

## 2054-09-12 Lecture #11

## Lecture #11 Meghalogial Operation Garrett Wells revised September 12, 2004

## Lecture #11

Morphological Operations

Garrett Wells revised September 12, 2024

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**Morphological Operations** 

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Opening

Closing

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Review



Thresholding

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# Lecture #11 -Review -Rev Review

Thresholding
1. Set/calculate threshold value

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—Review
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Thresholding
1. Set/calculate threshold

## Thresholding

- 1. Set/calculate threshold value
- 2. Compare to pixel values





#### Thresholding

- 1. Set/calculate threshold value
- 2. Compare to pixel values
- 3. Choose whether to keep/modify pixel values





Set/calculate threshold value

Compare to pixel values
 Choose whether to keep/modify pixel values

#### Thresholding

- 1. Set/calculate threshold value
- 2. Compare to pixel values
- 3. Choose whether to keep/modify pixel values
- 4. Output is a binary mask





- 2 Compare to pixel values
- 3. Choose whether to keep/modify pixel values
- 4. Output is a binary mask

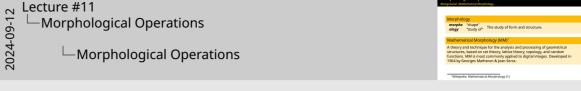
Background: Mathematical Morphology...

## Morphology

morpho "shape"
ology "study of"
The study of form and structure.

## Mathematical Morphology (MM)<sup>1</sup>

A theory and technique for the analysis and processing of geometrical structures, based on set theory, lattice theory, topology, and random functions. MM is most commonly applied to digital images. Developed in 1964 by Georges Matheron & Jean Serra.



- 1. MM was applied to binary images during the 1960s and 70s[1].
- 2. MM added gradient, top-hat, and watershed(segmentation) in the 1980-80 time range [1].

<sup>&</sup>lt;sup>1</sup>Wikipedia: Mathematical Morphology [1]

In image processing...

Morphological Image Processing<sup>1</sup>

Apply a "Structuring Element"<sup>2</sup> (kernel) to a function (image) to calculate an output.

<sup>2</sup>Wikipedia: Structuring Element [3]

-Morphological Operations

Lecture #11

1. Morphological operations apply structuring element to image to see how the element fits the image. Operations are defined mathematically as applying to two sets (source image and struct. element/kernel).

Wikipedia: Digital Image Processing (2)

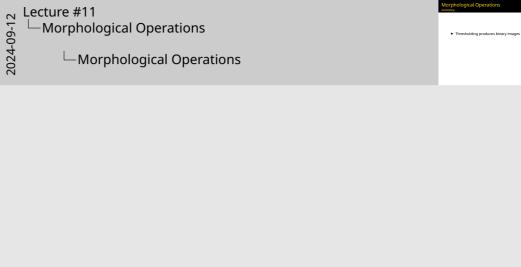
2. Example of simple operation: apply structuring element(set B) to image(set A), if completely contained by image, set output pixel (center/anchor pixel) to minimum value (0) if any pixel in source set A is 0. This is called erosion as it decreases size of objects (1's).

<sup>&</sup>lt;sup>1</sup>Wikipedia: Digital Image Processing [2]

<sup>—</sup>Morphological Operations

Summary...

► Thresholding produces binary images



Summary...

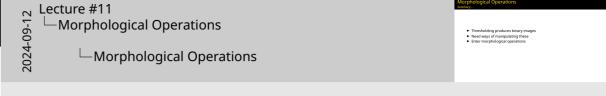
- ► Thresholding produces binary images
- ► Need ways of manipulating these



► Thresholding produces binary images

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- ► Thresholding produces binary images
- ► Need ways of manipulating these
- ► Enter morphological operations

