

1 a) Training Performance

Stage	TPR	FPR
Stage 1	1.0	2×10^{-3}
Stage 2	1.0	3.296×10^{-5}
Stage3	1.0	1.07166×10^{-6}

Figure 1: TPR vs FPR training

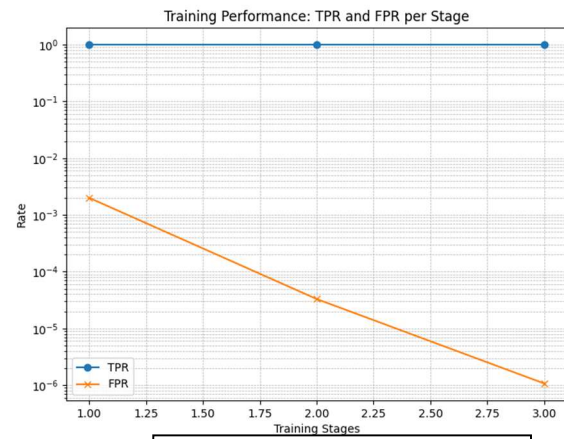


Figure 2: TPR vs FPR graph

As expected with AdaBoost it focuses on improving misclassification in subsequent stages. The False Positive rate decreases while the true positive remains stable, which is ideal since the TPR is already at its maximum value.

1. b) Test Performance

Image	TPR	F1
Image 0	1.0	0.27
Image 1	1.0	0.4
Image 2	1.0	0.22
Image 3	1.0	0.57
Image 4	1.0	0.33
Image 5	0.3	0.23
Image 6	0.5	0.4
Image 7	1.0	0.15
Image 8	0.75	0.67
Image 9	0.5	0.33
Image 10	0.67	0.5
Image 11	0.0	0.0
Image 12	0.5	0.55
Image 13	0.0	0.0
Image 14	1.0	0.22
Image 15	1.0	0.57
Average	0.7	0.33



Figure 3: Viola Jones

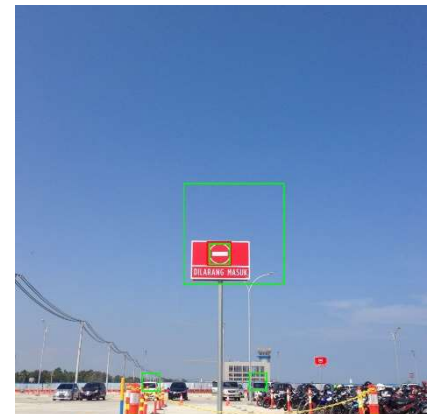


Figure 4: Viola Jones

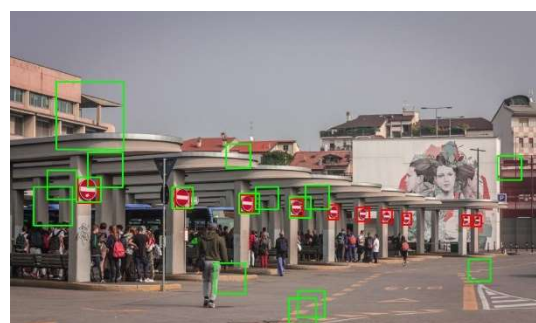


Figure 5: Viola Jones

Difference TPR:

The TPR values differ from a due to the noise or challenging scenarios like the ones seen in figure 2 where one of the signs is really far it appears really small and does not cover as many pixels. Or in figure 3 where it the signs are both distant and rotated in different angles. Noise, like the amount of people in figure 3 or because some signs are blocked by something or overlapping with other images.

Performance:

The detector has good recall but bad precision. It not able to deal with distance signs and can't distinguish signs of different colour i.e. thinks the blue direction to be a no entry sign this is due to viola jones using the greyscale image.

SUBTASK 2: Viola Jones with Hough Transform

Image	TPR	F1	Difference in TPR vs VJ	Difference in F1 vs VJ
Image 0	0.5	0.18	-0.5	-0.09
Image 1	1.0	0.67	0	+0.27
Image 2	1.0	0.4	0	+0.18
Image 3	1.0	0.57	0	+0
Image 4	1.0	0.4	0	+0.07
Image 5	0.3	0.35	0	+0.12
Image 6	0.5	0.44	0	+0.04
Image 7	0.0	0.0	-1	-0.15
Image 8	0.75	0.75	0	+0.08
Image 9	0.5	0.67	0	+0.34
Image 10	0.67	0.5	0	0
Image 11	0.5	0.22	-0.5	+0.22
Image 12	0.625	0.52	-0.125	-0.03
Image 13	0.0	0.0	0	0
Image 14	1.0	0.4	0	+0.18
Image 15	1.0	1.0	0	-0.43
Average	0.65	0.45	-0.05	+0.12

