologies that were indispensable in terms of Geographic process dynamic simulation, visual analysis and synergistic decision. This paper introduced WebGL+HTML5 technology as the underlying development platform, ArcGIS API for JavaScript as the map access interface, and realized the WebGL-based seismic rapid report 3D visualization platform. The coordinate conversion algorithm has been used to realize the latitude and longitude coordinate offset algorithm, which solved the position error caused by the secondary encryption of Baidu map and Google map during positioning location. The 3D measurement function in ArcGIS API for JavaScript realized the display of the distance, area and attribute information in 3D environment, used ECharts and memory optimization technology to improve the browsing efficiency of the platform on the mobile terminal and optimize the display interface. The implementation of this system could provide technical and decision support for earthquake workers in earthquake emergency response.

1. Introduction
In the era of big data, after the devastating earthquake, the amount of information needed for earthquake emergency has increased geometrically. In order to display various geological, environmental and meteorological information more intuitively, in the era of big data, network 3D visualization had become the Core technologies that were indispensable in terms of Geographic process dynamic simulation, visual analysis and synergistic decision. The traditional 3D geographic data visualization software has stayed in the fat client mode for a long time. Users generally needed to download the client plug-in, which was not only time-consuming and labor-intensive, poor browser compatibility, but also had huge security risks, and network integration applications were also more difficult. With the rapid development of the Internet in three dimensions, the development conditions for plug-in-free and lightweight three-dimensional geographic information systems had gradually matured.

In today's rapid development of data visualization and data mining, in order to display the charm of data more directly and make the visualization easier available for a wider range of users, this article took "mobile internet" as an opportunity, took the geographic data three-dimensional interactive visual service as the core, explained the adoption of WebGL+HTML5 technology as the underlying development platform, ArcGIS API for JavaScript was used as a map access interface, which could be
quickly rendered using the WebGL standard embedded in the browser. It could enhance the user interface of the web application using 3D graphics without any third-party plug-ins, and based on this, to display the three-dimensional scene of the earthquake sources. Then it can realize an earthquake quick report three-dimensional visualization platform based on WebGL. The system studied and elaborated on how to use the coordinate transformation algorithm to realize the latitude and longitude coordinate offset algorithm, which solved the position error caused by secondary encryption when Baidu map and Google map during positioning location. The system used the ArcGIS API for JavaScript technology to display the distance, area and attribute information in 3D environment. It also used the ECharts and memory optimization technology to improve the browsing efficiency of the platform on the mobile terminal and optimize the display interface, so that earthquake workers could quickly find residential areas according to the three-dimensional topographic map of the disaster area, and reach the disaster relief area faster; In order to facilitate the earthquake workers’ analysis of the earthquake situation and the decision of the rescue work as the research goal, the information could be quickly and accurately released, at the same time the 3D scene of the earthquake sources could be quickly displayed through the mobile app and the PC terminal page. The system provided a comprehensive understanding of the earthquake sources information to provide technical support, and it could provide earthquake workers with more intuitive, faster, more accurate and more comprehensive disaster information, and facilitate earthquake workers to analyze the earthquake situation and make decisions on rescue work.

2. Data collection
The core data in the earthquake rapid report was earthquake damage information. This paper used all historical disaster seismic information recorded since 1949 in China, information on environmental, population, economic, historical earthquakes of more than 3,000 cities, as well as global historical seismic information and fault zone information. Based on this, a geographic information base and a basic information base were built and stored in each module. On the Web terminal, ArcGIS API for JavaScript was used to embed the map resources and other resources (ArcGIS Online) provided by ArcGIS Server into the 3D scene of the earthquake center, and visually analyze the environmental information, economic information and population information of the nearby towns in the epicenter. On the mobile phone terminal, it was combined with the chart visualization library ECharts to draw a variety of charts, displayed the various data in the H5 page intuitively, rendering the page with JavaScript, CSS.

