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Image analysis using line segments extraction by chain code differentiation

A. Chalechale
University of Wollongong

G. Naghdy
University of Wollongong, golshah@uow.edu.au

Prashan Premaratne
University of Wollongong, prashan@uow.edu.au

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Abstract

This paper proposes a new fast method for line segment extraction from edge maps. It has a parallel nature and can be used on parallel machines easily. The method uses the chain codes in the edge map, namely macrochains, for line segment detection. In the first phase, it breaks the macrochains into several microchains by employing the extreme points of the first derivative of shifted-smoothed chain code function. Straight-line segments approximate the resulting microchains. In the second phase, the line segments are grouped together based on their proximity (collinearity and nearness) to make longer segments. The final set could be tailored for any minimum segment length and minimum error desired.

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Image Analysis Using Line Segments Extraction by Chain Code Differentiation

Abdolah Chalechale, Golshah Naghdy, and Prashan Pramaratne

School of Electrical, Computer & Telecommunications Engineering, University of Wollongong
{ac82,golshah,prashan}@uow.edu.au

Introduction

A line segment, as a primitive geometric object, is frequently used in higher-level processes such as object recognition, stereo matching, target tracking, image registration and also face recognition [1]. Employing lineal features in an image instead of using edge points solely, is noted widely in the literature. Hough transform has been used frequently for line detection.

Burns *et al.* [2] introduced an approach for the extraction of straight lines in intensity images. It begins at the level of lines directly without going through the intermediate stage of detecting local edges. Nelson [3] proposed a recursive-growing algorithm to the edges to identify the line segments in the images. In another approach developed by Etemadi [4], chains of edge points are obtained using the Marr-Hildreth edge finder. The chains are then segmented into pieces that are symmetric about their centroid and then related into longer segments.

This paper proposes a new fast method for line segment extraction from edge maps. It has a parallel nature and can be used on parallel machines easily. The method uses the chain codes in the edge map, namely macro chains, for line segment detection. In the first phase, it breaks the macro chains into several micro chains by employing the extreme points of the first derivative of shifted-smoothed chain code function. The resulting micro chains are then approximated by straight-line segments. In the second phase, the line segments are grouped together based on their proximity (co-llinearity and nearness) to make longer segments. The final set could be tailored for any minimum segment length and minimum error desired.

Image analysis using chain-based line segment extraction (IACLSE)

The input of the method is an edge map I derived by an edge operator such as Canny on any real image. In addition, any thinned sketched image e.g. cursive signature can be used as the input I. First, the starting point of an 8-connectivity chain code is determined. The macro chain $A_i = \{a_1, a_2 \ldots a_{n_i}\}$, $i=1,2 \ldots m$, where m is the number of chains in I and n_i is the chain length, is obtained and put in a chain set $\{A_i\}$. For each A_i we apply the following steps (see Fig. 1):

1. Eliminating chain noise: median filtering eliminates noisy points, which make the chain over oscillating. Applying a fifth-order one-dimensional median filter on the vector A_i reduces the effects of such points adequately.

2. Shifting operation: the standard chain code representation has the wraparound drawback. To eliminate it, we produce a new modified code $B_i = \{b_1, b_2 \ldots b_{n_i}\}$ for each $A_i = \{a_1, a_2 \ldots a_{n_i}\}$ by a shifting operation defined recursively as:

$$\begin{cases} b_1 = a_1 \\ b_i = q_i \text{ where } q_i \text{ is an integer such that } (q_i - a_i) \bmod 8 = 0 \text{ and is minimized for } i=1,2 \ldots n. \end{cases}$$

3. Smoothing operation: the shifted chain code B_i is then smoothed by a five-point Gaussian filter {0.2,0.3,0.5,0.3,0.2}. $\Gamma(\theta)$ is the resulting shifted and smoothed waveform where θ is the traversing variable.

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4. Fist derivative and break extraction: $d\Gamma/d\theta$ determines the rate of change of $\Gamma(\theta)$ *with respect to* θ. The extreme points of this derivative is considered as break points ξ, if they are greater than a threshold. Because the shifted smoothed $d\Gamma/d\theta$ mostly has adjacent values with the difference of 0 or 1, the maximum of the Gausian filter (0.5) is a good initial candidate for the threshold value.

The line segment l_i, which connects ξ_i to ξ_{i+1}, is considered as the lineal approximation of the micro chain lying between the two points. The total collection of l_i's, say *L*, is the line segment set of the image/sketch *I*.

In the second phase of the method, grouping the line segments obtained in the first phase will produce the final line segments set $\{f_i\}$. The main function of this phase is to replace two short line segments by a single longer one. The decision is based on co-linearity and nearness of the line segments.

Experimental results show better representation and much improved performance of the proposed method in comparison with three other well-known methods within the literature using criteria defined in [3], which are the number of line segments and their accumulative length. Figure 2 shows the test images used for line segments extraction and the results.

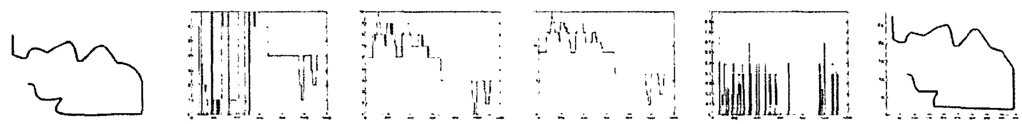

Fig. 1 From left to right: an example contour, median filtered chain code, shifted, smoothed, derivative representations, and extracted line segments

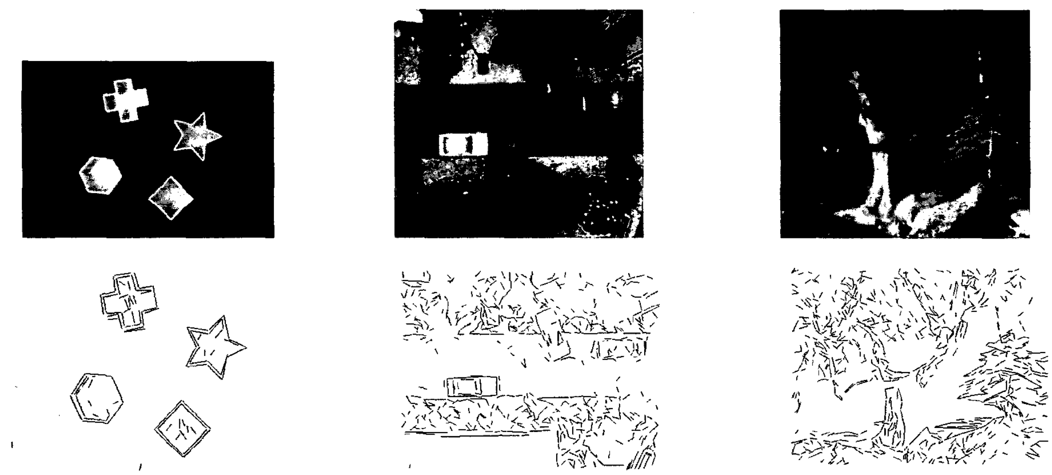

Fig. 2 Three image examples used for line segment extraction (top) and the results (bottom)

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