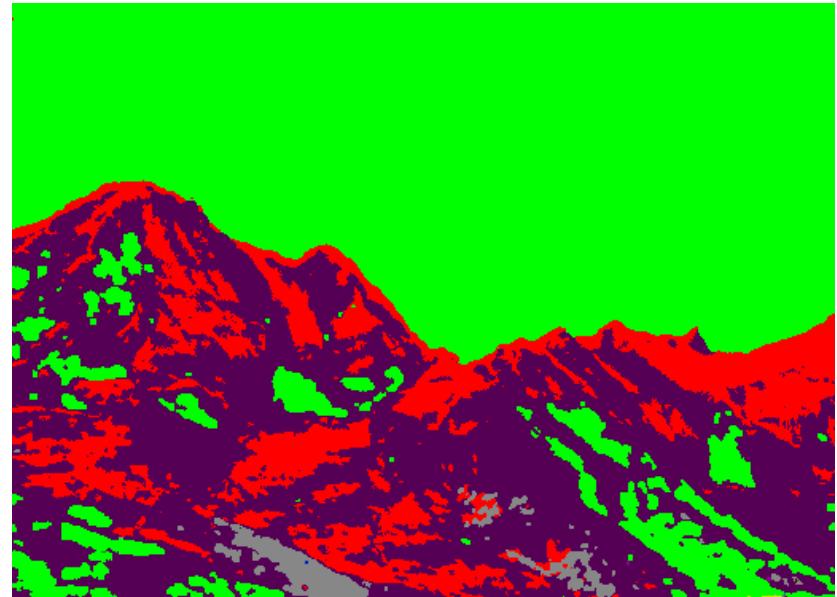
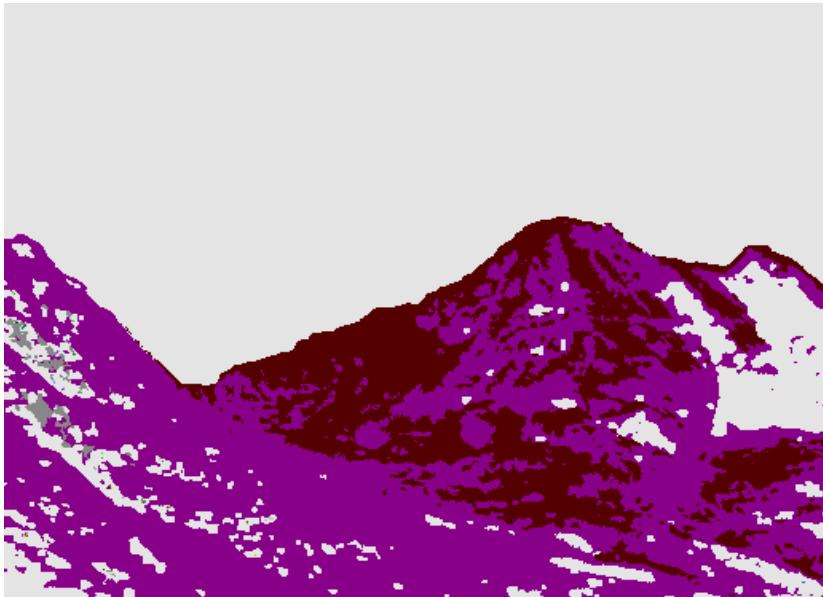
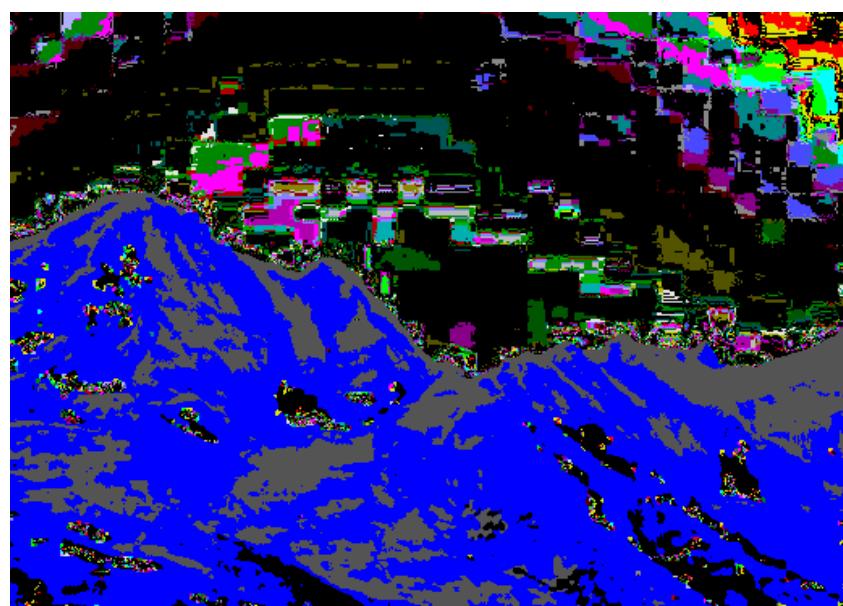
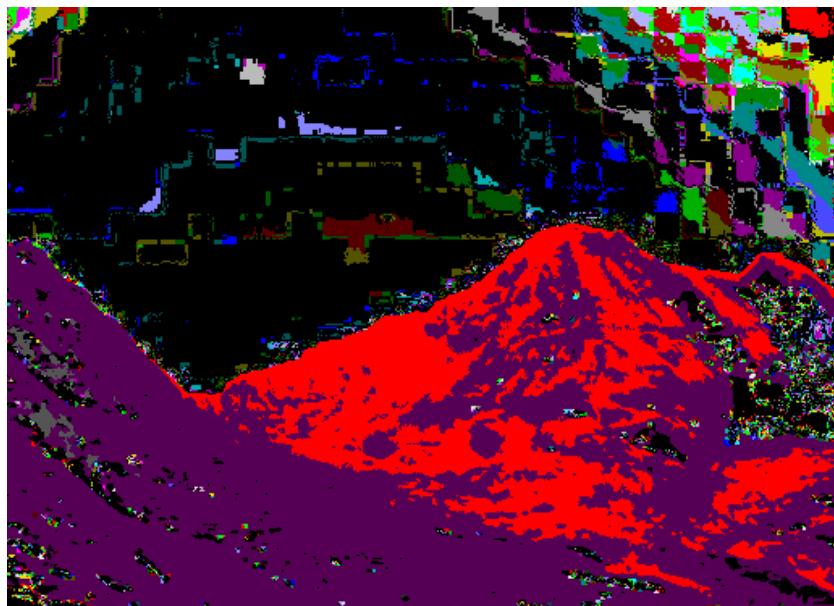


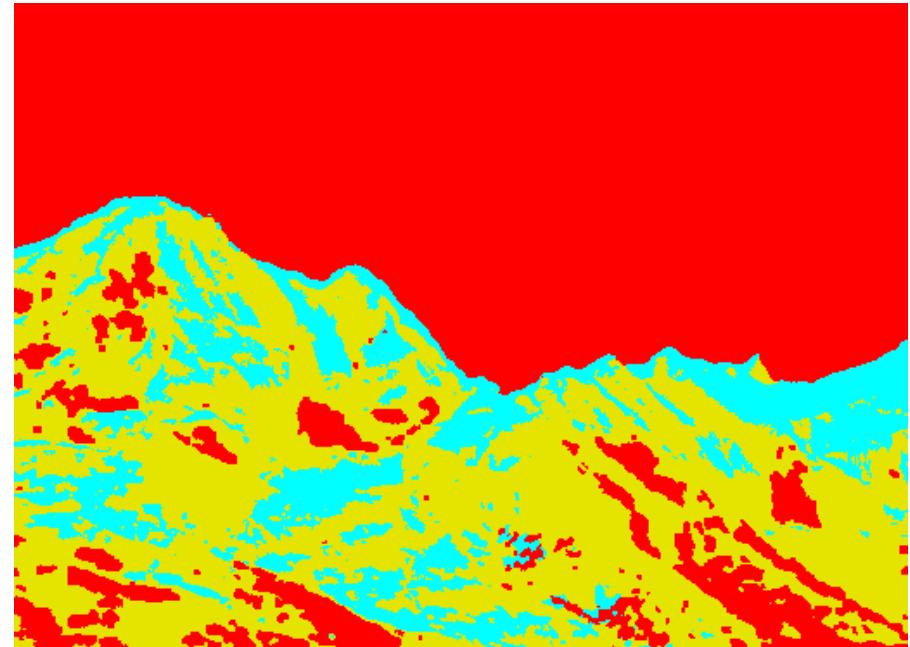
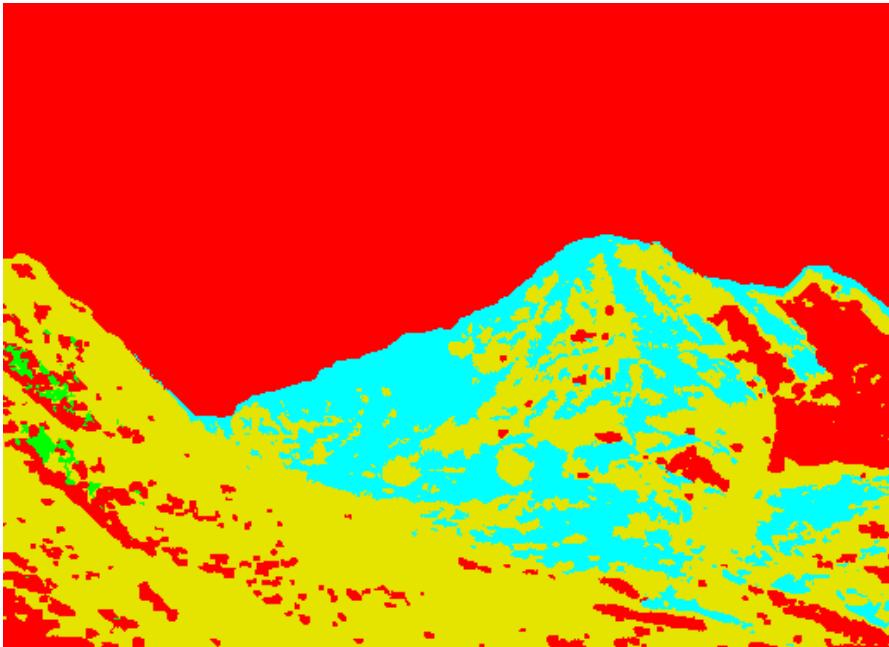
```
imageSegmentation.calculateUsingCIEXYAndClustering(gsImg1, true);
```



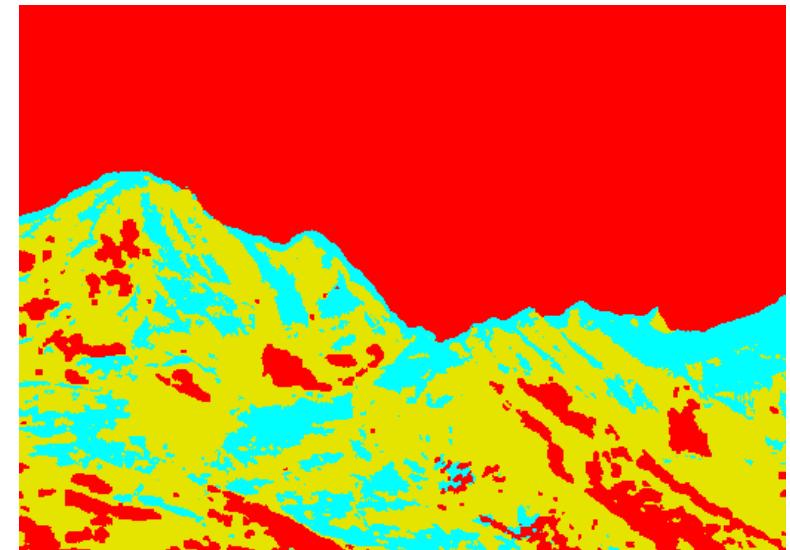
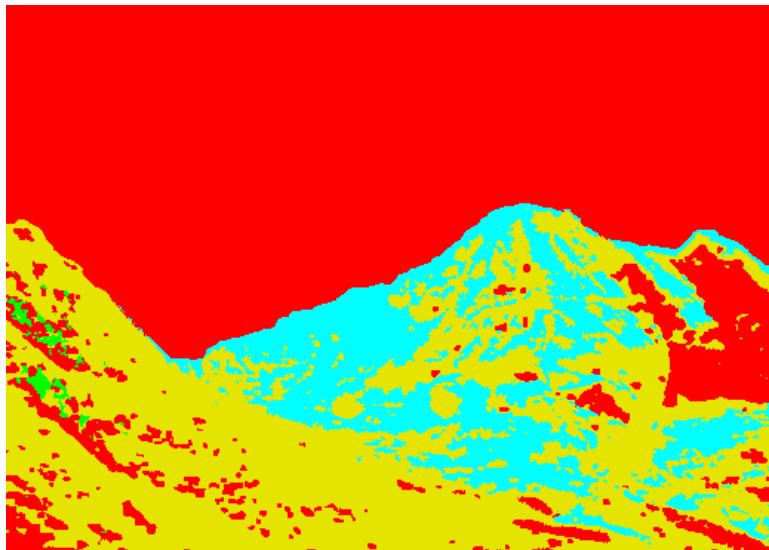
```
imageSegmentation.calculateUsingPolarCIEXYAndClustering(gsImg1, true);
```



```
imageSegmentation.calculateUsingPolarCIEXYAndFrequency(gslImg1, true);
```



```
imageSegmentation.calculateUsingPolarCIEXYAndFrequency(gslImg1, 0.2f, true);
```



```
int kBands = 2; imageSegmentation.applyUsingKMPP(gsImg1, kBands);
```



```
int kBands = 3; imageSegmentation.applyUsingKMPP(gsImg1, kBands);
```



```
int kBands = 8; imageSegmentation.applyUsingKMPP(gsImg1, kBands);
```



```
int kBands = 2; imageSegmentation.applyUsingCIEXYPolarThetaThenHistEq(gsImg1, kBands);
```



```
int kBands = 3; imageSegmentation.applyUsingCIEXYPolarThetaThenHistEq(gsImg1, kBands);
```



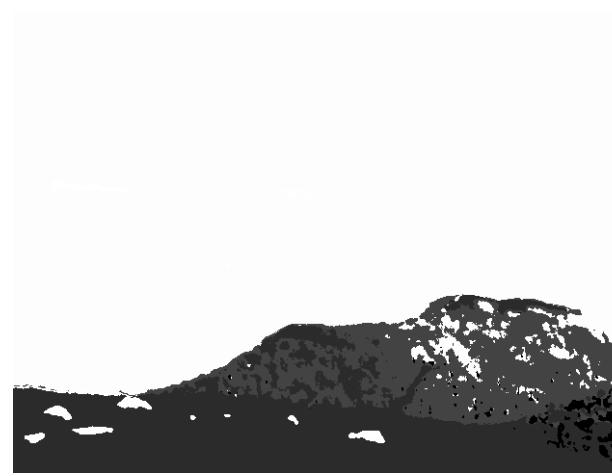
```
int kBands = 8; imageSegmentation.applyUsingCIEXYPolarThetaThenHistEq(gsImg1, kBands);
```



```
int kBands = 2; imageSegmentation.applyUsingCIEXYPolarThetaThenKMPPThenHistEq(gsImg1,  
kBands);
```



```
int kBands =3; imageSegmentation.applyUsingCIEXYPolarThetaThenKMPPThenHistEq(gsImg1,  
kBands);
```



