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# Using a smoothed continuous function as a replacement for a histogram of oriented gradients

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## Abstract


- The histogram of oriented gradients (HOG) is a popular feature descriptor. However, HOG does not have the rotation invariance property. This means that for different angles of rotation of an object, in particular, for rotation angles not multiple of the size of the histogram intervals, the histogram change is characterized not only by a cyclic shift of the values of the corresponding intervals, but also by the structure of their values.
- The method of solving this problem will be a continuous smoothed function describing a gradient block, which is more stable.
- The way to compare such characteristics is to decompose a one-dimensional function into a Fourier series.


## HOG Algorithm

1. The histogram of oriented gradients (HOG) and is effective and it is used to describe images. In many recognition problems, rotation-invariant analysis is necessary or preferable. HOG invariance is achieved by considering a gradient histogram as a continuous angular signal that can be well represented by a 2D Fourier basis. Since rotation invariance is established analytically, we can avoid sampling artifacts and create a continuous mapping from the image to the object space.

**Figure 1.** The resulting HOG image

2. An image descriptor is a vector of objects containing various information about the image. A good image descriptor should be able to capture significant image patterns and be resistant to object deformation or other various transformations. A histogram of oriented gradients, also known as HOG, is a feature descriptor that is used in computer vision and image processing to detect objects. This method counts the cases of gradient orientation in the localized part of the image. For image regions, it generates histograms using the magnitude and orientation of the gradient. HOG focuses on the structure of the object. It uses a 64×128 pixel detection window, so the image is first converted to an image of that size. Then the image is further divided into blocks, and the gradient of each pixel is calculated. We take gradient vectors from each block (each cell is 8×8 pixels in size) and place them in a histogram of 9 cells, which are then combined into one feature vector.

## Solving the problem

A histogram is simply a discretized density function. The initial information encoded by the HOG cell is a function of the density of the orientation gradient, which in the 2D case can be represented by a continuous function.

If a discrete gradient histogram is used to calculate the main direction, then only an approximate angular interval of the main direction can be obtained.

If a continuous gradient histogram is directly used to calculate the main direction, the results are easily distorted by noise and slight deformation. Some degree of smoothing is useful because it increases the stability of the description to small changes in appearance. The smoothed orientation histogram is used to estimate the basic orientation. This is what makes the result more stable and accurate. This is shown in the figure 2.

The values should approximately coincide for the rotation-invariant features. The figure 3 shows an image without rotation and with a rotation of 20°.

