DEVELOPMENT ADVANCED TOOLS SUPPORTING SIMULATIONS OF STEEL DEFORMATION IN THE SEMI-SOLID STATE - METHODOLOGY OF A STEREOSCOPIC VISUALIZATION

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Abstract

The article presents use of stereoscopic techniques for visualization of simulation results from heating/deformation process of steel with a semi-solid zone. The numerical model describes phases of material, solid, semi-solid and liquid. Taking into consideration the specific distribution of these zones, stereoscopic visualization is very helpful for understanding the process. Three-dimensional imaging is widely used in a medical systems, entertainment and scientific visualization. There are many techniques to creation of stereoscopic images, but all lead to present images for each eye in a different perspective. The immersion effect is achieved by interpreted in the brain prepared images. The article describes several techniques to create stereoscopic images. There are physical basis and equations for correct calculations of parameters for stereoscopic scenes. Finally, implementation of software with using OpenGLfor stereoscopic presentation of simulation results was presented.

Keywords: Computer simulation, graphical user interface, stereoscopic visualization

1.   INTRODUCTION

In the recent years, the techniques of generating and presentation of computer graphics for generating and presenting computer graphics have seen increasing interest in stereoscopic visualization technique. The solution is not new, but the modern technology enables its wider use in various areas of life. The general rule in stereoscopic display is to visualize different images for both eyes. On the market there are many available solutions [1]. Originally, a simple color filters and contemporary linear or circular polarizers were used. Recently, screens (Wavelength Multiplex Imaging WMI, Dolby 3D Digital Cinema) widely used in projection technology, based on sending different color spectrum to each eye and different images, are combined into the one. That composed screen can be seen by using the appropriate glasses. Simultaneously, autostereoscopic display technology is developed in order to achieve the stereoscopic effect which does not require the use of special glasses [2].

2.   STEREO RENDERING TECHNIQUES

Stereoscopic technology used active and passive projection. In the case of the active audience using snapshot, LCD glasses synchronized with the alternating images are displayed to the left and right eye [3]. In the case where a stereoscopic image is obtained by using two flat images, parallax phenomenon is used. If the observed object is outside the plane of the projection, image for the left eye is on the left side and right eye to the right side. The distance between the left and right is called a positive image of a horizontal parallax. If the object is in front of the plane, projection for the left eye image is displayed on the right side and right-eye image to the left. This is known as horizontal negative parallax. The creation of an image of two points on a flat screen is complex to commonly used approaches [2-6].

Toe-in - this approach is used because of the simplicity of the symmetrical projection and there are no special requirements to the used cameras. The cameras are not only shifted relative to each other, but also rotated and fixed at a common point. That creates a vertical parallax, increasing with distance from the center of the

image. This leads to discomfort for the observer after a long time. Despite the disadvantages, this method is still used because of easier use of the cameras in parallel where it is necessary trimming and cropping **(Figure 1)** [6].

Off-axis - this is a valid way to obtain stereo images which does not cause vertical parallax. It uses not only horizontal movement, but also the camera projection matrix is modified, which gives an asymmetric projection result [6].
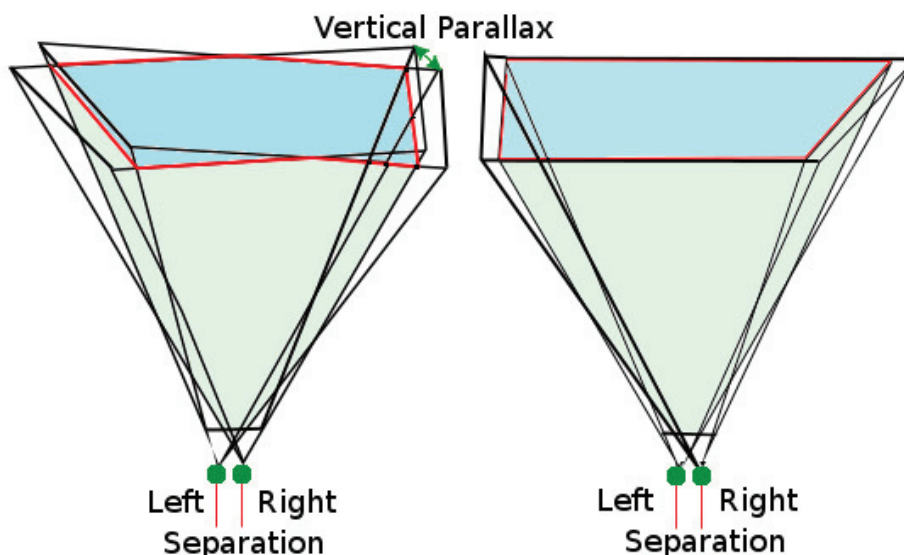

Figure 1 Diagram of the toe-in (left) and the off-axis (right) methods

3.   STEREOSCOPIC VIEWING SYSTEM

The construction of the software to the stereoscopic visualization of results was performed and tested using system comprising two Gemini Barco IQ R500 LCD projectors which works with SXGA+ (1400 x 1050) resolution. The modular system facilitates the crack-free floor installation or ceiling installation (**Figure 2**).

