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Sky and Foliage Detection using Perceptual object Tagging

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Abstract—Perceptual understanding of human observer is useful in image content understanding and finding the objects in image. One can do object based enhancement manually based on their perceptual understanding. Existing photo applications use low level description for performing similar tasks. However, there is gap between the output of operations by application and same task performed by human being. To bridge this gap, objects must be identified by photo applications before enhancement. In proposed system, object based enhancement is done by application through content understanding. The more we know about the objects in the photo, the better we can enhance and modify it according to preferences of user. This is achieved by breaking the image into significant segments and finding important perceptual objects including sky, snow and foliage.)

Keywords- *Sky detection, foliage detection,object tagging,segmentation.*

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I. INTRODUCTION

Photo applications that exist today, contains mature algorithms for image denoising, image sharpening, contrast enhancement, color correction etc which depends on local features. Some applications depend on some level of content understanding. For eg. Red eye removal . But these features are not sufficient for today's photo applications. Instead, such application requires enhancement based on specific object. Once object is detected, it can be modified easily without affecting other contents of image.

This requirement stems to object detection work. Object detection requires segmented images.

Segmentation algorithms that exist today, are mostly based on gray scale image.

Some color based algorithms clusters pixels only by considering color similarities, irrespective of their spatial location and correlation of pixels. Existing algorithms for skin,sky and foliage detection are based on color model and global threshold. M Jones and James M. Rehg[6],used histogram based color model for skin detection. Author used

large dataset, which improves performance of detector. This algorithm totally depends upon color characteristics of image.

E. Saber, A.M. Tekalp [8], uses adaptive threshold for object detection. Threshold adaption scheme reduces misclassification of pixels. Disadvantage is, this algorithm is based on color characteristic of image.

II. LITERATURE REVIEW

Here we present some existing segmentation techniques and previous object detection approaches for detecting sky and foliage.

A. *Segmentation*

Spectrum analysis is one technique of color image segmentation in which prior knowledge about colors is used to classify pixels. However in many real life applications prior knowledge about the colors of image may be difficult to gather.

Lim and Lee developed a two-stage color image segmentation technique based on thresholding and fuzzy c-means(FCM) methods[4].

Boykov et al. [9] discuss techniques for segmenting an object from the background using global optimization techniques. This technique uses graph cuts and binary segmentation. Any cut corresponds to some binary partitioning of an underlying image into object and background segments.

The difficulty with segmentation algorithms, in general, is that the relationship between the segments produced by these algorithms and perceptual regions is not strong. For example, a face that is partly shaded will be segmented to multiple regions[3].

Novel algorithm using Dynamic Color Gradient Thresholding (DCGT) operator technique uses region growing approach for image segmentation. Algorithm described by G. P. Balasubramanian in [5] is useful in unsupervised color image segmentation using dynamic color gradient thresholding scheme. In this method, color gradient

map is obtained by using vector based color gradient. Gradient map is converted into Enhanced gradient map, GE by mapping gradient values of each pixel between range 0 to 1. Weighted color gradient map, GW is calculated using GE. Low gradient regions in weighted color gradient map can form initial seed. 4-neighborhood connected pixels with intensities <0.1T0 (T0 is automatic optimal threshold calculated by Ostus method) are assigned initial seed labels. After generating seeds, remaining pixels of gradient map are input for next level of thresholding. Difference between initial thresholding and current thresholding is that, initial thresholding was computed by Ostus method on entire pixel set and next thresholding is done by applying Ostus method on unclassified pixels only. This is dynamic color gradient threshold. Iterations continues till new threshold and old threshold shows nearly same values. This means that only edges remains unclassified. Region growing approach is followed by region merging. Algorithm achieves a high level of accuracy in defining region boundaries and guarantees that the edges are not submerged, avoiding under-segmentation issues. Execution time for algorithm is approximately 40 secs to 4 mins. Performance of algorithm is affected for images with varying performance.[3]

GSEG (Gradient SEGmentation) algorithm described by L. Garcia and E. Saber in [2],segments image using three modules. In first module, edge map is produced using edge detection algorithm. Adaptive gradient threshold is generated using edge map which dynamically selects region of contiguous pixels which produces initial segmentation map. Second module creates a texture characterization channel by first quantizing the input image, followed by entropy based filtering of the quantized colors of the image. Last module generates final segmentation map by using initial segmentation map and texture channel. GSEG accurately segments complex images, images with different textures and varying illumination. It takes 24 secs for execution.

