

Advance Image Processing

Assignment 1 Max Entropy Thresholding

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Implementations

Max Entropy thresholding is thresholding histogram-based technique that use maximum inter-class entropy.

Pseudocode:

read image

get histogram of the image

normalize the histogram h_{ij_norm} (value 0-1)

compute cumulative histogram h_cum %simplified denominator calculations

calculate entropy between 2 classes

calculate entropy of black pixels

$$H_b(t) = - \sum_{i=0}^t \frac{h(i)}{\sum_{j=0}^t h(j)} \log \frac{h(i)}{\sum_{j=0}^t h(j)}$$

calculate entropy of white pixels

$$H_w(t) = - \sum_{i=t+1}^{imax} \frac{h(i)}{\sum_{j=t+1}^{imax} h(j)} \log \frac{h(i)}{\sum_{j=t+1}^{imax} h(j)}$$

Optimal threshold by select the max from sum of white and black pixel

$$Thresh = ArgMax H_b(t) + H_w(t)$$

Get the index of the max threshold

Apply threshold to image to get mask

Compute accuracy

$$Accuracy = \frac{tp + tn}{tp + tn + fp + fn}$$

Results

1. Result on greyscale image

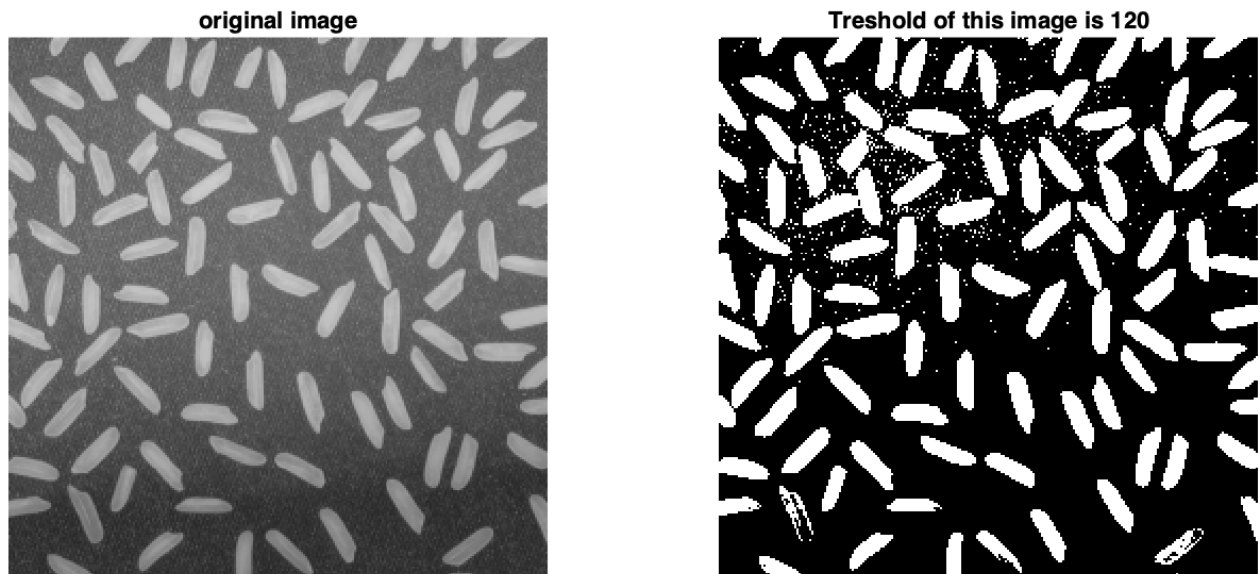


Figure 1 Input and Output on rice.png

In this experiment, we use greyscale image of rice with size 256x256 pixels. The left side is original image, it has uneven exposure, there are some part where the background has similar intensity to rice/foreground. We did not apply any image pre-processing and enhancement before thresholding.

The right side of the image is the result of thresholding using maximum entropy. The intensity threshold obtained from this image is 120. Intensity above 120 is segmented as foreground, otherwise background. We can see there are a lot of background pixels that are segmented to be a foreground. Also, there are some rice that are segmented as background.

