JAIST Repository

https://dspace.jaist.ac.jp/

Title	 定数作業領域だけを用いたアルゴリズムに関する研究
Author(s)	田中,宏
Citation	
Issue Date	2009-03
Туре	Thesis or Dissertation
Text version	author
URL	http://hdl.handle.net/10119/8110
Rights	
Description	 Supervisor:浅野 哲夫 教授,情報科学研究科,修士



Japan Advanced Institute of Science and Technology

Constant-Working-Space Algorithm

Hiroshi Tanaka (0710044)

School of Information Science, Japan Advanced Institute of Science and Technology

February 5, 2009

Keywords: algorithm, constant working space, components labeling, Euclidean Distance Transform, binary image.

Memorizing information is an indispensable function for a computer. There are several kinds of storage devices depending on their speed, capacity, and prices. Therefore, a layered structure is used in many cases in a memory storage of a general-purpose system. By making good use of the feature of storage due to the layered structure, two functions, efficient execution and handling of a large amount to data, are realized. However, all computers cannot use such an environment. An equipment called an embedded system cannot use such an environment mentioned above. Therefore, software embedded in such systems are forced to work in some local memory. For example, in scanners or digital cameras, we have to perform some image-processing algorithms on hardware. But, in many cases, the entire working space which can be utilized by the software is strictly restricted. On the other hand, the amount of data to be handled increases as hardware performance is being developed. In latest scanners, memory capacity is insufficient compared with their reading precision. So, for high resolution, the capacity of an image must be suppressed so that it is within the memory capacity by limiting the area that can be read. If we want to process images for correction and elaboration, memories for the work, and the space which can be used for a picture decreases.

The amount of data to be handled is sometimes huge. In such a case we have to use memory in an efficient way. Therefore, an algorithm which

Copyright © 2009 by Hiroshi Tanaka

is sapce efficient, especially, an algorithm requiring only constant working space independent of input size is needed. If we have a number of algorithms requiring constant working space, we can do with the minimum possible amount of memory and also the same size of memory admits larger data sizes to be handled or we can process more on hardware. Moreover, we would not need low-speed memory if we had such space-efficient algorithms. This is an advantage of the space-efficient algorithms even for general-purpose computers with hierarchical structures.

A poupose of this research is to develop those space-efficient algorithms requiring only constant amount of working space. Especially, the memory that is the limited resource can be used more effectively by developing the algorithms for processing often done on hardware.

One of those processing is a problem of Connected Components Labeling. When a binary image consisting of 0 and 1 is given, we want to label each pixel by its name of a connected component containing it. a connected component is a maximal set of connected 1-pixels. We have to use different labels in different connected components. This is a basic operation in image processing. Known algorithms for this problem are FILL algorithm and an algorithm by Rosenfeld and Pfaltz. The FILL algorithm is to spread labels by using a stack in a connected component. The algorithm by Rosenfeld and Pfaltz uses a union find tree for sets. Both algorithms run in linear time in input size, but the amount of its working space is proportional to input size.

Another important problem is a problem of Euclidean Distance Transform. It is also processing of a binary image consiting of 0 and 1. In this problem we are requested to compute distances from 0-pixels to their closest 1-pixels which are measured by straight line distances between two points. Two algorithms are known for this problem, both of which run in linear time. An idea of Voronoi diagram is used in the algorithm by Kirkpatrick and Breu which was presented in 1995. In 1996 Hirata developed another algorithm for computing the Euclidean distance based on calculation of a lower envelope of parabolas. Although these algorithms can solve the problem in time linear in input size, but they need working spaces proportional to the input isize.

This paper presents algorithms which are superior in the sense of their

working spaces for an imega of size $n \times n$. Algorithms for the Connected Component Labeling problem and the Euclidean Distance Transform problem are proposed. The known algorithm for the problems need $O(n^2)$ working space linear in the input size. The proposal algorithms need only O(1) working space. In other words, we have achieved constant-workingspace algorithm for the problems. Note that it is not difficult to solve it in constant working space if more time is spent. But, simple methods need $O(n^4)$ time in both of them. This cost of time is large. Therefore, our aim is to have algorithms with the same computation time while keeping the working space low.

Our algorithm for the Connected Component Labeling problem follow boundaries between 1-pixels and 0-pixels in an image, and puts signs there during the trace of the boundaries. Then, we use an efficient method for putting labels.

Our algorithm for the Euclidean Distance Transration problem is based on the algorithm by Hirata and Katoh. A key is to embed necessary information in an output matrix.