RECLAMATION *Managing Water in the West*

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The Knowledge Stream

Research Update

Filtering Light Detection and Ranging (LiDAR) Data for Rivers

A literature review of LiDAR tools, methods, and best practices

Bottom Line

This literature review identified methods and available tools to enhance Filtering Light Detection and Ranging (LiDAR) data to more accurately represent landscape features such as streambanks, levees, and bathymetry.

Better, Faster, Cheaper

This information will help identify practical processes to optimize LiDAR datasets for use in geomorphic studies and hydraulic modeling and engineering analyses. The result will help improve data quality, data quantity, and provide faster results with less expense.

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Problem

Reclamation uses Filtering Light Detection and Ranging (LiDAR) elevation data to support a variety of programs and applications. Often, LiDAR data are used for understanding river system forms, dynamics, and habitats, and to help design river-related projects. However, using these data in river systems projects has revealed several data quality issues, including inaccurate presentation of landscape features such as streambanks, levees, and water surfaces. Several peer-reviewed articles suggest that these data quality issues may arise from limitation of standard data processing procedures.

The initial LiDAR data capture consists of a dense, three-dimensional collection of sample points (i.e., LiDAR point cloud) for all data returns. This "raw" point cloud includes instrument returns for surfaces that may represent undesired objects, vegetation, manmade objects, and even birds in flight and unobstructed terrain surfaces. To make LiDAR useful as terrain surface data, the LiDAR point cloud must be filtered to separate the terrain and off-terrain data points. The separation and classification of LiDAR data into a terrain dataset is critical in developing accurate surface models. Accordingly, many studies have been conducted on filtering methods to process LiDAR data. The filtering process and final terrain data quality are particularly important during engineering applications.

Solution

This Science and Technology Program research project conducted a literature review to document current knowledge and tools for LiDAR data processing in the context of

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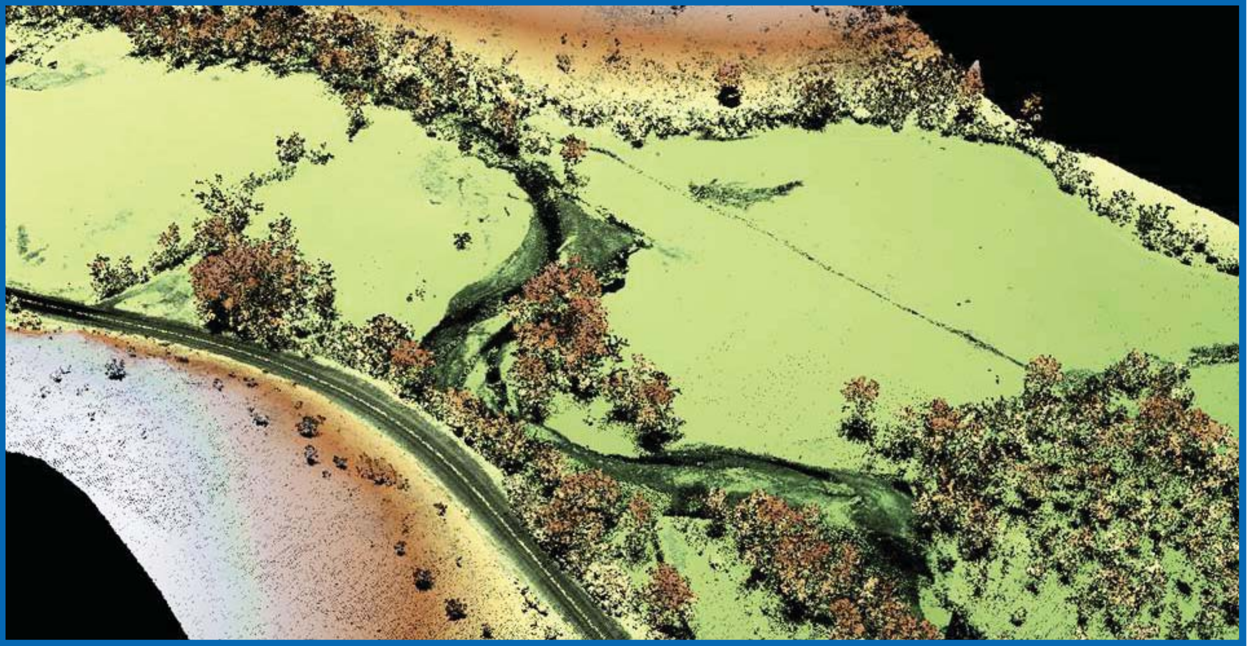

Terrain surface from LiDAR data.

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filtering point clouds to produce terrain datasets, and identifying potential solutions for enhancing the accuracy of the datasets.

