Re-arranging Time, Space and Scales A Framework for Multi-Scale Spatio-Temporal Analyses

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Presentation Outline



- Triangular Model (TM) for Temporal Analysis
 - Concept
 - Visualization
 - 'Spatial Analysis' in TM
- Pyramid Model (PM) for Spatial Analysis
 - Concept
 - Visualization
 - Machine learning
- A Framework for Multi-Scale Spatio-Temporal Analyses



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





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• Relational Zones in the TM





• Relational Zones in the TM





• Relations between intervals can be represented as zones.



13 atomic interval relations (J. Allen 1983)

Temporal relations in the triangular Model (2D)



- Graphic temporal queries
 - Creating zones over interval points
 - Query range expressed by the zone
 - Query composition modelled by geometric operation





Integration of the TM with a GIS





















Multi-scale Analysis of Time Series



- The Continuous Triangular Model (CTM)
 - Multi-scale visualization for linear data



• Map algebra on CTM: multi-scale comparison, selection and filtering.



Multi-criteria decision-making



- Cartographic modelling for time: combining map algebra in CTMs.
- Identify the most suitable time interval for certain activities.



Temporal Analysis with CTM



Comparing the movement of mini-soccer players



Average moving speed of players in two soccer teams

Temporal Analysis with CTM



Analyzing dancer's body movement



The Issue of Scale in GIScience



- Geographical phenomena present different patterns and relationships at different scales.
- Spatial analyses and modeling are sensitive to the scale, e.g. the modifiable areal unit problem (MAUP)
- GIS conventionally represents spatial data as 'flat layers' and lacks functionalities for multi-scale analysis and modeling
- Environmental and human models that involve data and processes at different scales are difficult to couple

Extending Triangular Model to 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









Local fractal dimension calculated in moving windows of different sizes



11 by 11 cell moving window

15 by 15 cell moving window



Constructing a PM for multi-scale representation of spatial data







Fractal dimension: 98%

Fractal dimension: 99%









Remote sensing image





A Framework for Multi-Scale Spatio-Temporal Analysis





Time series of spatial data

Time series of PMs

PMs aggregated in time intervals in a TM



Conclusion

- Spatial analysis tools developed in GIScience can **migrate** to analyze other types of spaces, such as scale-time space.
- Variations and patterns in the spatial and temporal scales provide additional information about the underlying processes.
- New visualization, analytical, and computing tools are needed to model the nested and complex relationships in coupled natural and human systems.
- A multi-scale analytical **framework** can guide appropriate decision-making at different scales.

Thanks for your attention



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