MARIUSZ WĄŻ
Naval University of Gdynia

3D PICTURE DISPLAY FOR NAVIGATION RADAR

ABSTRACT

Tree-dimensional sea space visualization become increasingly form of ship's environment presentation in maritime navigation systems. Sonograms and echograms for instance, should create underwater space in 3D because the object (or submerge unit) accurate localization in 2D is impossible between sea bottom and surface. For surface navigation 3D vector charts can be observed mostly in combat systems or ship's bridge simulators for some years. This article presents 3D radar screen visualization possibilities for navigation radar.

INTRODUCTION

Sea, air and ground navigation situation around ship visualization in 3D become more and more common data presentation possibility in navigation systems devices nowadays. Mentioned technology was the first and very fast upgrading step for air-control and air-navigation systems, but for maritime using in echo finder and more advanced sonar systems as well. Modern marketplace is filled with 3D charts which are constructed according to IMO standards. In close future 3D visualization might became the new standard for mostly all navigation systems. Some of mentioned charts can work properly witch radar devices where the radar data are transferred to system by digital transmission using. Preparation for 3D radar data visualization will demand the new tree-dimension object creating technology. These objects can be created only in base on gained digital radar images. For this case the new digital radar images gaining technologies should be created.

THE DIGITAL RADAR IMAGE

Almost all modern radars present digital environment visualization in Cartesian co-ordinates system. In difference to analog visualization presented on radarscopes, the digital display is created on tube computer screen or LCD as square matrix with the same numbers of pixels on both square borders (column and lines). The visualization structure is based on half-tone screens and how be mentioned previous, presented in Cartesian co-ordinates system. Picture like that can be saved in computer memory as BMP. BMP-eg is a bit grid which a single or three color films (single – 256 shades grey scale; three – 256 shades of colors: red – R, green – G and blue – B). Saving radar digital picture in CMYK (four color level wide used in the computer graphic tools) is also possible. The large number of navigation radar use two or three main colors to each characteristic picture elements separation: target echo and water surface as primary graphic elements, but movement vectors and acquisition zones as secondary.

There are differences between radar picture displayed in grey scale or colored. The first one is read with 8 bit precision but the second witch 24 bits. Color picture is archived as 3D matrix. The single pixel is a triple element vector which consist of single pieces of color information like: R, G and B (each spread in scale from 0 to 255). Each color data takes 3 bytes and each byte takes 8 bits, so it means: $3 \cdot 8 = 24\ \text{bits}$. In this case the single color is called 24 bits. Mathematical operations are possible after changing 8 bits to *double* class variables. The 24 bits half-tone screen used for navigation radar data display presents following fig. 1.

Fig. 1. The RGB 24 bits half-tone screen

Prepared by the author.

The radar picture can be displayed in grey-scale system, frankly speaking: black and white. Mentioned kind of picture is stored as 2D matrix, but data space takes only ‘single channel’. Each pixel is spread in scale from 0 to 255 (as single 8 bits element). B&W picture is presented on fig. 2.

Fig. 2. The B&W 8 bits half-tone screen

Prepared by the author.

The radar picture is stored in computer memory as raster image is a continuous data set which changes in dependence on elements in scanned environment space: coast line shape, weather conditions, number of object echoes etc. The continuous data set can be a regular point grid saved as vector. The nodal points are spread uniformly on the radar picture have own geographic coordinates (spread uniformly too). Each picture point is presented as following discrete vector coordinate – information about object radar echo occurrence.

Especially for sea radar pictures, where pixels which are present 'water surface' have the same value level and it means – no echo. This information can be just omitted. For this reason it is more easy to construct radar pictures by irregular point grid using, where each point has discrete value and following is used to create a lines and areas. See fig. 3.

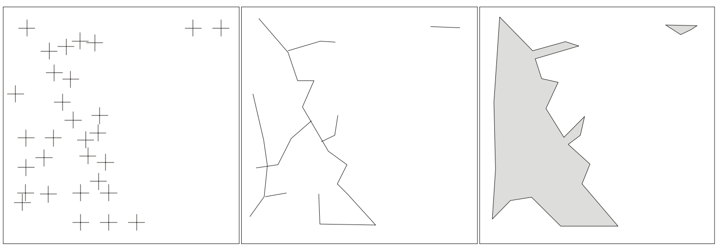

Fig. 3. The vector picture presentation: points situated irregular; lines; areas

Prepared by the author.

