

## Segmentation results with Mean shift clustering

Malaria.tif

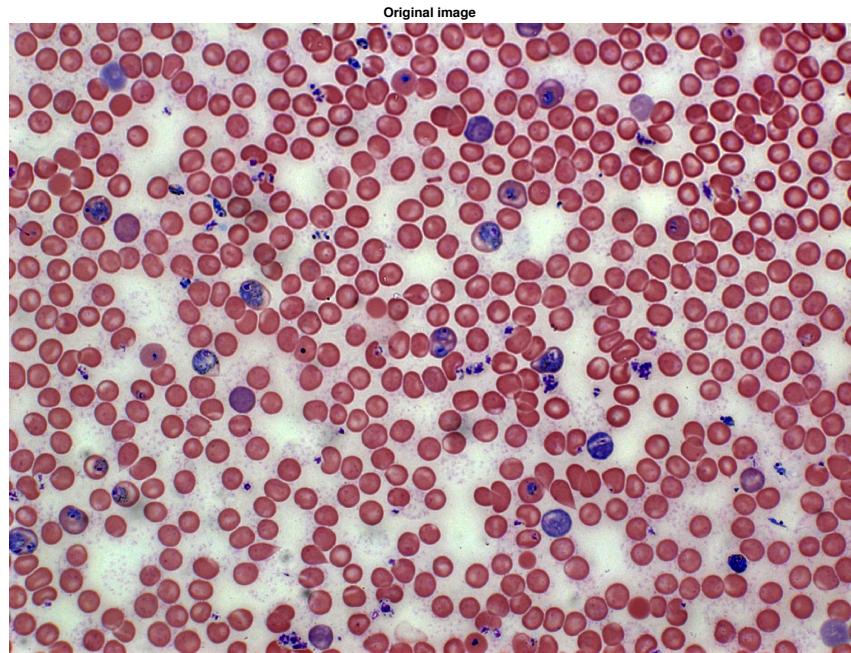


Figure 1 Original image malaria.tif

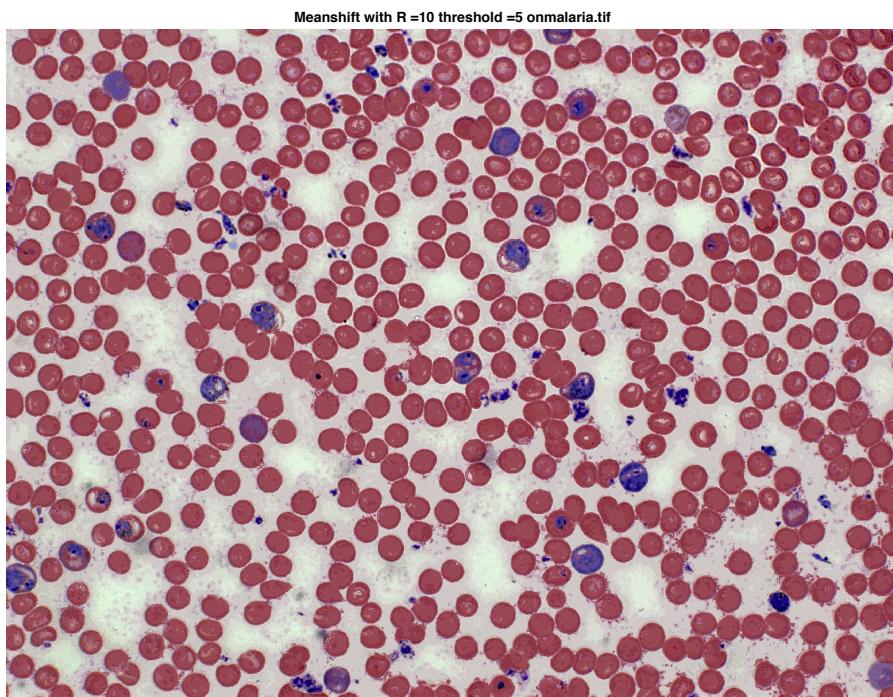


Figure 2 Segmented Image  $R = 10$  and threshold = 5

## Segmentation results with Mean shift clustering

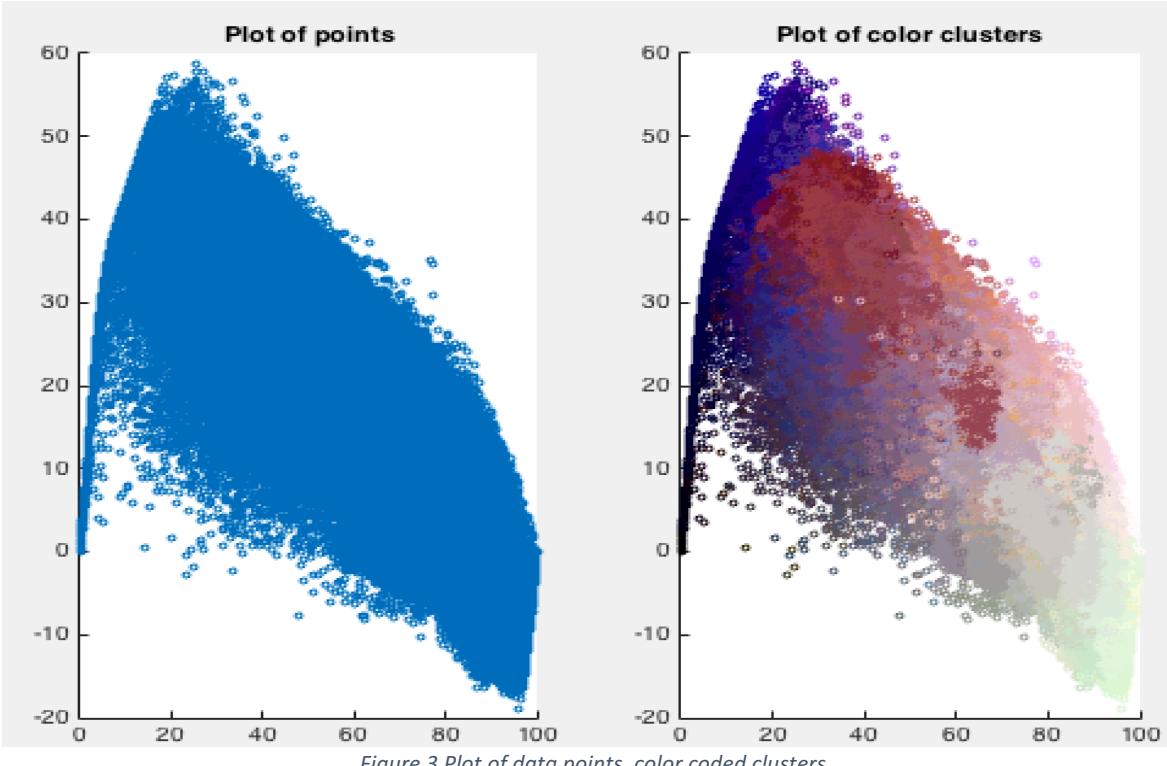


