

# Histogram of Oriented Gradients

John Charlesworth  
Michael Hodgson

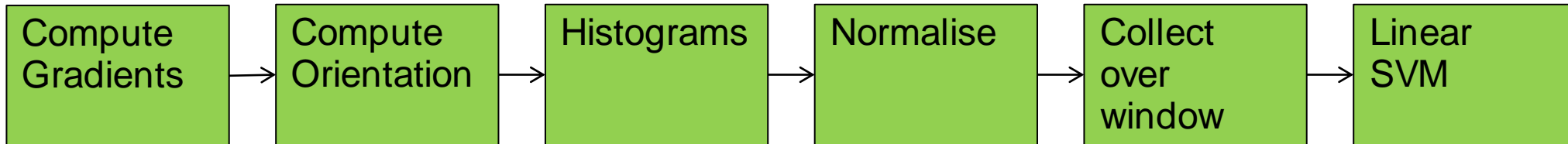
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# Introduction

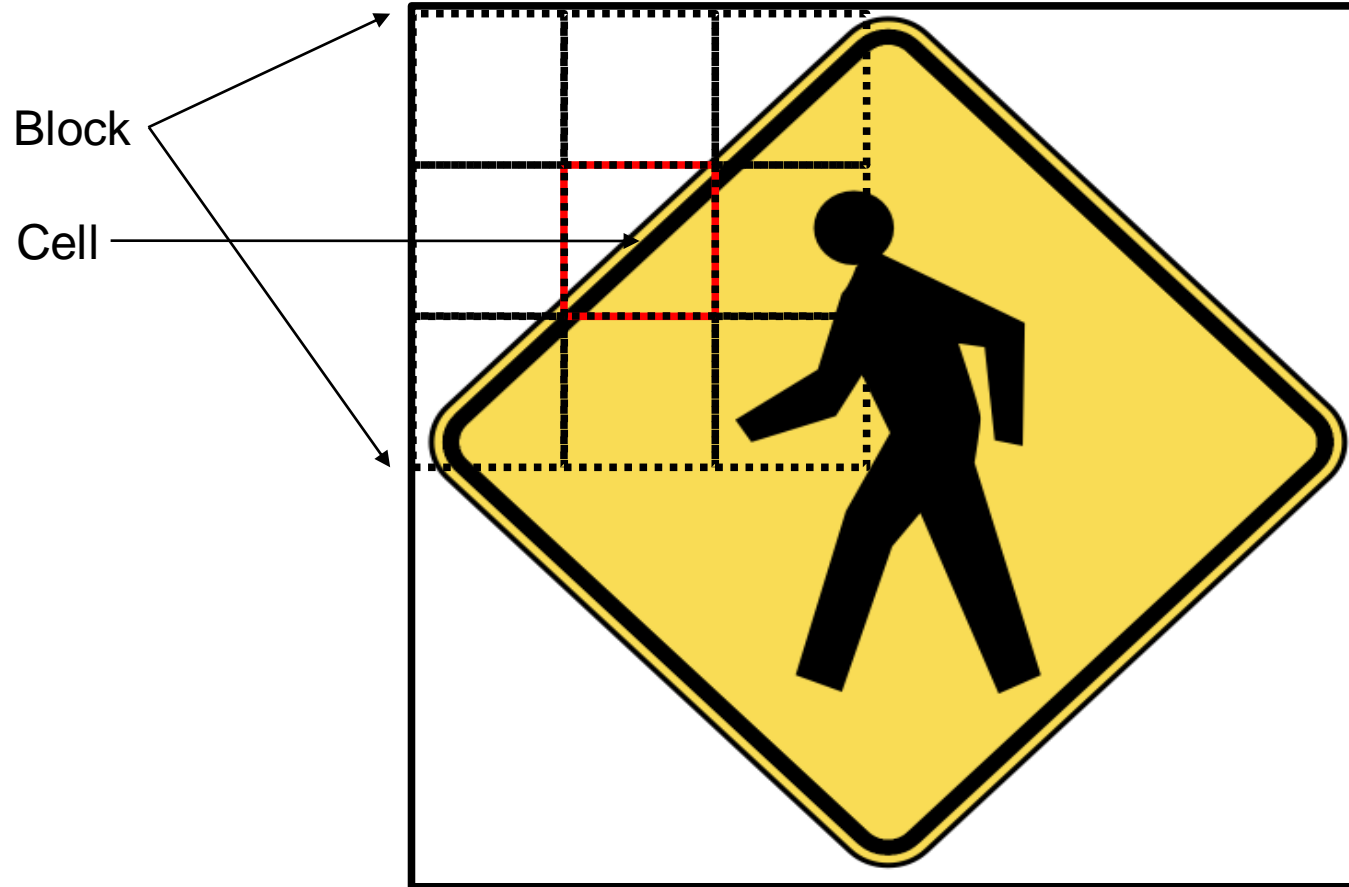
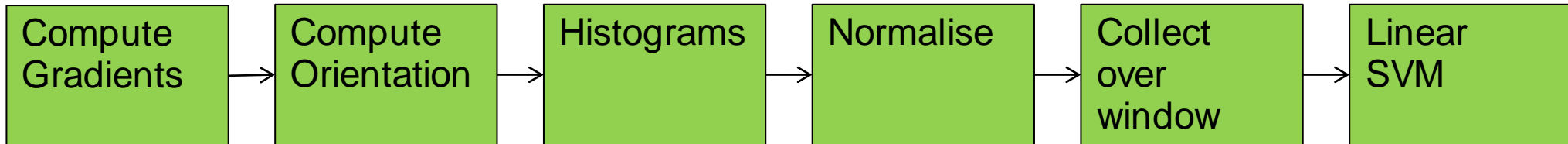
- Histogram of oriented gradients is a feature descriptor
- Used in conjunction with a training data set and a classifier

