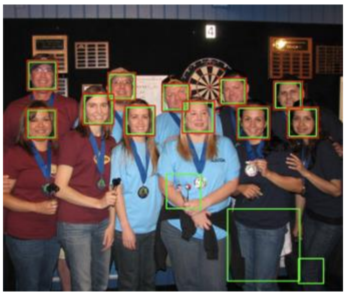
Image Processing and Computer Vision Report

Stage 1



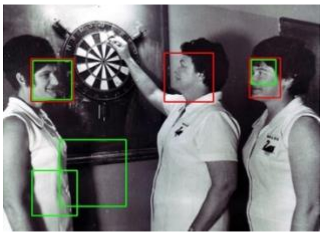


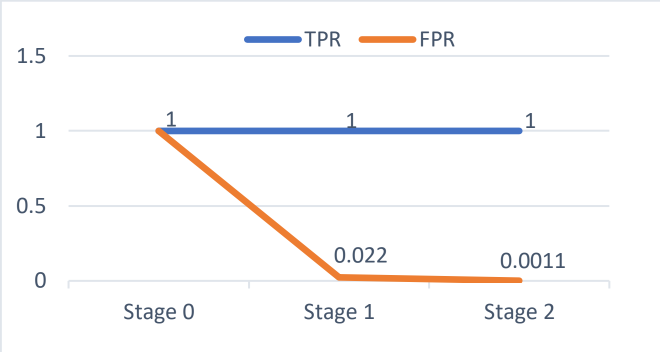
Image Name	Dart 0	Dart 1	Dart 2	Dart 3	Dart 4	Dart 5	Dart 6	Dart 7	Dart 8	Dart 9	Dart 10	Dart 11	Dart 12	Dart 13	Dart 14	Dart 15
TPR	0	1	1	1	1	1	0	1	0	1	1	1	1	1	1	0.67
F1-Score	0	0	0	0	1	0.88	0	1	0	0.4	0	1	0	0.67	0.44	0.57

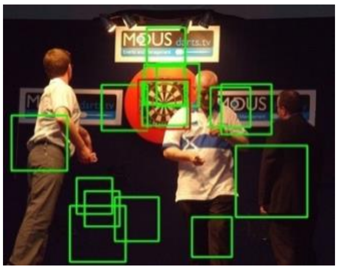
In order to assess the TPR (True Positive Rate) we must first provide a series of ground truths. We believe the main problem with assessing the true positive rate of any detector meaningfully is found in this step. For example, in the scenario presented above we were required to provide the ground truth for where faces could be found in an image. However, we had some trouble deciding whether we should consider faces that could only be seen from the side valid, as the detector we were using was presumably trained using faces that directly facing the camera. In this sense the problem came down to whether we wanted to determine the detectors capability to detect what it had been trained to recognise as a face, or whether we wanted to assess its ability to detect what we, as humans, could recognise as a face. In this case we decided to assess the detectors ability to recognise what we could recognise as a face. Another problem we encountered was how tight to a face our ground truth boxes should be, as we wanted to ensure that the areas in the image considered faces were generally restricted to the face itself in order to avoid validating large detections that just happened to contain a face. However, deciding how large of a detection is too large is quite subjective, and can result in detections that could be considered correct, being deemed too inaccurate.

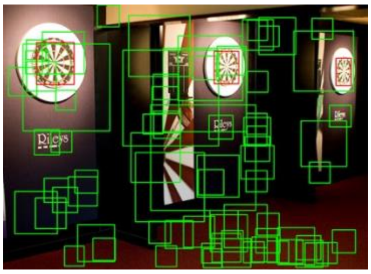
When performing a detection task, the TPR is a measure of the proportion of positive elements, that are correctly identified as positives.
The formula for this rate is: No. of Identified Elements / No. of positive elements. Assuming we only allow a positive element to be considered identified correctly once, this formula has a maximum value of 1. This value is achieved by having every positive element in the image be identified correctly. However, this value in isolation isn't a great indicator for the efficacy of our detector, as a TPR of 1 can be trivially attained in one of two ways. The first way is to simply run detection on an image with no positive elements, in this scenario the TPR will always be 1 as there are no positive elements that could be missed. The other way to guarantee a TPR of 1 is to simply indicate that every possible subsection of an image is a positive element, this method will guarantee that every positive element is identified but provides no useful information whatsoever.

