Restricted Bathymetric Tracklines Interpolation

Wenli Li, W. Randolph Franklin, Salles V. G. Magalhães, Marcus V. A. Andrade

Rensselaer Polytechnic Institute

liw9@rpi.edu, mail@wrfranklin.org, vianas2@rpi.edu, marcus@ufv.br

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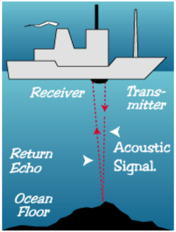
Motivation

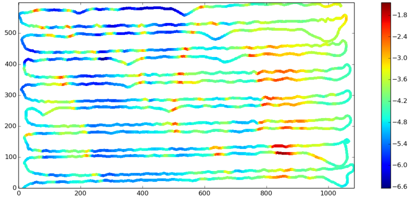
- Bathymetry (underwater terrain) is measured by a single beam or multibeam echosounder
- Measurement points are distributed along the track of the boat and are called a trackline

$$depth = \frac{v \times t}{2}$$



Echosounding
(Image from http://www.dosits.org/)

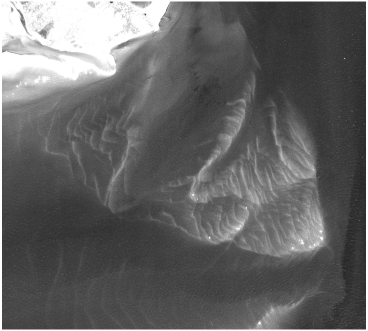
- Given a tracklines data represented as a 599×1084 DEM
- Single pixel wide and continuous



(Data courtesy of Peter Traykovski at Woods Hole Oceanographic Institution)

Satellite image

- A single beam survey of a 400 by 700 meters area of tidal sand bars off the coast of Martha's Vineyard, Massachusetts



(Images courtesy of Peter Traykovski at Woods Hole Oceanographic Institution)

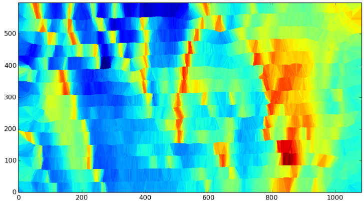
Existing methods

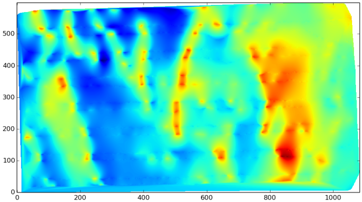
Nearest neighbor interpolation (left)

- Each unknown point is assigned the value of its nearest known point
- The result consists of patches of constant values and is not continuous

Natural neighbor interpolation (right)

- Each unknown point is assigned the weighted sum of the values of its nearest known points
- The result is much smoother, but too smooth between distant pieces of trackline so that features are almost lost





Existing methods (cont'd)

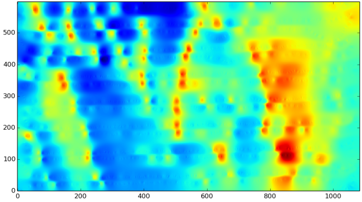
Inverse distance weighting (left)

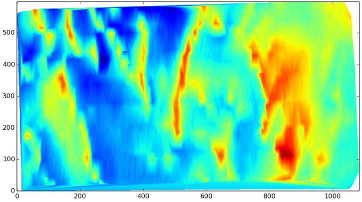
- Each unknown point is assigned a weighted average of some or all of the known points
- The result is computed with the power parameter $p = 4$

$$z_0 = \sum_{i=1}^{N} z_i \frac{1}{d_i^p} / \sum_{i=1}^{N} \frac{1}{d_i^p}$$

Linear interpolation (right)

- Linear interpolation by a triangulated irregular network
- The triangulation consists mostly of long and thin triangles that are not representative of the shape of a terrain





Existing methods (cont'd)

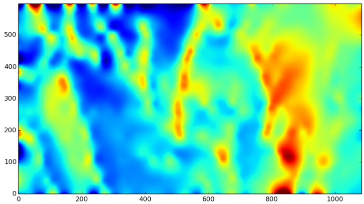
ODETLAP (left: $R = 10$; right: $R = 0.1$)

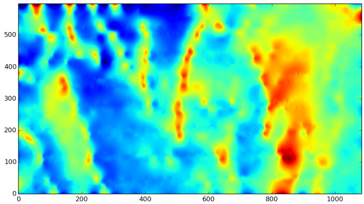
- Establish an overdetermined system of linear equations involving the value of every known or unknown point
- Two types of equations

$$R(4z_{i,j} - z_{i-1,j} - z_{i+1,j} - z_{i,j-1} - z_{i,j+1}) = 0 \quad (1)$$

$$z_{i,j} = h_{i,j} \quad (2)$$

- R is a constant scale factor setting the relative importance of the first type of equations
- Larger R – smoother interplation; smaller R – more accurate interpolated values of known points



