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AI385 lab 8

Hough Transform

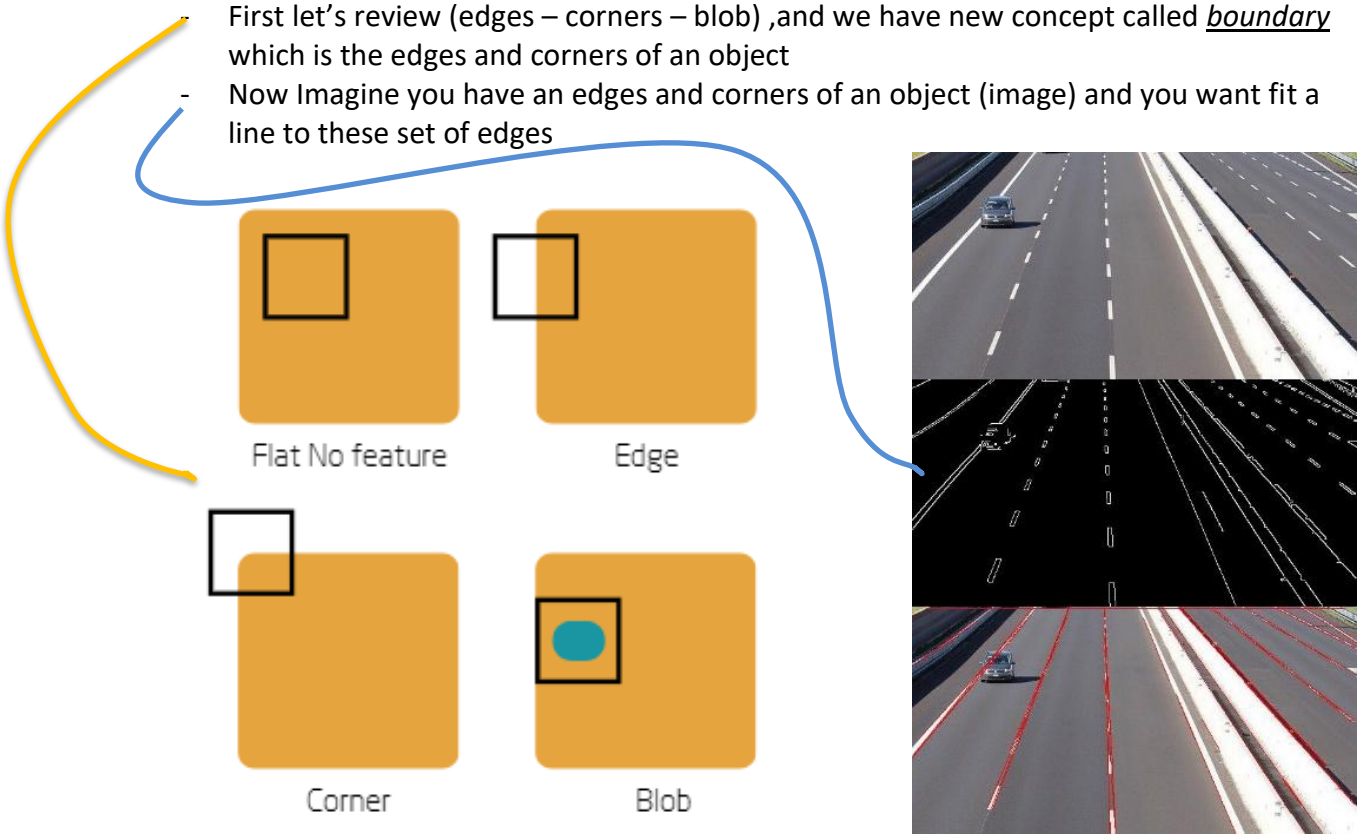
Learning Objectives:

- *To use OpenCV for understanding the concept of the Hough Transform.*
- Implement **Hough Line Transform** for edge-based boundary detection.
- Implement **Hough Circle Transform** for circular boundary detection.
- Apply boundary detection to a real-world medical data.