Figure 3 Plot of data points, color coded clusters

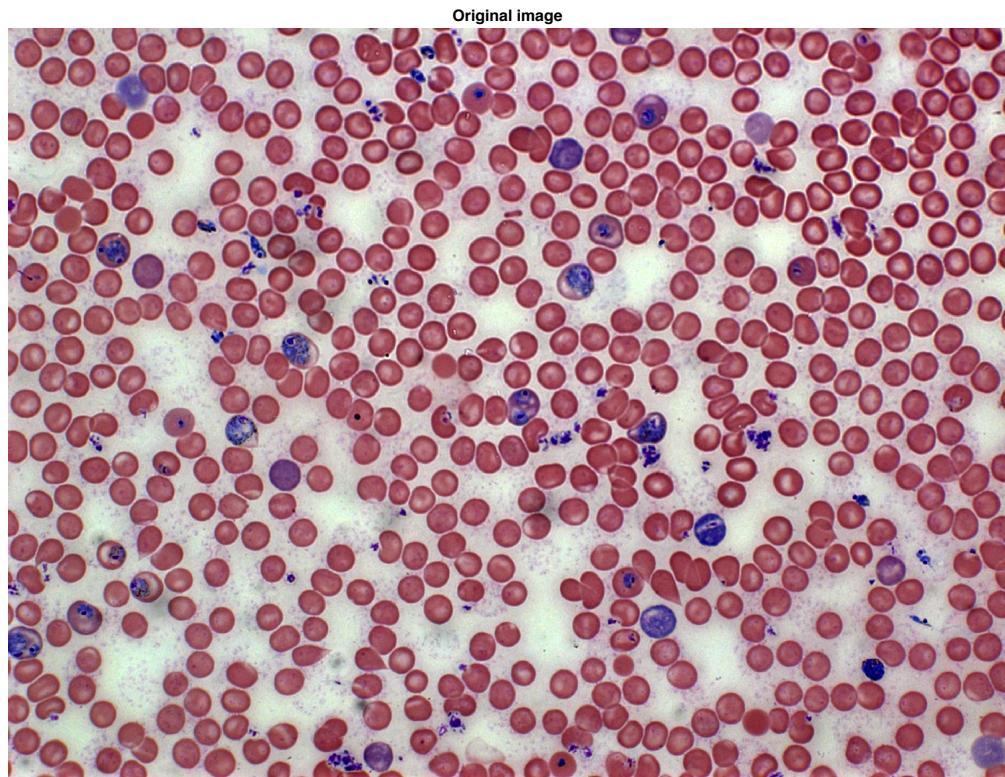


Figure 4 Original image malaria.tif

## Segmentation results with Mean shift clustering

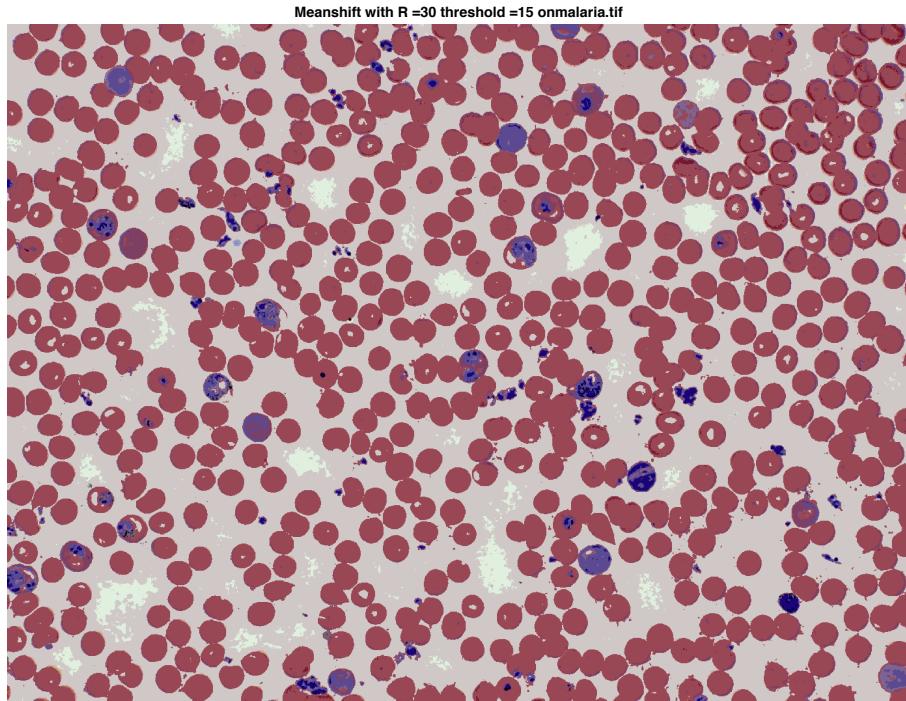


Figure 5 Segmented image with  $R = 30$  and  $\text{threshold} = 15$

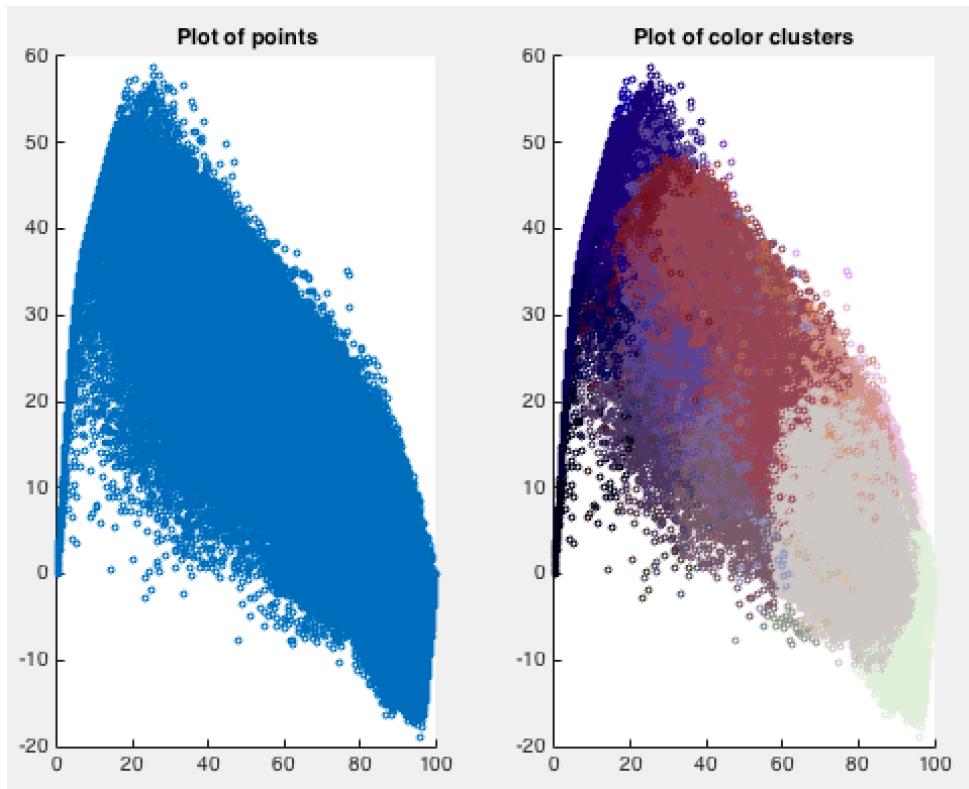


Figure 6 Plot of data points, color coded clusters

