University of Idaho
Department of Computer Science
Coeur d'Alene

Lecture #10

Thresholding

Garrett Wells
revised September 10, 2024

Table of Contents I

Table of Contents

Review

Types of Thresholding
- Simple
  - Binary
  - Inverted Binary
  - Truncated Threshold
  - To Zero
  - To Zero Inverse
- Adaptive
- Otsu’s Binarization
- NiBlack

Table of Contents I

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Review

Histograms

- count pixels
- search for matches in pixel distribution
  1. crude object recognition
  2. pattern matching

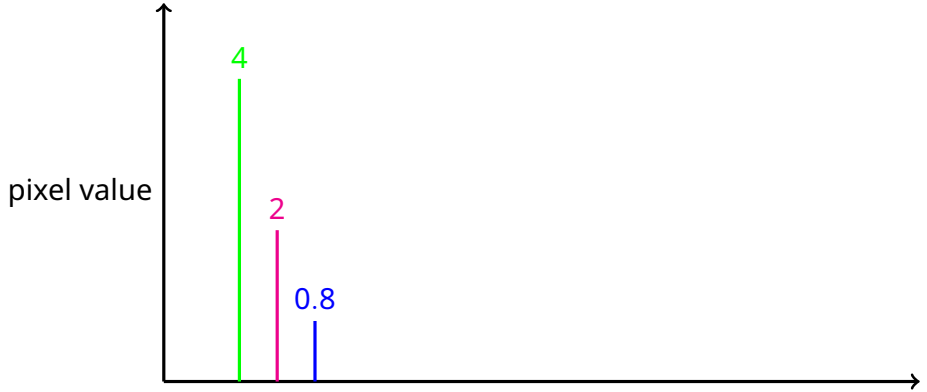
Review

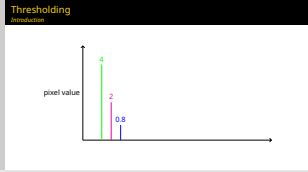
Histograms
- count pixels
- search for matches in pixel distribution
  1. crude object recognition
  2. pattern matching

