Study on Mobile Object Positioning and Alarming System Based on the “Map World” in the Core Area of the Silk Road Economic Belt

Kai.Mu\textsuperscript{1,2,3}

1 Xinjiang of Academy Surveying and Mapping, Urumqi 830002, China;
2 Engineering Research Center of Central Asia Geoinformation Development and Utilization, National Administration of Surveying, Mapping and Geoinformation, Urumqi 830002, China;
3 NO.2 Institute of Surveying and Mapping Xinjiang Uygur Autonomous Region, Urumqi 830002, China;
author’s e-mail 21650998@qq.com

Abstract. The established “Map World” on the National Geographic Information Public Service Platform offers free access to many geographic information in the Core Area of the Silk Road Economic Belt. Considering the special security situation and severe splittism and anti-splittism struggles in the Core Area of the Silk Road Economic Belt, a set of moving target positioning and alarming platform based on J2EE platform and B/S structure was designed and realized by combining the “Map World” data and global navigation satellite system. This platform solves various problems, such as effective combination of Global Navigation Satellite System (GNSS) and “Map World” resources, moving target alarming setting, inquiry of historical routes, system management, etc.

Key words: Positioning system; Alarming system; Ray casting algorithm; J2EE platform; B / S structure; GNSS; Silk Road Economic Belt.

1. Introduction
Locating in the northwest border of China, Xinjiang where covers an extensive territory and has special natural environment, climate conditions and frequent natural disasters is facing with very severe splittism and anti-splittism struggles, which is related with the complicated surrounding environment. This brings potential threats against stability. Therefore, the position-based geographic information service platform is crucial to autonomous region management.
The established system is to support service demands based on accurate positions in different industries and departments in the study area, promote the Map World service platform, make full use of the Map World data, fulfil the Map World safeguarding service based on the overall goal of social stability and long-term peace in Xinjiang, and protect life safety of stability protectors.

2. Materials and methods

2.1 System structure

The system employs the MVC framework, releases JSP (Java Server Pages) to server through Tomcat, accesses to the database by JavaBean, constructs the platform using JSP, JavaBean and Java Servlet of J2EE, and establishes the dynamic portal system.[1][2][3].

Model layer: it realizes business logics of the system, that is, the JavaBean [4].

View layer: it is responsible for communicating with users. In other words, data objects are displayed on the interface to users, that is, html and JSP [5].

Control layer: it serves as the communication bridge between the Model layer and View layer, and can assign user requests, choose appropriate views for display, explain user inputs and map them into executable operations of the Model layer. This is the responsibility of Servlet [6].

2.2 Map World API

As an application programmers interface based on new JavaScript upgrading, the Map World Web API (JavaScript) V2.1.2 provides developers a channel for fast call of online geographic information service of the Map World, including quick map creation, map access, POI search and adding covering on the map. Based on Web API of the Map World, developers can embed its abundant map functions into different application systems or websites as well as realize various value-added services and applications based on its data and function service resources [7].

The Map World Web API (JavaScript) V2.1.2 has following characteristics:

1. Quicker map loading and smoother display.
2. More stable map service and convenient use.
3. The latest map style and better visual effect.
4. Compatible with mainstream browsers.
5. Map browsing and switchover based on two projections: geographic coordinate system and spherical Mercator

2.3 Ray casting algorithm

Positional relationship between personnel and the “fence” was calculated through the underlaying programming and superposition of geographic information algorithm in the Ray casting algorithm (induce the ray through points, judge parity of times for the ray to pass through the polygon, and calculate hypernymy relation between the point and the polygon). Next, the logic relationship between personnel position and other “fences” was distinguished through the logic operation (in the administrator mode, it is also necessary to distinguish the logic relationship with other users). Finally, whether users are in the “fence” is determined and then alarming information is sent. It realizes communication with smart phone end.
through Web Service technology.

In this paper, the positional relationship between personnel and the “fence” was determined by encoding of the Ray casting algorithm. Firstly, personnel position information is the only one “fence”, which can refer to one or several persons. If the personnel is in the “fence”, it is “true”; otherwise, it is “false”. The positional relationships between this personnel and all “fences” were calculated by this algorithm. If all positional relationships are “false”, he sends the alarm information out of the “fence”. If one positional relationship is “true”, exit from the calculation and conclude that he is in the “fence”. In the administrator mode, it is necessary to analyze the multi-users situation by the same method. Finally, the communication between the platform and smart phone end was realized and alarm was sent to users through the Web Service technology when the personnel is out of the “fence”.

A concave polygon with 14 sides is shown in Fig.1. Whether the red point is in the polygon shall be determined.

The Y coordinate of the test point was compared with each point of the polygon, getting the list of intersection between the line where the test point lies on and the polygon. In this case, 8 sides intersected with the line and rest 6 sides didn’t. If the point number at two sides of the test point is odd, the test point is in the polygon; otherwise, it is out of the polygon. In this case, the test point had five intersections in the left and three in the right, indicating that it is in the polygon[8].

(Note: This algorithm is applicable to both clockwise and counterclockwise polygons.)

