The Use Of The Circle Tree For The Efficient Storage Of Polygons

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Biography

Lecturer in Spatial Information, University of Otago, NZ (2002-)
Recently completed PhD (Geographical Sciences, University of Plymouth, 2002) on reasoning with uncertainty in the context of a knowledge-based system for Integrated Coastal Zone Management.
Research interests also include spatial data structures, cartographic generalisation and visualisation (spatio-temporal, uncertainty)

Introduction

The circle tree (Moore, 2002) has been proposed as a novel hierarchical spatial data structure, promising efficient storage, fast access, and multiscale representation of spatial data. The testing of the storage aspects will be reported on in this paper. The theory behind the circle tree is that the conventional storage of polygonal data in terms of a series of xy points can be efficiently replaced by an array of variably-sized circles recursively filling the polygon to near-maximal effect (one of the assumptions is that there is a threshold minumum area; any areas smaller than this cannot have a circle occupying them). Each of these circles is indexed through a tree structure. The circle array has three values per entry: x, y and r, where r = radius of the circle.
The theory behind the circle tree draws from the fields of computer graphics (collision detection of 3D objects – Hubbard, 1996), databases (indexing through the R-tree – described in Rigaux et al. 2002 – and sphere tree structures – van Oosterom, 1993) and cartography (e.g. multiscale generalisation through use of the Douglas-Peucker algorithm – Jones and Abraham, 1987).

Details And Issues

The circle tree will be tested on a subset of the NZ 1:50000 coastline, where the circle storage method is compared with conventional point array storage and a reduced dataset produced from the Douglas Peucker line reduction algorithm (also in xy format). This paper will explore issues of data storage; the cartographic generalisation topics implied by use of the circle tree algorithm are dealt with in another part of this research project.
The main issues to be explored in detail are:

a) The size of circles to be used: should they operate on a maximum size first heuristic or would medium-sized circles fill a polygon in a more optimal manner? The answer may lie in the shape of any given polygon. Related to

this is the exploration of the threshold minimum area value: will a slight change result in a more efficient (i.e. smaller) storage structure?

b) Should a circle have sole occupancy of the space that lies within its boundary or could there be overlap? If there is overlap, should it only happen with descendents of a given node in the tree? For the latter question, there is an assumption that descendent circles should be contiguous with the parent node; the notion of overlap would enhance this relationship.
c) Tree morphology issues: These include, should there be a variable or fixed number of children for each node? If the latter, what should this fixed number be? A theoretical circle tree with four fixed descendents is shown in Moore (2002). Also, expanding on the relationship of data structure to geographic space, should the placement of circles be optimised so as to generate as well balanced a tree as possible?
d) Interior/Exterior circle placement: Would the use of negative space circles, that occupy space external to a polygon, allow a more efficient and accurate boundary representation?

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