**HOG:**

Histogram of Oriented Gradients, also known as HOG, is a feature descriptor like the Canny Edge Detector, SIFT (Scale Invariant and Feature Transform) . It is used in computer vision and image processing for the purpose of object detection. The technique counts occurrences of gradient orientation in the localized portion of an image.

**Steps to calculate HOG Features**

1. Take the input image you want to calculate HOG features of. Resize the image into an image of 128x64 pixels (128 pixels height and 64 width). This dimension was used in the paper and was suggested by the authors as their primary aim with this type of detection was to obtain better results on the task of pedestrian detection. As the authors of this paper were obtaining exceptionally perfect results on the MIT pedestrian database, they decided to produce a new and significantly more challenging dataset called the ‘INRIA’ dataset (http://pascal.inrialpes.fr/data/human/), containing 1805 (128x64) images of humans cropped from a varied set of personal photos.

A picture containing text

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Figure 1: The image imported to get HOG features of.

Figure 2: The imported image grayscale for the process.

Figure 3: Resized and grayscale image of the imported image. (Image by author)

2. The gradient of the image is calculated. The gradient is obtained by combining magnitude and angle from the image. Considering a block of 3x3 pixels, first Gx and Gy is calculated for each pixel. First Gx and Gy is calculated using the formulae below for each pixel value.



where r, c refers to rows and columns respectively. (Image by author)

After calculating Gx and, magnitude and angle of each pixel is calculated using the formulae mentioned below.



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Figure 4: Visualization of magnitude of the image.

Figure 5: Visualization of angle of the image. (Image by author)

3. After obtaining the gradient of each pixel, the gradient matrices (magnitude and angle matrix) are divided into 8x8 cells to form a block. For each block, a 9-point histogram is calculated. A 9-point histogram develops a histogram with 9 bins and each bin has an angle range of 20 degrees. Figure 8 represents a 9-bin histogram in which the values are allocated after calculations. Each of these 9-point histograms can be plotted as histograms with bins outputting the intensity of the gradient in that bin. As a block contains 64 different values, for all 64 values of magnitude and gradient the following calculation is performed. As we are using 9-point histograms, hence:



(Image by author)

Each Jth bin, bin will have boundaries from:



(Image by author)

Value of the center of each bin will be:



(Image by author)

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Figure 6: 8x8 blocks on the magnitude image.

Figure 7: 8x8 blocks on an angle image. (Image by author)

Table

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Figure 8: Representation of a 9-bin histogram. This one single histogram will be unique for one 8x8 block made up of 64 cells. All 64 cells will add their Vj and Vj+1 value to the jth and (j+1) th index of the array respectively. (Image by author)

4. For each cell in a block, we will first calculate the jth bin and then the value that will be provided to the jth and (j+1)th bin respectively. The value is given by the following formulae :

Shape

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5. An array is taken as a bin for a block and values of Vj and Vj+1 is appended in the array at the index of jth and (j+1)th bin calculated for each pixel.

6. The resultant matrix after the above calculations will have the shape of 16x8x9.

7. Once histogram computation is over for all blocks, 4 blocks from the 9 point histogram matrix are clubbed together to form a new block (2x2). This clubbing is done in an overlapping manner with a stride of 8 pixels. For all 4 cells in a block, we concatenate all the 9 point histograms for each constituent cell to form a 36 feature vector.

Chart

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Method for calculation of 9 bin histograms is illustrated in the above image. (Image by author) Inspired by [<https://www.programmersought.com/article/42554276349/>]



(Image by author)