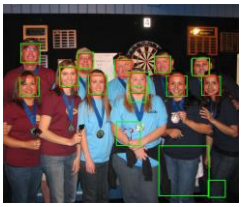
Dartboard Challenge: Image Processing and Computer Vision

Subtask 1: The Viola-Jones Object Detector

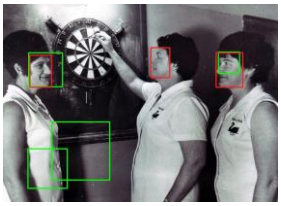


Image No.	0	1	2	3	4	5	6	7
Recall/TPR	0	1	1	1	1	1	0	1
F1 score	0	1	1	1	1	0.44	0	1

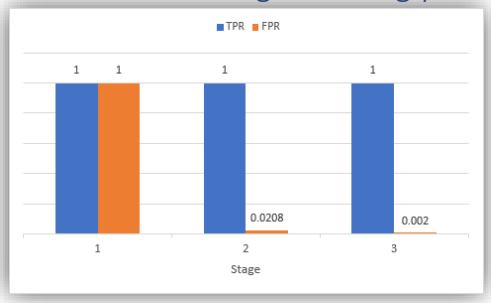
Image No.	8	9	10	11	12	13	14	15
Recall/TPR	0	1	na	1	1	1	0.66	1
F1 score	0	0.4	na	1	1	0.666	0.57	0.84

With many of the images, calculating a threshold was arbitrary. An example being Dart15.jpg [shown above], which while only meant to detect frontal faces, was able to pick up the two faces on the far left and right. Despite detecting them, they were not complete and required fine tuning the threshold to allow them as a True Positive. We started at a 0.5 threshold, but it missed a few faces. We lowered it to 0.4 and got a near 100% TPR across all images, even in image 14 where all the faces are at an angle, 2 of 3 were detected.

A result of this shows that with a lenient enough detector and threshold, you can achieve a 100% TPR. The problem with this would be detecting many False Positives, lowering the Precision. To see this, we look at the F1 score, a measure of precision and TPR [Hence Recall] combined. The F1 score drops dramatically with a low precision, even with a good Recall.

The way to circumnavigate this would be through appropriate training of the Viola-Jones algorithm. The detector currently detects many areas of images as FPs. With a better classifier this error rate should start to be reduced.

Subtask 2: Building & Testing your own Detector



The figure to the left is the chart depicting FPR and TPR during the training stages. Once the training has gone through one stage, the FPR drastically decreases. This is due to stage 0 not having a classifier yet thus the Viola-Jones algorithm accepts all images. Once the third stage has finished, the FPR is almost non-existent. Meanwhile the TPR does not decrease across all stages. This shows the adaboost training has found a progressively better classifiers by selecting and adding features. Here would be a good stage to end on as going any further increases the risk of overfitting without any major benefit.

Performance testing

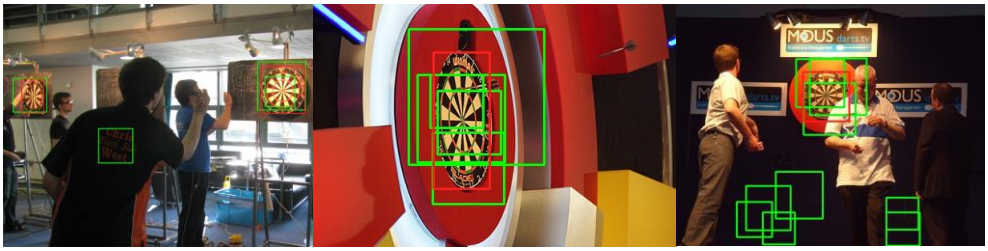


Image No.	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Recall/TPR	1	1	1	1	2	2	3	1
Precision	0.2	0.25	0.125	0.2	0.285	0.333	0.333	0.066
F1 score	0.333	0.4	0.222	0.333	0.5	0.571	0.6	0.125

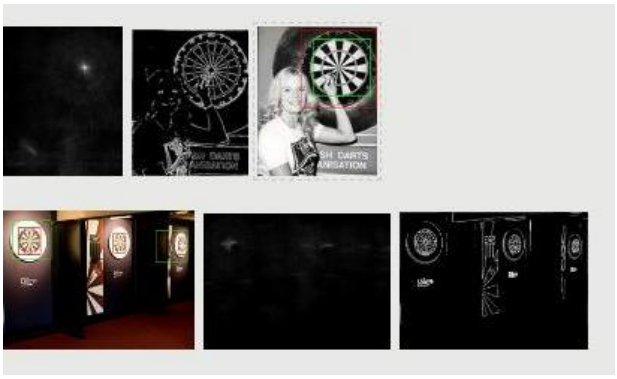
Image No.	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**Avg**
Recall/TPR	1.5	1	1	1	1	1	1	1	1.28
Precision	0.75	0.2	0.157	0.333	0.2	0.2	0.118	0.5	0.26
F1 score	1	0.333	0.272	0.5	0.333	0.333	0.211	0.667	0.42

Overall, every dart board was successfully identified but the precision left much to be desired. In many cases throughout the test data a dart board would be detected multiple times creating an issue of having the TPR calculation above 1. Which in turn throws off the F1 score. Compared to the performance seen from the training set, it is very lacking. There were many FPs throughout every image, as indicated by the precision in table 1. To reduce the False Positive Rate, the learning would need to be improved. With the training data given, the FPR was low so one method would be to increase the number of negative examples, perhaps increasing the complexity of these images to help isolate better features.

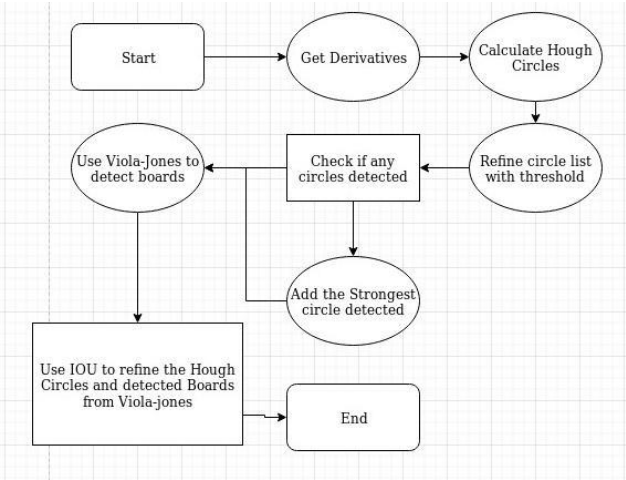
There are a few other ways to improve this method. One method, we could alter the program to take these multiple Detected Positives to create a new, single positive detection by averaging out the bounding boxes which overlap. Alternatively, using an altered Stable Match algorithm to pair the

Ground Truths with a detected board could also work to find the best single detection for each Truth. This would require less computation but would not improve the detection success.

Subtask 3: Integration with Shape Detectors



+ Very good at removing False Positives
+ Reuse of code from task 1 and 2 for max efficiency
+ Good with board that have occlusion
- Cannot detect Ellipses making angled boards much harder to detect
- If one function has a False Positive which is detected by the other, it is overall a false positive
- If the board is in shadow, it is having trouble detecting it



+ Clear to understand and debug
+ /Uses refinement to increase probability of detection being correct
+ Uses Hough first as that gave best results
+ Used Viola-Jones to show which Hough circle was a dart board