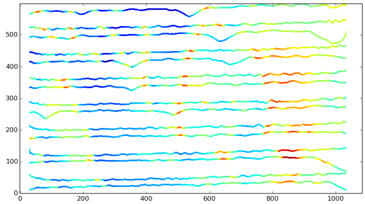


Outline

- Compute an intermediate trackline between a pair of tracklines
  - Determine the location of the intermediate trackline
  - For each intermediate trackline point c, find pairs of trackline points centered at c for pattern matching
  - Linearly interplate the value of c from the best matching pair of trackline points
- Use ODETLAP to interpolate all the tracklines

Simplify the data

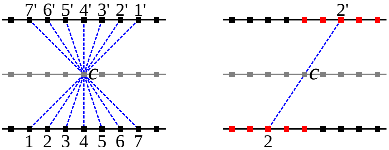
- Thin marginal areas are excluded from consideration, to give complete and distinct pieces of tracklines



Proposed methods (cont'd)

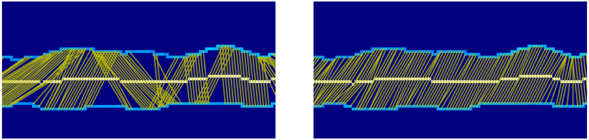
Pattern matching

- Compute the sum of squared difference between the values of two trackline segments centered at two trackline points
- The smaller the sum, the better the matching



Consistent interpolation

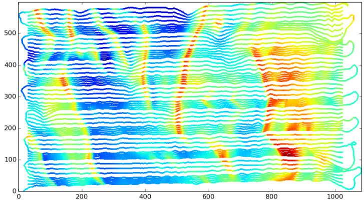
- A point *c* to the right of a point *b* on the intermediate trackline is not interpolated with trackline points to the left of those interpolating *b*

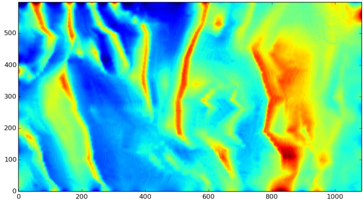


Proposed methods (cont'd)

Result

- Interpolate intermediate tracklines twice; three intermediate tracklines between two neighboring tracklines
- ODETLAP interpolation ($R = 0.1$)



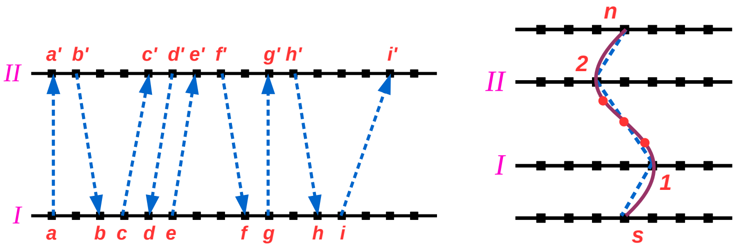


- Features are connected, maybe incorrectly in some places
- Sharp corners are visible due to linear interpolation

Proposed methods (cont'd)

Updated method

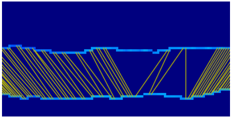
- For a pair of tracklines, alternatively match a south point with a north point, and match a north point with a south point
- For a pair of trackline points p_1 and p_2, the south point p_s of p_1, and the north point p_n of p_2, fit a degree 3 polynomial curve
- Interpolate the values of p_1 and p_2 linearly at one quarter, one half, and three quarters positions along the curve

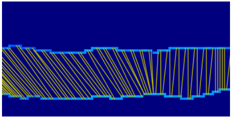


Proposed methods (cont'd)

Big gaps

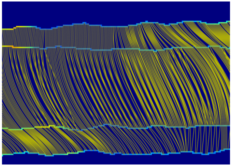
- Unlimited advancement
- Maximum advancement $= 3$

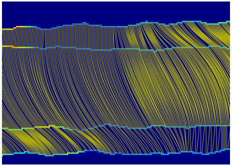




Curves intersecting

- Not every point has a north point or south point
- Give a north or south point position to points not having a north or south point

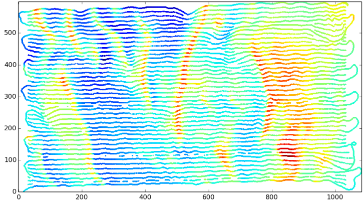


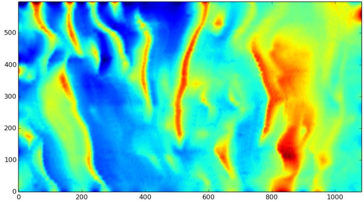


Proposed methods (cont'd)

Result

- The trackline and interpolated values
- ODETLAP interpolation $R = 0.1$
- Less sharp corners





Summary

- The big assumption of the restricted method is that tracklines are nearly parallel
- We will look for new methods for the general case