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A Display Method of Radar Terminal Based on Efficient Shader of GLSL

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Abstract. Base on the whole-ship integrated control system, the radar data is shared and processed for each terminal of command. To improve the display effect of radar, a display method is designed by the efficient shader generation method using the GL Shading language (GLSL), which utilizes different users' instructions to realize the Plan Position Indicator (PPI), AR, B display of radar video while the data comes from the DMA with PCIE. The method enriches the display effect of general radar terminal and makes the display control more flexible, which is valuable to meet the requirements of real-time display and control of the commander of the ship. The images of the radar terminal display with PPI, AR-scan and B-scan demonstrate the effectiveness of the proposed method.

Keywords: programmable pipeline, PPI, AR-can, B-scan, users' control

1. Introduction

There have been many studies so far about the display of radar terminals. On 1948, Payne talked how to display echoes on PPI. The United States had many patents which related to PPI in the direction of software on radar terminals[1]. Zetik R and Cuihai discussed algorithms which related to radar scan transformation[2]. Richard WD introduced a method for real-time digital scanning[3]. Cooper and Junyen discussed the construction of the entire PPI system[4,5]. Doderi talked about symbol representations[6]. Although these patents were relatively outdated and mostly limited to the hardware performance of computers, the relevant indicators proposed in them are used in current radar PPI display, which is significant guiding significance. The navigation radar technology in the UK was also advanced, and the terminal was a radar software display implemented by an embedded system based on MARPA processors[7].

Wu Wei proposed a design method for a radar PPI display system based on Direct3D in reference[8], with the aim of fully utilizing the high efficiency of graphic drawing in Direct3D, and the interface development library was MFC. Due to both MFC and Direct3D being development libraries provided by Microsoft, their applicability was limited to the Windows platform and cannot be applied to mobile portable platforms. Huang Xiaoyan and others optimized PPI for VTS radar[9] and proposed a circular queue and two-level caching mechanism, effectively solving the problem of data packet loss. It was worth noting that the article used Direct3D technology for layer fusion, effectively reducing the moer pattern caused by radar scan conversion. Chu Xiaojun and Fan Fengying studied the PPI display of radar in order to achieve an airborne radar simulator[10]. The paper elaborated on the key technologies of PPI, mainly including radar dot display, radar clutter target display, and radar sector scan display. He Yongxi designed a radar terminal based on OpenGL[11]. The paper pointed out that due to the large amount of content needed to display. The article provides a detailed introduction to how to achieve radar scanning afterglow. Due to the use of GLSL technology, it can greatly reduce the use of system resources while ensuring good rendering results.

In summary, the radar PPI display focuses on the efficiency of coordinate transformation and the use of GPU to accelerate drawing. The former mainly seeks efficient mapping methods, while the latter's development trend is gradually shifting from traditional CPU based Windows platform frameworks (MFC, GDI, etc.) to GPU based Direct3D, CUDA, OpenGL, and cross platform Qt frameworks, which ares also determined by the large amount of information that modern radar needs to display [12,13].

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Consider the studies above, the PPI of display are popular with software, but the user control method of all methods were not related. The author used different users' instructions to realize the PPI, the AR-scan and B-scan of display of radar video, which is suitable for the display of radar terminal.

2. Efficient Shader Generation Method

In order to meet the terminal requirements of multiplatform and multisystem, the programmable pipeline technology based on GLSL is used to design the programmable shader's algorithm,

Base on the capabilities of the local graphics processing unit for processing and displaying, the shader's codes are designed into two steps: vertex shader and fragment shader. The vertex shader is responsible for processing the data from the user, converting the position information to the screen position when it needs PPI and otherwise B-scan, and then passing it to the segment shader as input; The fragment shader is responsible for shading the data, taking the fragment output by vertex shader as input and calculating the output colors of all vertex pixels and texture's graphics.

