Feature Descriptors -
Histogram of Oriented Gradients (HOG)

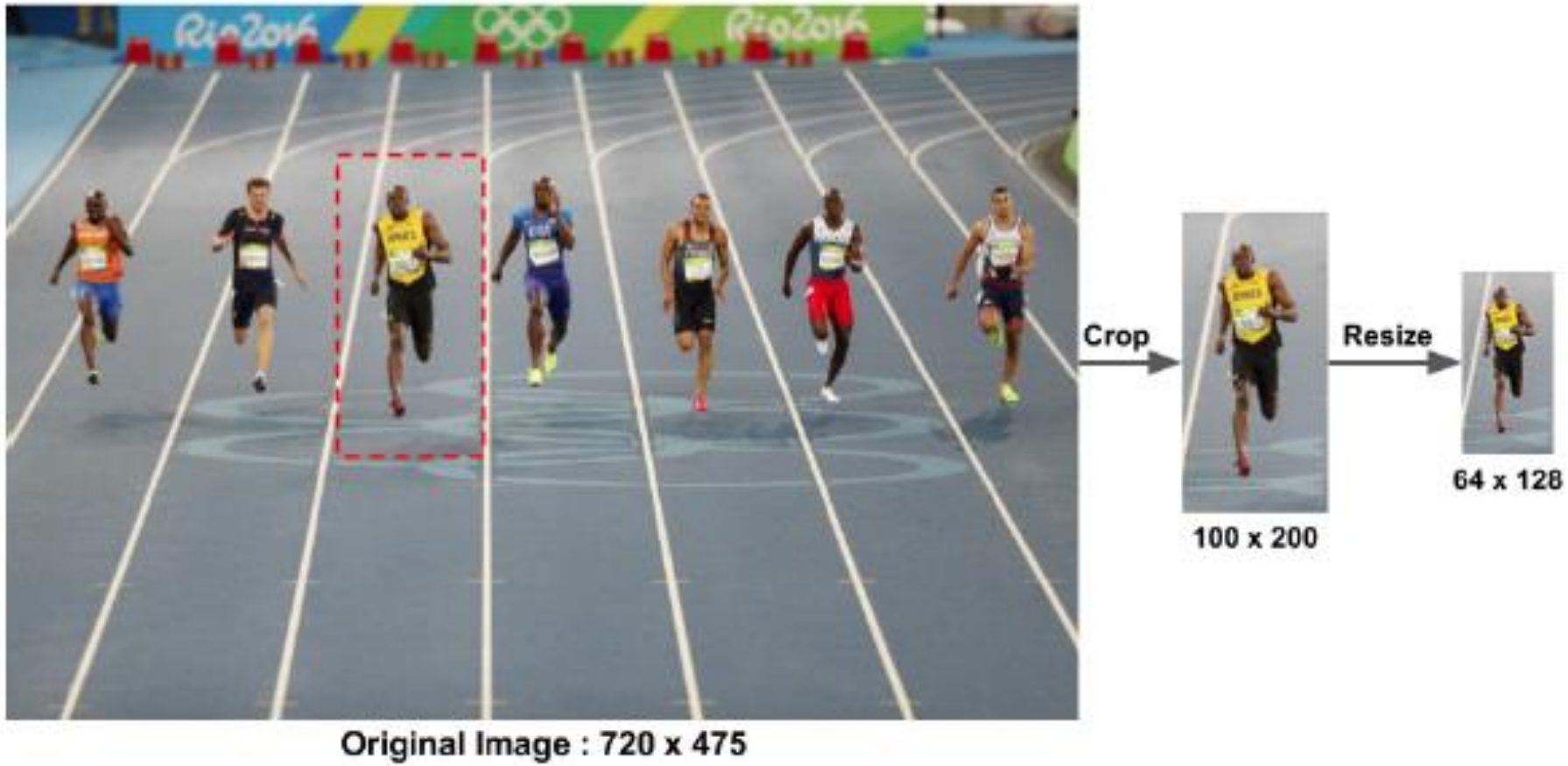
What is a Feature Descriptor?

- A feature descriptor is a representation of an image patch.
- Converts an image to a feature vector / array of length n.
- HoG feature descriptor, the distribution (histograms) of directions of gradients (oriented gradients) are used as features.

Reference

N. Dalal and B. Triggs, ***"Histograms of oriented gradients for human detection,"*** in Proceedings of the IEEE Computer Society Conference on Computer Vision and Pattern Recognition (CVPR'05) - pp. 886–893, 2005.

