K-Nearest Neighbors

Computer Vision

Carnegie Mellon University (Kris Kitani)

‘Classical’

Image Classification Pipeline

Input → **encoder** → **decoder** → **output**

image(s)

Extract features

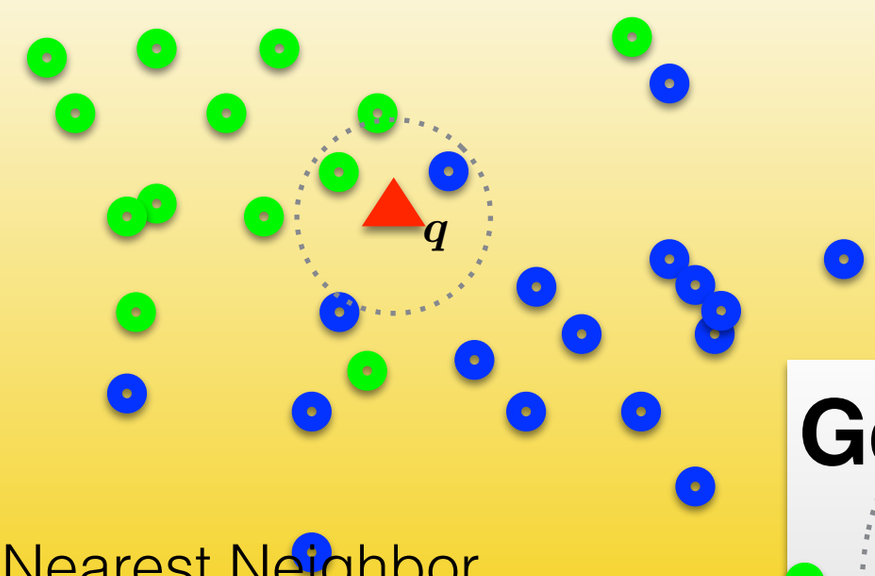
Build descriptor

Optimizer

semantic label

Today

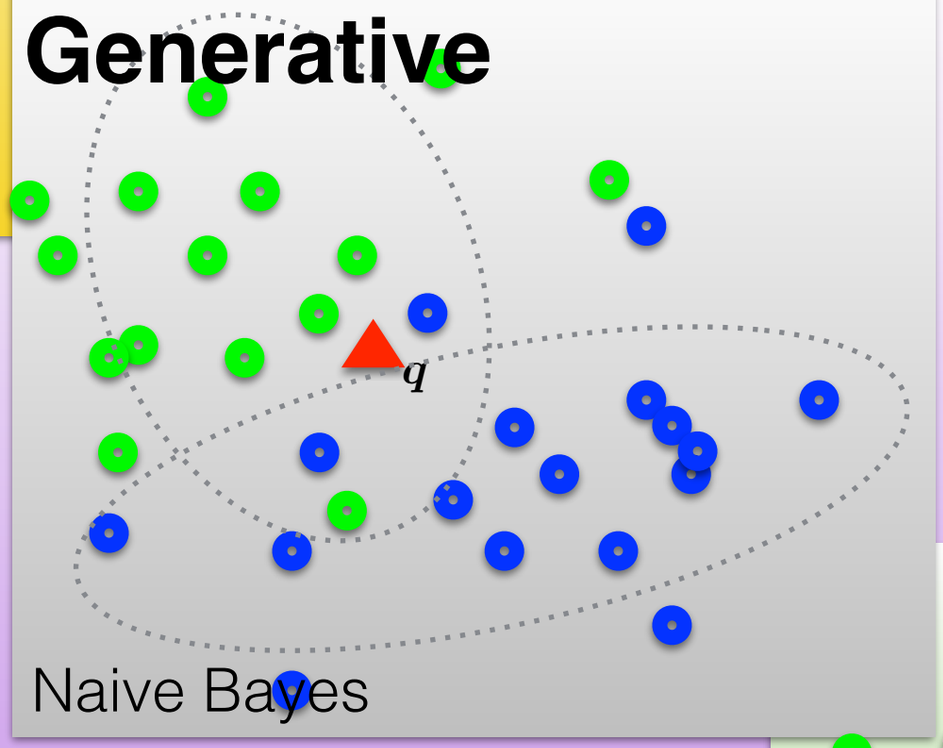
Non-parametric



Nearest Neighbor