B. *Sky Detection*

Work on blue sky detection in literature mainly depends either on color or combination of color and texture. In[8],E. Saber and A. M. Tekalp described a system which automatically annotates images with a set of pre specified keywords, based on supervised color classification of pixels into N pre-specified classes using simple pixel-wise operations. It uses adaptive thresholds instead of universal threshold. This technique is based on color characteristic only.

Rayleigh scattering is another unique characteristic to find out blue sky. Small molecules in the atmosphere scatter light short wavelengths (blue) more than light with long wavelengths. Red light and green light have similar distribution across the sky, and their distribution differs from that of the blue light. Due to this phenomenon the sky appears blue.

In [10],sky is detected using Rayleigh scattering. Luo proposed a model-based approach consisting of color classification, region extraction, and physics-motivated sky signature validation. First, the color classification is performed by a multilayer back propagation neural network trained in a bootstrapping fashion to generate a belief map of sky color. Next, the region extraction algorithm automatically determines an appropriate threshold for the sky color belief map and extracts connected components. Finally, the sky signature validation algorithm determines the orientation of a candidate sky region, classifies one-dimensional (1-D) traces within the region based on a physics-motivated model, and computes the sky belief of the region by the percentage of traces that fit the physics-based sky trace model.

These methods do not provides enough information to implement their method. Moreover, we are interested in detecting blue sky and gray sky. But above methods does not provide methods for detecting gray sky.

In[1], sky detection is done by considering color ,texture & gradient. Color model for sky in image is extracted by using multivariarte Gaussian function in LCH or L*a*b* color space. This model is applied to other pixels to compute average. Similarly, texture and correlation of gradients is computed. Overall likelihood for sky segment is obtained by combining likelihood of the color, texture &gradient correlation. Overall image sky color is probable sky color for all sky segments in image. This algorithm detects both blue and gray sky in image. Blue sky tagging rate is 85% with false alarm of 10%. Gray sky tagging rate is 63% with false alarm of 22%..

C. *Foliage Detection*

[8] describe a system which automatically annotates images with a set of pre-specified keywords, based on supervised color classification of pixels into N prespecified classes using simple pixelwise operations. It adapts thresholds to given image not the color model as in our algorithm. The most relevant prior work classifies image blocks that contain foliage. They report very high accuracy (94%). However, this result was obtained on the training set, and the authors report that green objects are mis-detected as foliage.

In [1]Bergman and Nachlieli explained the foliage tagging algorithm. It considers three color models for computing likelihood maps: general foliage model, shaded foliage(forest) model and ground color model. It also computes likelihoods due to texture characteristic using standard deviation and local direction of gradients as a feature. Order statistics and natural statistics for each of likelihood map for segment are computed and used in heuristic decision function. First decision function accepts only segments which are more likely as foliage and tag as a foliage. Next decision function accepts segments which have high likelihood of foliage color, moderate luminance, high texture and high natural statistic value. Last decision function detects shaded forest segment which have little texture and low luminance value. Use of texture characteristic along with color improves detection rate up to 92% but also has false detection rate of45% as it mis-detects water segments with reflection of foliage as foliage.

II. PROPOSED SYSTEM

To address the problem of object based enhancement, system is designed which will segment input image and tagging algorithms will tag sky and foliage region in image and remaining objects will be tagged as unknown. Tagged image can be used to identify specific object and enhancement will be done on the same object.

Architecture of proposed system is shown in fig. 1

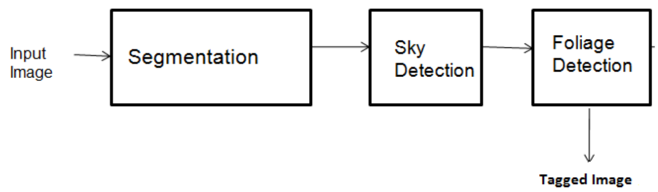
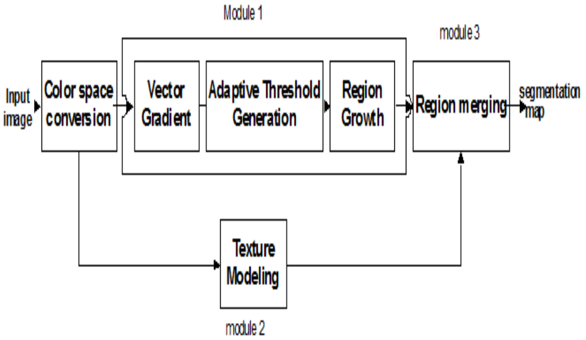


Fig. 1 Architecture of Proposed System

Figure 1 shows system architecture of object tagging. It consists of three modules. Color image is provided as input to segmentation algorithm. Segmented image is used as input to sky detection module. Segments which are tagged as sky are not checked for foliage detection. i.e. segments are checked according to order of precedence.