Step 1 : Preprocessing

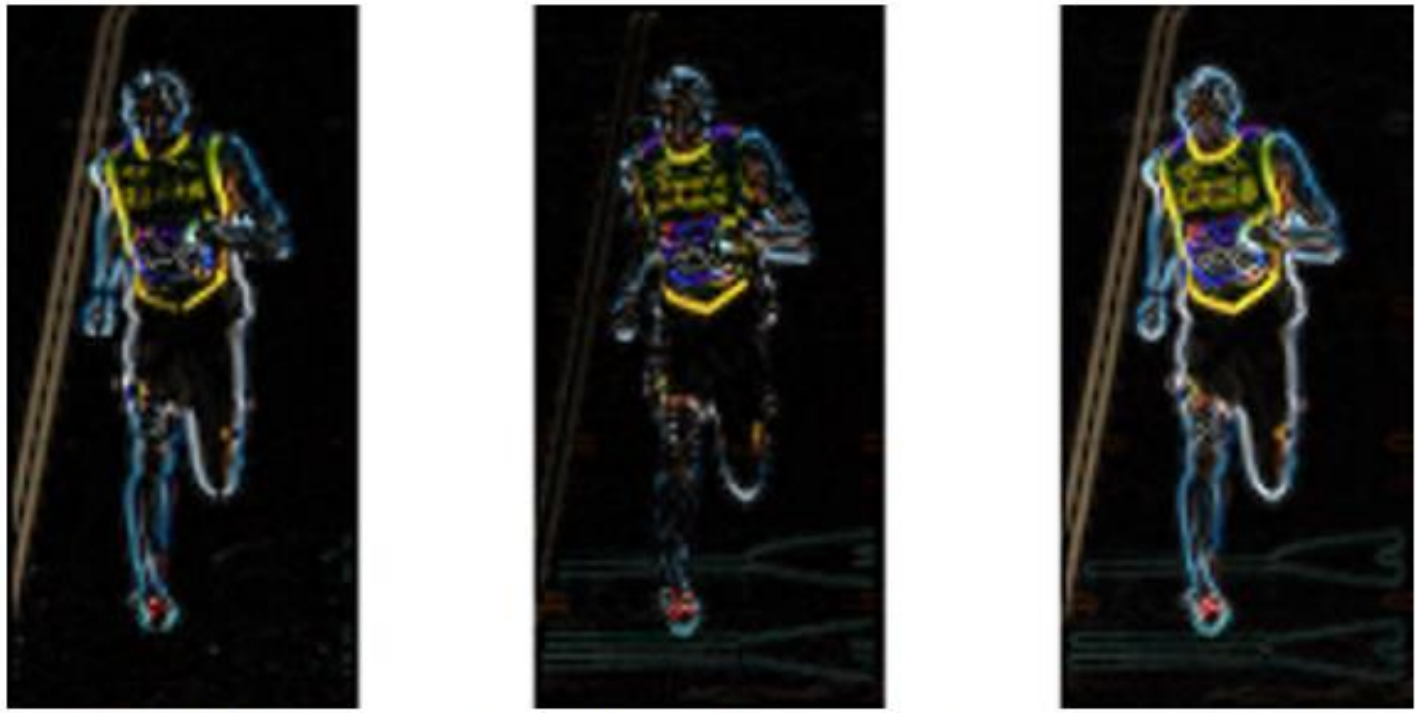


Step 2 : Calculate the Gradient Images

- Sobel operator can be used to compute gradient magnitude and direction.