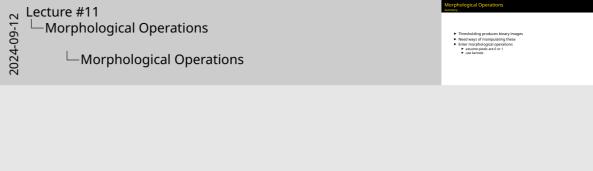


- ► Thresholding produces binary images
- ► Need ways of manipulating these
- ► Enter morphological operations
  - assume pixels are 0 or 1

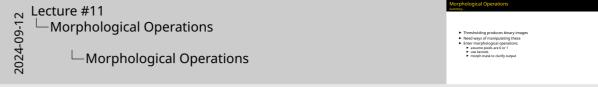




- ► Thresholding produces binary images
- ► Need ways of manipulating these
- ► Enter morphological operations
  - ► assume pixels are 0 or 1
  - ▶ use kernels



- ► Thresholding produces binary images
- ► Need ways of manipulating these
- ► Enter morphological operations
  - ► assume pixels are 0 or 1
  - ▶ use kernels
  - ► morph mask to clarify output



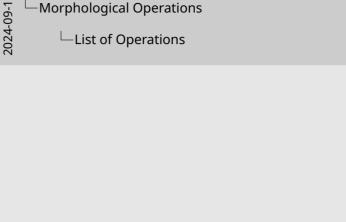
## List of Operations

Morphological Types<sup>12</sup> 1. Erosion 2. Dilation

- 3. Opening 4. Closing
- 5. Morphological Gradient
- 6. Top Hat
- 7. Black Hat
- 8. Hit or Miss
- - <sup>1</sup>Defined in enum cv.MorphTypes

<sup>2</sup>Sourced from OpenCV Docs[4]

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2 Dilation 3. Opening 4 Closing 5. Morphological Gradient 6. Top Hat

7. Black Hat 8 Hit or Miss

Defined in enum cv . MozphTypes Sourced from OpenCV Docs[4]

#### Erosion

Original image pixel is only 1 if *all* pixels under kernel are 1.

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—Morphological Operations
—Erosion
—Erosion

Eronion
Original image pixel is only 1 if all pixels under kernel are 1.

#### Erosion

Original image pixel is only 1 if *all* pixels under kernel are 1.

► Analogous to soil erosion, shrinks or "erodes" edges of foreground Figure: Original (white) object



Figure: Output



N Lecture #11 -Morphological Operations 2024-09-1 -Erosion └─Erosion

Original image pixel is only 1 if all pixels under kernel are 1. Analogous to soil erosion, shrinks or "erodes" edges of foreground

#### Erosion

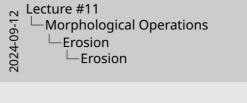
Original image pixel is only 1 if *all* pixels under kernel are 1.

- ► Analogous to soil erosion, shrinks or "erodes" edges of foreground (white) object Figure: Original
- (white) object▶ Decrease area of white objects



Figure: Output





Original image pixel is only 1 full pixels under kernel are 1.

Arabiggues to sail encolors, thrinks or Yauder edges of foreground (white) object

Decreases area of white objects









#### Erosion

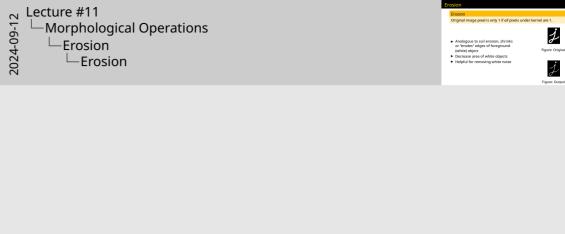
Original image pixel is only 1 if *all* pixels under kernel are 1.

- ► Analogous to soil erosion, shrinks or "erodes" edges of foreground (white) object
- ► Decrease area of white objects ► Helpful for removing white noise



Figure: Original

Figure: Output



#### Erosion

Original image pixel is only 1 if *all* pixels under kernel are 1.