Figure 2 The modular design of the system based on Barco Gemini
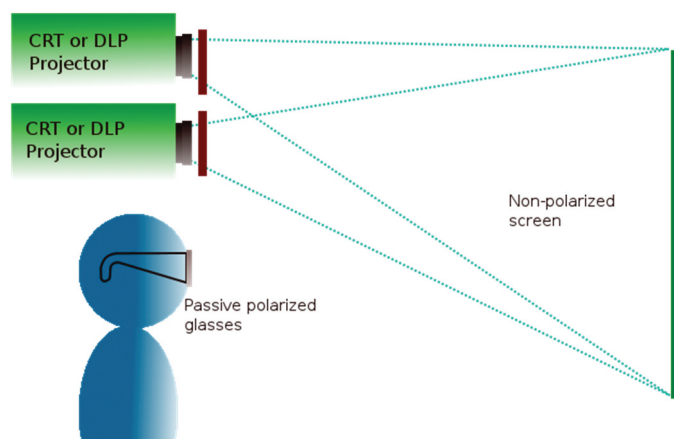

Figure 3 Chart of the display system

It consists of two projectors with polarizing circular filters and a screen which does not depolarizing light. Schematic of the applied solution was presented on **Figure 3**. In the presented solution, front passive

projection was used. The most important parameters of projectors are: effective brightness 59 % 4200 lm, color uniformity >95 %, brightness uniformity >95 %, Dual Lamp Mode 3000 h, built-in mechanical shutter, wired and wireless control.

4. IMPLEMENTATIONS

Implementations and tests of stereoscopic visualization were performed using OpenGL with nVidia Quad-buffed graphics card (Quadro FX Series) [7].

In **Figure 1** and **Figure 5**, a diagram and the parameters of the perspective projection view for symmetrical and asymmetrical case were presented. For building of correct perspective projection, it is necessary to perform matrix multiplication of the current view with the asymmetric projection matrix. A very important parameter for asymmetric projection is displacement of the front clipping plane for each eye. This parameter depends on the ratio of the distance between the coordinates defining the position of the front clipping plane and the projection plane.

The implementation of these visualization techniques can be performed using the OpenGL graphics library [6]. In order to use the presented functionality, it is necessary to initiate additional buffers at the stage of the rendering context. The diagram of the algorithm that generates a stereo pair is shown in **Figure 4**.
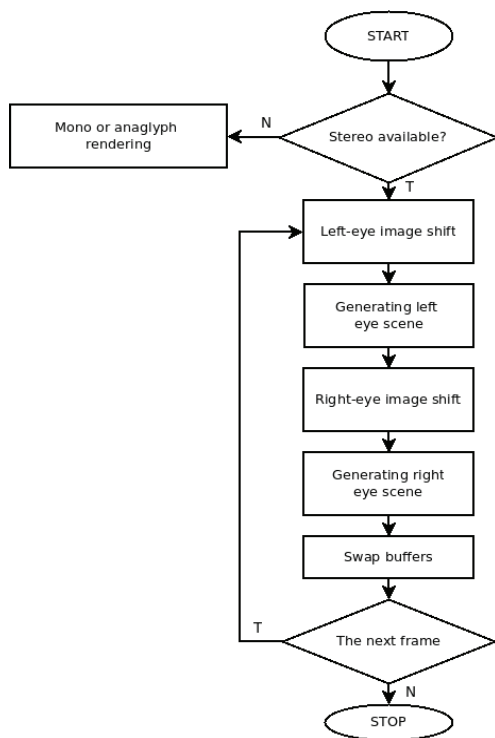

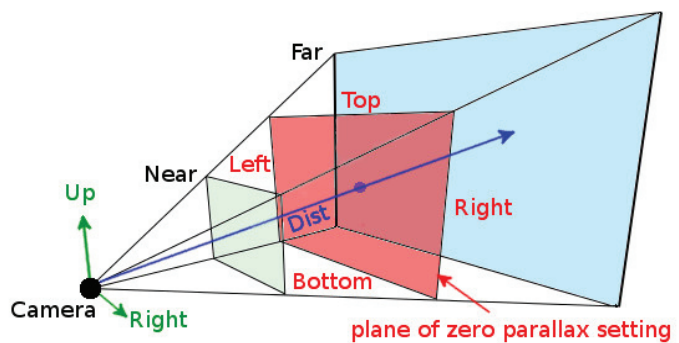**Figure 4** The diagram of the algorithm that generates a stereo pair

Figure 5 The perspective projection diagram for one eye's subfield

There are several OpenGL functions which allow configuring the projection parameters. The perspective projection and projection parameters evaluation are presented on **Figure 5** [8].