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

$$\theta = \arctan \frac{g_y}{g_x}$$



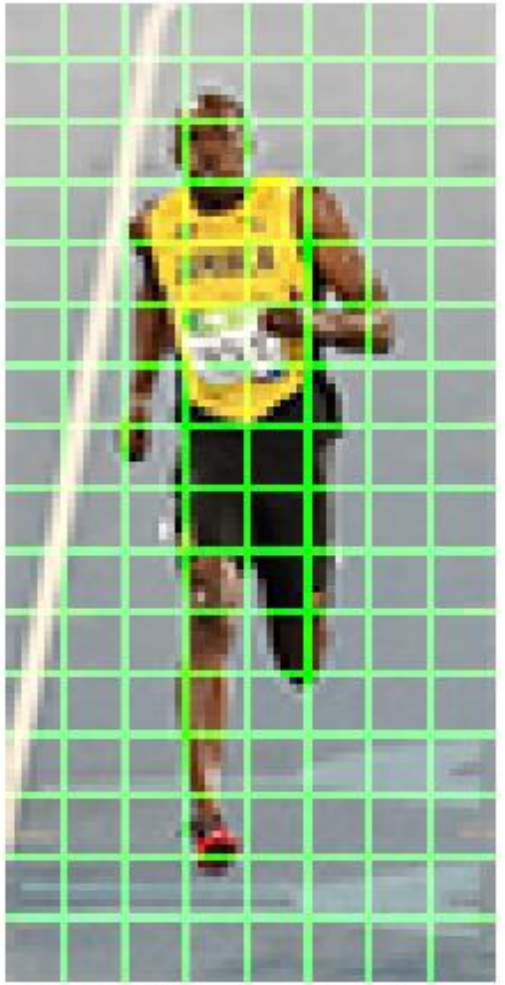
Left : Absolute value of x-gradient. Center : Absolute value of y-gradient.
Right : Magnitude of gradient.

Step 3 : Calculate Histogram of Gradients in 8×8 cells

- The gradient of this patch contains 2 values (magnitude and direction) per pixel which adds up to 8x8x2 = 128 numbers.

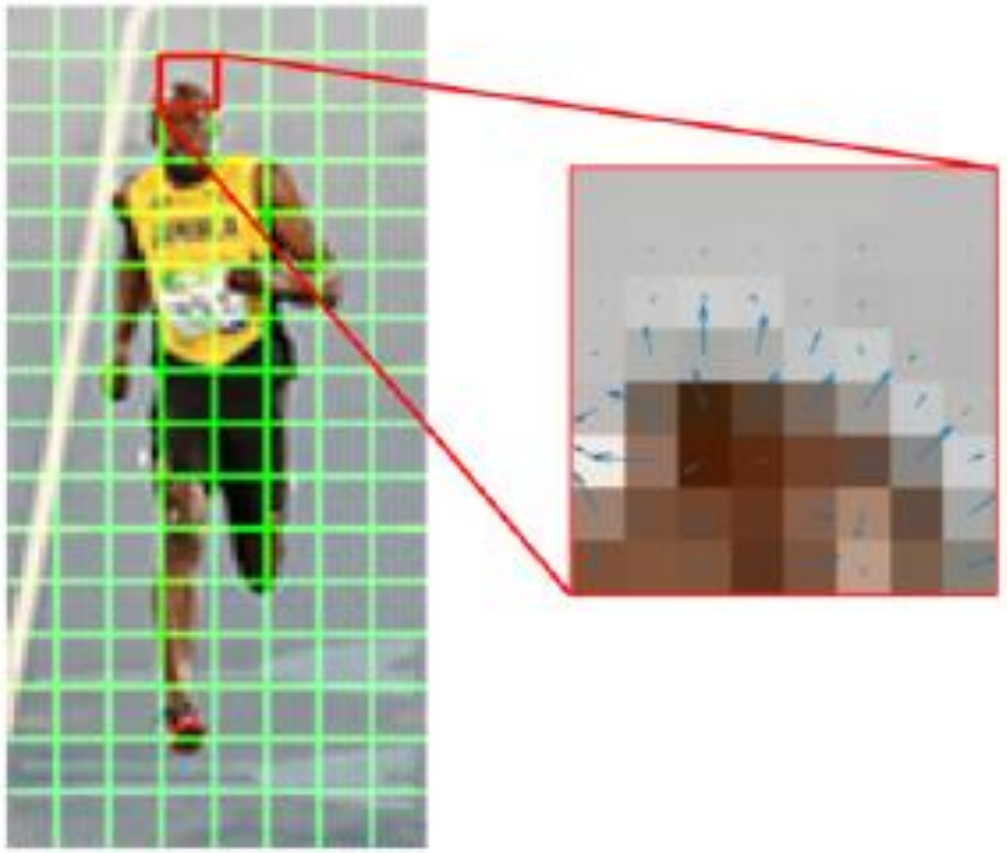
- 128 numbers are represented using a 9-bin histogram

- The histogram is a vector (or an array) of 9 bins (numbers) corresponding to angles 0, 20, 40, 60 … 160.



8×8 cells of HOG. Image is scaled by 4x for display.

