# Pedestrian Detection

Histograms of Oriented Gradients for Human Detection
Navneet Dalal and Bill Triggs
CVPR ‘05

Pete Barnum

March 8, 2006


CHANGE

# Challenges

- Wide variety of articulated poses
- Variable appearance/clothing
- Complex backgrounds
- Unconstrined illumination
- Occlusions
- Different Scales

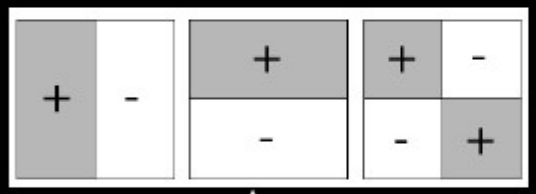
# Support Vector Machine Detector

*(Papageorgiu & Poggio, 1998)*

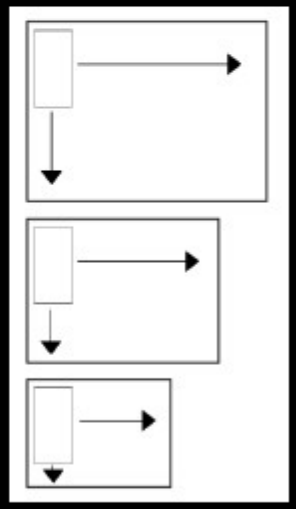
Training set

descriptors

training



descriptors



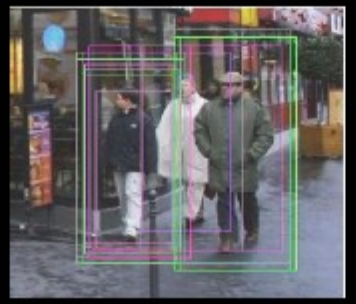
Multi-scale search

test

Support vector machine

results

Test image



Slides from Sminchisescu

# Dynamic Pedestrian Detection

*Viola, Jones and Snow, ICCV 2003*

- Train using AdaBoost, about 45,000 possible features
- Efficient and reliable for distant detections (20x15), 4fps

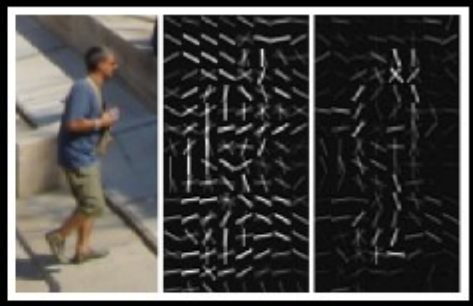
Slides from Sminchisescu

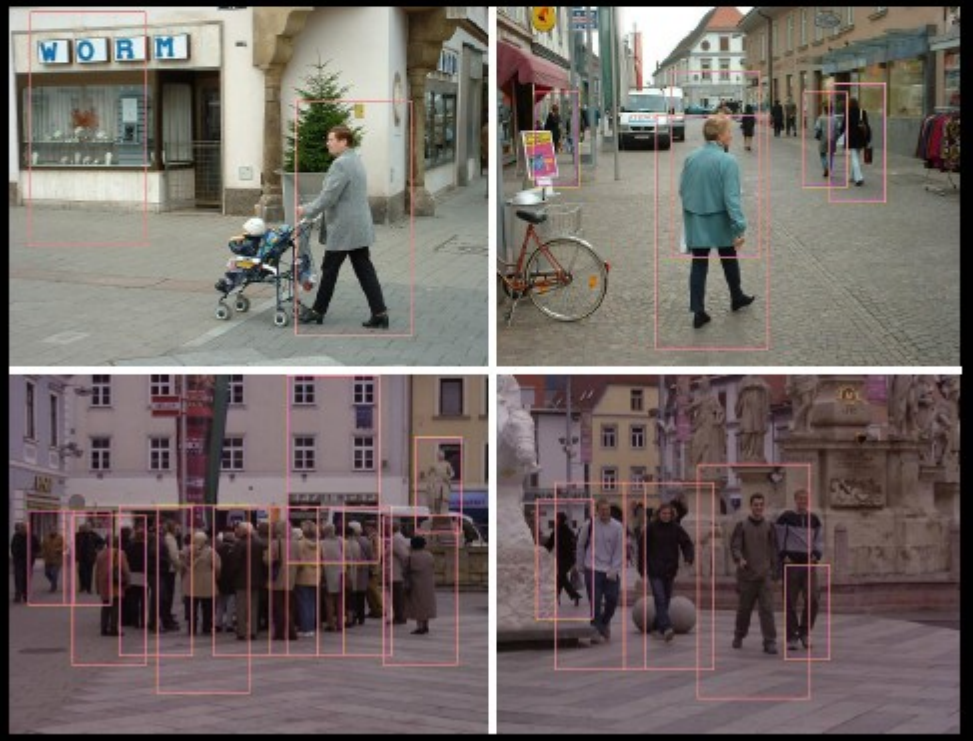
# 2d Global Detector

*Dalal and Triggs, CVPR 2005*

- 3-D Histogram of Oriented Gradients (HOG) as descriptors
- Linear SVM for runtime efficiency
- Tolerates different poses, clothing, lighting and background
- Currently works for fully visible upright persons

