IMAGE SEGMENTATION WITH IMAGE AND SHAPE PHASE ANALYSIS

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ABSTRACT:

Color image segmentation using perceptual attributes can be useful to identify objects of the same color that receive different illuminations The goal is to make the identification of objects analogous to the human visual process. But there are some issues related to digital image acquisition and rendering, which include variation in shade and illumination and compression artifacts, and can result in hue channel degradation, hue noises or vague contours. In this work we present an image segmentation method based on IHS transform of a color or a n-dimensional multispectral image. We group all the pixels in the image that have low level of saturation or high or low level of intensity, because in all of these cases the hue becomes unstable or undefined. We added the ability to perform shape analysis on each segment during the region growing algorithm, using shape phase information by computing the turning function of some segments. The geometric attributes of contours can be analysed and a resegmentation can be performed if necessary during the segmentation process. The shape modelling of each blob segment can be adjusted and analysed individually based on the geometric phase information. It becomes possible to extract indexes, change shapes, refine shapes, classify by shape and many other possibilities. Each segment can be tuned by its shape or provide graphical information before the next segment is drawn randomly. Thus, we present a juncture of a segmenter of phase channel and a shape phase analysis capability in order to best define objects. Several potential operations can be integrated with this approach with the view to achieve object based shape analysis at the time of identification of objects.

1. INTRODUCTION

1.1 Background/Scientific context

Human's subjective perception of colors can be helpful in certain cases of image object identification. The lighting and shading of an object modifies its color, but the hue component remains unchanged. Hue channel can be mathematically derived from image color bands. Moik (1980) proposed a model to achieve phase, intensity and saturation information from n-dimensional multispectral imagery. The goal is to make the identification of objects analogous to the human visual process.

There are some issues, which include variation in the illumination, black and white achromatic contrast delimitation (e.g., white boat with dark shadow produce a poorly defined boat silhouette) and image compression artifacts. These issues can result in hue channel degradation, hue noises and vague contours.

Tseng and Chang (1992) proposed an approach to simplify the image segmentation process using uniform-chromaticity-scale on perceptual color space making a split into chromatic and achromatic sets, and they conclude that the results are sensitive to the accurate measurement of the achromatic area.

Silva (1997) presented an image segmenter algorithm based on hue and in its angular properties to perform the segmentation. Souto (2000) developed a similar algorithm, but added some enhancements, including the perceptual multispectral transform as proposed by Moik (1980).

Two dimensional shape representations can be established by the application of contour and region descriptors. Gonzáles et al. (2012) lists some 2D contour representation methods: simple descriptors, shape signature, boundary moments, curvature scale space, Fourier descriptors, differential invariants, integral invariant and shape context.

To assess the correspondence among distinct representations of georeferenced and closed polygons, Coelho et al. (2009) introduced the CSI, a similarity metric that allows the identification of the similarity of given two segments produced in two distinct segmentations, when its areas and positions are known.

1.2 Image Segmentation

Satellite multispectral images are common and the amount of data points to automation in every image processing and analysis process. Raw images processed can become very useful if we can detect meaningful objects, but this is easy only when we have clear boundaries. In a complex urban area with several objects the problem becomes harder.

In this sense it is necessary to develop an adequate way to deal with pixels in order to recognize objects in image with minimum human interaction. But this job is still quite difficult because there are a big number of variants that a specialist should consider in image scene interpretation.

The job is, therefore, divided into a series of simpler (i.e., lower level) processes and segmentation, considering the proximity of values in the phase image. The identification of

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superpixels (i.e., sets of pixels) is the usual result of segmentation. Typically it is a grouping process that unites pixels with closest spectral information, hoping that this similarity in neighbor pixels means that the area is part of an object. But it is not granted that the object is finely represented by several factors: spectral mixing with a diversity of possible small objects, e.g., a dog house, a watering can, a shrub, a hose watering, a clothesline, a toy, the shadow of a tree and many other artifacts.

