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One Pass Region Labelling & Σ-pixel Properties of Binary Images

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Abstract

An algorithm has been developed based on mathematical morphology that labels the pixels of each connected region of a binary image on a single (forward only) pass. During the pass through the image a look up table (LUT) is constructed. At the same time, each pixel's contribution to various Σ-pixel properties is added to a labelled bucket. Although the numeric labels applied during the single pass may be different for certain pixels within a single region, the LUT gives unique region labels corresponding to each applied label. Upon completion of the pass, all buckets corresponding to a unique label on the LUT are summed.

Outline

Connected image regions may be classified in terms of Σ-pixel (pixel summable) properties, which depend only on each pixel's grey scale and position; such as areas, perimeters, and moments of all orders, as included in the SRI parameters for vision guided robotics. Our one-pass algorithm for labelling the pixels of connected regions and computing Σ-pixel properties of each connected regions is computable with either City Block (Manhattan), and Chess-board Connectivity: [See Fig (I)]

0 1 1 0 0 1 1 0 0 1 1 0 0 1 1 0 0 0 0 1 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 1 1 0 0 0 0 0 0 1 1 0	0 1 1 0 0 2 2 0 0 1 1 0 0 2 2 0 0 0 0 3 0 0 0 0 0 0 0 0 4 0 0 0 0 0 0 0 0 5 5 0 0 0 0 0 0 5 5 0	0 1 1 0 0 2 2 0 0 1 1 0 0 2 2 0 0 0 0 1 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 1 1 0 0 0 0 0 0 1 1 0
Fig (0 Binary Image with backgound pixels 0, region pixels 1,	Image segmented into five regions 1,2,3,4,5 via City Block Connectivity	Image segmented into two regions 1,2 via ChessBoard Connectivity

In our algorithm, pixels are progressively tagged with region labels {1,2,3..} with the Next available tag being the first 'unused' label. Each parameter to be computed during the pass is represented by an array, initially empty, labelled by these tags. The one-pass region labelling part of our algorithm extends the Rosenfeld-Pfaltz [1] sequential algorithm. In terms of mathematical morphology, the region labelling is based on the forward sequence masks:

- 0 -	0 0 0	- ignored neighbour
0 *	0 *	* current pixel
City Block	ChessBoard	

The mask scans the image left to right, top to bottom. At each pixel location the set of values Al = [mask element + overlaid pixel) is determined. Background pixels with grey-scale '0' are unchanged. . Elsewise the pixel is given a grey scale value m

$$m = \max \{v, y \in \mathcal{M}\};$$ If m=0, then m= Next available

If m= Next available, then LUT(m) := m else LUT(m) := minimum [LUT(v) ; $v \in \mathcal{M}$}

[Note LUT(0) = I If the current pixel contributes an amount q to a (summable) property Q, then Q[m] = Q[m] + q

Upon completion of the pass, the LUT is used so that, for each Σ -pixel property Q all Q[m] corresponding to a unique region label are summed.

[1] A. Rosenfeld and D. Pfaltz, *Sequential Operations in Digital Picture Processing* J.A.C.M. (1966) 13, No **4** pp 471-494.