Project Report

Team Name: Hidden Figures

Team Members :

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Github Link **:** https://github.com/KarthikaRamineni/DIP-Project

Problem statement :

Segmentation of color images using adaptive thresholding and masking with watershed algorithm.

Motivation :

In areas such as computer vision and image processing, image segmentation still is a relevant research area due to its widespread usage and application. In our project, we have considered a modified version of the watershed algorithm for image segmentation which uses an adaptive masking and a thresholding mechanism over each color channel to overcome over segmentation problem, before combining the segmentation from each channel into the final one. Also, this approach is faster than many other segmentation algorithms making it appropriate for real-time applications.

Introduction :

Image segmentation is a method of assigning a label to each pixel of an image by clustering pixels in the relevant regions. Properties like gray level, color, intensity, texture, depth or motion help in recognition of similar regions and similarity of such properties is used to construct groups of regions having a specific meaning. 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. It bridges the gap between low level and high level image processing. Some form of image segmentation can be found in any application involving the detection, recognition, and measurement of objects in an image. Segmentation algorithms are categorized into two types, supervised and unsupervised. Unsupervised methods are fully automatic and segment regions in feature space with high density. Segmentation techniques can be differentiated into the following categories - pixel based, edge based, cluster based, region based, model based, color based and hybrid. Pixel based and edge based segmentation are based on the concepts of similarity pixel value. Cluster based segmentation technique is similar to pixel based method. The objective of region based method to group pixels with similar properties to form a region. Though numerous algorithms have been proposed to segment color images, none of them could always work for different kinds of images. For example, edge based techniques cannot achieve enclosed region boundaries, while the region oriented algorithms may lead to over segmentation or under segmentation.

The watershed transformation is a powerful tool for image segmentation based on mathematical morphology.

Approach :

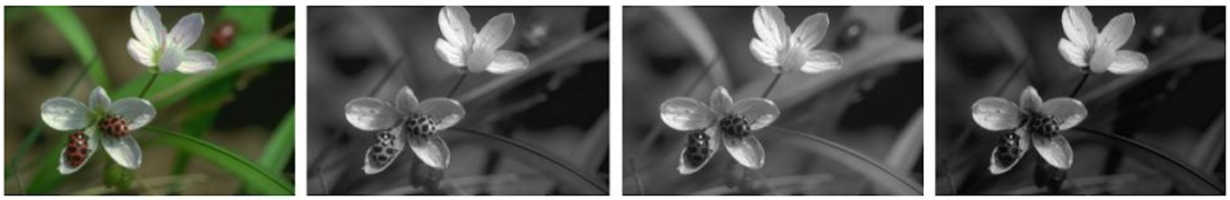
Watershed transform has been popularized as an efficient morphological image segmentation tool in recent years. It is similar to region based approach. It begins the growing process from every regional minimum point, each of which creates a single region after the transform. Watershed algorithm combines both the discontinuity and similarity properties successfully. It performs better when it can distinguish the background from the foreground object. It is based on grayscale mathematical morphology. The main drawbacks of watershed transform are over segmentation, sensitivity to noise and high computational complexity making it unsuitable for real time process. To overcome over segmentation, we have used adaptively selected threshold, adaptive masking operation, local minimum information and convolution for smoothing the image. This modified method can quickly find watershed segmentation for every region.

The following flow chart summarizes the approach:

Step 1 :

The input image is extracted into individual red, green and blue color channels as shown below and each channel is normalized(N) to the range 0 to 1

$$N = \frac{I - min\ (I)}{max\,(I) - min\ (I)}$$



Step 2 :

To determine the adaptive threshold (T_1 and T_2), we have used a dynamic threshold selection process based on gray threshold function.

$$T_1 = G_t(N)$$

$$T_2 = G_t(N(N > T_1))$$

where G_t is gray threshold based on Otsu's method.

We have considered Otsu's method because it maximizes inter class variance and minimizes intra class variance making it convenient for segmentation.

