SPATIAL SUBDIVISION AND CODING OF A GLOBAL THREE-DIMENSIONAL GRID: SPHERE DEGENERATED-OCTREE GRID

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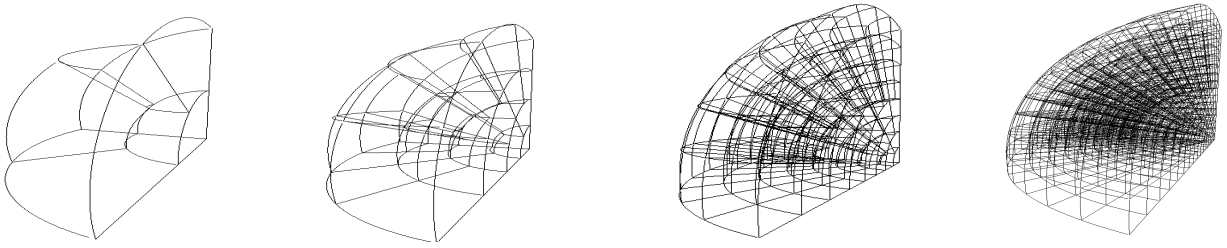
Abstract

Projections which transform geometric space of earth surface into Cartesian plane had brought a lot of problems to regional and global spatial data organization and analysis. One is that the projection distortion results in area, distance and angle can not be all controlled at the same time; another is that geometric fissure is evitable between different projection zones. The fundamental solution is to set up an uniform spatial reference framework for the Earth directly based on sphere space. Discrete Global Grid (DGG) is a spatial reference framework well studied, which takes recursive subdivision on spherical surface based on base platonic solids. Whereas, the subdivision of DGG was only confined to the Earth surface, not reached to the Earth inside and outside.

A discrete global three-dimensional grid, called as Sphere Degenerated Octree Grid (SDOG), whose base platonic solids is octahedron and spatial partition method is degenerated octree subdivision, is presented in this paper. The core idea of SDOG is to spatially subdivide the eight octants recursively using octree in meridian planes, latitude circle planes and spherical surfaces, and to merge neighboring degenerated grids together as one grid, for example, grids near the north and south poles or the earth core. Fig.1 shows the results of SDOG subdivision at level 1~4. A good discrete global grid system must have the property of stable distortion, so does SDOG. Mathematics calculation indicates that the distortions of area and volume of SDOG are relatively stable, with a limit of 2.23 for the ratio of area between the smallest and the biggest ones on the same surface, and 8.89 for the ratio of volume between the smallest and the biggest ones in the whole solid space. Except for the stable distortion features, SDOG also takes advantages of multi-hierarchy and multi-resolution that DGG has, and absolute regular of geometry, easy transformation to existing spatial data (format in Longitude, Latitude and Elevation) that DGG doesn't have. The surface of the grid inside and outside is a part of sphere, left and right is a part of plane, up and down is a part of cone surface. It is very simple, when expressed in mathematics forms. SDOG can provide a three-dimensional uniform spatial reference framework for global spatial data integral organization, indexing share, multi-hierarchy spatial modeling and large scale visualization.



a) level 1 b) level 2 c) level 3 d) level 4

Fig.1 The 3D visualization of octant grid subdivision of level 1~4

A grid division method always accompanies with a certain spatial coding method, this paper offers two kinds of coding method for SDOG: Single Degenerated Z-curve Filling (SDZ) and Multiple Degenerated Z-curve Filling (MDZ). Z curve (Peano curve) is a kind of space filling curve, which could be generated easily in mathematics and can keep highly spatial clustering characteristics. However, it needs to be improved as coding for SDOG, because four to eight child grids will be produced in a subdivision according to the different father grids. Improvements on Z curve are made in this paper to fit for SDOG. As the way of Morton Coding, SDZ travels through out all the grids at the specific division level using degenerated Z curve, recording the decimal trace number as its code. However, MDZ takes another way by using of numbers of zero to seven as code element, filling with degenerated Z curve between child grids who own the same father grid and adding the corresponding code element to the father grid code as a child grid code. The difference between SDZ and MDZ are that SDZ just coding grids at the specific division level, while MDZ at all the division levels. For checking the efficiency of the presented algorithms, performance on time consuming and code length was experimentally compared among SDZ, MDZ and QuaPA primary code. The test shows that MDZ is an excellent method for the multi-solution dynamic 3D SDOG grid, and can serve the SDOG-based three dimensional fundamental framework of the Earth.

Key words: sphere degenerated-octree grid(SDOG), spatial reference framework, discrete global grid, 3D grid, grid coding

Reference

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