Li Chen Found A Digital-Discrete Method For Smooth-Continuous Data Reconstruction

A systematic digital-discrete method for obtaining continuous functions with smoothness to a certain order (C^n) from sample data is designed by Professor Li Chen in computer science at University of the District of Columbia. This method is based on gradually varied functions discovered by Li Chen in 1989 and the classical finite difference method. This new method has been applied to real groundwater data and the results have validated the method. This method is independent from existing popular methods such as the cubic spline method and the finite element method. The new digital-discrete method has considerable advantages for a large amount of real data applications. This digital method also differs from other classical discrete method that usually uses triangulations.

This method can potentially be used to obtain smooth functions such as polynomials through its derivatives f^{(k)} and the solution for partial differential equations such as harmonic and other important equations.

This research has been partially supported by the USGS seed grants through UDC Water Resources Research Institute (WRRI) and Center for Discrete Mathematics and Theoretical Computer Science (DIMACS) at Rutgers University. UDC undergraduate Travis Branham extracted the application data from the USGS database. To get a smoothed function using gradual variation is a long time goal of Chen's research. Some theoretical attempts have been made before. But struggled on the actual implementation. Chen was invited to give a talk at the Workshop on the Whitney's Problem organized by Princeton University and College of William and Mary in Aug. 2009. He was somewhat inspired and encouraged by the presentations and the helpful discussions with the attendees of this workshop. Shortly after, he came up with the idea to implement the actual design in C++.

Li Chen's website is at www.udc.edu/prof/chen.
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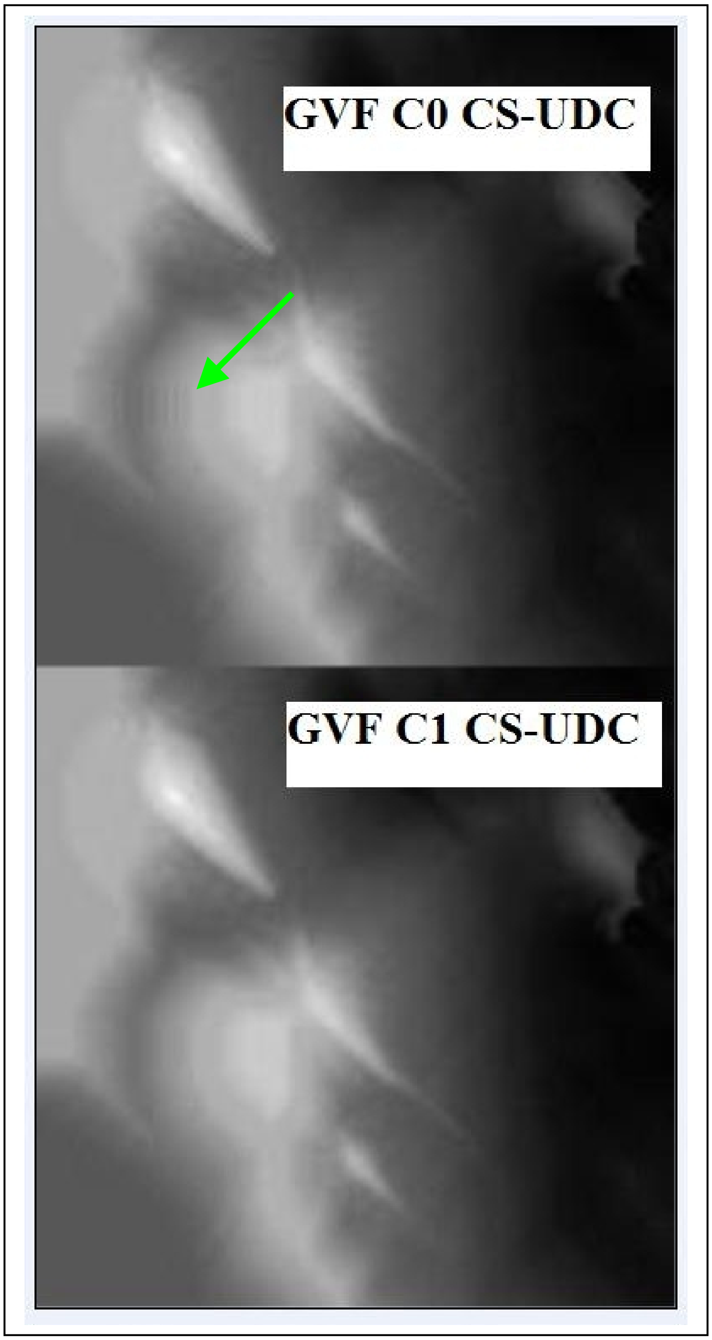
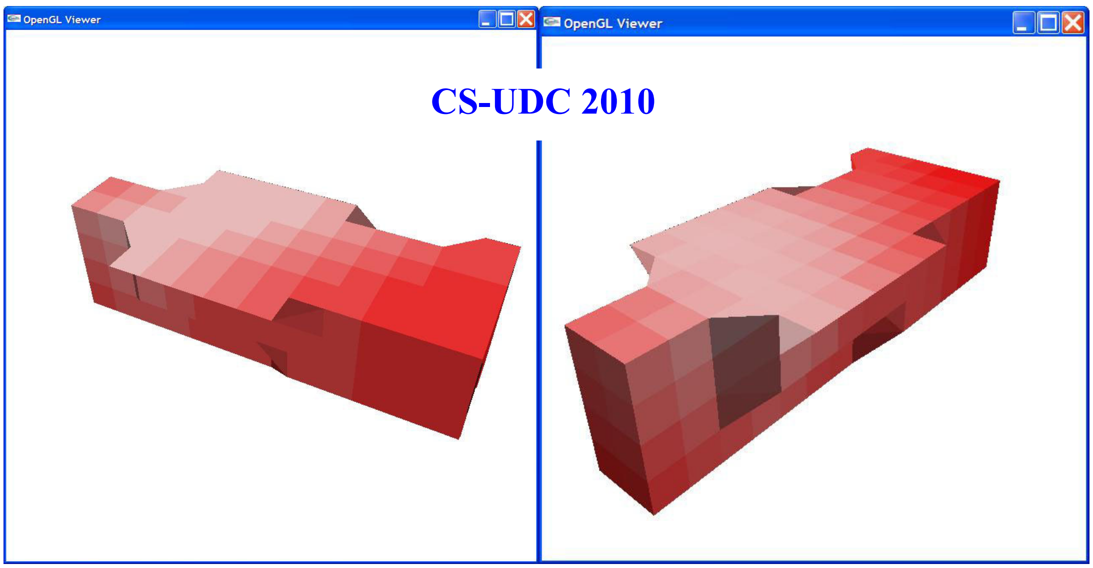


