Research on the Construction of Three-Dimensional Grain Temperature Data Field Model Based on Voxel Grid

Haowei Zhang, Xingdong Wang, Huilin Niu
College of Information Science and Engineering, Henan University of Technology, Zhengzhou, 450001, Henan, China

Abstract: At present, text and charts are still widely used in the display of grain depot information in our country, which is not conducive to the comprehensive display of grain depot layout and internal conditions because of the lack of three-dimensional effect. In order to enhance the ability of displaying the grain situation in a grain warehouse, this paper takes the grain temperature as an example, uses a new data field visualization technology, voxel raster, combined with ECharts components and Threejs, to build a three-dimensional temperature field model and a grain warehouse scene model on the web page. The results show that the model has better stereo display effect and is easier to understand the temperature distribution in the granary.

Keywords: volume grid; field model; grain temperature; visualization

1. Introduction

According to the survey results of the United Nations Food and Agriculture Organization, the average annual loss of global warehousing accounts for about 10% of total annual production, and even up to 30% in some underdeveloped countries and regions [1]. This is not only the immaturity of grain storage monitoring, but also the imperfect management mechanism. In order to strengthen management, visualization of grain temperature is particularly important. Since Philbrick published a document on the concept of visualization in 1953, visualization technology has made great achievements [2]. Starting from the computer science, the three-dimensional visualization technology has shown its usefulness in various disciplines and has promoted the development of various disciplines to a certain extent [3]. For example, A. Inselberg uses multidimensional data to build a visual graph, which combines multidimensional data well with parallel coordinate graphs [4,5]. Poco et al. visualized weather conditions by building a multi-angle climate model [6]. Siming et al. applied the spatial-temporal data visualization method to social media analysis [7], to provide people with more information. Jiansu et al. used it on urban traffic data [8], to get more traffic information. Tominski et al. combined 2D and 3D technology to visualize Taxi Data [9], to make it easier for passengers to master their travel time more quickly. At present, there are two main visualization methods of grain temperature. One is to display it in the form of table or curve chart and column chart. Although it has good analysis ability, it lacks interaction and sense of site. Simplification and low-resolution visualization of 3D scene data have become the mainstream method in today’s era [10].

Aiming at the display problem of grain temperature, a continuously changing physical quantity in space, this paper combines data field visualization theory, uses a new data field visualization technology, voxel grid, ECharts components and Threejs to build a three-dimensional temperature field model and exterior model of the grain silo on the web page. To improve the supervision capacity of the granary.

2. Theoretical Basis

The data field is the space where the data radiates its energy from the sample space to the entire parent space, receives the data energy and is covered by the data radiation [11]. As a new breakthrough in data field model technology, voxel grid is a new method for constructing data field model. A voxel grid is a breakthrough from a two-dimensional grid to a three-dimensional volume grid. Its essence is a three-dimensional grid obtained by interpolation of three-dimensional point data. This new three-dimensional data model can better express continuous and non-homogeneous three-dimensional space, such as atmospheric temperature and humidity, air pollution, electromagnetic fields and other data.

Voxel raster volume data is organized in a regular grid and uses two-dimensional grid pixel values to record the data. The data information is stored in grid cells in the form of values. The construction of voxel grids can use the interpolation method of inverse distance weights. This is based on the principle that the samples are similar and similar. Assuming that the closer the two samples are, the more similar the properties of the two samples are, and the greater the weight. For example, suppose the point to be interpolated in space is P (xp, yp, zp), and there are scattered points Q (xi, yi, zi), i=1, 2,…, n. Now interpolate the P point attribute value Zp. The interpolation formula is as follows.

$$Z_P = \frac{\sum_{i=1}^{n} \frac{z_i}{d_i^2}}{\sum_{i=1}^{n} \frac{1}{d_i^2}} \tag{1}$$

The distance between the point to be interpolated in the formula and the i-th point in its neighborhood. As a simple interpolation method, the distance inverse weight interpolation is relatively fast and suitable for uniformly distributed data. It is more suitable for the construction of grain temperature field model.

