- A feature descriptor is a representation of an image or an image patch that simplifies the image by extracting useful information and throwing away extraneous information.
- Typically, a feature descriptor converts an image of size width x height x 3 (channels) to a feature vector / array of length n.
- It is very useful for tasks like image recognition and object detection.
- HOG and LBP are popular visual descriptors used in computer vision.
- Both techniques use gradient information by exploiting pixel similarity with neighbourhoods.
- Widely used in creating several models for object detection and classification.

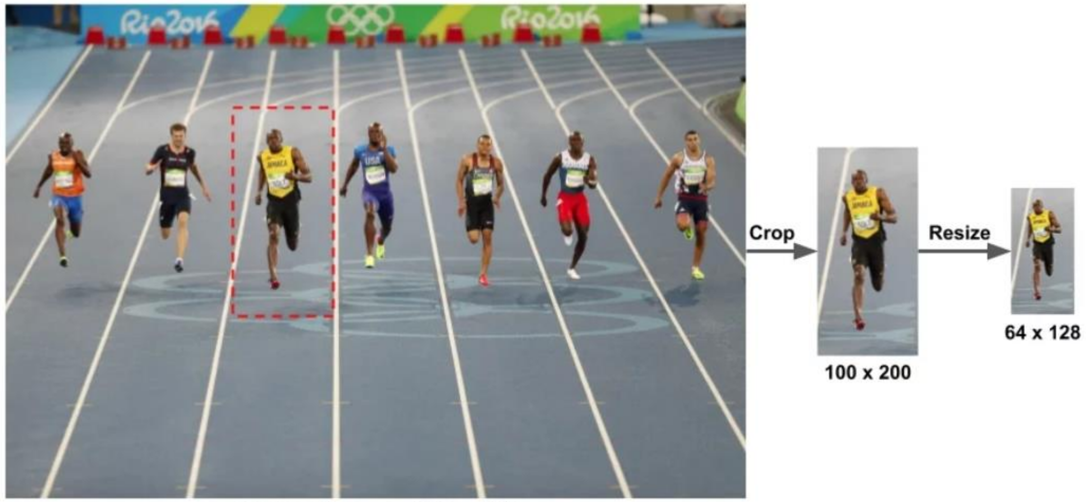
HOG concept is first introduced in a patent in 1986

“Marshall, W.W. and McWhortor, W.F.,1989. Method and apparatus for pattern recognition. *U.S. Patent4,817,176*”

Became popular through a human detection paper in 2005 (cited by 25K+)

Dalal, N. and Triggs, B., 2005, June. Histograms of oriented gradients for human detection. *In international Conference on computer vision & Pattern Recognition (CVPR'05) (Vol. 1, pp. 886-893). IEEE Computer Society*.

- The essential thought behind the histogram of oriented gradients descriptor is that local object appearance and shape within an image can be described by the distribution of intensity gradients or edge directions.
- The nature of pre-processing will be based on target application.
- Image cropping and resizing may be required.
- HOG uses pixel patches of 8x8 in further stages. So resizing image in multiples of 8 is preferred



Original Image : 720 x 475

https://www.learnopencv.com/histogram-of-oriented-gradients/

Calculate the Gradient Images

Helps to remove non-essential information (such as image background)