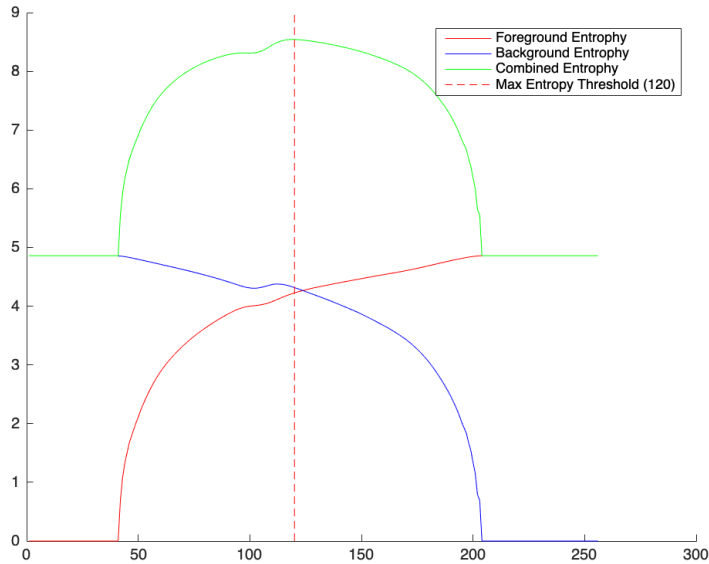


Figure 2 Plot all entropy calculations, color code based on the legend

Plot above depicting entropy for each intensity. In every iteration, entropy both background and foreground are calculated, then sum entropies on every index to get the maximum entropy as a threshold.

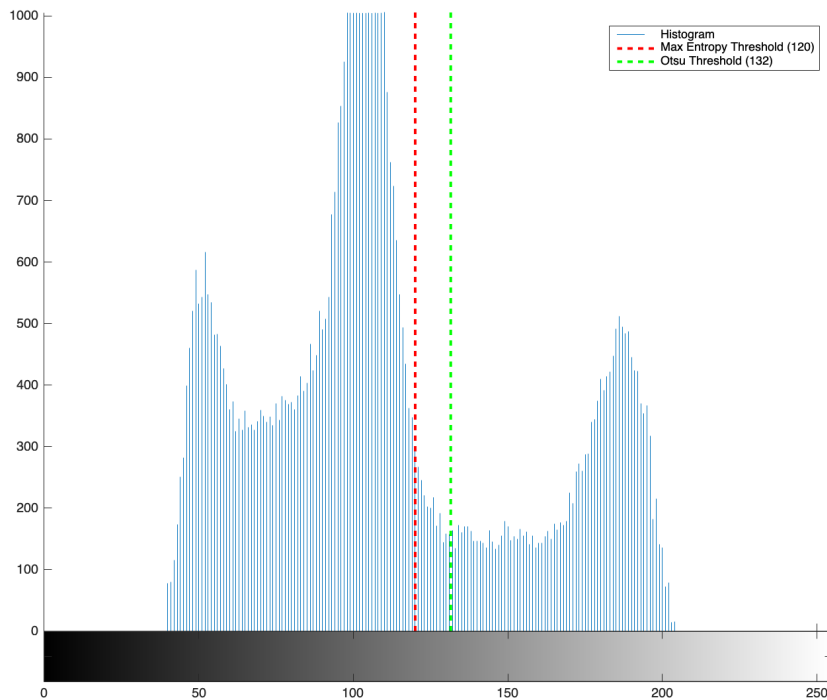


Figure 3 Plot Histogram and Max Entropy threshold

In this particular example, the max entropy is 8.542779942964500 and it belongs to intensity or index 120.

