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Automated tools for identifying bankfull river channel extents: developing and comparing objective and machine-learning methods

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Bankfull channel dimensions are of fundamental importance in fluvial geomorphology, to describe the geomorphic character of a river, as inputs to models which explain variations in morphology through time and space, and as initial processing steps in more detailed morphometric techniques. With ever-increasing availability of high-resolution elevation data (e.g. LiDAR), manual delineation of channel extents is a bottleneck which limits the geomorphic insights that can be gained from that data.

We developed and tested two automated channel delineation methods that define bankfull according to different criteria and thus reflect different conceptualisations of bankfull extent: (1) a cross-sectional method (termed *HydXS*) that identified the elevation which maximises hydraulic depth (cross-section area/wetted width); and (2) a neural network image segmentation model trained on images derived from a LiDAR digital elevation model.

HydXS outperformed the neural network method overall, but the two methods were comparable in larger streams (> 20 m bankfull width; Dice coefficient ~0.85). Prediction accuracy of *HydXS* was generally high (overall precision 89%; recall 81%), performing well even in small streams (bankfull width ~ 10 m). HydXS performed worst in incised and recovering stream sections (precision 93%; recall 64%) where the choice between macro-channel and inset channel was somewhat arbitrary (both for the algorithm and manual delineation). The neural network outperformed HydXS where an inset channel was present. The neural network method performed worst in small streams and where other features (e.g. road embankments, small ditches) were misclassified as channels. Neural network performance was improved markedly by trimming the area of interest to a 100-m wide buffer along the stream, eliminating many areas prone to misclassification.

The two methods provide different ways to effectively leverage high-resolution LiDAR datasets to gain information about channel morphology. These methods are a significant step forward as they can delineate bankfull elevation, as well as bankfull width, and operate using morphology alone. *HydXS* is an objective method that doesn't require training, can be run on consumer-level hardware, and can perform well in small streams, but requires manual work to develop the necessary spatial framework of an accurate channel centerline. The neural network model is a promising method to delineate larger channels (>20 m wide) without requiring detailed centerline or cross-section data, given adequate training data for the stream type of interest (i.e. expert-delineated bankfull channel extents). We envisage that further improvement of the neural network method is possible by scaling the input image extents to catchment area, and training on a larger dataset from multiple regions to increase generalizability.