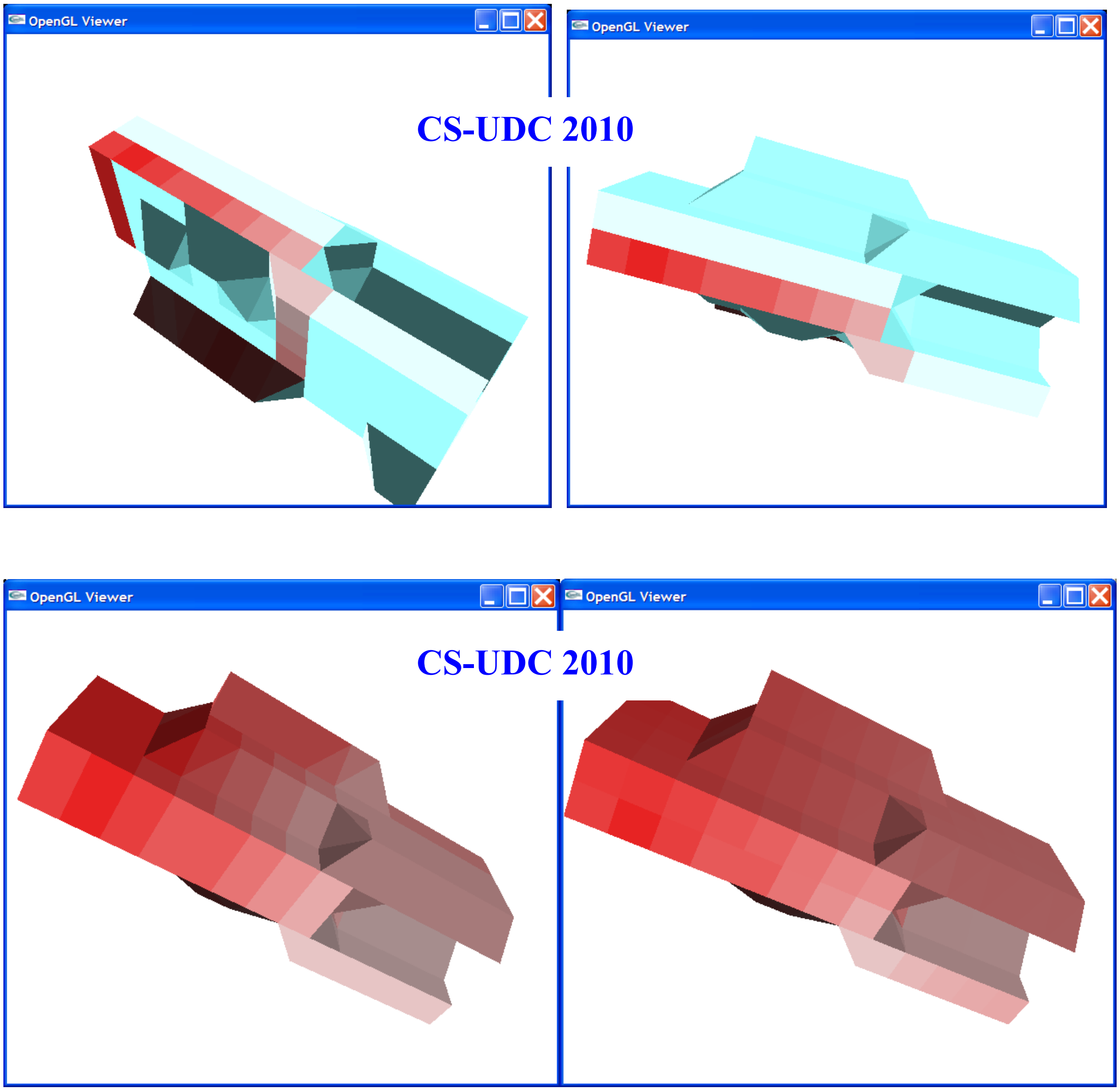
The picture is the result of fitting based on 29 sample points. The first is a "continuous" surface and the second one has "first derivative." The arrow indicated the interesting area disappeared in second image.

The following is the implementation of the method for digital-discrete surface fitting on manifolds (triangulated representation for the domain). Gradually varied fitting (GVF) does not rely on a simplicial decomposition, but GVF can work with such a decomposition. Data came from a modified example in Princeton 3D Benchmark data sets. (Jan. 18, 2010)



(a) (b)

Fig 2. Using 7 Points to fit the data on 3D surface: (a) the GVF result. (b) The Harmonic fitting (iterations few times) based on GVF.



(c) (d)

Fig 3. The selected cells form a boundary curve that is gradually varied: (a) and (b) three display for the guiding points (cells). (c) The GVF result. (d) The Harmonic fitting (iterations few times) based on GVF (100 iterations).