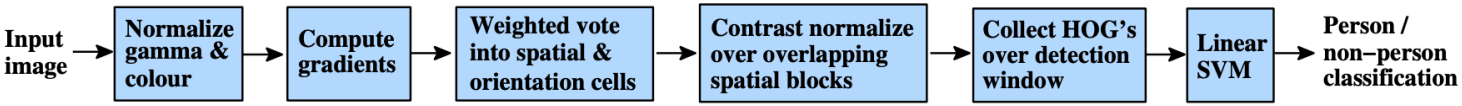
Histogram of Oriented Gradients (HOG*)

* N. Dalal; B. Triggs (CVPR'05) https://ieeexplore.ieee.org/document/1467360

Introduction

- Global features
- Sliding window
- Image subsampled to multiple sizes
- Normalized histograms

Steps



- Normalize and gamma color
- Find horizontal and vertical gradients
- Gradient Magnitude and orientations
- Use a patch of 64 x 128
- Divide the image into blocks of 8 x 8 cells
- Slide over 2 x 2 block cells
- Quantize the gradient orientation into 9 bins by gradient magnitude
  - Normailze each block
- Concatenate histograms into a feature of : 15 x 7 x 4 x 9 = 3780 dimensions.

Normalize

Gamma color

Image Normalization: Convert image to floating point numbers between 0 and 1

Gamma color : $I[x, y] = CI[x, y]^k$

C - constant, use a value of 1

k- exponent, use 1/2

Find horizontal and vertical gradients

Gradient Magnitude and orientations

$$\nabla f(x,y) = \begin{bmatrix} g_x \\ g_y \end{bmatrix} = \begin{bmatrix} \frac{\partial f}{\partial x} \\ \frac{\partial f}{\partial y} \end{bmatrix} = \lim_{d \to 0} \frac{f(x+d) - f(x-d)}{2d}$$

Filter Masks:

-1	0	1

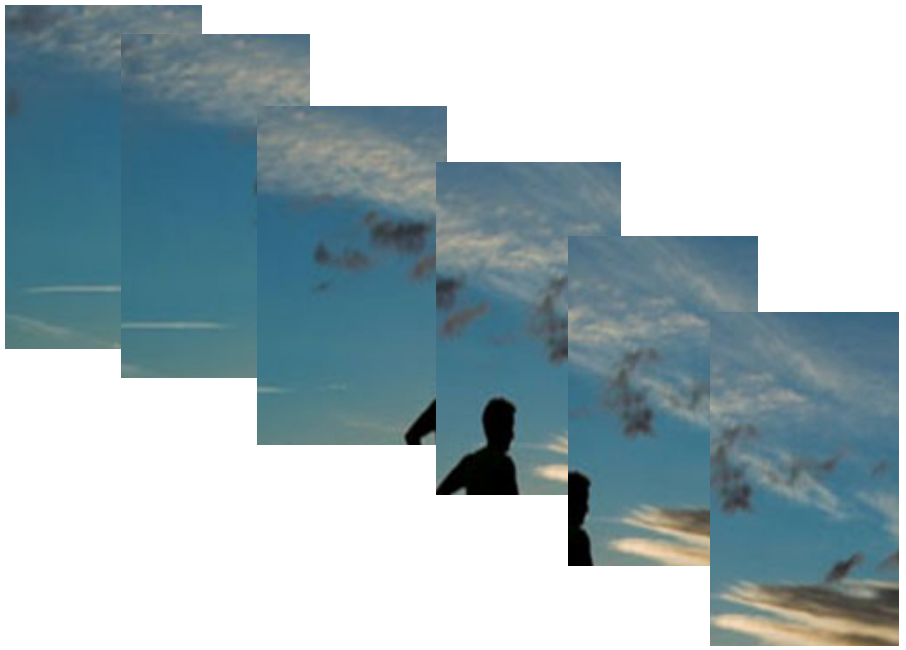
-1
0
1

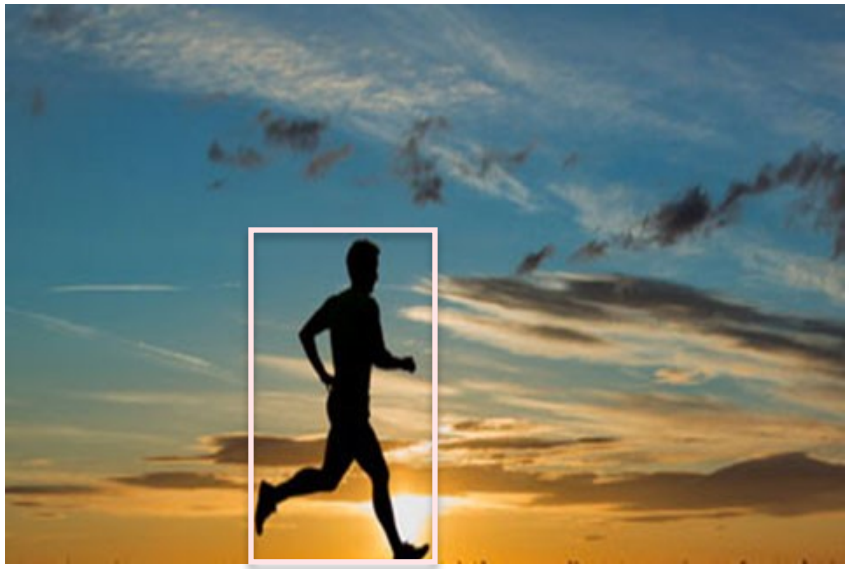
Gradient Magnitude: $g = \sqrt{g_x^2 + g_y^2}$

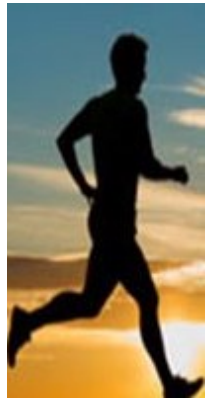
Gradient Orientation: $\theta = \frac{180}{\pi}(tan_2^{-1}\left(\frac{g_y}{g_x}\right) mod\ \pi)$

Gradient is transformed to polar coordinates and angle constrained between 0 and 180 degrees.

