

# Aside: Image Features

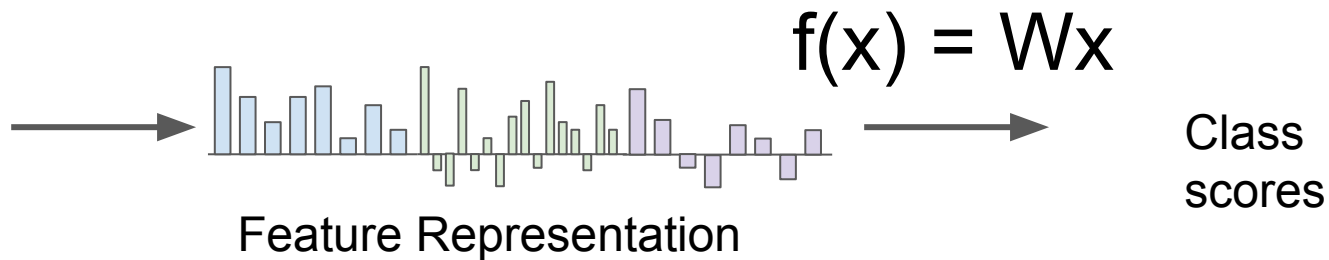


Class  
scores

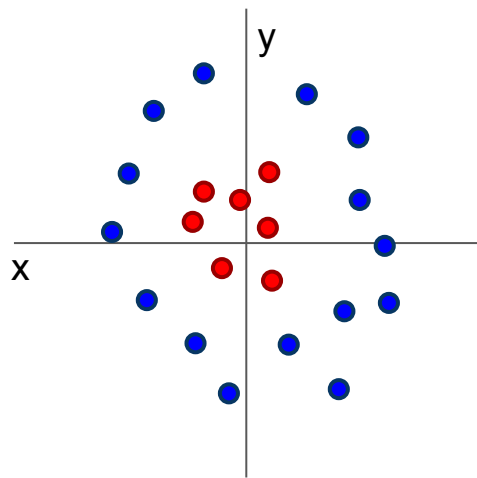
$$f(x) = Wx$$



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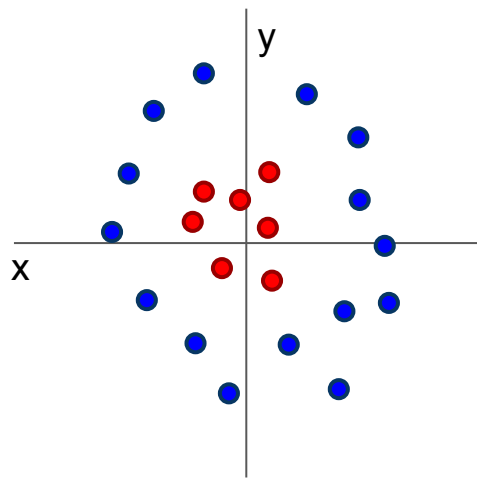


# Image Features: Motivation



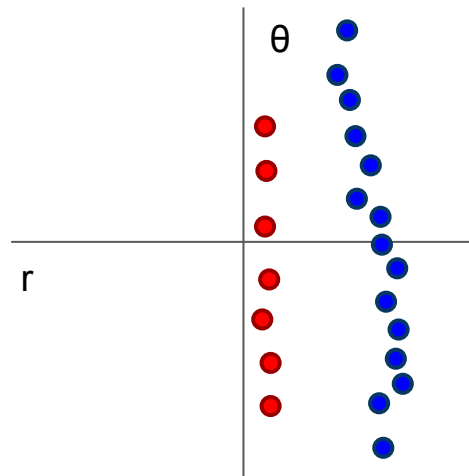
Cannot separate red  
and blue points with  
linear classifier