## Segmentation results with Mean shift clustering

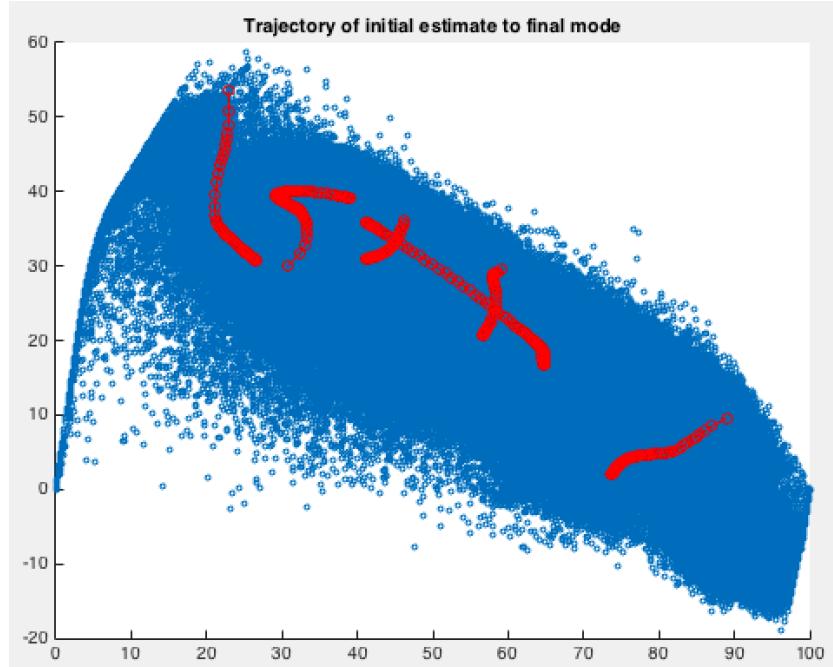


Figure 7 Trajectory of initial estimate to mode for few points

LungCT.jpg



Figure 8 Original image lungct.jpg

## Segmentation results with Mean shift clustering

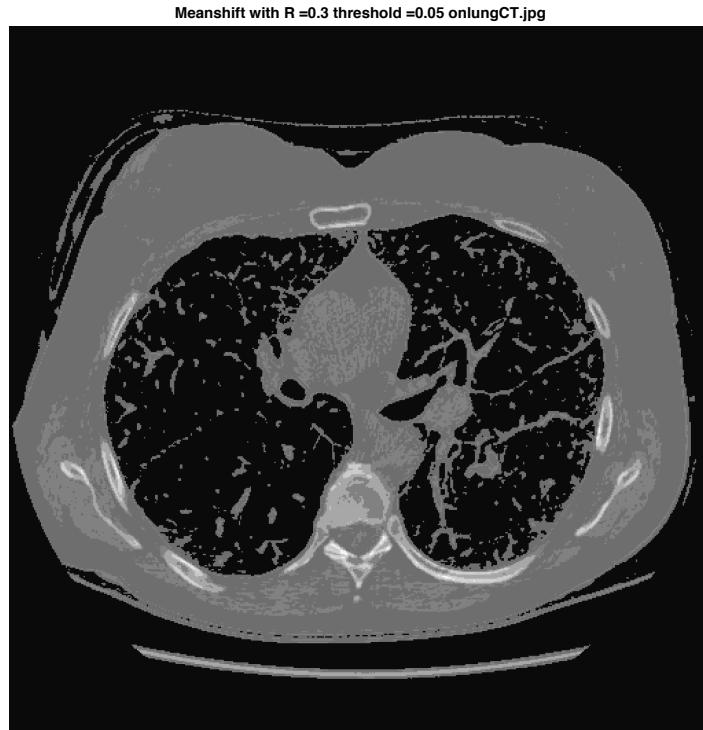


