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Applying Deep Learning to Predict Comprehensive Land and River Topography for Hydrological and Hydraulic Simulations

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Introduction: Riverbed topography or bathymetry is crucial for hydrologic and hydraulic applications, such as sediment transport, flooding inundation mapping, watershed conservation, and reservoir management. However, riverbed topography data are not easily accessible or widely available for large areas. Surface topography in the form of a Digital Elevation Model (DEM) is widely available, but river channels in a DEM are shown as flattened areas. Thus, there is a need to predict large-scale river bathymetry data. This study applies a deep learning (DL) model to address this need by using DEM and related river channel.

Methodology:

- A conditional generative adversarial neural network (CGAN) is utilized to predict cross-sections using selected channel properties, such as width, depth, bank height, and curvature.
- The model is trained with datasets from different study sites, including the Mississippi, Brazos, and Tombigbee Rivers.
- All input parameters and output cross-sections are normalized by critical scale properties of the river channel. Thus, the DL model can train and predict river bathymetry across different scales.

Results and Conclusions:

- The DL model can predict river cross-sections with a 20% to 30% error in normalized depth, which is half what has been published in the literature from conventional conceptual models.
- The curvature of the channel centerline and depth-to-width ratio are crucial properties for riverine cross-section geometry.

FOR FURTHER READING:

Liang, C. Y. & Merwade, V. (2024). Applying Deep Learning to Predict Comprehensive Land and River Topography for Hydrological and Hydraulic Simulations [Oral presentation]. *AWRA 2024 Geospatial Water Technology Conference*, Orlando, FL, US, 23 March 2024.

Liang, C. Y., Dey, S. & Merwade, V. (2024). Enhance River Geometry Representation Trough Appropriate Single-Beam Bathymetry Processing Approaches and Settings [Oral presentation]. AWRA 2024 Geospatial Water Technology Conference, Orlando, FL, US, 23 March 2024.

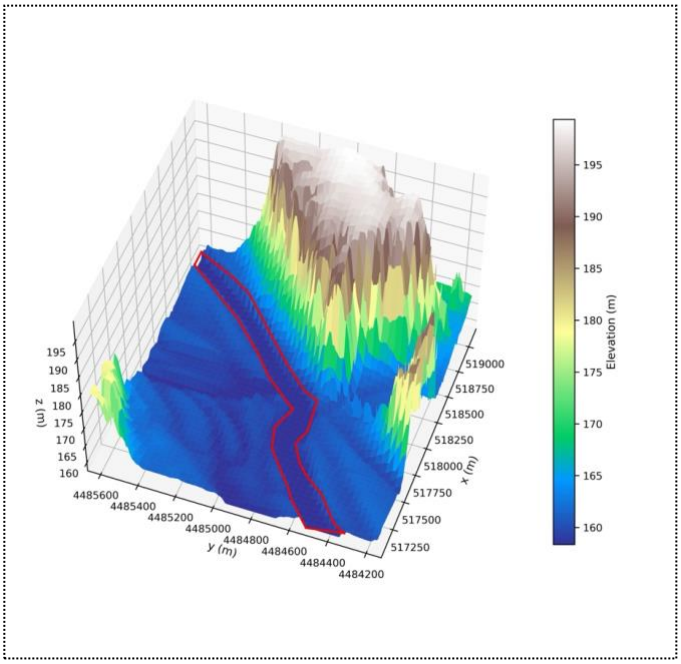

Figure 1. The DEM of the river segment. The red polygon indicates the hydro-flattened area.

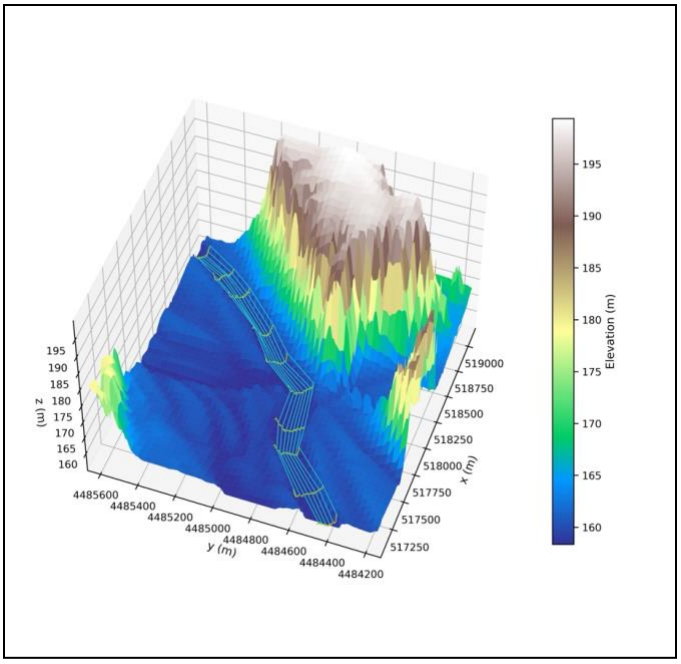

Figure 2. A synthetic mesh of the riverbed surface (blue and green lines) generated by the deep learning model (CGAN).