3. Modeling Process

3.1. Data Collection

Taking the measured data in a granary as an example, there are 216 temperature measurement points in the granary. The distribution is shown in Figure 1. The temperature point data in the warehouse is stored in a json file in the form of an array, and each array contains the X, Y, Z space coordinates and temperature information of the point data.

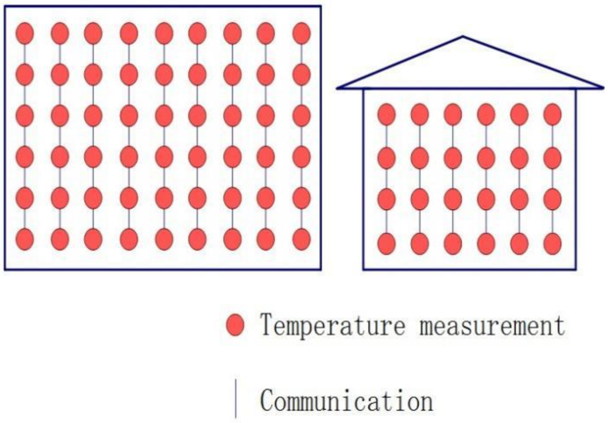

Figure 1. Distribution of temperature measurement points in granary

3.2. Build Process

This paper uses voxel grid technology combined with ECharts, 3DMax and Threejs to build a temperature field and granary exterior model. The construction process of the entire model is shown in Figure 2.

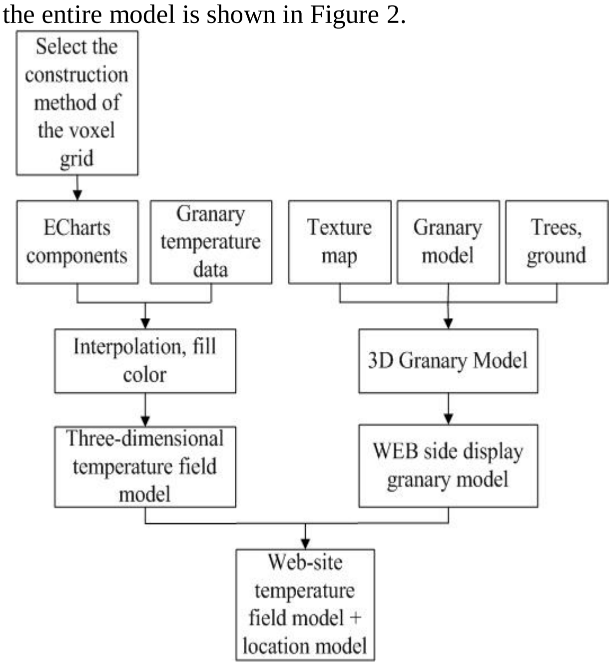

Figure 2. Model design flow chart

The construction process of the temperature field model is as follows:

1) Use PHPstudy to create web services.

2) Add the code of distance inverse weight interpolation method based on voxel grid and import the temperature data into Echar to obtain the processing result. The generated grain temperature field model is shown in Figure 3.

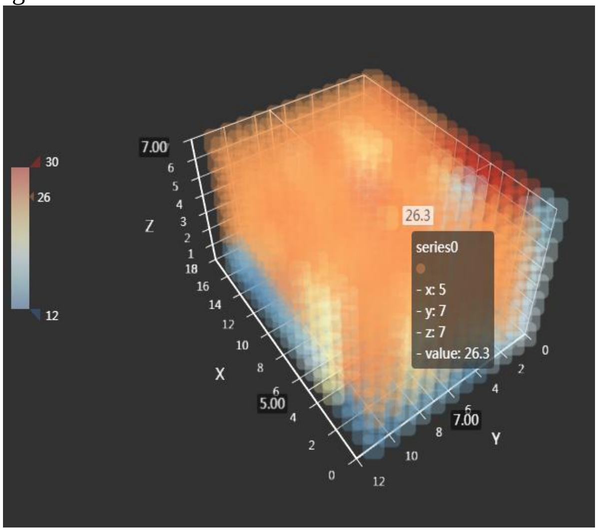

Figure 3. Grain Temperature Field Model

After the temperature field model inside the granary is constructed, the exterior model is constructed as shown below.