1. Remember three main histogram techniques: comparison, equalization, and back projection

Thresholding

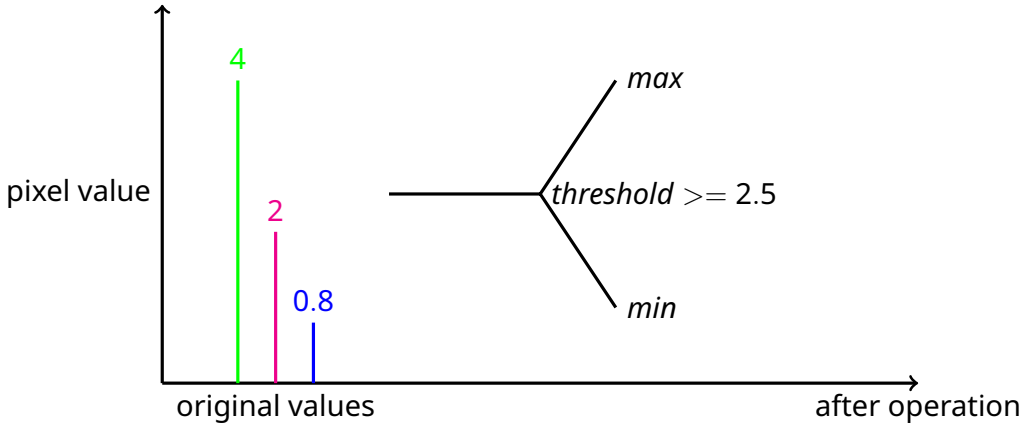
Introduction

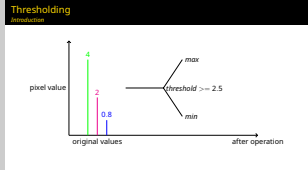




Thresholding

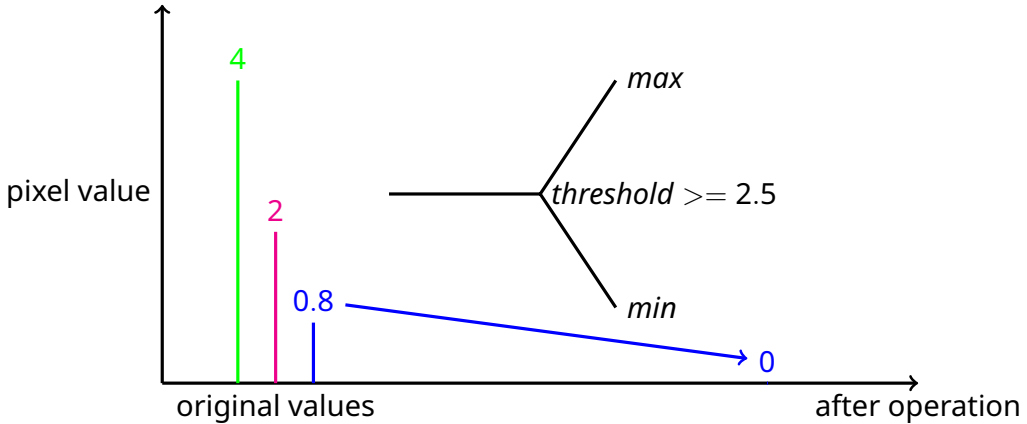
Introduction

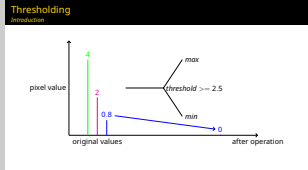




Thresholding

Introduction





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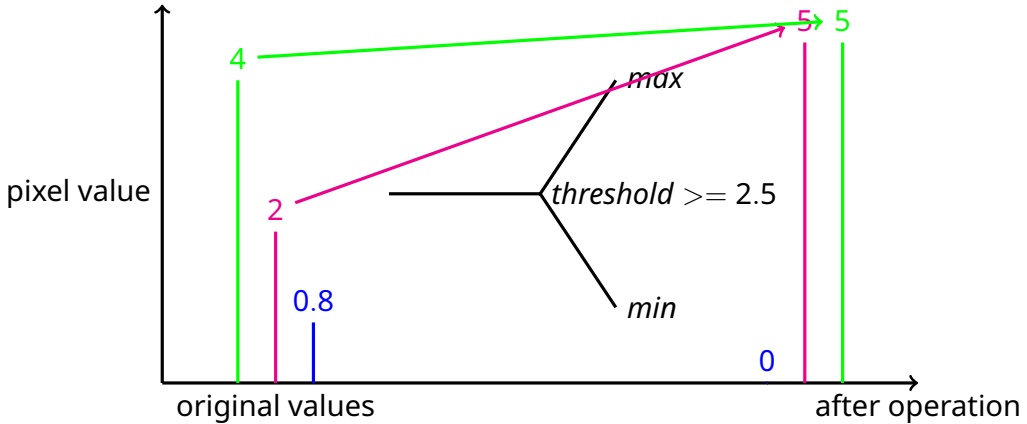

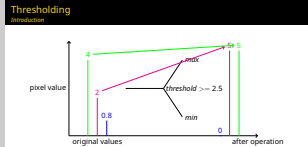

Thresholding

Types of Thresholding…

1. Simple thresholding
2. Adaptive thresholding
3. Otsu’s binarization

Thresholding
Types of Thresholding…
1. Simple thresholding
2. Adaptive thresholding
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Simple Thresholding

Simple Thresholding, Generalized

Applies the same threshold value, *threshold* to every pixel in the image.

```
if pixel_val >= threshold:
    pixel_val = upper_bound
else:
    pixel_val = lower_bound
```


Simple Thresholding
Simple Thresholding, Generalized
Applies the same threshold value, *threshold* to every pixel in the image.
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Simple Thresholding

```
cv.THRESH_BINARY
cv.THRESH_BINARY_INV
cv.THRESH_TRUNC
cv.THRESH_TOZERO
cv.THRESH_TOZERO_INV
```

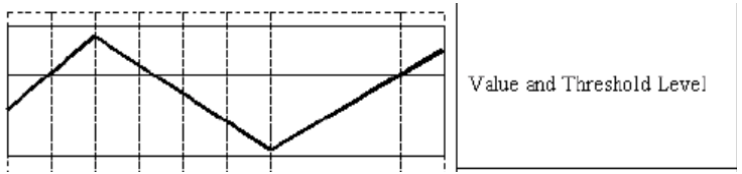

Figure: Normal Wave Form[1]

Simple Thresholding
cv.THRESH_BINARY
cv.THRESH_BINARY_INV
cv.THRESH_TRUNC
cv.THRESH_TOZERO
cv.THRESH_TOZERO_INV
Figure: Normal Wave Form[1]

Binary Thresholding

- Choose threshold value and maximum pixel value
- If pixel smaller than threshold → 0
- Pixel equal or larger → maximum value

