

# A Method to Build Web Raster Chart System

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**ABSTRACT:** Great attentions have been paying by many shipping countries to the digital chart application in the field of maritime traffic. To resolve “Information Isolation”, numerous Web chart systems have been developed over the world. Most of them, however, are vector chart based. This paper advances a method to build web chart system with raster data. System architecture, coordinate transformation as well as the splitting and rendering of raster charts are introduced in this paper. By using the pre-rendered chart tiles, the web raster chart system can be accessed with higher speed than most vector chart based web rendering system in wide bandwidth network. The experiment also shows the rendering error of this method is small enough for many kinds of application.

## 1 GENERAL INSTRUCTIONS

Great attentions have been paying by many shipping countries to the digital application in the field of maritime traffic. Recent pushes in these areas have opened up interesting new opportunities for maritime professionals. They have put forward the industry’s digital application strategy such as the “Digital Maritime Traffic”, which is based on information gathering and their utmost sharing. Unfortunately, due to “Information Isolation” (Guojun, P. & Tianhe, C. 2005a.) between different marine departments, it seems a bleak prospect in construction of “Digital Maritime Traffic” currently, so it is important to ameliorate the existing imperfect network releasing and sharing of information from digital chart on sea traffic space.

To overcome this barrel, many web chart systems have been developed. Due to their wider visit scope, browser interface, lower cost, easier to operate and faster release of safety message, web chart systems have been widely used in maritime traffic applications. Most of them (Guojun, P. & Tianhe, C. 2005b.), however, are vector chart based. They are not suitable for many applications where vector

charts are unavailable or not necessary. This paper tries to establish a B/S (Browser/Server) based three-layer raster chart system, working in the environment of Internet or Intranet, is virtually an industrial WEBGIS system designed for maritime traffic application, which stores, processes, analyzes, displays and applies sea digital geographical map information. Through popular Internet Browser, user can browse, inquire and obtain services based on spatial data in digital chart and related operational attribute data. With the development of technologies such as marine Navigation-Aids, AIS (Automatic Identification System), marine navigation and marine digital communications, the application of Web Raster Chart System, together with the above technologies, will help improve the safety level, traffic capacity and transport efficiency of marine traffic in particular area. This paper makes a detailed introduction to the research and realization of the Web Raster Chart system, and from the viewpoint of technology, it gives an example of its application.

## 2 SYSTEM ARCHITECTURE

The architecture of web raster chart system (see Figure 1) comprises of chart tiles database, the raster chart application server, web server and Internet explorer. The database, as its name shows, is used to store the chart tiles at the server side. All chart tiles in the database are well organized to accelerate the access speed. The function of raster chart application server is to accept certain chart operation request from the web server, select certain chart tiles from the database and send the tiles back to the web server. The web server accepts the user's requests from the internet browser, balances the load and manages the services, re-orientates the requests to the raster chart application server and accepts the chart tiles from the raster chart application server, and then sends them back to the web browser at the user's end in the PNG format. The web browser accepts and uploads the user's requests to the web server, downloads the raster chart rendering programs (in javascript) and chart tiles, and then displays the accepted chart tiles to the user.

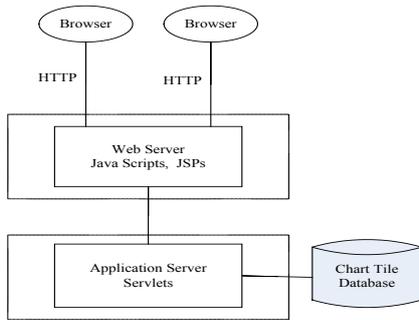


Fig. 1. System Architecture

## 3 CHART TILE DATABASE CONSTRUCTION

The chart tile database construction is a process to create pre-rendered chart tiles from paper charts or digital charts and to index them.

Paper charts have been refined over many years and give the mariner exactly what they need for certain purposes. Because of this, raster charts, scanned from the original charts, should be a good source for chart tile database. The digital charts, which are widely used in ECDIS or ECS, are alternative sources as they can be displayed by ECDIS or ECS and the rendered image could be saved as raster charts.

Due to the huge size of the raster charts (up to 10,000px × 10,000px), they will overload the network when users access them. In this research, raster charts are split into numerous chart tiles, which usually have small size and are downloaded on necessary.

This section will build a grid to split chart images into chart tiles, and then index them.

