Color Segmentation and Barrel Detection

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***Abstract*— This report is a project overview of a course project in which we aim to detect blue barrels and their relative position. To achieve this, the train set is being manually labeled and classified using logistic regression algorithm. The trained parameters are further implemented on the test detecting the barrel and its coordinates.**

I. INTRODUCTION

Detecting specific features from an image has been a very essential problem in today's scenario. It is basically used in many aspect of various fields and have also offered many such living solution in our day to day lives like face detection in cameras, forensics etc. One such attempt to understand this, and a start to many such complex problems in machine learning, robotics, we start with the simple yet essential problem to segment the image on the bases of the color and further detect an object and its relative position in the image. This problem statement when ensembled with other machine learning techniques can be used to detect, track moving objects, authenticate bio-metric and many more. In this project, our aim is to make a probabilistic model to segment the image on the bases of color, train a classifier to detect blue barrels in the image, obtain a bounding box and coordinates of the detected barrel. The color classifier is trained using logistic regression which classifies the image as blue and not-blue (binary approach). The image can been classified in other classes uses softmax regression and can be also be further refined by using algorithms like Gaussian mixture model and Expectation-Maximization Algorithm which takes into account the bigram and unigram characteristics to train on the images. This report is formulated in three different sections namely Problem Formulation, Technical Approach and Results which provides an overview of the project.

II. PROBLEM FORMULATION

The Problem defined above is formulated in three parts namely Hand labeling of the images to obtain labels of the training set, Logistic Regression to classify color space and train parameters, Obtain bounding box and coordinates.

A. Hand Labeling of the Image

In this part of the project, each image is read in the form of img=$(800, 1200, 3)\epsilon R^3$. Each image of the train set consisting of 46 images are hand labeled by making a polygon around the blue barrels and a one-hot encoded mask is obtained with labels -1 for the non blue pixels and 1 for the blue pixels. The obtained label for each image is of the form mask=$(800 * 1200, 1)\epsilon R^2$.

B. Logistic Regression to classify color space

In this part of the problem, we have trained the color space using logistic regression as this problem is a part of supervised learning where labels for each image were obtained in the previous part. Logistic regression follows as described below:

$$y\epsilon(-1,1)^n \tag{1}$$

$$p(y|x,\omega) = \prod_{1}^{n} \sigma(y_i x_i^T \omega) = \prod_{1}^{n} \frac{1}{1+exp(-y_i x_i^T \omega)} \tag{2}$$

Training, given a data D=(x,y), optimizing the model parameters by using gradient descent where α is the learning rate:

$$\omega_{MLE}^{t+1} = \omega_{MLE}^{t} + \alpha \sum_{1}^{n} y_i x_i (1 - \sigma(y_i x_i^T \omega_{MLE}^t)) \tag{3}$$

Testing:Given a test example $x\epsilon R^d$, using the optimizing parameter ω_{MLE}, we predict the label as:

$$y = 1; x^T \omega_{MLE} >= 0 \tag{4}$$

$$y = -1; x^T \omega_{MLE} < 0 \tag{5}$$

C. Obtain label, bounding box and coordinates of the test image

In this part of the problem, we have obtained the segmented image from the test image of the form $img = (800, 1200, 3)\epsilon R^3$ to a one-hot encoded binary image $img = (800, 1200, 1)\epsilon R^2$ where blue pixels are labeled 1 and non blue pixels are labeled 0 using the parameters obtained from the train set.

From the segmented image we obtained, we further obtained all the bounding box of the labeled image and classified them as barrels by finding their barrel score:

- Region is a rectangle; Aspect ratio= $height/width > 1$
- Region has $Area > 500$ to discard the small noise segmented regions.

After the bounding boxes are sorted with respect to the barrel score, we obtain the coordinates of the barrels i.e their relative position in the image.

III. TECHNICAL APPROACH

This section of the report discusses the technical aspects of each part of the problem and the way it was implemented.

