

Image Processing and Computer Vision

1st George Lancaster
dept. of Computer Science
University of Bristol
Bristol, United Kingdom
qv18258@bristol.ac.uk

2nd Ren Jiang
dept. of Computer Science
University of Bristol
Bristol, United Kingdom
mu18336@bristol.ac.uk

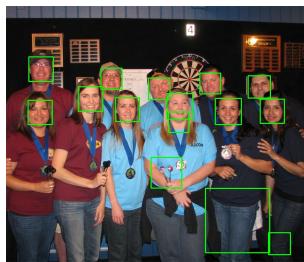
Abstract—This report outlines the tasks completed for Image Processing and Computer Vision assignment one. Our final classifier, which has been extended to do x, y and z has an F1 score of x.xx when tested against the 16 test images.

I. THE VIOLA-JONES OBJECT DETECTOR

Sixteen test images were annotated for ground truth. Each test image contains either faces, dartboards or a combination of both. In this first task, we use the Viola-Jones object detector to find faces within the test images.



(a) darts4.jpg



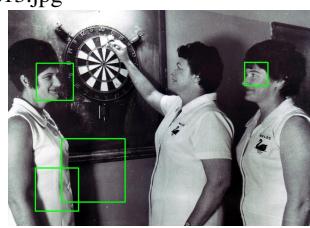
(b) darts5.jpg



(c) darts13.jpg



(d) darts14.jpg



(e) darts15.jpg

Fig. 1: Five images from the test data set. Green rectangles have been drawn where the Viola-Jones classifier has detected a face.

The true positive rate for images *darts5.jpg* and *darts15.jpg* when tested using the Viola-Jones face detector are 1 and 0.667 respectively.

Although the true positive rate can be used to indicate a classifiers accuracy, it does not reflect its true performance. It is always possible to get a 100 per cent detection rate on any classification task as we can select all possible areas of an image, regardless if they contain the target feature or not. The key to a good classifier is to get a high true positive rate, whilst keeping the false positive rate minimal. The F1 score measures the relationship between the precision and the recall of the model and can therefore be considered to be a more reliable measure of classifier performance.

The true positive rate can be difficult to assess as it requires the definition of a rule to determine what counts as a detection. For this task, a true detection is defined as an area that shares a 68 per cent overlap with a ground truth annotation. A value of 68 per cent was chosen as it is the largest area of overlap before the F1 score starts to decline. Table 1 shows how the F1 score changes when the percentage overlap area is changed.

TABLE I: All values of percentage overlap up to 68 per cent gave an identical F1 score when detecting faces from the test data set. This influenced the choice to set the overlap area to 68 per cent for this task.

Overlap Threshold (%)	F1 score
0	0.568
60	0.541
65	0.541
68	0.541
69	0.519
70	0.514
80	0.459

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II. THE DARTBOARD DETECTOR

To detect dartboards, the Viola-Jones classifier was trained on a data set generated from a single bitmap image of a dartboard, as well as a set of negative images.

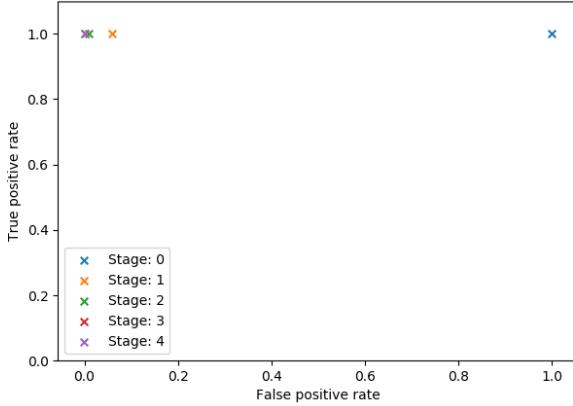


Fig. 2: True positive rate plotted against false positive rate when training the cascade classifier on 500 images of dartboards and 500 negative images. Each stage of training has been plotted as its own point.

