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Florida Institute for National Security (FINS)
UNIVERSITY of FLORIDA

IC SEM RE Tutorial using AI Part 2: Image Processing and Computer Vision

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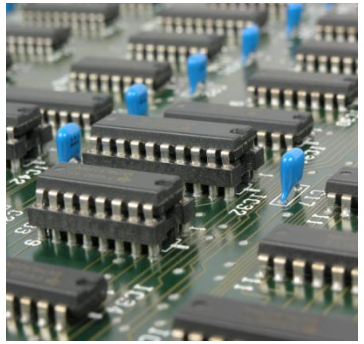
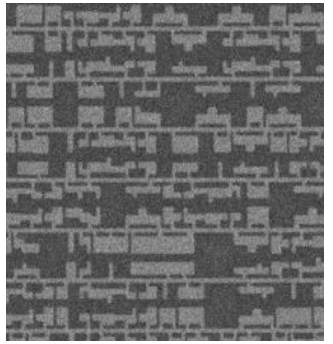




Florida Institute for National Security (FINS)

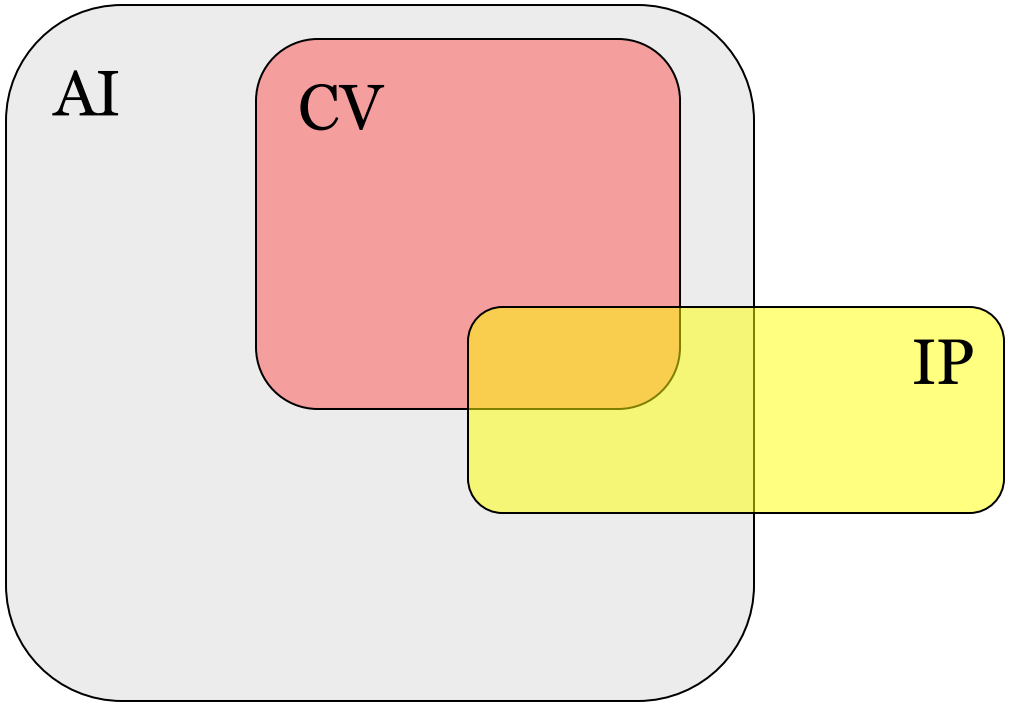
Objective

- Hardware Reverse Engineering Project using AI
  - Hands-on tutorial
  - Practical application in hardware assurance
  - Resume-builder / professional development
- Last Time
  - Introduction of the IC SEM RE problem
  - Code pipeline setup
- This lecture:
  - Introduce Image Processing and Computer Vision
  - Improve upon previous code pipeline