- ► Analogous to soil erosion, shrinks or "erodes" edges of foreground Figure: Original (white) object
- ► Decrease area of white objects
- ► Helpful for removing white noise

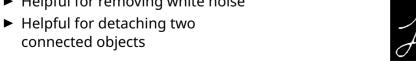
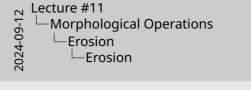


Figure: Output





Original image pixel is only 1 if all pixels under kernel are 1.

Figure: Output

#### Dilation

Set pixel to 1 if *any* pixel under the kernel is 1.

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—Dilation

Dilation
Set pixel to 1 if any pixel under the kernel is 1.

## Dilation

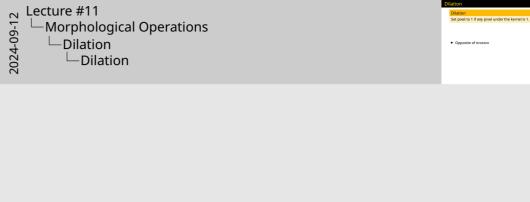
Set pixel to 1 if *any* pixel under the kernel is 1.

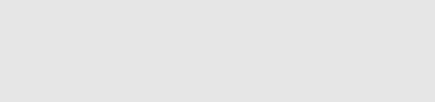
► Opposite of erosion

# Figure: Original



Figure: Output





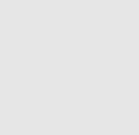


Figure: Output

#### Dilation

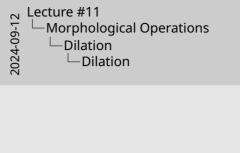
Set pixel to 1 if *any* pixel under the kernel is 1.

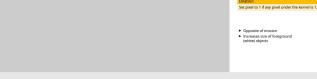
- ► Opposite of erosion ► Increases size of foreground

(white) objects

















#### Dilation

Set pixel to 1 if any pixel under the kernel is 1.

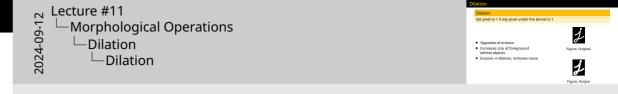
- ► Opposite of erosion
- ► Increases size of foreground
- (white) objects ► Erosion → dilation, removes noise



Figure: Original



Figure: Output



#### Dilation

Set pixel to 1 if *any* pixel under the kernel is 1.

► Opposite of erosion

objects

- ► Increases size of foreground (white) objects
- ► Erosion → dilation, removes noise ► Helpful for joining disconnected



Figure: Original

Figure: Output

N Lecture #11 -Morphological Operations 2024-09 —Dilation ☐ Dilation

➤ Opposite of erosion ► Increases size of foreground (white) objects Erosion → dilation, removes noise ► Helpful for joining disconnected

Set pixel to 1 if any pixel under the kernel is 1.



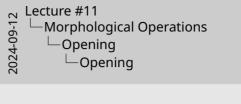




## Opening

## Opening

Another name for erosion → dilation.



Opening

Another name for erosion — dilation.

## Opening

#### Opening

Another name for erosion  $\rightarrow$  dilation.

- ► Helps maintain size
- Removes noise (gaps in background)



Figure: Input & Output

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Morphological Operations

Opening

Opening

Place of the proper control (ages in background)

jj

## Closing

Opening

Dilation → Erosion

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—Closing └─Morphological Operations └**Closing** └**Closing** 

## Closing

## Opening

Dilation → Erosion

- ► Closes gaps in foreground
- Helps maintain size of original object



Figure: Input & Output

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Morphological Operations

Closing

Closing

Closing

Industrial size of original object.

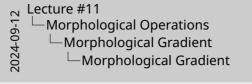
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Figure liquid & Output.