Figure 9 Segmented Image with  $R = 0.3$  and threshold = 0.05

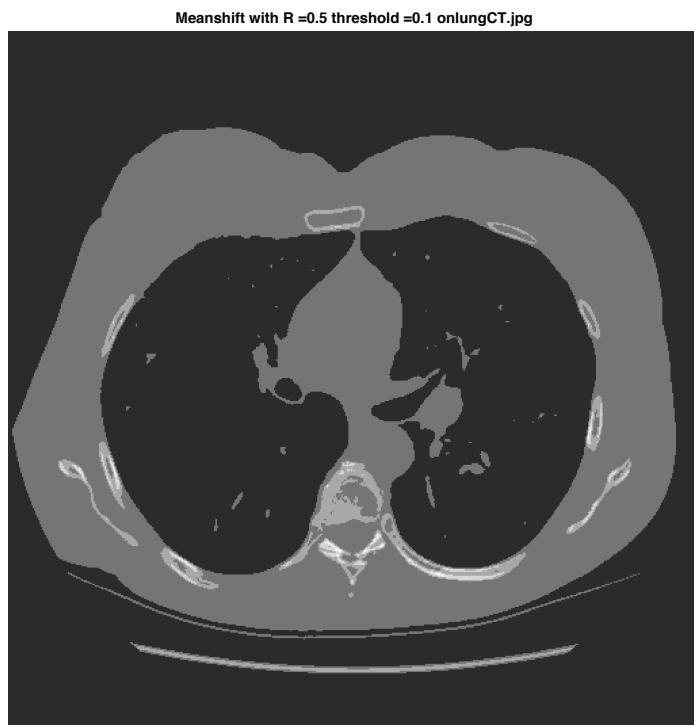


Figure 10 Segmented Image with  $R = 0.5$  threshold = 0.1

## Segmentation results with Mean shift clustering

ProstateCancer\_grade4.tif

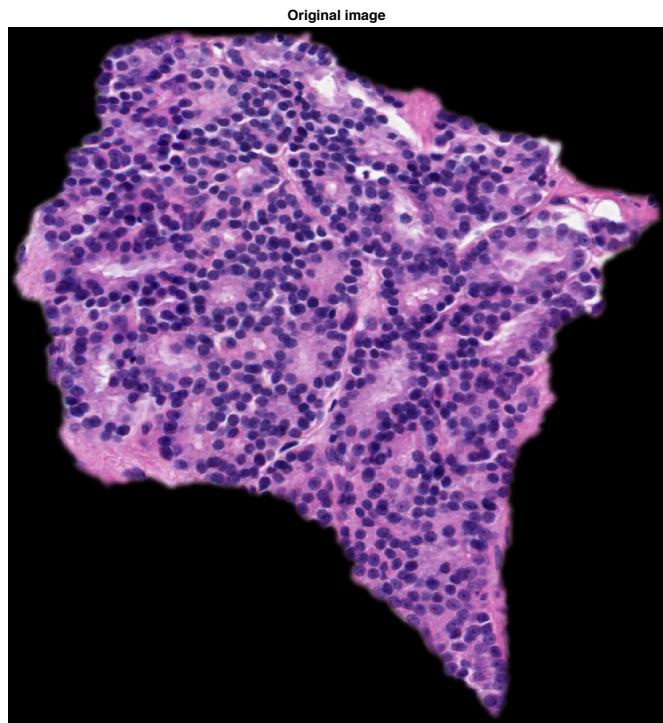


Figure 11 Original image prostatecancer\_grade4.tif

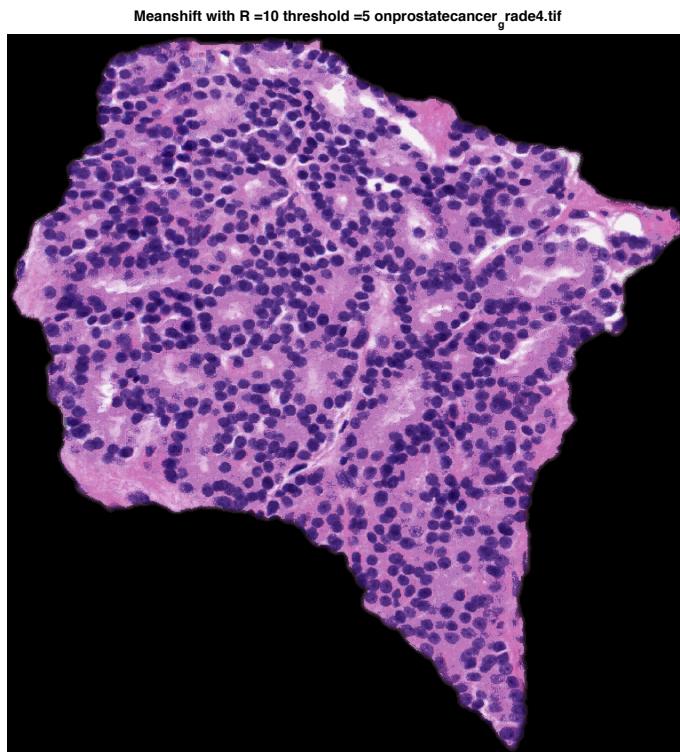