Importance weight responses

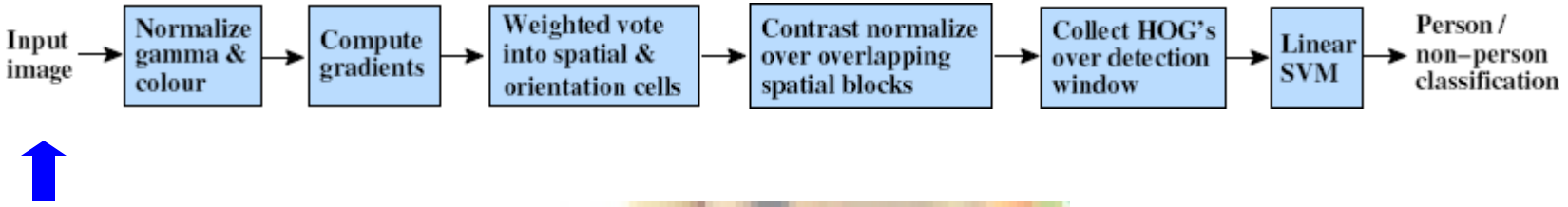


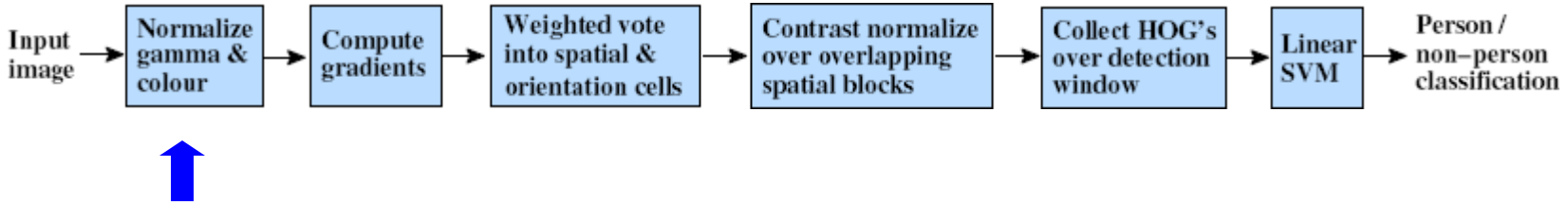



Slides from Sminchisescu

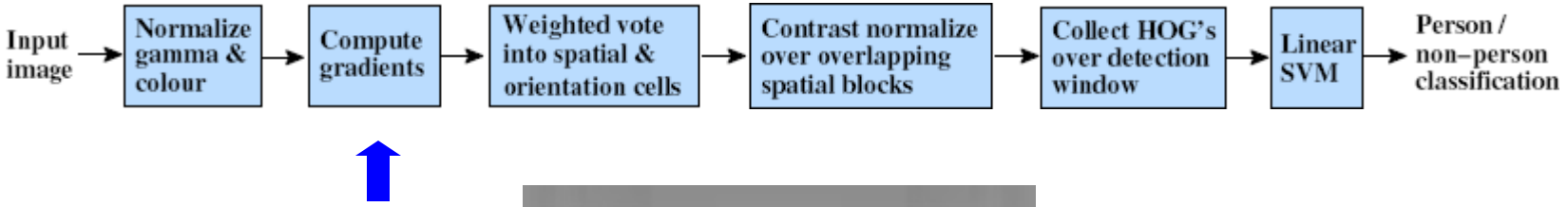
# Feature Sets

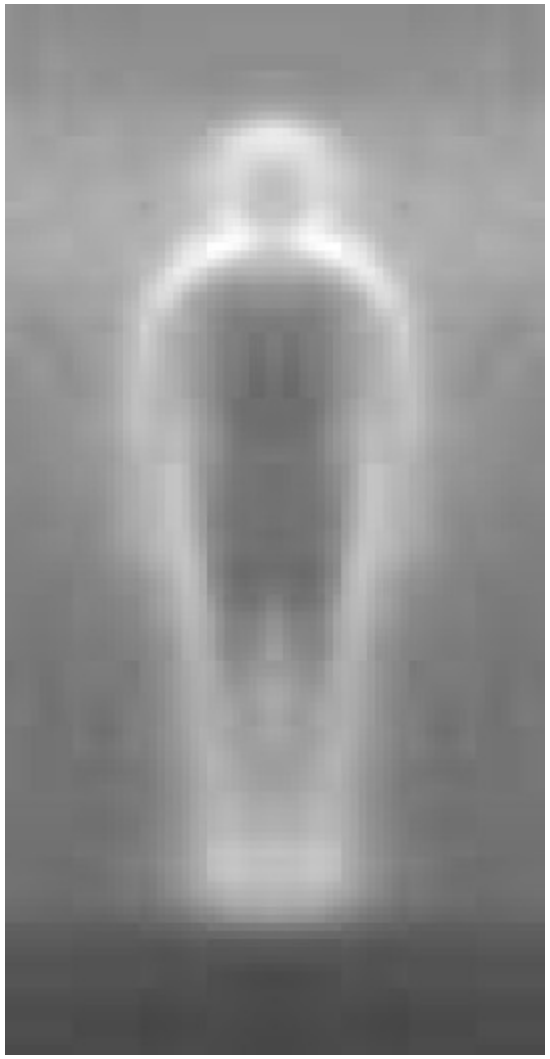
- Haar wavelets + SVM:
  - Papageorgiou & Poggio (2000)
  - Mohan et al (2001)
  - DePoortere et al (2002)
- Rectangular differential features + adaBoost:
  - Viola & Jones(2001)
- Parts based binary orientation position histogram + adaBoost:
  - Mikolajczk et al (2004)
- Edge templates + nearest neighbor:
  - Gavrila & Philomen (1999)
- Dynamic programming:
  - Felzenszwalb & Huttenlocher (2000),
  - Loffe & Forsyth (1999)
- Orientation histograms:
  - C.F. Freeman et al (1996)
  - Lowe(1999)
