**Instruction for model**

This instruction aims to guide the step-by-step implementation of spatial interpolation as described in the manuscript titled “Terrain breakline-aware smoothing interpolation for producing high-accuracy digital elevation models from LiDAR data”. 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 the International Society for Photogrammetry and Remote Sensing (ISPRS) commission to demonstrate how to use the model for spatial 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 spatial interpolation.

1. **Data Input**

In the “main.m” file, set the relative or absolute path of the input data (Figure I1). Specifically, the variable “data” represents all the sample data used for modeling; “testdata” represents all the sample data used for mode validation.

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Figure I1. The input data sources setting.

1. **Model Parameter Settings**

In the “main.m” file, set the following parameters (Figure I2): the interpolation of the number of iterations (“iterations”), the number of neighbors for the local interpolation (“nc”), the smoothing parameter (“lamba”) (refer to Equation (3) in the manuscript), the radius of the kernel function (“d”, “h”,“q”, “g”) (refer to Equations (6), (7), (8), and (9) in the manuscript), and the optimal grid resolution (“m”).

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Figure I2. Model parameter settings.

1. **Grid Point Construction, Iterative Computation**

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.

After that, enter the iterative interpolation process (Figure I3). 1. The normals and curvatures (N-Cs) of all DEM grid cells were computed using the maximum consistent set (MCS)-based algorithm (Figure I4). 2. The smoothing RBF with a trilateral kernel function was utilized to estimate the elevations of all DEM grid cells (by invoking the “predictLocal\_iteration03” function). 3. The N-Cs of all DEM grid cells were re-computed using the MCS-based algorithm on the neighboring grid cells rather than on the sampling points. 4. The smoothing RBF with the quadrilateral kernel function was utilized to estimate the elevations of all DEM grid cells (by invoking the “predictLocal\_iteration01” function). Steps (3) and (4) were repeated until the maximum absolute elevation difference between the current iteration and the last iteration was less than a given tolerance *tol* (e.g., *tol*=0.01 m), or the maximum number of iterations was reached.

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Figure I3. The codes for grid point construction,iterative computation.

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Figure I4. The normals and curvatures (N-Cs) of all DEM grid cells were computed using the maximum consistent set (MCS)-based algorithm.

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 I5).

Take s23 data as an example. Import the model’s output results (“griddem.txt”) into Surfer software for visualization (Figure I6). The visualization results of the traditional method are also plotted under the optimal parameters of the Surfer software.

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Figure I5.Precision validation and data save.

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Figure I6. DEMs of the proposed method and the comparative methods on s23

1. **Quantitative Analysis**

The following content focuses on the quantitative analysis of spatial interpolation using the publicly available airborne LiDAR benchmark dataset, provided by the International Society for Photogrammetry and Remote Sensing (ISPRS) commission.

The proposed method calculates the RMSE and MAE using “main.m”. The parameter reference for each data is as follows (Table I1). 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, with a 90-10 split (Figure I7).

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(a)

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Figure I7. Extract training and testing points.

* 90% of the data was used for generating DEMs (Figure I8).

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Figure I8. Interpolation.

* Record the trend value at the checking point into the point set property table (Figure I9).

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Figure I9. Extract multi values to points.

* In the “s23-checking” layer property sheet, create two new fields (“Diff” and “ID”) to calculate RMSE and MAE (Figure I10).

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(f)

Figure I10. Calculate RMSE and MAE.

Fig. I11 displays the RMSE and MAE values for our proposed method alongside those of the comparative methods on the 10 samples from the ISPRS dataset (bar graphs are drawn by Visio).

Table I1. The parameter reference for each data.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Plot | lamba | d | h | q | g |
| s11 | 13 | 3.5 | 3 | 20 | 1 |
| s21 | 13 | 3.5 | 3 | 15 | 1.5 |
| s22 | 13 | 3.5 | 1.6 | 20 | 1 |
| s23 | 5.8 | 2.8 | 4 | 20 | 2 |
| s24 | 3 | 1.2 | 1.2 | 20 | 1 |
| s31 | 5.8 | 2.8 | 1 | 20 | 0.5 |
| s41 | 5 | 2.5 | 1.5 | 13 | 2 |
| s51 | 10 | 3.5 | 1 | 20 | 1 |
| s53 | 2.5 | 1.5 | 2.5 | 20 | 1.5 |
| s61 | 5 | 1.5 | 2.1 | 20 | 1 |

图表, 条形图

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1. RMSE

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1. MAE

Figure I11. (a) RMSE and (b) MAE for the proposed method alongside those of the comparative methods across the 10 samples in the ISPRS dataset.