A perceptual feature is a representation in a way that is easy for humans to understand and then interact with the process by the use of parameters in order to tune the results. Segmentation is a very common task in image processing and it is performed without need of semantic knowledge. Santos et al. (1995) proposed a method to segment images using color and texture information, using histogram comparison of the surrounding area of a pixel. Pratt (1984) argues that artists analyse color relations by means of a sequence of comparative looks, and this happens because humans cannot quantify precisely and don't have a firm reference to describe a color. But in computer we associate color compositions with values.

It is possible to deal with uniformity in any sense, but in the approach used in this work we elected the use of hue uniformity. The imagery for hue segmentation has to be uncompressed or have low-compression since its digital acquisition. It is easy to observe the deteriorization caused by high compression and this confirms that the use of compressed images is contraindicated.

Lang et al. (2006) introduce object-based image analysis and the methods involved. Scene context have decisive information in detection and one of the most important elements is the object shape. As some 3D objects in real world are compound of complex elements with images represented by a set of diverse shapes, textures and spectral properties we have selected the shape because the contour in high resolution imagery seems to be of great importance in human interpretation of urban areas in most cases.

2. SHAPE TURNING FUNCTION

2.1 Shape Description

The first step in the process is to define a set of candidate pixels to define the segment, the shape description of a segment (i.e., a set of pixels) and we need rules to operate them.

Active shape model segmentation, as used in medical images by Ginneken et al. (2006), provide an object segmentation of specific and well-known objects. The results of several works in medical images shows that combining shape information with a difficult problem such as texture makes the segmentation to be restricted to valid shapes (Bourgeat, 2007). In this work we expect to add some shape information to hue images to obtain valid objects represented by their correctly segmented contours.

2.2 Turning functions

The delineation of a segment results in a shape. The notion of a shape is invariant to translation, scale and rotation. Shape analysis is used for object recognition, matching, registration and analysis and in many applications it is possible to reduce analysis of the image to shape analysis (Loncaric, 1998).

Tangent angle and turning function are shape descriptors and the chain code can be easily represented in this way. Shapes can provide unique signatures of image segments if the size is known. This representation addresses angles and lines in a step-shaped function, so we need to work in such a transformed space. Turning functions are phase mapping functions and the same properties of vectors have to be applied.

3. PHASE SEGMENTATION AND SHAPE ANALYSIS

3.1 Segmentation Algorithm

The application was implemented in IDL language and several features was modified is described above.

3.1.1 Format and Number of Files: The program offers the possibility of chose different external image file formats, including the ability of using one single file or multiple files to load the bands. As it uses the hue to segment, images of a single band are not available.

3.1.2 Weighting the Hue Channel: The main reason to use the weighting on the hue channel is to avoid the algorithm null color effect (i.e., null saturation) that turns pixels to red. Three choices are given: not to weight, to consider just the saturation or to compute the saturation and intensity channel product. This parameter makes a segment to be shown in blob coloring mode as the mean giving the greater weight to the purest colors and reducing the influence of dark and low saturated sub regions. Figure 1 shows graphically a cone, where the height is represented by the saturation axis, the hue is the cone surface. In this case, the weight ***w*** is the radius of the small circle defined as the plane orthogonal with the saturation axis. The product of saturation and hue gives priority to color purity. If the intensity is chosen to multiply the saturation, this enhances the purity even more.

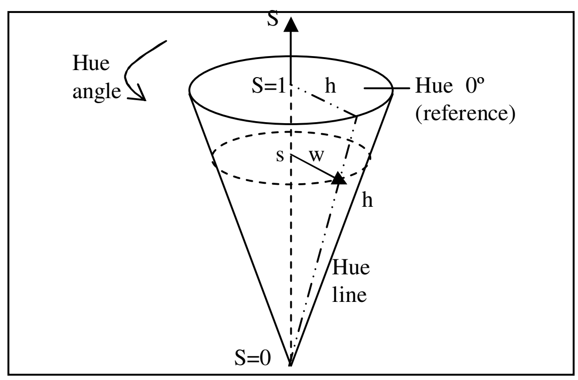

Figure 1. Weighting phase H by S or I channel

3.1.3 Hue Remapping: Hue channel represents the color phase in degrees and each color is associated to a defined angle. In the case of the three primitive colors Red, Green and Blue, by default the angle between each two is exactly 120 degrees. The user can define a new linear by parts mapping by defining the new positions of the reference colors, for any number of references. In Figure 2 the case of remapping the three colors at left is represented graphically in the right side.