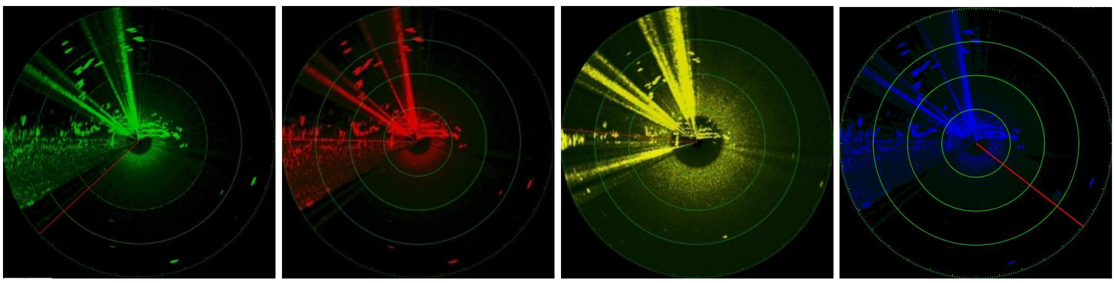
Using the performance of graphics processing unit, the texture mapping method design shaders based on the combination of texture to deal the transformation from rectangular coordinates to polar coordinates and the data to display when is PPI and there is no coordinate transformation when is B-scan. If it uses the forward mapping from the rectangular coordinate system to the polar coordinate system, the moire will be generated. Contrary, if it uses the reverse mapping, some important information will be lost. The fundamental problem of reverse mapping is that the amount of original data is less than the amount of pixel data which needed for drawing, interpolation is designed to make up for the lack of data. However, interpolation will bring extra computation, and also need to control the degree of interpolation. Excessive interpolation will take too much time, and too little may cause information loss. Therefore, it uses the texture mapping method which regards the radar's echo data that need to be drawn as a texture, when the interpolation function and fragment shader in the graphics library are used to realize efficient and accurate radar scanning transformation.

When the shaders are designed, the control variables such as the color of video, the afterglow, the bow, the eccentricity, the multilayer's control, the B-scan and the AR-scan. After updating the radar's data and with these variables, it is used to complete the processing and control of the data, using the shaders and the linear interpolation algorithm.

3. The Scheme of Method

3.1. The Module of PPI

The method of texture mapping is used to realize PPI display of radar. Firstly, texture sampler of 2D is used to define texture variable matching with the texture type of GL_TEXTURE_2D. Secondly, the function of atan2() is used to calculate the angle value of data points. Thirdly, it should determined the size of distance and the pixels beyond the radar visual range will be not colored. Finally, the coordinate after transformation is read by the function of TEXTURE. These values are used as the original colors for subsequent color mapping. It receives the front radar's video data, uses the texture mapping method and sets the video's color to green after coordinate conversion. A green radar image is displayed as Fig. 1 (a). We can controll 65535 colors of radar image which are red, yellow and blue and so on, using the way of color mapping table, and it is shown on Fig. 1 (b), Fig. 1 (c) and Fig. 1 (d), and provide the more rich control methods than the other methods.