- Shape contexts:
  - Belongie et al (2002)
- PCA-SIFT:
  - Ke and Sukthankar (2004)


Input image
Normalize gamma & colour
Compute gradients
Weighted vote into spatial & orientation cells
Contrast normalize over overlapping spatial blocks
Collect HOG's over detection window
Linear SVM
Person / non−person classification




- Tested with
  - RGB
  - LAB
  - Grayscale
- Gamma Normalization and Compression
  - Square root
  - Log



| -1 | 0 | 1 |
|---|---|---|

centered

| -1 | 1 |
|---|---|

uncentered

| 1 | -8 | 0 | 8 | -1 |
|---|---|---|---|---|

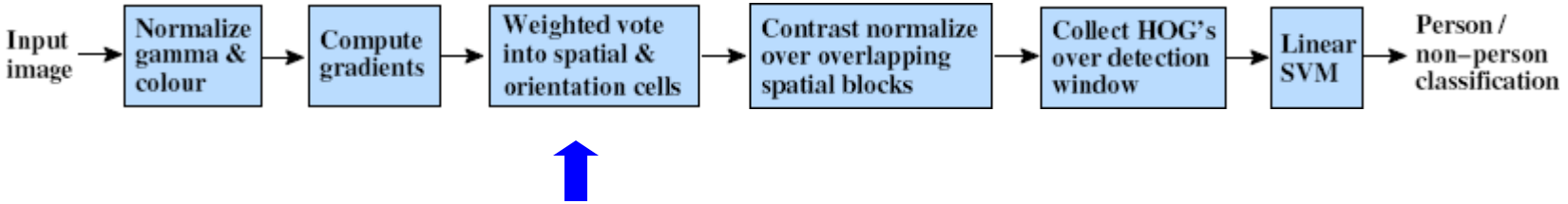
cubic-corrected

| 0 | 1 |
|---|---|
| -1 | 0 |

diagonal

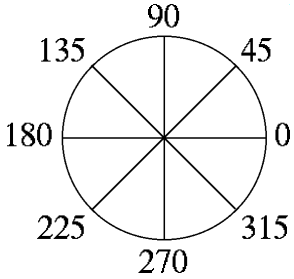
| -1 | 0 | 1 |
|---|---|---|
| -2 | 0 | 2 |
| -1 | 0 | 1 |