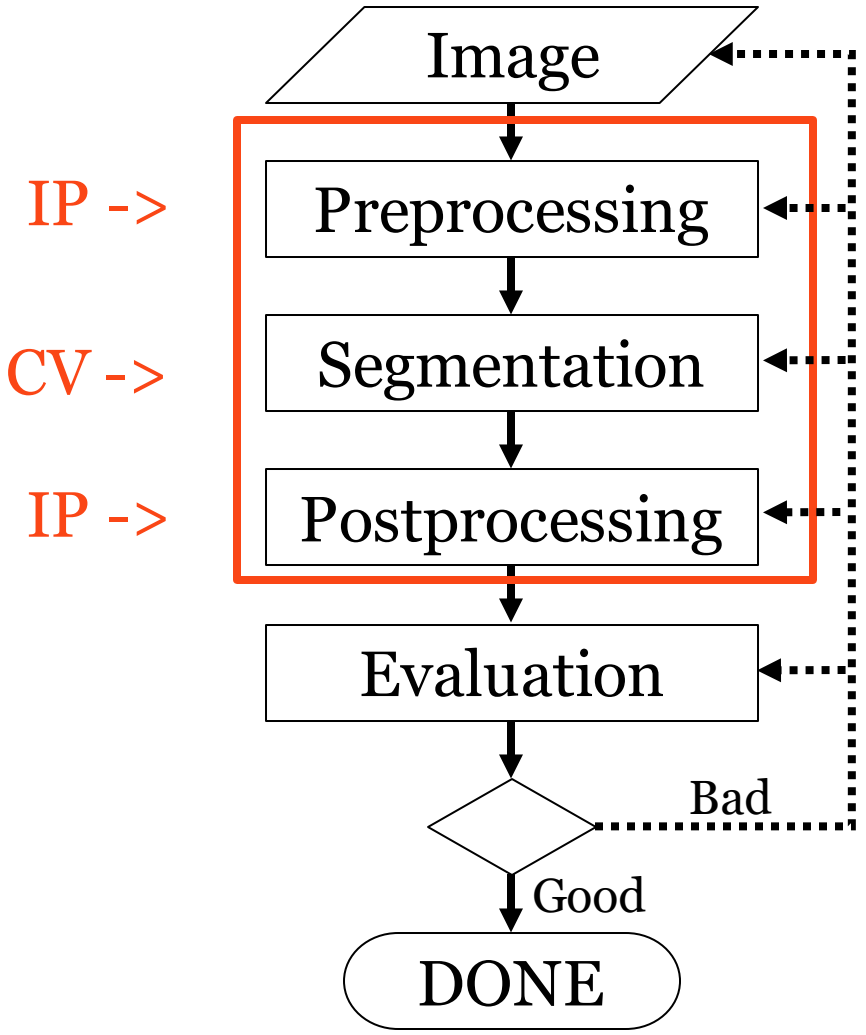
Refer to the prerequisites and documentation!

Image Processing and Computer Vision

- Image Processing (IP) transforms an image into another image
- Computer Vision (CV) recognizes patterns in an image
- TL;DR:
  - IP: Image in, Image out
  - CV: Image in, Knowledge out