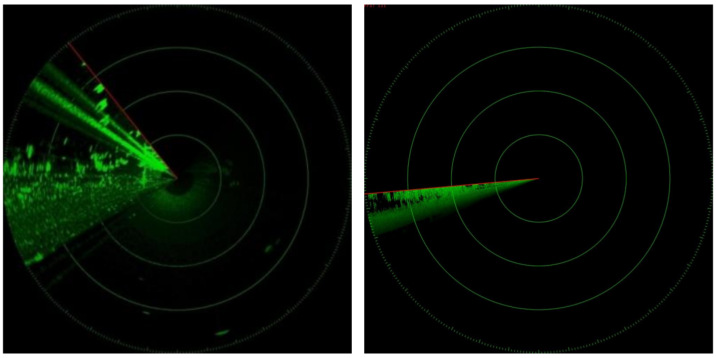


(a) green image (b) red image (c) yellow image (d) blue image

Fig. 1: The display of PPI

3.2. The Control of Afterglow

The afterglow of radar's video is achieved by controlling the transparency of programmable pipeline data pixels. Each pixel is controlled by the fragment shader. When the transparency of the afterglow is negative, it can use one minus the afterglow of transparency which is because of the function of atan2(). When the current position of scanline is constant, the result is equivalent to gradual transparent color mixing of the original image. In order to achieve the effect of circular scanning, the variable of scanline needs to be increased circularly outside the pipeline, and the increasing speed should be consistent with the angular speed of radar scanning. At the same time, it needs to set the glEnable() and glBendfunc() to enable the color mixing function of the graphics processing unit, and choose the GL_SRC_ALPHA as the source factor of mixing function, GL_ONE_MINUS_SRC_ALPHA as the target factor. When the method of texture mapping is used, the graphic processing unit will update all echo data matrix as a whole texture, even if the radar only updates the echo data of one azimuth at a time. When the parameter of afterglow sets to 4 and 1 the effect of afterglow is show on Fig. 2(a) and (b), which the parameter range is from 1 to 8.

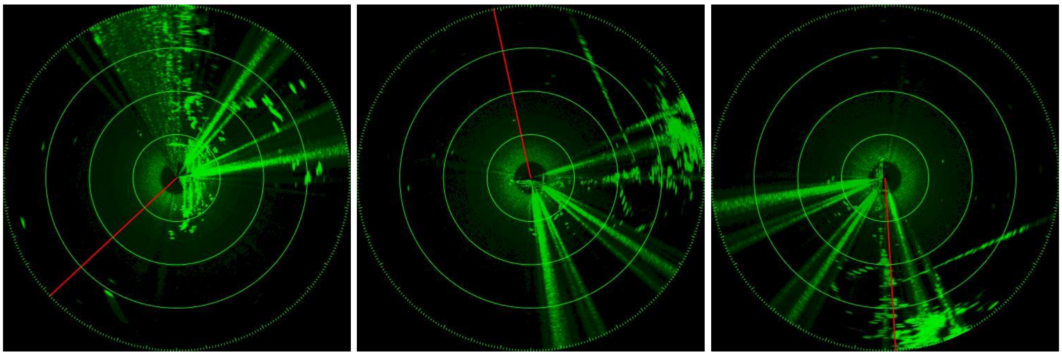


(a) the parameter of afterglow is 4 (b) the parameter of afterglow is 1

Fig. 2: The afterglow of PPI

3.3. The Control of Bow

The traditional PPI display is generally in the north-up direction, which is the geographic north direction drawing above and the basic requirement of shipborne radar. With the increasing demand, PPI display of modern radar needs to support any azimuth upward display. The essence of setting bow's function is rotating image, so the rotation's matrix can be used. In the graphics processing unit, it defines the vec4 of modelview. rotate(r, 0.0f, 0.0f, 1.0f). The r is the angle of rotation, and the last three parameters form a vector (0,0,1), which represents the unit vector on the Z axis. This is because the plane to be rotated is the X and Y planes. The parameter r should be the angle of rotation around the Z axis, which is the angle of rotation around the unit vector on the Z axis. The display effect of setting the bow to 90°, 180° and 270° is shown in Fig. 3.