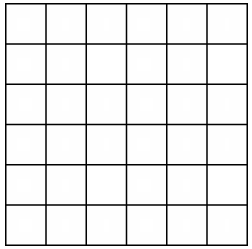
Sobel



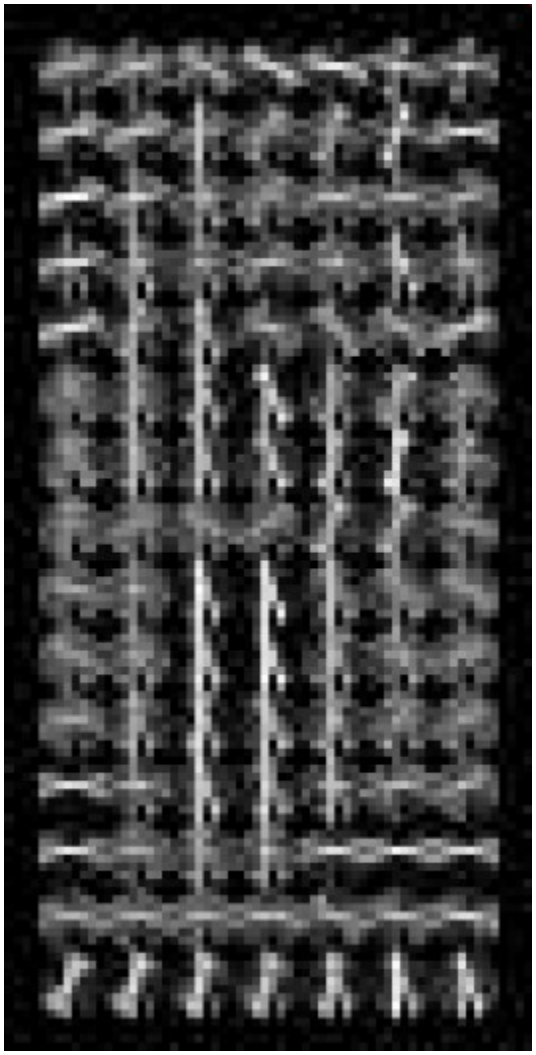

- Histogram of gradient orientations

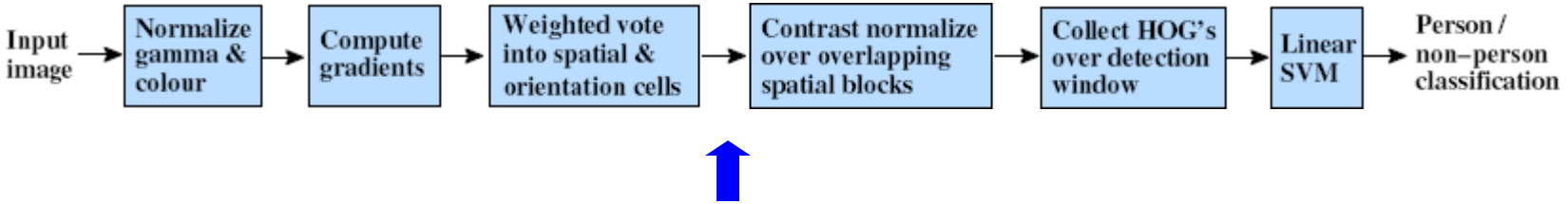
  -Orientation -Position



