Remote sensing for riverbed DTM generation and river morphodynamic evolution analysis

Bozzano M.[1], Varni F.[2], Quarati A.[2], De Martino M.[2], Tambroni N.[1], Federici B.[1]

[1] Department of Civil, Chemical and Environmental Engineering, Università di Genova, Genova, Italy, matteo.bozzano@edu.unige.it, (bianca.federici, nicoletta.tambroni)@unige.it
[2] Institute for Applied Mathematics and Information Technologies, National Research Council, Genova, Italy, (monica.demartino, alfonso.quarati, francesco.varni)@ge.imati.cnr.it

Abstract. River inlets, deltas, and estuaries are vulnerable to climate change. Morphodynamics has advanced, but models need comprehensive data. Remote sensing is a powerful tool for monitoring river systems.

This work proposes an automatic procedure to generate a continuous Digital Terrain Model (DTM) of riverbeds, covering both emerged and submerged areas, by integrating data from remote sensing. A MATLAB script derives bathymetry from multispectral imagery using a model [2] calibrated with Single-Beam Echo-Sounder (SBES) data. A QGIS procedure integrates bathymetric with photogrammetric and/or LiDAR surveys. This method was applied to the Roia River.

The proposed approach utilizes a multispectral orthophoto with blue, green, red, and near-infrared bands, applying a threshold to the near-infrared band to distinguish between wet and emerged surfaces; then a supervised classification with the maximum likelihood algorithm is applied to classify the emerged areas into vegetated and sandy categories, and a mask to not process shadows from bridges and vegetation. Water depth estimation employs a non-linear model based on the ratio of log-transformed water reflectance bands [1,2], calibrated and validated using in situ bathymetric data from an SBES survey, that is previously resampled to match the orthophoto's resolution. The water surface can be approximated as a tilted plane derived from LiDAR data, using Voronoi polygons along the main watercourse. If LiDAR data isn't available, the plane is created by interpolating photogrammetric point clouds of sand/gravel areas near wet regions. The orthometric height of submerged areas is calculated by subtracting bathymetry from the water surface height. LiDAR can also provide ground level data under vegetation; otherwise, this is estimated by interpolating photogrammetric data from surrounding sand/gravel areas.

The riverbed DTM is generated using interpolation techniques, primarily cubic spline interpolation and TIN, to fill data gaps. This DTM provides a continuous representation of both dry and submerged riverbed sections (see Fig. 1a). The DTM's accuracy depends on the quality of the remote sensing data, including instrument accuracy and spatial and temporal resolutions. Hence a quality map is produces to allow quick identification of the data sources for different DTM areas (see Fig. 1b).

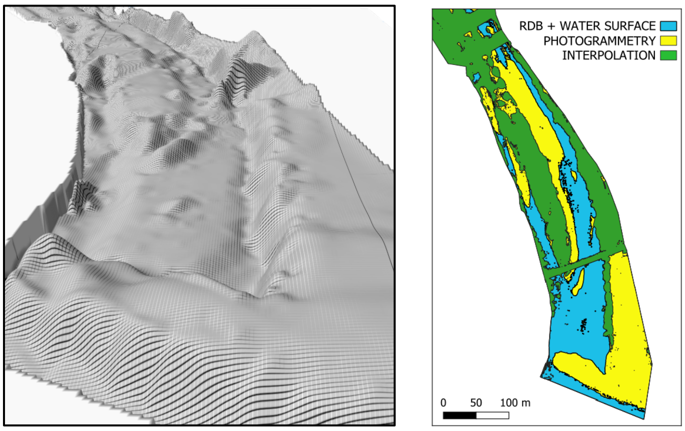

Fig. 1. Example of 3D view of riverbed DTM (on the left) and of the quality map (on the right).

Preliminary outcomes demonstrate the potential of remote sensing data for generating riverbed DTMs. Current efforts include analyzing a time series of images to track changes in emerged and submerged sections of the riverbed. These results will inform and validate a new theoretical model [3] predicting conditions for sediment pattern formation, such as bars, especially in river-to-sea transition zones. Future research will extend this methodology to other rivers.

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