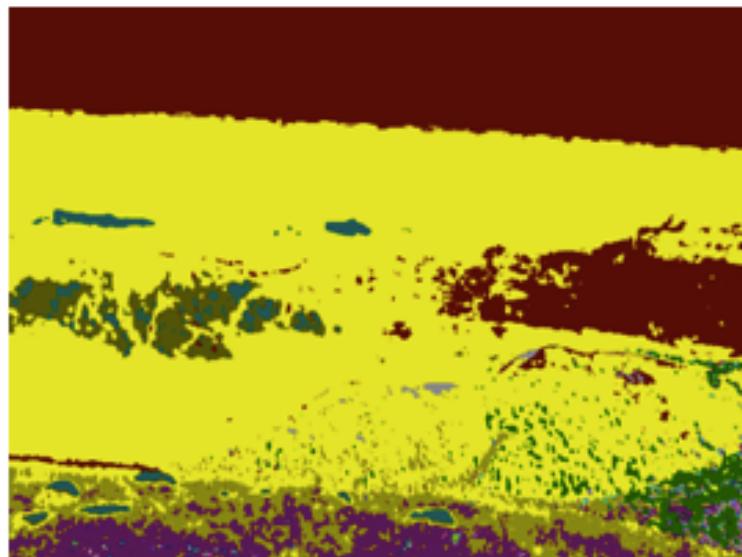
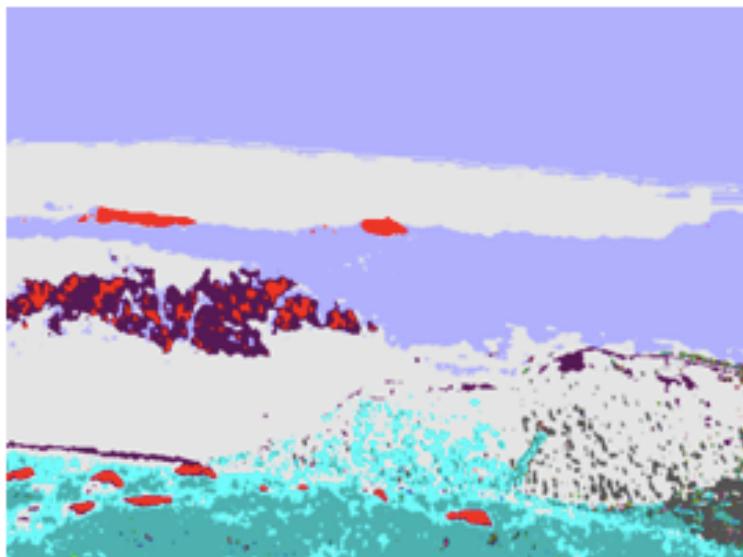
```
int kBands =8; imageSegmentation.applyUsingCIEXYPolarThetaThenKMPPThenHistEq
```



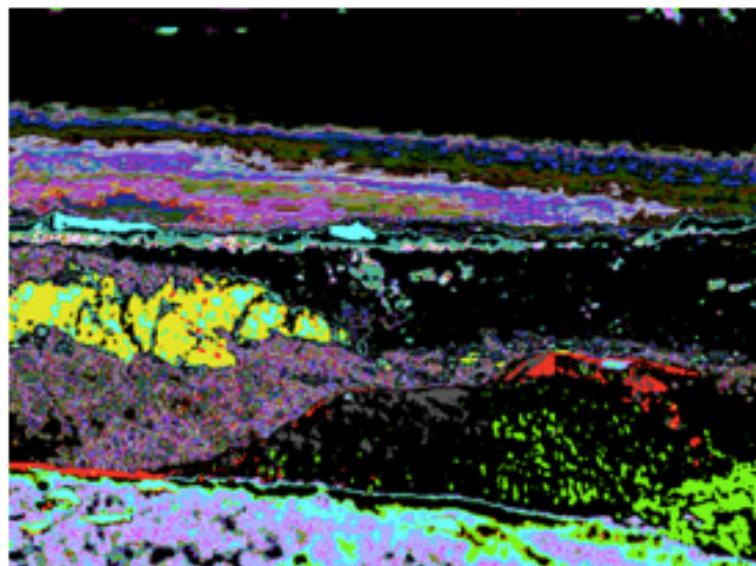
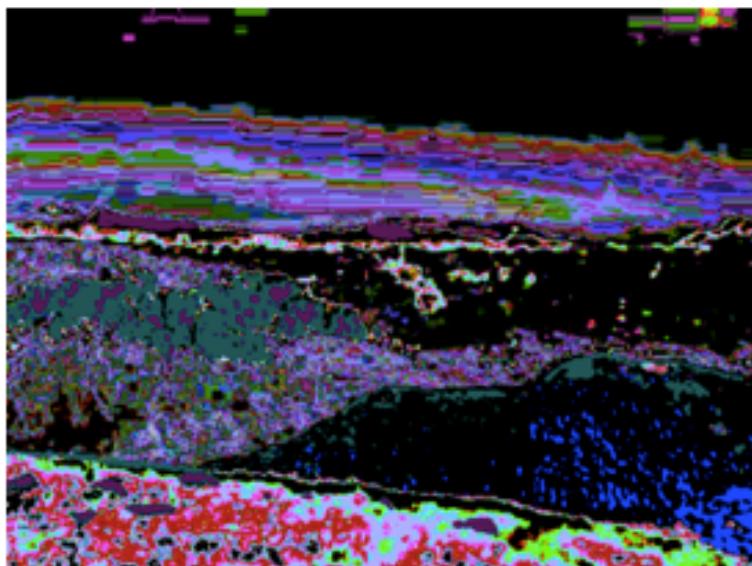
```
int kBands = 2; imageSegmentation.applyUsingCIEXYPolarThetaThenHistogram(gsImg1, kBands);
```



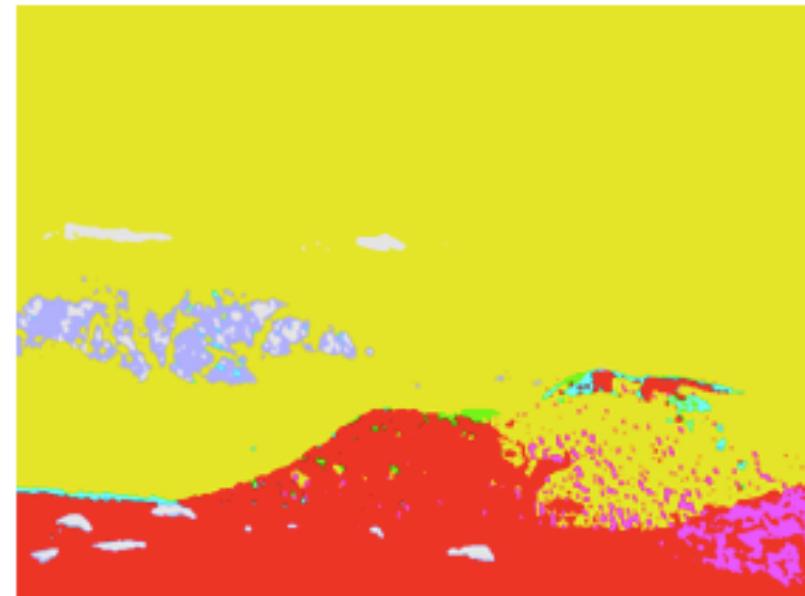
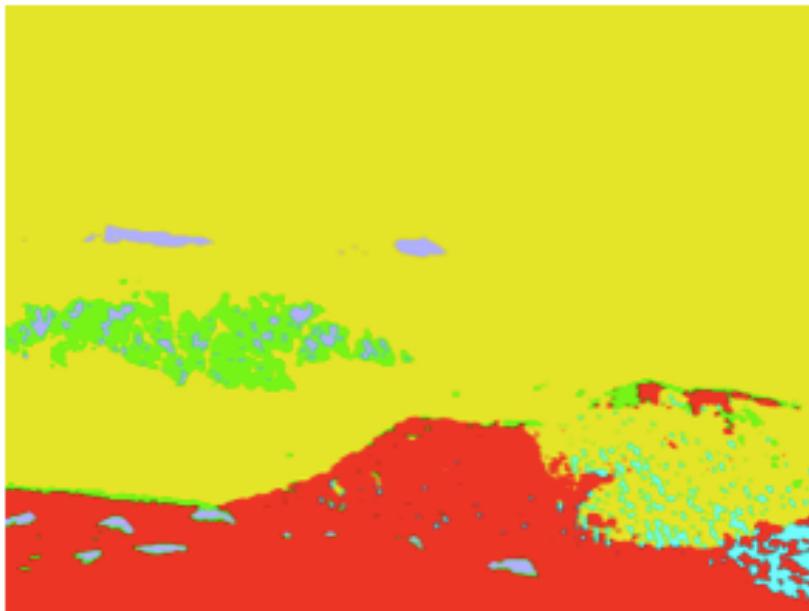
```
imageSegmentation.calculateUsingCIEXYAndClustering(gslImg1, true);
```



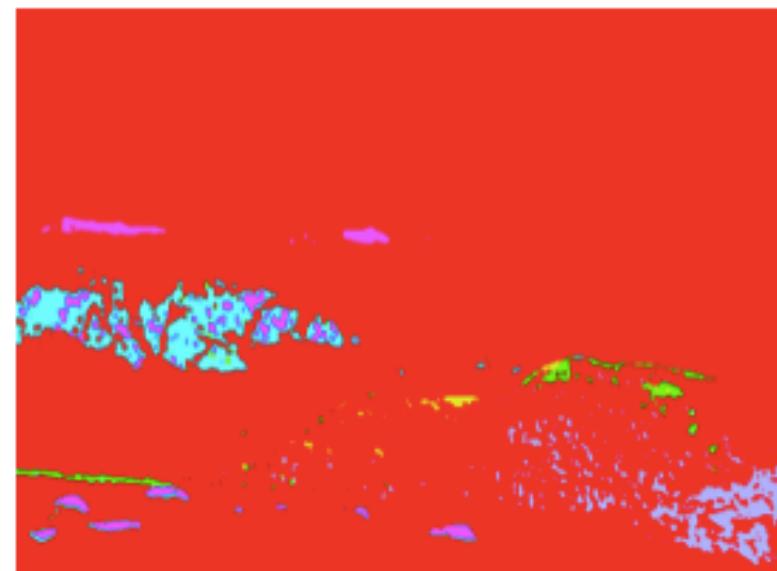
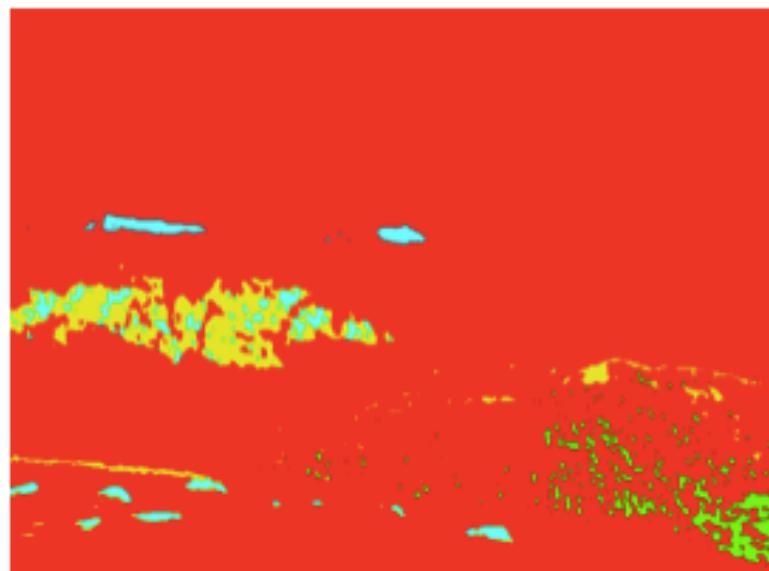
```
imageSegmentation.calculateUsingPolarCIEXYAndClustering(gslImg1, true);
```



```
imageSegmentation.calculateUsingPolarCIEXYAndFrequency(gslImg1, true);
```



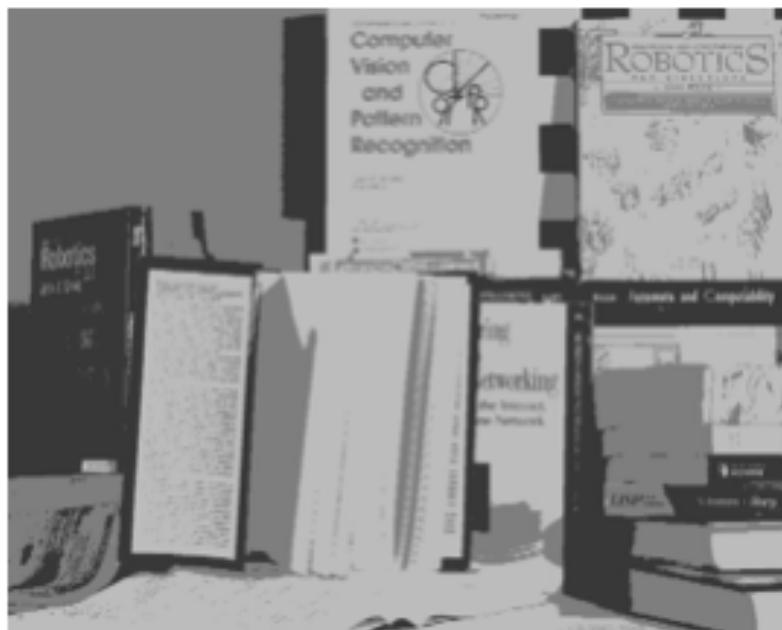
```
imageSegmentation.calculateUsingPolarCIEXYAndFrequency(gslImg1, 0.2f, true);
```



```
int kBands = 2; imageSegmentation.applyUsingKMPP(gslImg1, kBands);
```



```
int kBands = 3; imageSegmentation.applyUsingKMPP(gslImg1, kBands);
```



```
int kBands = 8; imageSegmentation.applyUsingKMPP(gsImg1, kBands);
```



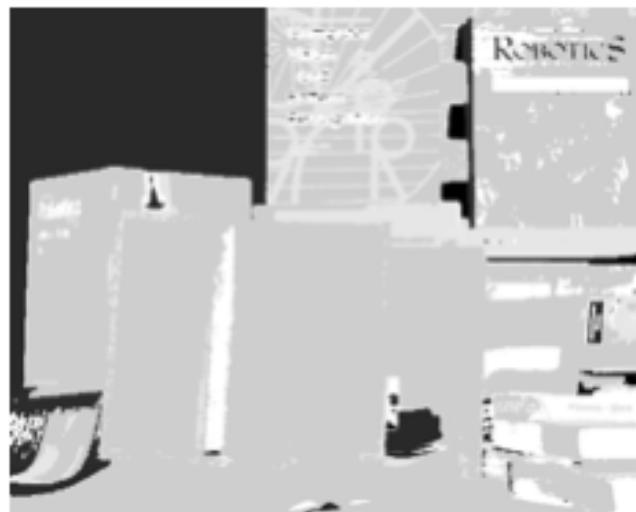
```
int kBands = 2; imageSegmentation.applyUsingCIEXYPolarThetaThenHistEq(gsImg1, kBands);
```



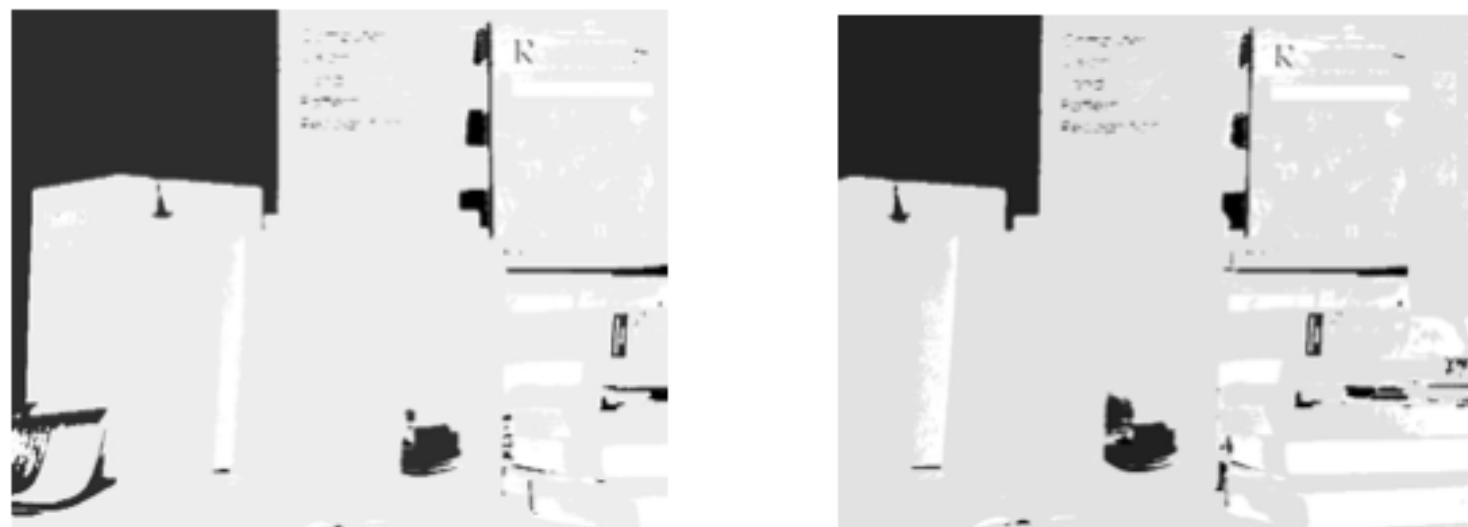
```
int kBands = 3; imageSegmentation.applyUsingCIEXYPolarThetaThenHistEq(gsImg1, kBands);
```



```
int kBands = 8; imageSegmentation.applyUsingCIEXYPolarThetaThenHistEq(gsImg1, kBands);
```