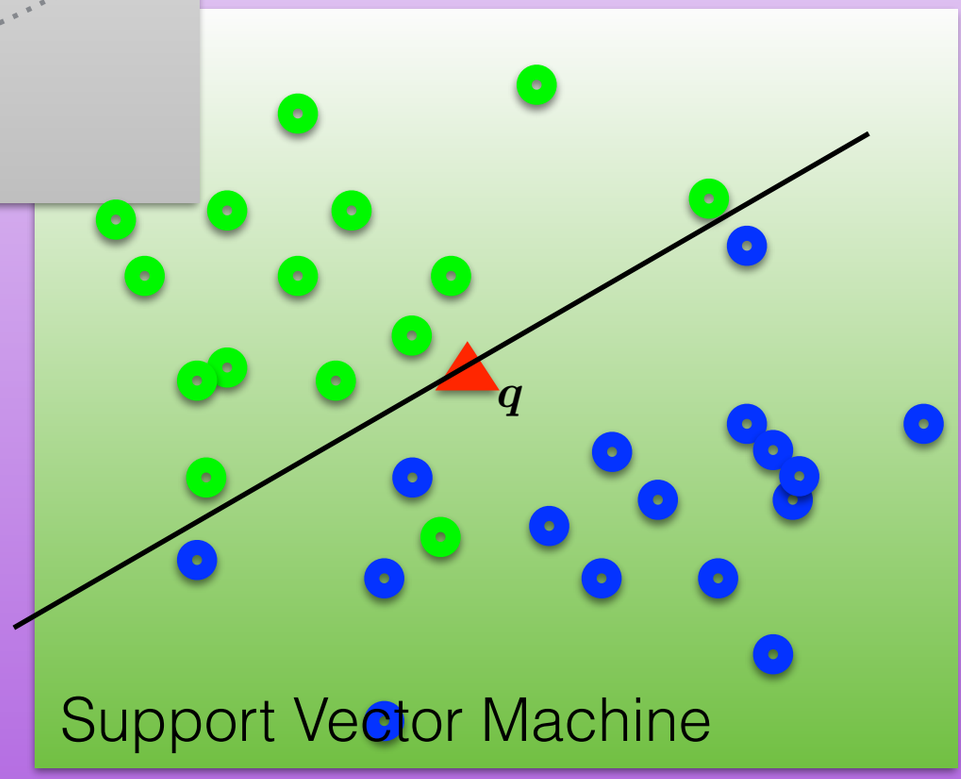
Parametric

Generative



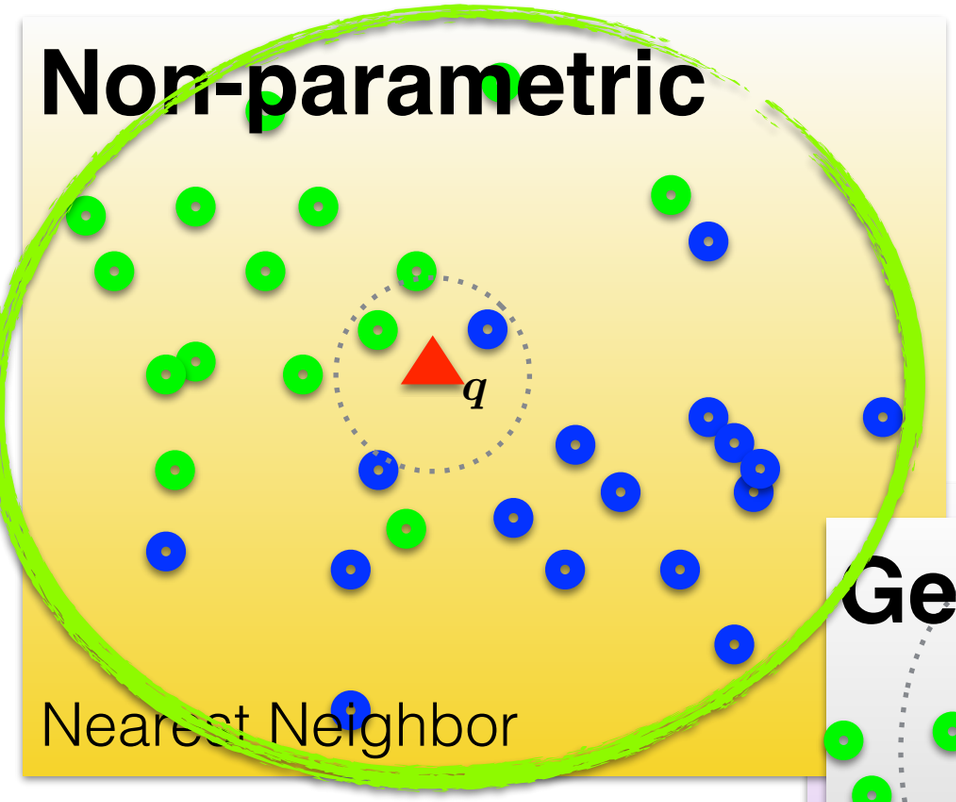
Naive Bayes

Discriminative



Support Vector Machine

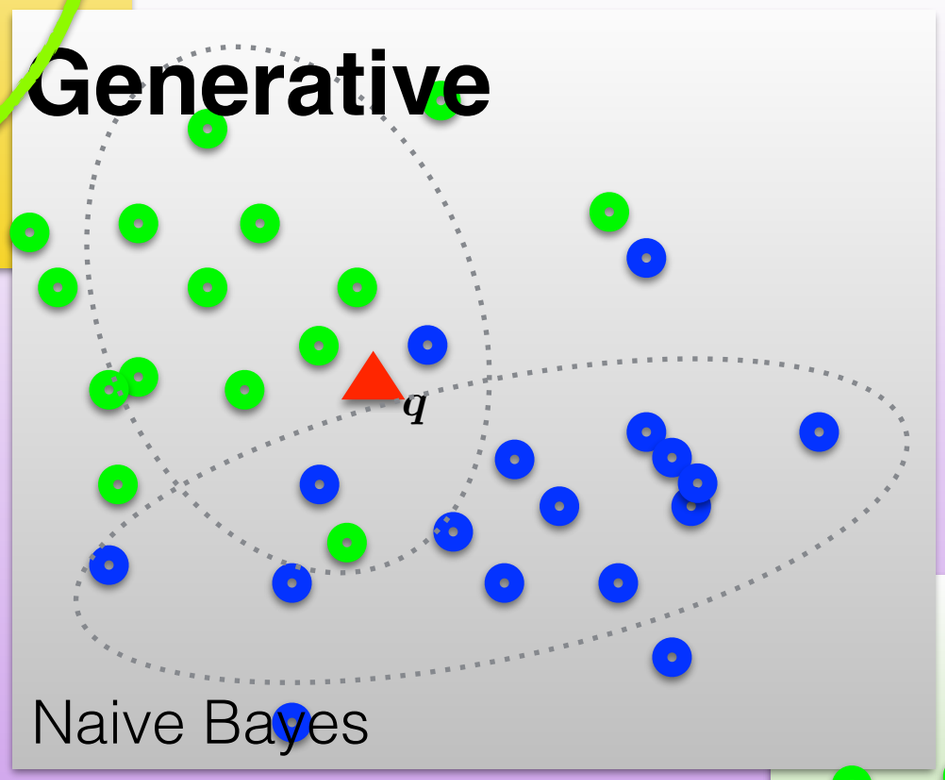