  – Weighted by magnitude

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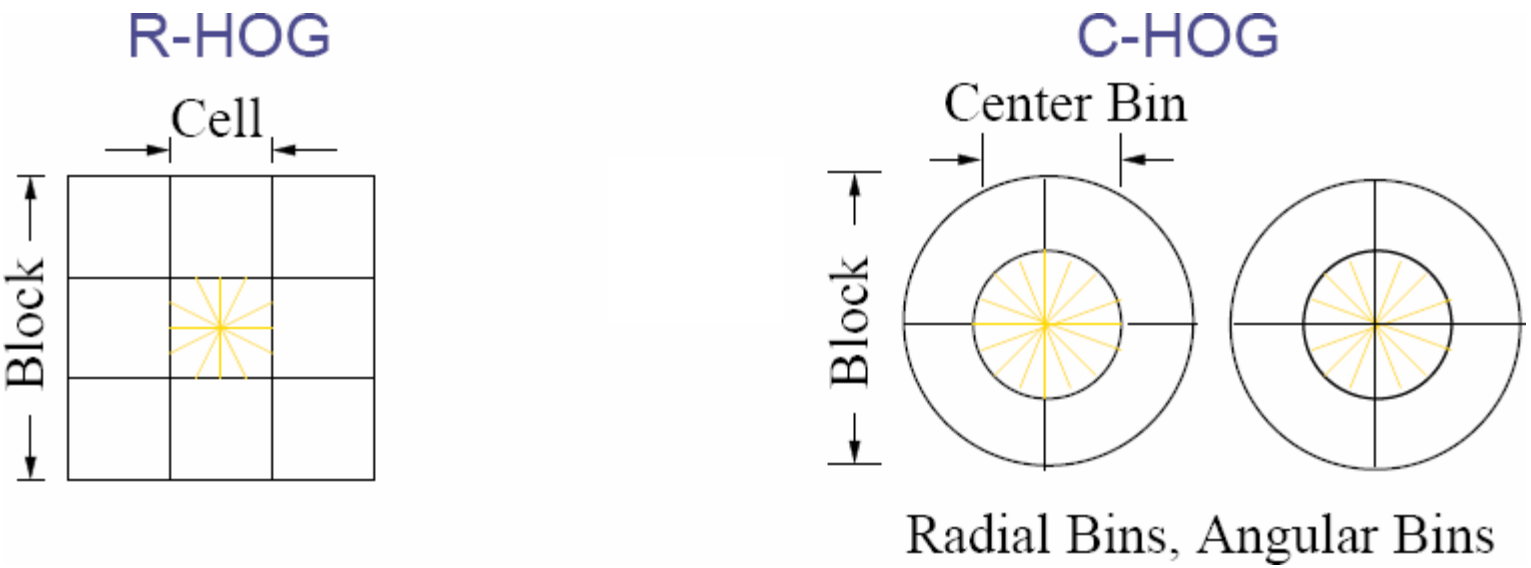
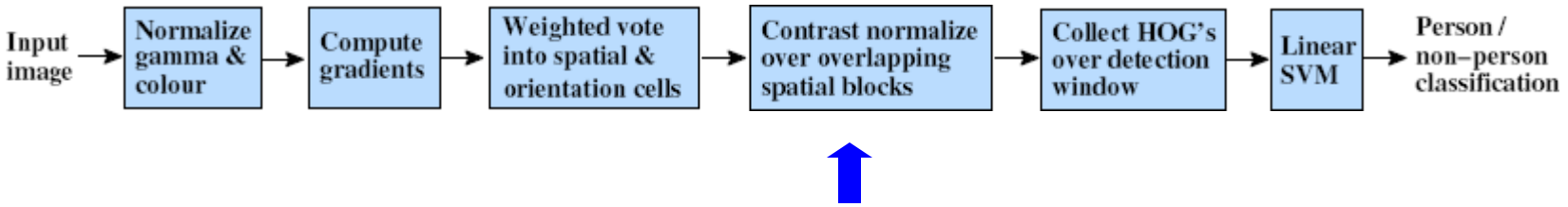
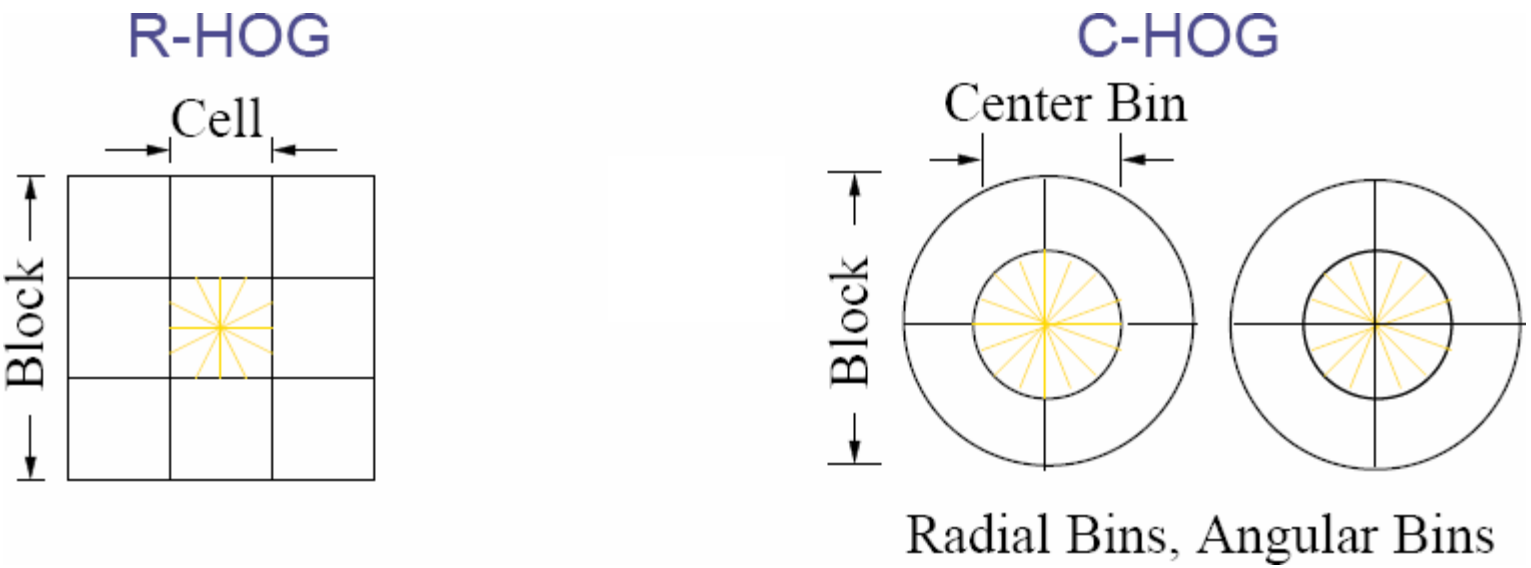

