AN EFFICIENT COMPUTATIONAL GEOMETRY METHOD FOR DETECTING DOTTED LINES IN NOISY IMAGES

F. DEHNE [1]
School of Computer Science, Carleton University, Ottawa, Ontario, Canada K1S 5B6

L. FICOCELLI
Grande Prairie Regional College, Grande Prairie, Alberta, Canada T8V 4C4

ABSTRACT

In this paper we present an efficient O(n log n) time, linear space, algorithm for detecting a line, or line segment, represented by a set of n_L collinear points contained in a rectangular window with an additional set of n_N independant, uniformly distributed random noise points; $n=n_L+n_N$. Empirical results show that the algorithm is very reliable for $n_N/n \leq 75\%$.

1 INTRODUCTION

In this paper, we study the well known problem of detecting dotted lines in noisy images; i.e. detecting a line, or line segment, represented by a set of n_L collinear points (referred to as *line points*) contained in a circular or rectangular window with an additional set of n_N independant, uniformly distributed random *noise points*. Several methods for solving this problem have been proposed in the literature [CT, DH2, GL, MA, RT, ST]. However, most of them are based on the Hough Transform which is computationally very costly. This motivated our research in studying more efficient methods for line detection; in particular, we considered the application of efficient Computational Geometry methods since some of these tools have already been successfully applied to other image processing and statistics problems [S,To].

We present an efficient O(n log n) time, O(n) space, algorithm for detecting dotted lines in noisy images; $n=n_L+n_N$. Our method is based on convex hull and peeling algorithms. Empirical studies have shown that the algorithm is very reliable for up to 75% noise; i.e., $n_N/n \leq 75\%$.

The remainder is organized as follows: Section 2 will review the concept of convex hulls and peelings and discuss some statistical properties. In Section 3, we will then present our algorithm and discuss its rational; Section 4 will analyse its time complexity and discuss some empirical results with respect to the accuracy of our method.

2 HULLS AND PEELING

One of the most extensively studied structures in Computational Geometry is the *convex hull* of a planar point set $S=\{p_1,\ldots,p_n\}$; i.e., the smallest convex set containing S. The points of S located on the border of the convex hull are referred to as *extreme points* of S; removing the extreme points and iterating this process for the remaining points until all points have been removed is called *peeling*. A variety of algorithms has been proposed for computing the convex hull [PS, LP]; for peeling a set S of n points, Chazelle [Ch] has presented an optimal O(n log n) time, linear space, algorithm.

In addition to its efficient computation, several authors have also studied the properties, in particular the statistical properties, of convex hulls [Ca, E, H, S, Tu]. Tukey suggested (as reviewed in [H]) that the convex hull could be used for getting a robust estimator for mean values in higher dimensions similar to computing trimmed means for one-dimensional data sets; i.e., a fraction of the upper and lower extreme points of the data set is removed before the mean value is computed, thereby making it less sensitive to exceptional values in the data set. For two-dimansional data sets, a portion of the first hulls in the peeling process may be considered as exceptions and deleted.

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