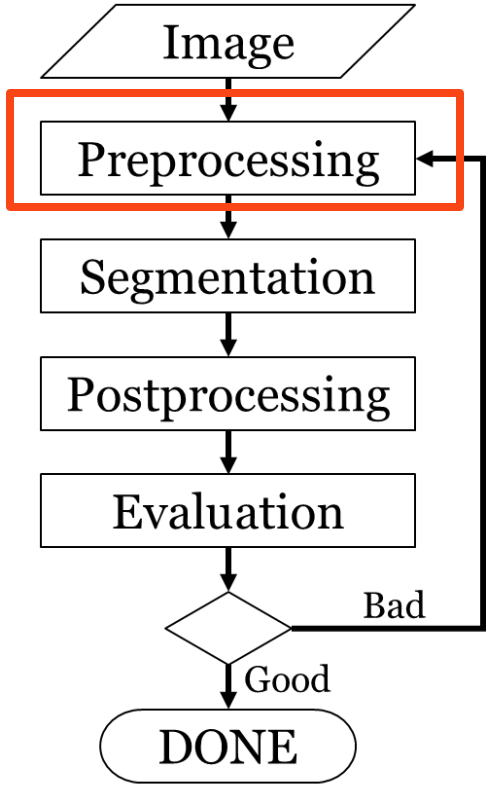


Typical IP/CV Segmentation Pipeline



Preprocessing: Filtering

- IP technique to enhance/remove features in an image
- Image blurring, sharpening, edge enhancement, etc.
- Needs: input image, kernel (i.e. filter)
- Example:



input image

1	0	0	0
1	0	0	0
1	1	0	0
1	0	0	1

kernel

x 1/9	x 1/9	x 1/9
x 1/9	x 1/9	x 1/9
x 1/9	x 1/9	x 1/9

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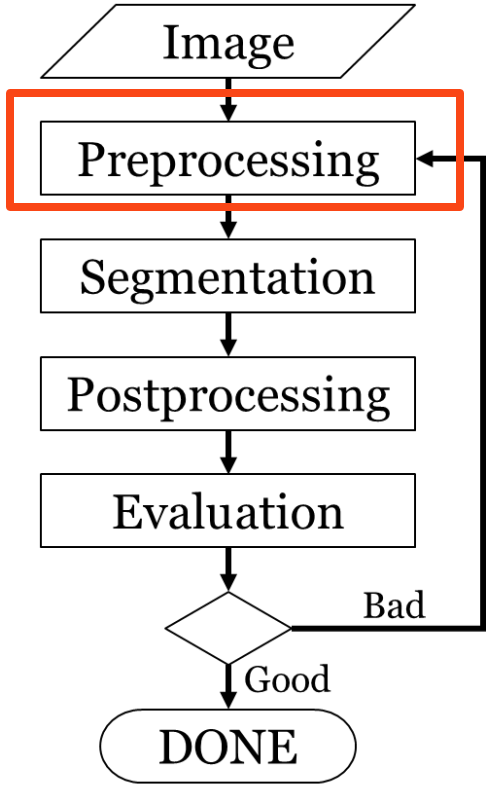

input image

1 x 1/9	0 x 1/9	0 x 1/9	0
1 x 1/9	0 x 1/9	0 x 1/9	0
1 x 1/9	1 x 1/9	0 x 1/9	0
1	0	0	1

output image

4/9	

$$(1+0+0 + 1+0+0 + 1+1+0) \times 1/9 = 4/9$$

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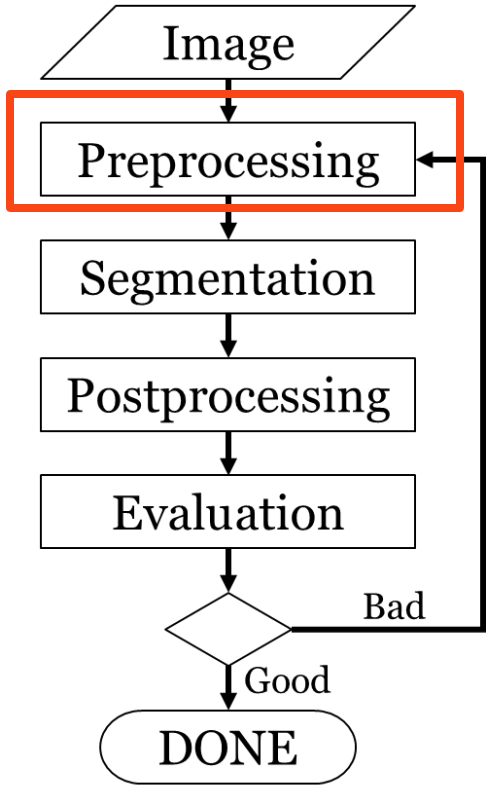