# The HOG Process

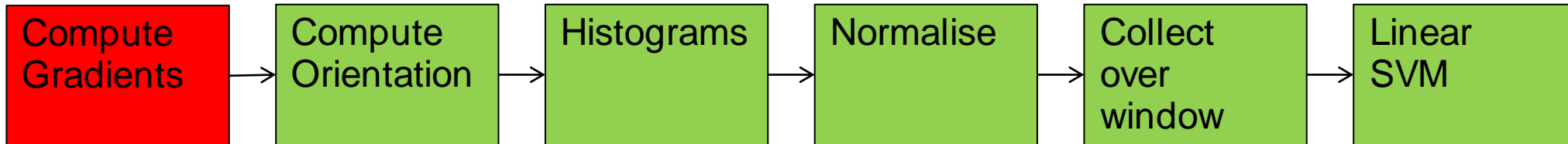


- Compute Gradients
- Compute Orientation of Gradients
- Compute a Histogram of these for a “Cell”
- Normalise the “Cell” over a “Block”
- Collect for Entire Image

# Blocks and Cells



# The HOG Process



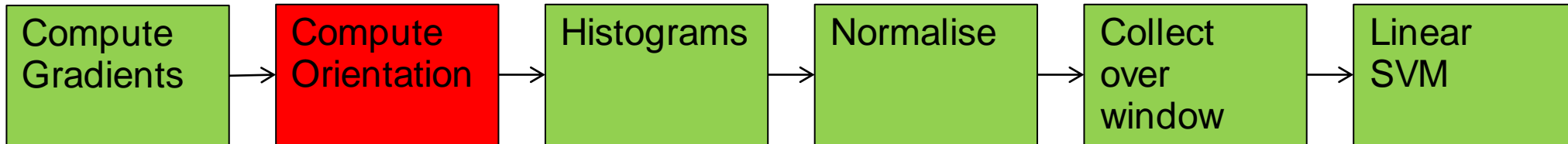
- Gradients Calculated by convolution with simple kernels

0	0	0
-1	0	1
0	0	0

0	-1	0
0	0	0
0	1	0

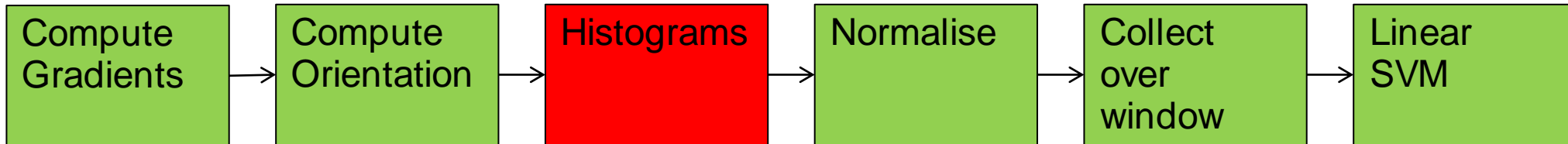


# The HOG Process



- The orientation of the gradient at each pixel is calculated
- Orientation (in Radians) =  $\arctan(\text{horizontal gradient} / \text{vertical gradient})$