Compare to Otsu thresholding

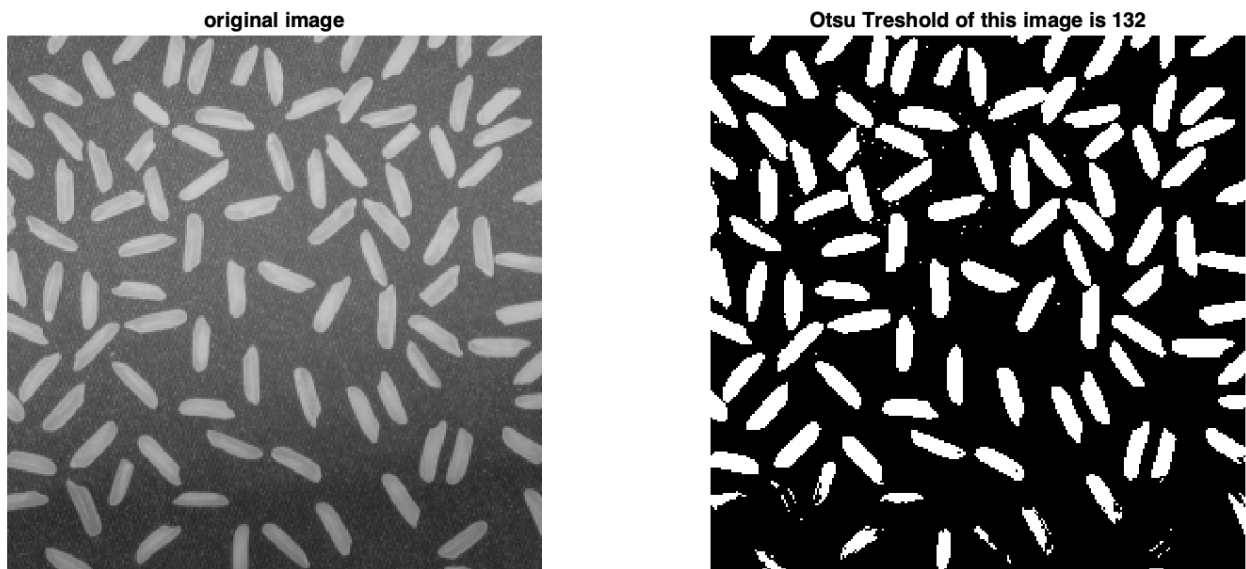


Figure 4 Thresholding using Otsu

Otsu threshold for the same image is 132. Intensity above 132 is segmented as foreground, otherwise background. Visually speaking, on this particular image, Otsu performed better compare to max entropy. We can see less white pixel spreading on top left area.



Figure 5 Ground truth

	Max Entropy	Otsu
Accuracy	94.1%	97.9%

I calculated the accuracy of both max entropy and otsu result compare to the ground truth of rice.png (beside). Matematically speaking, otsu has a better accuracy compare to max entropy by 3.8%.

