Computer Vision - Homework 2

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1 Introduction

This report provides an overview of feature extraction technique and scale-invariant feature transform algorithm in Computer Vision. To extract feature, we have employed Hough transform. To perform scale-invariant feature transform, we have applied SIFT algorithm.

2 Input

As an input, 10 images were taken from each of the 10 classes from the CIFAR-10 dataset. The CIFAR-10 provides tiny images of the dimensions 32x32 and image classes like airplane, automobile, bird, cat etc. Figure 1 shows the original set of the images.

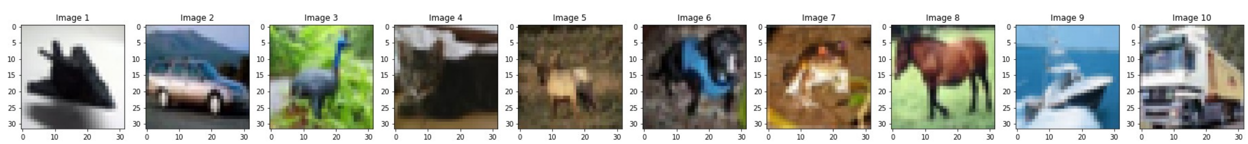

Figure 1: CIFAR-10 dataset original images

3 Hough Transform

Hough transform is a feature detection technique. As part of this homework, we applied the technique to detect lines and circles in an image.

3.1 Line Detection Hough Transform

To detect lines, we applied line detection Hough transform algorithm. The first step of this algorithm is to detect edges for which any edge detection algorithm can be used. For this homework, the Canny edge detection algorithm was utilized. The original image is converted to a grayscale image. Then, the edge points are mapped to the Hough space and stored in an accumulator. The accumulator is interpreted to yield lines of an infinite length. Finally, these infinite lines are converted to finite lines.

To apply line detection Hough transform, below method was applied. Various parameters are provided for this technique. Table 1 consists the definition of all parameters.

```
cv.HoughLines(edges, lines, rho, theta, threshold, srn, stn)
```

Parameter	Description
edges	Output of the edge detector
lines	Vector that will store the parameters (r, theta) of the detected lines
rho	Distance resolution of the accumulator in pixels
theta	Angle resolution of the accumulator in radians
threshold	Minimum number of intersections to detect a line
srn	0, to use classical Hough transform, else Multi-scale Hough transform is used
stn	0, to use classical Hough transform, else Multi-scale Hough transform is used

Table 1: Line Detection Hough Transform Parameters

Figure 2 shows the output of applying line detection Hough transform with different threshold values.

Figure 2: Image output on applying Hough Transform with different threshold values

Different threshold values like 25, 50, 100, 150, 250 were used for the threshold parameter. It is observed that with lower threshold values, more lines are detected. With high threshold values, less but prominent lines are detected. Even though high threshold value provides less number of lines, they are the main and important lines of the object. Hence, high threshold value is recommended. A smaller value for the accumulator's resolution will lead to the detection of more lines, whilst a greater value will lead to the detection of fewer lines.

3.2 Circle Detection Hough Transform

To detect circle, we applied circle detection Hough transform algorithm. We first create the circles in the (a, b) space corresponding to each edge point, much like in the line detection Hough transform. Then we find the point of intersection which will correspond to the original circle center. To apply CIRCLE detection Hough transform, below method was applied. Various parameters are provided for this technique:

cv.HoughCircles(grayscale image, method, dp, minDist, param1, param2, minRadius, maxRadius)

Table 2 consists the definition of all parameters.

Parameter	Description
image	Grayscale input image
method	HOUGH GRADIENT, this is the only current implemented method
dp	Inverse ratio of the accumulator resolution to the image resolution
minDist	Minimum distance between the centers of the detected circles
param1	Higher threshold of the two passed to the Canny edge detector
param2	Accumulator threshold for the circle centers at the detection stage
minRadius	Minimum circle radius
maxRadius	Maximum circle radius

Table 2: Circle Detection Hough Transform Parameters

Figure 3: Image output on applying circle detection Hough transform with different threshold values

Different threshold values like 25, 50, 100, 150, 250 were used for the threshold parameter. The change of value for the minimum distance between the centers of the detected circles impacts how many circles can be found. It is observed that, the smaller distance value will lead to detecting more circles. A smaller value will lead to more circles being identified by the accumulator's resolution, whilst a greater value will lead to less circles being detected.