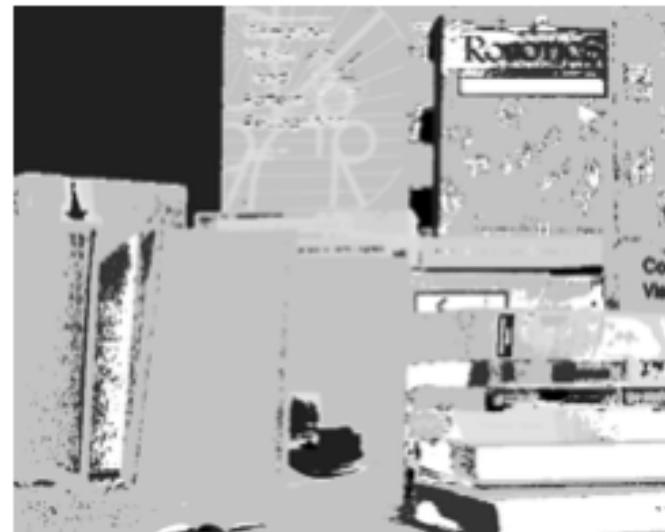
```
int kBands = 2; imageSegmentation.applyUsingCIEXYPolarThetaThenKMPPThenHistEq(gslImg1,  
kBands);
```



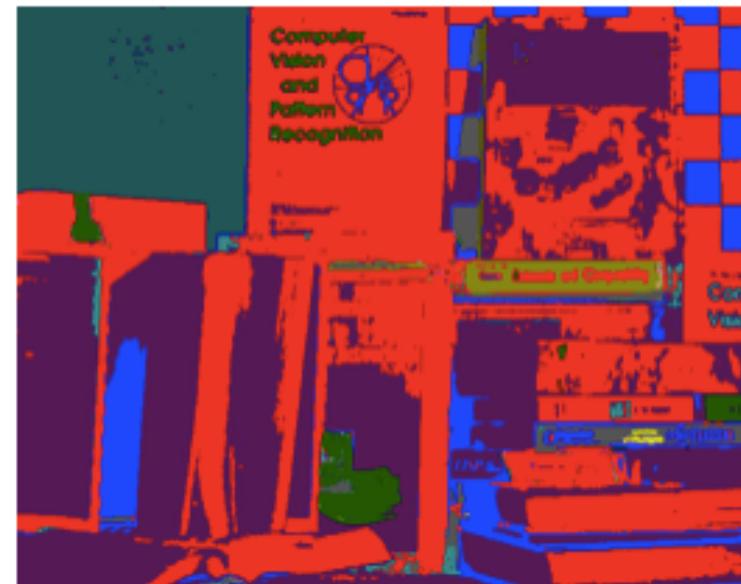
```
int kBands = 3; imageSegmentation.applyUsingCIEXYPolarThetaThenKMPPThenHistEq(gslImg1,  
kBands);
```



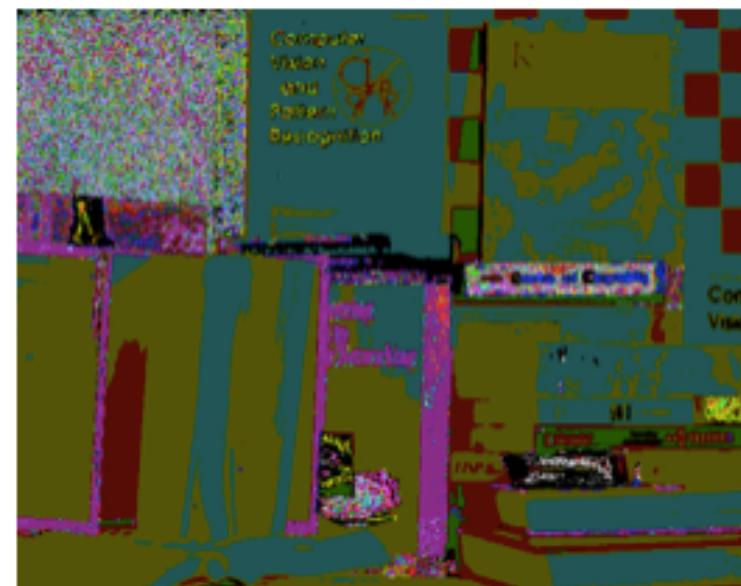
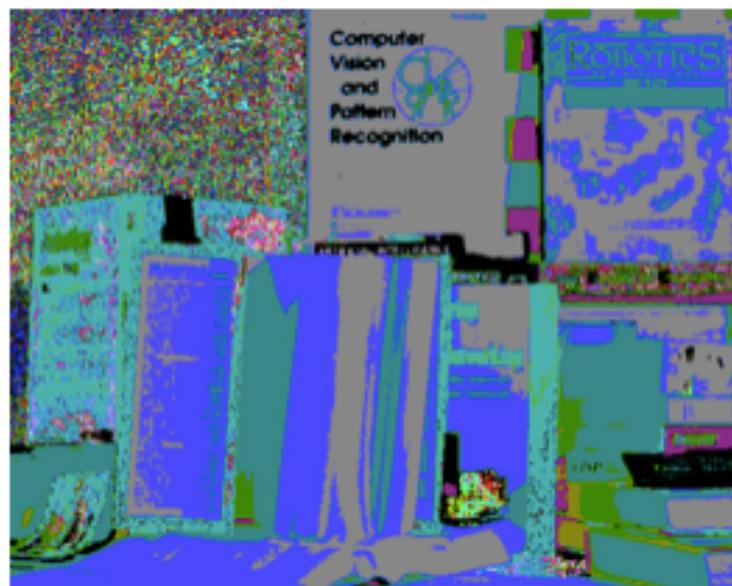
```
int kBands = 8; imageSegmentation.applyUsingCIEXYZPolarThetaThenKMPPThenHistEq(gsImg1,  
kBands);
```



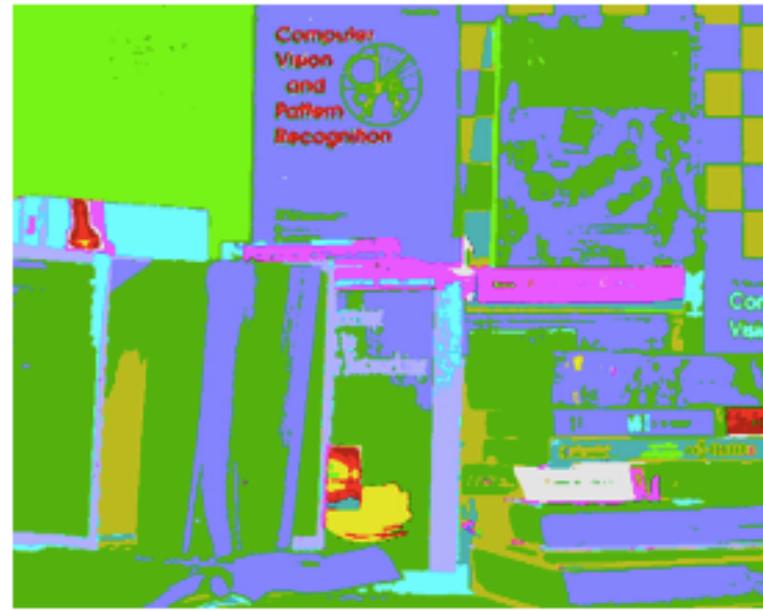
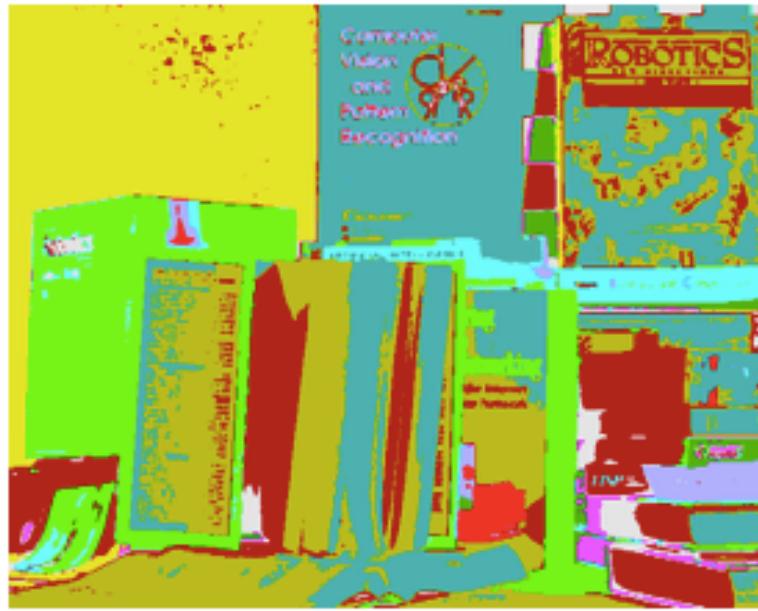
```
imageSegmentation.calculateUsingCIEXYAndClustering(gsImg1, true);
```



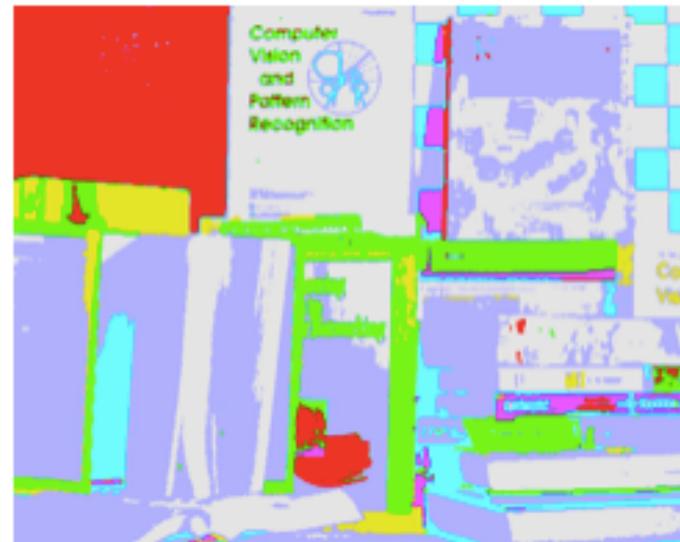
```
imageSegmentation.calculateUsingPolarCIEXYAndClustering(gsImg1, true);
```



```
imageSegmentation.calculateUsingPolarCIEXYAndFrequency(gsImg1, true);
```



```
imageSegmentation.calculateUsingPolarCIEXYAndFrequency(gsImg1, 0.2f, true);
```



```
int kBands = 2; imageSegmentation.applyUsingKMPP(gslImg1, kBands);  
zoom in
```

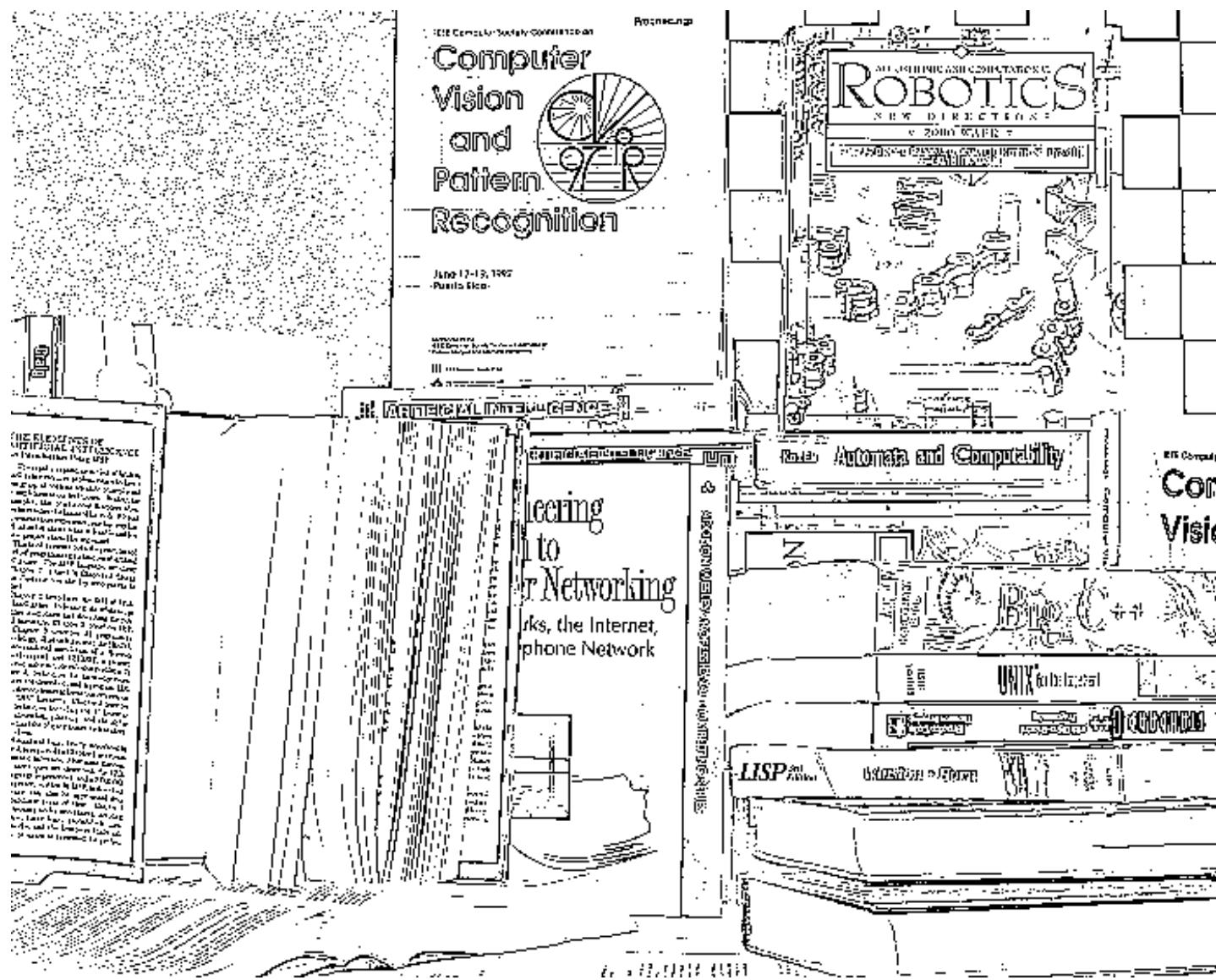
Computer  
Vision  
and  
Pattern  
Recognition