2. Result on RGB image but first convert to greyscale

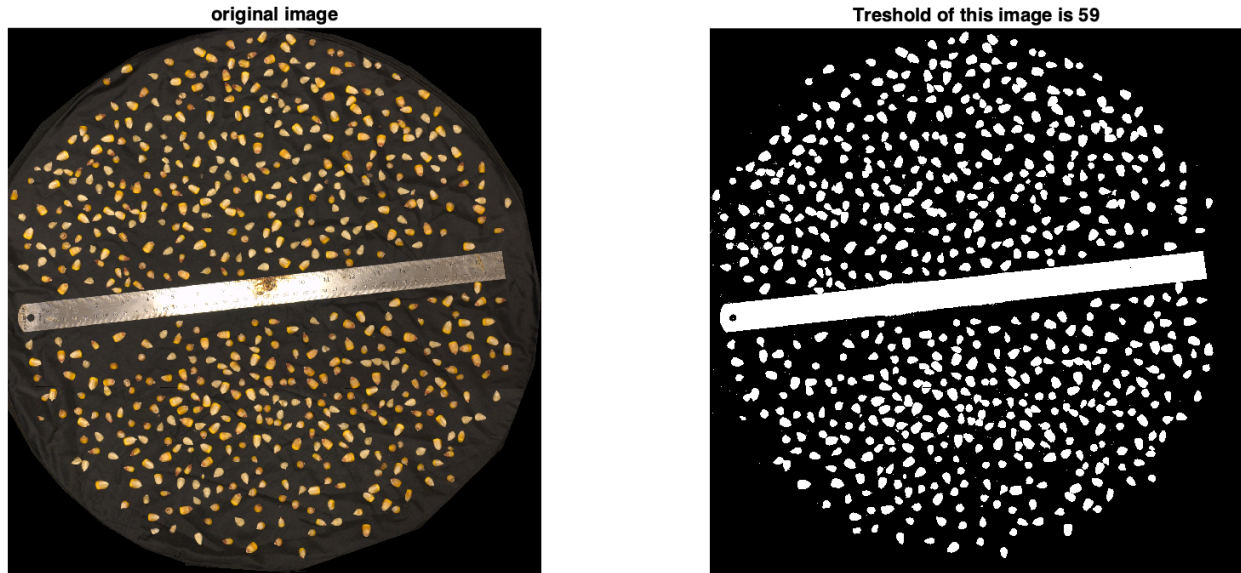


Figure 6 Max Entropy Segmentation

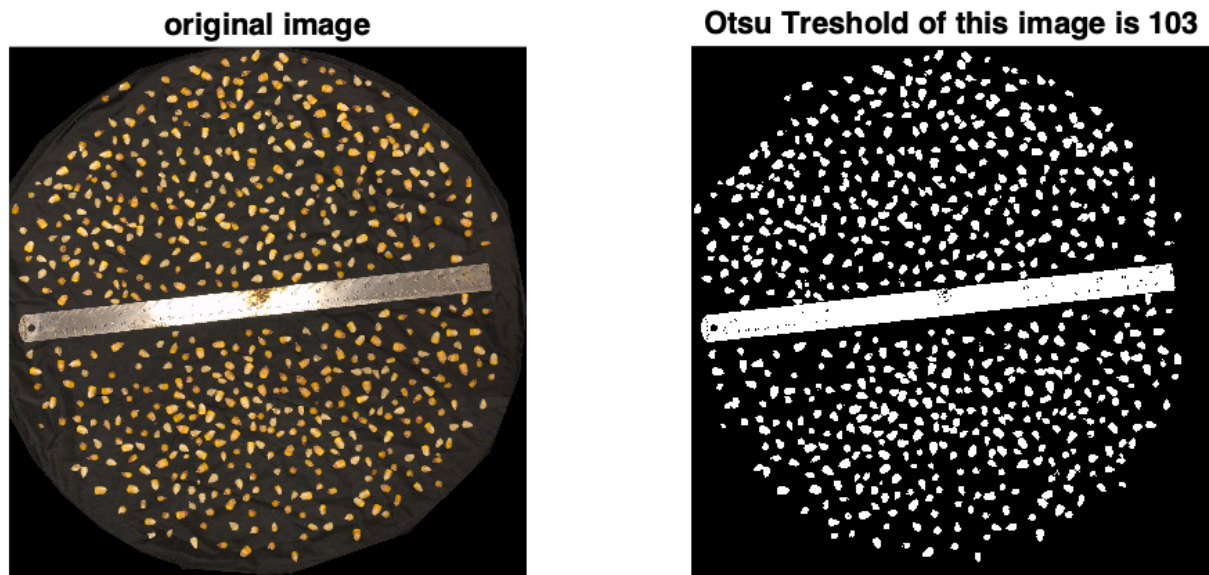


Figure 7 Otsu thresholding

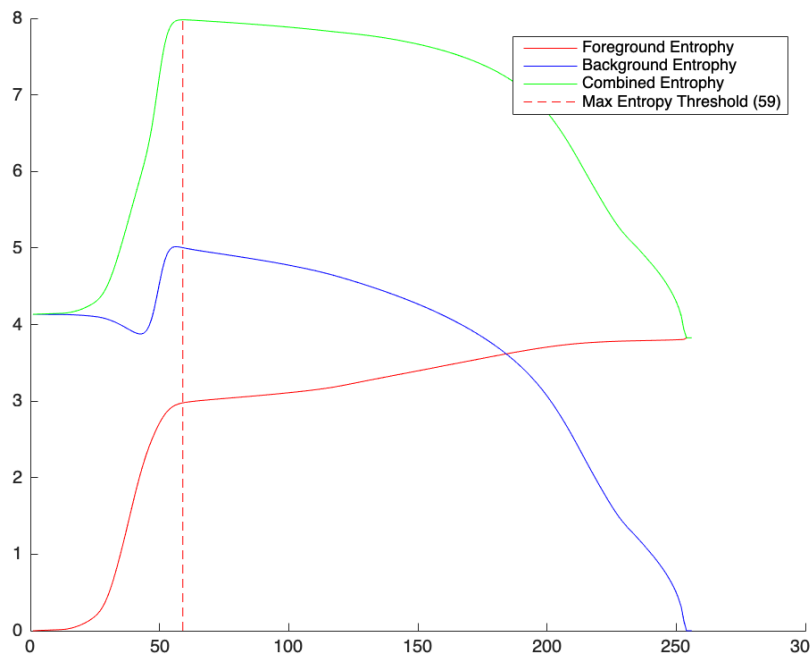


Figure 8. entropies plot

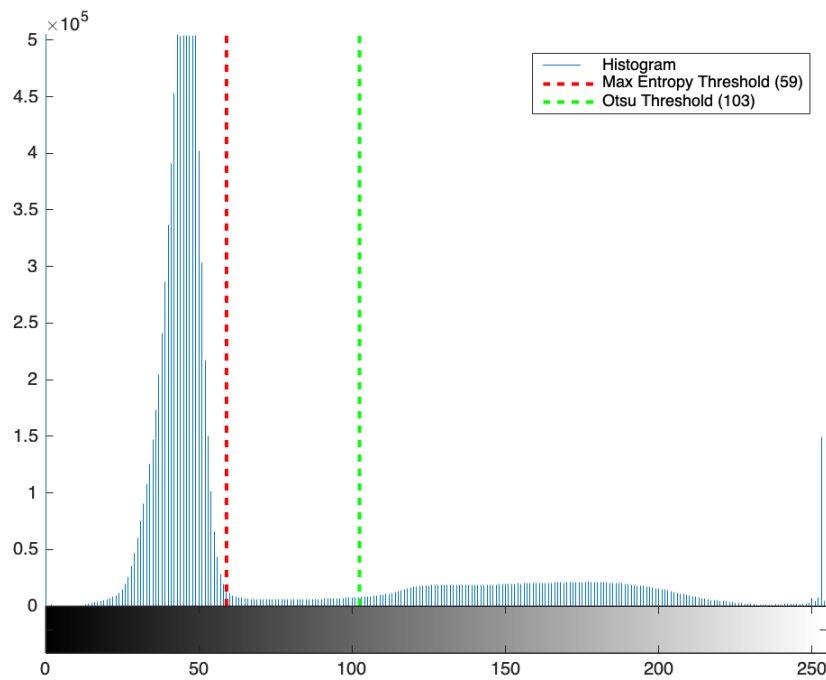


Figure 9. histogram plot

	Max Entropy	Otsu
Accuracy	95.7%	99.3%

From 2 examples, Otsu is performed better compare to max entropy thresholding.

3. Result on R, G, B channels

In this experiment, I tried to take max entropies on each channel on RGB images. After obtained threshold on each channel I union all 3 mask together.

