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Embedding Rivers in Polyhedral Terrains

Data conflation is a major issue in GIS: spatial data obtained from different sources, using different acquisition techniques, needs to be combined into one single consistent data set before the data can be analyzed. The most common occurrence for hydrological applications is conflation of a digital elevation model and rivers. We assume that a polyhedral terrain is given, and a subset of its edges are designated as river edges, each with a flow direction. The goal is to obtain a terrain where the rivers flow along valley edges, in the specified direction, while preserving the original terrain as much as possible.

We study the problem of changing the elevations of the vertices to ensure that all the river edges become valley edges, while minimizing the total elevation change. We show that this problem can be solved using linear programming. However, several types of artifacts can occur in an optimal solution. We analyze which other criteria, relevant for hydrological applications, can be captured by linear constraints as well, in order to reduce such artifacts. We implemented and tested the approach on real terrain and river data, and describe the results obtained with different variants of the algorithm. Moreover, we give a polynomial-time algorithm for river embedding for the special case where only the elevations of the river vertices can be modified.