![Figure 1.normal situation of ray casting algorithm.](image)

However, there are some special situations. Self-intersecting of a polygon is shown in Fig.2. In this case, 10 sides of the polygon cross mutually, which is similar with “XOR” in assembly language. Overlaps in the polygon were deleted[9]. Therefore, the test point is out of the polygon, which was proved by the intersection number (2 intersections) at two sides of the test point.

In Fig.2, the polygon has no overlap, but two sides intersect. The algorithm is also applicable under this circumstance.
In Fig. 3, the scanning line where the test point lies on just passes through one vertex of the polygon and intersects with side a and side b, forming two intersections. Similar phenomenon is found on the right of the test point. According to the proposed algorithm, the test point is out of the polygon. However, this is obviously wrong.

Figure 2. Self-intersecting polygon situation.

Figure 3. Two edges intersect but no overlap polygon.

Figure 4 shows that test point leads rays through exactly one vertex of the polygon. Therefore, there is a ray with a side of the intersection, and the side b is also a point of intersection, a total of two corners, right test point is the same situation. According to the algorithm that test point outside the polygon conclusion [11].

It is simple to solve this problem. Two end point at two sides of the scanning line is the key to determine whether the point on the side intersects with the scanning line. In this paper, end points on or above the scanning line is viewed same. In Fig. 4, one end point of side a is below the scanning line and the other one is on or above the scanning line, indicating that side a intersects with the scanning line. Two ends of sides are on or above the scanning line, so it doesn’t intersect with the side b.
Figure 4. The ray through exactly one vertex of the polygon.

One side of the polygon exactly coincide with the ray of the case shown in Figure 5. According to one FIG. 4 specifically described an endpoint of the edge c below the rays and another endpoint on or above the ray, so there is the edge c and ray have one intersection point. Two endpoints of the edge d are on the ray, so no intersection point. Two endpoints of the edge e are on or above the ray, so there is no intersection point. Finally judgment test points inside the polygon because test point and c, d, e the edge have an intersection point [12].

Figure 5. One side of the polygon exactly coincide with the ray.

3. Results and test

3.1 System Architecture

The system is mainly divided into 8 modules (positioning module, alarm module, query model, communication model, user module, map module, linking module and maintenance module) and 22 main functions. Modules are described as follows:

Linking module: it is responsible for connection of GPS, transmission data of BD satellite receiver and the database.

Positioning module: it is mainly to feedback data through the receiver and realize real-time personnel positioning, assigned “fence” positioning and historical track positioning on the Map World based on “fence” setting data.
Alarm module: it calculates positional relationships between the personnel and the corresponding “fence” by the ray method, realize “fence” alarm based on logics operation, and give power alarm and SOS alarm by judging feedback data of the receiver.

Query module: it is mainly to search with key words, give amplified display the interested personnel information in the middle of the map, browse complete information in the left column, search “fences” in list pattern, query historical records based on the structure tree, and search information under limited conditions, including unit, instrument mode, alarm type, etc.

User module: It is mainly in charge of user registration, account management, personnel management, permission assignment and login verification.

Map module: it is equipped with interested information selection, personnel display and “fence” display except for the basic map service functions of the Map World API.

Maintenance module: it offers database maintenance, including adding, deletion, modification and query of personnel information as well as visual adding and deletion of “fences”.

Communication module: alarm information is sent to appointed cell phone as SMS.
Positioning
module

Alarm
module

Query
module

Communication
module

Map
function
modules

User
module

Connection
module

Maintenance
module

Positioning
and
Alarming
System
Based on
"Map
World"

Personal
positioning

Historical
track
positioning

Fence
positioning

Fence
alarming

SOS
alarming

Low
battery
alarming

User
information
query

Fence
query

Historical
track
query

Other
query

Calling
"world
map" API

Personal
information

Created
fence

Historical
track

Account
management

User
management

Privilege
management

Logon
management

User
information
maintenance

Fence
maintenance

Sending
message

Data access

Figure 6. System structure drawing
3.2 System test
System was tested by STONEX S7-S receiver several times in August 2015 at Urumqi. STONEX S7-S is able to connect GPS single point positioning accuracy of 2.5m, post-processed differential precision 0.2m, real-time differential accuracy of less than 0.5m e.g. Figure 7.

Figure 7. STONEX S7-S receiver

Tests to determine the real-time Positioning by receiving GPS receiver and set the time to send Positioning information to the server at intervals of four seconds. Test distance of about 200 meters. After the test found that the process of sending data from the receiver to the server and then from the server to appear on the system average delay of 1 second. Under built-up blocking more serious cases the position error is within 10 meters. In normal circumstances, the position error is about 2.5 meters. After several tests proven to target the mobile “fence” alarm and the alarm system is successful e.g. Figure 8. After several tests proven to the system is able to alarm and send text message to phone of user when target move out “fence”.

Figure 8. Alarm Demo

4. Conclusion
The “Map World” possesses abundant accurate basic surveying and mapping data and image data, which are valuable information resources for construction of the economic belt
core of the Silk Road. The moving target positioning and alarm platform based on “Map World” is one application that integrates “Map World” data, GNNS data and GIS technology. Except for some GIS functions, this platform realizes the alarm function through the ray method. Its practicability is further proved by tests and use. In future, the platform will employ smaller receivers (e.g. necklace and watch) and achieve more accurate positioning through cooperation with CORS.

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