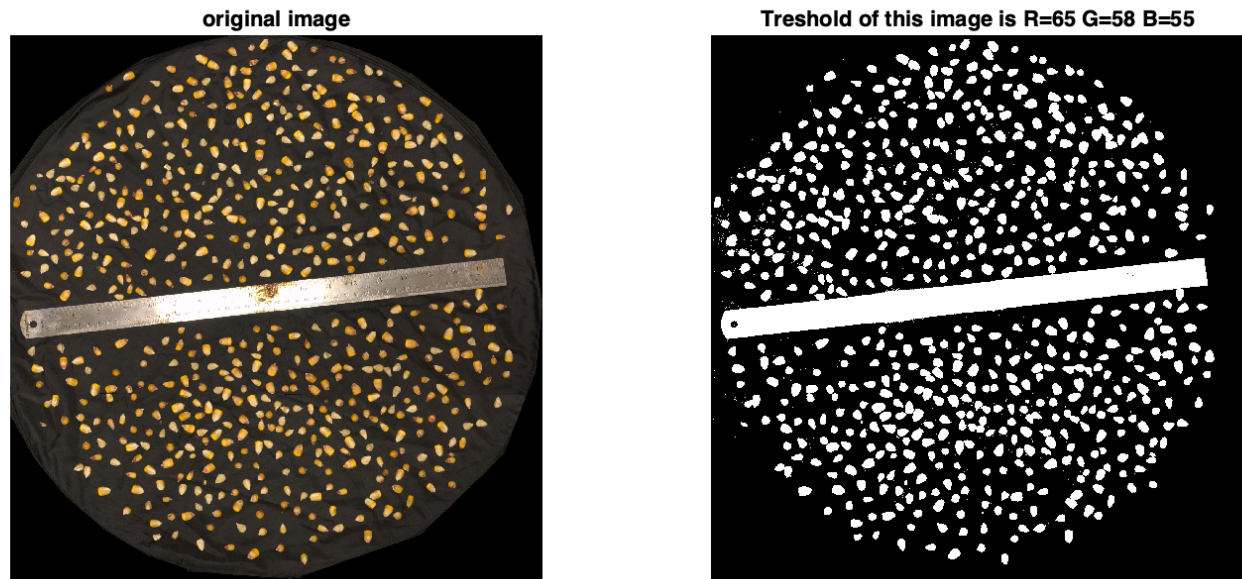
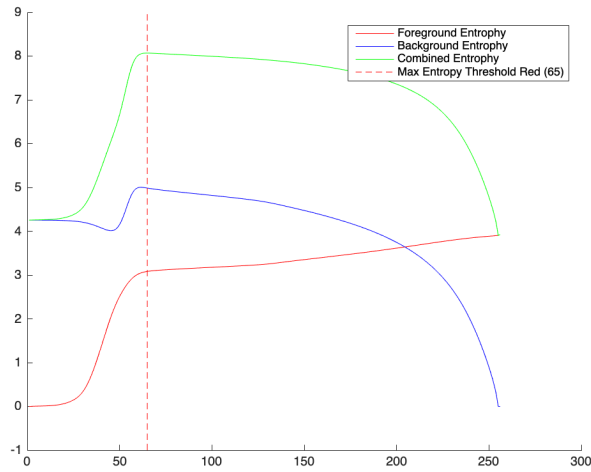


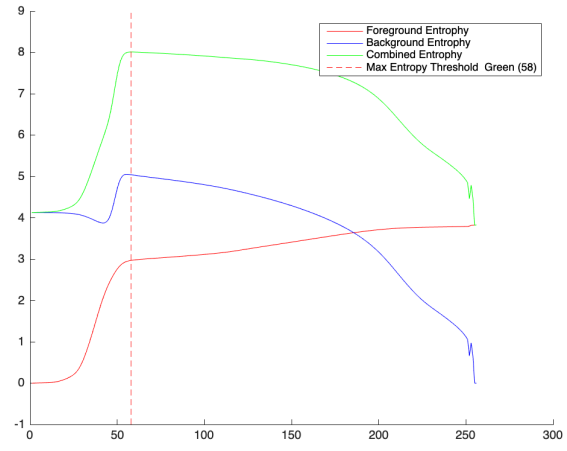
Figure 10. Result R G B each channel entropy

	Max Entropy (convert to grayscale)	Max Entropy (R,G,B each channel)
Accuracy	95.7%	94.7%

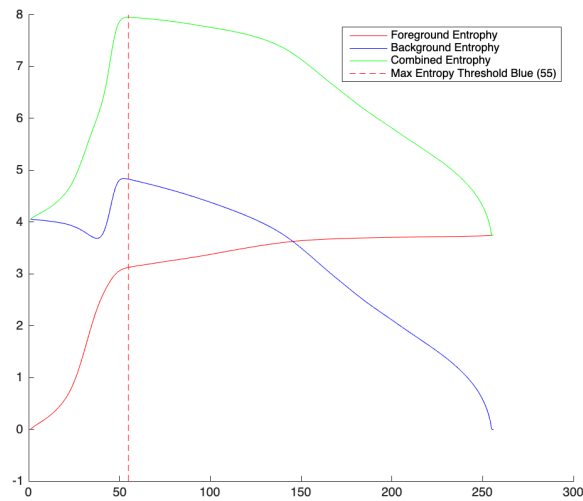
The accuracy of converting rgb to grayscale is better compare to combining threshold from each channel together. One factor that influence this result is when we convert to grayscale, the converter considers all channels with some other properties, such as hue, saturations, etc. So, it has more balance conversion in more aspect.



(a)



(b)



(c)

Figure 11. Entropy on each channel plot (a) Red; (b) Green; (c) Blue

I was wondering how different entropy value on each channel. As we can see on the graph above, they have similar curve on foreground, but somehow different on the background.