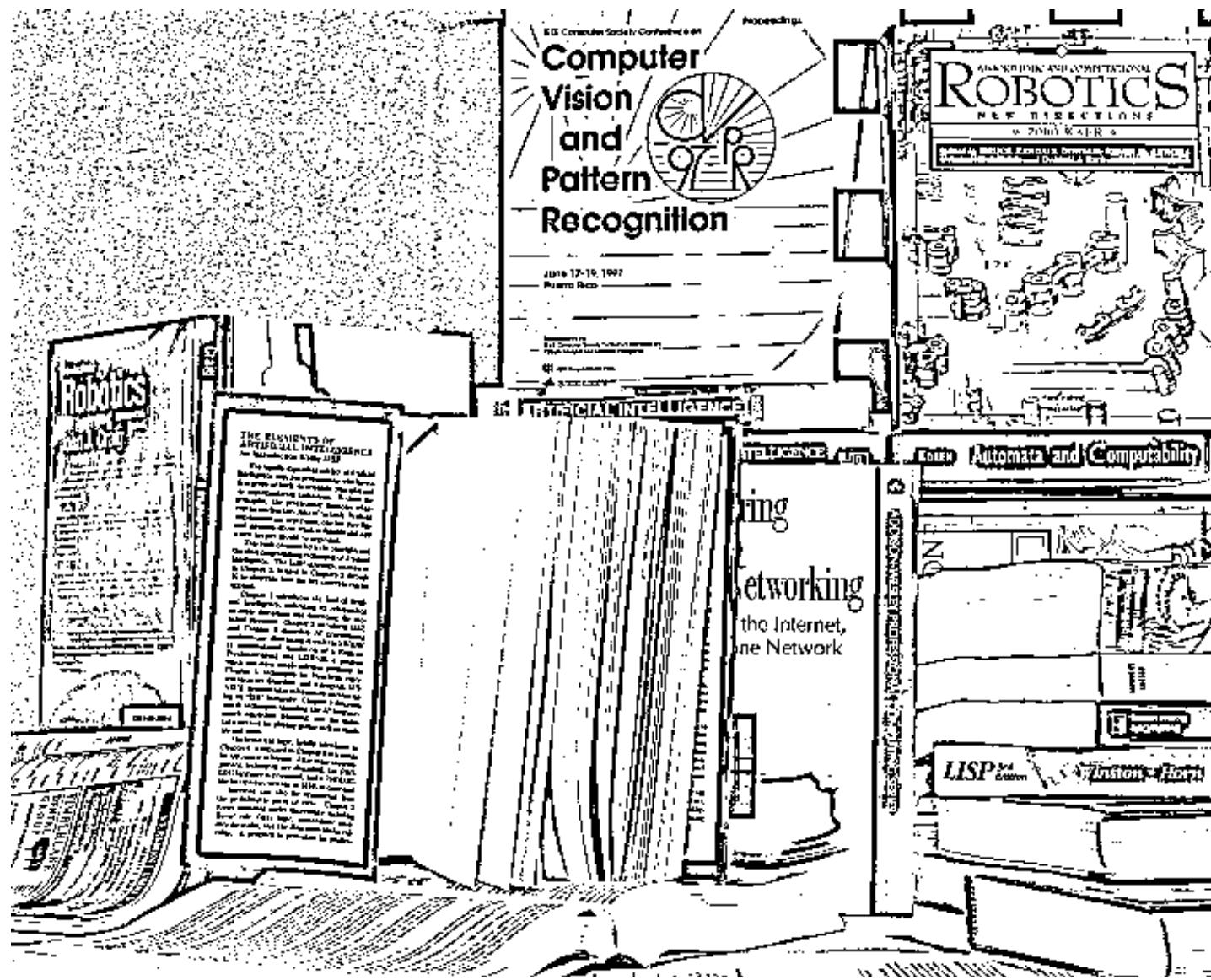
Computer  
Vision  
and  
Pattern  
Recognition



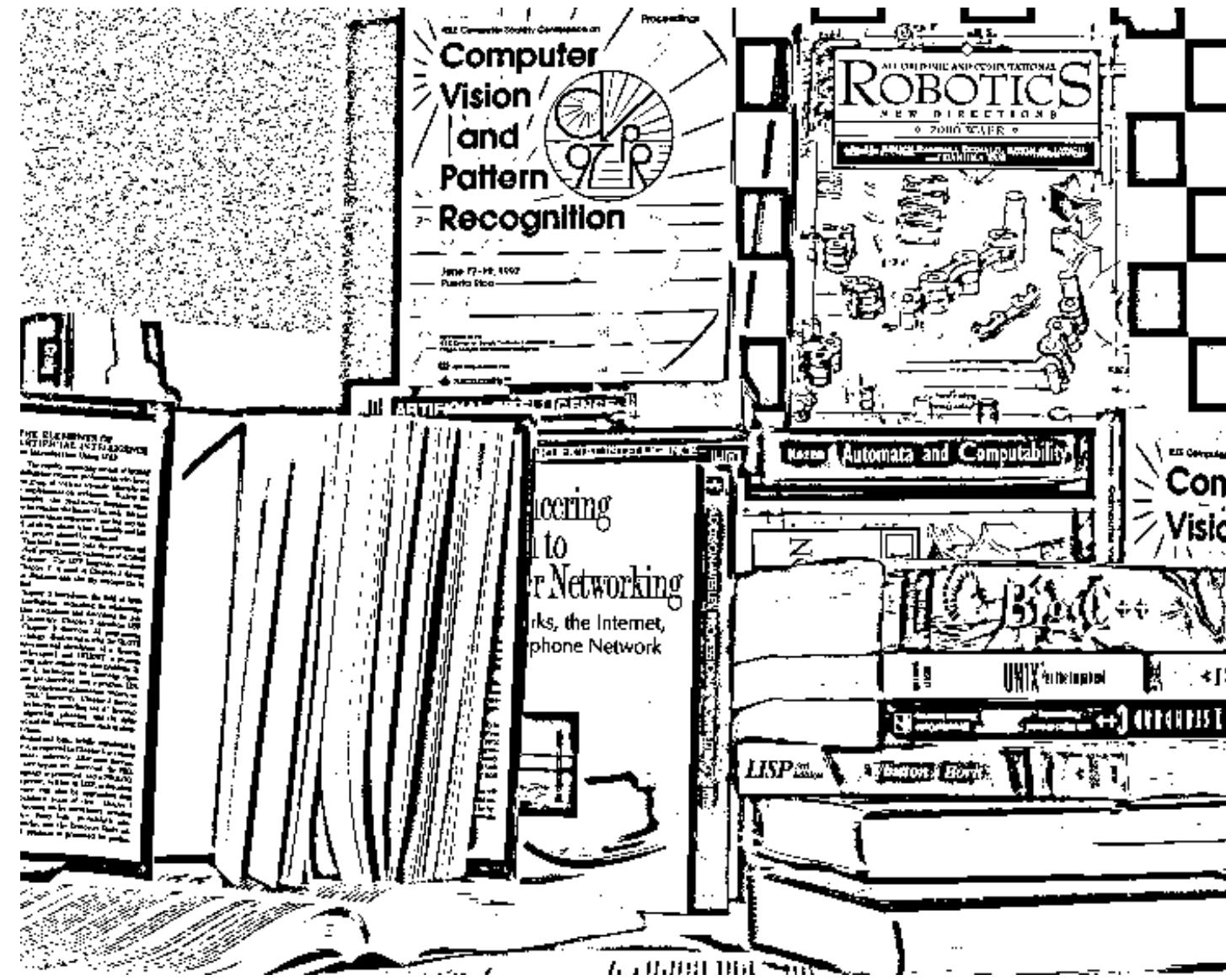
adaptive means,  $h=1$



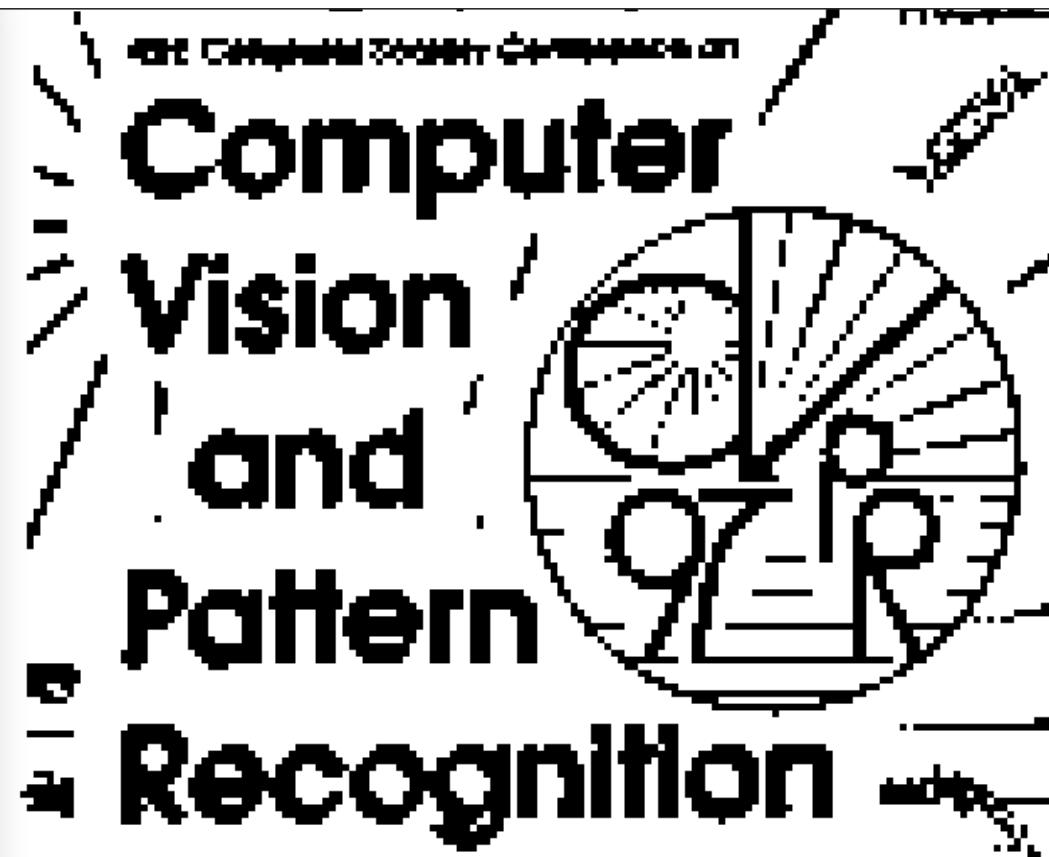
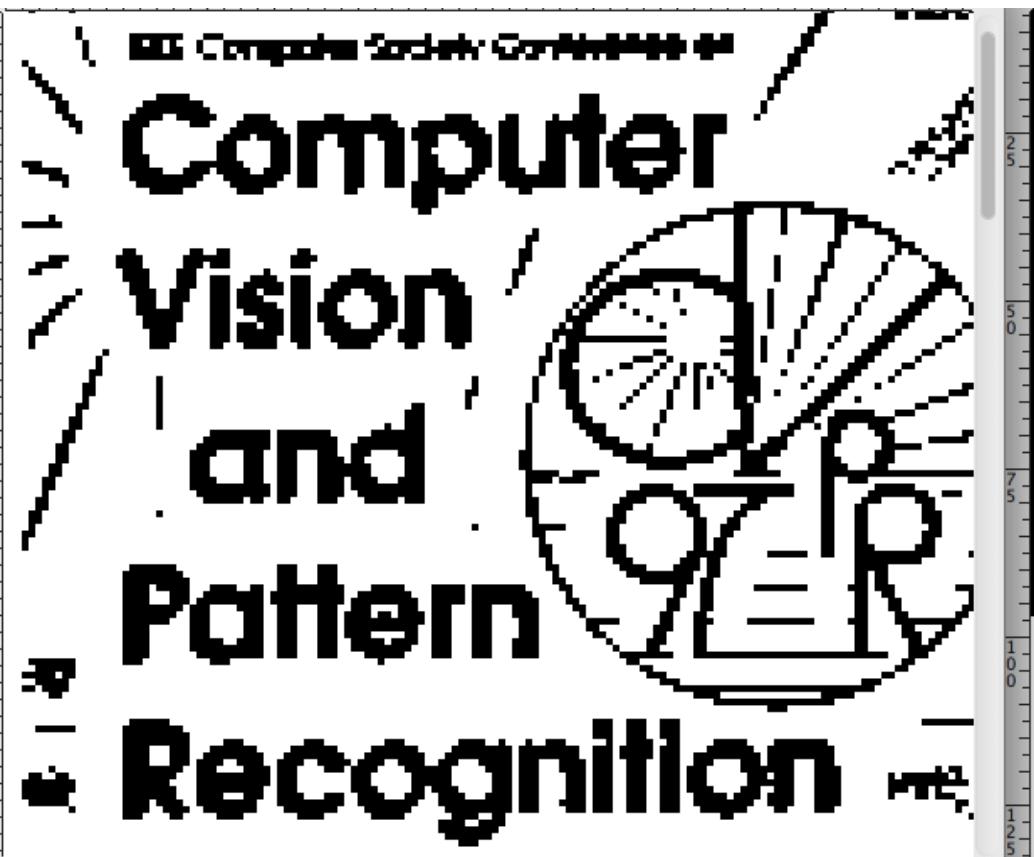
adaptive means, h=3



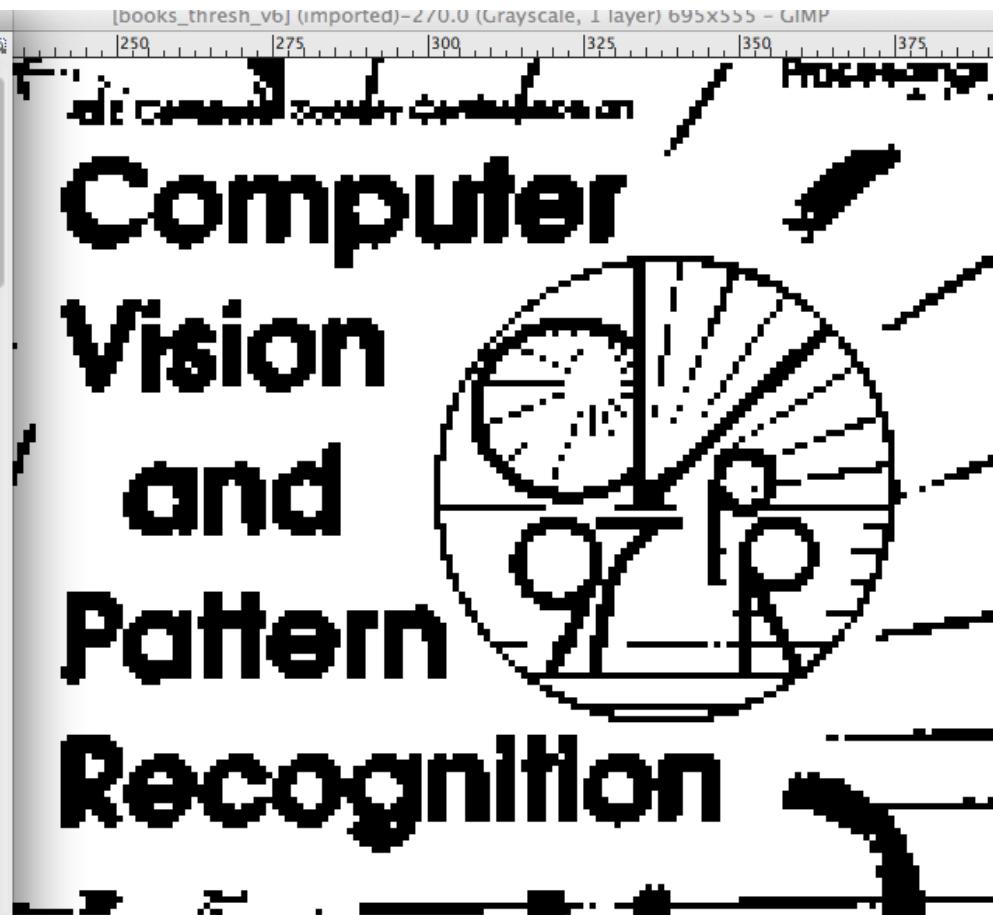
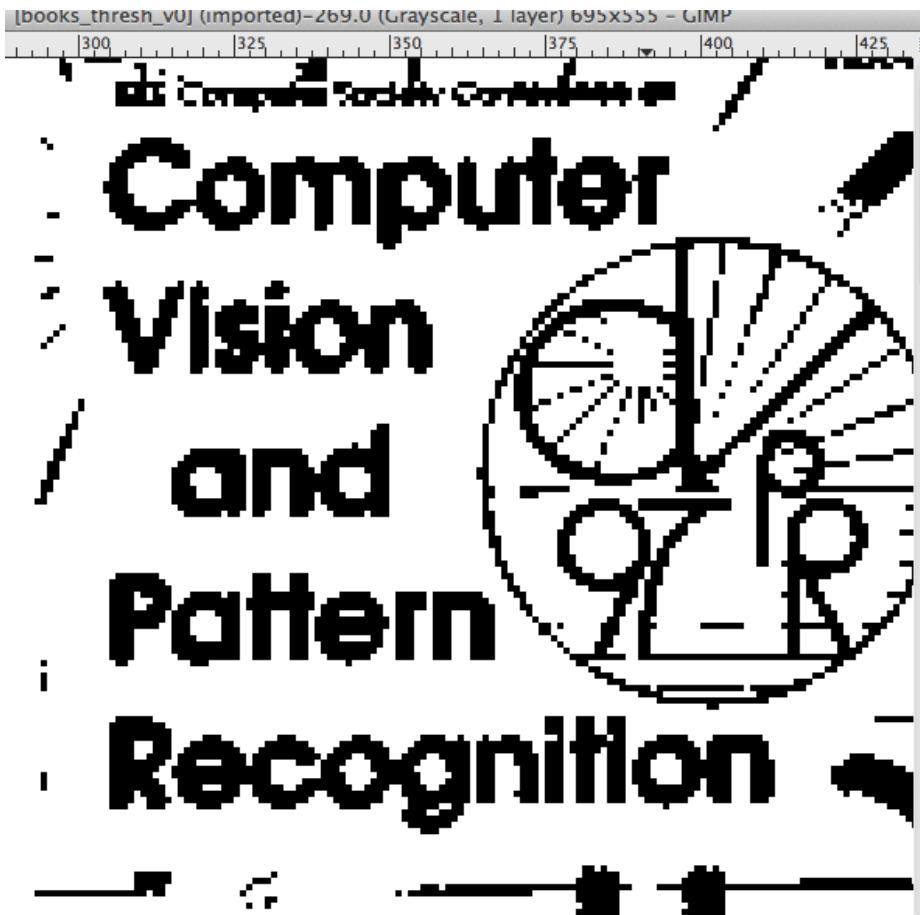
## adaptive means, h=5



