Geospatial Representation of River Channels

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Abstract: A geographic information system (GIS) approach for creating a three-dimensional (3D) topographic data set for straight or meandering river channels is presented. As input, the approach requires channel banklines, an initially arbitrary centerline, and a set of (x,y,z) river bathymetry points. A curvilinear orthogonal s,n-coordinate system that references data along and transverse to flow in the river channel is used. The methodology includes locating the channel centerline along the thalweg and then using it as a reference for assigning s,n-coordinates to the bathymetric data. The resulting bathymetric data in the s,n,z-coordinate system are used to create a square mesh, or FishNet, and this FishNet is then transformed back to the original x,y,z-coordinates to get a flow-oriented 3D mesh. The resulting 3D mesh is a network of lines transverse to the flow (cross sections) and lines parallel to the flow (profile lines). The output thus provides a flow-oriented 3D representation of channel geometry that can be used for river habitat and hydraulic modeling.

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Introduction

The geospatial representation of rivers has been materially improved in recent years by the dense mapping of land surface terrain using such techniques as LIDAR (light detection and ranging). However, currently used LIDAR methods cannot penetrate water, so the most critical part of the terrain from the river hydraulic viewpoint, namely, the channel bed shape, has to be measured by other means. The traditional method of such measurement has been to use surveyed cross sections, but they can only be approximately integrated with a terrain surface. A precise way of measuring river bathymetry is by using depth-sounding measurements from a boat combined with global positioning system GPS location of the measuring device to generate a set of scattered (x,y,z) points over the riverbed. To adapt river bathymetry measured in this manner to form the framework for two-dimensional (2D) and three-dimensional (3D) hydraulic models, it is necessary to re-form the data into a spatial mesh that represents the river channel at regular intervals, preferably oriented in the direction of flow. This paper presents a geographic information system GIS approach for creating 3D data sets for river channels by using the channel boundary, an arbitrary centerline, and three-dimensional measurement points of river bathymetry.

Given the channel boundary, an arbitrary centerline, and 3D measurement points of river bathymetry, the procedure presented in this paper produces two outputs: the thalweg and a 3D mesh. The thalweg is the line connecting the points of lowest bed elevation in a river channel. The 3D mesh is a flow-oriented network of lines that are transverse to the flow (cross sections) and parallel to the flow (profile lines). The 3D mesh provides geometric data that can be used as an input to one-, two-, and 3D hydraulic models. The procedure presented in this paper is applicable only to straight or meandering river channels and is not applicable to braided river channels, floodplains, or river channel confluences.

Coordinate Systems

This paper uses two different coordinate systems, namely, Cartesian coordinates and curvilinear orthogonal coordinates. These coordinate systems are briefly explained here with reference to Fig. 1. In a Cartesian coordinate system (x,y), any point P is identified by its location east and north of a fixed origin (x_o,y_o). For any point, the x-coordinate (easting) is the perpendicular distance to the point from the y-axis, and the y-coordinate (northing) is the perpendicular distance to the point from the x-axis.

The curvilinear orthogonal s,n-coordinate system, explained in detail later, assigns coordinates to the points in a river channel with reference to its centerline (Fukuoka and Sayre 1973; Holley and Jirka 1986; Nelson and Dungan 1989; Johannesson and Parker 1989). Any point P within the channel has two coordinates: s and n. The s-coordinate is equal to the flow distance along the centerline at that location, and the n-coordinate is equal to the perpendicular distance from that point to the centerline. The points lying on the left-hand side of the centerline (looking downstream) have negative n-coordinates, and the points lying on the right-hand side of the centerline have positive n-coordinates.

Previous Work

GIS data may be presented in vector and raster forms. Vector data are represented by points, lines, and polygons; raster data are

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