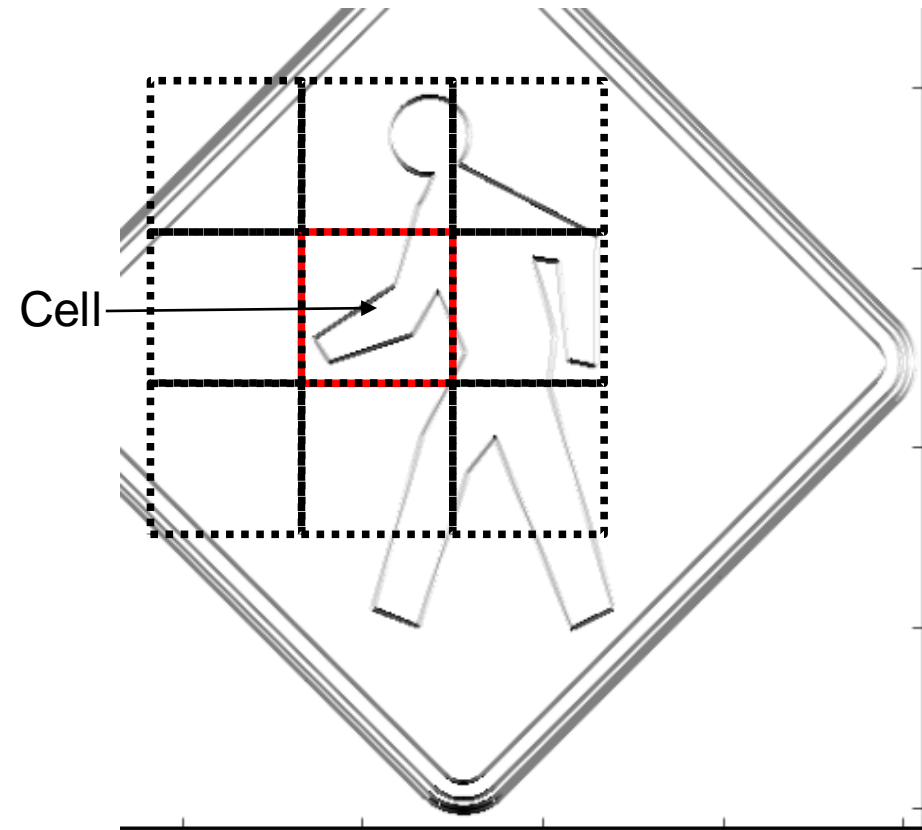
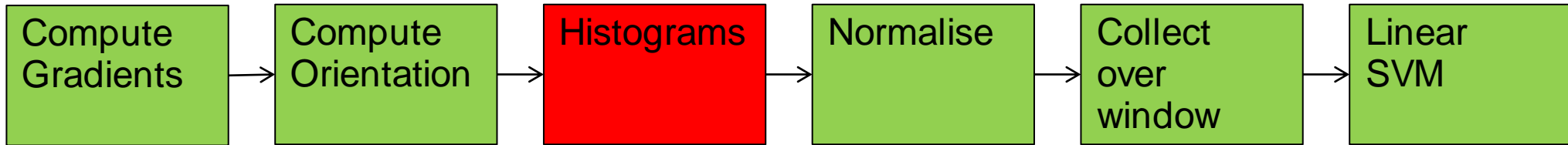
# The HOG Process



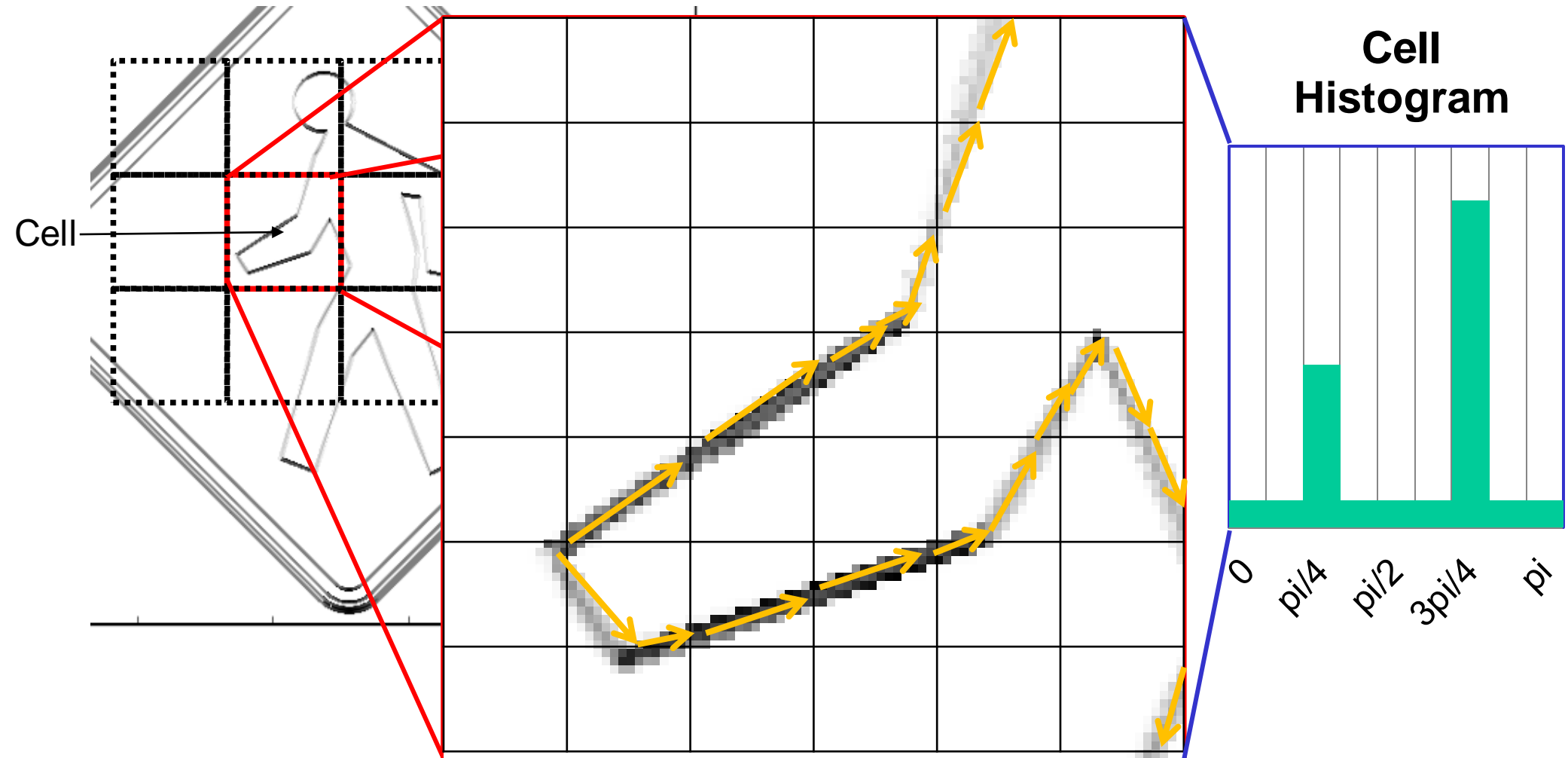
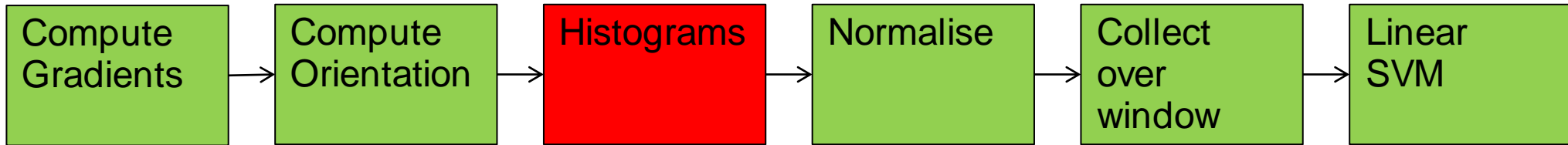
- A histogram is then computed over a cell with 9 bins between 0 and  $\pi$  (unsigned orientation) or  $-\pi$  and  $\pi$  (signed orientation)
- Number of bins and signed or unsigned orientations chosen from paper