# Image Features: Motivation



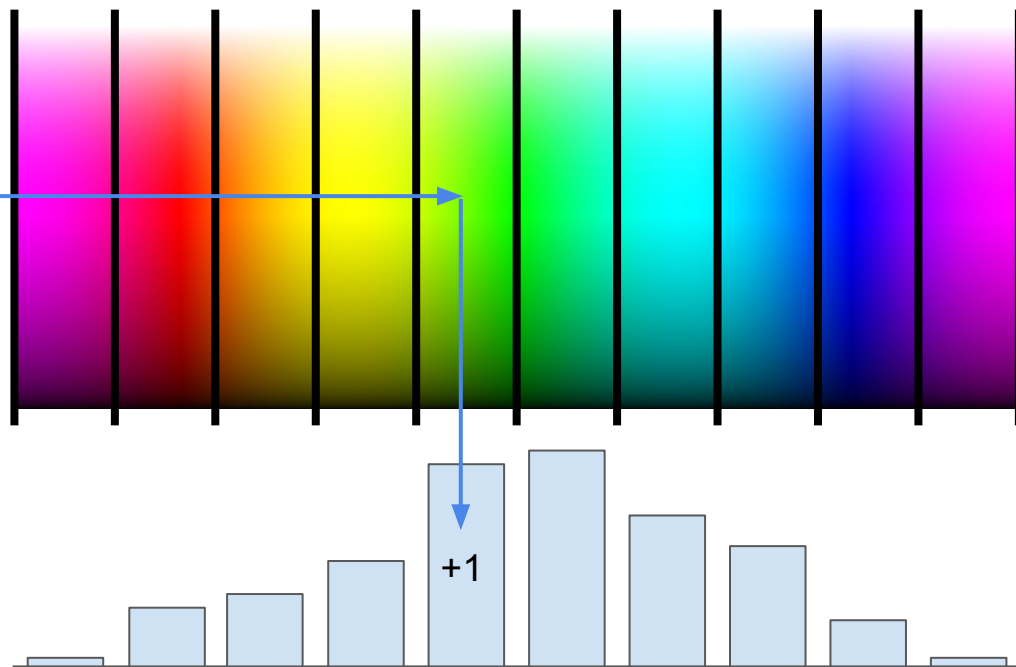
Cannot separate red  
and blue points with  
linear classifier

$$f(x, y) = (r(x, y), \theta(x, y))$$



After applying feature  
transform, points can  
be separated by linear  
classifier

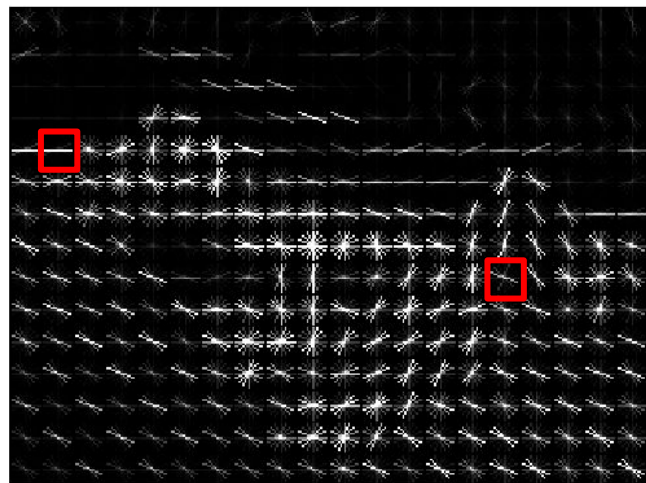
# Example: Color Histogram



# Example: Histogram of Oriented Gradients (HoG)



Divide image into 8x8 pixel regions  
Within each region quantize edge  
direction into 9 bins



Example: 320x240 image gets divided  
into 40x30 bins; in each bin there are  
9 numbers so feature vector has  
 $30 \times 40 \times 9 = 10,800$  numbers

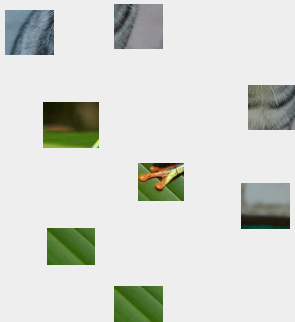
Lowe, "Object recognition from local scale-invariant features", ICCV 1999  
Dalal and Triggs, "Histograms of oriented gradients for human detection," CVPR 2005