Stage 2

The graph provided shows how the TPR and FPR (False Positive Rate) of the classifier change at different stages in the boosting process. In stage 0 the TPR and FPR are both 1, which indicates that every element of the image is being considered a positive element. However, during the next two stages the FPR drops drastically, to a little above zero, while the TPR remains at 1. Which would suggest that after the boosting algorithm has selected its first Haar-like feature it is able to create a classifier that will always recognise a dartboard, while mostly being able to ignore negatives. This trend continues for the third stage, albeit with a much smaller drop in the FPR. This indicates that further iterations of the boosting algorithm would serve only to reduce the FPR by a small amount.







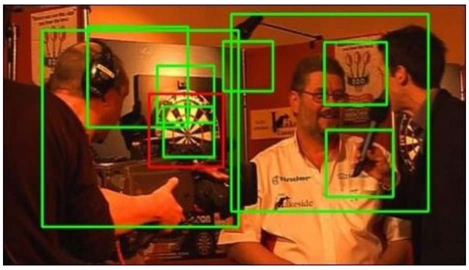


Image Name	Dart 0	Dart 1	Dart 2	Dart 3	Dart 4	Dart 5	Dart 6	Dart 7	Dart 8	Dart 9	Dart 10	Dart 11	Dart 12	Dart 13	Dart 14	Dart 15
TPR	1	1	1	1	1	1	1	1	1	1	0.33	1	1	1	1	1
F1-Score	0.074	0.1	0.077	0.077	0.054	0.11	0.13	0.058	0.07	0.1	0.026	0.22	0.13	0.1	0.05	0.18

Average TPR	0.958
Average F1-Score	0.096

In general, the classifier produced using opencv_traincascade, can be seen to be capable of identifying most of the dartboards in the images it was supplied. However, as can be seen by looking at its F1-score, it also generated many false positive detections. Due to this the classifier can't be considered precise, or particularly useful for identifying dartboards in its current form, as for many of the images it identified dartboards in numerous areas where there were none.

As can be seen above, when compared to the TPR during training, the generated classifier doesn't maintain a TPR of 1 for all images. Specifically, on image 10. In this case, we believe that the primary reason that two of the dartboards were missed is due to their angle to and distance from the camera, and the brightness of the light shining on them. Their distance and angle can cause a sort of distortion to occur to the typical circular shape of a dartboard, making them appear as ellipses, which may not fit the Haar-like features that the classifier was trained to use. In addition to this, the general brightness of the light in this image means that the contrast between the white and green segments of the dartboard is heavily downplayed, to the point of the white and green segments being nearly indistinguishable. This could result in some of the features that the classifier is looking for being missed.

Stage 3

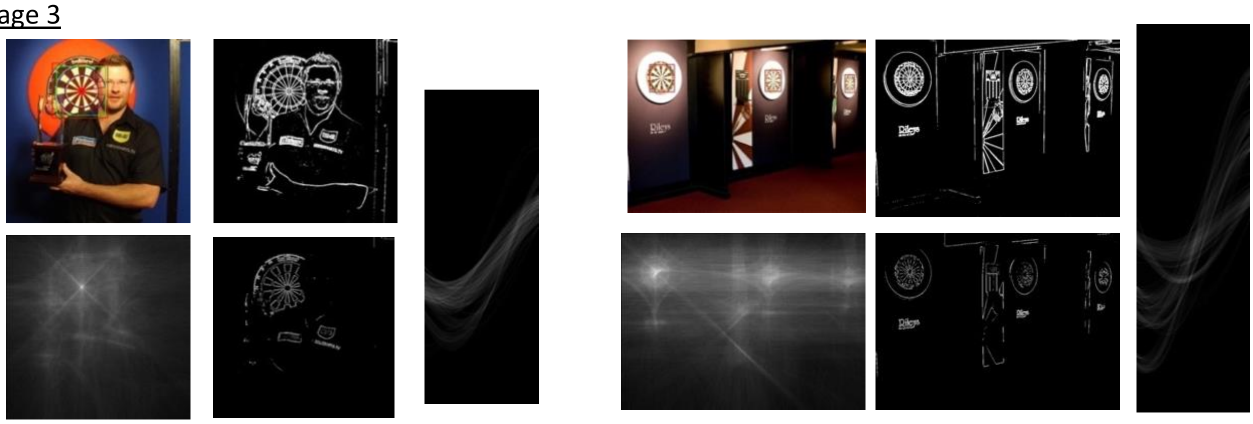


Image Name	Dart 0	Dart 1	Dart 2	Dart 3	Dart 4	Dart 5	Dart 6	Dart 7	Dart 8	Dart 9	Dart 10	Dart 11	Dart 12	Dart 13	Dart 14	Dart 15
TPR	0	1	1	0	1	1	0	1	0.5	1	0	0	0	1	1	1
F1-Score	0	1	1	0	1	1	0	1	0.67	1	0	0	0	1	1	1