input image

1	0 x 1/9	0 x 1/9	0 x 1/9
1	0 x 1/9	0 x 1/9	0 x 1/9
1	1 x 1/9	0 x 1/9	0 x 1/9
1	0	0	1

output image

4/9	1/9

(0+0+0 + 0+0+0 + 1+0+0) x 1/9 = 1/9

Preprocessing: Filtering

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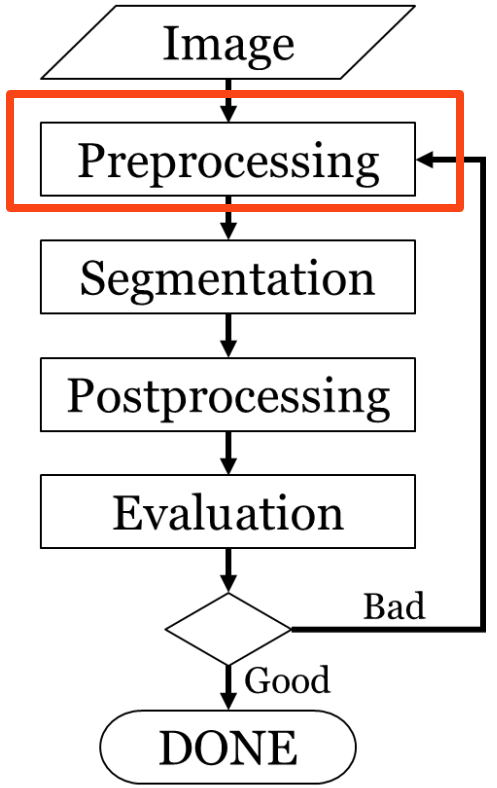
- Example:



input image

1	0	0	0
1 x 1/9	0 x 1/9	0 x 1/9	0
1 x 1/9	1 x 1/9	0 x 1/9	0
1 x 1/9	0 x 1/9	0 x 1/9	1

output image

4/9	1/9
4/9	

$$(1+0+0 + 1+1+0 + 1+0+0) \times 1/9 = 4/9$$

Preprocessing: Filtering

- IP technique to enhance/remove features in an image
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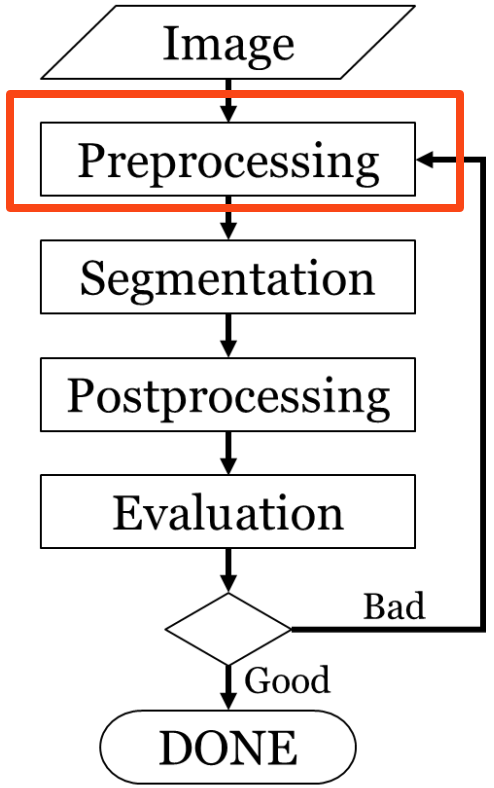
- Needs: input image, kernel (i.e. filter)
- Example:



input image

1	0	0	0
1	0 x 1/9	0 x 1/9	0 x 1/9
1	1 x 1/9	0 x 1/9	0 x 1/9
1	0 x 1/9	0 x 1/9	1 x 1/9

