Histograms of Oriented Gradients for Human Detection

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CVPR 2005

HOG Steps

- HOG feature extraction
  - Compute centered horizontal and vertical gradients with no smoothing
  - Compute gradient orientation and magnitudes
    - For color image, pick the color channel with the highest gradient magnitude for each pixel.
  - For a 64x128 image,
  - Divide the image into 16x16 blocks of 50% overlap.
    - 7x15=105 blocks in total
  - Each block should consist of 2x2 cells with size 8x8.
  - Quantize the gradient orientation into 9 bins
    - The vote is the gradient magnitude
    - Interpolate votes bi-linearly between neighboring bin center.
    - The vote can also be weighted with Gaussian to downweight the pixels near the edges of the block.
  - Concatenate histograms (Feature dimension: 105x4x9 = 3,780)

Computing Gradients

- Centered: $f'(x) = \lim_{h \to 0} \frac{f(x+h) - f(x-h)}{2h}$

- Filter masks in x and y directions

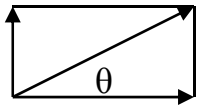
  - Centered:

-1	0	1

-1
0
1

- Gradient

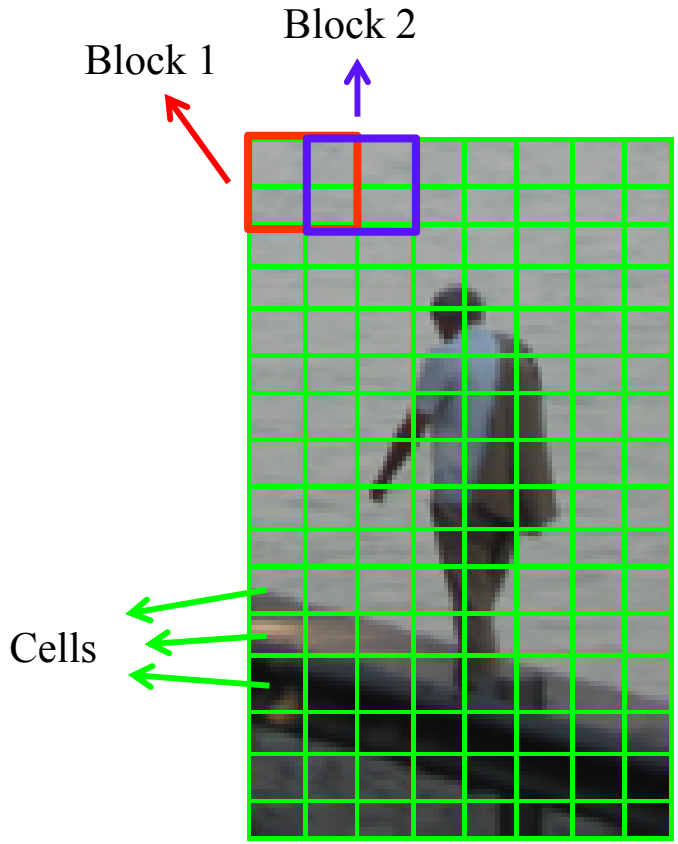
  - Magnitude: $s = \sqrt{s_x^2 + s_y^2}$



  - Orientation: $\theta = \arctan(\frac{s_y}{s_x})$

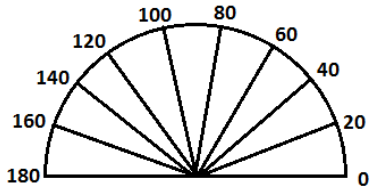
Blocks, Cells

- 16x16 blocks of 50% overlap.
  - 7x15=105 blocks in total
- Each block should consist of 2x2 cells with size 8x8.

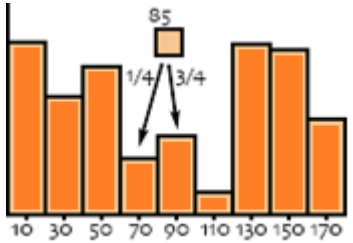


Tri-linear Interpolation

- Each block consists of 2x2 cells with size 8x8
- Quantize the gradient orientation into 9 bins (0-180)



9 Bins



Bin centers

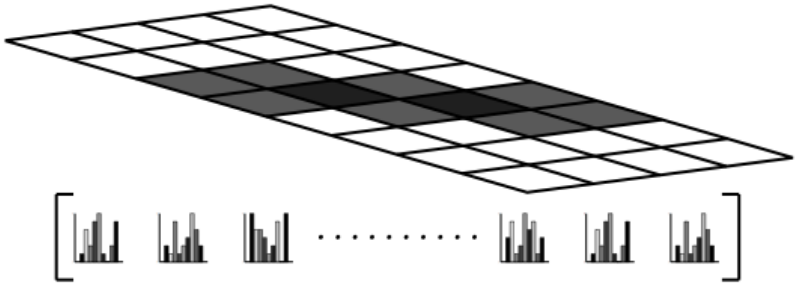
  - The vote is the gradient magnitude

  - Interpolate votes linearly between neighboring bin centers.
    - Example: if θ=85 degrees.
    - Distance to the bin cente Bin 70 and Bin 90 are 15 and 5 degrees, respectively.
    - Hence, ratios are 5/20=1/4, 15/20=3/4.

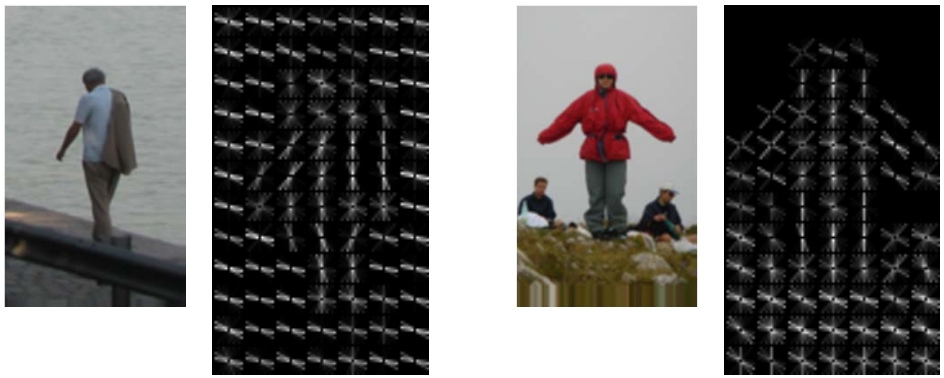
  - The vote can also be weighted with Gaussian to downweight the pixels near the edges of the block.

Final Feature Vector

- Concatenate histograms
  - Make it a 1D matrix of length 3780.



- Visualization



Results

Navneet Dalal and Bill Triggs “Histograms of Oriented Gradients for Human Detection” CVPR05