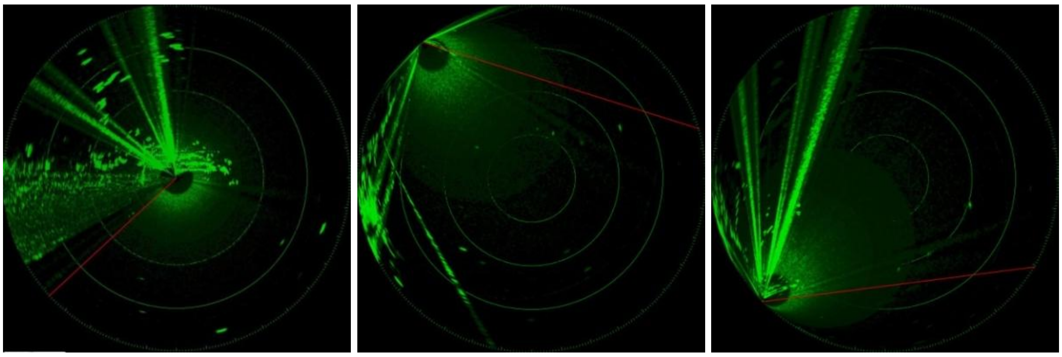


(a) the bow of 90° (b) the bow of 180° (c) the bow of 270°

Fig. 3: The bow of radar

3.4. The Control of Eccentricity

Generally, the origin of radar scanning is at the center of PPI, which is shown on Fig. 4 (a). In order to observe the information of a certain direction clearly, the eccentric display is needed, which is no longer located in the PPI center. Eccentricity is the relative translation of the image and the viewpoint, which is keeping the viewpoint still, using the model-view's transformation to display the image. With using the variable model-view in the previous section, translate method is used to translate the image. In this method, the two parameters are input, which are the distance of translation along the X axis and the distance of translation along the Y axis. The effect is shows on Fig. 4.

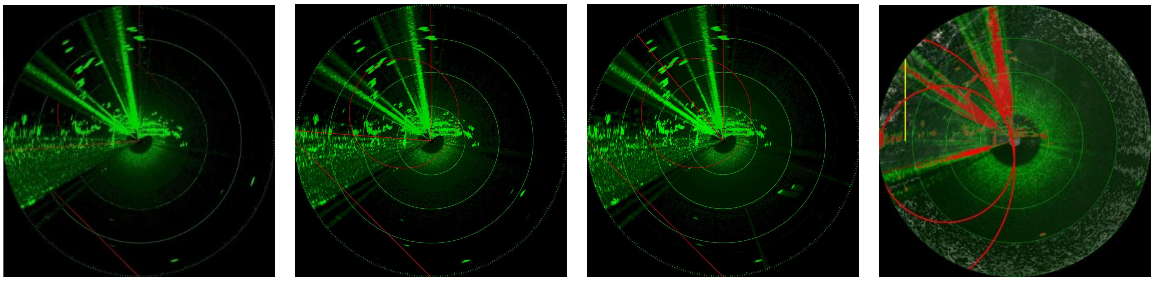


(a) the center display (b) the up-left corner display (c) the down-left corner display

Fig. 4: The center and eccentricity display of radar

3.5. The Multilayer's Control

With marking signal, chart, and displays in different levels, mixing is realized by using Alpha in pixel information. When the video's amplitude is zero, there is no display on the bottom layer, when it is non-zero, it is used the Alpha value of each pixel in the clip shader. The display of radar image adopts the multitexture rendering technology of image processing unit, which takes different data as one layer of texture and binds it to the texture object. According to the output sequence set by the user, it reads the data of different layers in the texture object, and realizes the independent user display of radar video layer, range ring, sea chart and various plotting information, which is shown on Fig. 5(a), Fig. 5 (b), Fig. 5(c), Fig. 5 (d).



(a) the radar video on the top (b) the rang ring on the top (c) the plotting on the top (d) the sea chart on the bottom

Fig. 5: The user's control

3.6. The B-scan of Display

In order to better view the target features, radar terminal requires B-scan display. Using the X-axis as the orientation and the Y-axis as the distance, it forms a B-scan display of the video while scaning the radar azimuth and distance video frame by frame. The B-scan display can select a certain distance as the target center, take a certain step length distance, and display data within a certain angles and azimuths. In the vertex shader, when is needed the B-scan, the original data is not subjected to coordinate transformation, and it is mapping directly to form a B-scan, which is shown in Fig. 6.