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Binary Thresholding

- values in desired range → become brighter
- values below threshold, discarded

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Inverted Binary Threshold

- values over threshold → 0
- values below threshold → max value

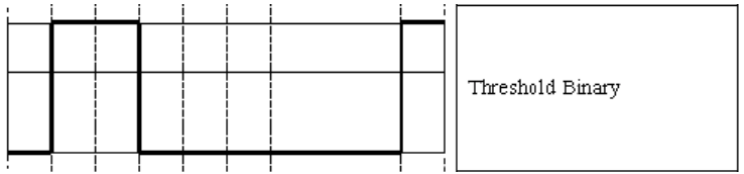

Figure: Binary Threshold[2]

[2] OpenCV Image Processing [1]

Inverted Binary Threshold
- values over threshold → 0
- values below threshold → max value
Figure: Binary Threshold[2]
[2] OpenCV Image Processing [1]

Truncated Threshold

- Values higher than threshold → set to threshold
- Otherwise pixel retains original value

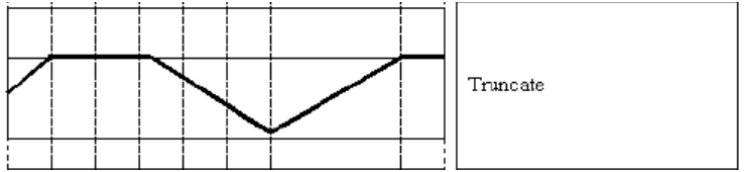

Figure: Truncated Threshold[3]

[3] OpenCV Image Processing [1]

Truncated Threshold
- Values higher than threshold → set to threshold
- Otherwise pixel retains original value
Figure: Truncated Threshold[3]
[3] OpenCV Image Processing [1]

To Zero Threshold

- Set threshold value
- If pixel *higher* than threshold → keep value
- Otherwise → 0

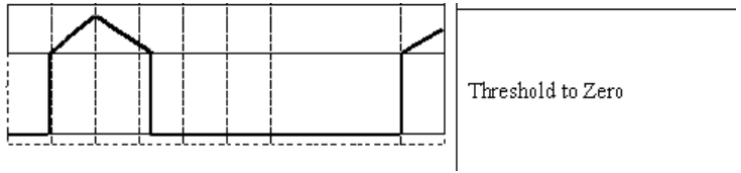

Figure: To Zero Threshold[4]

[4] OpenCV Image Processing [1]

To Zero Threshold
- Set threshold value
- If pixel *higher* than threshold → keep value
- Otherwise → 0
Figure: To Zero Threshold[4]
[4] OpenCV Image Processing [1]

To Zero Inverse Threshold

- Set threshold value
- If pixel *lower* than threshold → keep value
- Otherwise → 0

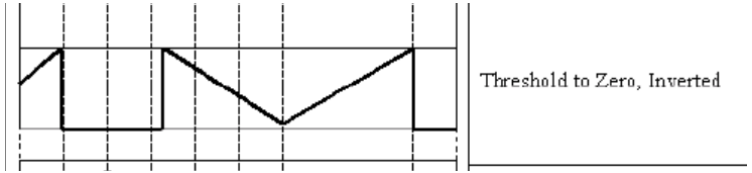

Figure: To Zero Threshold Inverted[5]

[5] OpenCV Image Processing [1]

To Zero Inverse Threshold
- Set threshold value
- If pixel *lower* than threshold → keep value
- Otherwise → 0

Figure: To Zero Threshold Inverted[5]
[5] OpenCV Image Processing [1]

Code Example

Simple thresholding snippets...

Code Example
Simple thresholding snippets...

Adaptive Thresholding

Definition...

- Calculates a threshold for each pixel
- Threshold is based on values of surrounding pixels

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Adaptive Thresholding

Definition...

- Calculates a threshold for each pixel
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  1. Mean
  2. Gaussian

Adaptive Thresholding
Definition...
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Adaptive Thresholding

Adaptive Mean

1. Calculate **mean** or Gaussian-weighted sum of neighborhood of pixels

Adaptive Thresholding
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2. Subtract constant, C

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1. Calculate mean or Gaussian-weighted sum of neighborhood of pixels
2. Subtract constant, C
3. Apply a form of simple thresholding

Adaptive Thresholding
Adaptive Mean
1. Calculate mean or Gaussian-weighted sum of neighborhood of pixels
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Adaptive Thresholding

Simple vs. Adaptive...

Simple Thresholding

1. One threshold value

Adaptive Thresholding

Adaptive Thresholding
Simple vs. Adaptive...
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Simple vs. Adaptive...

Simple Thresholding

1. One threshold value

Adaptive Thresholding

1. Threshold dynamically set

Adaptive Thresholding
Simple vs. Adaptive...
Simple Thresholding
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Adaptive Thresholding
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Adaptive Thresholding

Simple vs. Adaptive...