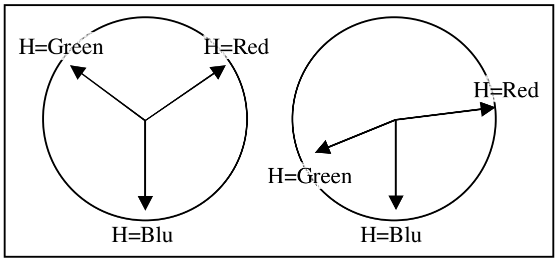

Figure 2. Hue remapping. Example showing 3 colors case.

3.1.4 Radiometric Normalization: Before proceeding to the creation of the hue channel, adjust original image contrast and brightness based on three options: a) the original data; b) a normally distributed data, scaling the data and shifting the mean to 127; c) a histogram stretching. As histogram operations changes visually the data it changes the perceptual channels and can affect the results.

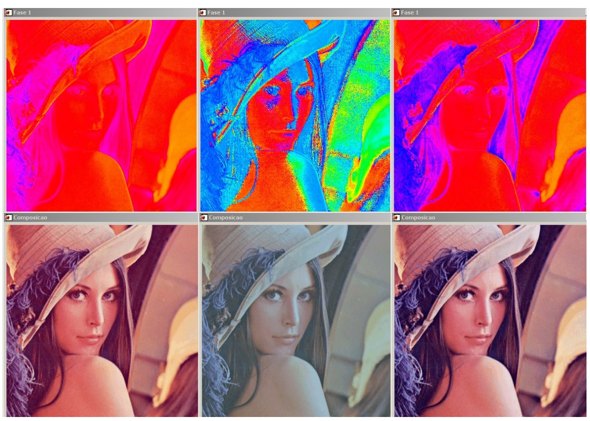

Figure 3. Hue (above) from respective (below) image. Original (left), normalized (center) and stretched image (right).

3.1.5 Turning Function: shape analysis module to analyze segments with compatible size. In the present work we consider the turning function (Ballard and Brown, 1982; Rangayyan, 2008; Zhang, 2009) a tool to locate regular parts of the shape and an additional way to collect information about the segment silhouette. Figure 4 shows a single example of the representation of a segment shape. In this case it is possible to recognize visually four main steps of a noisy square.

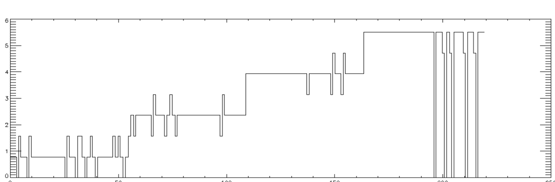

Figure 4. Example of turning function of a closed shape.

3.1.6 Threshold: Define an integer number that means the amount of degrees used to be used in the region growing algorithm to define the homogeneity in hue angle. The lower this number, the higher the chance to restrict the growth area.

3.1.7 Void Regions: Enable the void class to include all pixels and segments that does not adhere to the necessary conditions for inclusion in a new segment. The base algorithm (Souto, 2000) uses the void class to receive the lower saturation pixels and then included in some adjacent segment at a later stage.

3.1.8 Saturation and Intensity: Makes the algorithm to compute saturation and/or intensity channel in the region growing mechanism, using these channels values to weight the new border mean hue value to be compared in the next iteration. If these options are enabled, the purest pixels will dominate the procedure because of their higher weights. If both saturation and intensity are computed, this influence will be increased.