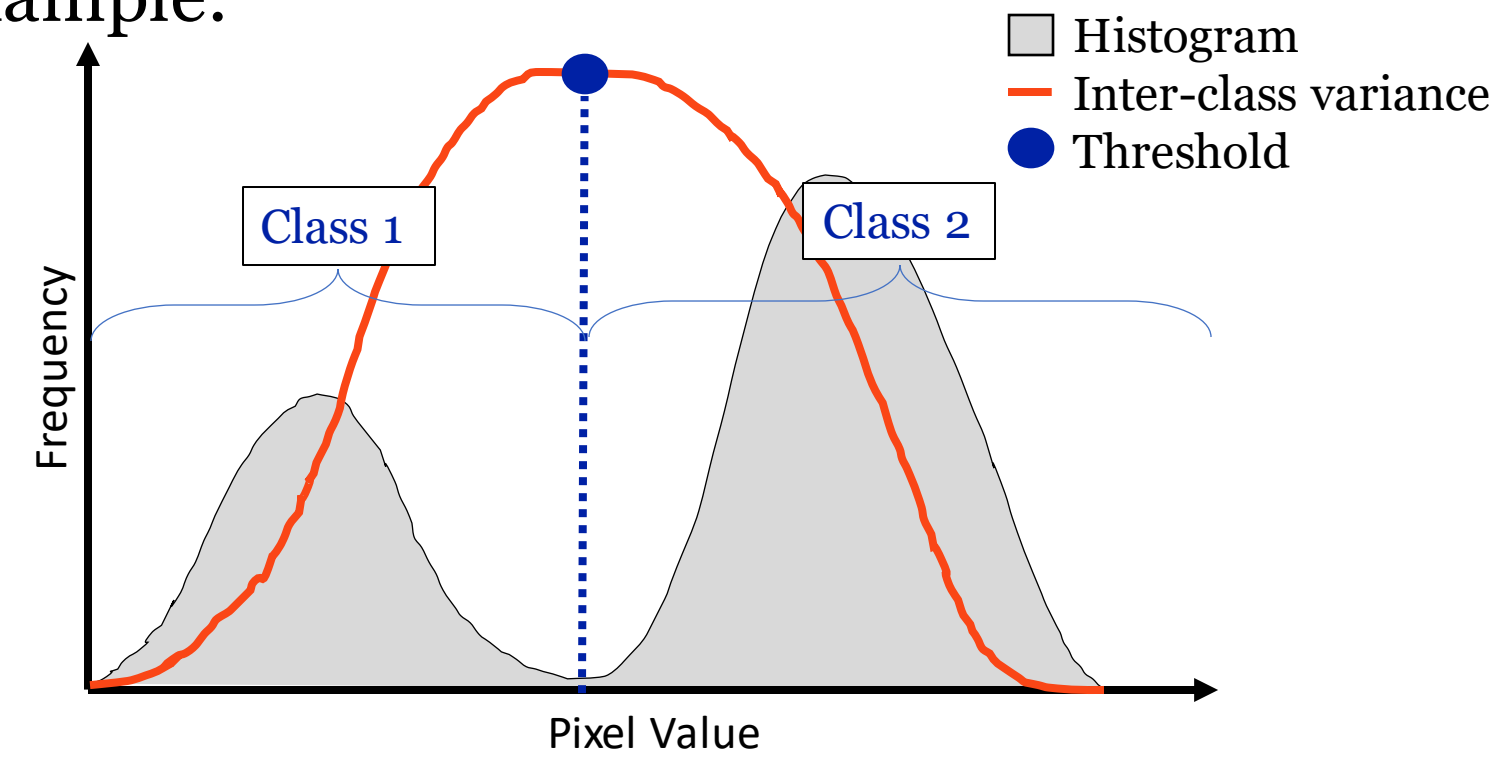
output image

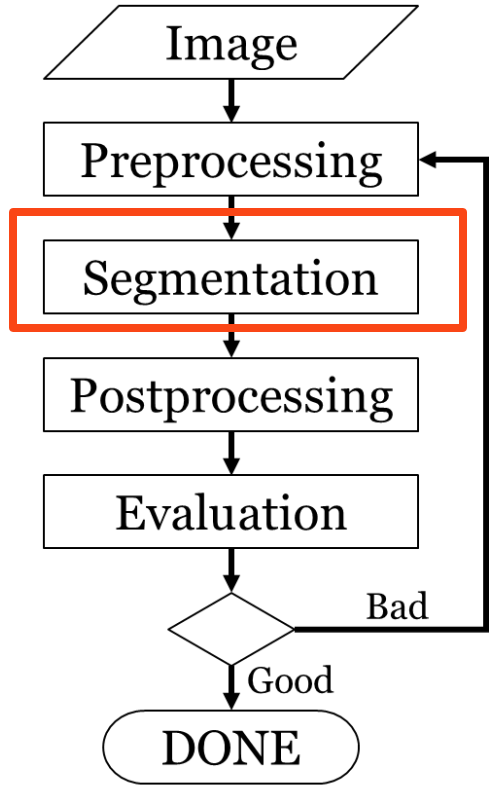
4/9	1/9
4/9	2/9

$$(0+0+0 + 1+0+0 + 0+0+1) \times 1/9 = 2/9$$

Segmentation Method 2: Otsu Thresholding

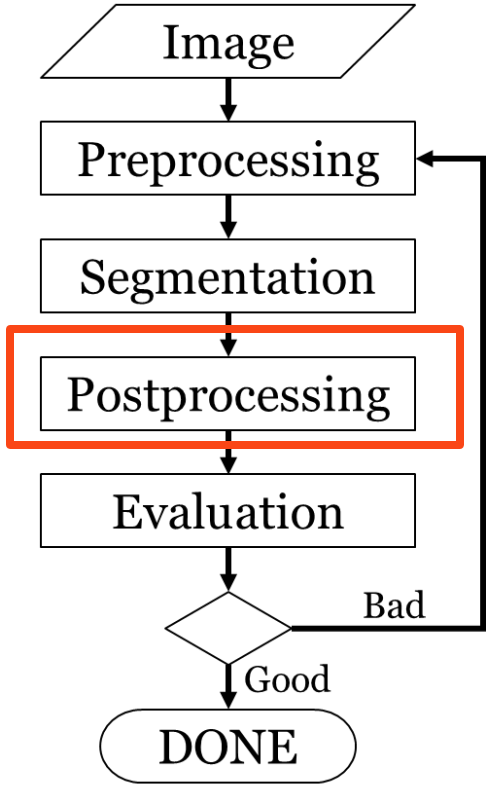
- CV technique to automatically segment an image
- Works by maximizing histogram inter-class variance
- Example:





Postprocessing: Morphological Operations

- IP techniques that concern image shapes and structures
