Project Process: Pedestrian Detection Using HOG + SVM

Data Loading:

- Loaded a static image using OpenCV (cv2.imread()), which contains potential pedestrians to be detected.
- Resized the image using imutils.resize() to standardize input dimensions, ensuring consistent detection results.

Initial Exploration:

- Visualized the original image to understand scale, lighting, and pedestrian positioning.
- Made an initial copy of the image for visual comparison before and after post-processing.

Feature Extraction:

- Initialized the **Histogram of Oriented Gradients (HOG)** descriptor using OpenCV.
- Set up the **pre-trained SVM classifier** with cv2.HOGDescriptor_getDefaultPeopleDetector() for pedestrian recognition.

Pedestrian Detection:

- Used the hog.detectMultiScale() method with parameters like:
    - winStride to determine the step size of the detection window,
    - padding to fine-tune detection coverage,
    - scale to manage image pyramid scaling.
- Detected bounding boxes (rects) and associated confidence levels (weights) for each region flagged as a pedestrian.

Visualization (Before Suppression):

- Drew **red bounding boxes** on a copy of the image to display all raw detections, including overlapping boxes.
- Displayed the image using cv2.imshow() to observe preliminary detection results.

Post-Processing – Non-Maximum Suppression (NMS):

- Converted detection rectangles into the [x1, y1, x2, y2] format required by the NMS algorithm.
- Applied non_max_suppression() from imutils to:
    - Remove overlapping bounding boxes,
    - Retain the most confident and distinct detections using an overlapThresh of 0.65.

Visualization (After Suppression):

- Drew **green bounding boxes** on the original image for refined results.
- Compared these with the initial detections to highlight the improvement achieved through NMS.
- Used OpenCV windows (cv2.imshow(), cv2.waitKey(), cv2.destroyAllWindows()) to present results clearly.

Modeling and Analysis:

- Evaluated the effectiveness of the HOG + SVM approach in detecting pedestrians under varying scale and lighting conditions.
- Observed how tuning parameters like stride size, padding, and scale influenced detection precision and speed.
- Analyzed detection errors (false positives or missed detections) and noted potential improvements using advanced models (e.g., YOLO, SSD).

Evaluation:

- Compared detection results before and after applying NMS to quantify the reduction in redundant detections.

- Measured the model’s ability to correctly identify pedestrians in crowded or cluttered scenes.
- Analyzed limitations of traditional HOG-based methods compared to deep learning alternatives.