### 3.1 Building Splitting Grid

We suppose that at zoom level  $m$ , the earth surface is divided into a grid with  $2^m \times 2^m$  cells (or tiles). The value of  $m$  could be 0 or more. Obviously, the bigger  $m$  is, the more tiles the globe is divided into (see Figure 2).

In Figure 2, we suppose a tile have a size of 256px × 256px and the center point has a pixel coordinate of (0,0), then the pixel coordinate of any point (include the intersect points) on the grid can be easily determined.

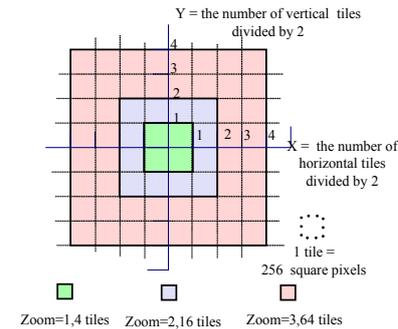


Fig. 2. Splitting grid at different zoom level

### 3.2 Coordinates Transformation

To facilitate the splitting of the chart images, coordinate transformation equations between the above grid coordinates and geographical coordinates should be built. The coordinate transformation depends on the projection the source chart adopted. Since Mercator projection (Richardus. & Peter. 1972.) is widely used in nautical chart plotting, we only consider the Mercator chart image in this research for simplicity.

To transform a geographical coordinate, i.e.  $(\varphi, \lambda)$  into a plane rectangular coordinate, i.e.  $(x, y)$  by Mercator projection, Equ.(1) and Equ.(2) are usually used.

$$x = a \times \lambda \quad (1)$$

$$y = a \ln \left[ \tan \left( \frac{\pi}{4} + \frac{\varphi}{2} \right) \left( \frac{1 - e \sin \varphi}{1 + e \sin \varphi} \right)^{\frac{e}{2}} \right] \quad (2)$$

where  $a$  denotes the semi-major axis of the ellipsoidal globe,  $e$  stands for the eccentricity of the ellipsoidal globe,  $\lambda$  is longitude in radians (positive east), and  $\varphi$  is latitude in radians (positive north).

We assume the earth is a Krassowski-1940 ellipsoidal globe (Moritz, H. 1990), so we can let  $e = 0.08181333$ .

At a certain zoom level  $m$ ,  $a$  can be calculated by Equ.(3):

$$a = \frac{w \times 2^m}{2\pi} \quad (3)$$

where  $w$  is the width of a tile (256 pixels in this research).

### 3.3 Splitting Chart Image into Tiles

Given the splitting grid at certain level, the coordinate transformation equations, a chart image can be easily split into tiles. Firstly, select several control points on the chart image, measure their geographical coordinates and calculate their corresponding splitting grid pixel coordinates with Equ. (1) and Equ. (2). Then place the chart image on the splitting grid according to the splitting grid pixel coordinate of the control points. Since the distortion may occur when digitizing the original paper chart, least square algorithm is applied to calibrate the chart image and the splitting grid (Qinyou, H. 1999). After locating the chart image at the right position on the splitting grid, cut the image along the vertical and horizontal line on the splitting grid, tiles are created. Each tile will get a name according to its tile coordinate and zoom level.

Figure 3 give a simple illustration of chart image splitting by the splitting grid.

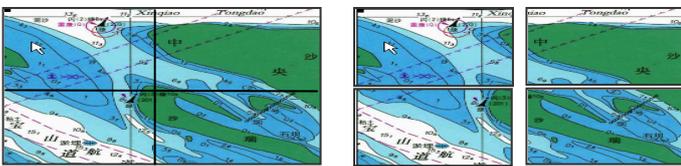


Fig. 3. Splitting chart image into tiles

## 4 TILES RENDERING

As described in previous sections, the surface of the earth is mapped to a grid space which comprises  $2^m \times 2^m$  cells (or tiles) at zoom level  $m$ . In a HTML document, we create a “div” element for the whole grid space, and name it inner div (see Figure 4). Also, we create a “div” element for the rendering area and name it outer div (see Figure 4). Because we can’t load all the tiles in the grid up front, we’ll need to calculate which of these grid cells are visible and load the tiles needed to fit into these cells. As Figure 4 shows, this is accomplished by calculating which grid cells are visible within the area created by the size of the outer div. In the figure, we see that nine cells are visible across three rows. Note that those cells that are only partially visible still count as being visible.