- Shape erosion and dilation, gap opening and closing
- Needs: input image, structuring element
- Example:



input image

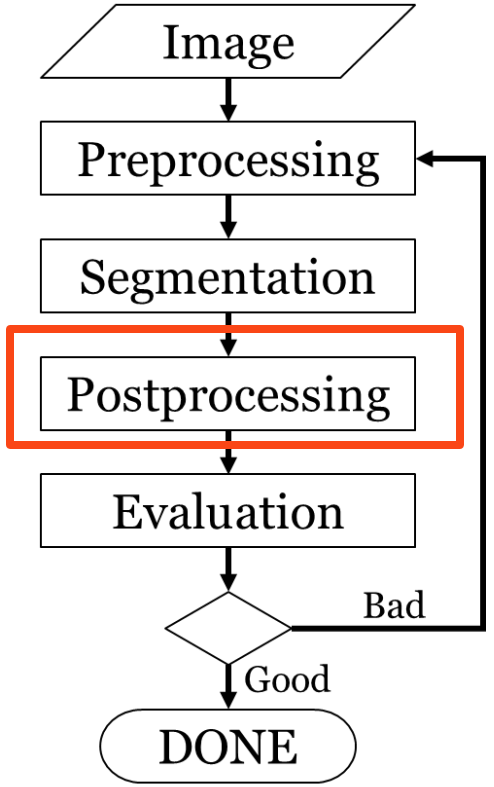
1	0	0	0
1	0	0	0
1	1	0	0
1	0	0	1

structuring element

==1
==1

Postprocessing: Morphological Operations

- IP techniques that concern image shapes and structures
- Shape erosion and dilation, gap opening and closing
- Needs: input image, structuring element
- Example:



input image

1 ==1	0	0	0
1 ==1	0	0	0
1	1	0	0
1	0	0	1

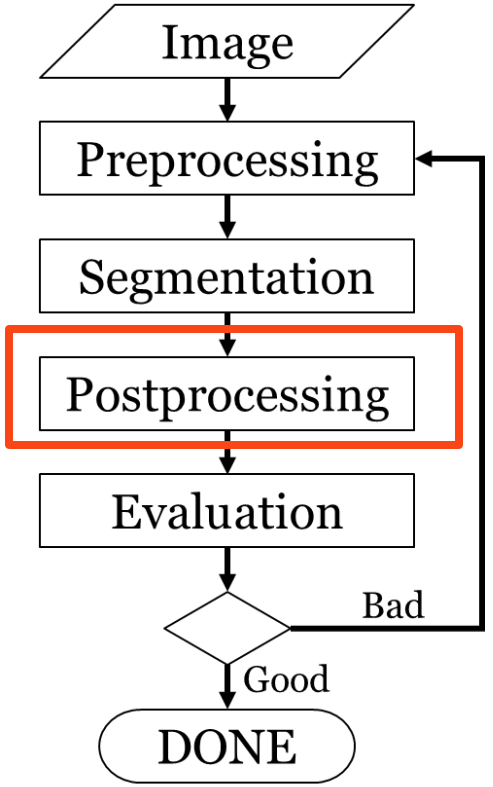
output image (erosion)

1			

(1==1) AND (1==1) = 1

Postprocessing: Morphological Operations

- IP techniques that concern image shapes and structures
- Shape erosion and dilation, gap opening and closing
- Needs: input image, structuring element
- Example:



input image

1	0 ==1	0	0
1	0 ==1	0	0
1	1	0	0
1	0	0	1

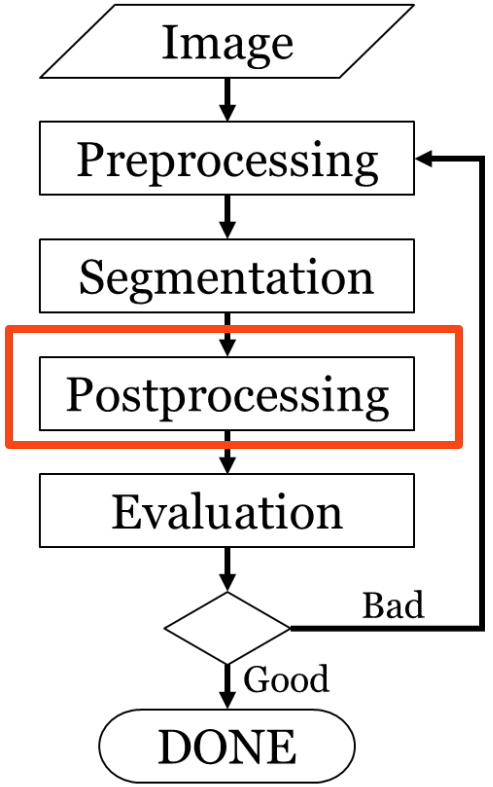
output image (erosion)