Step 3 : Calculate Histogram of Gradients in 8×8 cells



2	3	4	4	3	4	2	2
5	11	17	13	7	9	3	4
11	21	23	27	22	17	4	6
23	99	165	135	65	32	26	2
91	155	133	136	144	152	57	28
98	196	76	38	26	60	170	51
165	60	60	27	77	85	43	136
71	13	34	23	108	27	48	110

Gradient Magnitude

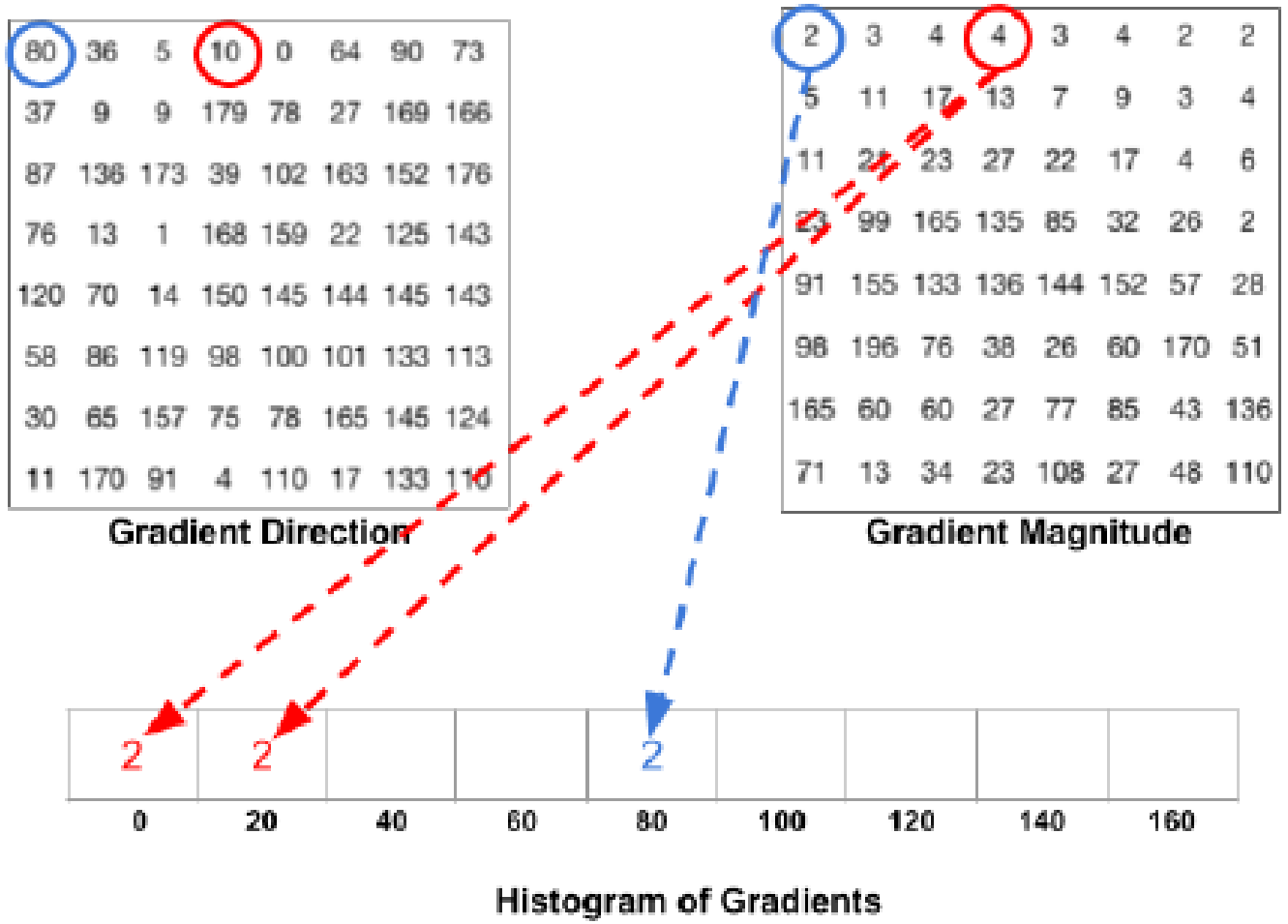
80	36	5	10	6	64	90	73
37	9	9	179	78	27	169	166
87	136	173	39	102	163	152	176
76	13	1	168	159	22	125	143
120	70	14	150	145	144	145	143
58	86	119	98	100	101	133	113
30	65	157	75	78	165	145	124
11	170	91	4	110	17	133	110