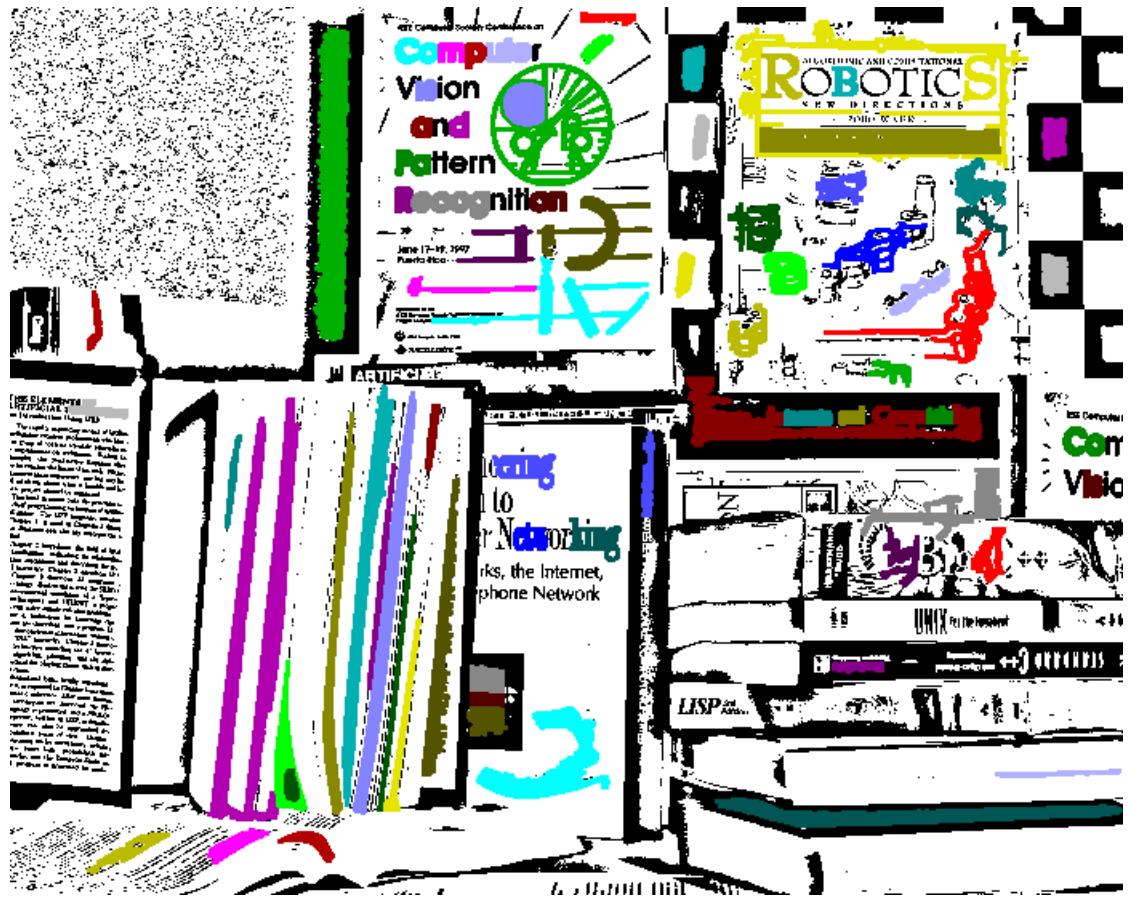
adaptive means,  $h=7$



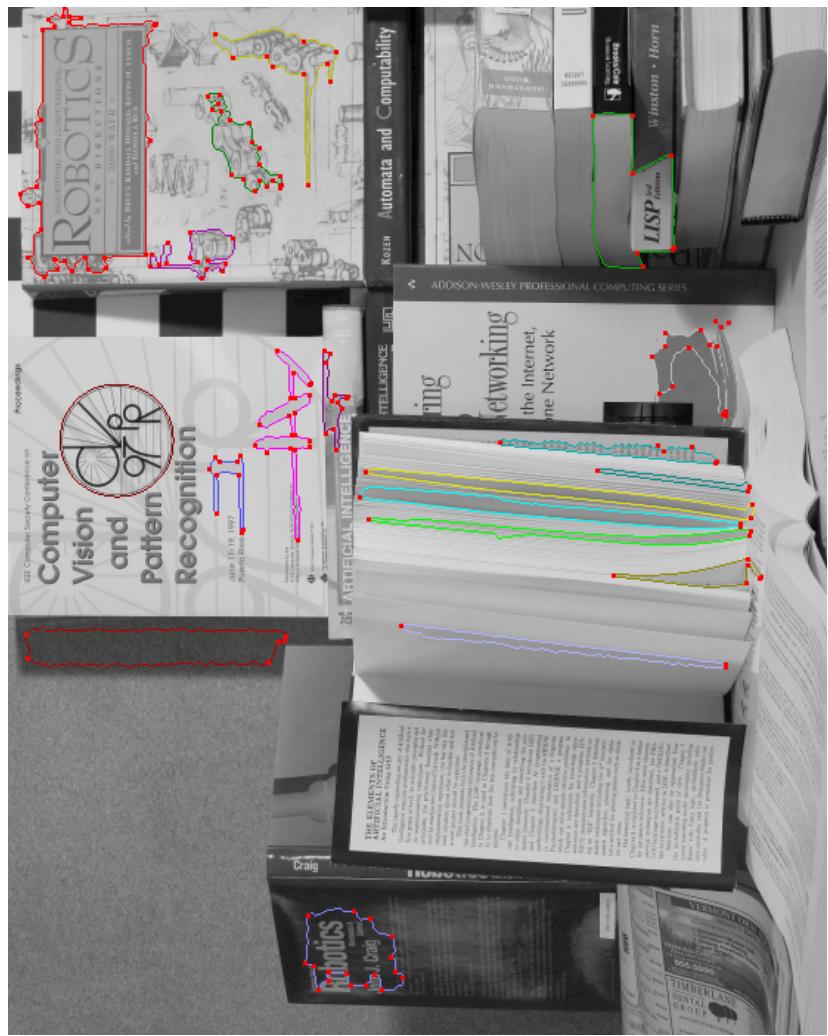
adaptive means, h=11 for adaptive to join close letters



adaptive means, h=11 blobs (extr using scale calc code)

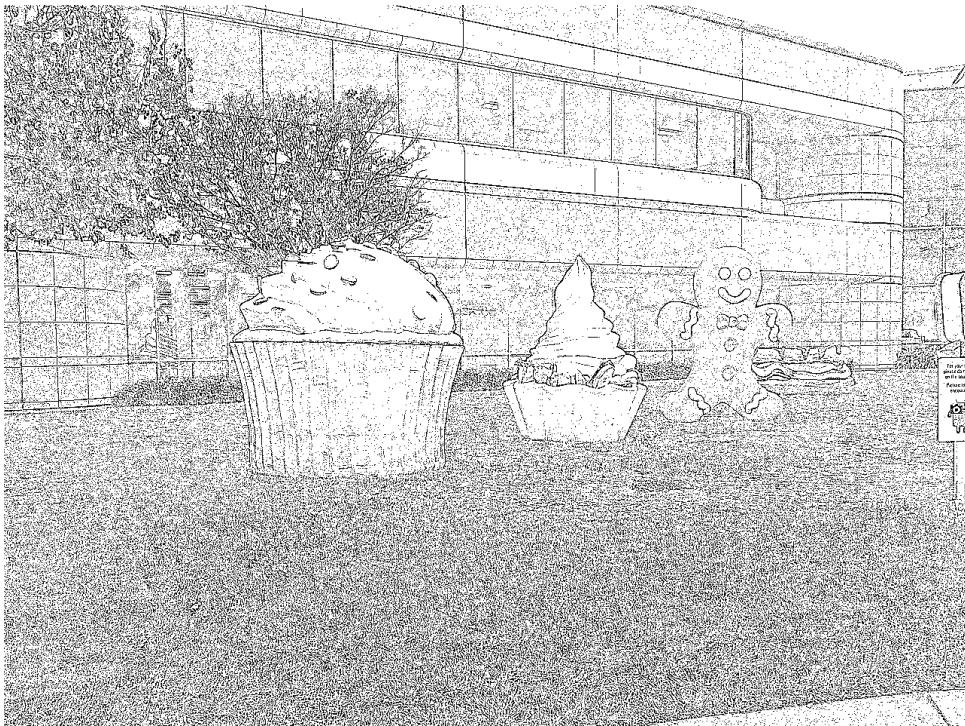


# adaptive means, h=11 blob corners

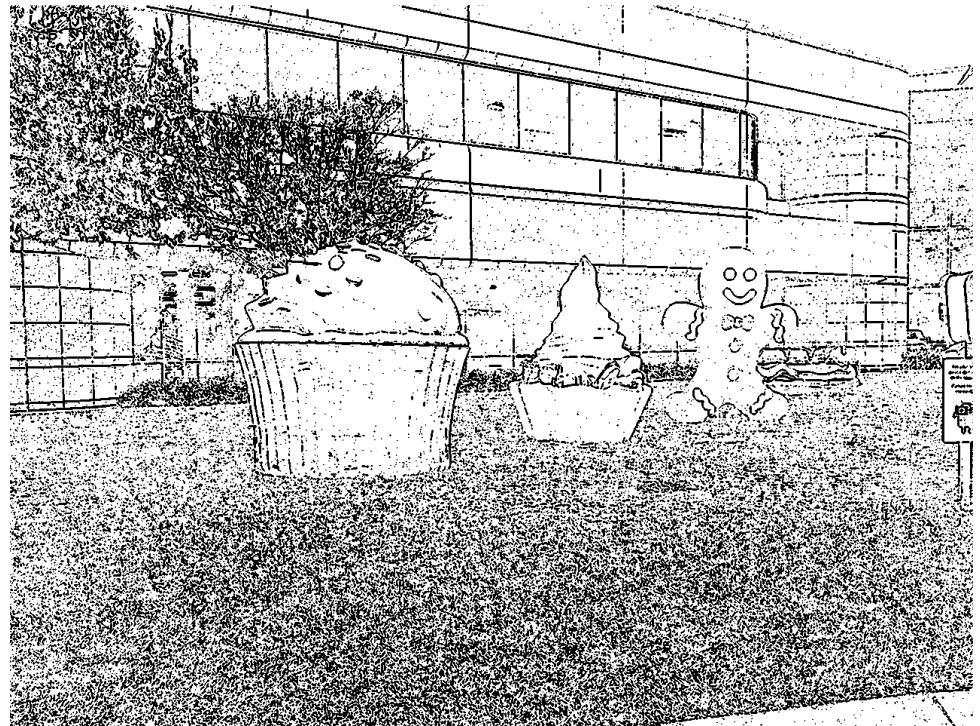


the letters are filtered out due to large nPerimeter compared to nInternal  
adaptive means, h=3 was better for letters as blobs

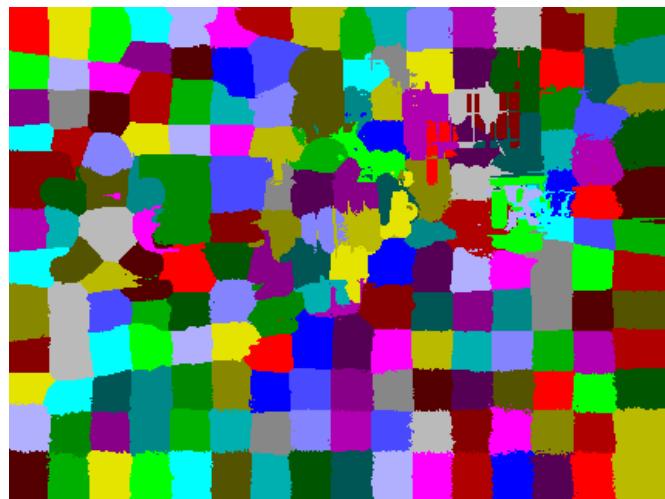
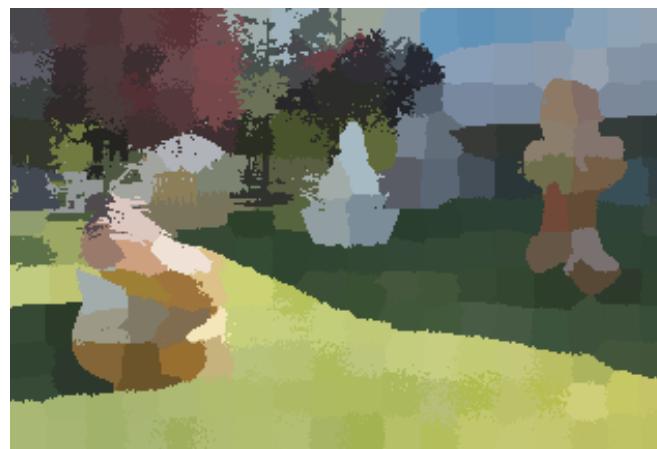
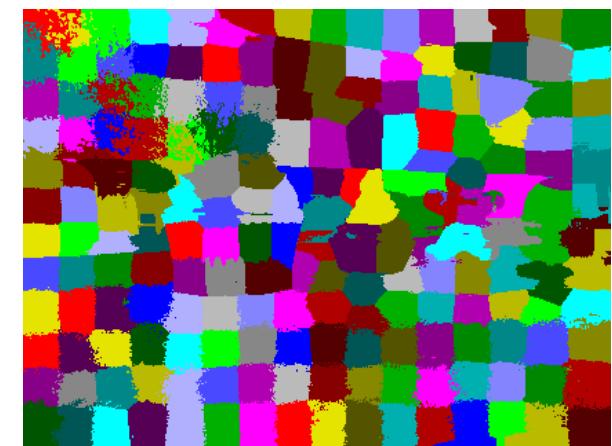
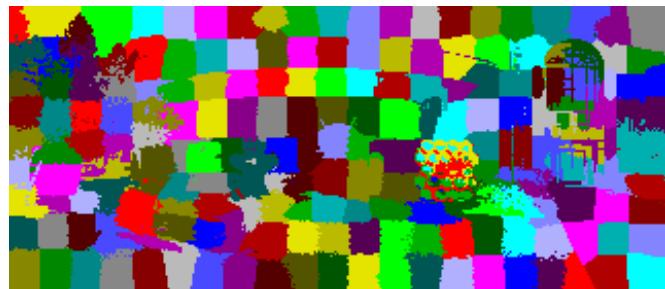
adaptive means, h=1



