Segmentation of Color Images

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Using adaptive thresholding and masking with watershed algorithm to overcome over segmentation problem

What is image segmentation ?

Image segmentation is a method of assigning a label to each pixel of an image by clustering pixels in relevant regions. Properties like gray level, color, intensity, texture, depth or motion help in recognition of similar regions.

Why image segmentation ?

Segmentation is a valuable tool in many fields including industry, health care, astronomy, image processing, remote sensing, traffic images, content based images, pattern recognition, videos, computer vision etc. It is the first stage in any effort to analyze or interpret an image automatically. Some form of image segmentation can be found in any application involving the detection, recognition, and measurement of objects in an image.

Types of image segmentation

1. Supervised - prior knowledge required
2. Unsupervised - fully automatic and segment regions in feature space with high density

Segmentation techniques

Pixel based, edge based, cluster based, region based, model based, color based and hybrid

Though numerous algorithms have been proposed to segment color images, none of them could always work for different kinds of images.

Watershed Transform

Watershed transform is an efficient morphological segmentation tool. MATLAB uses Fernand Meyer's flooding. It is performed on the gradient images. A set of local minima are chosen. Each is given a different label. The neighboring pixels of each marked area are inserted into a priority queue with a priority level corresponding to the gradient magnitude of the pixel. The pixel with the lowest priority level is extracted from the priority queue. If the neighbors of the extracted pixel that have already been labeled all have the same label, then the pixel is labeled with their label. All non-marked neighbors that are not yet in the priority queue are put into the priority queue. This is continued till the priority queue is empty. The non-labeled pixels are the watershed lines

Modified Watershed Transform

The main drawbacks of watershed transform are over-segmentation, sensitivity to noise and high computational complexity. To overcome over segmentation, we use a modified watershed algorithm by considering adaptive threshold and adaptive masking. This approach is faster than other segmentation methods making it appropriate for real-time application.

Reasons for over-segmentation

Oversegmentation occurs because every regional minimum, even if tiny and insignificant, forms its own catchment basin. Solution is to modify the image to remove minima that are too shallow

The Process

The image is divided into R, G, B channels and each channel is normalized

The Process

We find two thresholds using Otsu’s method. The first threshold is to separate the image into foreground and background. The second threshold further divides the foreground into two regions.

The Process

We smooth the image using bilateral filter to preserve edge information.

The Process

We divide the resultant image into cell and nucleus masks. The cell and nucleus masks are obtained by applying the first threshold and second threshold respectively on the smoothened images.

Cell Mask



Nucleus mask



The Process

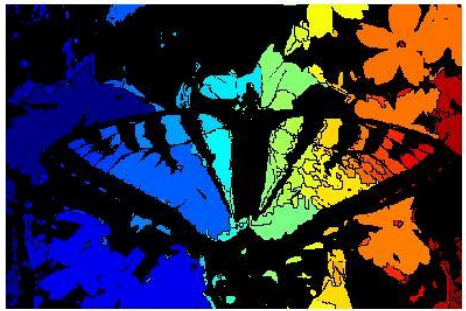
An image can have several regional maxima or minima. We have used Impose Minima to eliminate all the minima from the smoothened image except the minima specified by nucleus mask.

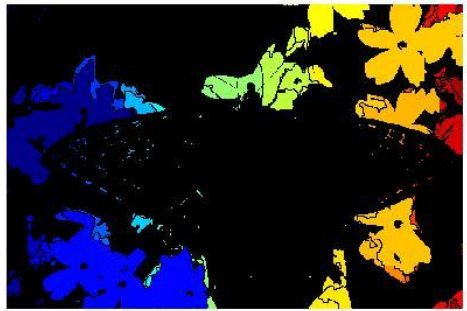
The Process

Watershed transform is applied on the above morphologically processed images.

The Process

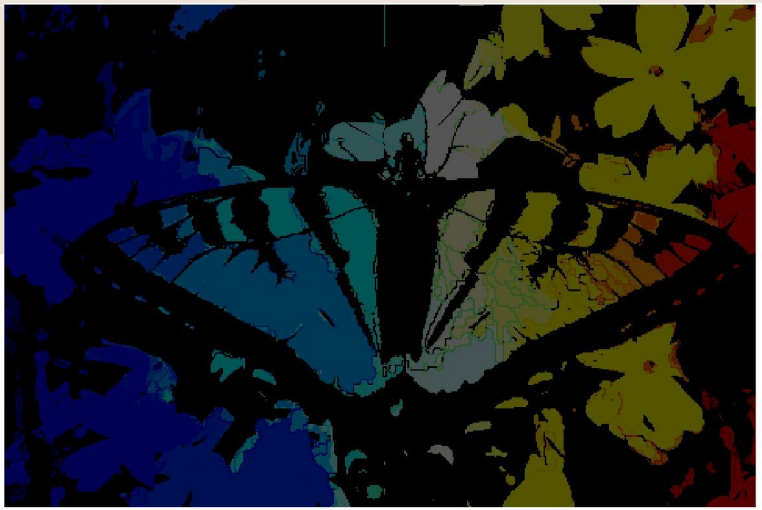
The background region can be specified using cell mask. The rest of the image is labelled based on the connected components and converted into RGB.