R-HOG
Cell
Block
C-HOG
Center Bin
Block
Radial Bins, Angular Bins



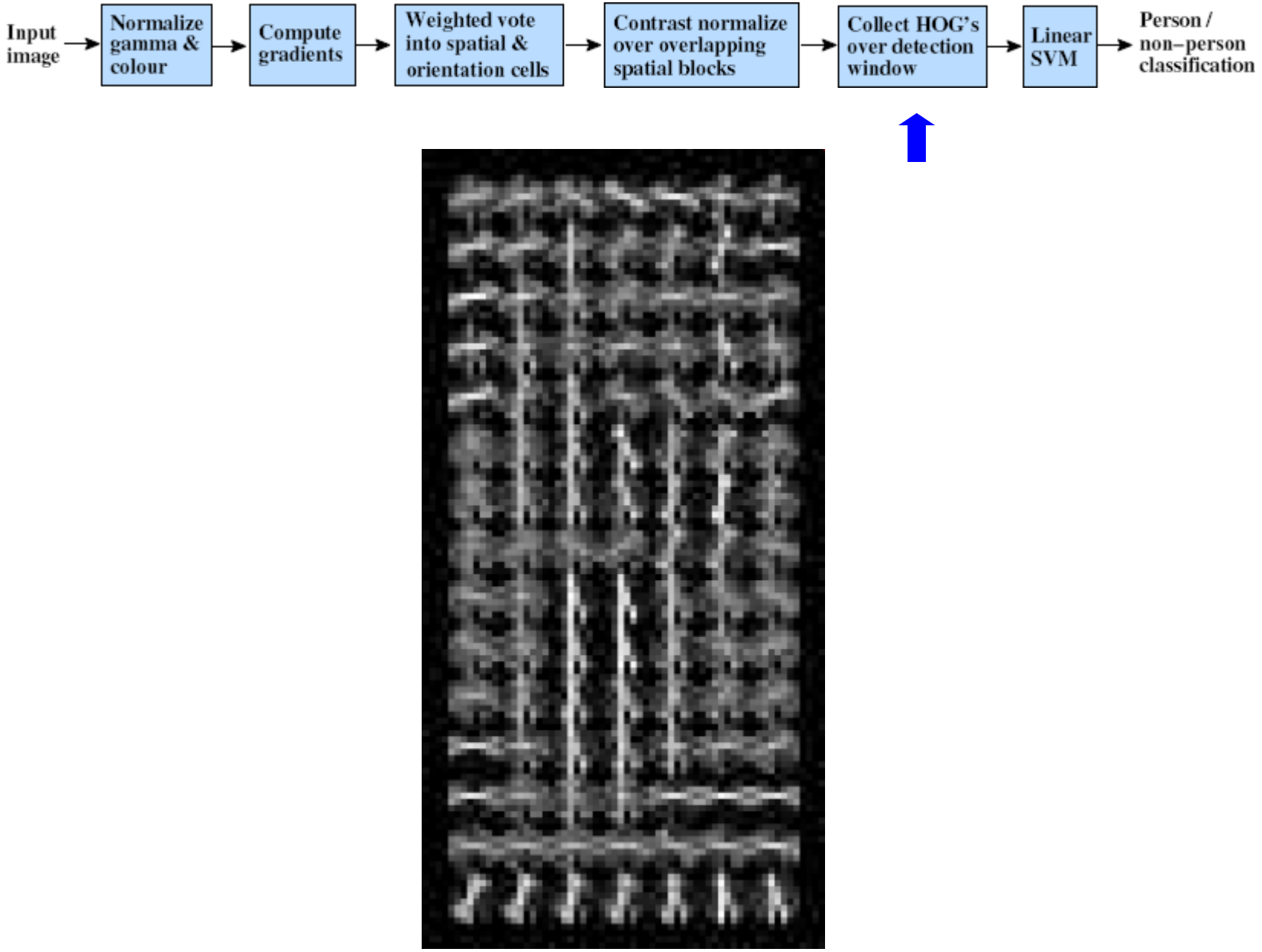




$L1-norm: v \longrightarrow v/(||v||_1+\epsilon)$

$L1-sqrt: v \longrightarrow \sqrt{v/(||v||_1+\epsilon)}$

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

