CS 5330: Pattern Recognition and Computer Vision

Northeastern University

Lab 7: Thresholding

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Thresholding

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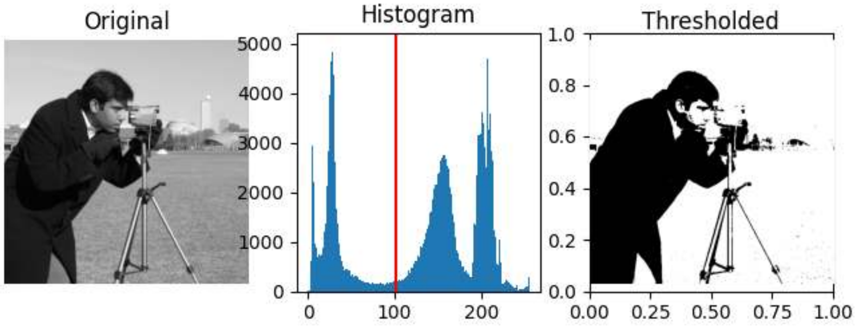
Introduction to Thresholding

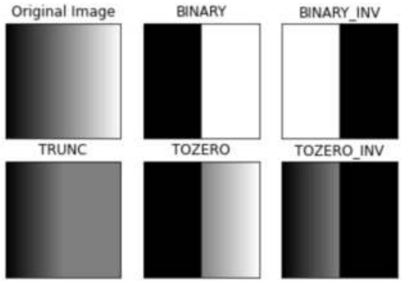
- Thresholding: A simple way to segment images by turning grayscale image into binary images
- There are different kinds of thresholding:
  - Our lab will focus on:
    - Simple Thresholding
    - Adaptive Thresholding
    - Otsu's Binarization



https://scikit-image.org/docs/stable/auto_examples/segmentation/plot_thresholding.html

Simple Thresholding

- Simple Thresholding: a fixed threshold value is used for the entire image. Each pixel value is compared to this threshold value and the pixel is assigned a binary value.
- Pros: easy to implement, works well for uniform lighting
- Cons: not good for images with varying lighting conditions



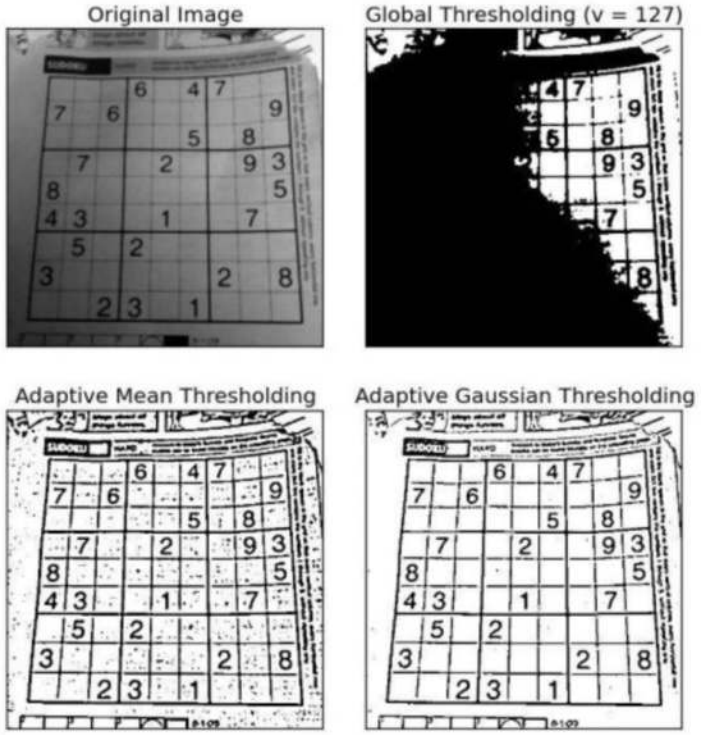
image

https://docs.opencv.org/4.x/d7/d4d/tutorial_py_thresholding.html

Adaptive Thresholding

- Adaptive Thresholding: a threshold value is calculated for smaller regions of the image rather than the entire image.
- Helpful in cases where lighting conditions vary across an image
- Two main types of adaptive thresholding:
  - Mean Adaptive Thresholding: threshold is set to be the mean of the neighborhood values minus a constant
  - Gaussian Adaptive Thresholding: threshold is set as the weighted sum of the neighborhood values minus a constant
- Pros: handles varying lighting conditions, robust
- Con: slower than simple thresholding

Adaptive Thresholding


Original Image
Global Thresholding (v = 127)
Adaptive Mean Thresholding
Adaptive Gaussian Thresholding

image

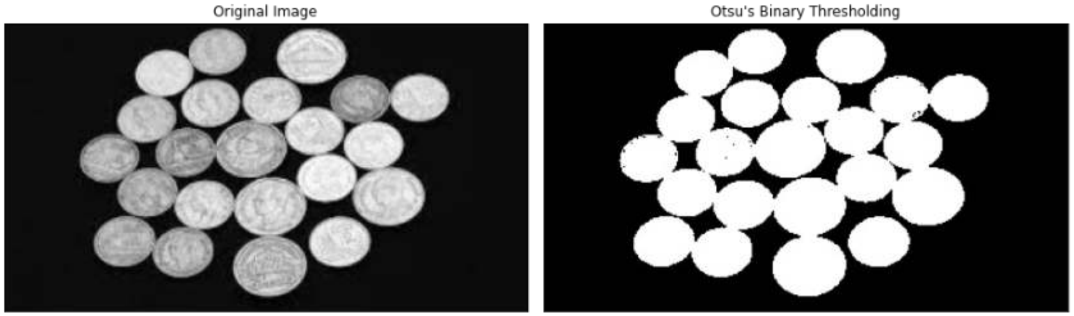
https://docs.opencv.org/4.x/d7/d4d/tutorial_py_thresholding.html

