LECTURE 3 : IMAGE FEATURES

Motivation : We have seen in Viola-Jones' face detection, one important components is image features : Haar-like features.

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Image features are important, because original pixel intensity values are not reliable (= not consistent enough). They are easily affected by changes in light, occlusions, viewing points, etc.

There are two other important features : HoG & SIFT.

[1] Histogram of Oriented Gradients (HoG)

Q : What is gradient?

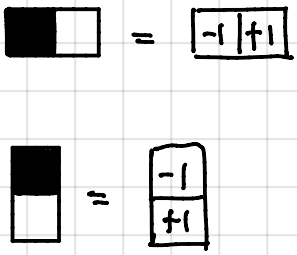
A : Image gradient is basically image derivative, which is expressed as follows.

Derivative :

(1) $\frac{\partial I(x,y)}{\partial x} = I(x+1,y) - I(x,y)$

(2) $\frac{\partial I(x,y)}{\partial y} = I(x,y+1) - I(x,y)$

Convolution :



Q : What is oriented gradient?

A : One pixel has two gradient values : $\frac{\partial I(x,y)}{\partial x}$ & $\frac{\partial I(x,y)}{\partial y}$.

Thus, a pixel gradient is a vector, and a vector has orientation and magnitude.

Orientation : $\tan\theta = \frac{\partial I/\partial y}{\partial I/\partial x} = \frac{I_y}{I_x}$; $\theta = \tan^{-1}\left(\frac{I_y}{I_x}\right)$

Magnitude : $m = \sqrt{I_y^2 + I_x^2}$

Notes on the orientation (θ):

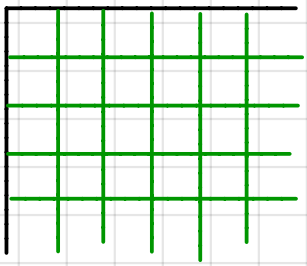
1. θ will be the same when $(I_y=1, I_x=1)$ and $(I_y=-1, I_x=-1)$.
   Hence, dealing with this, we define:

$$\theta = \tan^{-1}\left(\frac{|I_y|}{|I_x|}\right)$$; and keep the signs of I_x & I_y.

   If both are positive, then we consider θ in quadrant 1, and otherwise depending on the signs, it can be all other quadrants.
2. Hence, $0^\circ \leq \theta \leq 360^\circ$.

Q: How can we obtain the histogram of the oriented gradients?
A: Two important concepts: ① Block operation, ② Histogram.

① Block Operation: Divide the input image into blocks:



Each block can be 4x4 or 16x16 pixels
(The choice depends on the image size & applications)

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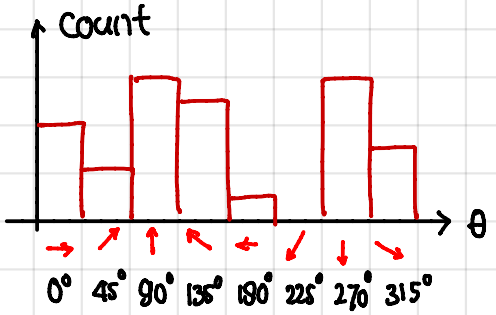
For each pixel in the block we will have one set of oriented gradient information: (θ_i, m_i)

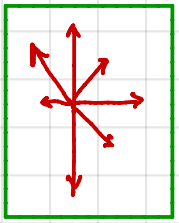
If we have 4x4 pixels (= 16 pixels), then we have 16 sets of (θ_i, m_i), where some of them might have the same/similar values.

② Histogram of Oriented Gradients

1. For each block (cell), we can group the gradients (16 of them) using a histogram with 8 bins (= 8 groups of orientations)

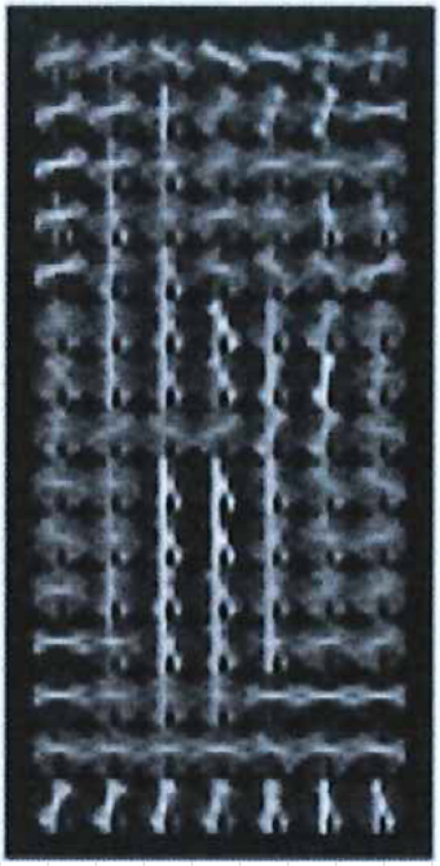


The magnitude influences the height of each bin.



A HoG descriptor: concatenates the histograms of all blocks (or cells) in one long vector!

Input image



HoG

Dominant HoG