# Example: Bag of Words

## Step 1: Build codebook



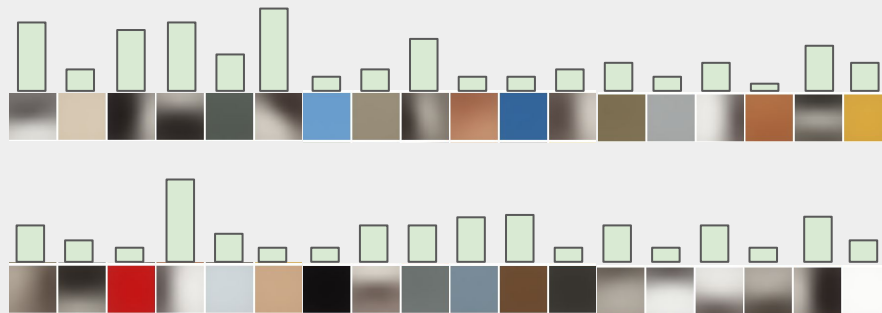
Extract random  
patches



Cluster patches to  
form “codebook”  
of “visual words”

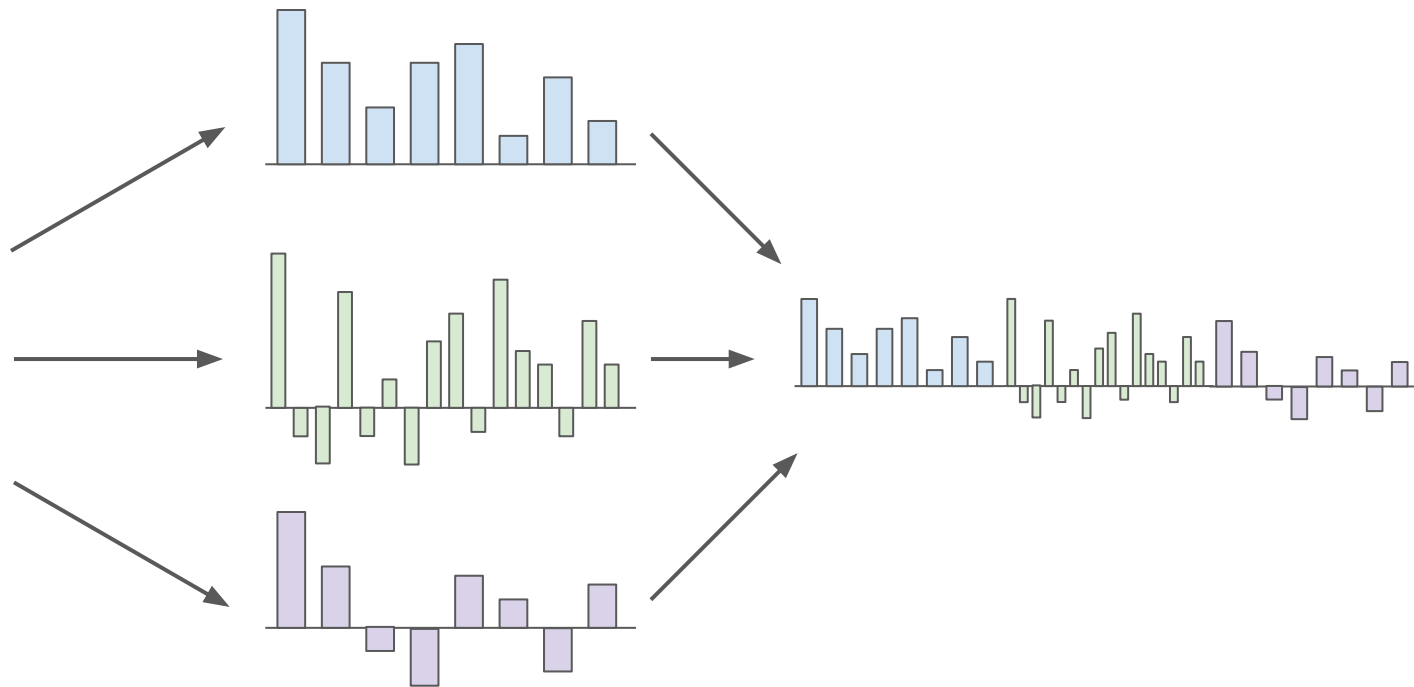


## Step 2: Encode images



Fei-Fei and Perona, “A bayesian hierarchical model for learning natural scene categories”, CVPR 2005

# Aside: Image Features





# Image features vs ConvNets

