**Instruction for model**

This instruction aims to guide the step-by-step implementation of global interpolation as described in the manuscript titled “HFSM: high-fidelity surface modeling for large-scale DEMs with terrain discontinuity preservation”. For detailed information regarding the provided data and codes, please refer to the “Readme.txt” file located in the same directory as this instruction.

The following contents mainly use the publicly available airborne LiDAR benchmark dataset, provided by https://portal.opentopography.org to demonstrate how to use the model for global interpolation.

All modules of the proposed model have been integrated into the “main.m” file, with all parameter configurations finalized within the script. Executing the “main.m” file will generate all necessary data for global interpolation.

1. **Data Input**

In the “main.m” file, set the relative or absolute path of the input data (Figure I1).

图表

描述已自动生成

Figure I1. The input data sources setting.

1. **Model Parameter Settings**

In the “main.m” file, set the following parameters (Figure I2):the parameter of the Γ-convergence(“epsilon”) (refer to Equation (7) in the manuscript), the smoothing parameter (“delta”) (refer to Equation (2) in the manuscript),the regularization parameters (“alpha” and “beta”) (refer to Equation (6) in the manuscript), the number of solution iterations (“max\_iter”) (refer to Equation (10) in the manuscript), and the grid resolution (“m”).

文本

描述已自动生成

Figure I2. Model parameter settings.

1. **Grid Point Construction, Compute and Define initial value ,** **Objective function solving**

After configuring the parameters, grid point construction based on maximum and minimum coordinates of sampling points. Next, invoke the “scatteredInterpolant” function to calculate initial values. Then, define the functions m, n. Final, enter the solution of the variational model objective function process (Figure I3).

文本

低可信度描述已自动生成

Figure I3. Grid point construction,Compute and Define initial value, Objective function solving.

1. **Precision** **Validation, Data Save, Data Visualization**

The interpolation accuracy metrics for the test samples (“RMSE”, “MAE”), utilized for model validation. Next, invoke the “saveM2GisFile” function to save data (“griddem.txt”) (Figure I4).

Take Data4 data as an example. Import the model’s output results (“griddem.txt”) into Surfer software for visualization (Figure I5). The visualization results of the traditional method are also plotted under the optimal parameters of the Surfer software.

文本

中度可信度描述已自动生成

Figure I4.Precision validation and data save.

地图

描述已自动生成

Figure I5. DEMs of the proposed method and the comparative methods on Data4

1. **Quantitative Analysis**

a. RMSE and MAE

The following content focuses on the quantitative analysis of spatial interpolation using the publicly available airborne LiDAR benchmark dataset, provided by https://portal.opentopography.org.

The proposed method calculates the RMSE and MAE using “main.m”. The RMSE and MAE of the traditional method are calculated under the optimal parameters of the ArcGis software. Take Ordinary Kriging (OK) as an example, the calculation process is as follow:

* The ground data was randomly partitioned into training and testing points (Figure I6).

图形用户界面, 文本, 应用程序

中度可信度描述已自动生成

(a)

图形用户界面, 应用程序

描述已自动生成

(b)

Figure I6. Extract training and testing points.

* Training data was used for generating DEMs (Figure I7).

图形用户界面, 文本, 应用程序

描述已自动生成

(a)

图形用户界面, 应用程序

描述已自动生成

(b)

Figure I7. Interpolation.

* Record the trend value at the checking point into the point set property table (Figure I8).

图形用户界面, 文本, 应用程序

描述已自动生成

(a)

图形用户界面, 应用程序

描述已自动生成

(b)

表格

描述已自动生成

(c)

Figure I8. Extract multi values to points.

* In the “checking” layer property sheet, create two new fields (“Diff” and “ID”) to calculate RMSE and MAE (Figure I9).

图形用户界面, 应用程序

描述已自动生成

(a)

图形用户界面

描述已自动生成

(b)

图形用户界面, 应用程序, 电子邮件

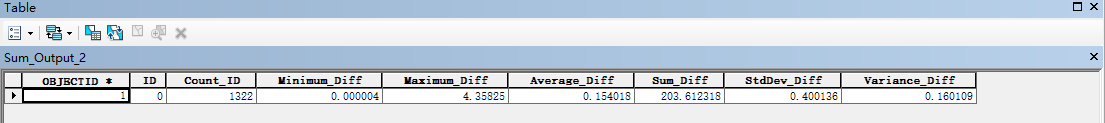
描述已自动生成

(c)

图形用户界面, 应用程序

描述已自动生成

(d)



(f)

Figure I9. Calculate RMSE and MAE.

Fig. I10 displays the RMSE and MAE values for our proposed method alongside those of the comparative methods on the six datasets under different data densities (bar graphs are drawn by Visio).

各种颜色的铅笔

描述已自动生成

Figure I10. DEM RMSE and MAE values of HFSM and the five classical interpolation methods on the six datasets under different data densities

b. SMR

In order to further test the ability of each method to preserve terrain, the DEM generated by each method is used to extract terrain feature lines. Then the index SMR is used to check the degree of agreement between the feature lines generated by each DEM and the hand-crafted truth values.

* Extract terrain feature lines (take the valley line as an example, and invert the DEM on the ridge line) (Figure I11).

ArcToolbox > Spatial Analyst > Hydrology >Fill

图形用户界面, 文本, 应用程序

描述已自动生成

(a)

ArcToolbox > Spatial Analyst > Hydrology >Flow Direction

图形用户界面, 文本, 应用程序, 电子邮件

描述已自动生成

(b)

ArcToolbox > Spatial Analyst > Hydrology >Flow Accumulation

图形用户界面, 文本, 应用程序, 电子邮件

描述已自动生成

(c)

图形用户界面, 应用程序, 表格

描述已自动生成

(d)

ArcToolbox > Spatial Analyst > Hydrology >Stream Order

图形用户界面, 文本, 应用程序

描述已自动生成

(e)

ArcToolbox > Spatial Analyst > Hydrology >Stream to Feature

图形用户界面, 文本, 应用程序, 电子邮件

描述已自动生成

(f)

Figure I11. Extract terrain feature lines.

Take Data5 data as an example. The terrain feature lines extracted by each method and by hand are shown in Figure I12.

图示

描述已自动生成

Figure I12. Terrain breaklines of all the interpolation methods on Data5 under the data density of 90%

* The manually extracted terrain feature lines are used as buffer zones (Figure I13).

图形用户界面, 文本, 应用程序

描述已自动生成

Figure I13. Building buffers.

* The terrain feature lines extracted from each DEM are intersected with the buffer zone separately (Figure I14).

图形用户界面, 应用程序

描述已自动生成

Figure I14. Intersect.

* The length of terrain feature lines extracted manually and generated by each DEM were counted respectively, and then the SMR was calculated.
* Figure. I15 displays the SMR values for our proposed method alongside those of the comparative methods on the six datasets under different data densities.

图表, 折线图

描述已自动生成

Figure I15. Relationship between data density and SMR on the six datasets.