The literature review revealed several useful tools that could be used to enhance LiDAR data for use in hydraulic modeling and stream geomorphology studies. It also revealed several data gaps, which could be addressed in potential studies worthy of being undertaken by Reclamation.

Future Plans

Though numerous comparative studies have been conducted evaluating the efficacy of various tools and approaches, the tools that show most promise for use in Reclamation's applications have not been comparatively evaluated to date. A more current and focused comparative study is therefore warranted.

The proposed study would compare the filtering processes of interest. Filtering results would be evaluated against delivered commercial products as the reference dataset. The point of the comparative review would be to assess filter performance using two criteria:

- Minimizing Type I and II errors relative to the reference dataset
- Representing surface shape relative to field surveyed transects

Type I errors represent data points being identified in the filtering process as terrain points that actually are off-terrain points. The erroneous points are included the resulting terrain dataset. Inversely, Type II errors identify true terrain points as off-terrain points and excludes these points from the final terrain dataset. These errors combine to reduce the accuracy of surface model. Testing for Type I and II errors is only one part of assessing outcomes of the filtering process.

Comparison of the surface model derived from LiDAR against field survey data assesses limitation of the filtering processes and capabilities of the LiDAR itself to accurately represent real surfaces.

LiDAR technology is continually improving and advancing. Currently, Reclamation acquires near-infrared LiDAR, which is collected using laser pulses with wavelengths that are absorbed by water. Newer scanners are becoming commercially available, known as "green LiDAR," that use laser pulses with wavelengths that can penetrate water, bounce off the stream bottom, and return; thereby producing bathymetry data. This technology could provide important stream bathymetry data that is otherwise expensive to acquire using manual surveying techniques and limited in extent. Stream bathymetry is currently acquired through field survey, taking measurements across transects at broad intervals along a river. Future studies with green LiDAR could build off proposed studies involving near-infrared to explore the potential of providing accurate full surface models (terrain surface and stream bathymetry) to Reclamation hydrologists and geomorphologists.

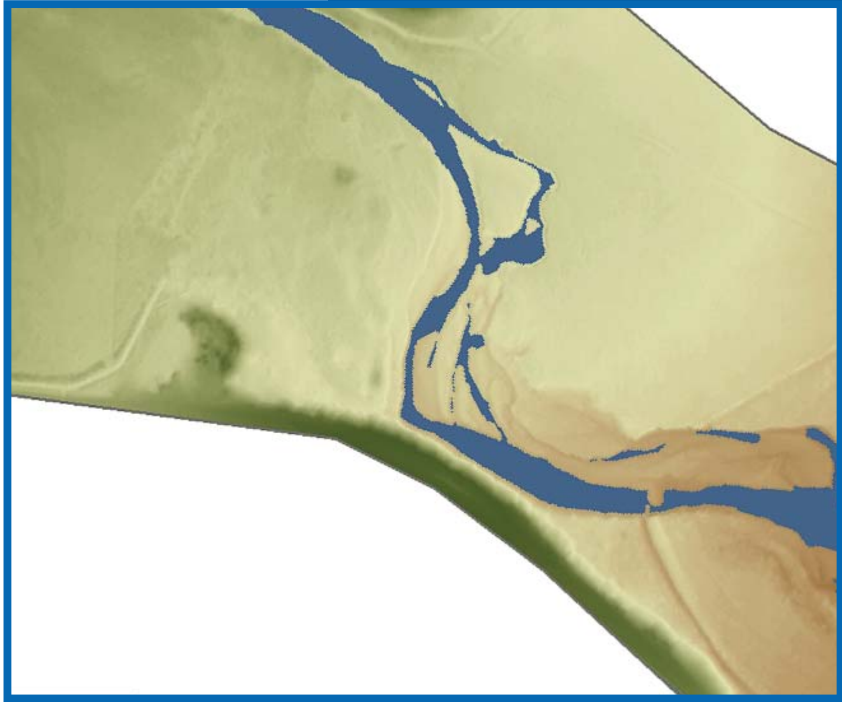
"Overall, this will allow for more accurate analyses of geomorphic forms, processes, and habitat types and provide a basis for more accurate engineering analyses and design."

Christopher Cuhaciyan
Project Manager, Reclamation

More Information

Lindeman, D. 2012. *"Literature Review Focused on Data Processing Techniques for the Selective Filtering of Light Detection and Ranging (LiDAR) Data for Enhanced Surface Representation of River Geomorphology."* Reclamation, www.usbr.gov/research/projects/detail.cfm?id=657.

Science and Technology Program Research Project: www.usbr.gov/research/projects/detail.cfm?id=657



Results from a selective filtering of LiDAR data.