A. Hand Labeling of the images

Each labeled in the train set is hand labeled by drawing a polygon around the blue barrels, using roipoly and labeled the image as 1 for the blue pixels and -1 for the non-blue pixels.

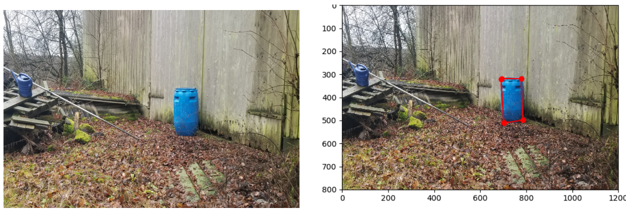

Fig. 1. Hand Labeling of the image by making a polygon around the barrel

Figure 1 shows the image and the hand labeled bounding polygon around the blue barrel. The one-hot encoded mask image of the hand-labeled image are obtained using the "getmask" function. This process is implemented for all the images of the train set and the corresponding labels are stored in the pickle file for the next step of the problem.

B. Learning Algorithm

The train set is split into 80 percent train set and 20 percent validation set to avoid over fitting on the data. The train set is trained using logistic regression as defined above in Section II of this report. Following steps are being implemented to train the data:

- The R, G, B components of the image are extracted and flattened and normalized to form the columns of the feature matrix, appended with a column of ones to incorporate bias.
- Train parameters are initially assigned some arbitrary values.
- Parameters are trained using Maximum Likelihood estimation to maximize probability of the train data.
- Parameters are trained using gradient descent as defined in equation 3 and the learning rate is chosen as 0.0001.
- Parameters are looped for 50 epochs size initially till the Root Mean Square Error (RMSE) value on the validation set start rising again. That optimum epoch size is chosen, which comes out to be 37.
- Parameters are again trained for the train set using the epoch size as 37.

C. Labeling the test image and finding the bounding box

This part of the problem is further divided in two parts as follows:

1) Labeling the test image: In this part of the problem the image is read and the feature matrix is formed. The segmented image or the labels are obtained by using the trained parameters and the feature matrix as described in equation 3.

2) Finding the bounding box, barrel score, coordinates: In this part of the problem, the bounding boxes of the segmented image are obtained using the functions "regionprops" and further filtered to be classified as barrels on the basis of their shape i.e the barrel score. The following filtering features are used.

- Region is a rectangle; Aspect ratio= $height/width > 1.5$
- Region has $Area > 500$ to discard the small noise segmented regions.

After application of the above filters, coordinates of the bounding boxes which resemble barrel are returned.

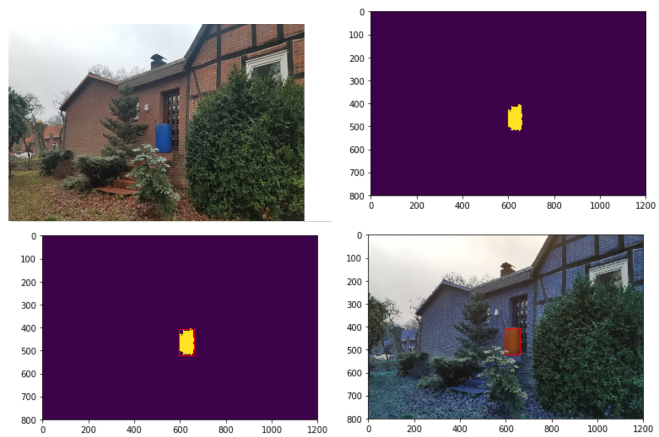

Fig. 2. From left to right 1)Test Image 2)Corresponding segmented image classified by our trained algorithm 3)Bounding box coordinates obtained on the segmented image 4) Plotted coordinates on the test image

Figure 2 shows the test image and the segmented image classified by our trained learning algorithm.

- The bounding box coordinates obtained after filtration are [597, 405, 660, 520]. i.e [x1,y1,x2,y2] where (x1,y1) are the coordinates of the top left point and (x2,y2) are the coordinates of the bottom right point, where X axis in the horizontal direction, Y axis in the vertical and origin at the top left point.
- Figure 2 shows the bounding box coordinates obtained on the segmented image and plotted on the real image. Therefore, our algorithm is able to detect the barrel in the image correctly.