1) Build and export location model in 3Dmax. The model file is in OBJ format, and the texture map file is in MTL format.

2) Use Threejs and related libraries to import the exported model into the web page. The display effect is shown in Figure 4.

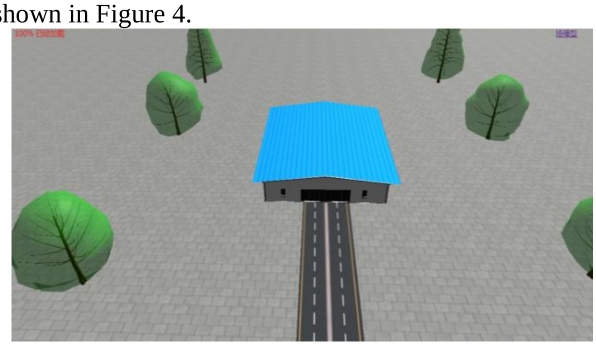

Figure 4. Granary external scene model

4. Conclusion

In this paper, the construction method of data field model based on voxel grid is applied to the study of grain temperature visualization. Using the ECharts component, a Web-based development model is used to build a visual model of the grain temperature data field, and a three-dimensional visual display of the temperature in the grain silo is realized. Change the temperature display form of the granary in the past to display the temperature information in the granary in a three-dimensional way. At the same time, a 3D exterior model of the granary warehouse is established, which is combined with the temperature field model to enhance the user's understanding of the on-site situation and realize the model display on the web page.

References

[1] Wang, S. Design and implementation of a three-dimensional reconfigurable stored grain pest monitoring system based on virtual reality technology. *Beijing University of Posts and Telecommunications*, **2018**.

[2] Philbrick, A.K. Toward a unity of cartographical forms and geographical content: Professional Geographer. **1953**, 5(5): 11-15.

[3] Xu, M.C. On the development and application of 3D visualization at home and abroad. *Modern Surveying and Mapping*, **2012**, (6): 59-60.

[4] Inselberg, A.; The plane with parallel coordinates. *The Visual Computer*, **1985**, 1(2): 69-9.

[5] Wegman, E.J. Hyperdimensional data analysis using parallel coordinates. *Journal of the American Statistical Association*, **1990**, 85(411): 664-675.

[6] Poco, J.; Dasgupta, A.; Wei, Y., et al. Similarity Explorer: A Visual Inter-Comparison Tool for Multifaceted Climate Data. *Computer Graphics Forum*, **2014**, 33(3): 341-350.

[7] Chen, S.; Yuan, X.; Wang, Z., et al. Interactive Visual Discovering of Movement Patterns from Sparsely. *IEEE Transactions on Visualization & Computer Graphics*, **2016**, 22(1): 270.

[8] Pu, J.; Liu, S.; Ding, Y. et al. T-Watcher: A New Visual Analytic System for Effective Traffic Surveillance IEEE. *International Conference on Mobile Data Management*, *IEEE*, **2013**, pp. 127-136.

[9] Tominski, C.; Schumann, H.; Andrienko, G., et al. Stacking-Based Visualization of Trajectory Attribute Data. *IEEE Transactions on Visualization & Computer Graphics*, **2012**, 18(12): 2565.

[10] Pajarola, R. Large scale terrain visualization using the restricted quadtree triangulation. Research Triangle Park, NC. USA: IEEE Computer Society Press, **1998**, pp. 2-4.

[11] Li, D.Y.; Liu, C.Y.; Du, Y. et al. Uncertainty artificial intelligence. *Journal of Software*, **2004**, 15(11): 1583-1594.