In conclusion, threshold values for both line detection Hough transform and circle detection Hough transform depends on the specific inputs and expected results. The values can be experimented to achieve desired results.

4 Scale-invariant feature transform (SIFT)

The scale-invariant feature transform (SIFT) is an algorithm to detect and match local features in images, which are in-variant to image scale and rotation.

The two primary stages of the SIFT algorithm are feature detection and feature description. Scale-invariant keypoints, which can withstand changes in picture scale and rotation, are found in the image during the feature detection stage by the SIFT algorithm. In the feature description stage, a descriptor is computed for each keypoint.

To apply SIFT algorithm, couple of methods are required like creation, detect and compute and to draw key points. Different sigma values can be provided while creating the SIFT detector. For this homework, apart from default values, 0.5, 1.5 and 3.0 were used as the sigma values. Following figures illustrate the output for different values of sigma.

Figure 4: Image output on applying SIFT with default sigma value

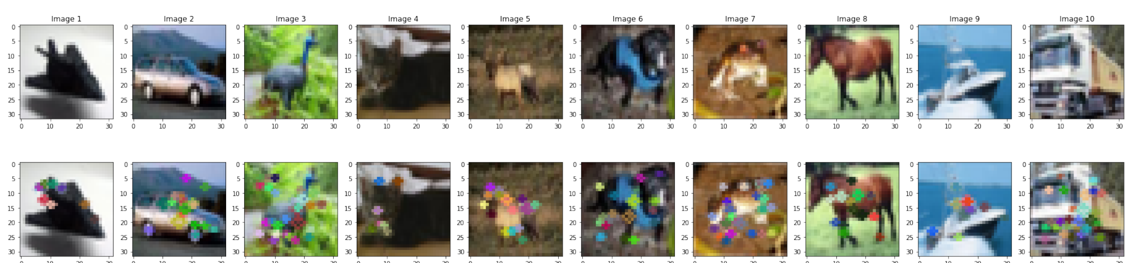

Figure 5: Image output on applying SIFT with 0.5 sigma value

On changing the sigma value while creating the SIFT detector, the observation of the output images was more number of features are detected. In Figure 5, we can see features

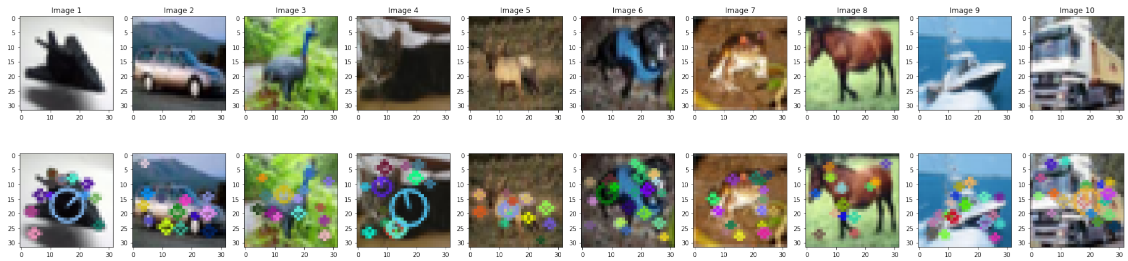

Figure 6: Image output on applying SIFT with 1.5 sigma value

Figure 7: Image output on applying SIFT with 3.0 sigma value

are detected but not that appropriately. As we increase the value, more prominent features start getting detected.

The correct value for sigma would depend on the features we would like to detect. It also depends on the size of the feature we would like to detect. If we want to detect features at small scale, less value of sigma is recommended. If we want to detect features which cover large area, large value of sigma would be appropriate.

5 Conclusion

With the help of this assignment, we explored line detection and circle detection algorithm of Hough Transform. We experimented with different threshold values. Similarly, using SIFT algorithm, we learnt about feature detection. The different set of values for sigma gave us an insight of what value should be used to detect different size of features.