



Histograms  
of Oriented  
Gradients

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The Flow Chart  
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# Histograms of Oriented Gradients

## 梯度方向直方图

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# Main Thoughts

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Histograms of Oriented Gradients (HOG) is a technique for feature extraction, which is extensively used in human detection:

- **Substance:** the statistics of gradient information in some dense overlapping grids.
- **Basic Idea:** local object appearance and shape can often be characterized rather well by the distribution of local intensity gradients edge directions.



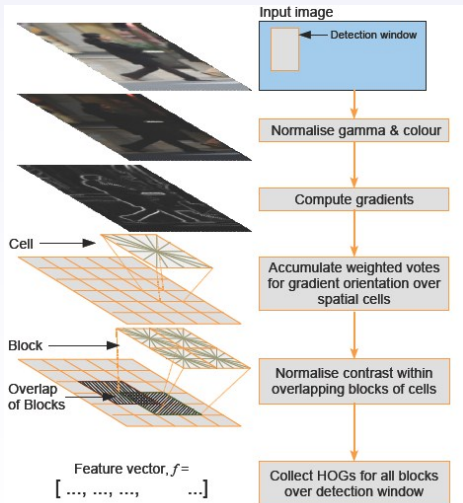
# The Flow Chart of HOG Feature Extraction

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# The Detailed Process of HOG

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## 1. Gamma Normalization:

reduce the local shadow and illumination changes in image, yet it has a modest effect on performance because the subsequent normalization. (can be omitted)

$$I(x, y) = I(x, y)^{gamma}$$

for example,  $gamma = \frac{1}{2}$



# The Detailed Process of HOG

## 2. Gradient Computation:

capture the contour, human shadow, and texture information, weaken the effect of illumination. (Simple masks without Gaussian smoothing work best)

**Horizontal gradient operator:**  $[-1, 0, 1]$

**Vertical gradient operator:**  $[-1, 0, 1]^T$

The **magnitude** of the gradient:

$$M(x, y) = \text{mag}(\nabla f) = \sqrt{g_x^2 + g_y^2}$$

The **direction** of the gradient:

$$\alpha(x, y) = \arctan \left[ \frac{g_x}{g_y} \right]$$

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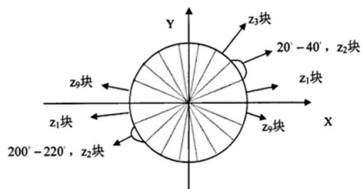
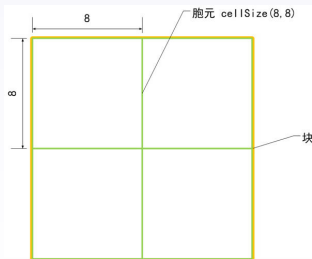
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# Spatial / Orientation Binning

## 3. Spatial / Orientation Binning:

each pixel calculates a weighted vote for an edge orientation histogram channel in the cell which belongs to. (For getting the best results: the orientation bins is  $0^\circ$ - $180^\circ$ , the number of orientation bins is 9, the vote is magnitude)



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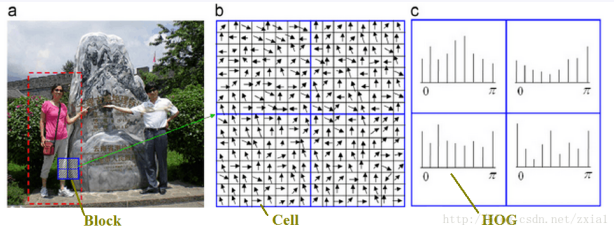
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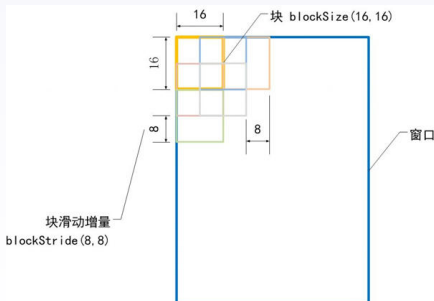


# Normalization and Descriptor Blocks

## 4. Normalization and Descriptor Blocks:

gradient strengths vary over a wide range owing to local variations in illumination and foreground-background contrast

- grouping cells into larger spatial blocks. (Two arrangements: R-HOG, C-HOG)



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- contrast normalizing each block separately. Let  $\mathbf{v}$  be the unnormalized descriptor vector,  $\|\mathbf{v}\|_k$  be its  $k$ -norm for  $k=1, 2$ , and  $\epsilon$  be a small constant.

(a) *L2 - norm*:  $\mathbf{v} \rightarrow \mathbf{v} / \sqrt{\|\mathbf{v}\|_2^2 + \epsilon^2}$

(b) *L2 - Hys*: *L2 - norm* followed by clipping (limiting the maximum values of  $\mathbf{v}$  to 0.2) and renormalizing.

(c) *L1 - sqrt*:  $\mathbf{v} \rightarrow \sqrt{\mathbf{v} / (|\mathbf{v}|_1 + \epsilon)}$



# Collect HOG Features for All Blocks

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## 5. Collect HOG Features for All Blocks:

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