PROPERTIES AND APPLICATIONS OF FORESTS OF QUADTREES FOR PICTORIAL DATA REPRESENTATION

VASUDEVAN RAMAN* and S. SITHARAMA IYENGAR **

* Department of Electrical and Computer Engineering, Louisiana State University, Baton Rouge, Louisiana 70803, USA
** Department of Computer Science, Louisiana State University, Baton Rouge, Louisiana 70803, USA

Abstract.

Region representation as a quadtree data structure is a rich field in computer science with many different approaches. Forests of quadtrees offer space savings over regular quadtrees by concentrating the vital information [4, 5, 6]. They scavenge unused and unneeded space (i.e., node containing no information). This paper investigates several properties of forests of quadtrees which can be used to design manipulation algorithms for forest-quadtree data structure. In addition, the paper discusses the space saving and shows how the basic operations that can be performed on a quadtree can also be done on the more space efficient representation (a forest of quadtrees).

Keywords and phrases: quadtree, forest, data structure, image processing, algorithm.
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1. Introduction.

Efficient data structures for region representation are important for use in manipulating pictorial information. Recent research [1, 2, 3, 7, 8, 9] on quadtrees has produced several interesting results in different areas of image processing. A good tracing of the history of the evolution of quadtrees is provided by Klinger and Dyer [12]. Much work has been done on the quadtree properties and algorithms for manipulations and translations have been derived by Samet [9, 10], Dyer [1] and others [2, 5, 6]. For overviews of related research on image data structures see [4, 11, 12]. In 1981, methods of refining the quadtree were proposed by Jones and Iyengar [5]. The new refinements were called virtual quadtrees. Virtual quadtrees include both compact quadtrees and forests of quadtrees. The paper by Jones and Iyengar [4] further illustrates the usefulness of a forest of quadtrees as an efficient representation for binary images.

This paper is concerned with the properties of forests of quadtrees and their applications for picture processing and discusses development of forest manipulation algorithms.

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Before the results are described, we begin by giving definitions and summary of previous results [4, 5, 6] in the next section of our paper.

2. Definitions and summary of previous results.

*Pictures*: A picture or raster is defined to be a grid of $2^n \times 2^n$ colored points (pixels), the color representing properties associated with the points.

*Quadtrees*: A quadtree is a tree structure with the restriction that any node must have either four offspring (or children or descendents) or none.

*Quadtrees for pictorial representation*. In a quadtree representing a picture, the root represents the whole picture. Its offspring represent each one quadrant in the order Northwest (NW), Northeast (NE), Southwest (SW), and Southeast (SE). These four children are numbered from 0 to 3. In turn, their offspring each represents a subquadrant of the four quadrants and so on until the maximum number of subdivisions have been made as determined by the resolution of the image. In addition, if the children of a node are all the same color, they are deleted and their parent receives the information that was common to the four children. They are simply not needed as they carry redundant information. Figures 1a and 1b show a typical picture of a simple region and its quadtree.

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Fig. 1(a). Sample region.

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Fig. 1(b). Quadtree for sample region shown in Fig. 1(a)