Gradient Direction

Center : The RGB patch and gradients represented using arrows. Right : The gradients in the same patch represented as numbers

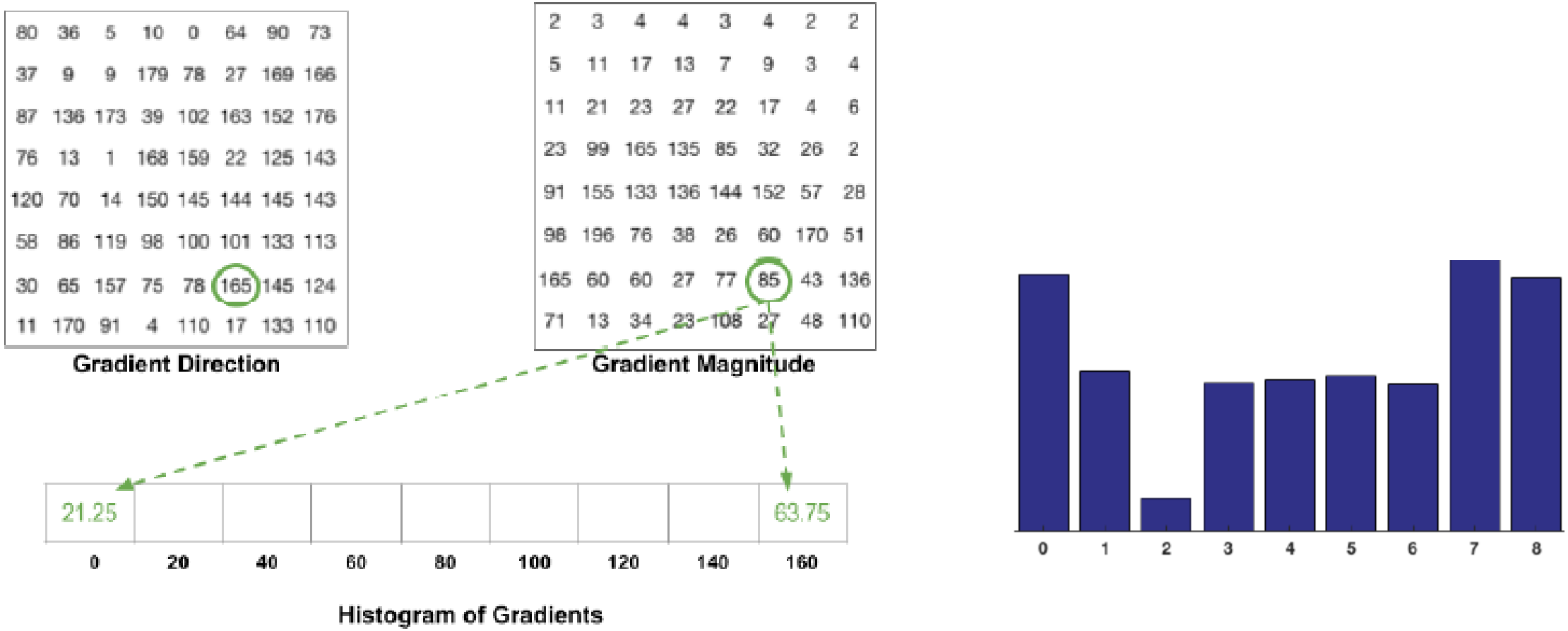
Step 3 : Calculate Histogram of Gradients in 8×8 cells

- A bin is selected based on the direction, and the vote (the value that goes into the bin) is selected based on the magnitude.



Step 3 : Calculate Histogram of Gradients in 8×8 cells

- If the angle is greater than 160 degrees, it is between 160 and 180, it contributes proportionally to the 0 degree bin and the 160 degree bin.

