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Image Classification Using Local Binary Pattern Features

In the following assignment we are required to implement an image classification algorithm using the Local Binary Pattern features and the Nearest Neighbor Classifier. For this assignment we are provided with 5 sets of images (building, beach, car, tree, mountain and tree) with 20 images each for training the algorithm and 5 images for testing the algorithm

1. LBP Feature Extraction

The Local Binary Pattern algorithm is used to create rotationally and gray scale invariant characterization of image texture. The following are the steps to implement the LBP algorithm to an image.

a. For every pixel in each image find its P nearest neighbors in a circle of radius R units using the following formula.

$$(\Delta u, \Delta v) = \left(Rcos\left(\frac{2\pi p}{P}\right), Rsin\left(\frac{2\pi p}{P}\right)\right), where\ p = 0, 1 \ldots . P - 1$$

For this experiment I have taken R be to 1 and P to be 8.

b. Calculate the grey value at each location x on the circular using bilinear interpolation

$$gray_{level(x)} = (1 - \Delta u)(1 - \Delta v)A + (1 - \Delta u)\Delta vB + \Delta u(1 - \Delta v)C + \Delta u\Delta vD$$
$$where\ A, B, C, D\ are\ the\ corners\ of\ the\ rectangle$$

c. Threshold the grayscale values at the 8 neighbor locations based on the gray level of the pixel at the center of the circle. If the gray level at the neighbor locations is greater than or equal to the gray level at the center pixel the bit value is set to 1 if not the bit value is set to 0.

d. Next use the in order to reject in plane rotations we rotate the obtained bit pattern one bit at a time until we find the minimum value of the bits . This is done using the BitVector module in python.

e. Once the minimum bit pattern is calculated we encode the minimum bits based of the following method:
   i. If the minimum bit pattern consists of all zeros the encoding will be 0
   ii. If the minimum bit pattern consists of all ones the encoding will be P.
   iii. If the minimum bit pattern consists of more than two runs the encoding will be P+1
   iv. If the minimum bit pattern consists of a binary pattern of exactly two runs, encoding is presented by the number of ones in the second run, that is it lies between 1 and P-1

f. The encoding is then used to create the LBP histogram consisting of P+2 bins per image.

g. Repeat this procedure for all the images in the training set to create a set of 20 x 5 LBP histograms.

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2. NN – Classifier & Image Classification

First, we train the 20 images in each of the 5 sets of images to creating an array consisting of 20 x 5 LBP histograms. Once the training procedure is completed the NN classifier is then used to classify the test image using the following procedure:

a) First create the LBP histogram of the test image.
b) NN – classifier uses the Euclidean distance to find the k nearest neighbors to the test images from the set of 20 x 5 LBP histograms. The Euclidean distance is calculated using the following formula

$$D = \sqrt{\Sigma_0^9 (f_i - g_i)^2},$$

In the following assignment we have set the value of k to 5.
c) Thus, we get k sets of possible labels for the test image. The test image is then given the same label as the most common label of its k nearest neighbors.

3. Performance Measures

The following is the confusion matrix obtained after using the above algorithm to classify the test images

	beach	building	car	mountain	tree
beach	4	1	0	0	0
building	0	3	0	2	0
car	0	2	3	0	0
mountain	0	1	0	4	0
tree	0	2	0	0	3

The accuracy of the algorithm is calculated using the following formula:

$$\text{Accuracy} = \frac{No\ of\ correct\ classification}{Total\ number\ of\ classifications} = \frac{17}{25} = 68\ \%$$

Thus, the algorithm has an accuracy of around 68 %.

4. Observations on performance of the Image recognition system

a. The following algorithm has an overall accuracy of 68%, which is much higher than randomly classifying the images.
b. The overall performance of the algorithm can also be potentially improved by further increasing the number of nearest neighbors k.
c. The overall performance of the algorithm could also be potentially improved by using training images of higher resolution.

5. Results : Histogram

a. Histogram for Image 1 of the beach training set

{ 0 : 9226, 1 : 17265, 2 : 8404, 3: 23723, 4 : 36857, 5 : 39886, 6 : 17227, 7 : 23579, 8 : 39361, 9 : 28986 }

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b. Histogram for Image 1 of the building training set

{ 0 : 2657 , 1 : 5213 , 2 : 1746 , 3: 4009 , 4 : 6480 , 5 : 6913 , 6 : 2211 , 7 : 5309 , 8 : 7087 , 9 : 7893 }

c. Histogram for Image 1 of the car training set

{ 0 : 1769 , 1 : 3339 , 2 : 1410 , 3: 3099 , 4 : 6204 , 5 : 5965 , 6 : 2309 , 7 : 3765 , 8 : 16936 , 9 : 4617 }

d. Histogram for Image 1 of the mountain training set

{0 : 2926 , 1 : 3323 , 2 : 2169 , 3: 3118 , 4 : 3668 , 5 : 5183 , 6 : 2778 , 7 : 5259 , 8 : 10630 , 9 : 10290 }

e. Histogram for Image 1 of the tree training set

{ 0 : 4859 , 1 : 4910 , 2 : 3410 , 3: 4331 , 4 : 5049 , 5 : 3839 , 6 : 3141 , 7 : 4875 , 8 : 5853 , 9 : 9146 }