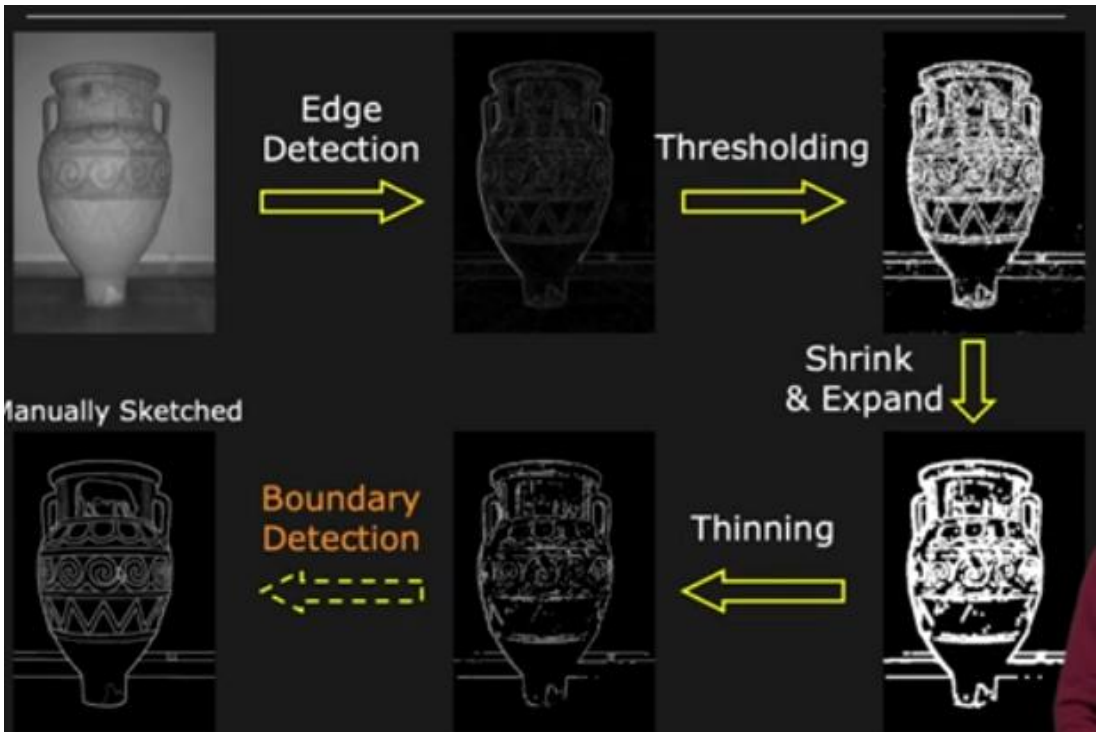
Introduction

Hough Line Transform is a powerful technique in computer vision used to detect **lines and curves** in an image. It is widely used in applications such as **lane detection in self-driving cars, document analysis, object detection, and medical imaging**.

- First let's review (edges – corners – blob) ,and we have new concept called *boundary* which is the edges and corners of an object
- Now Imagine you have an edges and corners of an object (image) and you want fit a line to these set of edges



- To Summarize this is our problem: **(WE NEED A METHOD THAT ENABLE US TO CONNECT DETECTED FEATURES IN ORDER TO YIELD THE BOUNDRY OF THE OBJECT)**
- this problem call *boundary detection*



1- Understanding Hough Line Transform

📌 Why Is Hough Transform Important?

Hough Transform is a feature extraction technique used to detect geometric shapes like **lines, circles, and ellipses**. Unlike edge detection techniques, it can identify **incomplete and occluded lines**, making it robust for real-world applications.

📌 How Does Hough Line Transform Work?

1. **Edge Detection:** Convert an image to grayscale and apply **Canny Edge Detection** to highlight edges.
2. **Hough Space Representation:** Transform image space (x, y) into **parameter space (ρ, θ)**, where:
    a. **ρ** (rho) is the perpendicular distance from the origin to the line.
    b. **θ** (theta) is the angle between the x-axis and the perpendicular line to the detected edge.
3. **Voting Mechanism:** Every detected edge point **votes** for possible lines that pass through it.
4. **Line Detection:** The peaks in Hough space represent the most probable lines in the image.

2- Detecting Boundaries Using Hough Line Transform

🛠️ **Task: Implement Hough Transform for Boundary Lines**

This task will help you detect straight-line boundaries in an image using Hough Line Transform.