Step 3 :

We have performed bilateral filtering on each (normalized) channel to smooth the image. The weights depend not only on Euclidean distance of pixels, but also on gray intensity values thereby preserving sharp edges.

$$w(i,j,k,l) = \exp\left(-\frac{(i-k)^2 + (j-l)^2}{2\sigma_d^2} - \frac{\|I(i,j) - I(k,l)\|^2}{2\sigma_r^2}\right)$$

$$I_D(i,j) = \frac{\sum_{k,l} I(k,l)w(i,j,k,l)}{\sum_{k,l} w(i,j,k,l)}$$

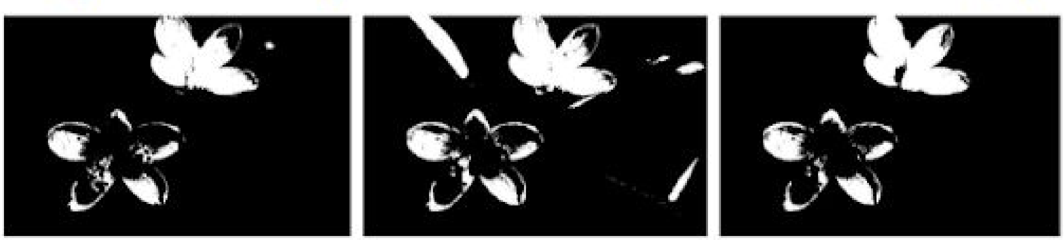
where I is the input and I_D is the smoothened image.

Step 4 :

The masking operations are divided into two stages: cell (M_1) and nucleus (M_2) masking. $M_1 = N > T_1$

$M_2 = N > T_2$

The cell and nucleus mask are obtained by applying the adaptive thresholds as above.

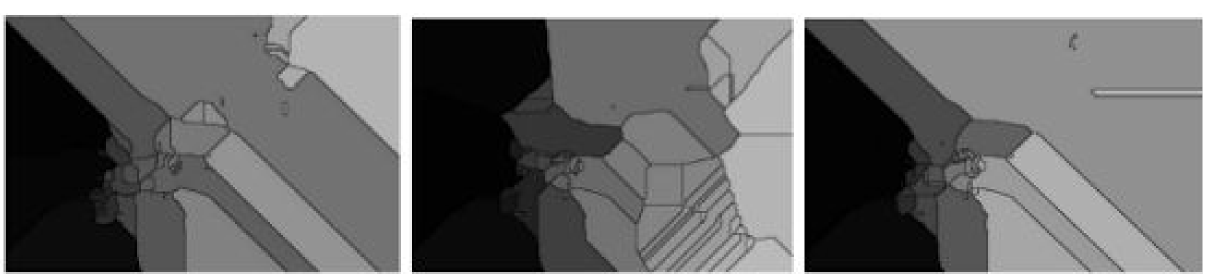


Step 5 :

An image can have several regional maxima and minima but only one global maximum and minimum. We have used impose minima (imimposemin from matlab) to create new minima in the mask image at certain desired location by adaptively selecting thresholds (T_1 and T_2) for morphological reconstruction to eliminate all minima from the image except the minima we specified. For morphological processing, we have applied impose minima to create morphological processed image using nucleus masking (M_2) and adaptive mask image on three color channels.

Step 6 :

Watershed transform (W) is applied on the above morphologically processed image channels.



Step 7 :

To determine a background image, we have used $W(\sim M_1) = 0$ and then labelled the connected components in each channel.

Step 8 :

We have converted the above labelled images into an RGB image using Label2rgb from matlab for the purpose of visualizing the labelled regions as shown below.

Step 9 :

The three color channels are added to generate the final segmented image as shown below.

Work performed :

We have used matlab for coding. We tested the algorithm on images taken from the Berkeley image database.

In step 2, we have experimented on various thresholding methods. In step 3, we tuned the parameters of bilateral filter for better results.

Results :

This algorithm takes into account factors such as the color feature of the image region, edge information, and adjacency relationship between the regions. Hence, its segmentation results are closer to the human visual perception.

Our method (MWS), Fuzzy C Means (FCM), Region Growing (RG), Hill-climbing with K Means (HKM), Otsu's K means clustering (KMC) are compared below.

