CroScalar: A Multi-Scale Modeling Framework for Spatio-Temporal Data

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CroScalar: A Multi-Scale Modeling Framework for Spatio-Temporal Data

• Multi-Scale Temporal Analysis (Triangle Model)

• Multi-Scale for Spatial Analysis (Pyramid Model)

• Higher-Dimensional Models for Spatio-Temporal Analyses (CroScalar)

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Triangular Model: Mapping Time Intervals in a 2D Space

- Time interval is an extent in time, which is usually represented as linear interval in a 1D linear space.
- The linear model is inefficient for data visualization and analysis.
- Alternatively, time intervals can be represented as points in a 2D space.
Triangular Model: Mapping Time Intervals in a 2D Space

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Uncertainty Assessment of Distance Measurement

Distance Measurement in 3D terrain

Surface-Adjusted Distance Measurement

- Closest centroid
- Weighted Average
- TIN
- Nearest Neighbor
- Bi-Linear
- Bi-Cubic
- Bi-Quadratic
Uncertainty Assessment of Distance Measurement

Measurement residuals in 9-meter intervals

Transects in a study area in Nebraska
Uncertainty Assessment of Distance Measurement

Transects in a study area in Nebraska

Triangle Models of residuals at different intervals
Uncertainty Assessment of Distance Measurement

Transects in a study area in Nebraska

Residual of Transect 1 at 10m resolution DEM
Uncertainty Assessment of Distance Measurement

Transects in a study area in Nebraska

- Residual of Transect 1 at 10m resolution
- Residual of Transect 1 at 30m resolution
- Residual of Transect 1 at 500m resolution
- Residual of Transect 1 at 100m resolution

Legend:
- WeiAv
- BiLin
- BiQuad
- BiCub
- TIN
- NN
Pyramid Model

- Pyramid Model (PM): **Multi-scale representation** for 2D spatial data
- Similar concept as Image Pyramid
- Integrating the scale dimension \( z \) with the spatial \( (x,y) \) dimension
Pyramid Model

Each node (voxel) represent a specific cell in the tessellation in the base layer
Scale Issue in Point Pattern Analysis

Quadrat density

(a)

Kernel Density

(b) BW = 10

(c) BW = 20

(d) BW = 50
Multi-Scale Quadrat Density in PM

(a) Moving window rolling through a point set
(b) Color-coded point density in moving windows
(c) A point set in the 2D space
(d) Point density in different sizes of moving windows
(e) A 3D pyramid representing all moving windows
Global Peaks of Quadrat Density

Global density peaks at different scales

Global density peaks viewed from different angles
Isosurface of Quadrat Density

High density (99\textsuperscript{th} percentile) voxels across scales

Voxels of density at the 99\textsuperscript{th} percentile
Global Peaks and Isosurface of Kernel Density

Linking global peaks of kernel density at different scales

Global density peaks viewed from different angles
Local Peaks

Local peaks detected at different scales

Local density peaks viewed from different angles
Isosurface of Kernel Density

High density (99th percentile) voxels across scales

(d) Azimuth: 0°  Altitude: 0°
Voxels of density at the 99th percentile
Land Cover Change Analysis

Land cover change detection and modeling are scale-dependent

Land loss and gain from 1930 – 2010 in Mississippi Delta

Wetland fragmentation is a driving factor of land loss
Multi-Scale Modeling of Land Loss

Land cover 2001

Multi-scale fractal dimensions in PM

Areas with high fractal dimension

Land loss 2001 - 2016

Multi-scale land loss ratio in PM

Areas with high land loss rate

Visual analytics
Multi-Scale Modeling of Land Loss

Land cover 2001

Land loss 2001 - 2016

Multi-scale fractal dimensions in PM

Multi-scale land loss ratio in PM
CroScalar: A Multi-Institution Collaboration

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Thank you!

Reference


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Website: https://croscalar.github.io