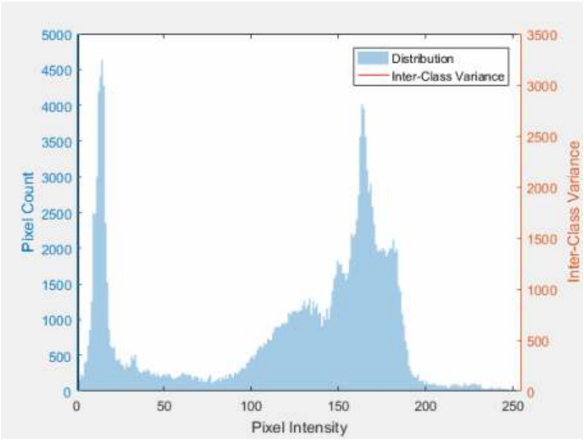
Otsu’s Binarization

- Otsu’s Binarization: automatically calculates the optimal threshold value based on the image’s histogram
- Minimizes the variance with the foreground & background pixels to find the best threshold
- Process:
  - Compute the histogram of the grayscale image
  - Automatically find the optimal threshold value
  - Apply thresholding to binarize the image
- Pros: automatic thresholding, good to use with images with bimodal histogram
- Con: doesn’t work well with more complex histograms or uneven lighting

https://www.projectpro.io/recipes/what-is-otsus-binarization-opencv
https://en.wikipedia.org/wiki/Otsu%27s_method

Otsu’s Binarization





https://www.projectpro.io/recipes/what-is-otsus-binarization-opencv
https://en.wikipedia.org/wiki/Otsu%27s_method

Simple Thresholding Example

Code

```
import cv2
import numpy as np
import matplotlib.pyplot as plt

# Load image in grayscale
image = cv2.imread('your_image.jpg', cv2.IMREAD_GRAYSCALE)

# Apply simple thresholding
_, thresh_simple = cv2.threshold(image, 127, 255, cv2.THRESH_BINARY)

# Show the image
plt.imshow(thresh_simple, cmap='gray')
plt.title('Simple Thresholding')
plt.show()
```

cv2.threshold(src, thresh, maxval, type):

- **src**: The source image (must be a grayscale image).
- **thresh**: The threshold value.
- **maxval**: The value to be given to pixels exceeding the threshold.
- **type**: The type of thresholding to be applied (e.g., cv2.THRESH_BINARY, cv2.THRESH_BINARY_INV, etc.).

Adaptive Thresholding Example

Code

```
# Apply adaptive mean thresholding
thresh_adaptive_mean = cv2.adaptiveThreshold(image, 255, cv2.ADAPTIVE_THRESH_MEAN_C
, cv2.THRESH_BINARY, 11, 2)

# Apply adaptive Gaussian thresholding
thresh_adaptive_gaussian = cv2.adaptiveThreshold(image, 255, cv2.ADAPTIVE_THRESH_GAUSSIAN_C
,  cv2.THRESH_BINARY, 11, 2)

# Show both results
plt.subplot(1, 2, 1), plt.imshow(thresh_adaptive_mean, cmap='gray')
plt.title('Adaptive Mean Thresholding')

plt.subplot(1, 2, 2), plt.imshow(thresh_adaptive_gaussian, cmap='gray')
plt.title('Adaptive Gaussian Thresholding')

plt.show()
```

cv2.adaptiveThreshold(src, maxval, adaptiveMethod, thresholdType, blockSize, C):

- **src**: The source image (grayscale).
- **maxval**: The value to be given to the pixels that exceed the threshold.
- **adaptiveMethod**: The method for calculating the threshold (e.g., cv2.ADAPTIVE_THRESH_MEAN_C or cv2.ADAPTIVE_THRESH_GAUSSIAN_C).
- **thresholdType**: The type of thresholding to apply (e.g., cv2.THRESH_BINARY).
- **blockSize**: Size of the neighborhood area used to calculate the threshold for each pixel (must be an odd number).

Otsu’s Binarization Example

Code

```
# Apply Otsu’s binarization
_, thresh_otsu = cv2.threshold(image, 0, 255, cv2.THRESH_BINARY + cv2.THRESH_OTSU)

# Show the result
plt.imshow(thresh_otsu, cmap='gray')
plt.title('Otsu’s Binarization')
plt.show()
```

cv2.threshold(src, thresh, maxval, type + cv2.THRESH_OTSU):

•**src**: The source image (grayscale).

•**thresh**: Set to 0 because Otsu’s method automatically determines the optimal threshold.

•**maxval**: The maximum value to assign to thresholded pixels.

•**type**: The thresholding method (e.g., cv2.THRESH_BINARY) combined with cv2.THRESH_OTSU for automatic threshold determination.

- In the example above, **cv2.THRESH_BINARY + cv2.THRESH_OTSU** tells OpenCV to first apply binary thresholding, but to determine the threshold value using Otsu's method.

Summary

- **Thresholding** is a great and efficient tool for image segmentation!
- **Simple thresholding** works for well-lit, simple images, but isn’t good for images with varying lighting conditions.
- **Adaptive thresholding** is works well when the lighting varies but is slower.
- **Otsu’s binarization method** is best for images with clear intensity separation, and but may struggle with images with uneven lighting or more complex images.