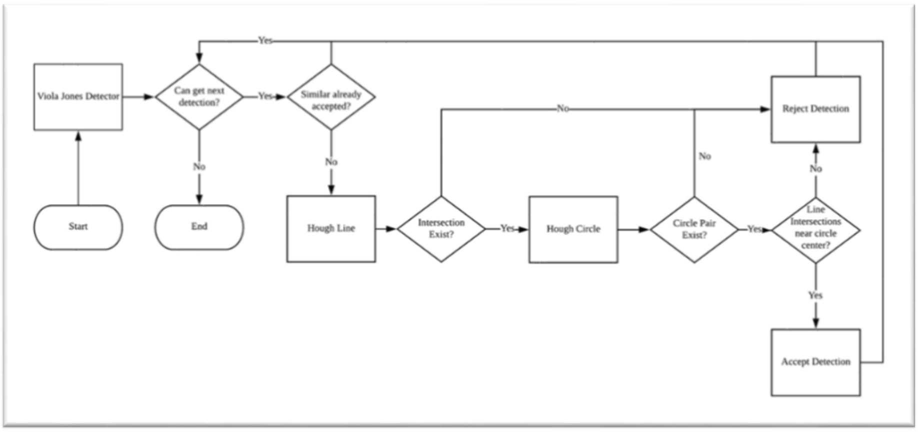
Average TPR	0.594	TPR Diff.	-0.364
Average F1-Score	0.604	F1 Diff.	+0.508

Merits:

- Our system has an improved F1 score, as it is quite selective, and requires a number of features to be present before accepting a dartboard detection.
- Our system can take a guess made by the Viola-Jones detector, and improve it by finding the approximate centre, and size of a dartboard, and using this to size and position the detected region appropriately.

Shortcomings:

- Our system may be too strict at this point, as many of the dartboards are positioned in such a way that either the lines, or circles required can't be detected, while the other is present. This has led to a number of obvious dartboards being ignored, and a reduced average TPR.
- Hough circle transform can take a few seconds when run on large detection areas.



Rationale:

- When designing this process, we decided to try and refine the existing detections, as opposed to adding more. To do this we run the process above within the regions detected by Viola-Jones, both to improve the accuracy, and avoid computing the Hough transform for the whole image.
- In this process, we look for some of the expected features of a dartboard, such as concentric circles, and a number of lines intersecting at one point, we then use this to predict the centre and size of any dartboards we find.
- We also avoid looking at areas that already have a dartboard in them, so as to avoid recomputing data, and having multiple overlapping detections.

Stage 4

Rationale:

- To improve our detector further we decided that we needed to be less strict with the detections we accepted as valid dartboards.
- The basic idea was to have a list of potential dartboards, that fulfilled one of the two requirements we set-out: concentric circles or having a number of lines intersect at a single point. In these cases, we would centre the detection on either: the centre of the circles, or the intersection point with the most neighbouring points. This frame would then be stored as a potential dartboard.
- These potential detections would then be stored. If a stronger detection came along in the same region of the picture that satisfied our original, more stringent requirements, then we would ignore any potential dartboards in the same area.
- This methodology would allow us to detect both dartboards that, due to the angle of the photo have been distorted, and dartboards that may be too obscured to detect the circles that comprise them.

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TPR	1	1	1	1	1	1	1	1	1	1	0.33	1	1	1	1	1
F1-Score	1	1	0.67	0.67	1	1	1	0.67	0.8	0.5	0.29	1	1	1	0.44	1

Average TPR	0.956	TPR Diff.	+0.362
Average F1-Score	0.815	F1 Diff.	+0.211

Merits:

- Improved our detectors ability to pick up dartboards that are obscured, distorted from perspective, and otherwise aren't directly facing the camera.
- Can again take an existing guess generated by Viola-Jones detector, and reposition it, to be centred correctly on a dartboard, when unable to generate own rectangle size. This can now also be done without requiring the existence of concentric circles in the detection area being considered.

Limitations:

- As can be seen in the images above, this approach does cause our detector to allow more false positives through. This is due to us making the requirements to be considered a dartboard less stringent.
- Still can take a few seconds to complete circle transform, when investigating large detection areas.
- We are constrained by the detection results of the Viola-Jones detector.

SIGN-OFF

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Contributions

Aaron: 1 Jonah: 1