Step-by-Step Explanation:

- Convert the image to grayscale.
- Apply Canny Edge Detection to highlight edges.
- Use Hough Line Transform to detect straight lines.
- Convert detected ρ, θ values into (x, y) line coordinates.
- Draw the detected lines on the image.

```
import cv2
import numpy as np

# Load an image in grayscale
gray = cv2.imread(r'C:\Users\m.nasif\Desktop\OneDrive - University of Prince
Mugrin\CV\Lab 78\chess.jpg', cv2.IMREAD_GRAYSCALE)
# Apply Canny Edge Detection
edges = cv2.Canny(gray, 50, 150)
# Apply Standard Hough Line Transform
lines = cv2.HoughLines(edges, rho=1, theta=np.pi/180, threshold=100)
# Convert edges to color image to draw lines
output = cv2.cvtColor(edges, cv2.COLOR_GRAY2BGR)

# Draw detected lines
if lines is not None:
    for line in lines:
        rho, theta = line[0]
        a = np.cos(theta)
        b = np.sin(theta)
        x0 = a * rho  # x-coordinate of the line's intersection with the
normal
        y0 = b * rho  # y-coordinate of the line's intersection with the
normal
        x1 = int(x0 + 1000 * (-b))  # Compute x-coordinates for line extension
        y1 = int(y0 + 1000 * (a))   # Compute y-coordinates for line extension
        x2 = int(x0 - 1000 * (-b))
        y2 = int(y0 - 1000 * (a))
        cv2.line(output, (x1, y1), (x2, y2), (0, 0, 255), 2)  # Draw line in
red
# Display results
cv2.imshow('Edges', edges)
cv2.imshow('HoughLines - Standard', output)
cv2.waitKey(0)
cv2.destroyAllWindows()
```

📌 **Adjusting Parameters of `cv2.HoughLines()` for Different Results**

- **Increase threshold** → Detect fewer but stronger lines (useful in noisy images).
- **Decrease threshold** → Detect more lines (can introduce false positives).
- **Increase rho** → Lower precision but faster execution.
- **Decrease rho** → Higher precision but slower computation.
- **Use theta=np.pi/90** instead of np.pi/180 → Detects lines at a **2-degree** resolution.

3- Detecting Circular Boundaries Using Hough Circle Transform

🛠️ **Task: Implement Hough Circle Transform**
This task will help you detect circular boundaries using **Hough Circle Transform**.
Step-by-Step Explanation:

- Apply **Canny Edge Detection** to detect edges.
- Use **Hough Circle Transform** to detect circular boundaries.
- Set parameters like:
  - param1 → Edge detection threshold.
  - param2 → Circle detection threshold.
  - minRadius, maxRadius → Define the range of detected circle sizes.
- Draw detected circles on the image.

```
import cv2
import numpy as np

# Load an image in grayscale
gray = cv2.imread(r'C:\Users\m.nasif\Desktop\OneDrive - University of Prince
Mugrin\CV\Lab 78\temp1.png', cv2.IMREAD_GRAYSCALE)
# Apply Gaussian Blur to reduce noise
blurred = cv2.GaussianBlur(gray, (9, 9), 2)
# Apply Hough Circle Transform
circles = cv2.HoughCircles(blurred,
                           method=cv2.HOUGH_GRADIENT,
                           dp=1.2,
                           minDist=30,
                           param1=50,
                           param2=30,
                           minRadius=10,
                           maxRadius=100)

# Convert to color image for drawing
output = cv2.cvtColor(gray, cv2.COLOR_GRAY2BGR)

# Draw detected circles
if circles is not None:
    circles = np.uint16(np.around(circles))
    for i in circles[0, :]:
        cv2.circle(output, (i[0], i[1]), i[2], (0, 255, 0), 2)  # Draw circle
in green
        cv2.circle(output, (i[0], i[1]), 2, (0, 0, 255), 3)  # Draw center in
red

# Display results
cv2.imshow('Blurred', blurred)
cv2.imshow('HoughCircles - Detected Circles', output)
cv2.waitKey(0)
```

```
cv2.destroyAllWindows()
```

📌 **Adjusting Parameters of `cv2.HoughCircles()` for Different Results**

- **Increase minDist** → Prevents detecting too many nearby circles (useful for detecting **individual objects** like coins).
- **Decrease minDist** → Detects circles even if they are close to each other (useful for **clustered objects**).
- **Increase param2** → Only strong, well-defined circles will be detected.
- **Decrease param2** → More circles will be detected, including weak or false positives.
- **Increase dp** → Speeds up the algorithm by reducing resolution.
- **Increase minRadius and maxRadius** → Restricts detection to specific-sized circles.