The system obtained the town information in the Google map by inversely analyse the latitude and longitude address, and matched the information with those in the basic information database, and inserted the information obtained after the matching was successfully into the earthquake sources record table in the database in sequence, and generated an earthquake sequence, after the earthquake was released, the system will use WebGL drawing technology to display the terrain near the epicenter in 3D. However, when the latitude and longitude address was reversedly analyzed to obtain the town information, the latitude and longitude will be deviated. The reason was that not any map product in China was allowed to use GPS coordinates, which was intended to be confidential. According to the Internet map service regulations, the domestic Internet map must use the gcj02 coordinate system encrypted by the National Bureau of Statistics. The Google map introduced in this system was using the coordinate system. However, the displayed page of seismic information in the system was based on Baidu map. Baidu used BD90 coordinates for double encryption of latitude and longitude, bd09l indicates Baidu latitude and longitude coordinates, and bd09mc indicates Baidu Mercator coordinates. This is the reason why we used Baidu map in the displayed page of seismic information in the system. Therefore, it was necessary to use a latitude and longitude offset algorithm to convert the coordinates accordingly. The latitude and longitude offset algorithm was as follows:

Define a constant k, k was obtained by a series of conversions from the pi, define the variables Z, theta, set the latitude to m, set the longitude to n, the converted latitude to m1, and the converted longitude to m2. As shown in equation (1):

\[ K = \frac{\pi \times 3000.0}{180.0} \]

\[ Z = \frac{\sqrt{m \times m + n \times n}}{0.00002} \times \sin(n \times k) \]
\[ \theta = \tan^2(n, m) + 0.000003 \times \cos(m \times k) \]
\[ m_1 = Z \times \sin(\theta) + p_1 \]
\[ n_1 = Z \times \cos(\theta) + p_2 \]

After many calculations, the latitude and longitude offset constants were obtained, as shown in equation (2):
\[ p_1 = 0.006 \]
\[ P_2 = 0.0065 \]

Through the algorithm, the correct epicenter of the earthquake was obtained, it ensured the accuracy of the seismic information.

3. Construction of 3D Platform

3.1. Platform architecture

The system used the progressive front-end framework Vue combined with HTML5, ArcGIS API for JavaScript, CSS3, JavaScript to develop client terminal, PHP as the background development language, with the ThinkPHP framework to provide background interface services, used MySQL database to store data, open source server Apache as the Web server Using axios technology to asynchronously load data to achieve data access and transmission, used ECharts and memory optimization technology. It used a front-end separation architecture to build a three-dimensional platform for earthquake rapid reporting.

3.2. 3D map visualization

3D map was a 3D model built by using virtual reality technology. It used multimedia technology and 3D visualization technology to incorporate images, texts, sounds into the application under the same window system, so it has virtual, dynamic, interactive and other network features. Therefore, the production process was more complicated.

At present, the traditional Web3D technology for implementing three-dimensional data includes: VRML, X3D, JAVA3D and other technologies, all of these need to install plug-ins or load components, and it had the disadvantages of complicated operation and poor compatibility. In addition, some domestic 3D map applications, such as Baidu, AMAP and other map services, they could only achieve a pseudo-three-dimensional effect of a single perspective, while other applications had not achieved a true three-dimensional effect. Therefore, after many discussions and research as well as refer to a large number of domestic and foreign books, the system used WebGL-based ArcGIS API for JavaScript technology, the ArcGIS API for JavaScript was a set of scripts that ESRI implements based on JavaScript technology to invoke the ArcGIS Server REST API interface. Map resources and other resources (ArcGIS Online) provided by ArcGIS Server could be embedded into web applications through the ArcGIS API for JavaScript. In support of HTML5 browsers, the JavaScript API provided a smooth user experience by integrating CSS3 when scaling and panning. ECharts was also used to display...
weather information on the App, web terminal, and optimized the display interface. The use of data stream analysis in memory optimization technology improved the browsing efficiency of the platform on the mobile terminal. It was a compile-time technology that collects the semantic information of the program from the program code and determines the definition and use of variables at compile time through algebraic methods. Through data flow analysis, user could discover the behavior of the program at runtime without actually running the program, which could help user understand the program. Data flow analysis was used to solve problems such as compiler optimization, program verification, debugging, testing, parallelism, vectorization, and line-programming environments.