Blocks and Cells
Use a patch of 64 x 128



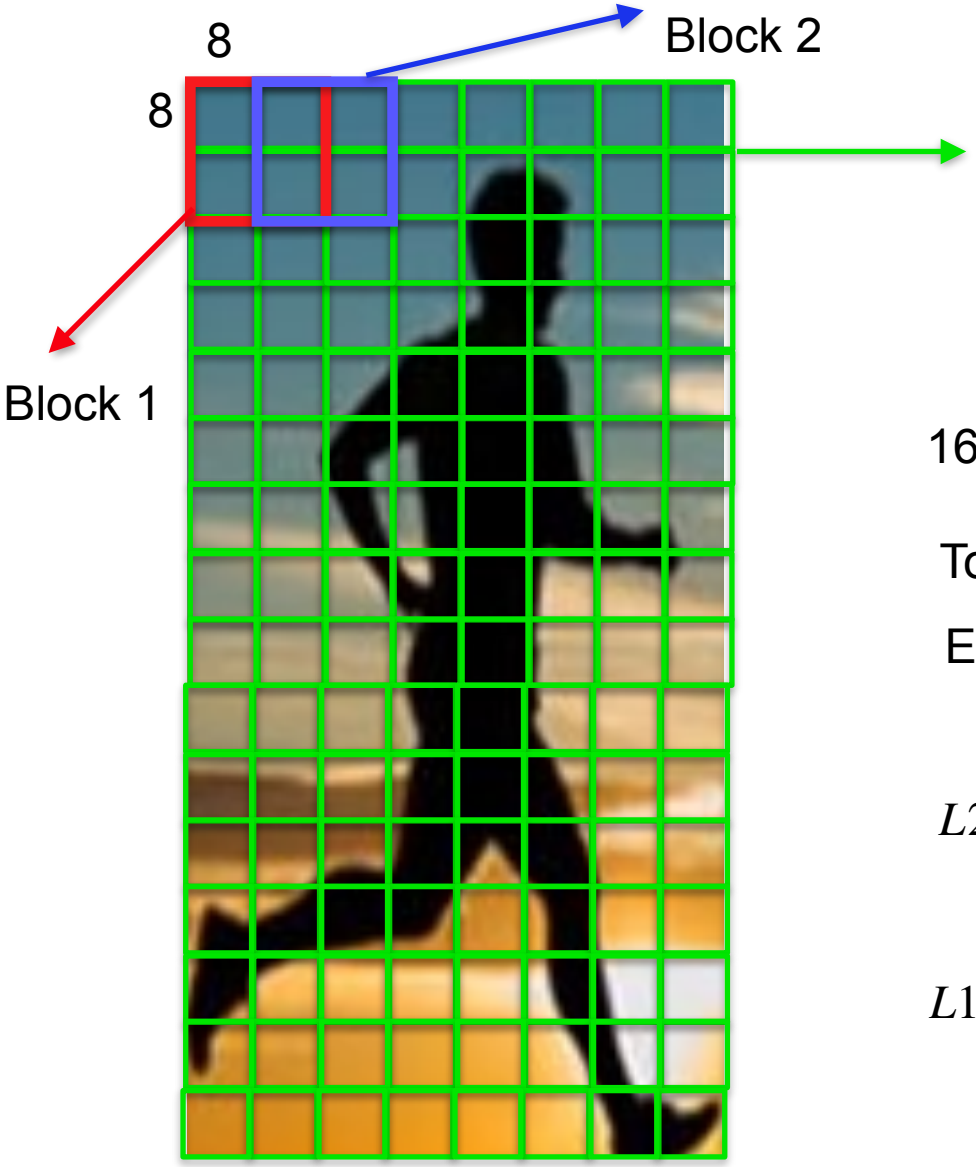




128

64

Divide the image into blocks of 8 x 8 cells
Slide over 2 x 2 block cells



16 x 16 blocks with an overlap

Total blocks: 15 x 7

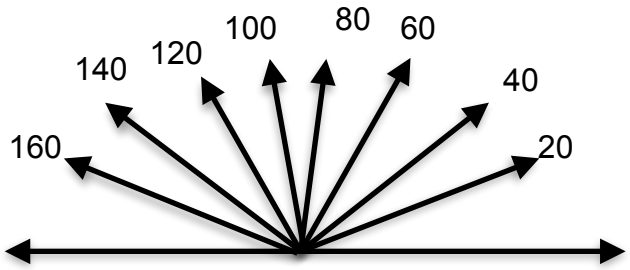
Each block is 2 x 2 of 8x8 cells

$$L2-norm: v \rightarrow \frac{v}{\sqrt{||v||_2^2 + \epsilon^2}}$$

$$L1-norm: v \rightarrow \frac{v}{||v||_1 + \epsilon}$$

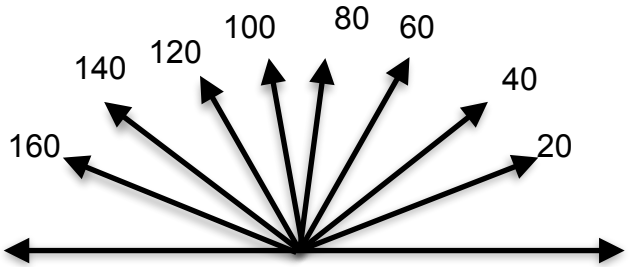
Histogram bins

Quantize the gradient orientation into 9 bins by gradient magnitude



Histogram bins

Quantize gradient orientations into 9 bins

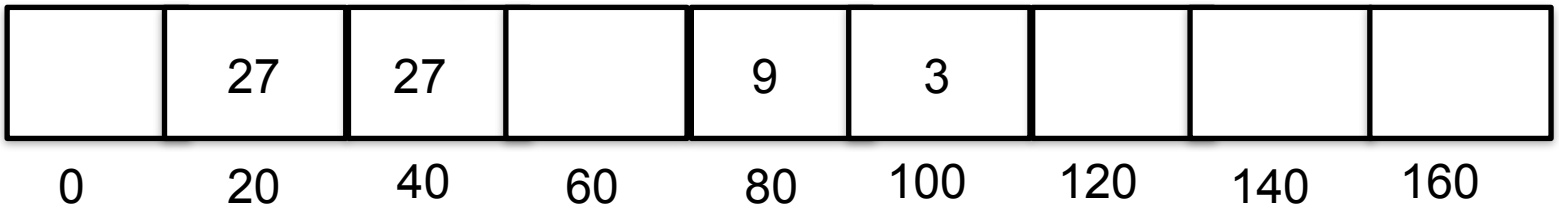


70	35	5	10	64	0
57	85	160	0	120	65
22	45	90	145	30	18
12	4	134	6	75	57
43	30	23	5	119	14
67	57	98	11	9	77
3	11	23	54	78	90

Gradient direction

2	5	4	85	2	0
106	12	13	77	3	6
37	86	48	180	12	37
108	3	87	33	81	27
23	54	11	186	19	114
7	210	19	33	24	12
112	4	34	9	3	12

Gradient Magnitude



Concatenate Histograms

15 x 7 * 9 * 4 = 3780