
Definition

Thresholding is a technique used to separate an object from its background in an image. It converts pixel values to either black (0) or white (255) based on a defined threshold:

- **Pixels below the threshold** represent the background.
- **Pixels above the threshold** represent the object.

This makes it easier to analyze or process the image.

Global Thresholding

Definition

Applies a single threshold value to the entire image.

Code Example

```
success, binary_threshold = cv2.threshold(img, 64, 255, cv2.THRESH_BINARY)
# Pixels with values <= 64 are set to 0 (black), and > 64 are set to 255 (white)
# In color images, each channel is thresholded and appears in different colors
cv2.imshow("Binary Threshold", binary_threshold)
cv2.waitKey(0)
```

Adaptive Thresholding

Definition

Adaptive thresholding is a method to calculate the threshold dynamically for small regions of the image. Unlike global thresholding, it determines the threshold value based on the local neighborhood of each pixel, making it effective for images with uneven lighting conditions.

Why Adaptive Thresholding?

- Useful when the lighting in the image is not uniform.
- Ensures better segmentation in areas with varying illumination.

```
cv2.adaptiveThreshold( gray_img, 255, {type}, cv2.THRESH_BINARY, block_size, offset )
```

Types of Adaptive Thresholding

1. Gaussian Adaptive Thresholding

- Uses the weighted mean of pixel values within the block (neighborhood) to calculate the threshold.

```
gaussian_threshold = cv2.adaptiveThreshold( gray_img, 255,
cv2.ADAPTIVE_THRESH_GAUSSIAN_C, cv2.THRESH_BINARY, 11, 3 )
cv2.imshow("Gaussian Threshold", gaussian_threshold) cv2.waitKey(0)
```

2. Mean Adaptive Thresholding

- Uses the simple mean of pixel values within the block to calculate the threshold.

```
mean_threshold = cv2.adaptiveThreshold( gray_img, 255,
cv2.ADAPTIVE_THRESH_MEAN_C, cv2.THRESH_BINARY, 11, 3 ) cv2.imshow("Mean
Threshold", mean_threshold) cv2.waitKey(0)`
```

Key Parameters in Adaptive Thresholding

1. Block Size

- **Definition:** The size of the neighborhood (square) used to calculate the threshold. Must be an odd number (e.g., 3, 5, 7, etc.).
- **Effect:**
 - Smaller block sizes make the method sensitive to fine details but also noise.
 - Larger block sizes smooth out local variations but may miss finer details.

2. Offset

- **Definition:** A constant subtracted from the mean or weighted mean.
 - **Effect:**
 - A positive offset results in fewer foreground (white) pixels.
 - A negative offset results in more foreground pixels.
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Differences Between Global and Adaptive Thresholding

Feature	Global Thresholding	Adaptive Thresholding
Threshold Value	Single value for the entire image	Varies for different regions of the image
Lighting Conditions	Works well with uniform lighting	Suitable for uneven lighting conditions
Complexity	Simple and fast	Computationally more expensive
Edge Detection	May fail in non-uniform lighting	Better edge preservation in varied lighting

When to Use Which?

- **Global Thresholding:**
 - Use when the image has **uniform lighting**.
 - Suitable for simple segmentation tasks.
- **Adaptive Thresholding:**
 - Use when the image has **uneven lighting** or complex backgrounds.
 - Ideal for detailed segmentation and preserving finer edges.

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 *"Turning thoughts into insights."*