## Morphological Gradient

## Morphological Gradient

- 1. Dilation
- 2. Erosion
- 3. Output is difference between dilation and erosion



3. Output is difference between dilation and erosion

## Morphological Gradient

#### Morphological Gradient

- 1. Dilation
- 2. Erosion
- 3. Output is difference between dilation and erosion

► Looks like an object outline



Figure: Input & Output

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-Morphological Gradient
-Morphological Gradient



## Top Hat

## Black Hat

- 1. Opening
- 2. Output is difference between opening of image and source image





### Top Hat

#### Black Hat

1. Opening

► Enhance bright objects in dark

background [5]

2. Output is difference between opening of image and source image



Figure: Opening Input & Output



Figure: Top Hat Input & Output

N Lecture #11 -Morphological Operations 2. Output is difference between opening of image and source image 2024-09 11 └─Top Hat Figure: Opening Input & Output ► Enhance bright objects in dark └─Top Hat background [5] Figure: Top Hat Input & Output

## Top Hat Example: Galaxy

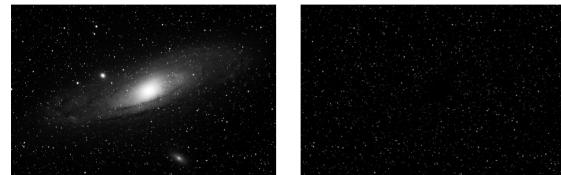


Figure: Top Hat Input Figure: Top Hat Output

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Morphological Operations

Top Hat

Top Hat Example: Galaxy

Injure Top Hat Example: Galaxy

## Black Hat

## Black Hat

- 1. Closing
- 2. Output is difference between closing of image and source image

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—Black Hat

Black test

1. Custing

2. Output is difference between closing of image and source image

#### Black Hat

#### Black Hat

1. Closing

background

► Enhances dark objects on bright

2. Output is difference between closing of image and source image



Figure: Closing Input & Output



Figure: Black Hat Input & Output

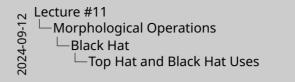
N Lecture #11 -Morphological Operations 2. Output is difference between closing of image and source image 2024-09 -Black Hat Figure: Closing Input & Outpu └─Black Hat Figure: Black Hat Input & Output

## Top Hat and Black Hat Uses

► Good for small details



Figure: MRI Brain Scan





► Good for small details

## Top Hat and Black Hat Uses

- ► Good for small details
- ► Feature extraction

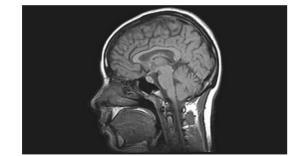
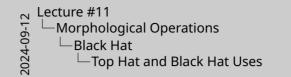


Figure: MRI Brain Scan





## Top Hat and Black Hat Uses

- ► Good for small details
- ► Feature extraction
- ► Medical imaging

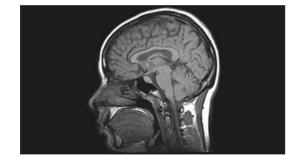
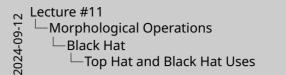


Figure: MRI Brain Scan





- Feature extraction
- ► Medical imaging



Figure: MRI Brain Scan

## Morphology in OpenCV

```
cv.erode(
    src,
    kernel, # kernel of desired size, all ones
           # other params have default values
cv.dilate(
    src,
    kernel, # kernel of desired size, all ones
           # default values
```

```
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Morphological Operations

Morphology in OpenCV

Morphology in OpenCV

Morphology in OpenCV

Stere, a kernel, a kernel of desired size, all ones contained to the contained of the co
```

## Morphology in OpenCV

```
cv.morphologyEx(
    src,
    op,  # operation type enum value, cv.MorphTypes
    kernel, # supply kernel, all ones
    ...  # other params have default values
)
```

```
Lecture #11
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—Morphology in OpenCV
—Morphology in OpenCV
```



## Looking Ahead...

edge detection, outlines, segmentation

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—Morphology in OpenCV
—Looking Ahead...

Morphology used for:

er contours
er edge detection, outlines, segmentation

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—Bibliography

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