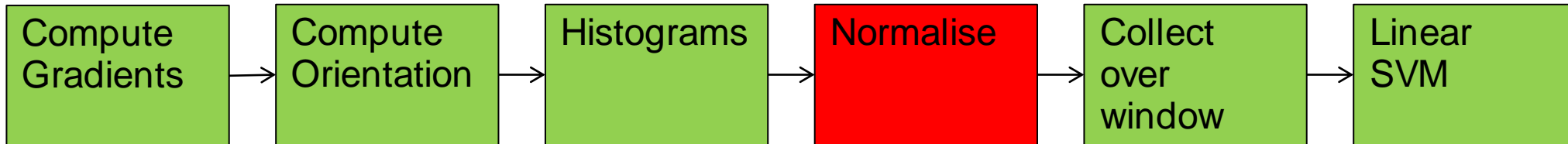
# The HOG Process



# The HOG Process



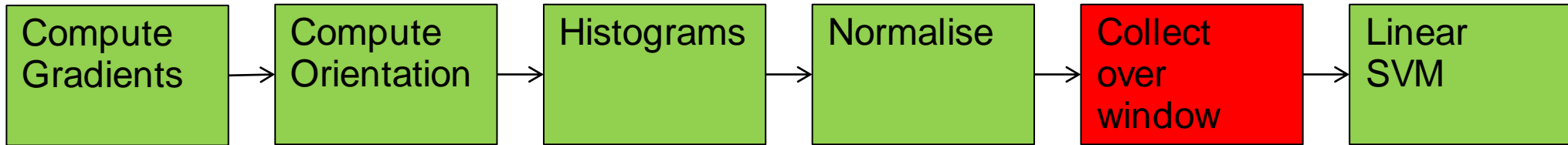
# The HOG Process



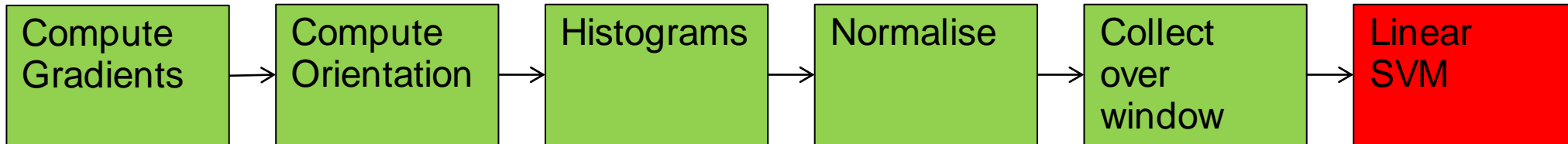
- The histogram of a cell is normalised with respect to a block
- The L2-norm of the block is taken
- $\epsilon$  is a small constant

$$\text{New Cell} = \frac{\text{Cell}}{\sqrt{\| \text{Block} \|_2^2 + \epsilon^2}}$$