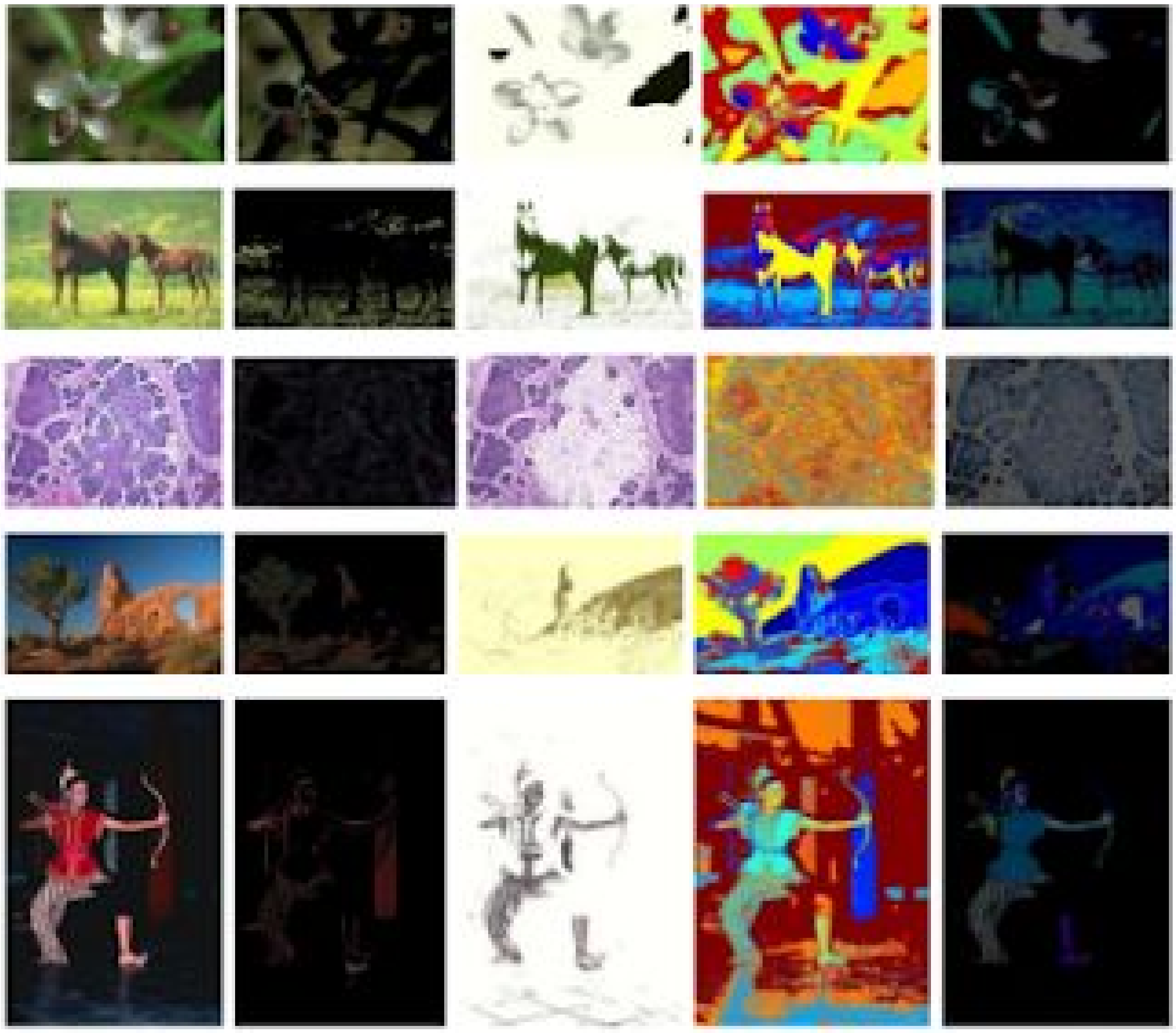
Reference:

http://www.academia.edu/28460635/Color_Image_Segmentation_Features_and_Techniques_A_Comparative_Study

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

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

Although FCM is slightly better (in terms of PSNR) than our method, the running time of our method is significantly less than FCM.



(Original) (FCM) (RG) (HKM) (MWS)

Task Assignment

Karthika Ramineni

Implemented Adaptive thresholding, Watershed transform, Pixel Labeling, Main function - 50%, Post Processing and Segmentation, Project Proposal - 50%, Final Report

Soumya Taurani

Bilateral filter parameter tuning, Adaptive masking operation, Morphological Processing, Main function - 50%, Project Proposal - 50%, Running the code on dataset