For correct setting of perspective parameters, calculation of new left, right, top, bottom parameters is needed. Equations are presented below from (1) to (7).

$$\text{clip}_{\text{near}} = \text{dist} + \text{zero}_{\text{plane}} - \text{near} \tag{1}$$

$$clip_{far} = dist + zero_{plane} - far \qquad (2)$$

$$noverd = \frac{clip_{near}}{dist} \qquad (3)$$

$$top_w = noverd \cdot \frac{top - bottom}{2} \qquad (4)$$

$$bottom_w = - topw \qquad (5)$$

$$right_w = noverd \cdot \left(\left(\frac{right - left}{2} \right) - eye \right) \qquad (6)$$

$$left_w = noverd \cdot \left(- \left(\frac{right - left}{2} \right) - eye \right) \qquad (7)$$

Finally, calculated parameters are used in OpenGL function that sets perspective, glFrustum (...) [10]. The discussed algorithms were used in visualization of the calculations results for the heating/deformation process with semi-zone. Because the process is difficult and complex, both technically as well as numerically, presenting the visualization technique will facilitate the interpretation of the results of calculations. The examples of results in the following **Figures** from **6** to **13** in both techniques (quad buffer, anaglyph) were presented. There are results of heating process for samples with square cross section. This technique can be used for visualization more complex processes like simulations for the rolling process of steel in terms of coexistence of liquid and solid phases which are presented in papers [11-13].
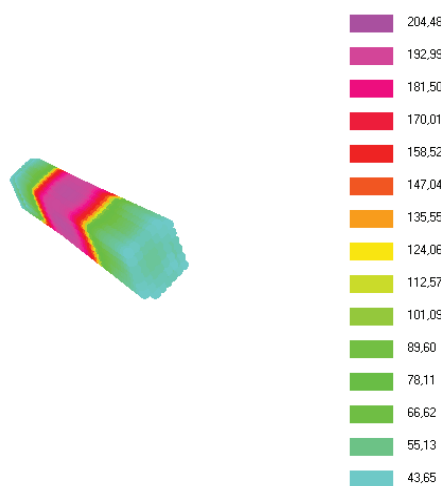

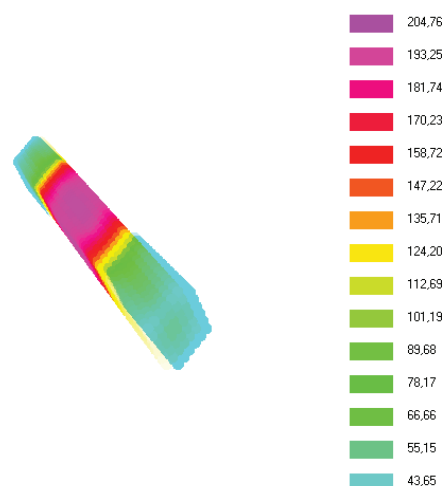**Figure 6** Temperature (stereo) step 10
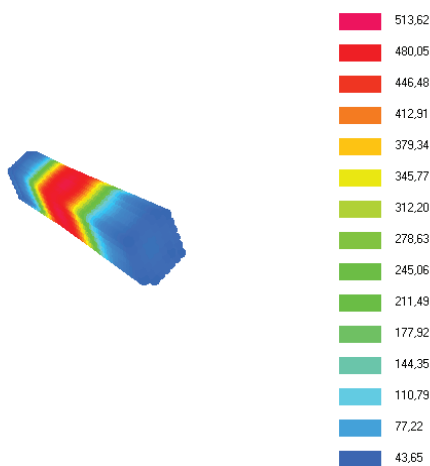

Figure 7 Temperature (anaglyph) step 10

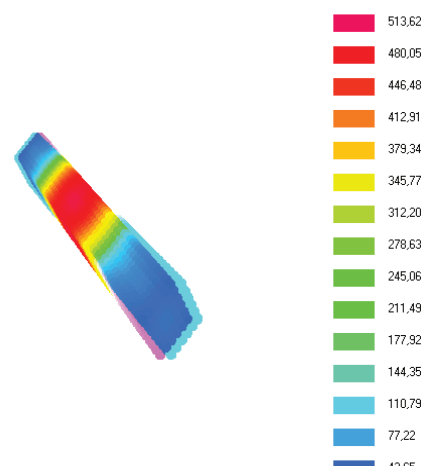**Figure 8** Temperature (stereo) step 25