On the first stage of training, all samples are classified as true. This is reflected by a value of 1 for both the true positive rate and false positive rate. As the classifier progresses through further training stages, the false positive rate decreases, whilst the true positive rate remains the same. This indicates that the classifier is improving after each training stage.

TABLE II: F1 scores for all images, when detecting for dartboards using a cascade classifier trained on dartboards.

Image Name	F1 Score	
	500 Training Images (a)	1000 Training images (b)
dart0.jpg	0.500	0.250
dart1.jpg	0	0.500
dart2.jpg	0.250	0.400
dart3.jpg	0.538	0.333
dart4.jpg	0.400	0.250
dart5.jpg	0.154	0.200
dart6.jpg	0.333	0.500
dart7.jpg	0	0.250
dart8.jpg	0.160	0.250
dart9.jpg	0.222	0.200
dart10.jpg	0.400	0.545
dart11.jpg	0.222	0.222
dart12.jpg	0.667	0.500
dart13.jpg	0.200	0.333
dart14.jpg	0.087	0.138
dart15.jpg	0.667	0.500
Average F1 score	0.276	0.336

Two identical Viola-Jones classifiers were trained on sets of 500 (a), and 1000 (b) true images and negatives. The F1 score of classifier b was 0.06 higher than classifier a.

Observed differences in accuracy between training and testing can be attributed to the training data consisting of

a small set of critical features. In contrast, the test images contain a large amount of irrelevant background noise, which needed to be discarded by the cascade.

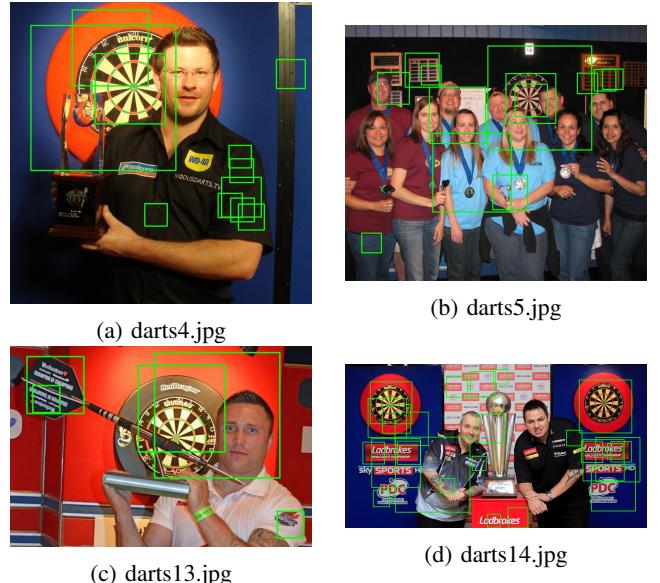


Fig. 3: Five images from the test data set. Green rectangles have been drawn where the Viola-Jones classifier has detected a dartboard.

III. INTEGRATION WITH SHAPE DETECTORS

Both linear and circular hough transforms have been used in conjunction with the Viola-Jones classifier to improve accuracy.

TABLE III: F1 scores, precision and recall for all images, when detecting for dartboards using the cascade classifier combined with shape detection techniques.

Image Name	F1 Score	Precision	Recall
dart0.jpg	1.000	1.000	1.000
dart1.jpg	1.000	1.000	1.000
dart2.jpg	1.000	1.000	1.000
dart3.jpg	0.333	0.200	1.000
dart4.jpg	1.000	1.000	1.000
dart5.jpg	1.000	1.000	1.000
dart6.jpg	1.000	1.000	1.000
dart7.jpg	1.000	1.000	1.000
dart8.jpg	1.000	1.000	1.000
dart9.jpg	0.000	0.000	0.000
dart10.jpg	1.000	1.000	1.000
dart11.jpg	0.222	0.125	1.000
dart12.jpg	0.667	0.500	1.000
dart13.jpg	1.000	1.000	1.000
dart14.jpg	0.500	0.333	1.000
dart15.jpg	0.667	0.500	1.000
Average	0.774	0.729	0.938