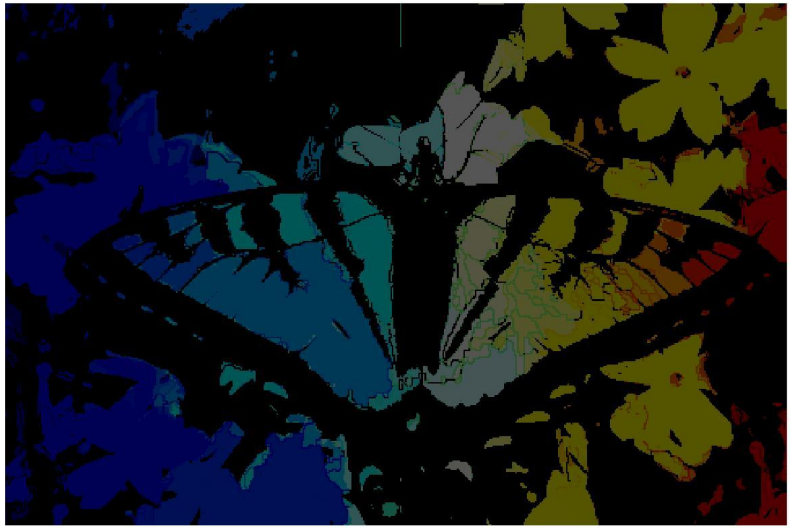


The Process

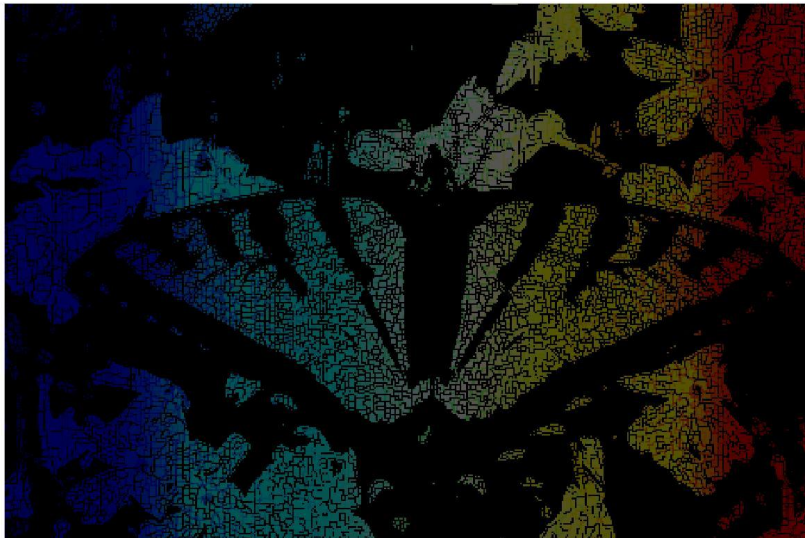
Finally all the channels are added to get the segmented image.



Modified watershed



Watershed (over segmented)



Comparison with other methods

Image	Average Times (second)			
	FCM	*RG*	*HKM*	*MWS*
Beach	5.05	6.21	8.28	2.66
Bird	4.65	7.86	9.33	3.90
Building	2.81	4.63	12.49	1.58
Car	3.40	4.82	4.00	1.39
Elephant	3.17	10.67	7.13	1.46
Flower	2.88	5.57	5.13	1.44
Horse	3.28	9.22	7.29	1.52
Medical	4.14	2.70	5.71	1.62
Mountain	3.73	6.80	7.25	1.50
People	4.06	7.50	5.30	1.53