-1	0	1

-1
0
1

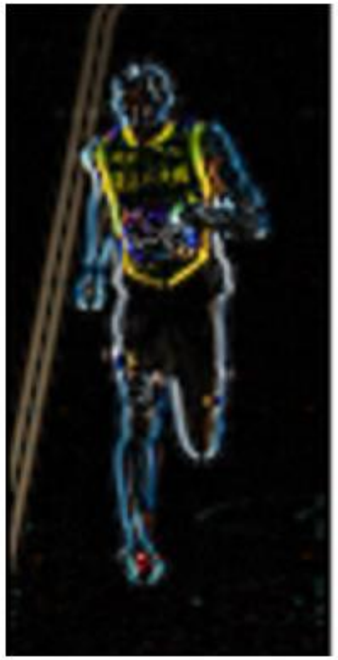
-1	0	+1
-2	0	+2
-1	0	+1

Gx

+1	+2	+1
0	0	0
-1	-2	-1

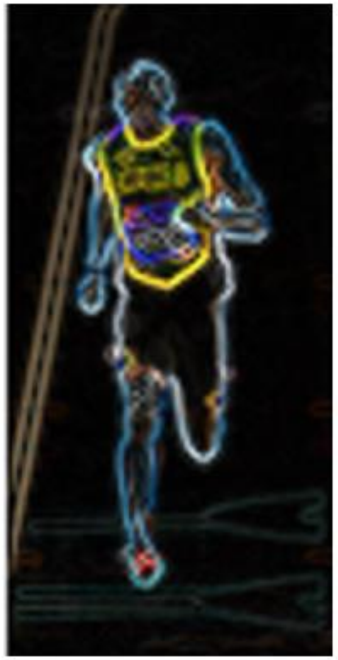
Gy

Input Image

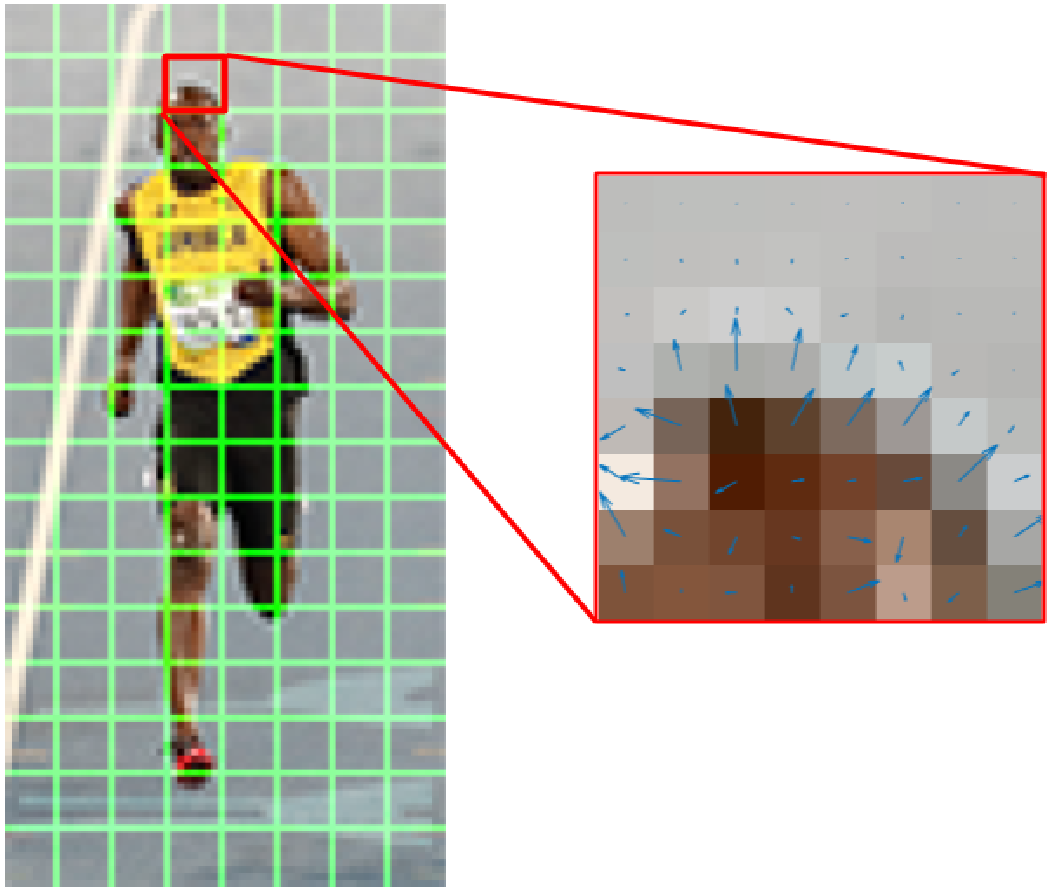


Absolute value of x gradient

Absolute value of y gradient



Magnitude of gradient

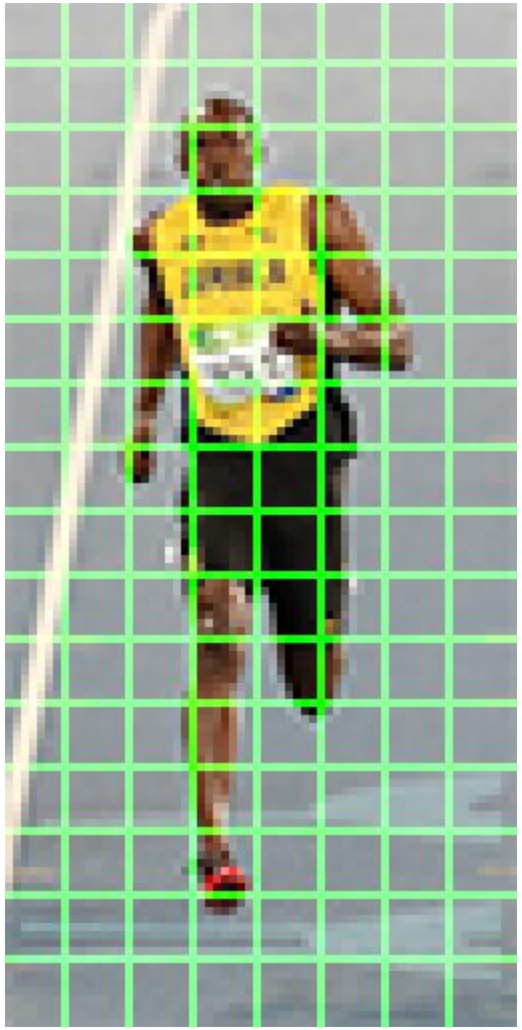


2	3	4	4	3	4	2	2
5	11	17	13	7	9	3	4