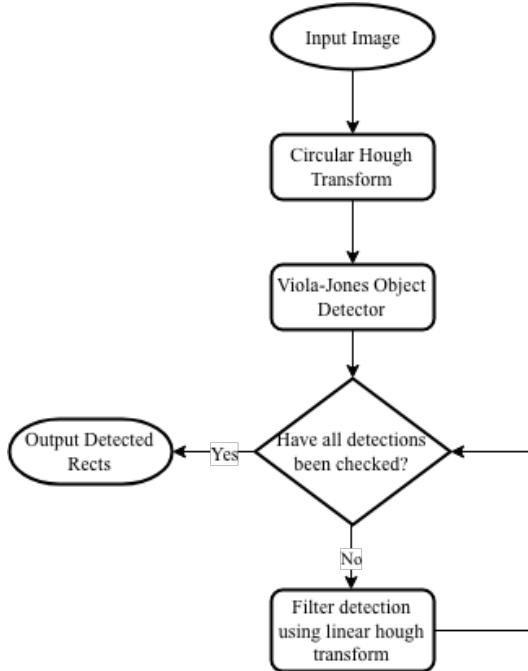
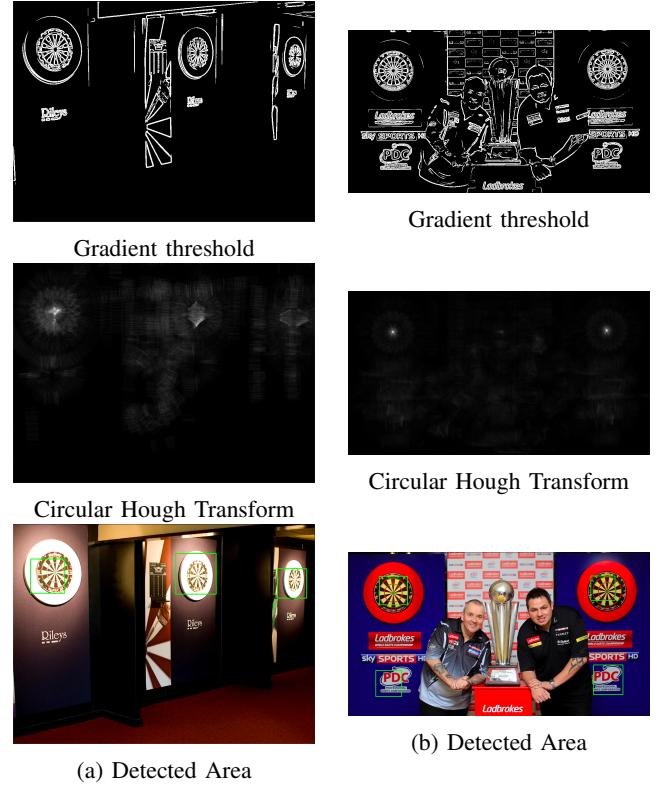


Fig. 4: Flow diagram of image detection algorithm.

The rationale for building the classifier in this way include:

- A circular hough transform is used to find circular features in the image;
- The Viola-Jones object detector then determines if there are dartboards in the important area of the image;
- Using the linear version of the hough transform allow for false detections to be filtered out.

Fig. 5: Best and worst cases for the dartboard detector. Column a shows the best case, and has a F1 score of 1. Column b shows the worst case is the worst case, and has an F1 score of 0.667

The solution at this level gives very good results, achieving a true positive rate of 1 for all images. Only images 9 and 14 have imperfect F1 scores, caused by false positives. Image 9 could be considered to be a true positive as the classifier has detected a dartboard on a t-shirt.

IV. FURTHER IMPROVEMENTS