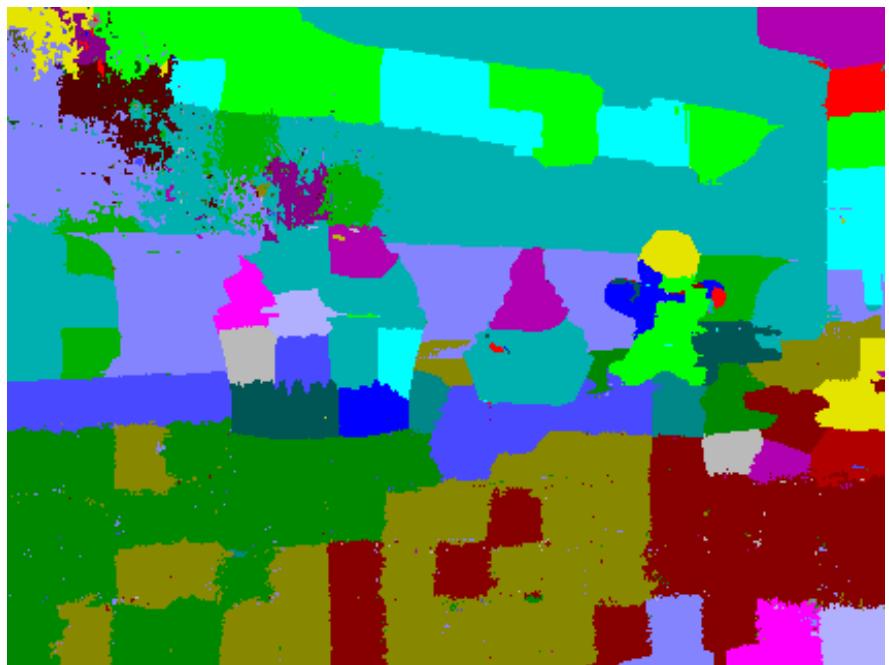
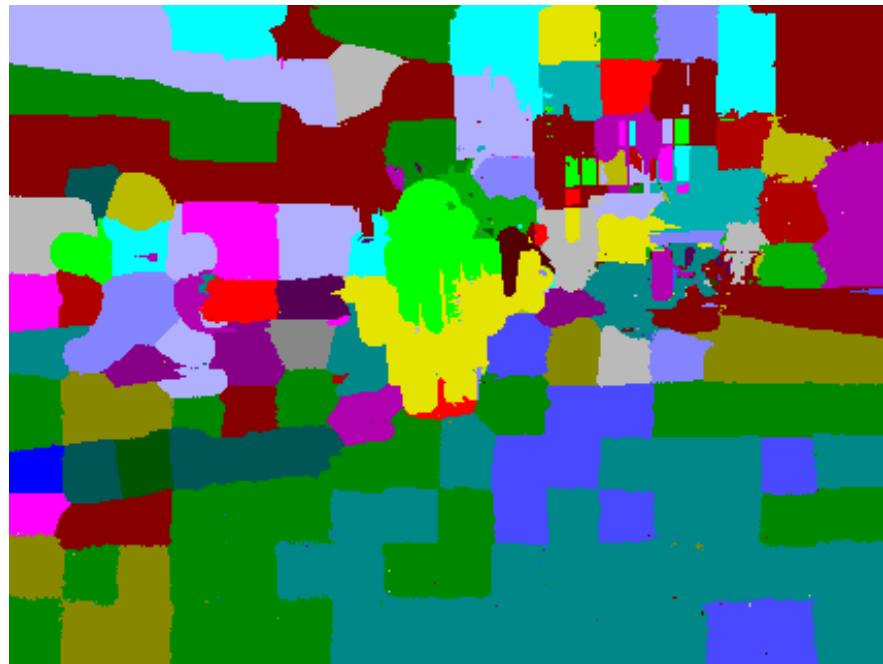
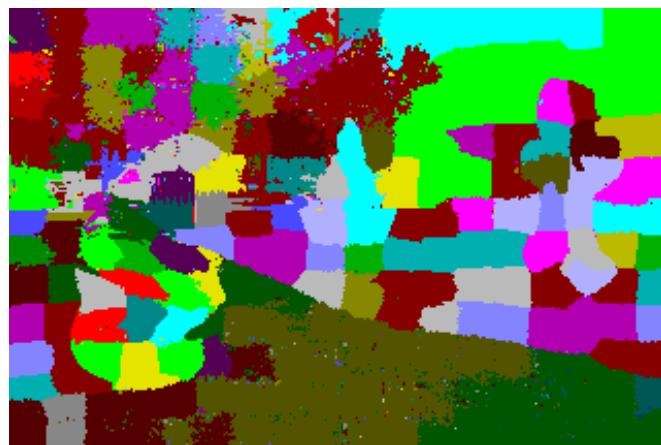
two median smooth with h=2



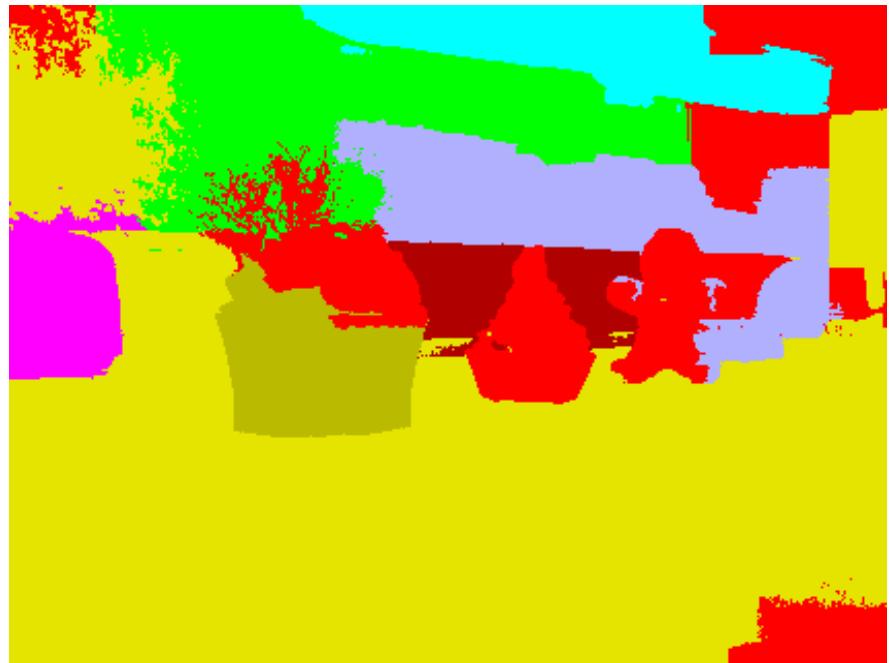
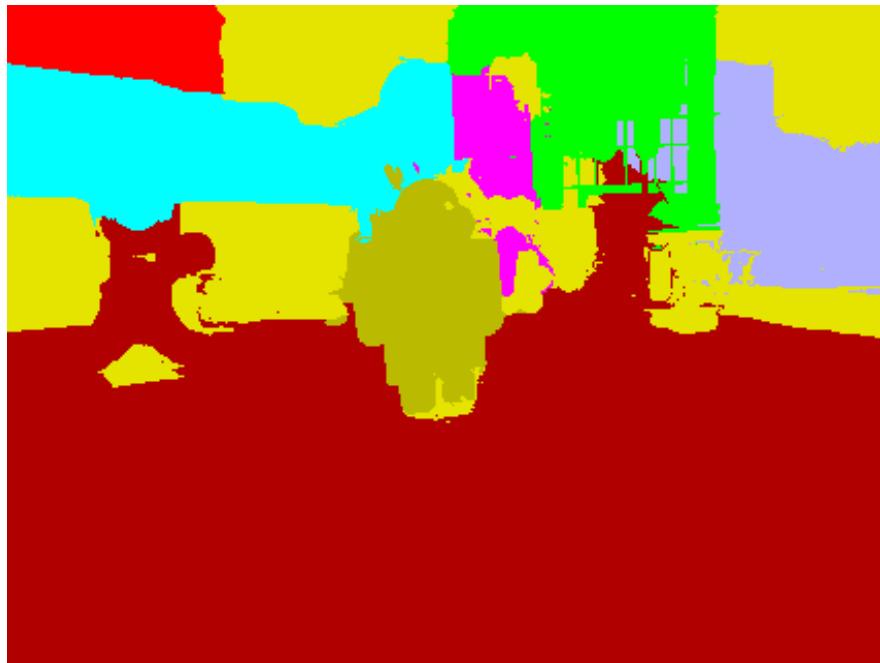
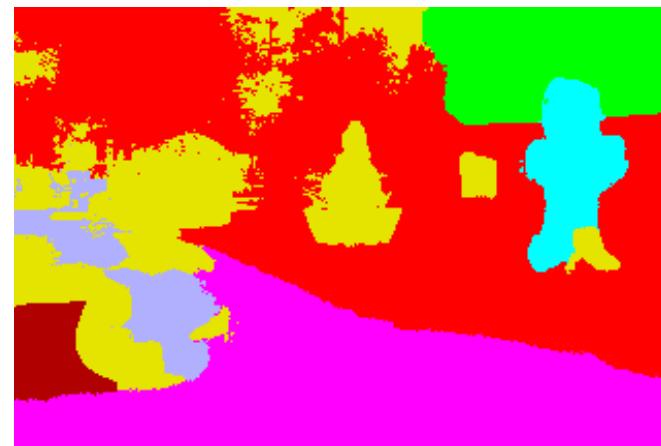
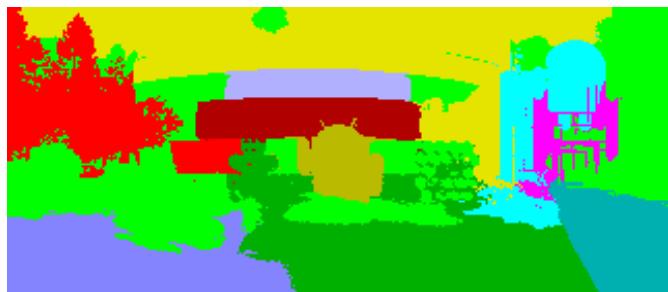
# SLIC super pixels algorithm



# CIE XY Theta Clustering of the super pixels



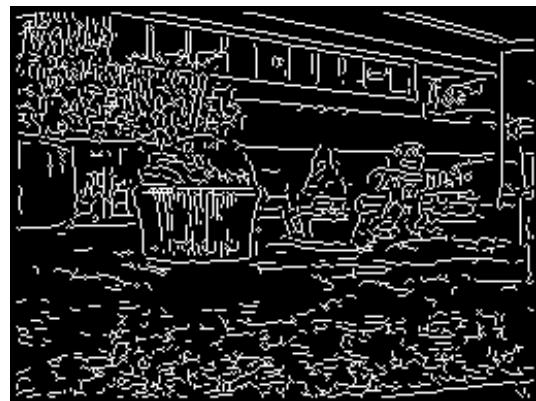
# Normalized Cuts w/ HSV cs on the super pixels



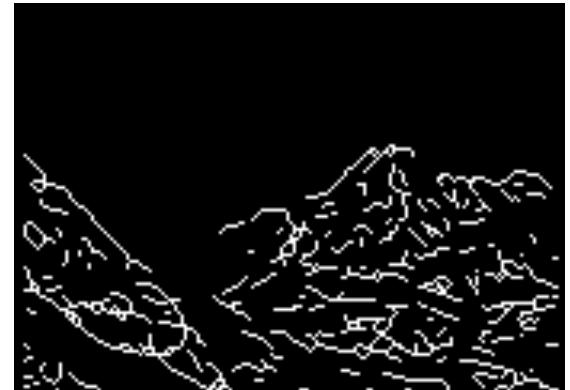
canny greyscale



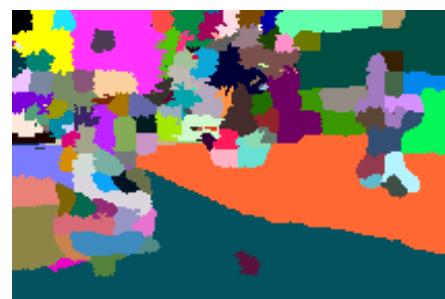
canny deltaE 2000



# phase congruence

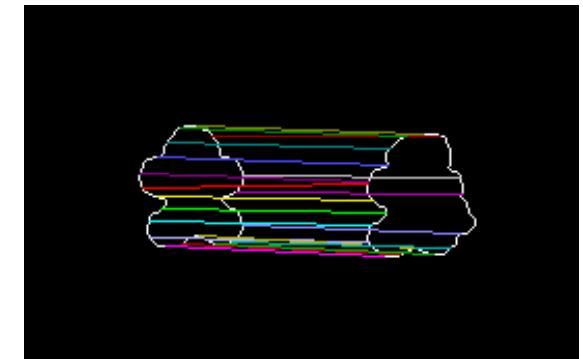
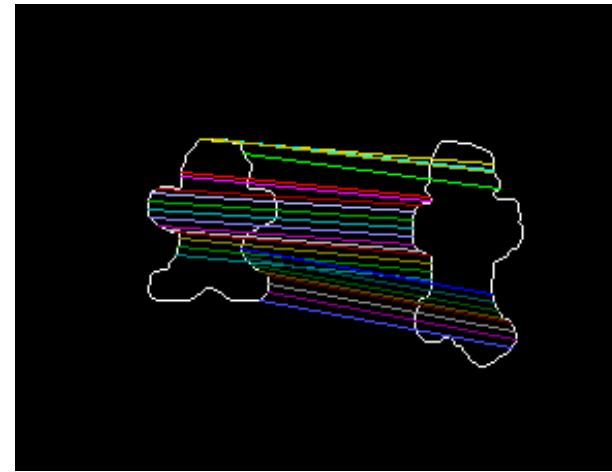
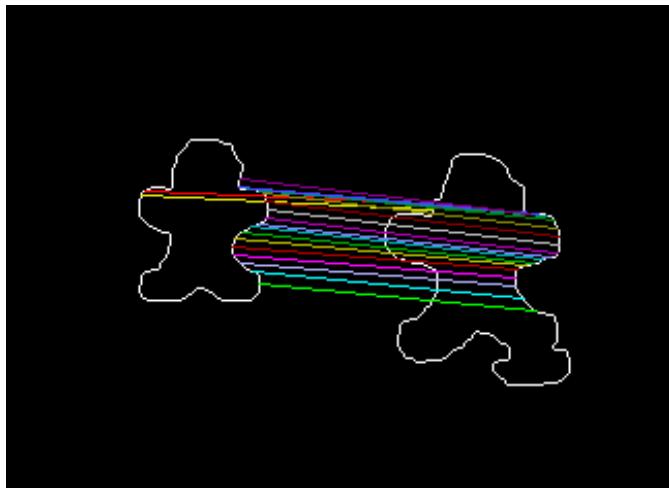
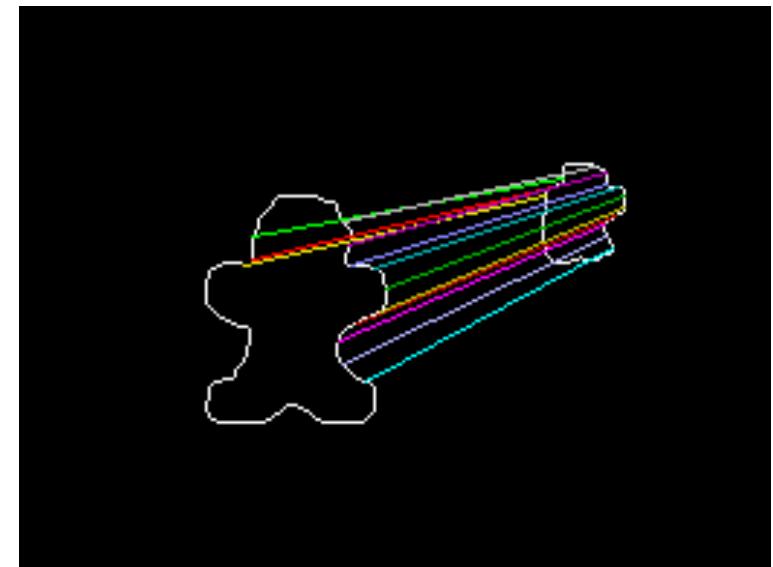
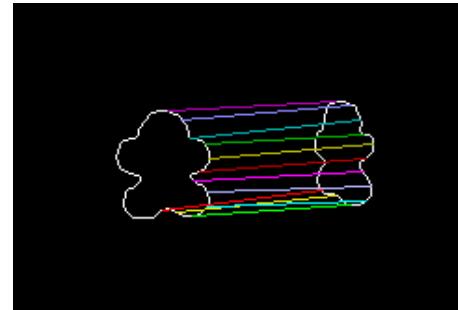
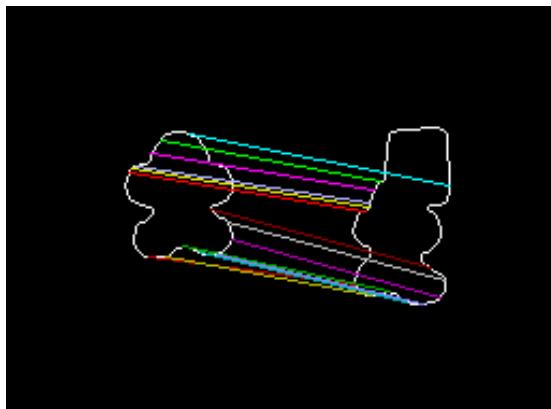


# super pixels and moderate merging by HSV color



# Partial Shape Matching of the gingerbread man

extract ordered borders of shapes, blur them by one or two sigma, then ordered bipartite matching algorithm using difference of chords as a descriptor.



# Shape Finding in over-segmented images

Exploring using the partial shape matcher and a local aggregated search pattern within a global search pattern to find an object by shape alone.