11	21	23	27	22	17	4	6
23	99	165	135	85	32	26	2
91	155	133	136	144	152	57	28
98	196	76	38	26	60	170	51
165	60	60	27	77	85	43	136
71	13	34	23	108	27	48	110

Gradient Magnitude

80	36	5	10	0	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

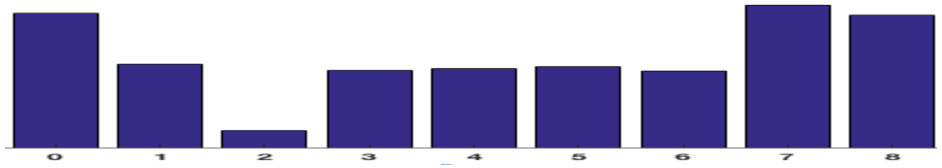


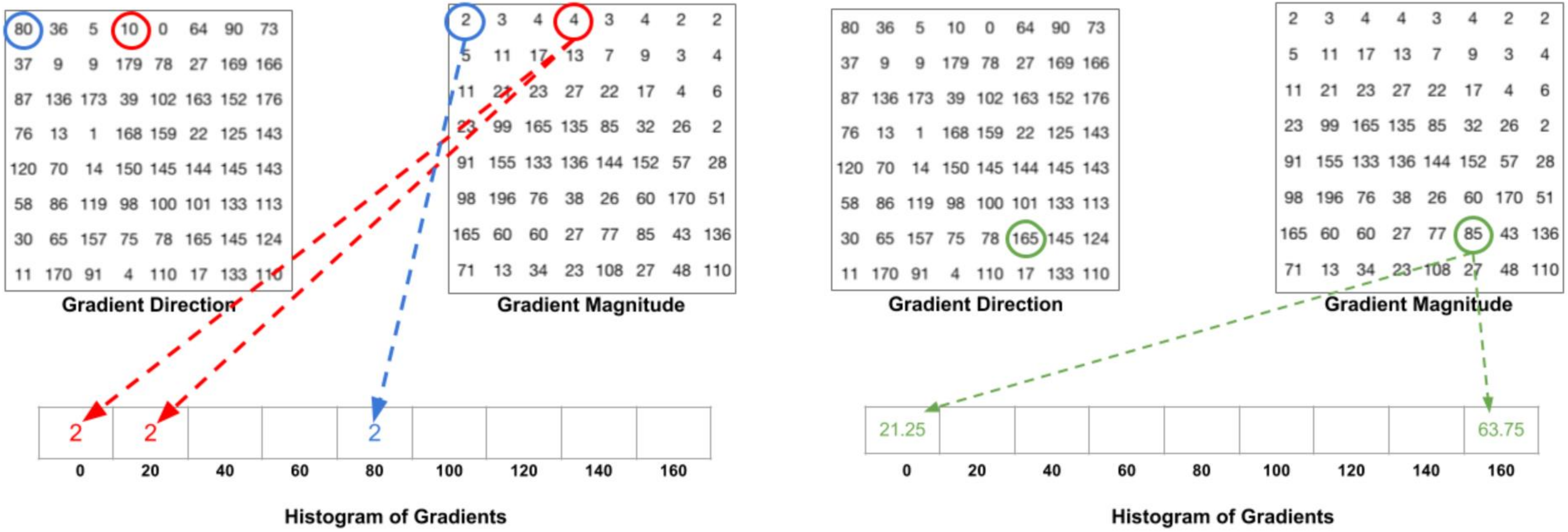
Calculate Histogram of Gradients in 8×8 cells