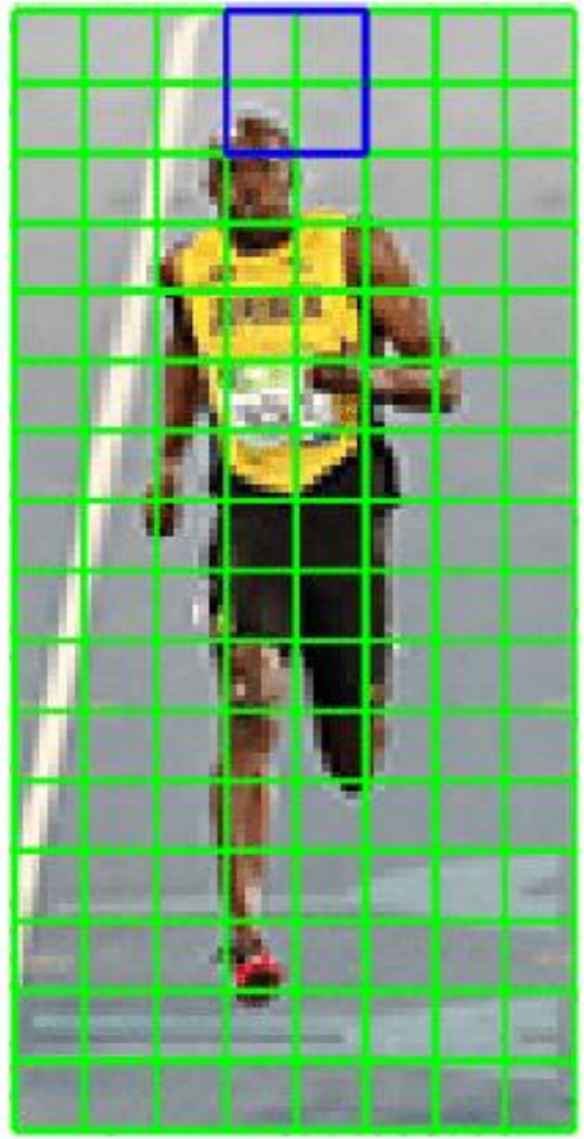


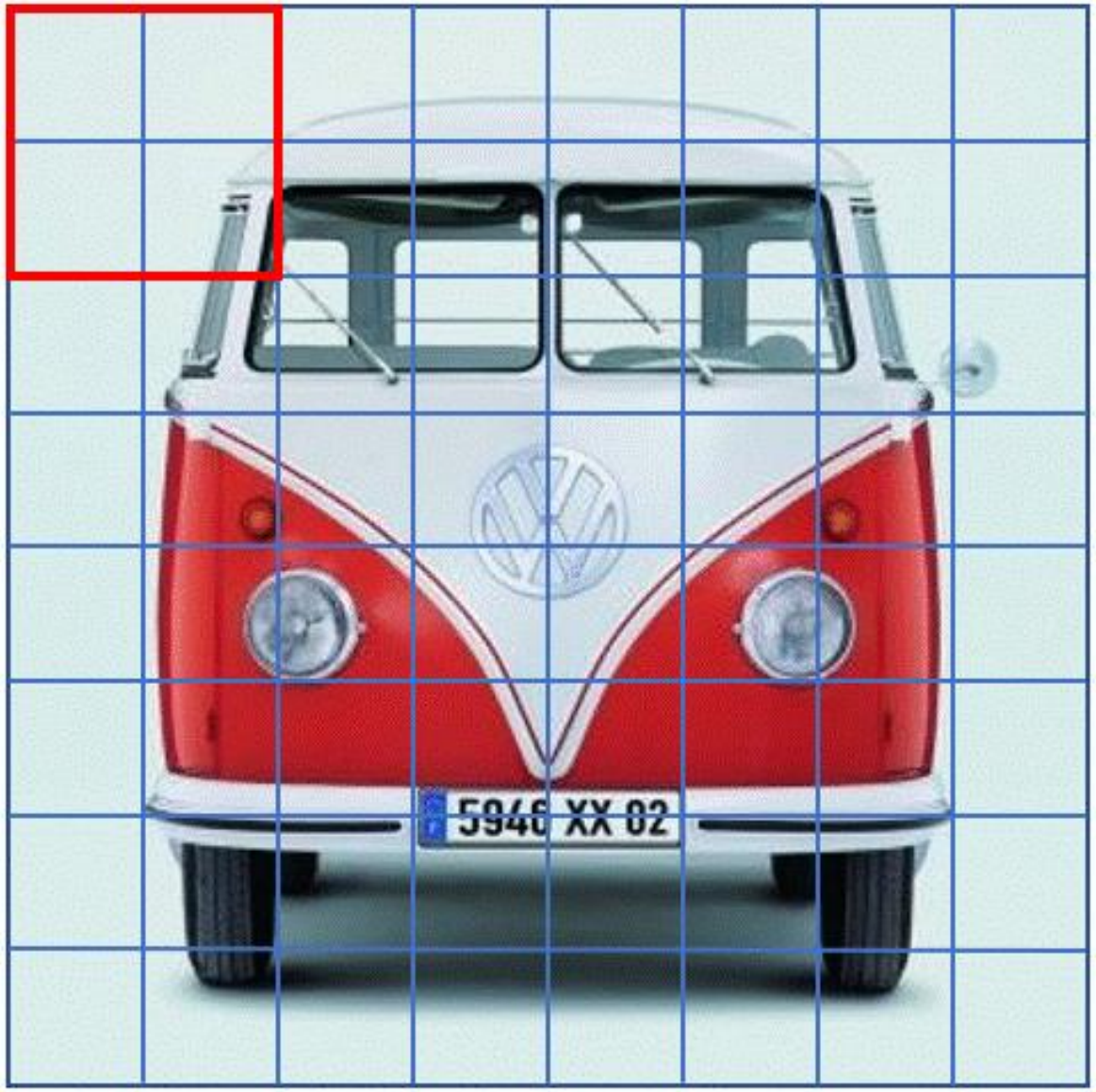
Step 4 : 16×16 Block Normalization

- Gradients of an image are sensitive to overall lighting.
- Descriptor has to be independent of lighting variations.
- For vector [128, 64, 32], the length of this vector is

$$\sqrt{128^2 + 64^2 + 32^2} = 146.64$$

- Dividing each element of this vector by 146.64 gives us a normalized vector [0.87, 0.43, 0.22].
- A 16×16 block has 4 histograms which can be concatenated to form a 36 x 1 element normalized vector





Source: HOG Feature Descriptor. In computer vision there are many… | by Dahi Nemutlu | Medium

Step 5 : Calculate the HOG feature vector