A. *SEGMENTATION*

To identify any object and tagging those objects require segmented image. The primary objective of any segmentation algorithm is to break an image up into a small number of contiguous regions of similar type. For color image segmentation, color is important perceptual property which considers three psychological properties-hue, saturation and brightness. Proposed system uses GSEG algorithm[2] for segmentation. Flow of algorithm is shown in fig. 2



This algorithm consists of following three modules

-First Module calculates vector gradient, adaptive threshold and generates seed for region growth. It consists of following steps:

Convert input image from RGB to CIE L*a*b*
2. Generate gradient map.
3. Histogram analysis of gradient map
4. Generate adaptive threshold
5. Generate initial seed
6. Detect adjacent area to existing seed
7. Compare seed. If both are similar then merge regions to existing seeds. Otherwise discard.
8. Repeat steps till region growth completes.

- Second module is used for Texture modeling.
- Last module is Region merging, which will take input from first two modules and gives final segmented image.

B. *Sky Detection*

Sky is most important object in outdoor images. It occupies upper large region of image with light blue or gray color. Sky detection aims to find all the pixels in an image which satisfies characteristics of sky. Algorithm computes statistical models based on color, texture and gradient direction features. Algorithm consists of following steps:

Input : Segmented Image
Algorithm:
1. Initial sky tagging For each segment Compute probability of sky region based on region characteristics a. Color may be blue sky or gray sky or snow b. Location, size, Texture of segment, luminance, and c. color gradient's Correlation
2. Find probable segments for sky Tag each as blue sky or gray sky or snow according to the sky color characteristic
3. Determine color of sky If there is a blue probable sky region, then set the sky color to blue Otherwise if there is a gray probable sky region, then set the sky color to gray
4. Reassign probabilities based on luminance values
5. Tagging from per-image map of sky Compute a color model from the most probable region for sky Apply this color model to the rest of segments of the image For each segment tagged as unknown in previous step: If the mean probability of sky region according to this color model is greater than threshold Tag that segment as the sky

Likelihood that a given pixel with LCH values (l,c,h) matches a color model for some object O is given by formula:

$$L(O|l,c,h) = Ze^{-\left(\frac{f_l^O(l-\mu_l^O)^2}{2\sigma_l^{O^2}} + \frac{f_c^O(c-\mu_c^O)^2}{2\sigma_c^{O^2}} + \frac{f_h^O(h-\mu_h^O)^2}{2\sigma_h^{O^2}}\right)} \qquad (1)$$

Where,
μ - mean
σ - standard deviation
f - flag indicates whether the l,c, and h channels are used for object O
Z - Normalization factor

The likelihood that a given pixel with feature X value x matches a model for some object O is given by:

$$L(O\,|\,x) = Ze^{-\left(\frac{f_X^O(x-\mu_X^O)^2}{2\sigma_X^{O^2}}\right)} \qquad (2)$$

Where, X may be the texture or the direction features.

The overall likelihood of sky for each segment is given by combining the likelihoods of the color, texture and gradient correlation together as follows:

$$L(sky\,|\,L_{col}, L_{tex}, L_{dir}) = L_{col}.L_{tex}.L_{dir} \qquad (3)$$

First Step of sky detection algorithm is obtained by calculating color and texture and gradient direction likelyhood by using equestions (1) and (2) respectively. For step 2 i.e probable sky segments are chosen by using likelyhood values. segments with probable sky segments and sky color(blue, gray, snow). step 3 determines probable sky color by using segments probable sky color. If it is blue, then sky color is blue,for example.In step 4, we use a histogram of luminance values in the image, to compute a regional measure of probability due to luminosity. As a final step, the algorithm uses the most probable sky region in the image to compute color and location models for the sky in given image. A sky probability is then recomputed for pixels in regions that were rejected because of their size or location earlier in the algorithm.

C. *Foliage Detection*

Color range for foliage detection is broader than sky and skin color. For e.g. bright green of grass, dark green of trees, browns which tend to appear within foliage regions and black which appears in shaded foliage regions. Foliage detection consists of following steps:

Input : Segmented Image with sky and skin segments tagged
Algorithm:
1. Compute likelihood maps for color, texture and local gradient direction
2. Compute segments representative statistics and natural statistics
3. Reject likely ground segment
4. Accept likely grass segment
5. Accept likely foliage segment
6. Accept likely forest segment
7. Tag the detected segment

In step 1,likelyhoods are calculated by using equation (1) and (2). Then, representative statistics of each of the likelihood

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maps are computed for the segment. Median is used as representative statistics. Compute the entropy of the histogram of gradient directions as measure of natural statistic. The grass and trees have gradients in every direction. The sky has very low gradients. The histograms of the segments shows relatively uniform distribution of directions for the forest segment, compared with the very peaked distribution of the manmade object .The distribution of directions in a grass segment is less uniform than the forest segment, but less peaked than the man-made segment. This difference is measured using histogram of gradient directions as natural statistics. Based on above calculated values for likelyhood and statistics, algorithm rejects ground segment and tags foliage segments.