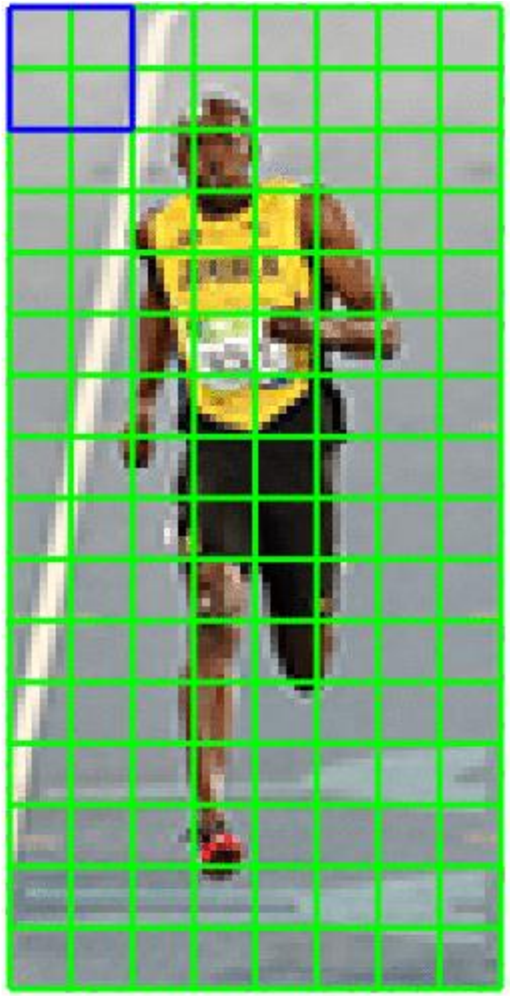
- The image is divided into 8×8 cells and a histogram of gradients is calculated for each 8×8 cells.
- The size of cells is a design choice informed by the scale of features we are looking for
- Unsigned histogram bins are opted from 0 to 180 degree range
- 9 bins are used (0, 20, 40, 60, … , 160)
- Empirically it has been shown that unsigned gradients work better than signed gradients for practical object detection systems

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







16×16 Block Normalization

- Gradients of an image are sensitive to overall lighting
- Histogram normalization is required to make the descriptor illumination invariant
- Considering adjacent 16x16 pixels (4 cells) to do the block normalization
- Overlapping blocks are used with a stride of 8 pixels
- 36 histogram values (4 x 9) are normalized at a time
- L2-Norm is commonly used to normalize the histogram vectors

1.How many positions of the 16×16 blocks do we have ? There are 7 horizontal and 15 vertical positions making a total of 7 x 15 = 105 positions.

2.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

Local Binary Pattern (LBP)

- Local Binary Patterns is an important feature descriptor that is used in computer vision for texture matching.
- LBP is the particular case of the Texture Spectrum model proposed in 1990

“DC. He and L. Wang (1990), "Texture Unit, Texture Spectrum, And Texture Analysis", Geoscience and Remote Sensing, IEEE Transactions on, vol. 28, pp. 509 – 512”