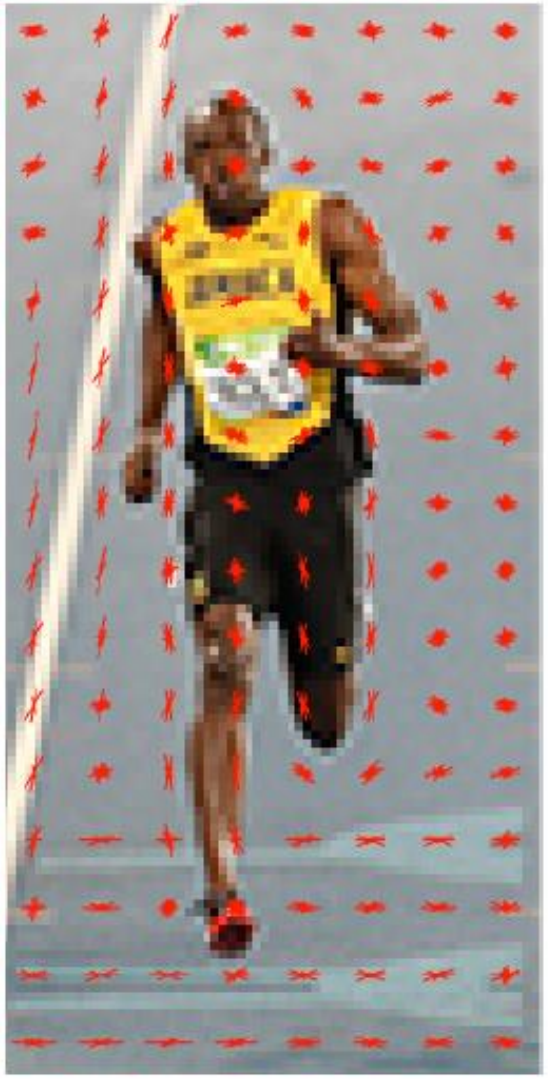
- To calculate the final feature vector for the entire image patch, the 36×1 vectors are concatenated in to one giant vector.

- There are 7 horizontal and 15 vertical positions making a total of 7 x 15 = 105 positions.

- Each 16×16 block is represented by a 36×1 vector. So when we concatenate them all into one gaint vector we obtain a 36×105 = 3780 dimensional vector.

Visualizing Histogram of Oriented Gradients

The HOG descriptor of an image patch is usually visualized by plotting the 9×1 normalized histograms in the 8×8 cells.



Source: Learn OpenCV

OpenCV examples and tutorials (C++ / Python)