IV. Results

From the above implementation, following conclusion and results are obtained:

- Test case 1: Figure 3 shows the test case and the result we obtained. This test case was a success as the algorithm detected the barrel correctly.The coordinates of the bounding box is [262, 447, 298, 513].
- Test case 2: Figure 4 shows the test case and the result we obtained. The coordinates of the bounding box is [668, 242, 673, 250]. This test case was a unsuccessful due to following reasons:

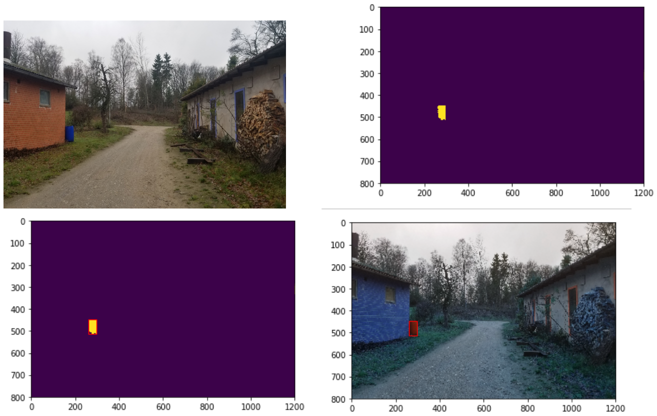

Fig. 3. Test Case 1: From left to right 1)Test Image 2)Corresponding segmented image classified by our trained algorithm 3)Bounding box coordinates obtained on the segmented image 4) Plotted coordinates on the test image

  - The light exposure is very low.
  - The barrel is rotated therefore it fails the filtration criterion of aspect ratio.

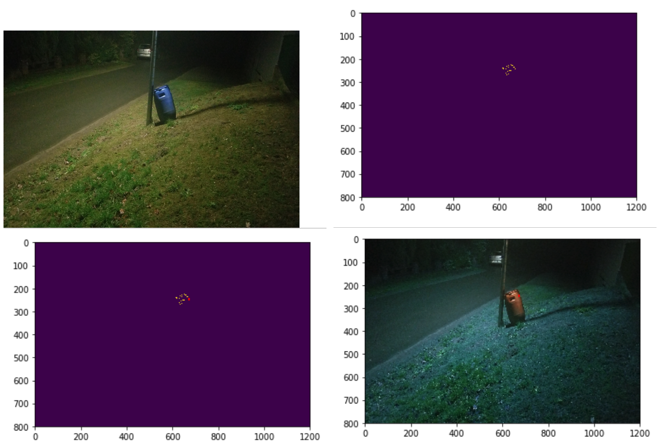

Fig. 4. Test Case 2: From left to right 1)Test Image 2)Corresponding segmented image classified by our trained algorithm 3)Bounding box coordinates obtained on the segmented image 4) Plotted coordinates on the test image

- Test case 3: Figure 5 shows the test case and the result we obtained. The coordinates of the bounding box is [571, 371, 572, 374]. This test case was a unsuccessful due to following reasons:
  - There are obstacle in front of the barrel, so it fails to bound the blue pixels.
- Test case 4: Figure 6 shows the test case and the result we obtained. This test case was a success as the algorithm detected the barrel correctly. The coordinates of the bounding box is [585, 412, 627, 492].
- Test case 5: Figure 7 shows the test case and the result we obtained. This test case was a success as the algorithm detected the barrel correctly.The coordinates of the bounding box is [360, 347, 361, 350].