$L2-hys$ : L2-norm, plus clipping at .2 and renomalizing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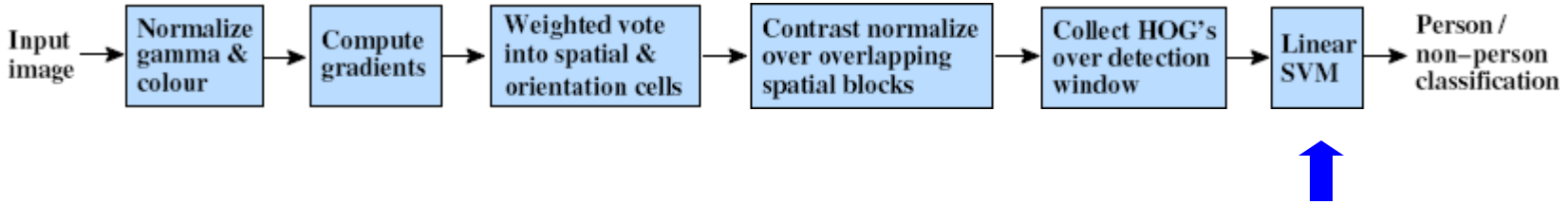
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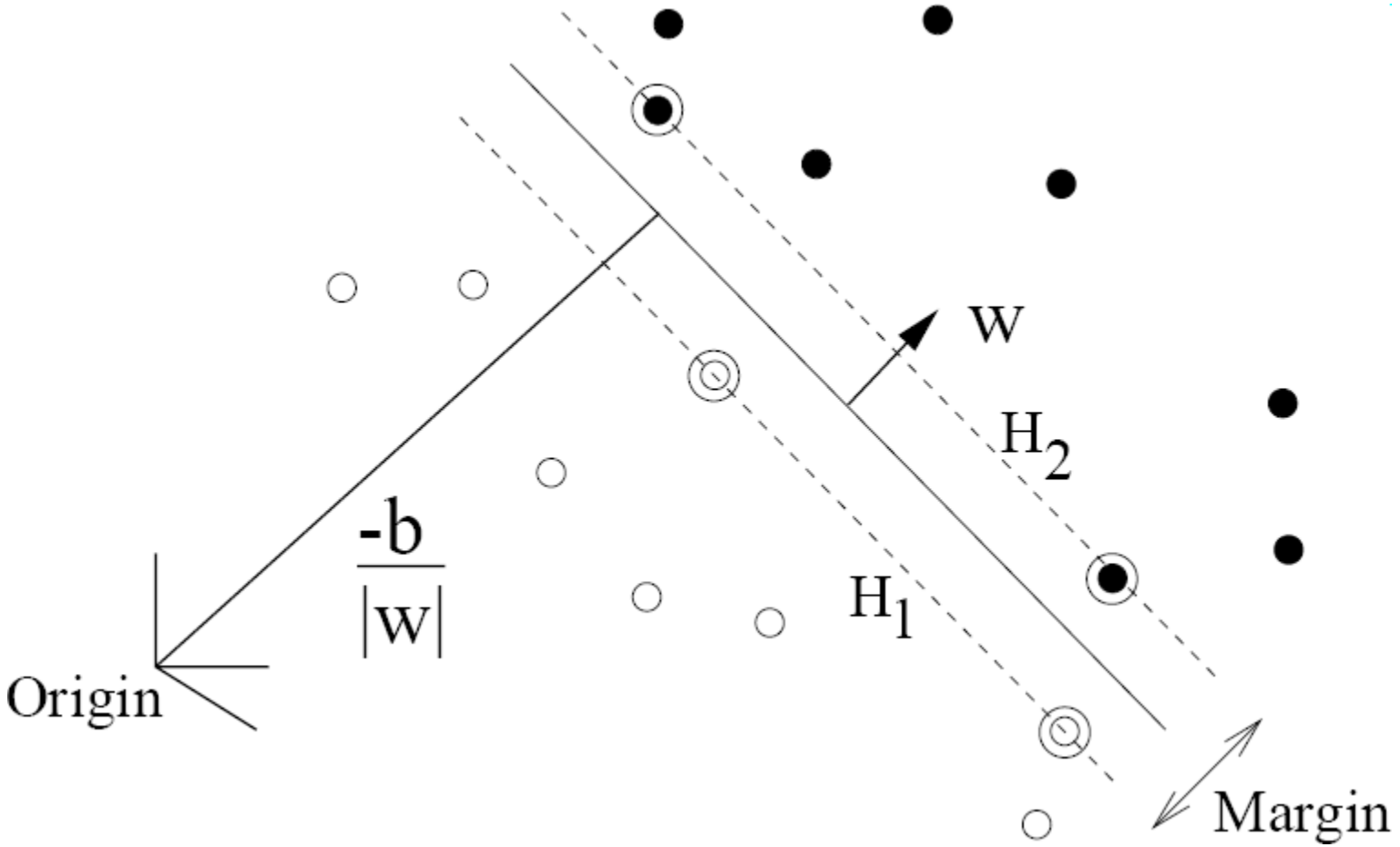
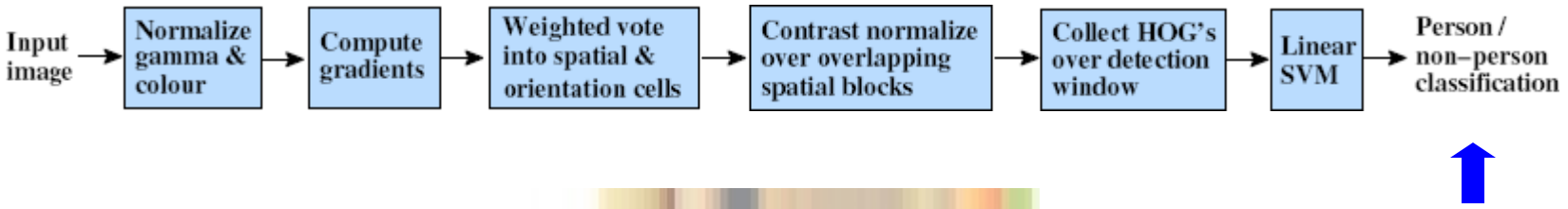