Comparison with other methods

Image	KMC	FCM	RG	HKM	MWS
PSNR	58.38	55.40	52.43	55.52	57.91
MSE	0.10	0.2	0.33	0.25	0.11

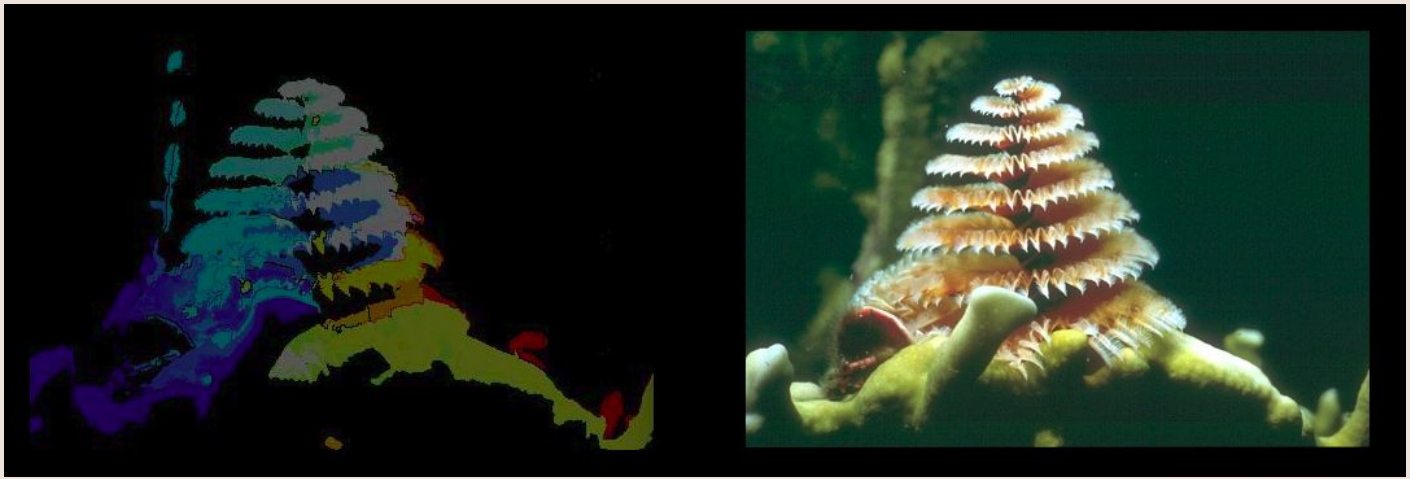
KMC - K Means Clustering
FCM - Fuzzy C Means
RG - Region Growing
HKM - Hill climbing K Means
MWS - Our Approach

MSE - Mean Square Error
PSNR - Peak Signal to Noise Ratio

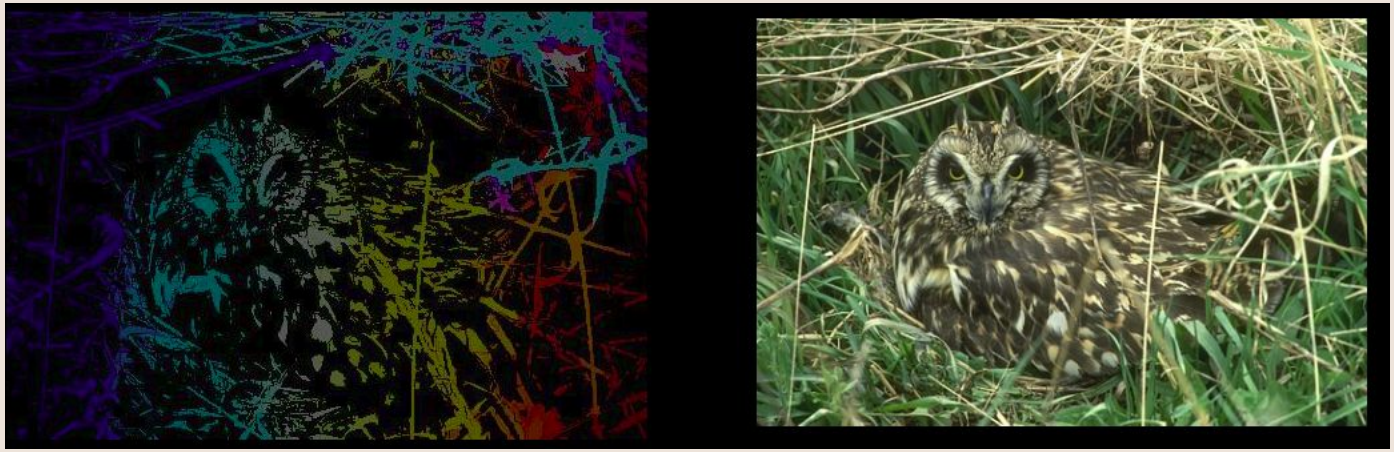
Observations

This algorithm takes into account factors such as the color feature of the image region, edge information. Hence, its segmentation results are closer to the human visual perception. Although KMC is slightly better (in terms of PSNR) than our method, the running time of our method is significantly.