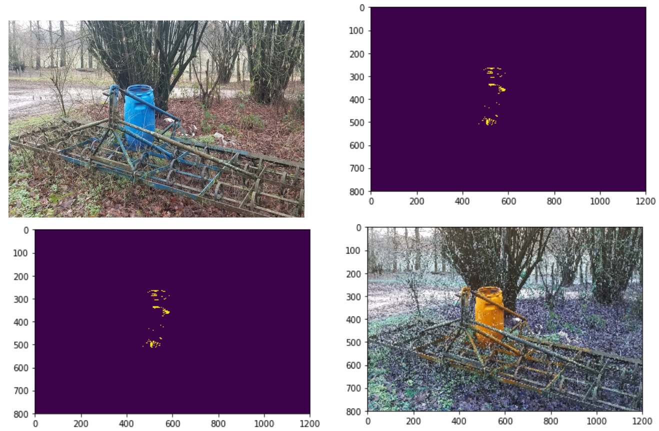

Fig. 5. Test Case 3: From left to right 1)Test Image 2)Corresponding segmented image classified by our trained algorithm 3)Bounding box coordinates obtained on the segmented image 4) Plotted coordinates on the test image

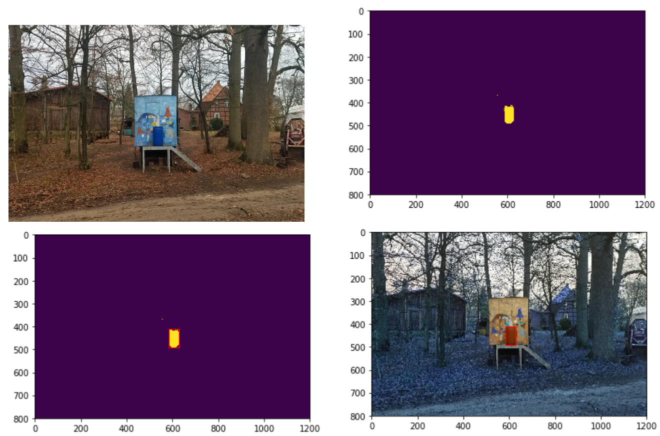

Fig. 6. Test Case 4: From left to right 1)Test Image 2)Corresponding segmented image classified by our trained algorithm 3)Bounding box coordinates obtained on the segmented image 4) Plotted coordinates on the test image

- Test case 6: Figure 8 shows the test case and the result we obtained. This test case was a partial success. The coordinates of the bounding box is [0, 332, 67, 448].
  - Since the are of the other barrel did not match the filtration criterion, the algorithm returned just one barrel.

V. Conclusions

- From the results obtained, it is observed that the algorithm performs decently well on the test set. The code when implemented on the test set gave more than 70 percent accuracy.
- This algorithm can be used decently if the images are bright and the barrel is clearly visible.
- The algorithm fails to classify when the images are too dark, the barrel is oriented, size is too small or if their are obstacles in front.

Fig. 7. Test Case 5: From left to right 1)Test Image 2)Corresponding segmented image classified by our trained algorithm 3)Bounding box coordinates obtained on the segmented image 4) Plotted coordinates on the test image

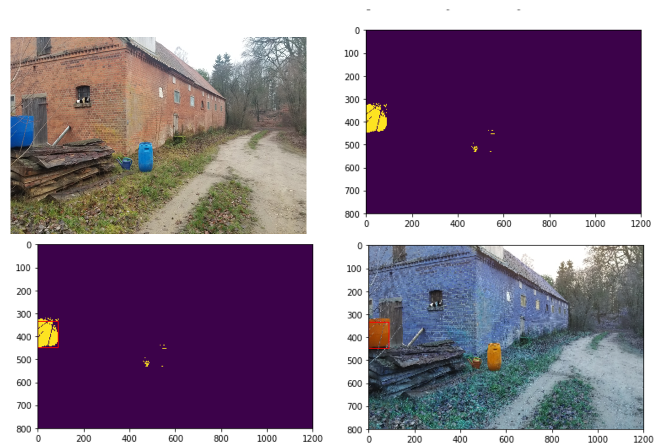

Fig. 8. Test Case 6: From left to right 1)Test Image 2)Corresponding segmented image classified by our trained algorithm 3)Bounding box coordinates obtained on the segmented image 4) Plotted coordinates on the test image