Simple Thresholding

1. One threshold value
2. Applied to all pixels

Adaptive Thresholding

1. Threshold dynamically set

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Simple vs. Adaptive...
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Adaptive Thresholding

1. Threshold dynamically set
2. Potentially different for each pixel

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Code Example

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Otsu’s Binarization

1. Calculate image histogram

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1. Calculate image histogram
2. Select threshold value from histogram

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Benefits

- Bimodal images
  - images whose values should fall into two peaks
- Minimize within class variance

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Benefits

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Otsu Example

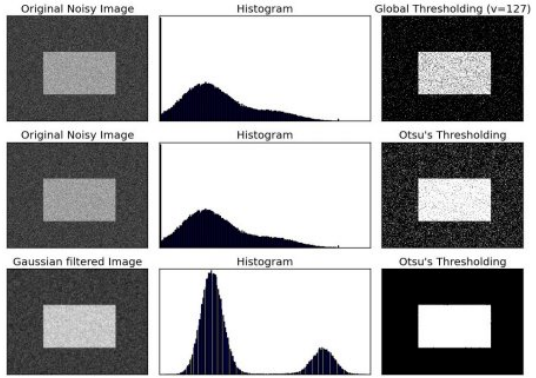

Figure: Otsu Example Output [2]

Otsu Example

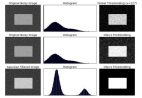

Figure: Otsu Example Output [2]

1. The final histogram in shows a somewhat bimodal distribution

NiBlack Thresholding

- Pixel neighborhood + mean & standard deviation [3]
- Useful for images without uniform background
  - example: page scan with uneven lighting

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Thresholding: What is it good for?

1. **In General:** using contrast to find features
2. separating foreground and background of image
3. finding edges
4. preprocessing for other algorithms

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Notes

1. Can also apply to color channels
2. Some may have higher contrast in certain channels
3. Can apply filter to camera to enhance this effect

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Preprocessing

- Thresholding usually for preprocessing

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- But may benefit from preprocessing itself

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Preprocessing

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- But may benefit from preprocessing itself
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Preprocessing

- Thresholding usually for preprocessing
- But may benefit from preprocessing itself
  - Denoising
  - Blurring

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- Thresholding usually for preprocessing
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LIGHTING!!

- Thresholding ☞ using lighting to *your advantage*
- Yet still susceptible to changes in lighting

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Ideal Lighting

1. “Diffuse” or flat [6]

[6] Guide to Lighting for Machine Vision [4]

Ideal Lighting
1. “Diffuse” or flat [6]
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Ideal Lighting

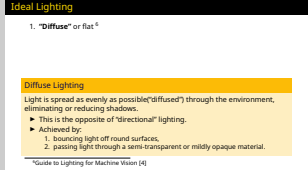
1. **“Diffuse”** or flat [6]

Diffuse Lighting

Light is spread as evenly as possible(“diffused”) through the environment, eliminating or reducing shadows.

- This is the opposite of “directional” lighting.
- Achieved by:
  1. bouncing light off round surfaces,
  2. passing light through a semi-transparent or mildly opaque material.

[6] Guide to Lighting for Machine Vision [4]



Ideal Lighting

1. “Diffuse” or **flat** [6]

Flat Lighting

Place lighting source orthogonal to subject and attempt to align camera with axis of lighting source. Goal is to place shadows directly behind subject, minimizing their impact on image.

- Easier, cheaper to achieve than diffuse lighting.
- Good for surface inspection.
- Susceptible to glare if surface is polished.

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1. “Diffuse” or flat [6]
2. Consistent light source

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Ideal Lighting

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   2.1 Color spectrum

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   - 2.4 The sun is terrible

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[3] J. Sauvola and M. Pietikäinen, "Adaptive document image binarization," *Pattern Recognition*, vol. 33, no. 2, pp. 225–236, Feb. 2000, ISSN: 00313203. DOI: 10.1016/S0031-3203(99)00055-2. [Online]. Available: https://linkinghub.elsevier.com/retrieve/pii/S0031320399000552 (visited on 09/11/2024).

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Bibliography II

[4] “https://www.advancedillumination.com/wp-content/uploads/2018/10/A-Practical-Guide-to-Machine-Vision-Lighting-v.-4-Generic.pdf,” (), [Online]. Available: https://www.advancedillumination.com/wp-content/uploads/2018/10/A-Practical-Guide-to-Machine-Vision-Lighting-v.-4-Generic.pdf (visited on 09/11/2024).

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