University of Idaho
Department of Computer Science
Coeur d'Alene

Lecture #11

Morphological Operations

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revised September 12, 2024

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1. Set/calculate threshold value

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Morphological Operations

Background: Mathematical Morphology…

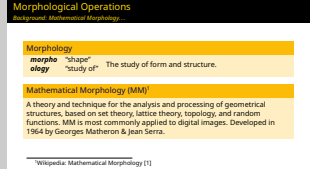
Morphology

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

Mathematical Morphology (MM)[1]

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] Wikipedia: Mathematical Morphology [1]



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].

Morphological Operations

In image processing…

Morphological Image Processing[1]

Apply a “Structuring Element”[2] (kernel) to a function (image) to calculate an output.

[1] Wikipedia: Digital Image Processing [2]
[2] Wikipedia: Structuring Element [3]

Morphological Operations
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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).
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).

Morphological Operations

Summary...

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List of Operations

Morphological Types[1][2]

1. Erosion
2. Dilation
3. Opening
4. Closing
5. Morphological Gradient
6. Top Hat
7. Black Hat
8. Hit or Miss

[1] Defined in enum `cv.MorphTypes`
[2] Sourced from OpenCV Docs[4]

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Figure: Output

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Opening

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- Removes noise (gaps in background)

Figure: Input & Output

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Closing

Opening

Dilation → Erosion

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Dilation → Erosion

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

Figure: Input & Output

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Dilation → Erosion
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Morphological Gradient

Morphological Gradient

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

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Top Hat

Black Hat

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

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- Enhance bright objects in dark background [5]

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Top Hat Example: Galaxy

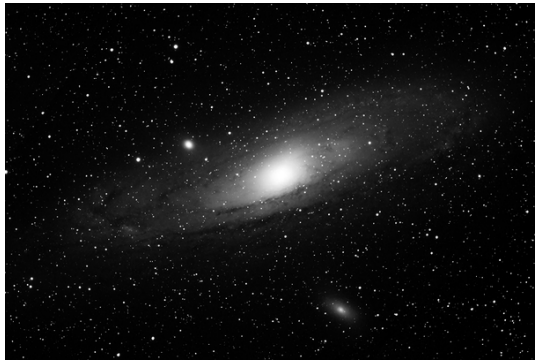

Figure: Top Hat Input

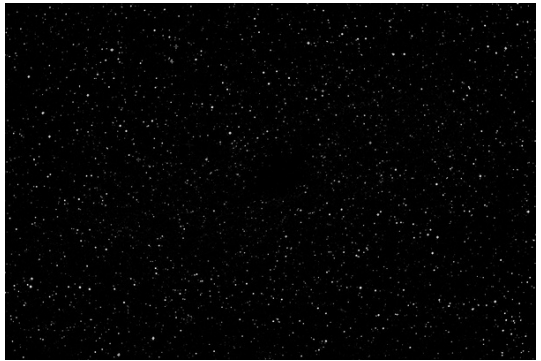

Figure: Top Hat Output

Top Hat Example: Galaxy

Figure: Top Hat Input

Figure: Top Hat Output

Black Hat

Black Hat

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

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Figure: Closing Input & Output

- Enhances dark objects on bright background

Figure: Black Hat Input & Output

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Black Hat
1. Closing
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Figure: Closing Input & Output
- Enhances dark objects on bright background
Figure: Black Hat Input & Output

Top Hat and Black Hat Uses

- Good for small details

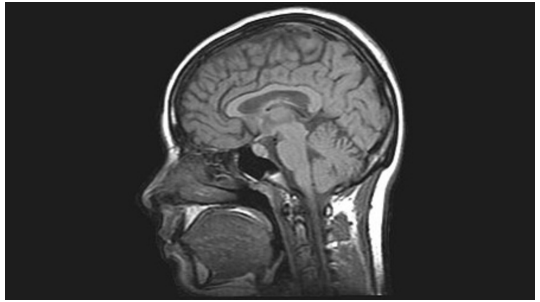
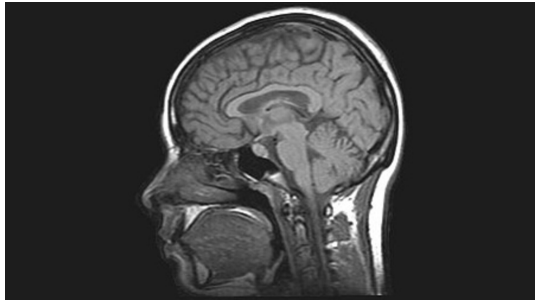


Figure: MRI Brain Scan

Top Hat and Black Hat Uses
- Good for small details
Figure: MRI Brain Scan

Top Hat and Black Hat Uses

- Good for small details
- Feature extraction



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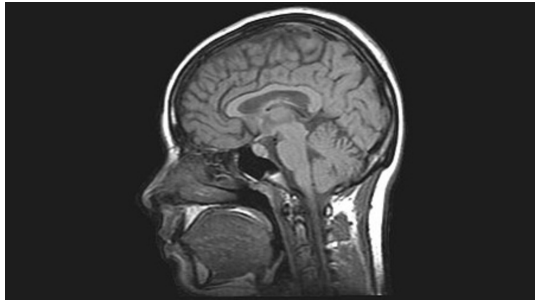

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- Good for small details
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Morphology in OpenCV

```
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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```
cv.erode(
    src,
    kernel, # kernel of desired size, all ones
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cv.dilate(
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```

Morphology in OpenCV

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


Morphology in OpenCV

```python
cv.morphologyEx(
    src,
    op,     # operation type enum value, cv.MorphTypes
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Looking Ahead...

Morphology used for:

- ☞ contours
- ☞ edge detection, outlines, segmentation

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[1] *Mathematical morphology*, in *Wikipedia*, Aug. 5, 2024. [Online]. Available: https://en.wikipedia.org/w/index.php?title=Mathematical_morphology&oldid=1238788185 (visited on 09/12/2024).

[2] *Digital image processing*, in *Wikipedia*, Sep. 7, 2024. [Online]. Available: https://en.wikipedia.org/w/index.php?title=Digital_image_processing&oldid=1244485894#Image_denoising_with_Morphology (visited on 09/12/2024).

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