The next step requires us to populate our inner div with the map tiles. Our approach to this will be fairly simple. Initially, nine tiles the outer div covered are added to the inner div. The scrolling map effect is achieved by moving the inner div inside of the outer div; therefore, the tiles we need to display are calculated by determining the current position of the inner div relative to the outer div and then working out which tiles are visible in the portion of the inner div that is visible. We’ll then add those tiles to the inner div.

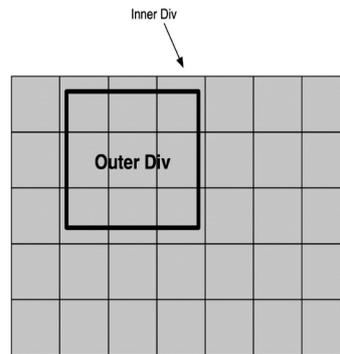


Fig. 4. Tile rendering

## 5 EXPERIMENTAL ANALYSIS

According to the technologies introduced in the previous sections, we developed an experimental system (see Figure 5). Common functions, such as moving, zooming in, zooming out, bird’s eye, relative bearing and distance measuring, etc., have been implemented. To experience the experimental system and the above functions, please visit our website (<http://www.voffer.org/webchart/>).

Rendering error is one of the most important evaluation parameters for chart displaying system. As a test, we measured, at a zoom level of 13 and with a sampling interval of 0.5', the rendering error on 121°40'E longitude line and 31°40'N latitude line of nautical chart No. 13170 (Chang Jiang Kou, China). Figure 6 and Figure 7 shows the error curves respectively.



Fig. 5. Interface of the Web raster chart system (from <http://www.voffer.org/webchart/>)

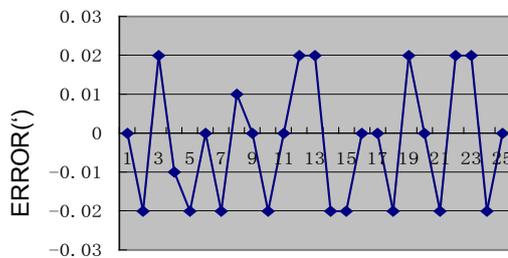


Fig. 6. The error curve in longitudinal direction

The maximum rendering error (not include the source chart error) shown in Figure 6 and Figure 7 is 0.02'(about 37m), which is acceptable for many kinds of maritime traffic application, such as vessel monitoring, tracking etc.

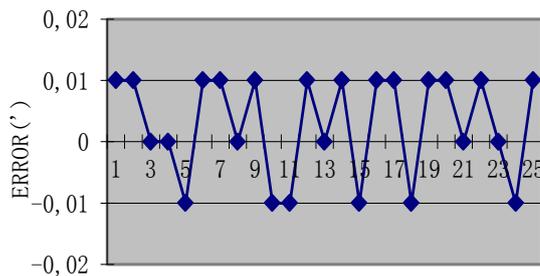


Fig. 7. The error curve in latitudinal direction

## 6 RELEVANT WORK

Generally, Web vector chart system, such as Sea Digital Map based on WEBGIS (Guojun, P. & Tianhe, C. 2005a), need an additional database to store the vector data as well as a GIS engine (ArcGIS, GeoBeans, etc.) to support the geographical queries. On the contrary, in our research, all chart tiles are managed by a file manager, which is available from most computer operation systems. Moreover, The GIS engine is not necessary in our research. Therefore, our work provides a more economic solution for Web chart system than the vector systems. Besides that, due to the pre-rendered chart tiles, the Web raster chart systems can be accessed with higher speed than the vector systems, especially in a wide bandwidth network.

We borrow some ideas from several popular map sites (Google maps, Yahoo maps etc.), such as tile technology, tile rendering, etc. The major difference between our work and the popular technologies is the coordination transformation. In the coordination transformation, we suppose the earth to be ellipsoid while in other work the earth is assumed to be a sphere.

## 7 CONCLUSION

This paper makes a detail introduction of the method to realize a Web raster chart system. According to this method, we developed a Web raster chart system successfully.

By using the pre-rendered chart tiles, the web raster chart system can be accessed with higher speed than most vector chart based web rendering system in wide bandwidth network. The experiment also shows the rendering error of this method is small enough for many kinds of application.

With the development of technologies such as AIS and marine digital communications, the Web Raster Chart System, together with the above technologies, could be used to improve the information sharing in marine traffic field.

## ACKNOWLEDGEMENTS

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