III. Result Analysis

This section also deals with performance analysis and comparison of object tagging algorithm with ground truth images present in given database. All the classes in proposed system were coded and compiled in the C#.Net using Visual Studio 2012.The obtained results might slightly differ for other settings. All tests were carried out on an Intel Dual Core CPU with 2.30GHz Pentium processor and 2 GB RAM under MS Windows 7 (32 bit) operating system. In proposed system 39 images dataset which is subset of MSRC 21 Class object dataset is used for testing results. Compare to all other techniques seen in literature survey our approach gives good results. All small segments are checked by each of tagging algorithm.I compared results of our system with ground truth images provided in dataset. For all images our algorithm tags each pixel more correctly than ground truth labels. Results presented below are pixel based rather than region based. Figure 3 shows graphical representation results of sky detection algorithm.

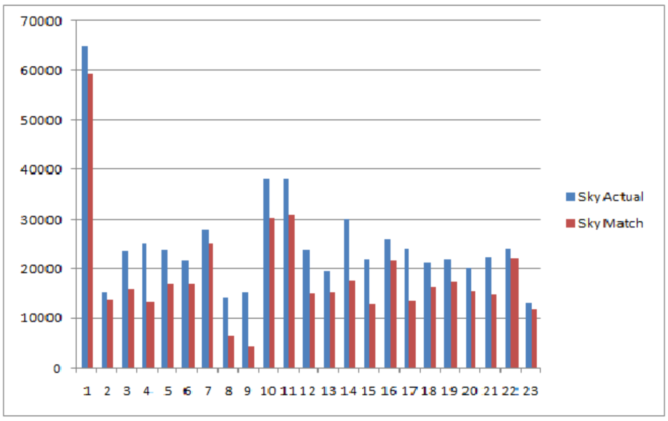

Fig 3. comparison of Sky detection algorithm with ground truth images

Horizontal axis shows image and vertical axis shows number of pixels detected. Sky actual and sky match values for each image are shown. For sky detection, 23 images, out of 39 image dataset are chosen because only 23 images contain sky segments. Sky actual shows number of pixels detected by our algorithm and sky match value shows number of pixels in ground truth image which are labeled as sky and also detected as sky by our algorithm.

Figure 4 shows graphical representation results of foliage detection algorithm. Horizontal axis shows image and vertical axis shows number of pixels detected. Foliage actual and foliage match values for each image are shown. For foliage detection, 28 images from 39 image dataset are chosen because only 23 images contain foliage segments. foliage actual shows number of pixels detected by our algorithm and foliage match value shows number of pixels in ground truth image which are labeled as grass or tree and also detected as foliage by our algorithm.

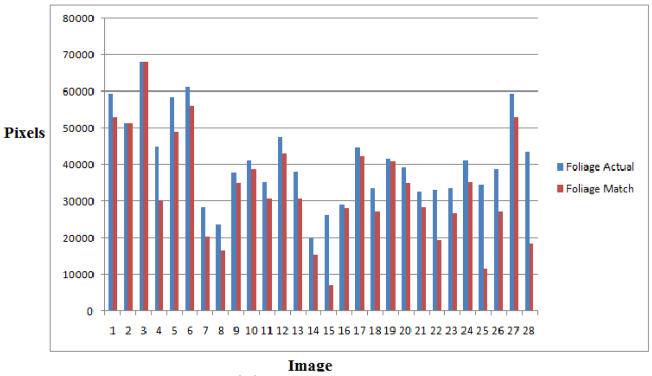

Fig. comparison of foliage detection algorithm with ground truth images.

IV. Conclusion

This paper presents algorithm for automatic detection of some objects i.e. sky and foliage. Segmentation is done using region growing method followed by region merging. Region merging step combines segments with similar features. The approach thus overcomes issues posed by disconnected edges. Segmentation is followed by perceptual object tagging. Tagging algorithms detects the object considering location, color, texture properties of each segment. Considering all these properties instead of single property is more beneficial for object detection work and finds object more accurately. Segments with high confidence as object are compared with image to find out more occurrences of that object in image. Object can be easily enhanced after detecting and tagging them.

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