The over segmented labeled regions tend to be a large enough number that thorough combinations of labeled regions within a total object size range is often infeasible.

Filtering the labeled regions by information that is thought to be conserved between images can be done to filter the regions.  
A couple of the tests use HSV and CIE color filters.

A texture filter can be built from the template object image (for each pyramid image), but this has a slightly large runtime (add complexity here).

The search using just shape on the filtered labeled regions has a long runtime complexity (add details here), and the true match is within the top results, but is not always the top result.

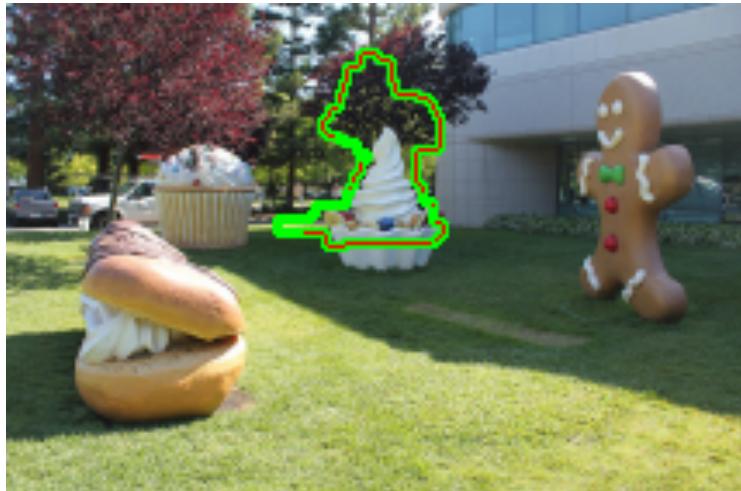
(a shape descriptor applied after top objects is a faster approach...see subsequent results)

# top matches to template shape within a test image



# best match

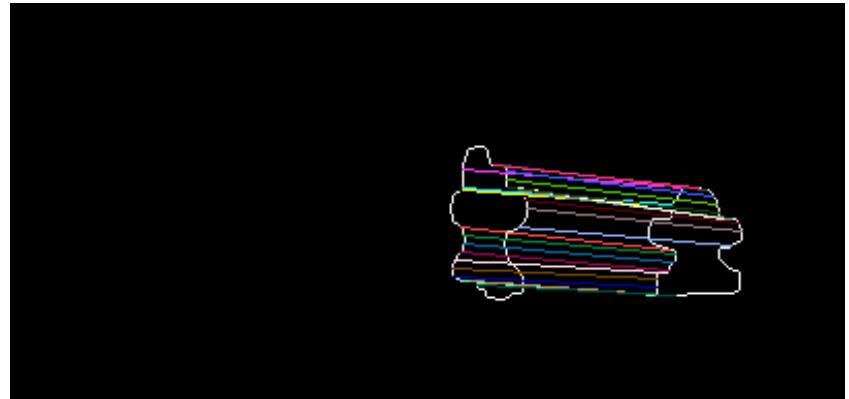
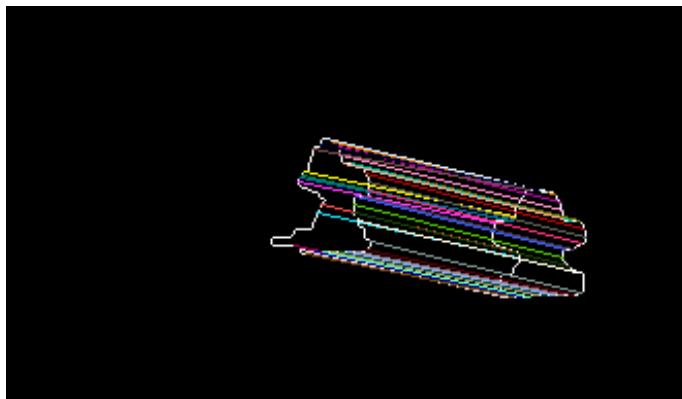
and true match



the min cost match to the template shape



the true match has higher cost. (due to scale, and pose)



# ORB key points and descriptors

The key points for the template are at the left and on the right are key points filtered to those present in the segmented cells of the image to search, those cells were filtered by color histogram intersections with the template gingerbread man.



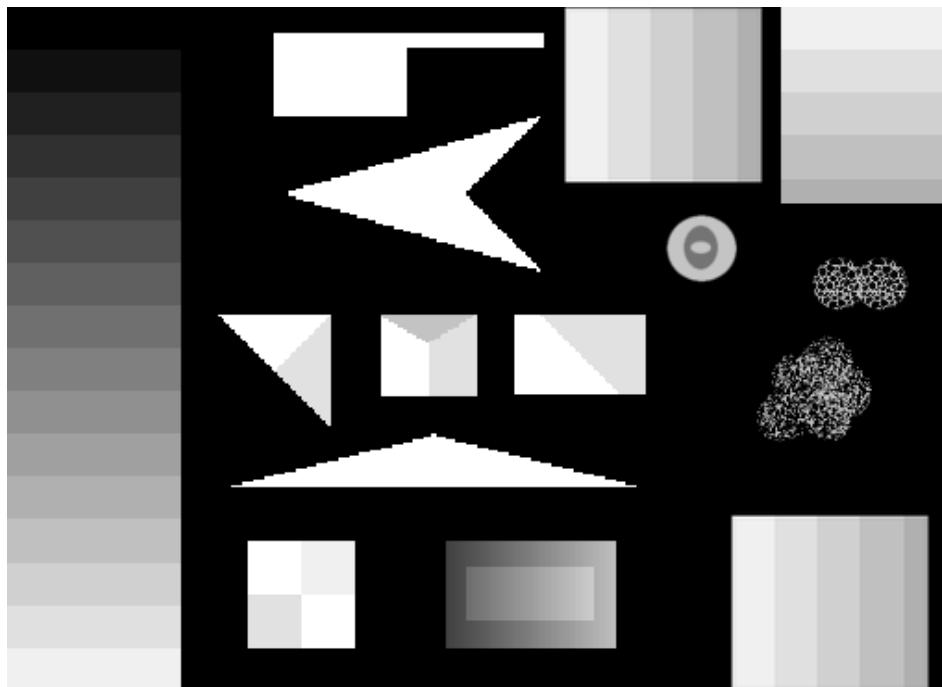
# texture

The highly textured regions such as vegetation produce many key points and those need to be filtered out for this case.

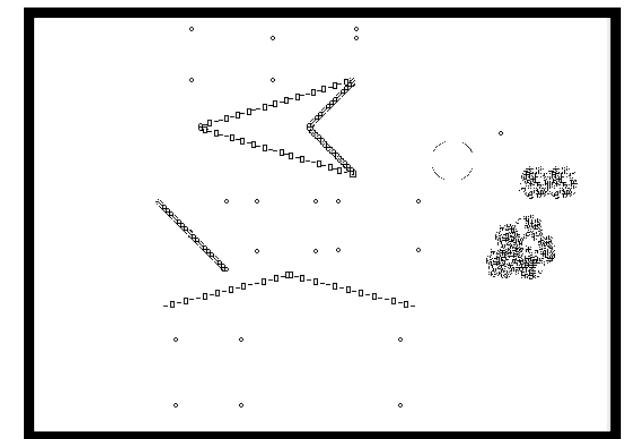
The Law's 1980 texture transforms (combinations of gaussian derivative convolutions) show that R5R5 may be a good way to find regions of high spatial and intensity variability, that is high density changes.

E5 = [-1 -2 0 2 1] 1st deriv, sigma=1  
R5 ripple = [1 -4 6 -4 1] 3rd deriv

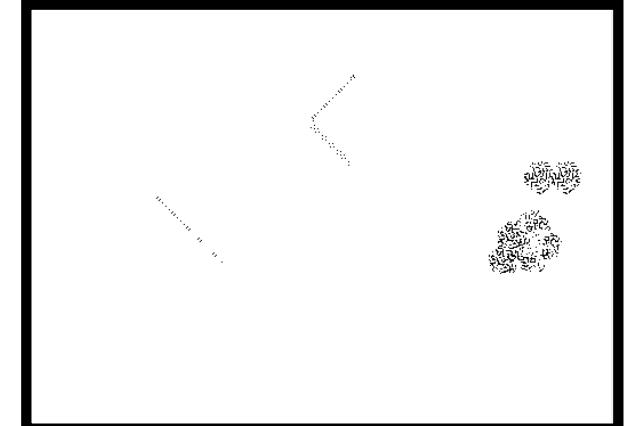
original image



E5E5  
then  
adap  
med



R5R5  
then  
adap  
med



# **Shape Finding in over-segmented images (cont)**

Finding the object (gingerbread man) in another image where it has changed location, lighting and pose requires very local and grouped information because the number of possible true key point matches compared to the total number of key points in the image is small.

## **one approach in progress:**

- (1) filter key points and segmentation in the image to be searched by filters of difference from the template object's colors (HSV and CIE LAB usually)
- (2) filter the segmentation in the image to be searched to remove labeled regions with a higher surface density of key points after the region statistics have been scaled using size arguments. (substitution for a texture filter)
- (3) for each labeled region, calculate euclidean transformation using point pair combinations and evaluate the pairs using all key points within a radius of template object size.
- (4) using the octave combination and the labeled region's best transformation, include all the bounds of the matched key points' regions in a transformed nearest neighbor match within tolerance

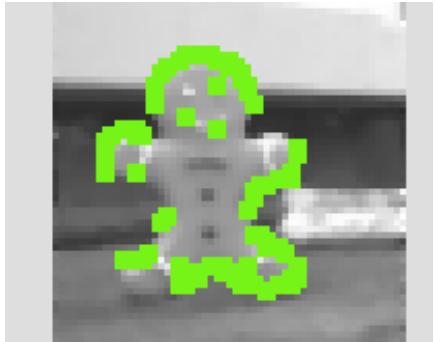
# Shape Finding in over-segmented images (cont)

- (5) for the octave and labeled region best result, used the matched boundary correspondence to calc chord difference costs within tolerance
- (6) determined the cost of those “descriptors”, that is key point hsv costs, euclidean transformation distance costs, and chord difference costs to find the best results, then those within a percentage of best if any.

The best result at this point for one test is not yet the true match, but the 2nd best result is the true match.

*Further information is needed to determine that the true match is better.*

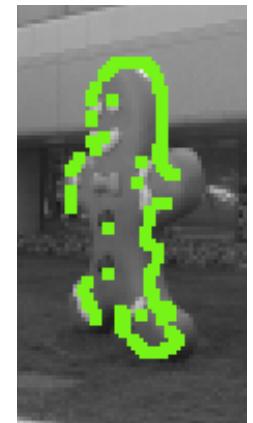
**best match**



**and**



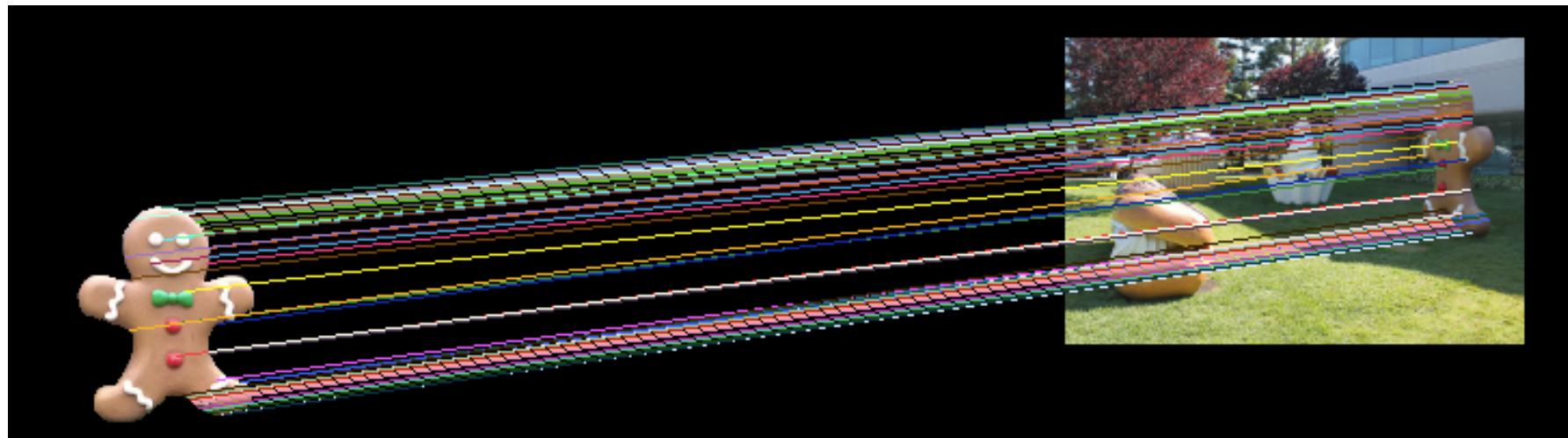
**true match**



# Shape Finding in over-segmented images (cont)

(7) using the combined labeled region as contiguous small hsv descriptors to calculate the pixel by pixel similarity between transformed frame 2 and frame`1 pixels.

**true match is found**, at least for the test w/ largest projection effects



but alot of time is spent in pairwise euclidean transformations and evaluations

# Maximally Stable Extremal Regions (MSER)

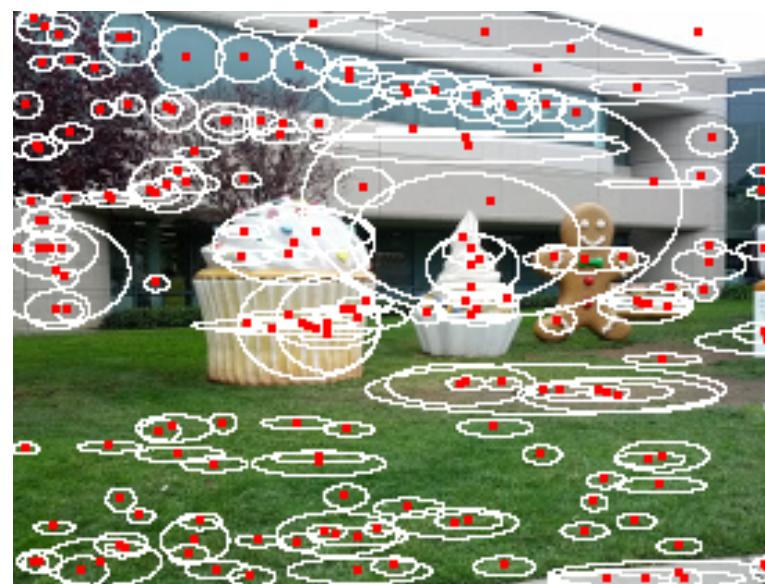
blob detection with MSER followed by canonicalization and descriptor matching is in progress.

*plotted below and on the next page are the MSER regions found on the inverted images. The other sets of regions derived from the images are not plotted here.*

*especially useful for corner-less objects*



## MSER (cont.)



# MSER (cont.)

Finding the object (gingerbread man) in another image where it has changed location, lighting and pose, requires very local and grouped information because the number of possible true key point matches compared to the total number of key points in the image is small.

## **the general approach:**

- (1) filter key points and segmentation in the image to be searched by filters of difference from the template object's colors (HSV and CIE LAB usually)
- (2) filter the segmentation in the image to be searched to remove labeled regions with a higher surface density of key points after the region statistics have been scaled using size arguments. (substitution for a texture filter)
- (3) Build an RGB pyramid for both images and calculate MSER regions for the largest image in both pyramids.
- (4) Canonicalize the MSER regions and copy them scaled down to the other pyramid image scales. The canonicalized regions (CRegions) are the coordinates and bounding information for the descriptors.

