Task 1

The images below have green boxes for the detected faces, red boxes for the ground truths and blue boxes for ground truths which were successfully detected with an Intersection-Over-Union greater than the threshold of 0.7.
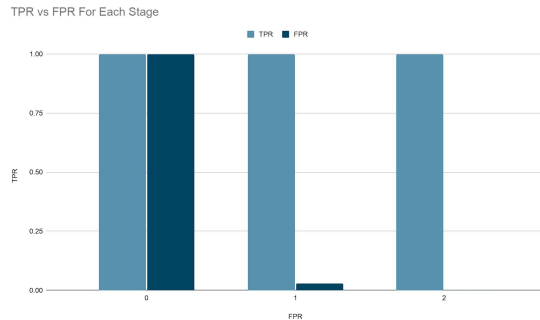

It's always possible to achieve a true positive rate of 100% because if every possible bound is detected then although there will be a high false positive rate, the true positive rate will be 100%.

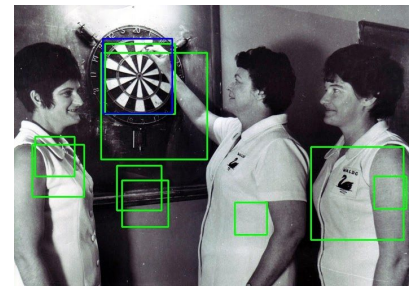| Test Image	True Positive Rate	F1-Score
dart0.jpg	0/1	
dart1.jpg	0/0	
dart2.jpg	0/0	
dart3.jpg	0/0	
dart4.jpg	1/1	1.0
dart5.jpg	11/11	0.88
dart6.jpg	0/1	
dart7.jpg	1/1	
dart8.jpg	0/1	
dart9.jpg	1/1	
dart10.jpg	0/0	
dart11.jpg	1/1	
dart12.jpg	0/0	
dart13.jpg	1/1	0.667
dart14.jpg	1/2	0.25
dart15.jpg	0/3	0.0

Task 2

The graph below shows the TPR vs FPR for each stage of the training. We can see that for all stages the TPR is 1 so all the positive images are detected for all stages. In each stage the FPR decreases so more of the negative images are rejected in each stage.

Testing Performance

The images below have green boxes for the detected faces, red boxes for the ground truths and blue boxes for ground truths which were successfully detected with an Intersection-Over-Union greater than the threshold of 0.7.

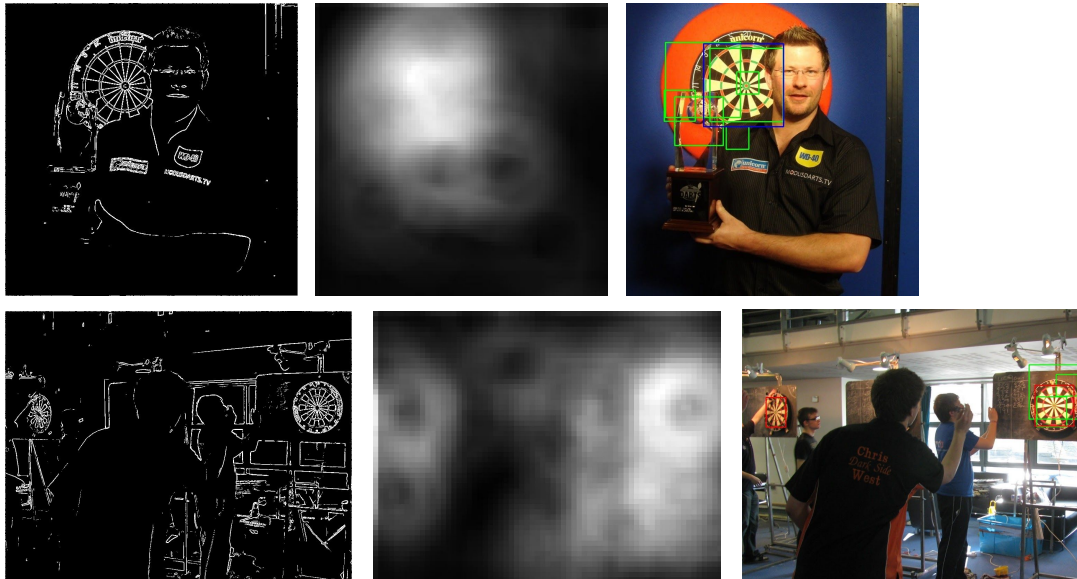| Test Image	True Positive Rate	F1-Score
dart0.jpg	1/1	0.167
dart1.jpg	1/1	0.125
dart2.jpg	0/1	0
dart3.jpg	1/1	0.333
dart4.jpg	1/1	0.077
dart5.jpg	0/1	0
dart6.jpg	1/1	0.182
dart7.jpg	0/1	0
dart8.jpg	0/2	0
dart9.jpg	0/1	0
dart10.jpg	0/3	0
dart11.jpg	1/1	0.154
dart12.jpg	0/1	0
dart13.jpg	0/1	0
dart14.jpg	0/2	0
dart15.jpg	1/1	0.2

Average TPR = 0.438
Average F1-Score = 0.077

The performance of the dartboard detector is a lot worse than the face detector which had an average F1-Score of 0.559 and an average TPR of 0.591.

Although the average TPR of the dartboard detector isn't much worse than the face detector, the average F1-Score is significantly lower because of the very high FPR.

Task 3

Below are the thresholded gradient magnitude images, 2D representations of the Hough Space and final detection images for dart4.jpg and dart8.jpg. The final detection images have green boxes for the detected faces, red boxes for the ground truths and blue boxes for ground truths which were successfully detected with an Intersection-Over-Union greater than the threshold of 0.7.

Test Image	TPR	F1-Score	F1 Difference
dart0.jpg	1/1	0.5	0.333
dart1.jpg	1/1	0.286	0.161
dart2.jpg	0/1	0	0
dart3.jpg	1/1	0.4	0.067
dart4.jpg	1/1	0.286	0.209
dart5.jpg	0/1	0	0
dart6.jpg	1/1	0.333	0.151
dart7.jpg	0/1	0	0
dart8.jpg	0/2	0	0
dart9.jpg	0/1	0	0
dart10.jpg	0/3	0	0
dart11.jpg	1/1	0.167	0.013
dart12.jpg	0/1	0	0
dart13.jpg	0/1	0	0
dart14.jpg	0/2	0	0
dart15.jpg	1/1	0.667	0.467

Average TPR = 0.438
Average F1-Score = 0.165

In this improved detector I implemented a Circle Hough Transform which I then combined with the Viola-Jones detector. I combined them by removing any detected dartboards that didn't intersect a detected circle. Initially I removed them if they didn't contain the center of a circle and although it resulted in a higher average F1-Score (0.177), it also caused a lower average TPR (0.25).

- Improved average F1-Score
- Reduced number of false positives

- TPR remained the same
- Hough Transform couldn't detect some dartboards because of the angle (See dart8.jpg example above)