# The HOG Process



# The HOG Process



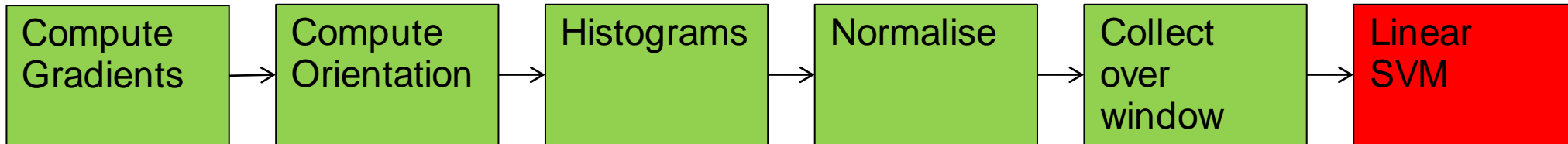
- Trained with large selection of pictures of people



- And of not people

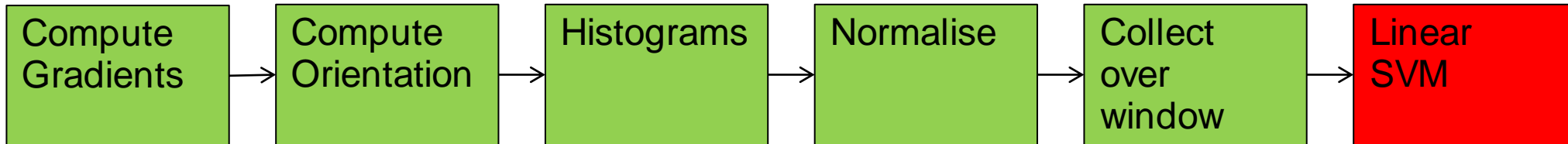


# The HOG Process

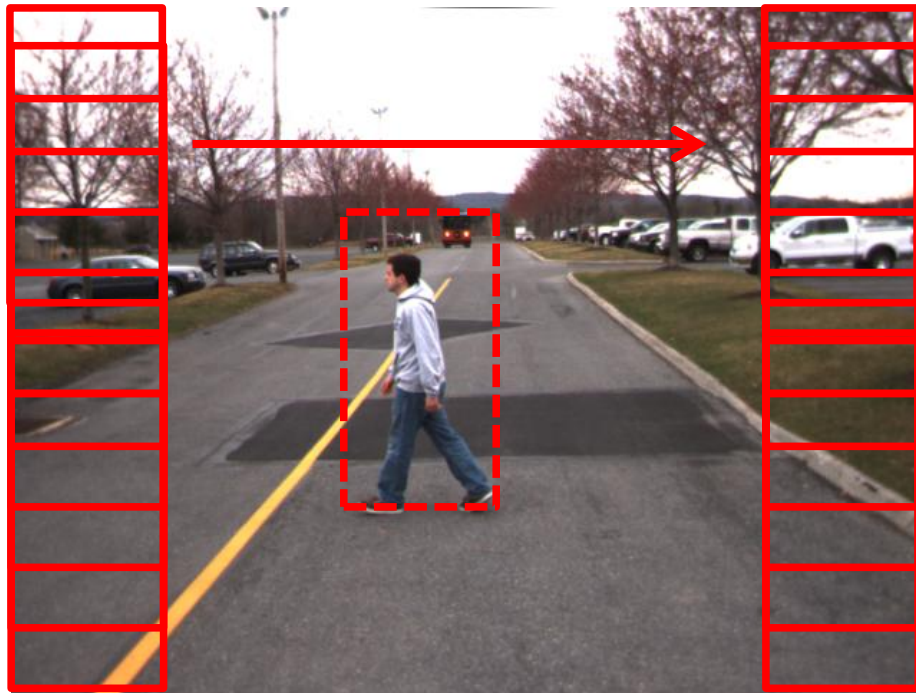


- Retrained on false positives
- SVM predicts whether a HOG window contains a person
- Scale sensitive

