# *Miner: A Spatial and Spatiotemporal Data Mining System

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## SSTDM Overview

Spatial and Spatiotemporal Data Idiosyncrasies

- Huge Amounts of spatial and spatiotemporal data
- Multimodal, multi-source, multi-resolution
- Complex data types (points, lines, polygons, raster, networks, graphs, ...)
- Spatial and spatiotemporal autocorrelation
- Spatial constraints (non-Euclidian distance, obstacles, ...)

- Limitations of conventional techniques
  - Independent and identically distributed (iid)
  - Hypothesis driven analysis may not be practical in many situations
  - Spatial analysis and spatial statistics do not scale well

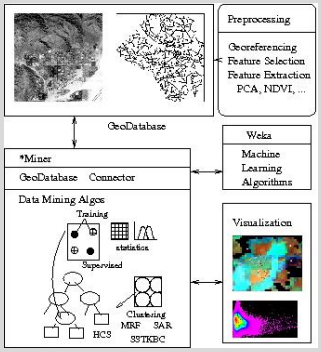
## Definition

- Spatial Data Mining (SDM) is the process of discovering interesting, useful, and non-trivial patterns from large spatial databases [1]

## Spatial Pattern Families

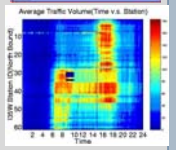
- Spatial outliers, discontinuities, extremes
- Spatial Clustering
- Spatial Classification
- Spatial Prediction
- Spatial Co-location

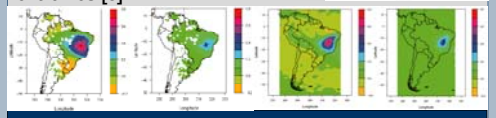
## Architecture




## Spatial Outliers

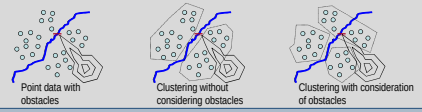
- Spatial outlier is a spatially referenced object whose non-spatial attribute is significantly different in its neighborhood though it may not be significantly different in the entire population [2].
- Multivariate extreme value theory for estimating multivariate dependence among climate extremes [3]



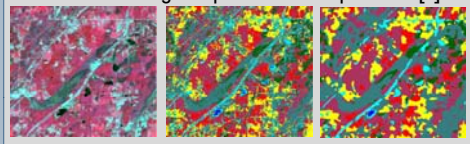
## Spatial Clustering

- Spatial Clustering is the process of grouping a set of spatial objects into clusters such that intra-class similarity is high and inter-class similarity is low.
  - Spatial similarity
  - Spatial constraints (physical obstacles, network distance)




## Spatial Classification

- Given a set of input-output pairs (training data), the objective of supervised learning is to find a function that learns from these i-o pairs, and predicts an output for any unseen input data (new samples).
  - Spatial Autocorrelation (near-by pixels may have same labels) – Markov Random Fields
  - Fewer training samples – Semi-supervised [4]

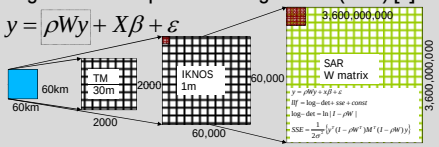


Landsat ETM – FCC Image | Classification with iid assumption | Spatial classification

## Spatial Prediction

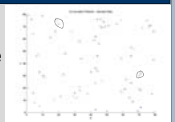
- Regression vs. Spatial Autoregression (SAR) [5]

$$y = \rho W y + X\beta + \varepsilon$$



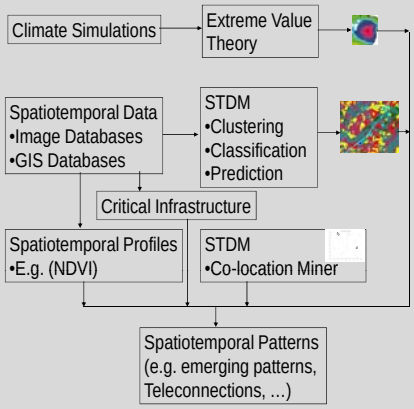

## Spatial Co-location Mining

- Co-location patterns represent subsets of Boolean spatial features whose instances are often located in close geographic proximity (e.g., Nile crocodile and Egyptian plover) [6].



| | | Spatial Data Mining (SDM) | Spatiotemporal Data Mining (STDM) |
|---|---|---|---|
| Input Data | | Often implicit Relationships, complex types | Another dimension-Time<br>Implicit relationships<br>Changing over time |
| Statistical Foundation | | Spatial autocorrelation | Spatial autocorrelation and Temporal correlation |
| Output | Association | Co-location | Spatiotemporal association<br>Mixed-Drove pattern<br>Sustained Emerging pattern |
| | Clusters | Hot-spots | Flock pattern<br>Moving Clusters |
| | Outliers | Spatial outlier | Spatiotemporal outlier |
| | Prediction | Location prediction | Future Location prediction |

## Application

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