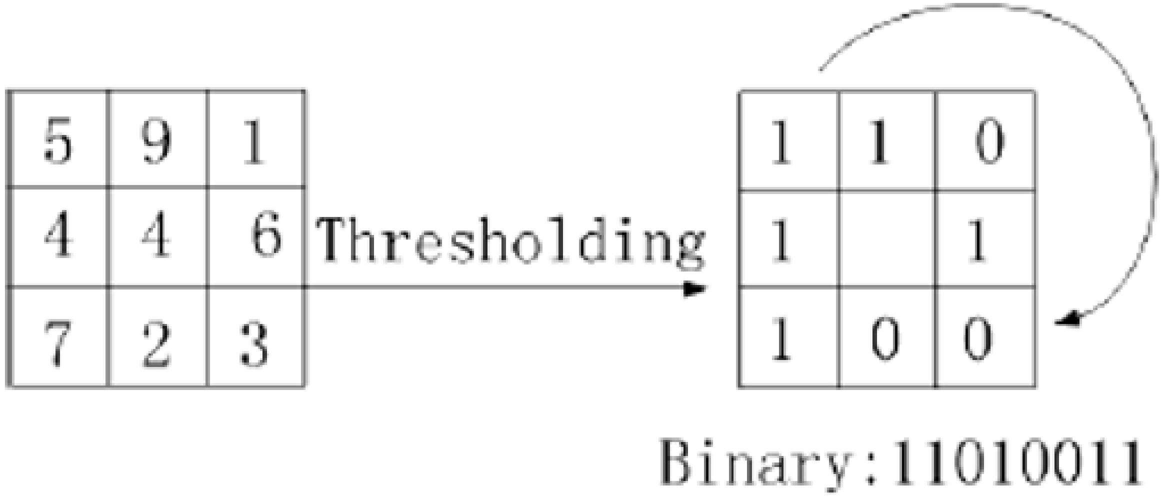
“L. Wang and DC. He (1990), "Texture Classification Using Texture Spectrum", Pattern Recognition, Vol. 23, No. 8, pp. 905 – 910”

- LBP was first described in 1994 (cited by 6K)

“T. Ojala, M. Pietikäinen, and D. Harwood (1994), "Performance evaluation of texture measures with classification based on Kullback discrimination of distributions", Proceedings of the 12th IAPR International Conference on Pattern Recognition (ICPR 1994), vol. 1, pp. 582 – 585”

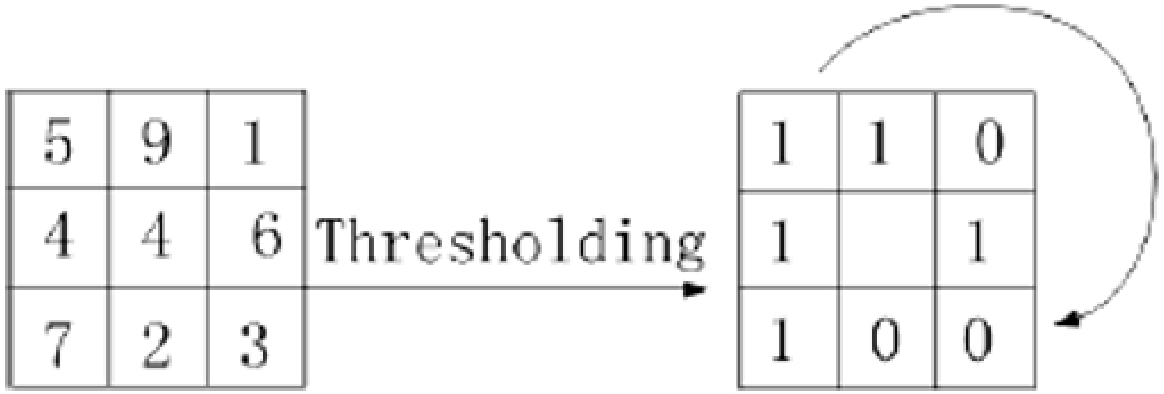
“T. Ojala, M. Pietikäinen, and D. Harwood (1996), "A Comparative Study of Texture Measures with Classification Based on Feature Distributions", Pattern Recognition, vol. 29, pp. 51-59”

- Each pixel in the grayscale image, a neighbourhood is selected around the current pixel and then we calculate the LBP value for the pixel using the neighbourhood.
- To calculate the LBP value for a pixel in the grayscale image, we compare the central pixel value with the neighbouring pixel values.
- We can start from any neighbouring pixel and then we can transverse either in clockwise or anti-clockwise direction but we must use the same order for all the pixels.
- If the current pixel value is greater or equal to the neighbouring pixel value, the corresponding bit in the binary array is set to 1 else if the current pixel value is less than the neighbouring pixel value, the corresponding bit in the binary array is set to 0.



