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From 1 dimension to N dimensions-fractal in automated cartographic generalization

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Automated cartographic generalization has been an intensive research topic in cartography for decades. Some problems associated with this topic could be resolved to a certain extent using fractal analysis and fractal dimension. This p aper investigates the fundamental theories and operational methods of generalization. Among others, methods of calcul ating fractal dimensions of curves and even complicated 3-dimensional geographic objects are explained. Fractal dimen sions can be used as an objective criterion for both scaling the natural geographic objects and economical computer s torage. More important is that the generalization algorithms based on fractal dimensions can be performed automatical ly.

From 1 dimension to N dimensions-fractal in automated cartographic generalization JIANG Dong, YANG Xiaohuan, WANG Nai bin, LIU Honghui (Institute of Geographic Sciences and Natural Resources Research, CAS, Beijing 100101, China) Abstra ct: Automated cartographic generalization has been an intensive research topic in cartography for decades. Some probl ems associated with this topic could be resolved to a certain extent using fractal analysis and fractal dimension. Th is paper investigates the fundamental theories and operational methods of generalization. Among others, methods of ca lculating fractal dimensions of curves and even complicated 3-dimensional geographic objects are explained. Fractal d imensions can be used as an objective criterion for both scaling the natural geographic objects and economical comput er storage. More important is that the generalization algorithms based on fractal dimensions can be performed automat ically. Key words: fractal dimension; cartographic generalization; cartographic visualization; virtual reality CLC nu mber: P283.7 1 Introduction Cartographic generalization has its primary goal to transform map features such as lines and polygons among different scales (Muller, 1987). Automated cartographic generalization is a research focus in cart ography. The motivations of generalization are (1) map scale reduction; (2) elimination of random errors in data acqu isition; (3) computer economy in storage, processing and plotting; and (4) visual enhancement (Lam, 1993). Although q uite a few methods and rules have been presented, problems still exist due to lack of objective criteria to evaluate their effects. With the help of fractal theory, these problems can be resolved to a certain extent. The paper review s the applications of fractal dimensions on line generalization and then introduces an efficient way for the automati c generalization of polygons. Finally, these ideas are extended from 2 dimensions to 3 and even N dimensions. These i deas and methods could be widely used in cartographic visualization and virtual reality studies. 2 Fractal and fracta l dimension Fractals were mainly used to describe complex characters of natural phenomena, such as the length of coas tal lines and the areas of a snowflake. They were first indicated clearly by Benoit Mandelbrot, the father of fractal s, in the 1960s. The definition of fractals depends on a formal description of dimension. According to the traditiona l concept of Euclidean space, a dimension is obviously an integer: a straight line has the dimension 1 because there is only 1 way to move on a line. A plane is two-dimensional because there are 2 moving directions along which length and width can be measured. Similarly, a cube is three-dimensional because it has 3 moving directions along which leng th, width and height can be measured. However, the Hausdorff-Besicovitch dimension may be a fraction. In Benoit Mande lbrot' famous work, 'Fractals: Form, Chance and Dimension' (Mandelbrot, 1977), he defined fractal as: A fractal i s by definition a set for which the Hausdorff-Besicovitch dimension strictly exceeds the topological dimension. Forma l definition of this quantity requires a good deal of the Measure Theory. But fortunately for a class of sets Hausdor ff-Besicovitch dimension can be easily evaluated. These sets are known as the self-similar fractals and, the propert

y of self-similarity is often considered to be germane to fractals in general (Mandelbrot, 1975). 2.1 Fractal dimension of curve 2.2 Fractal dimension of polygons 3 Application of fractals to cartographic generalization 3.1 Methodology 3.2 Case study 4 Discussion The fractal approach for cartographic automatic generalization has been proved to be efficient and reasonable. Because fractal dimensions are independent of scale and measure units, they can be applied to 3-dimension space and even N-dimension space in future studies. Some work has been conducted in this study. For instance, the fractal dimension of a complex curve surface shown in Figure 5a can be estimated using a 3D measure model (Figure 5b). References

关键词: fractal dimension; cartographic generalization; cartographic visualization; virtual reality