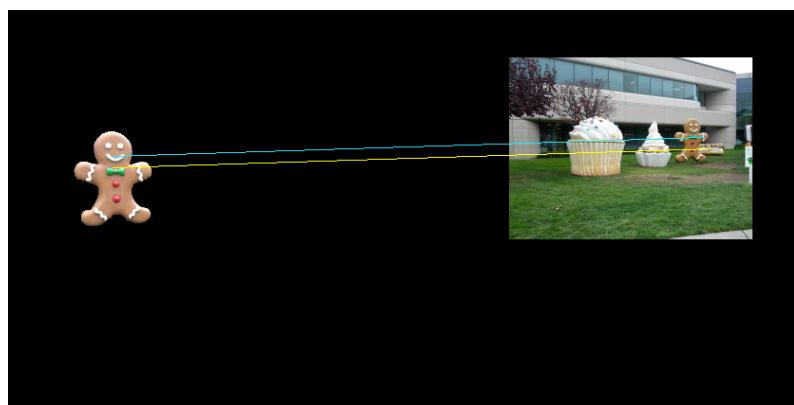
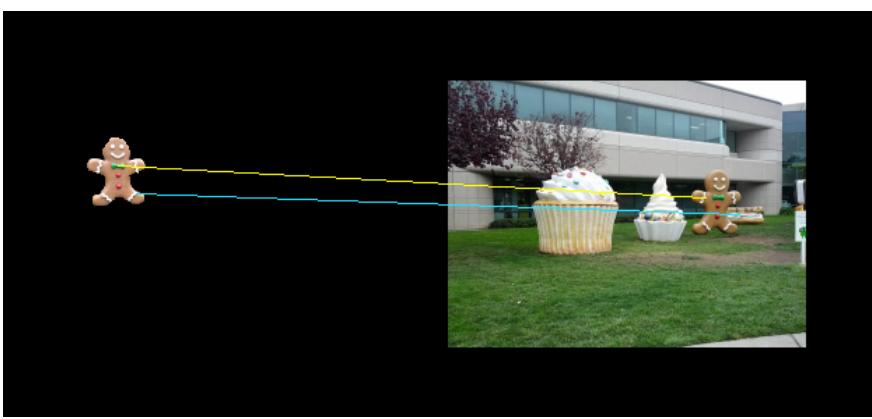
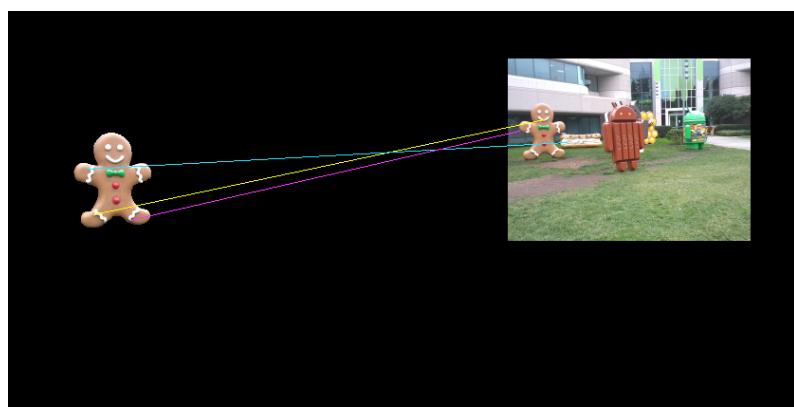
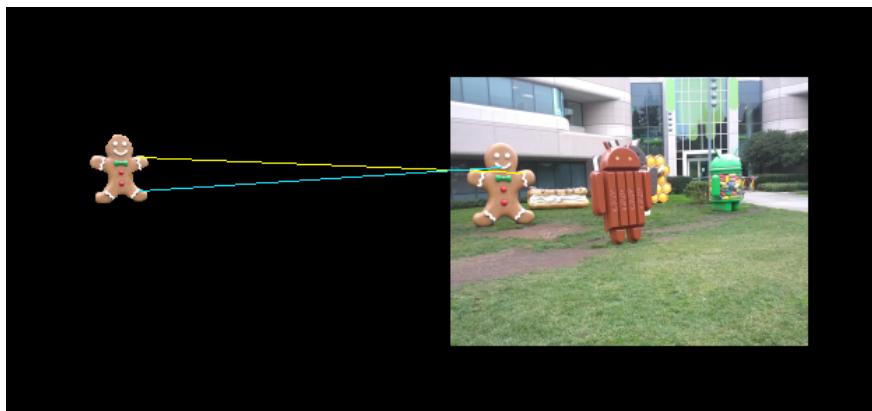
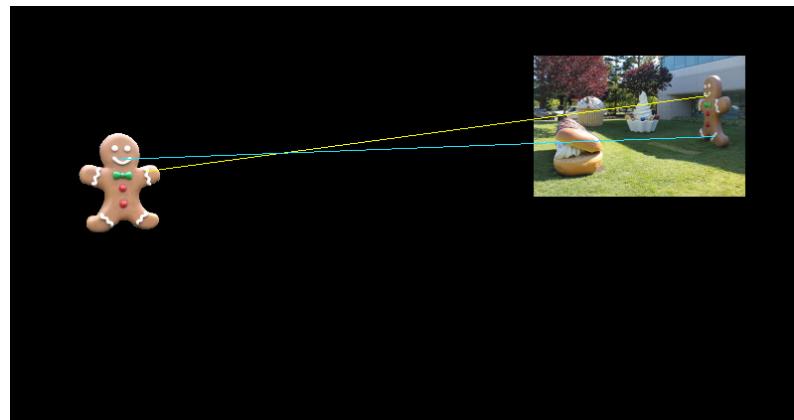
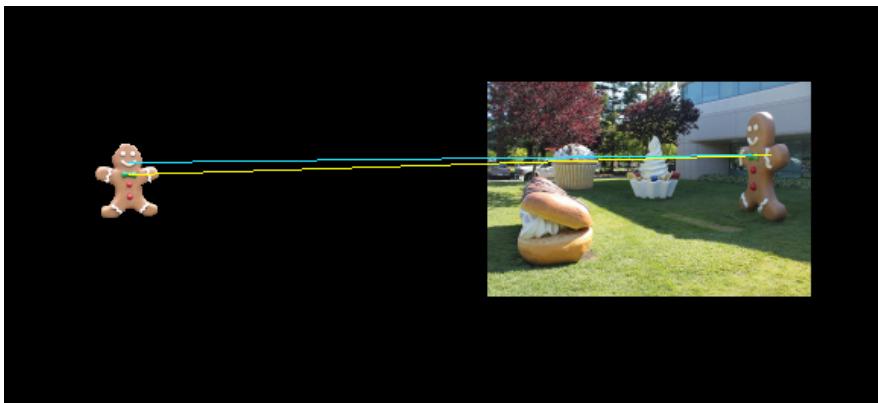
## MSER (cont.)

- (5) for each pair of octaves, MSER Region descriptors are compared and the top k are kept.
- (6) Pairwise combinations of key points are made from the top k for each octave and euclidean transformations made from those. The transformation is evaluated by transforming the other dataset 0 points at that octave and finding the nearest dataset 1 key point within a distance.
- (7) The best of each octave pair are kept and then the best overall is kept

The tests pass for gingerbreadman, but marginally so and the **algorithm likely needs changes** for the tests for finding the cupcake..

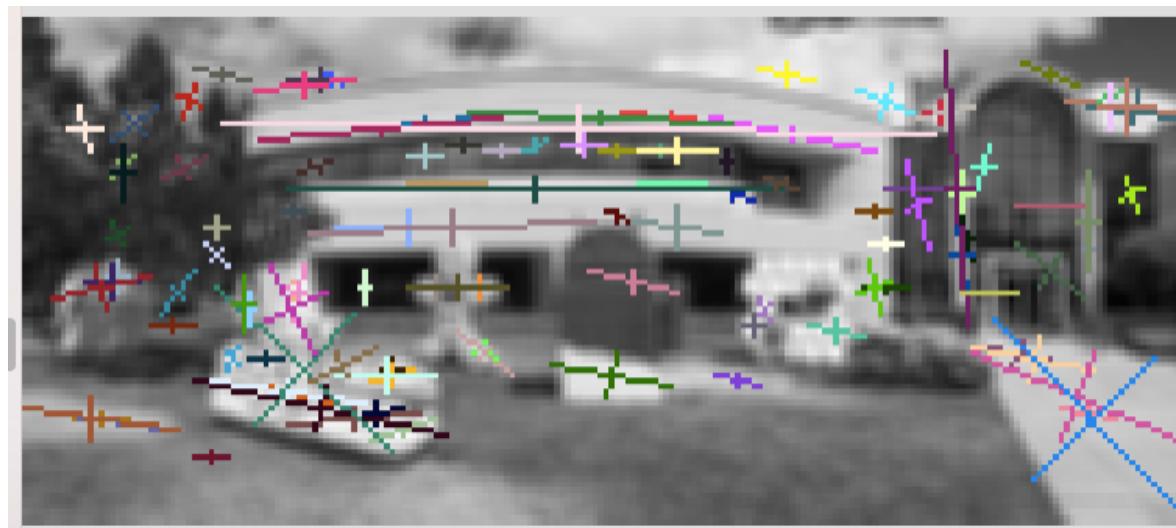
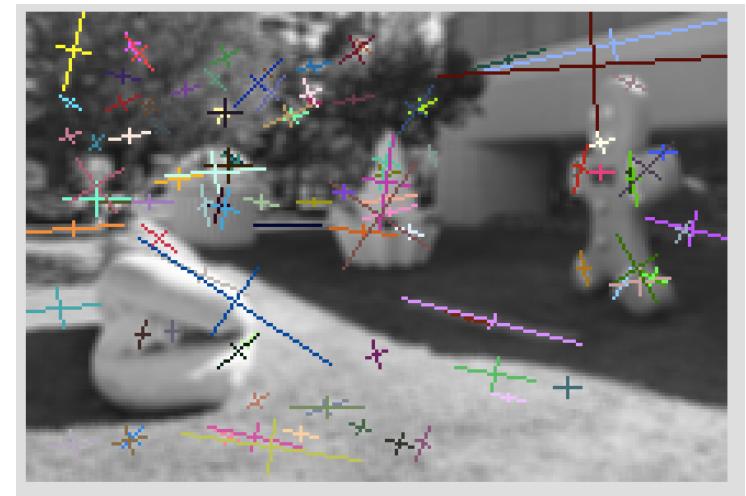
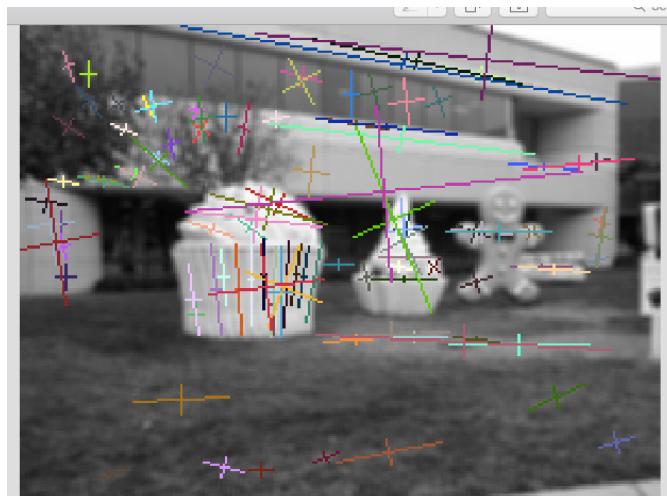
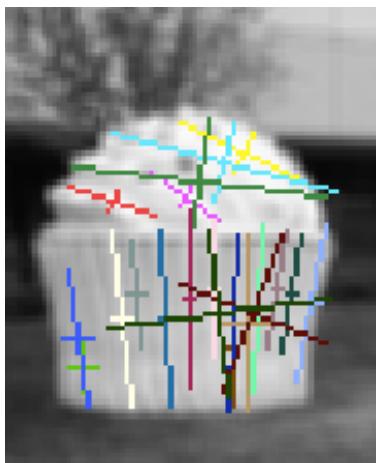
see images on next page

# MSER (cont.)

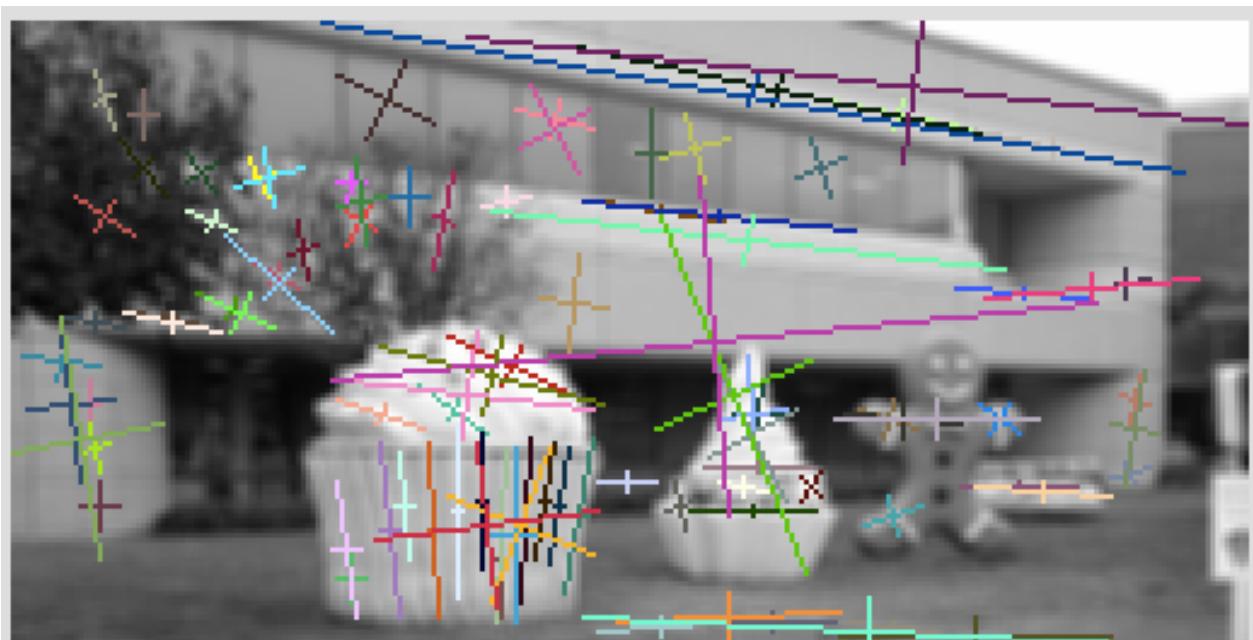
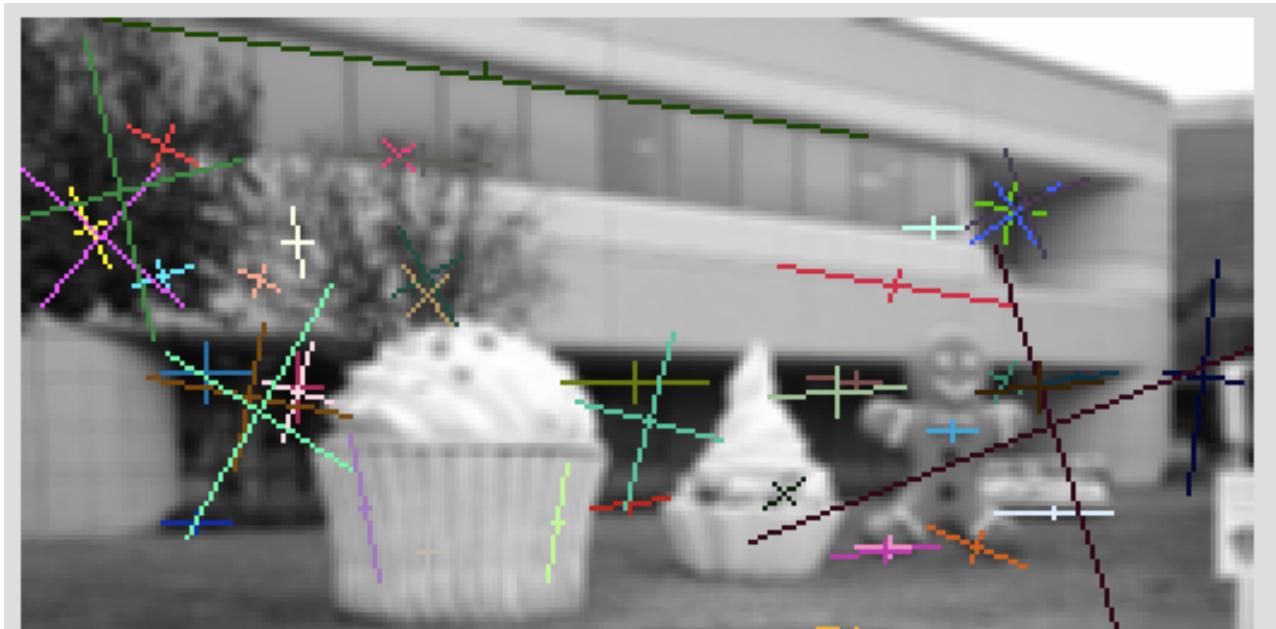


## MSER (cont.)

for the cupcake, there is extreme repetition of a pattern that if present in the searchable image, would help to further filter matchable mser regions.



## MSER (cont.)



**By the way, the MSER semi-major axes possibly are very fast ways to find lines in an image.**

(imgs were filtered)