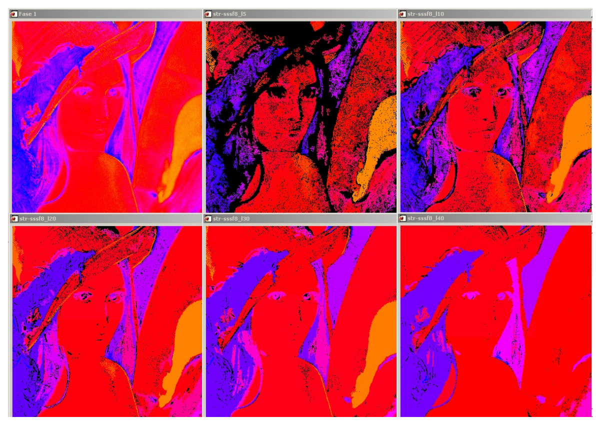

Figure 5. Threshold variation: hue channel used (top left) and segmentations using 5 (top center), 10 (top right), 20 (bottom left), 30 (bottom center) and 40 (bottom right)

3.1.9 Growing Algorithm Mean: This is a crucial parameter. The search for the bounded region considers the threshold value (as described above) for the test of the adjacent pixels to define the interval, adding or subtracting this constant to a fixed value by default. We added the possibility to work with a mobile average, whereas the mean values of edge previously detected define the new moving mean.

3.1.10 Maximum Cluster Size: The segment can be limited by a parameter to limit the number of pixels acceptable to be grouped in a segment. In the current version the limit is imposed with rigidity.

3.1.11 Neighborhood Type: Chose between 4 or 8 neighborhood search. If set to 8 a diagonal line of pixels are acceptable to compound a segment and the process speeds up for considering more pixels at the same iteration.

These main parameters and many other internally defined parameters (e.g., minimum size of a segment) were all tuned in order to allow the identification of urban objects. These segments are processed by an edge following algorithm using Freeman's chain code and then a turning function conversion. Turning functions turns polygons to stair functions and we can make a dual processing in the shape by analyzing and modifying the stair shape. Presumably a regular polygon is a perfectly regular stair and a circle is the limit when this stair has each step tending to zero. So a circle arc in a high resolution image tends to result in a sloped line. To find angles and circles and noisy shapes we can take advantage of the turning function and rectify them as well.

3.2 Hue segmentation

In our research we started by the method proposed by Souto (2000). The core algorithm hence provides ability to handle unlimited multispectral channels as input and to group all the pixels with low intensity into a single class to reduce the lack of meaning of hue where saturation or intensity tend to zero or intensity tend to maximum. Lossy compression produce coarse hue images but can produce fine intensity and fine saturation images.

Based on the conversion equations, hue channel is not recommended to deal with high contrast, extremely dark or light areas and images with lossy compression because the hue channel becomes unstable or inaccurate. This hue segmenter can deal well with problems related to variable illumination, gradients of colors and defined shadow.

3.3 Shape analysis

We added the ability to perform shape analysis on each segment during region growth process, integrating the ideas presented in Volotão et al. (2010a; 2010b; 2011). These works relate to geometric attributes of contours.

The main focus is upon the shape modeling of each blob segment, based on turning function, being possible to extract indexes, change shapes, refine shapes, classify by shape and many other possibilities. Each segment can be tuned by its shape or provide graphical information before the next region is drawn randomly.

4. DISCUSSION AND CONCLUSION

Segmentation is a base step in image recognition, where pixels are grouped in a first instance and provide more complex information.

We presented a juncture of a hue segmenter with shape analysis on-the-fly in order to achieve better object shape contour of known types of objects.

If the objects in study are low contrast, very colorful and the file format is compacted in a lossless format, a useful analysis is very likely to be achieved. Using the turning function it is possible to detect shape roughness and perform smoothness or other shape model process.

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