Figure 12 Segmented image with  $R = 10$  and Threshold = 5

## Segmentation results with Mean shift clustering

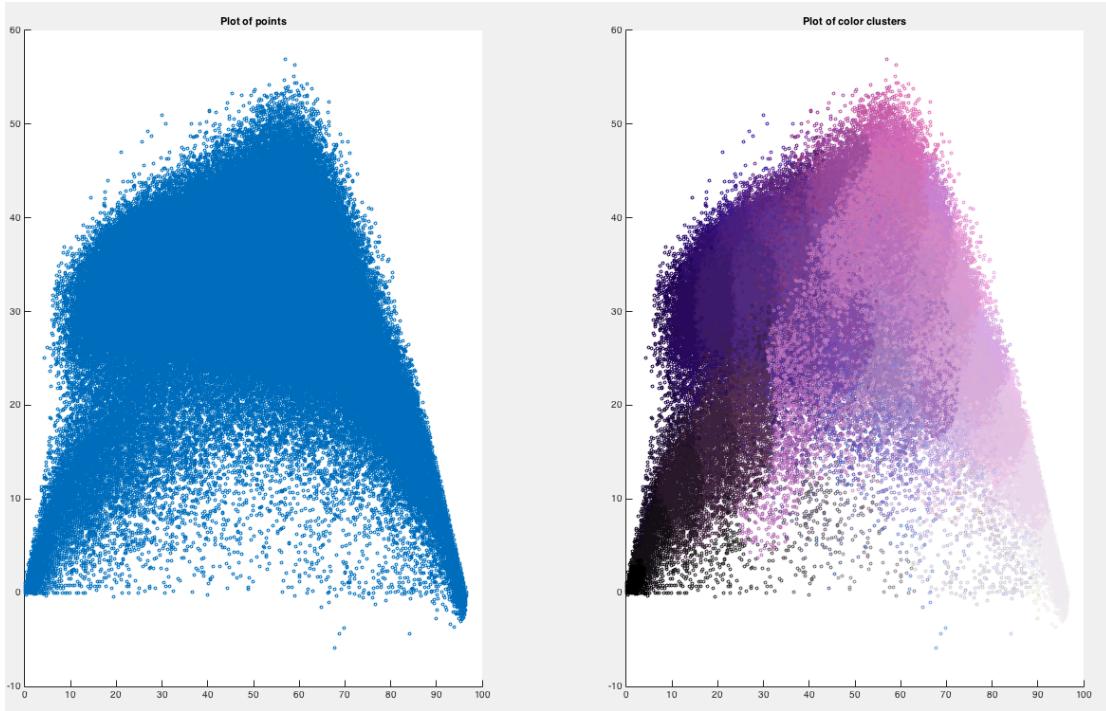


Figure 13 Plot of points in dataset, color coded clusters

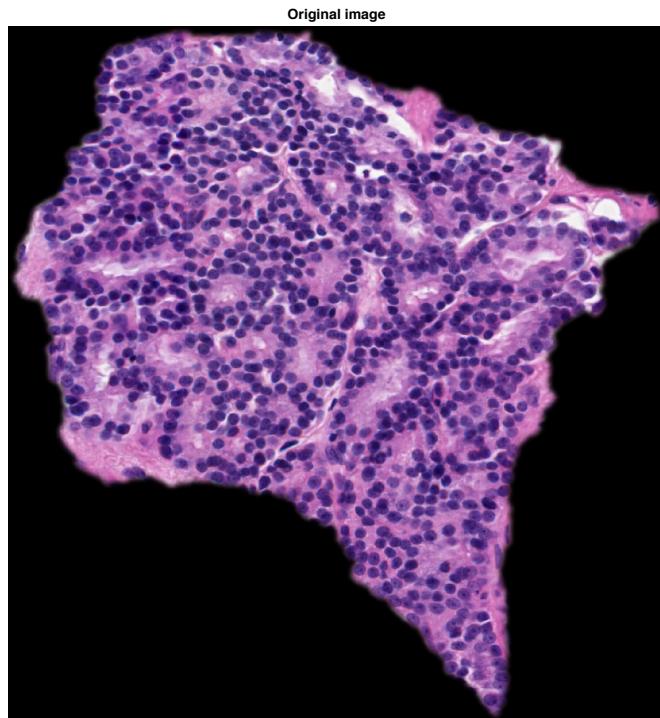


Figure 14 Original image prostatecancer\_grade4.tif

