Production and Research of Digital Elevation Models of Complex Mountain Areas Based on 3D Printing Technology

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Abstract: This paper uses 3D printing technology to make a 3D model of a complex mountainous area vividly visible as a solid visualisation. Firstly, ArcGIS is used to produce a DEM (Digital Elevation Model) of the mountain area; secondly, 3dsmax is used to convert the model into a solid model and print the model layer by layer in conjunction with the reality; finally, the accuracy of the produced model is evaluated using the method of predicting the medium error. The results show that the visualisation of the digital elevation model was combined with 3D printing technology to produce a personalised and intuitive digital elevation model entity, further enhancing the in-depth application of 3D printing technology in 3D modelling.

Keywords: 3D Printing Technology; Digital Elevation Models; Visualisation

Introduction

In today's world, the geographical information data is mainly simulated with the help of software to solve practical problems, but there is still a big difference between the 3D images simulated by software and the real 3D information, which cannot convey objective and accurate 3D information to people in practical life. 3D printing technology (rapid prototyping technology) is based on digital models and applies rapid layer manufacturing technology to print metal, plastic and other adhesive materials layer by layer, which eventually constructs a clear and visible solid model. 3D printing technology is a perfect complement to the disadvantages that have always existed between 3D visualisation and manual production of physical models, and is a more intuitive, realistic and comprehensive response to topographic models. It is worth mentioning that fused deposition (FDM) 3D printing technology can turn DEM 3D terrain data into a realistic and comprehensive model, which fully demonstrates the recognition, simulation and information transfer functions of geographic information data, and is of great importance in real life applications.

1. Data area

In this paper, the longitude range 124.31459427 - 124.42995071 and latitude range 41.30824500 - 41.37139828 of Nandian Town, Benxi Manchu Autonomous County, Benxi City, Liaoning Province, were selected as the study area, which has a complex environment and steep terrain. Firstly, the satellite map was downloaded from Big Map and the download level was selected as level 17, as shown in Figure 1; secondly, GDEMV2 30M resolution digital elevation data was obtained from the Geospatial Data Cloud website (https://www.gscloud.cn/search).

Figure 1 Data area

2. Digital elevation modeling

2.1 DEM raster data

The steps to create a digital elevation model are to load the DEM raster data that needs to be clipped, and then load the satellite image. Firstly, open ArcGIS software, enter the DEM data, search for "mosaic to new raster" in the search bar, load the DEM elevation data into it, select the projection coordinate system UTM-WGS1984, the number of bands is 1 and the pixel type is 16. Secondly, import the satellite image of the study area into the software and open the satellite image by pickling The satellite image is opened by film extraction. Finally, the DEM elevation data is cropped.

2.2 Solid model visualisation

This article is based on 3dsmax 3D modelling software to achieve the conversion of solid models. First open 3dsmax and import the model in the STL file into 3dsmax. As there are multiple objects on the surface of the model, it needs to be integrated into a group first and turned into a whole. This is done by selecting the model, converting it to an editable polygon, clicking on the polygon in the selection and entering the required extrusion height in the Edit Polygon dialog box. Then select the boundary and turn the curved boundary into a straight line by flattening it and having it appear in the same plane. Click on the seal inside the Edit Boundary tool box, as shown in Figure 2, to turn it into a solid model.

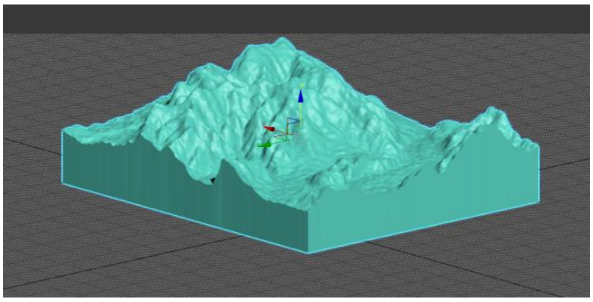

Figure 2 Visualisation of the digital elevation model

3. 3D printing technology

The 3D printing technology is based on the STL format of the 3D model digital file as a socket, on which the model is printed in layers. Due to the large size of the model it is necessary to split it. Before splitting it, the resulting solid model is integrated into a group, the axes are zeroed and then switched to the front view. In the create option, a rectangle is drawn for the model and then switched to the left view to draw another rectangle. In the Modify option, extrude the two rectangles to obtain a quarter of the model. Following this method, the remaining three quarters of the model can be drawn in turn.

The quarter model in 3dsmax is first transferred to the Ultimaker Cura software, and then the object model graphics are fed into the FDM unit through the software. The nozzle of the unit heats the moulding material (PLA) and support material to a molten state, and the heated nozzle moves across the surface of the 3D model drawing under the control of the system, first extruding the hot molten material in a semi-fluid state, and extruding the model The base is printed and the material rapidly cures to form the base profile. Once the base is formed, the printhead prints in layers, moving vertically up and down according to the shape of the model. Once the layers of material have built up and solidified, a 3D solid model is formed, from which the remaining parts of the model are printed and finally stitched together.

4. Accuracy assessment

In assessing the accuracy of the model, the method of predicting the medium error was chosen. The method is as follows: firstly, in the 3D software, the distances of the trait points are measured, the trait points must be in pairs, and any two trait points are selected in sequence, secondly, according to the trait points selected in the 3D model, the distances of the two trait points are measured in sequence in the solid model, and then the dimensions are reduced according to a certain scale. The dimensions of the two feature points are then compared to the dimensions of the two feature points at the same locations in the 3D model, resulting in a difference value. A number of sets of differences are then obtained, and an estimate of the median error is then obtained according to the formula for calculating the median error.

After several measurements, the data in Table 1 were obtained. l1 (mm) represents the 3D model feature point spacing, l2 (mm) represents the solid model feature point spacing, and Ed represents the medium error.

Table 1 Table of trait point spacing

No.	11	12	13	14	15	16	17	18	19	20
l1/mm	376.1	79.2	365.7	591.6	709.0	117.4	225.9	343.3	442.7	325.3
l2/mm	122.4	32.3	119	190.4	227.8	39.1	76.5	113.9	142.8	107.1

The data in the table was checked several times by measuring and comparing the spacing of the feature points in the 3D model with the original data in the solid model after scaling, and then calculating the final difference according to the following 1-1 equationmedium error formula.

$$E_d = \pm \sqrt{\frac{l_1 l_2}{n}} \quad (1\text{-}1)$$

No.	1	2	3	4	5	6	7	8	9	10
l1/mm	184.9	242.3	64.2	226.9	298.2	169.4	237.4	191.2	304.8	262.6
l2/mm	71.4	85	20.4	76.5	100.3	57.8	79.9	73.1	102	88.4

From the above data it is calculated that Ed = 3.379mm where the magnitude of the error reflects the accuracy of the model.

5. Conclusion

At present, digital elevation models are increasingly used in engineering construction, farmland planning and other practical aspects of life. 3D printing technology has a very important role to play in simplifying the production process of model materialisation, thus realising the presentation of digital elevation models to visualised solid models, and also breaking the gap between virtual and reality. This paper combines the visualisation of mountain models with 3D printing technology as a further extension of the application of 3D printing technology in the modelling of complex mountain 3D entities, producing realistic, individual and intuitive 3D models of mountain entities.

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