Color Image Segmentation Using Minimum Spanning Tree and Cycles

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Abstract. An unsupervised and robust algorithm for segmenting color images using graph theoretic concepts is proposed in this paper. A novel region growing procedure is proposed for cycle (segments) formation and cycle merging. Experiments were carried out on standard Berkeley Segmentation Database Set (BSDS) and other public domain images and the results show the efficacy of the proposed method.

Keywords: Color image segmentation, graph theory, minimum spanning tree, cycles.

1 Introduction

Human visual system plays an integral part in the theory of color. Color vision results from the action of three spectral sensitivities such as Red (R), Green (G) and Blue (B) of the visible light spectrum. Color is the complex perceptual phenomenon and the sensation of the color images arises due to the response of the threeneuro-chemical sensors or receptors in the retina to the visible light [1]. As color images are order of the day, their high prevalence motivated to extend the earlier work proposed on color images.

Color is a useful property which adds additional information to the images. The color perceived by human beings is a combination of three stimuli R, G and B which forms a color space. As compared to monochrome images, color images have information of brightness, hue and saturation for each pixel [2]. The color edge detection approaches are broadly classified into two categories.

(i) Synthetic approaches: The monochrome image edge detection method is applied to three color channels independently and the results are combined using certain logical operations.

(ii) Vector approaches: A color image can be viewed as 2D and 3-Channel vector field, where each pixel is defined by a 3D vector in a given color space. The edges are detected using different properties of space vector.

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2 Background

Researchers have concentrated in the past few decades on devising algorithms for grayscale image understanding [3]. The major advantage of color is increase in quantity of information and it can be used for more accurate object location, preprocessing and the possibility of processing more complex images. A typical color image capturing system relies on a trichromatic input based on the additive primary colors red, green and blue [4-5]. In [6], an adaptive and unsupervised scheme for pixel clustering and color image segmentation was proposed. In [7], the authors dealt with region matching problem of a pair of color stereoscopic images. As a first step, the candidate selection which met relative position and overlapping constraints and in the second stage the correct match was determined based on cost function. In this paper, the work proposed in [8] was extended to color images after making substantial modifications.

3 Proposed Method

The steps involved in the proposed method are as follows: (i) Read the given image, (ii) Perform Gaussian smoothing (optional), (iii) Separate R, G and B channels and (iv) For each channel, do

a. Graph representation
b. Apply Hybrid MST algorithm
c. Call ADD_EDGE procedure
d. Call CYCLE_MERGE procedure.

3.1 Graph Representation

The input image is represented as a graph G= (V, E) where V represents the set of vertices and E, the set of edges. 8-connectivity of vertices is considered for edges. Thus, for a graph G of size $N \times N$ image, there will be N^2 vertices and $4N^2 - 6N + 2$ edges and looks like a grid graph.

3.2 Hybrid MST

The combination of Boruvka and Prim's algorithm called Hybrid algorithm has been chosen for generation of MST due to its lower time complexity $O(|N| \log \log |N|)$. Thus, the edge set is divided into two sets MST edges and non-MST edges.

$$E = E_1 \cup E_2 \tag{1}$$