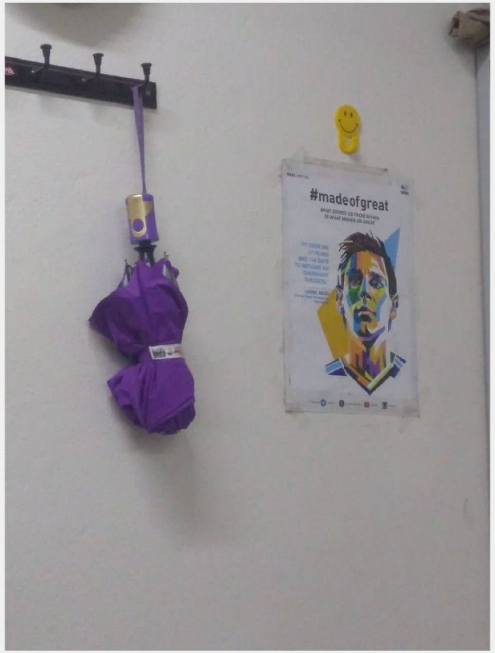
Results

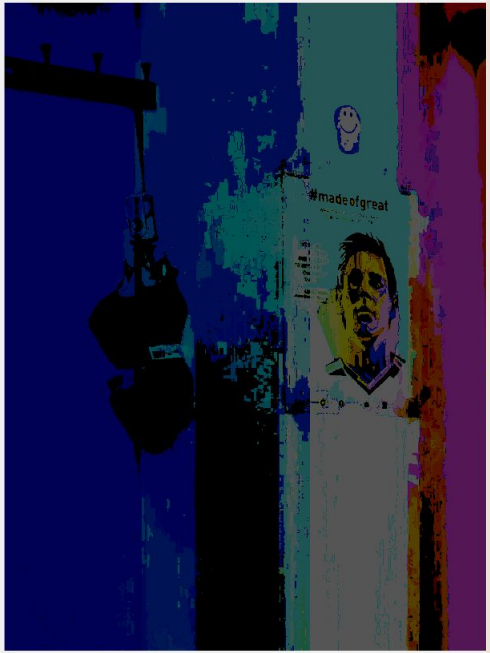


Results

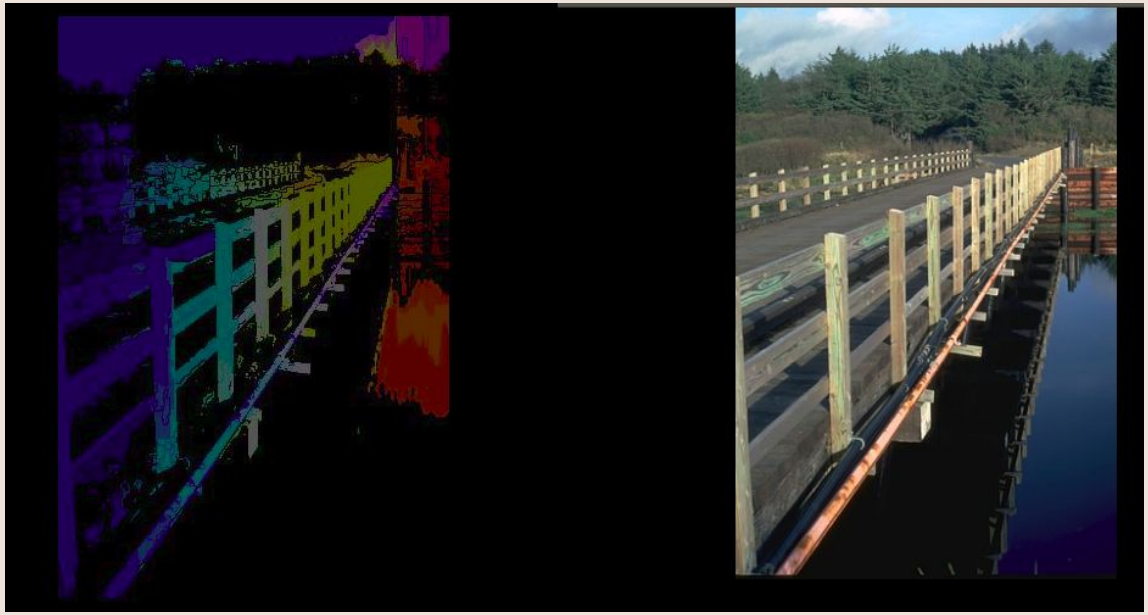


Results





Results



Cases of Failure

THANK YOU