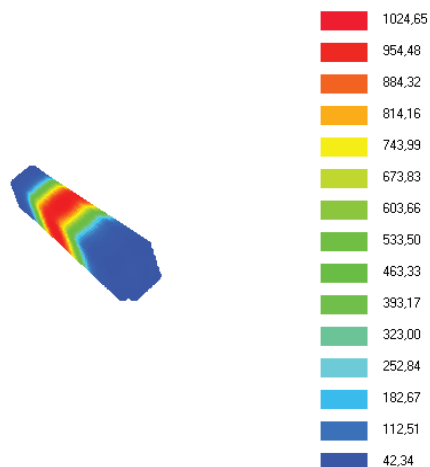**Figure 9** Temperature (anaglyph) step 25

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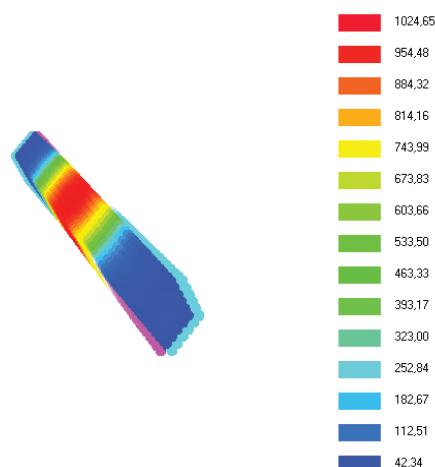**Figure 10** Temperature (stereo) step 50

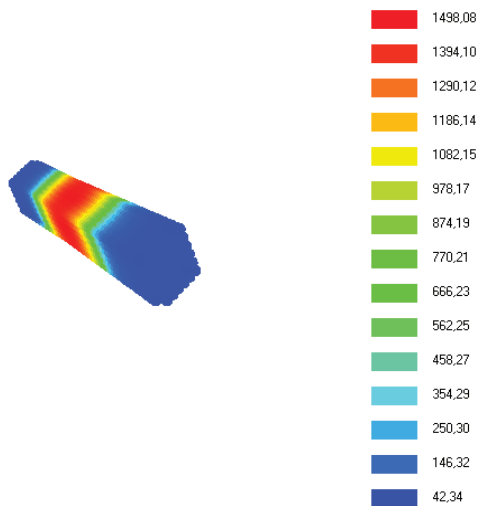**Figure 11** Temperature (anaglyph) step 50

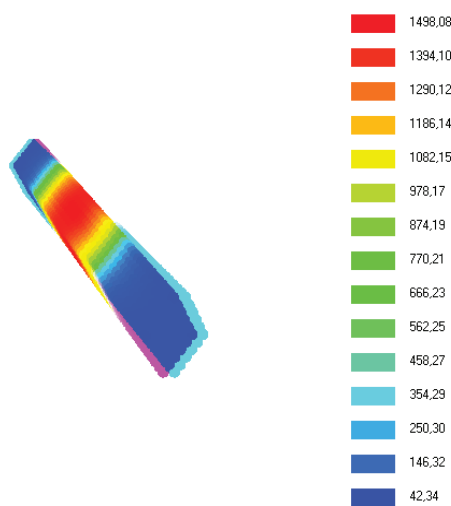**Figure 12** Temperature (stereo) final step

Figure 13 Temperature (anaglyph) final step

5. CONCLUSIONS

In this article, the problem of stereoscopic projection is presented with the most frequently used techniques and their advantages and disadvantages. The implementation techniques, modifications in OpenGL projection matrix are also presented. The best way for stereoscopic visualization is use of dedicated hardware with quad buffer, anaglyph presentation can cause incorrect display of colors.

The present algorithm for creating stereo pairs allows building new software and reconstruction and adaptation of existing one for stereoscopic visualization. Good knowledge of techniques to generate images with the depth impression enables proper assessment and proper selection of image parameters in your own applications. Available tools make it possible to build applications using stereoscopic visualization technology and adapt existing programs to the new projection methods with built-in functions and enable the use of modern hardware. Due to increasing use of that technique, this type of presentation provides a new quality and attractive form of presentation, which is a big help in the visualization of scientific computing.

Finally, the application for visualization of simulation for deformation process of sample in a semi-liquid state was presented. This type of presentation allows a better reception for the observers by making it easy interpretation of results.

ACKNOWLEDGEMENTS

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