1	0		

(0==1) AND (0==1) = 0

Postprocessing: Morphological Operations

- IP techniques that concern image shapes and structures
- Shape erosion and dilation, gap opening and closing
- Needs: input image, structuring element
- Example:



input image

1	0	0	0
1	0 ==1	0	0
1	1 ==1	0	0
1	0	0	1

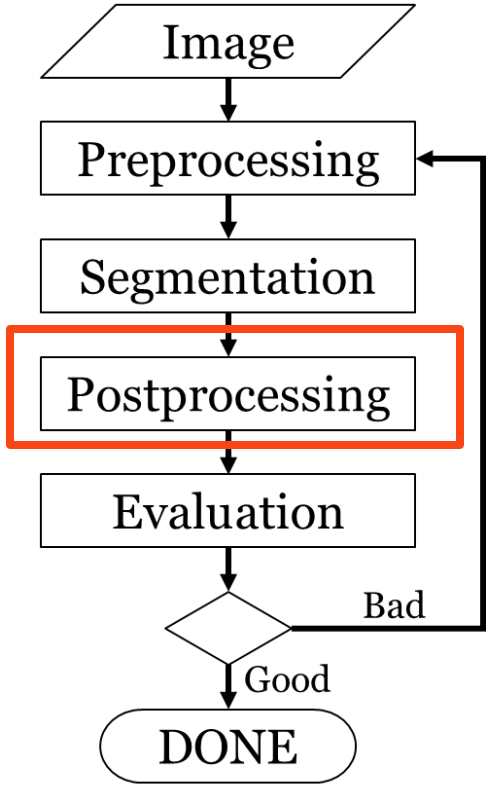
output image (erosion)

1	0	0	0
1	0		

(0==1) AND (1==1) = 0

Postprocessing: Morphological Operations

- IP techniques that concern image shapes and structures
- Shape erosion and dilation, gap opening and closing
- Needs: input image, structuring element
- Example:



input image

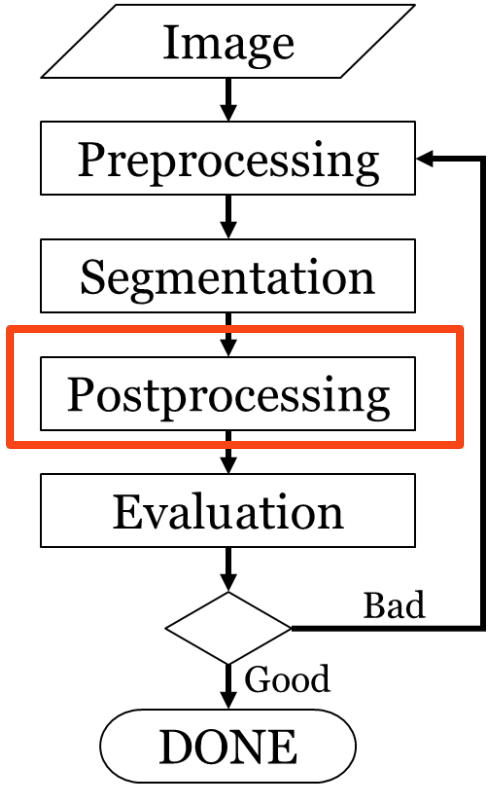
1	0	0	0
1	0	0	0
1	1	0	0 ==1
1	0	0	1 ==1

output image (dilation)

1	0	0	0
1	1	0	0
1	1	0	1

Postprocessing: Morphological Operations

- IP techniques that concern image shapes and structures
- Shape erosion and dilation, gap opening and closing
- Needs: input image, structuring element
- Binary Morphological Operations: 4 techniques
  - Erosion: reduces shape sizes
  - Dilation: increases shape sizes
  - Opening: removes background noise, separate shapes
  - Closing: removes foreground noise, connects shapes



Extensions

- Preprocessing:
  - Kernel parameters
  - Other filters: Gaussian, Median
- Segmentation:
  - Adaptive thresholding
- Postprocessing
  - Structuring element parameters
  - Other morphological operations: hole filling

Experiment!

Key Takeaways

1. Image Processing and Computer Vision
2. Preprocessing: Mean filtering
3. Segmentation: Otsu thresholding
4. Postprocessing: Opening and Closing
5. Extensions

Next: Machine Learning