## Segmentation results with Mean shift clustering

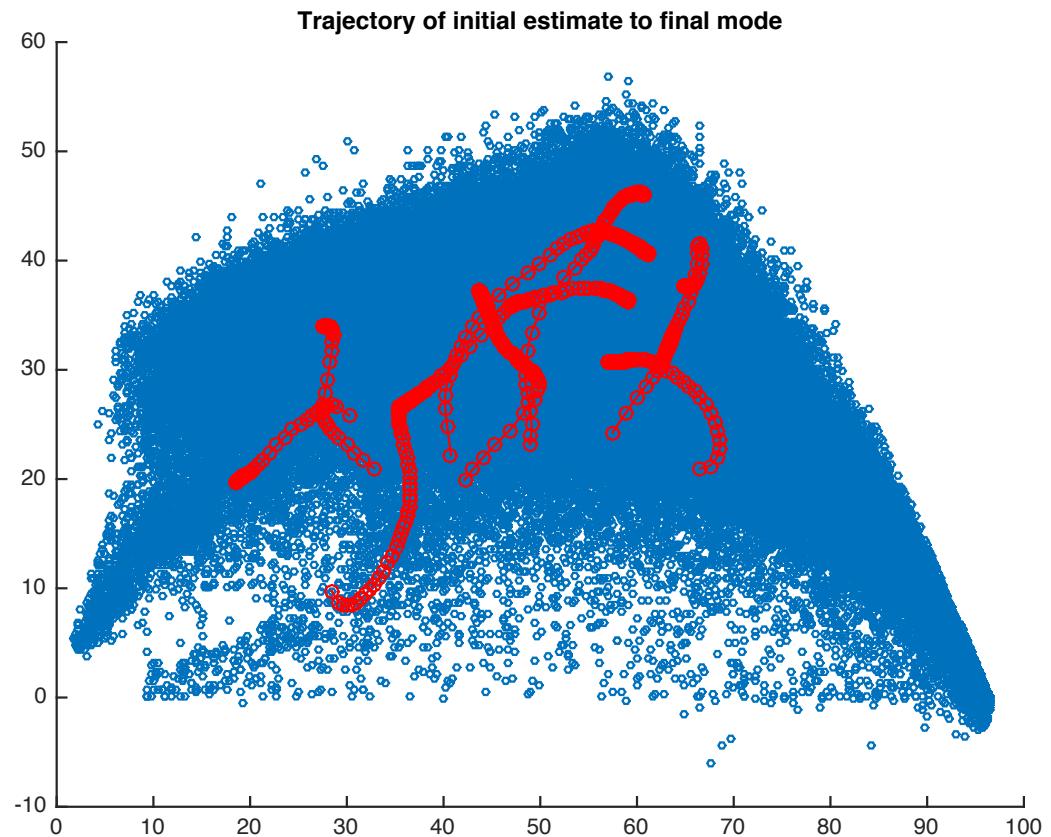


Figure 15 Trajectory of initial estimate to mode for few points

## Segmentation results with Mean shift clustering

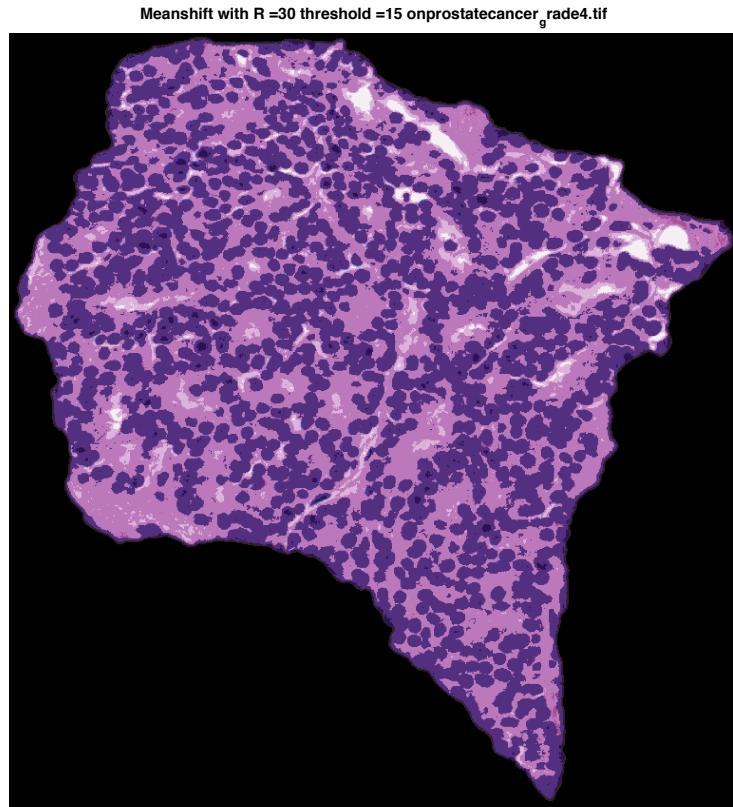


Figure 16 Segmented image with  $R = 30$  and threshold = 15

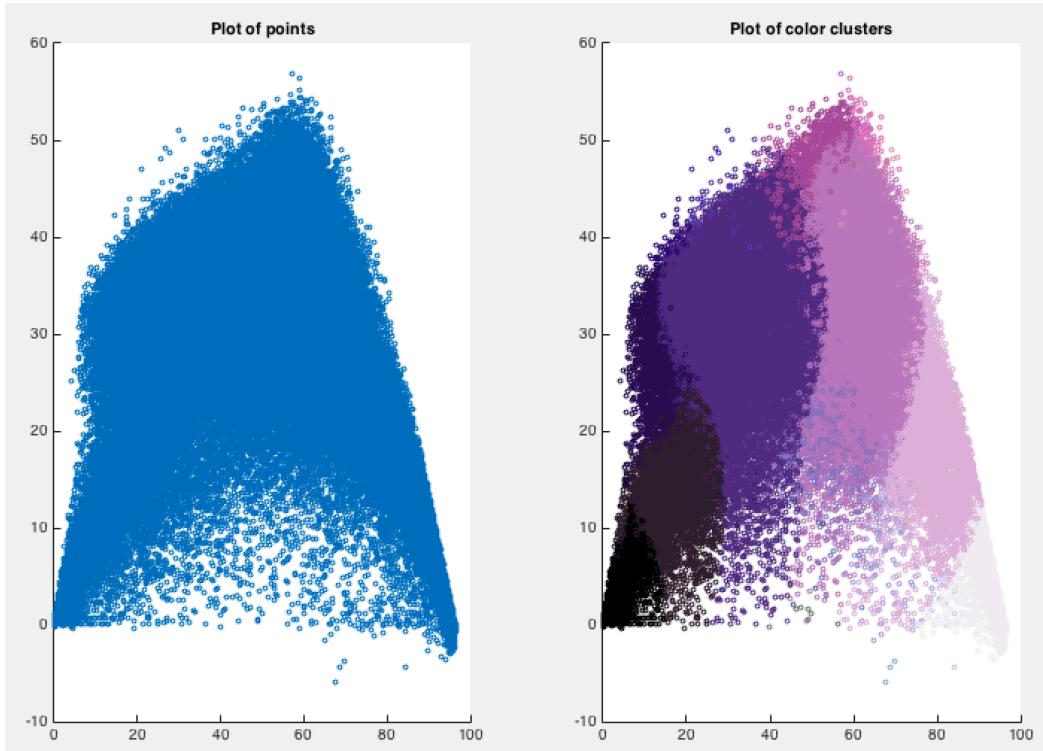
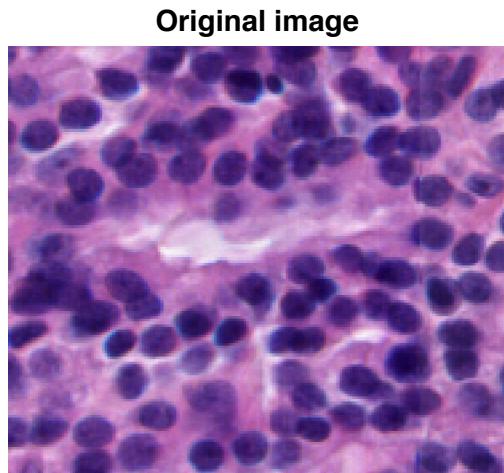