Mentioned objects means usually: the coast line, land area, fixed or moving objects on water region scanned by radar. The coast line and single points are parts of the radar picture invariant representation. The invariant's creating method and other forms of radar picture representation were often shown in authors publication earlier [1], [2], [3], [4]. The most important task before 3D representation creating is radar picture saving in digital form because of three pixel coordinates reading possibility. Previous representations apply to radar picture saved as vector described on real number set:

$$\mathbf{O}^k \to R \tag{1}$$

where:

$\mathbf{O}^k = \{(\varphi,\lambda,W): \varphi \in <0,90^0>, \lambda \in <0,180^0>, W \in <0,K> \wedge \varphi,\lambda,W \in R \wedge K \in N\}$

φ , λ – each pixel geographic coordinates in radar picture;

W – pixel identified as radar echo intensification level.

And for invariant pictures in polar co-ordinates system:

$$\mathbf{O}^b \to R \tag{2}$$

where:

$\mathbf{O}^b = \{(\alpha,d,W): \alpha \in <0,360^0>, d \in <0,Z>, W \in <0,K> \wedge \alpha,d,W \in R \wedge Z,K \in N\}$

α , – polar coordinate identified as bearing (NR);

d – polar coordinate identified as distance (d_r).

DIRECTX TECHNOLOGY USING

When radar picture exist as three-coordinated vector, it is possible to use the special software packets – API (Application Programming Interface) during 3D visualization creating. API using gives a possibility to tree-dimension graphic applications coding which can work under operation system control. Well known API exist as graphic libraries DirectX made by Microsoft. All 3D pictures are created in DirectX according to vector graphic creation rules. Each object consist of some polygons number (in DirectX – triangles). The most important step is to place objects in order from the outlying to the closest to antenna, in DirectX this task realize the z-Buffer algorithm. Z-Buffer is the memory structure, where the each pixel *Z-axis* coordinates are saved and stored as data. For each animation frame every pixels which create 3D object *Z-axis* coordinates are compared to previous frame *Z-axis* coordinations saved in Z-Buffer. According to this rule, pixel with smaller *Z-axis* coordinate value is replaces previous pixel with *Z-axis* coordinate higher value. The next step during 3D scene visualization is texturing (or texture mapping) process. This task is usually realized by 2D bitmap interference on object consist of 3D polygons. Texture mapping algorithm works by at least two bitmaps with different sizes using on line. If the antenna is situated close to object the larger bitmap is used. When object – antenna distance increasing, system use smaller and smaller bitmaps fluently. The next step is the object illumination. DirectX offers the following illumination sources:

1) point light – spread the same in each direction (calculations require the large processor capacity);
2) spotlight – reflector light, emitted in cone (lighter for instance), only object in cone are illuminated;
3) directional – direction light with defined orientation in 3D scene, used for sunlight simulation (calculations can be provided without large processor capacity).

The next step is the polygons shading, when whole polygon is filled with one of vertex color or the summary color is created by each vertex colors interpolation on line. By DirectX library using the 3D radar pictures can be constructed very fast with excellent quality. The example is presented on picture below.

Fig. 4. The Gdansk Gulf 3D radar picture
(visualization from Radar 3D application built in base on VisualBasic 6.0)

Prepared by the author.

SUMMARY

The modern navigation radar have no 3D visualization creation possibility. Digital signal processing technology progress gave the new possibilities in radar data transforming process to many kinds of digital picture representation. The picture saving methodes was upgraded last time and tools used during picture transformation become popular and useful. For instance the RSC (Radar Scan Converter) – digital radar picture recording and transforming tool can be used to create new picture on line.

The 3D radar picture creating become easy and fast because of modern computer graphic techniques. The radar 3D digital picture creating should be standardized with 3D digital chart creating by IMO, because the navigation near future will be probably based on digital information created in digital devices.

REFERENCES

[1] Stateczny A., Wąż M., Neural algorithm of fixing the ship's position, Annual of Navigation, 2000, no. 2.

[2] Wąż M., Methods of transformation radar pictures in comparative navigation, XII International Scientific and Technical Conference 'The Role of Navigation in Support of Human Activity on the Sea', Gdynia 2000.

[3] Wąż M., Radar pictures using in maritime navigation, Scientific and Technical Conference 'Radioelectronic systems and devices UiSR', 2005 (in Polish).

[4] Wąż M., Nowak D., The vector radar image, VI International Symposium on Navigation, Gdynia 2005 (in Polish).

Received October 2006
Reviewed November 2006