ArcGIS for JS was a JavaScript framework based on WebGL combined with the elevation information published by ArcGIS, the 2D map was used as a basemap to load 3D scenes. The elevation information was used to describe the terrain fluctuations, and 3D map visualization was realized. The reality of the scene was preserved to a large extent, providing more accurate data for earthquake workers.

3.3. 3D utility function

The three-dimensional map combines elevation information and satellite image data to more realistically present a three-dimensional terrain scene of the disaster area. It enabled the earthquake workers to understand the disaster area most intuitively. This system accurately render the epicenter by obtaining the detailed position by latitude and longitude on the 3D topographic map, taking the epicenter as a basic coordinate. The two-point latitude and longitude distance algorithm was used to find the historical earthquake near the point and rendered it on the 3D topographic map. The system took the epicenter point as a basic coordinate, the nearest towns closest to the earthquake point were obtained by the two-point latitude and longitude distance algorithm and rendered on the three-dimensional topographic map. The information such as time, population, economy, and magnitude of the epicenter could be displayed by clicking the epicenter icon, nearby towns, historical earthquakes could also pop up the corresponding information of the annex towns and historical earthquakes.

Based on the two-dimensional map, this paper added elevation information and appropriate space distortion, introduced the sky map, used the tile technology to process the map and slices the map, used a certain slicing algorithm, and formed map tiles by equal division of latitude and longitude, to locate a specific place. In a traditional two-dimensional map, the scale could easily estimate the distance between two points. However, 3D maps were not that simple. The variable viewing angle transformation and the different heights of the viewing angle from the ground greatly increase the difficulty of estimating the distance. For this reason, the system added the measurement function to the 3D topographic map, using the DirectLineMeasurement3D function in the ArcGIS API for JavaScript. If user used this widget in SceneView to operate, it can measure calculations and display the 3D distance between two points. The DirectLineMeasurement3D part marks the line, the horizontal and vertical orange distance lines, and displayed the same value in the UI panel. When the widget was active, a horizontal "laser" line was drawn to indicate the height of the current mouse position. This line could help analyze the height of objects relative to each other and the terrain. The second laser line showed the point of intersection of the scene and the vertical plane through the grid line. In a WGS84 or WebMercator scenes, when the distance between points was greater than 100 km, the DirectLineMeasurement3D component switched...
to display only the horizontal and vertical distances, it took into account the curvature of the Earth (the ellipsoid-based geodetic distance). By obtaining the latitude, longitude and elevation information of the two points selected by the user's mouse in the map, the horizontal distance was calculated by using the latitude and longitude, and then the vertical distance was obtained according to the altitude information. Finally, the actual distance between the two points was calculated by using the Pythagorean theorem, and used lines to mark the path between two points in the map, and provided a variety of distance units conversion to achieve distance measurement. Similarly, the WereaMeasurement3D component was used to calculate and displayed the area and perimeter of the polygon. It was also used in SceneView to measure the area and perimeter of the polygon to achieve area measurement. Measurement components could also be used for all types of layers, including PointCloudLayer or IntegratedMeshLayer. If the user needed to save the 3D scene after a series of operations, we also provided a screenshot download function in the 3D topographic map to facilitate the user to save the information. Because the traditional satellite image could not display the annotation information, ArcGIS only provided the English annotation service, which was not convenient for users. Therefore, the system finally used the satellite image as the 3D base map of the map, and introduced the domestic road network information in the sky map service as map annotation.

Figure 3. 3D measurement tools.

4. Conclusion
This paper combined the advantages of WebGL, based on HTML5, ArcGIS API for JavaScript, combined with latitude and longitude migration algorithm, tile technology and 3D scene scheduling technology to establish a 3D visualization system of earthquake rapid report with B/S architecture, which could provide faster, more accurate and more comprehensive disaster information for earthquake workers. Then it can also facilitated earthquake workers' analysis of the earthquake situation and provided decision support of rescue work, and promoted the development of the 3D seismic Web terminal.

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