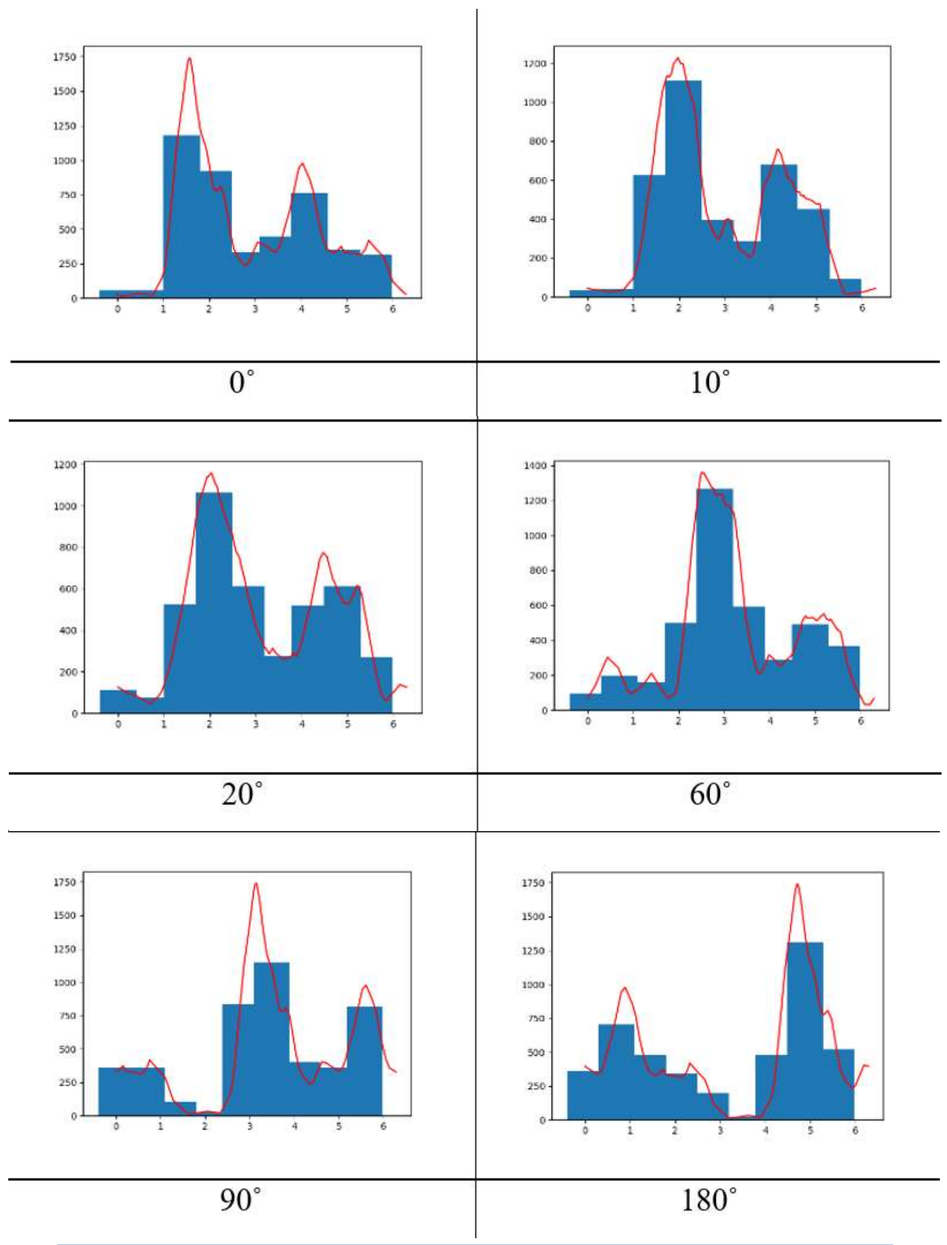


**Figure 2.** Comparison of HOG and continuous smoothed gradient function in a block when the image rotation angle changes

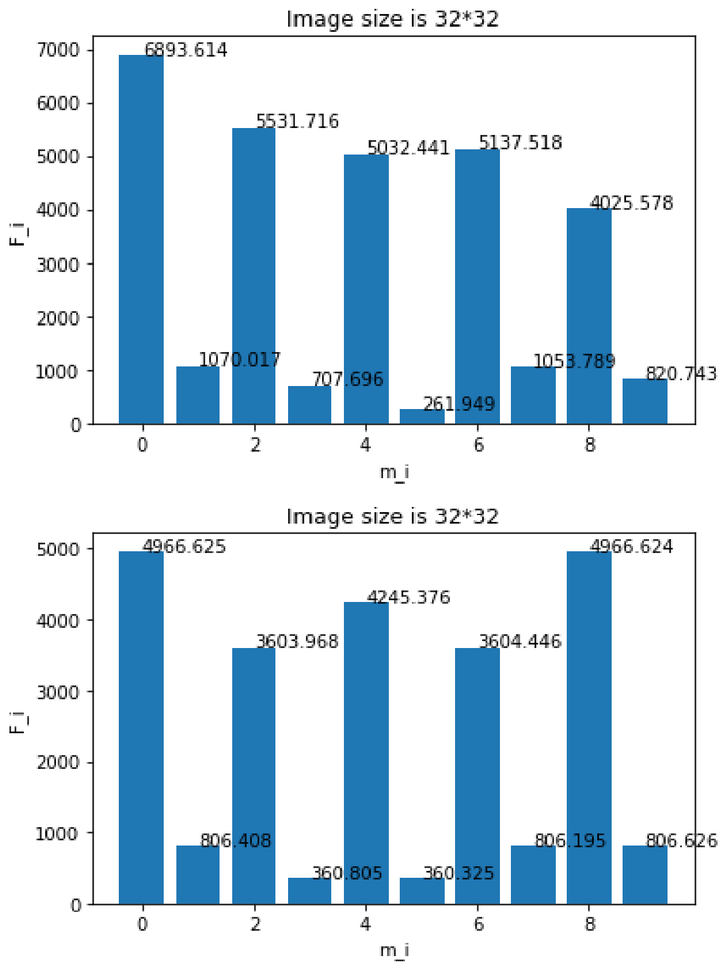


**Figure 3.** Comparison of HOG and continuous smoothed gradient function in a block when the image rotation angle changes

## Discussion and Conclusion

- As a result, the algorithm of histograms of oriented gradients works correctly only when the rotation angles are multiples of the size of the histogram intervals.
- For the correct operation of HOG, it is possible to apply a rotation-invariant Fourier analysis.
- A possible solution is to use a continuous smoothed gradient function in the block

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