# The HOG Process

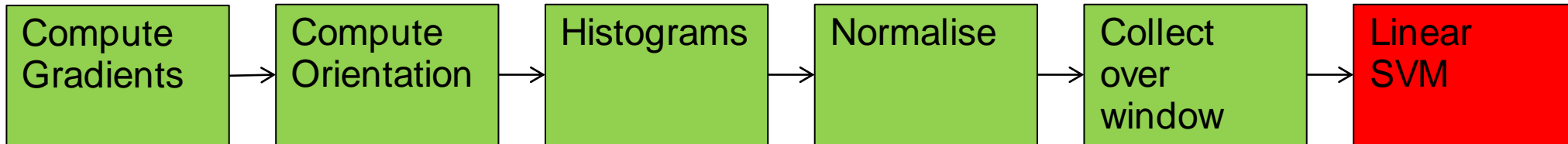


- For locating objects a sliding window is used





# The HOG Process



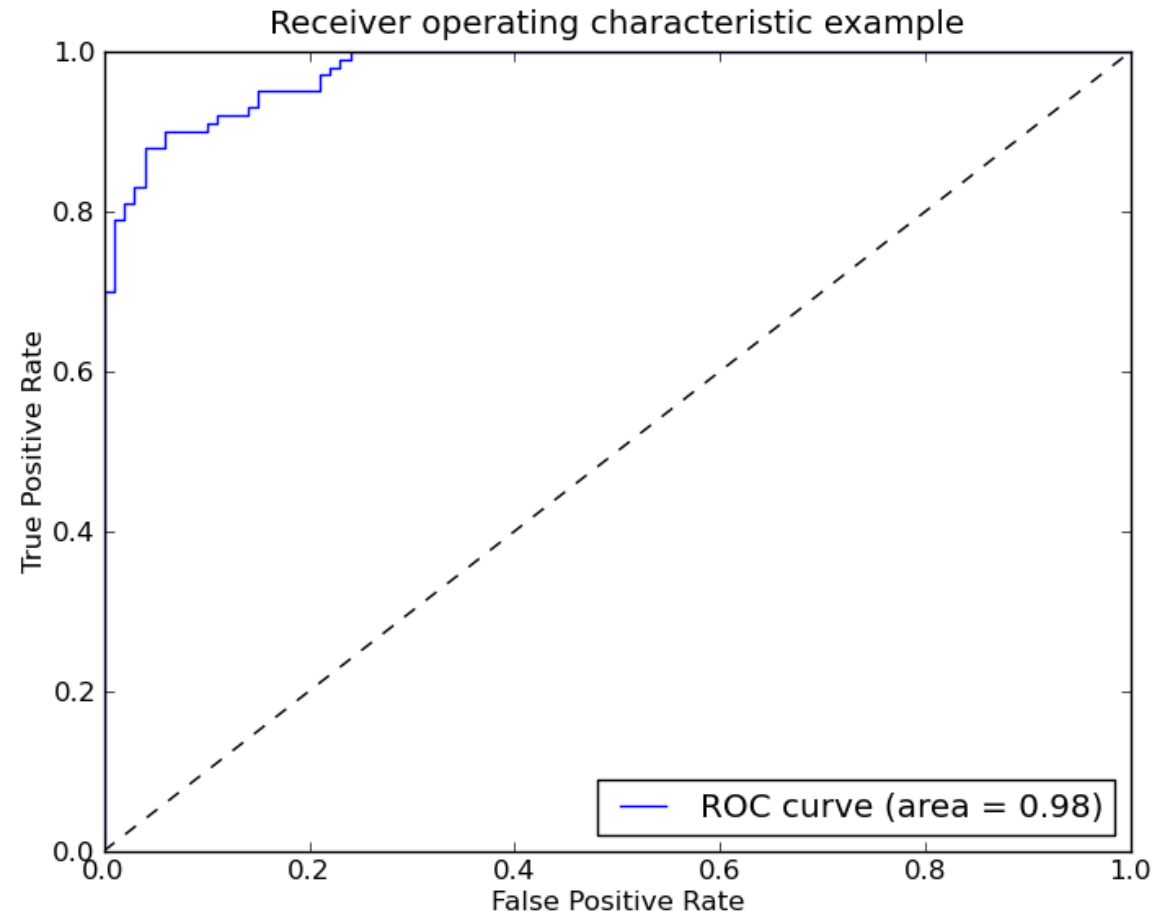
- Experimented with scale invariance



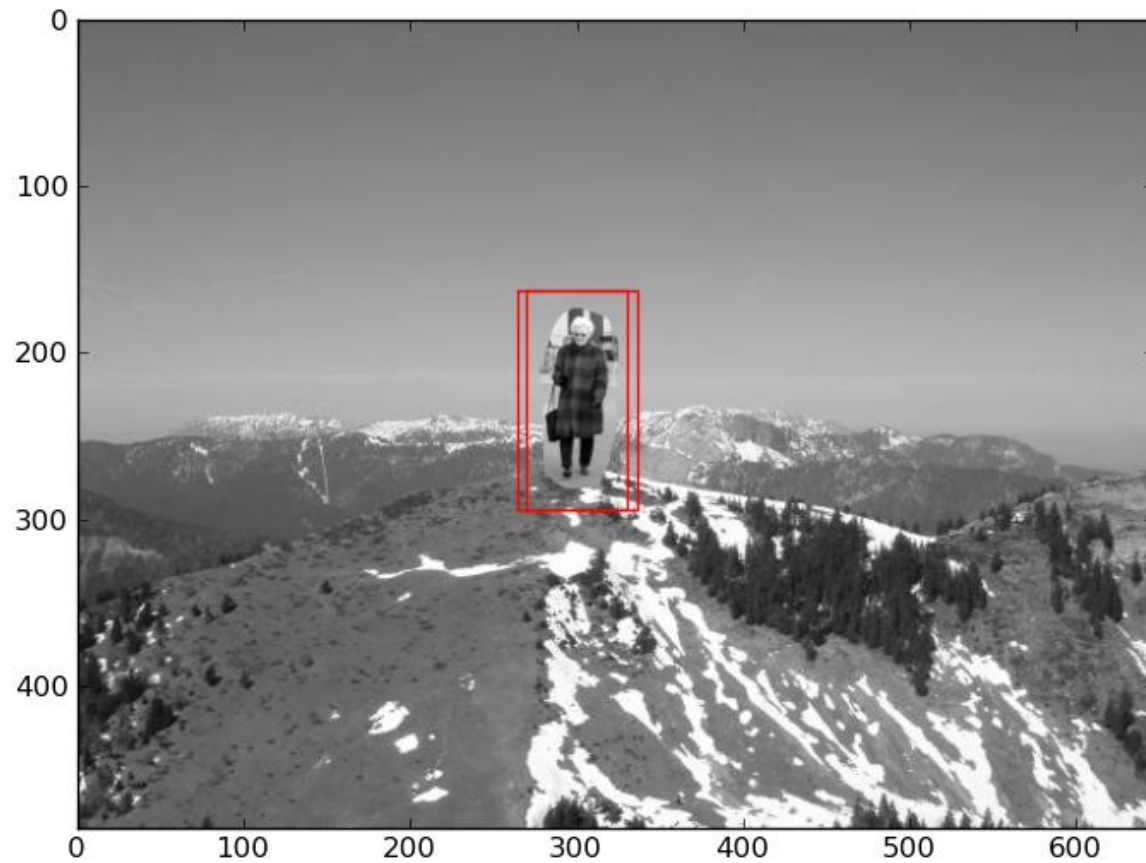


# Results

- ROC curve



# Results

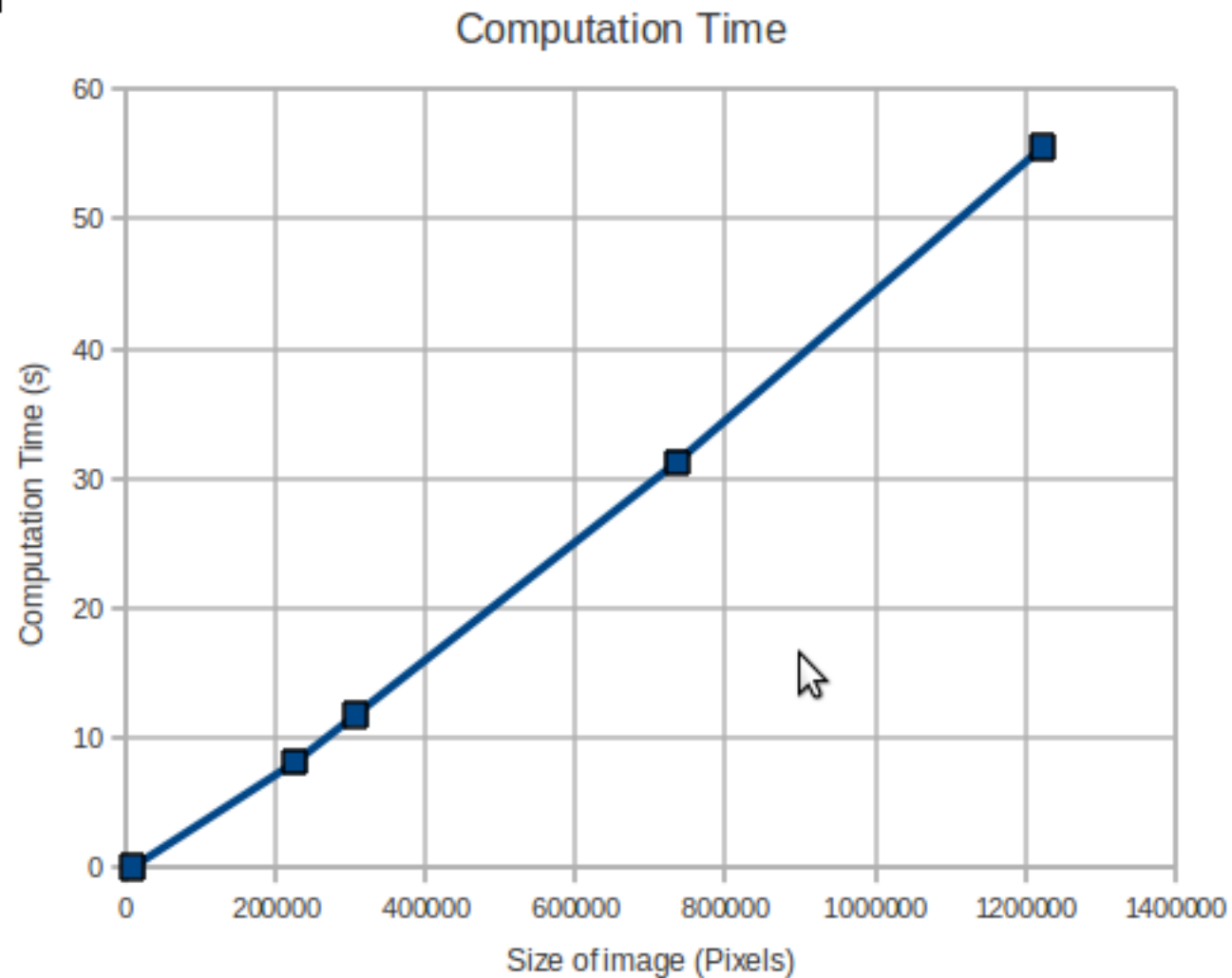


# Results

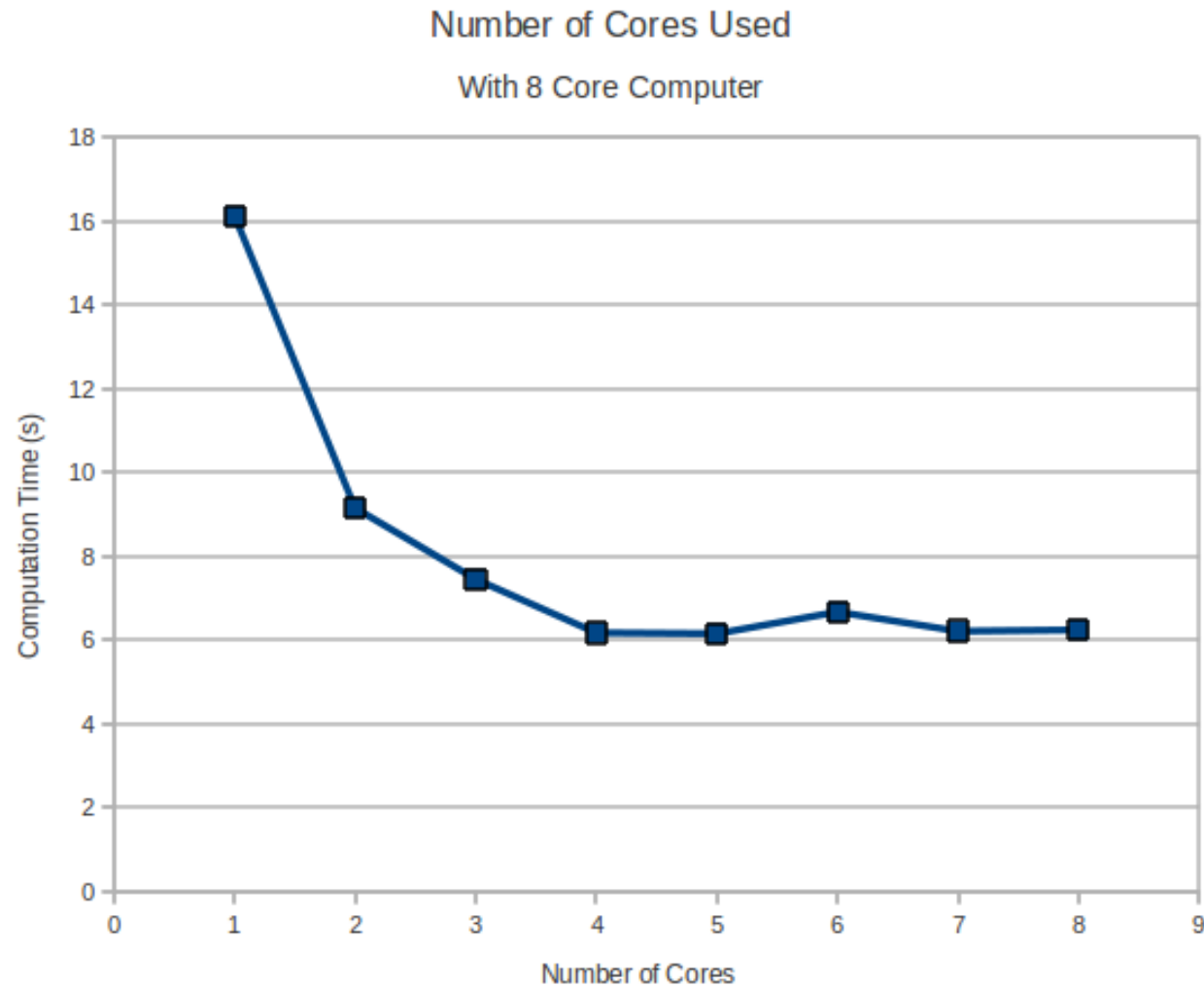


Effect of  
scale  
sensitivity  
and a  
false  
positive

# Results – Computation Time



# Results – Multi-threading



# Demo



# Extensions



Images taken from [2] showing use of scale space to add robustness to detection

- Results from the paper show better detection through use of scale space and mode filter

# Conclusions

- High performance on test set
- Real world gives lower performance
- Scale sensitive
- Requires careful training
- Multi-threading improves computation time



# References

1. Histograms of Oriented Gradients for Human Detection, Naveet Dalal and Bill Triggs, Available: <http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=1467360>
2. Object detection using Histograms of Oriented Gradients, Naveet Dalal and Bill Triggs, Available: <http://pascallin.ecs.soton.ac.uk/challenges/VOC/voc2006/slides/dalal.pdf>