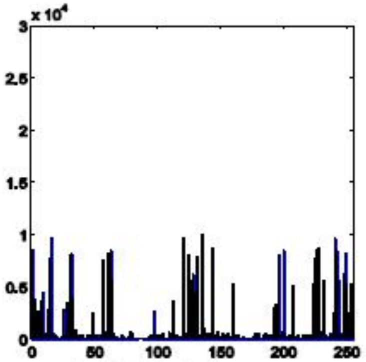
Compare each pixel with its neighbourhoods

- If the centre pixel's value is greater than the neighbour, use "1". Otherwise, use "0“
- Here in this example, the decimal value corresponding to 11010011’ is 211.
- The value can be from ‘00000000’ to ‘11111111’ (decimal 0 to 255).



Input image

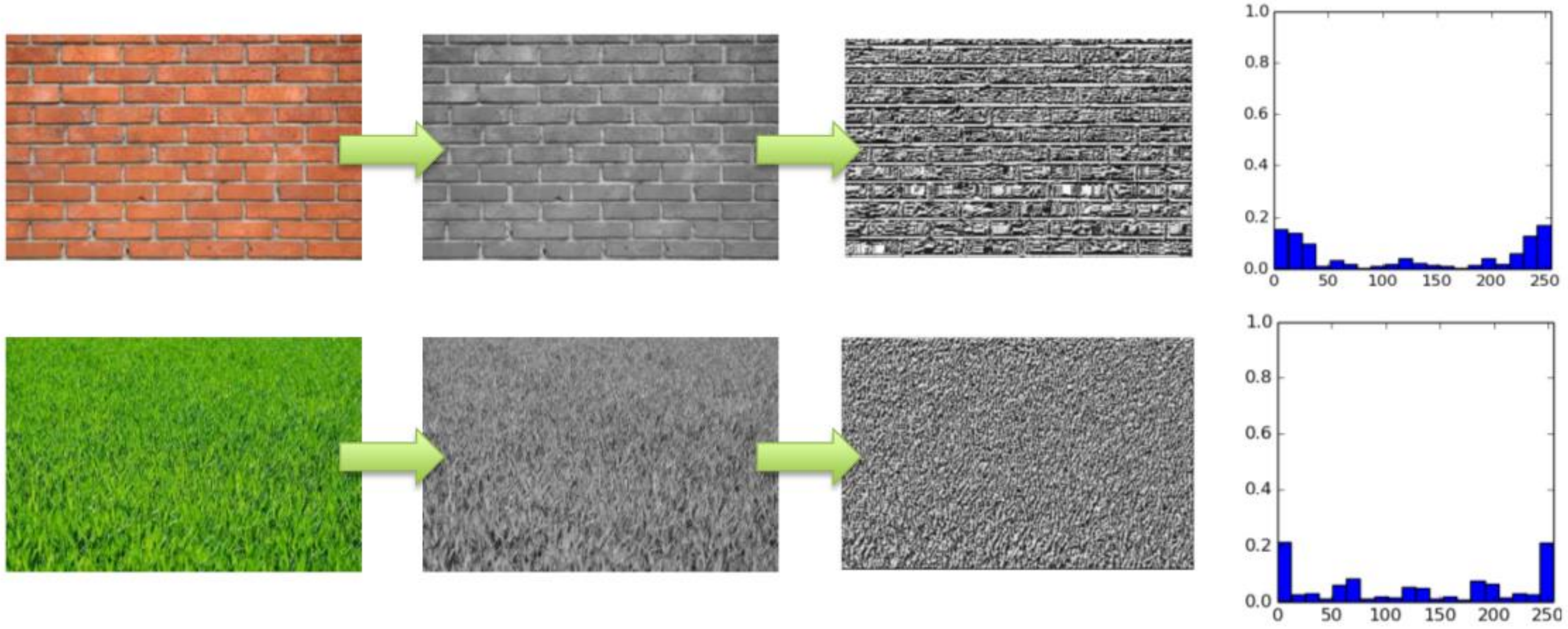
LBP image



LBP histogram

- Once we have calculated the LBP Mask, we calculate the LBP histogram. The LBP mask values range from 0 to 255, so our LBP Descriptor will be of size 1x256. We then normalize the LBP histogram.
- The image below shows the scheme of the algorithm

1. Load the color image.
2. Convert to grayscale image.
3. Calculate the LBP image.
4. Calculate the LBP Histogram and normalize it.



One advantage of LBP is that it is illumination and translation invariant. We have selected a 8 point neighbourhood, but most implementations use a circular neighbourhood as shown below.