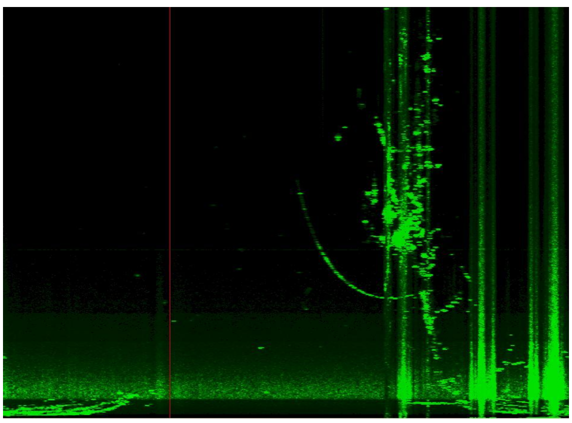


Fig. 6: The B-scan with one circle of 360°

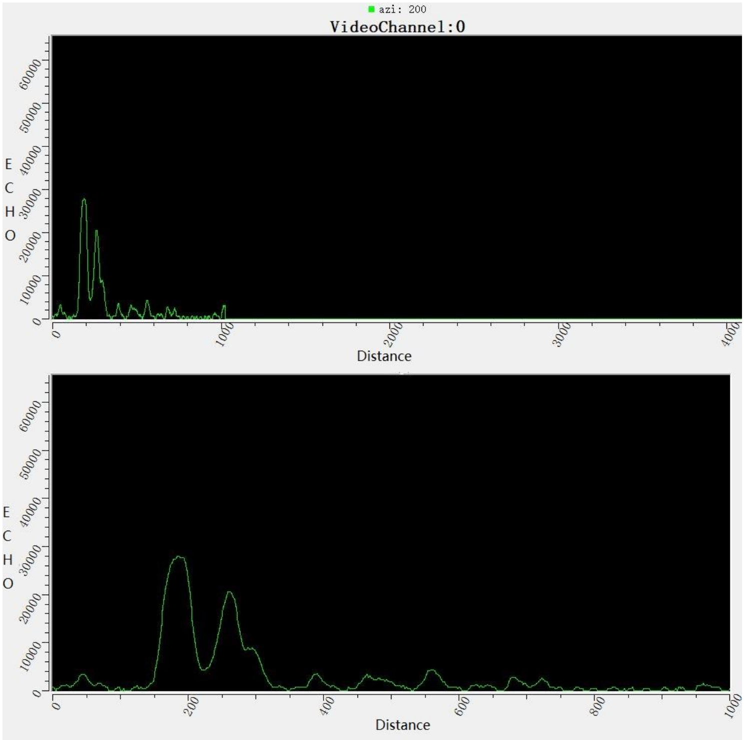


Fig. 7: The AR-scan with one azimuth

3.7. The AR-scan of Display

In order to better observe the characteristics of the target, A-can is also a commonly used in radar terminal. Due to the fact that AR-scan is the one-dimensional amplitude data in a certain direction, it uses the Qwt controls to display the one-dimensional radar data. It selects the echo data of a certain length in a certain direction for AR-scan, and at the same time, it zooms in on local data to form a R-scan display, which effect is shown in Fig. 7.

Summary: From the above displays, it could be effect while using the shader generation method with the development environment is QT5.6.3, the version of OpenGL is 3.0, the CPU is i7 with eight cores whose operating frequency is 2.59GHZ and the GPU is Quad T2000 of NVIDI, and when is implementing, the PPI, B-scan and AR-scan window refresh rate can reach over 60fps. Compared with the methods of graphics device interface and the blend of images, it could be the best one[14].

4. Conclusion

Terminal software display is a developing trend of shipborne radar equipment and the multimedia effects becomes more and more important. It shows not only lower cost, but also is flexible in signal processing and manipulation. Based on the programmable pipeline rendering technology, it can make good use of the powerful processing unit of the video card, and can share more processing tasks for user with the least version of OpenGL3.0. Facing the difficulties of radar display, it refers the method of texture mapping which was used to map the shared radar video data to the display output texture. By controlling the mixing characteristics of alpha coefficient in the color component, video rotation, translation, amplitude control and other multimedia instructions, the multimedia display at the end was realized. This method had rich display content, flexible control method and cost saving, which could play an important role in the subsequent application of software radar system and is suitable.

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