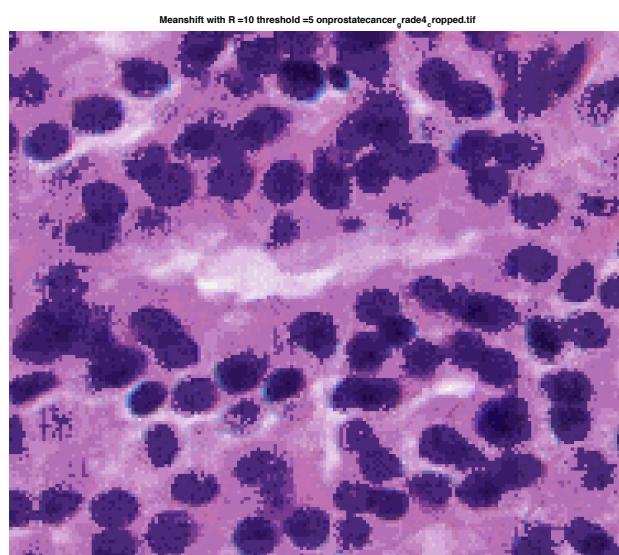
Figure 17 Plot of data points, color coded clusters

## Segmentation results with Mean shift clustering

ProstateCancer\_grade4\_cropped.tif



*Figure 18 Original image prostatecancer\_grade4\_cropped.tif*



*Figure 19 Segmented image with  $R = 10$  and threshold = 5*

## Segmentation results with Mean shift clustering

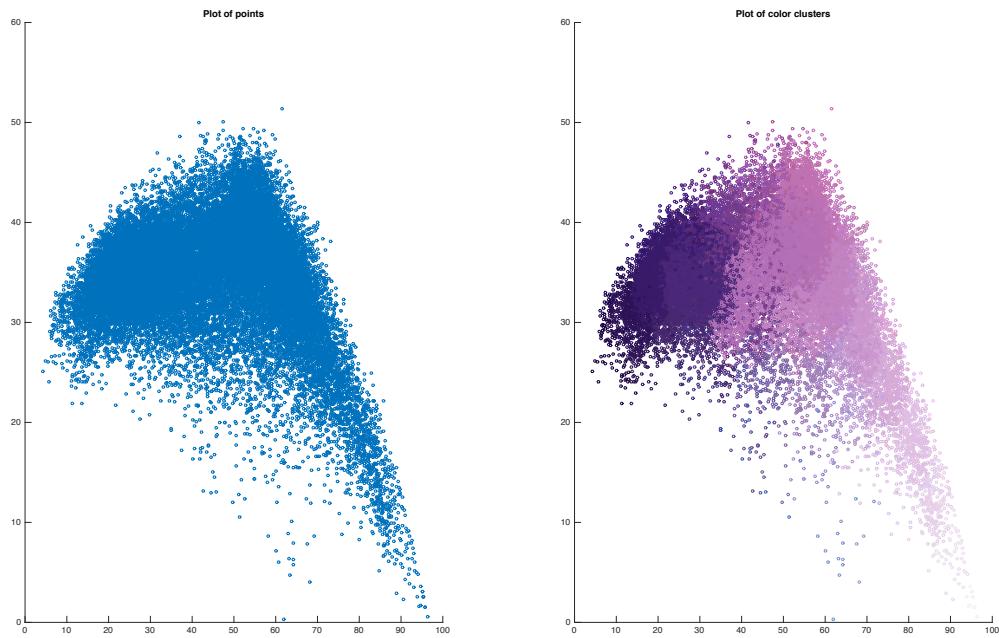


Figure 20 Plot of data points, color coded clusters

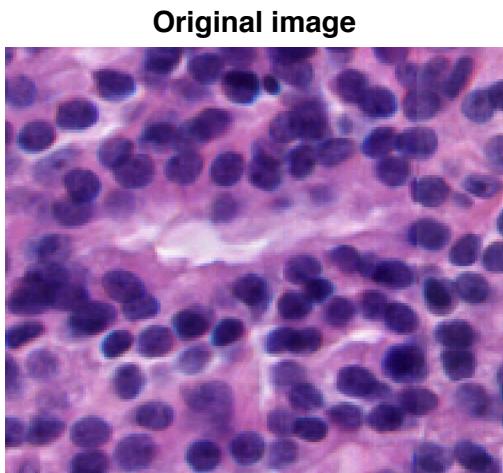


Figure 21 Original image prostatecancer\_grade4\_cropped.tif

## Segmentation results with Mean shift clustering

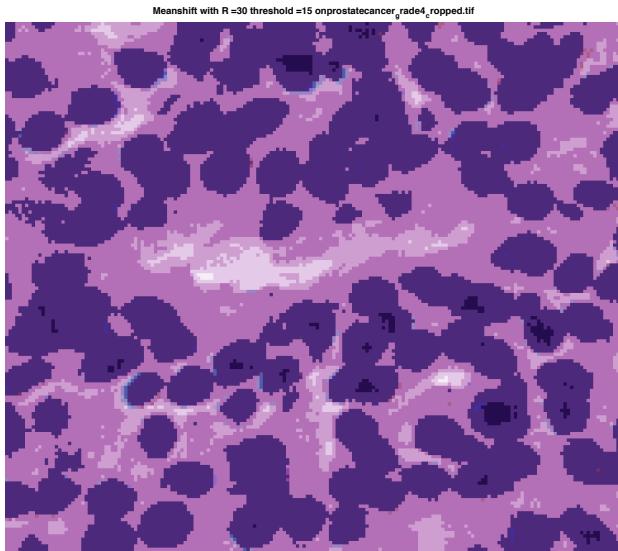


Figure 22 Segmented image with  $R = 30$  and threshold = 15

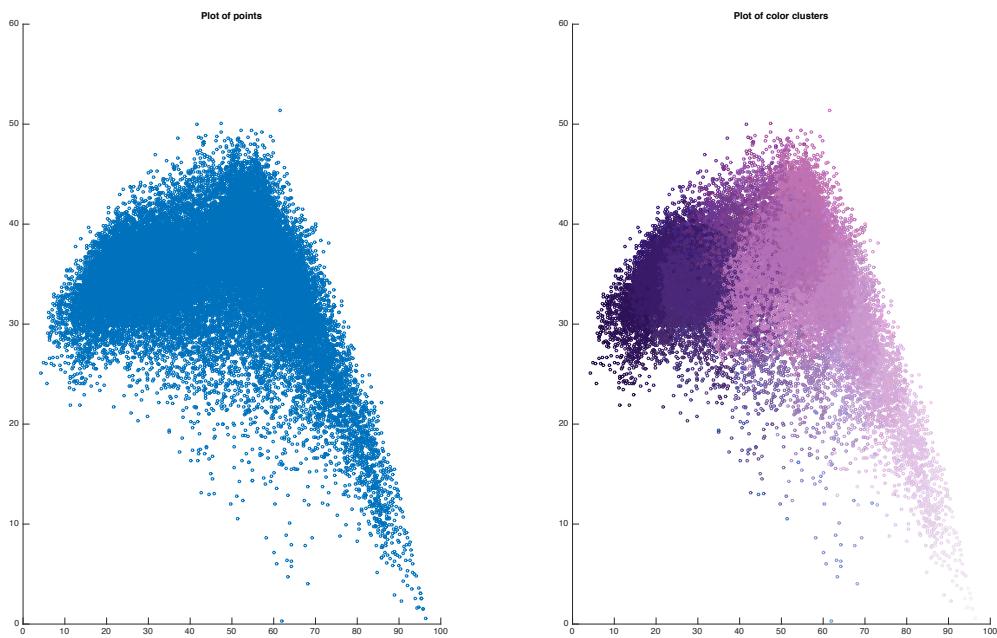


Figure 23 Plot of data points, color coded clusters

## Segmentation results with Mean shift clustering

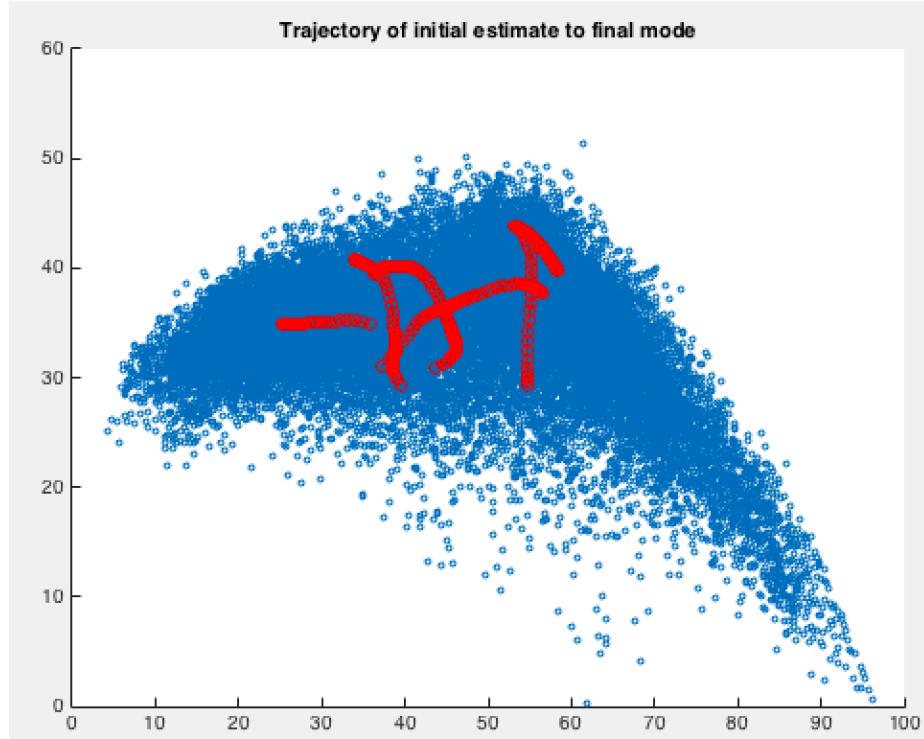


Figure 24 Trajectory of initial estimate to mode for few points

### Observations:

For a small radius of neighborhood, a large number of clusters of small size were formed. As we increase the radius of neighborhood, the size of the cluster has increased and the number of clusters were reduced. For an optimal value of R the number of clusters would equal the actual number of clusters present in the image. The increase in radius has led the merging of cells.

Unlike the k-means or GMM, mean shift does not assume any shape for the clusters. Thus the obtained clusters were of arbitrary shape.

The execution times drastically varied with the change in radius and threshold. For small radii the execution times were higher, lower execution times were reported for larger radii and larger threshold values.

### Algorithm speedup:

In order to speedup my implementation of mean shift clustering I adopted following steps

1. Perform a mean shift to find the peak corresponding to a point. While finding the peak, we would go through an intermediate of means. I assign the points that are closer to these intermediate means to the same cluster. The closeness is measure in terms of Euclidian distance in feature space.
2. In order to speedup the distance calculation, I set the features of points that are already assigned to a cluster to NaN. Distance calculation was faster with NaNs than the legal RGB values.

## Segmentation results with Mean shift clustering

With the specified changes the run times of algorithm are as follows

Image	Radius	Threshold	Execution times in seconds
Malaria.tif	10	5	458.78
Malaria.tif	30	15	49.02
LungCT	0.3	0.05	0.66
LungCT	0.5	0.1	0.32
Prostatecancer_grade4	10	5	113.83
Prostatecancer_grade4	30	15	14.90
Prostatecancer_grade4	10	5	2.41
Prostatecancer_grade4	30	15	0.35