# Voronoi Region-Based Spatiotemporal GIS Databases

Lixin Li [1] Reinhard Piltner [2]

[1] Georgia Southern University, Statesboro, GA 30460-7997, USA
lli@georgiasouthern.edu

[2] University of Nebraska-Lincoln, Lincoln, NE 68588-0526, USA
rpiltner@unlserve.unl.edu

**Abstract:** The use of Voronoi diagrams in GIS-oriented spatiotemporal databases is considered. The Voronoi algorithms generate appropriate meshes for data interpolation. We illustrate the data representation in this database generated from a point-based spatiotemporal relation in the National Agricultural Statistics Service (NASS) database.

## 1. Introduction

For many GIS applications the use of only spatial data is insufficient. Whenever time effects are important, we like to manage spatiotemporal data in an efficient way. Interpolating, querying and visualizing spatiotemporal GIS data are areas of growing interest. For example, Grumbach et al. (2000) consider the snapshots of the trajectories of moving points as a sample of points with time and position and uses linear interpolation between the snapshots to recover the full trajectory. Revesz and Li (2002) represent the 2-D shape function based spatial interpolation using *linear constraint databases* (Revesz 2002). Representing interpolation in constraint databases is an advantage since there are many constraint database queries that are not expressible in current geographic information systems. Li and Revesz (2003) give an overview of three major types of GIS-oriented spatiotemporal databases, namely point-based, region-based, and constraint-based. As a continuation of the work by (Li and Revesz 2003), we consider Voronoi region-based spatiotemporal databases, which can be viewed as a special type of region-based spatiotemporal database.

## 2. Voronoi Region-Based Spatiotemporal Databases (STDB)

Voronoi algorithms are important tools for generating meshes in two, three and higher dimensions. Based on point clouds we can generate triangular or tetrahedral meshes for two or three dimensional problems. Regarding spatiotemporal databases, region-based STDBs can be derived from point-based STDBs. Voronoi diagrams can be used for a special type of region-based STDBs generated from point-based STDBs. There are two types of Voronoi diagrams: (i) ordinary Voronoi diagrams, (ii) higher-order Voronoi diagrams. The ordinary Voronoi diagram of a finite set S of points in the plane is a partition of the plane so that each region of the partition is the locus of points which are closer to *one member* of S than to any other member. Higher-order Voronoi diagrams generalize ordinary Voronoi diagrams by dealing with k closest points.

**Example 2.1** The point-based spatiotemporal relation *Drought_Point(x, y, year, SPI)* stores the average yearly SPI (Standardized Precipitation Index) values sampled by 48 major weather stations in Nebraska from year 1992 to 2002 (see Li and Revesz (2003) for details). Assume that in this relation, the locations the 48 weather stations have not been changed through the last 10 years and SPI values have been measured every year. The spatial and temporal parts of 2nd-order Voronoi region-based relations generated from *Drought_Point* are shown in Tables 2 and 3, respectively.

**Drought_Point**

| x (easting) | y (northing) | year | SPI |
|---|---|---|---|
| -315515.56 | 2178768.67 | 1992 | 0.27 |
| ⋮ | ⋮ | ⋮ | ⋮ |
| -133759.02 | 1985122.32 | 2002 | -0.22 |

Table 1: The point-based spatiotemporal relation *Drought_Point*.

**Drought_Vo2_Space**

| $\{(x_1, y_1), (x_2, y_2)\}$ | boundary |
|---|---|
| { ( -9820.18, 1929867.40) , (-42164.88, 1915035.54) } | { (-17122.48, 2203344.58), (3014.51, 2227674.50) (33051.50, 2227674.50), (33051.5, 2140801.51) } |
| ⋮ | ⋮ |
| { (-507929.66, 2216998.17), (-247864.81, 1946777.44) } | { (-274044.43, 2109969.45), (-273957.42, 2110648.46), (-245744.29, 2136492.60), (-205869.74, 2142110.52), (-198942.71, 2115609.44), (-227141.62, 2099273.50) } |

Table 2: The spatial part of the 2nd-order Voronoi region-based *Drought_Point* relation.

**Drought_Vo2_Time**

| $\{(x_1, y_1), (x_2, y_2)\}$ | year | avgSPI |
|---|---|---|
| { (-9820.18, 1929867.4), (-42164.88, 1915035.54) } | 1992 | -0.47 |
| { (-9820.18, 1929867.4), (-42164.88, 1915035.54) } | 1993 | 0.71 |
| ⋮ | ⋮ | ⋮ |
| { (-507929.66, 2216998.17), (-247864.81, 1946777.44) } | 2001 | 0.65 |
| { (-507929.66, 2216998.17), (-247864.81, 1946777.44) } | 2002 | -0.03 |

Table 3: The temporal part of the 2nd-order Voronoi region-based *Drought_Point* relation.

The data representation in the above format has the following advantage: translation into constraint databases can be easily achieved, therefore enabling animation and powerful queries which are not possible in current GIS systems.

## References


S. Grumbach, P. Rigaux, and L. Segoufin. Manipulating interpolated data is easier than you thought. In *Proc. IEEE International Conference on Very Large Databases*, pages 156–165, 2000.

L. Li and P. Revesz. The relationship among GIS-oriented spatiotemporal databases. In *Proc. of the Third National Conference on Digital Government Research*, Boston, 2003.

P. Revesz. *Introduction to Constraint Databases.* Springer, New York, 2002.

P. Revesz and L. Li. Representation and querying of interpolation data in constraint databases. In *Proc. of the Second National Conference on Digital Government Research*, pages 225–228, Los Angeles, California, 2002.