Exercises

Exercise 1: Boundries Detection:

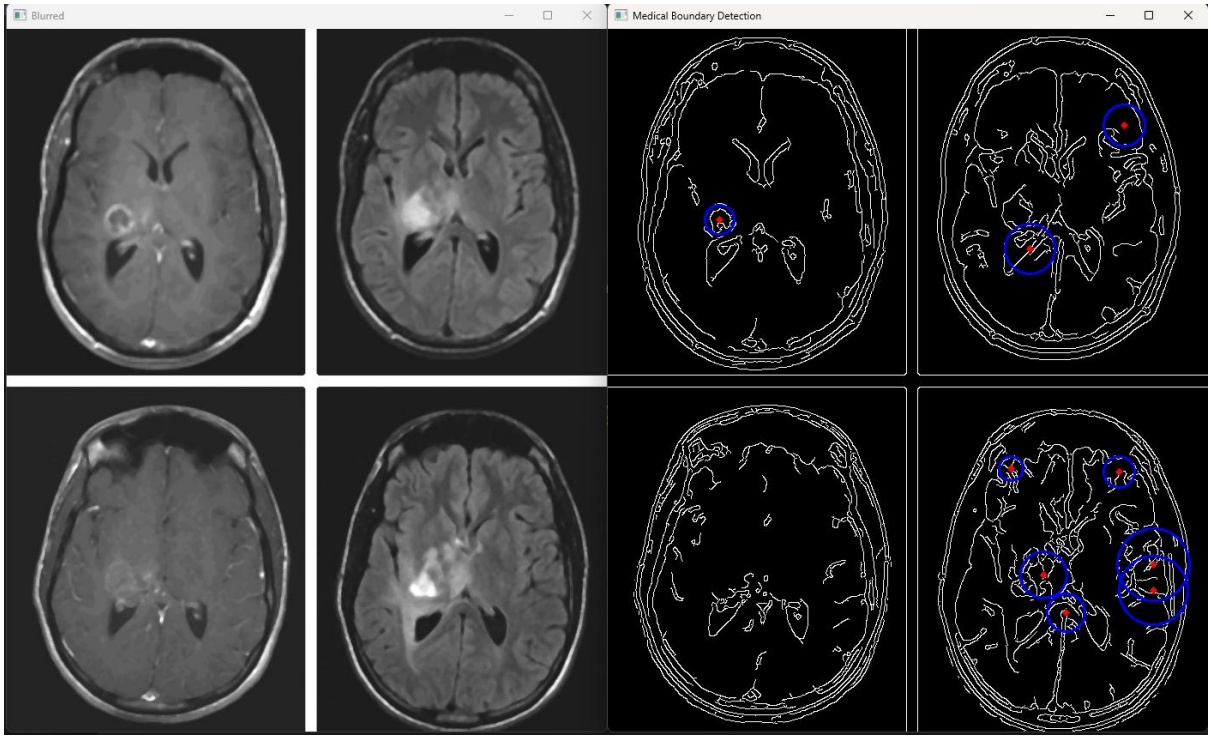
a- **Modify the parameters of the `cv2.HoughLines()` function and observe any changes**
b- **Modify the parameters of the `cv2.HoughCircles()` function and observe any changes**

Exercise 2: Detect Circular Boundaries in Medical Images

apply Hough Transform to medical images to detect circular structures like tumors, blood vessels, or cells.

Step-by-Step Explanation:

- Apply Median Blurring to remove noise.
- Use Canny Edge Detection to highlight edges.
- Detect circular boundaries using cv2.HoughCircles().
- Draw detected boundaries on the medical image.



Expected output