w
$H_2$
$H_1$
-b
|w|
Origin
Margin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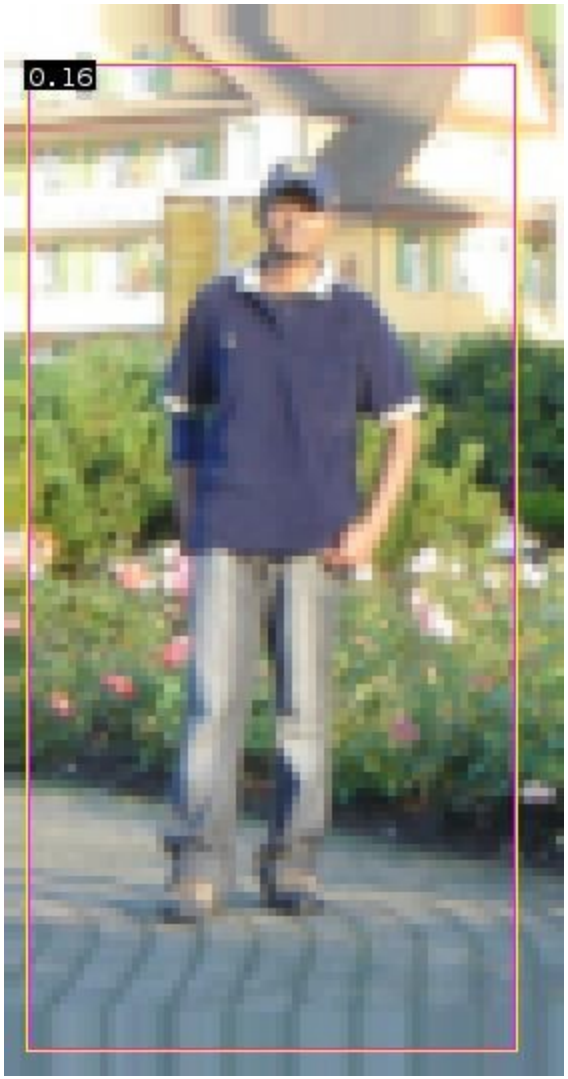
0.16


0.62
1.21