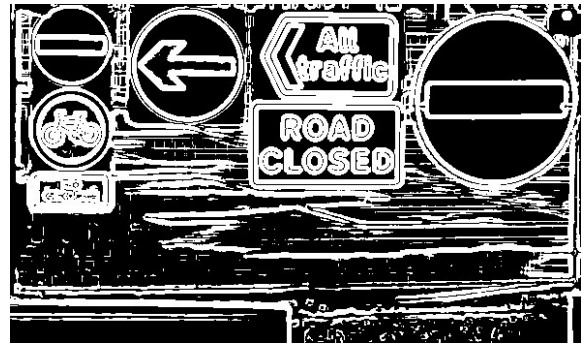


Figure 5: magnitude



Figure 6: Hough space



Figure 7: results



Figure 8: magnitude



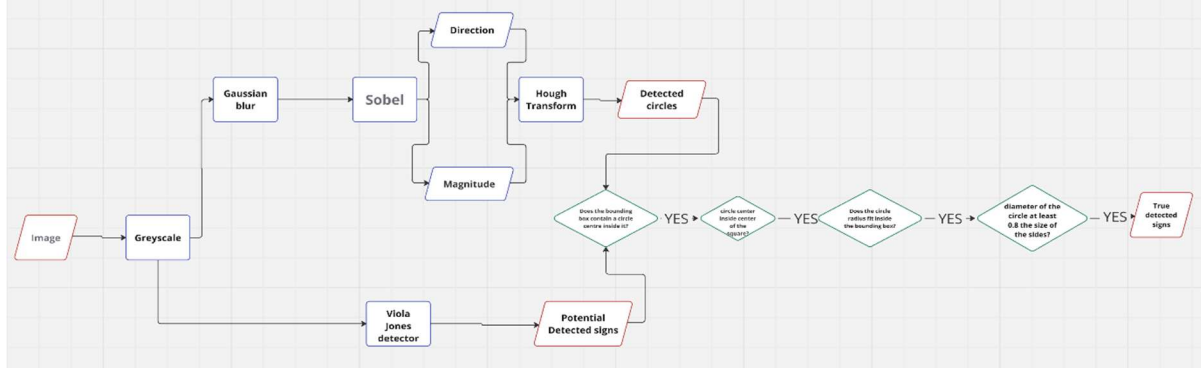
Figure 9: Hough space



Figure 10:
results

Merits and shortcomings:

- increased F1 score by 12% while maintaining the TPR rate i.e. increased precision without decreasing recall
- still cannot filter out the blue direction sign due to being a circle.
- Hough transform accurate on images with low edge pixels see figure 8 and 9
- gets rid of disproportionate bounding boxes and ones that overlap the sign but not actually detecting it see figure 10 and figure 4



- Apply the Hough Transform to the entire image and use a threshold of 8 votes to filter out potential circles.
- Use a more lenient Viola-Jones detector on the image, requiring only one neighbor for a potential bounding box instead of three.
- This leniency is introduced to account for the stricter filtering steps that follow.
- For each bounding box:
 - Check if it contains any of the potential circles detected earlier.
 - Verify that the circle centre is within the central region of the bounding box, ensuring it is at least a quarter of the bounding box width away from each side.
 - Confirm that the circle's diameter fits within the bounding box by multiplying the bounding box dimensions by 1.2 to account for pixel noise.
 - Ensure the circle's diameter is not smaller than 0.8 times the bounding box dimensions to avoid circles disproportionately smaller than the bounding box.
- If a potential circle meets all these conditions, classify the corresponding bounding box as a true bounding box.

Subtask 3: RED PASS filter

HSV Conversion: Separates color (Hue) from intensity for precise red detection.

Dual Red Ranges: Captures all red shades spanning 0-10° and 170-180° in Hue.

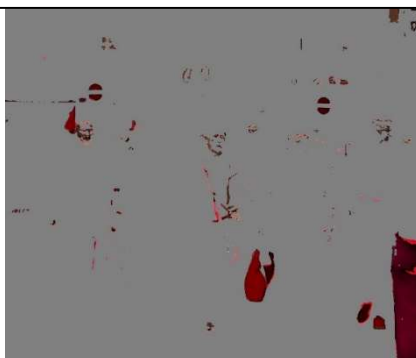
Mask Creation: Combines masks for both red ranges using bitwise OR.

Mask Application: Isolates red regions by applying the mask to the original image.

Brightness Boost: Enhances red regions by increasing the V (Value) channel.

Reconversion: Converts back to BGR for standard output compatibility

Image	TPR	F1	VJ and hough imp F1	Improv TPR
Image 0	1	1	+0.5	+0.82
Image 1	1	1	0	+0.33
Image 2	0	0	-1	-0.4
Image 3	1	1	0	+0.43
Image 4	1	1	0	+0.6
Image 5	0.4	0.5	+0.1	+0.15
Image 6	0.75	0.86	+0.25	+0.42
Image 7	1.0	0.67	+1	+0.67
Image 8	0.75	0.86	0	+0.11
Image 9	0.5	0.4	0	-0.27
Image 10	1.0	0.67	+0.33	+0.17
Image 11	1.0	1.0	+0.5	+0.78
Image 12	0.75	0.86	+0.125	+0.34
Image 13	1.0	1.0	+1	+1
Image 14	0	0.67	-1	+0.27
Image 15	1	1	0	0
Average	0.76	0.78	0.11	0.33



Merits:

- precision just as good as recall, while gaining an even higher TPR than viola jones on its own
- removes majority of the noise in the image like you see in the first example
- able to distinguish different coloured signs in the image, like in the second example.
- Reduces edge pixel and decreases computational time.
- Improves F score by 45% and TPR by 6% over VJ
- Improves F score by 33% and TPR by 11% over VJ and Hough detector