Non-parametric



Nearest Neighbor

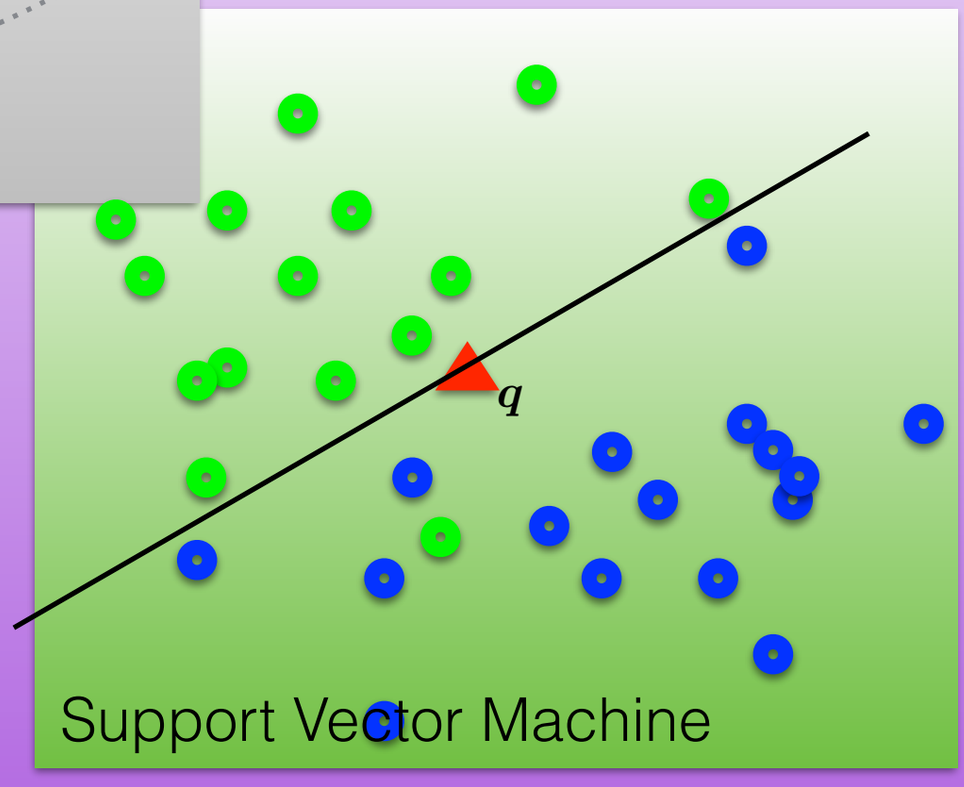
Parametric

Generative



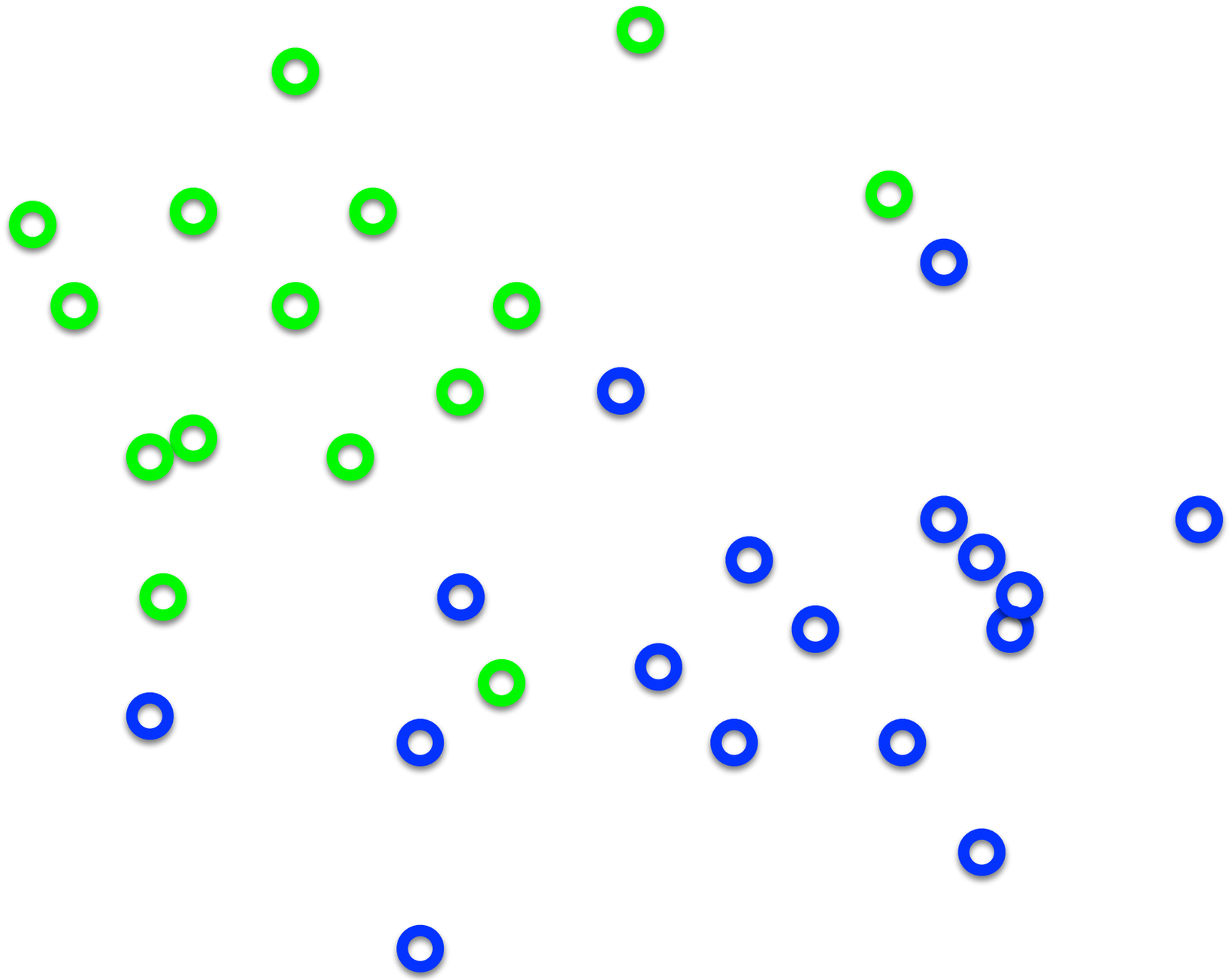
Naive Bayes

Discriminative

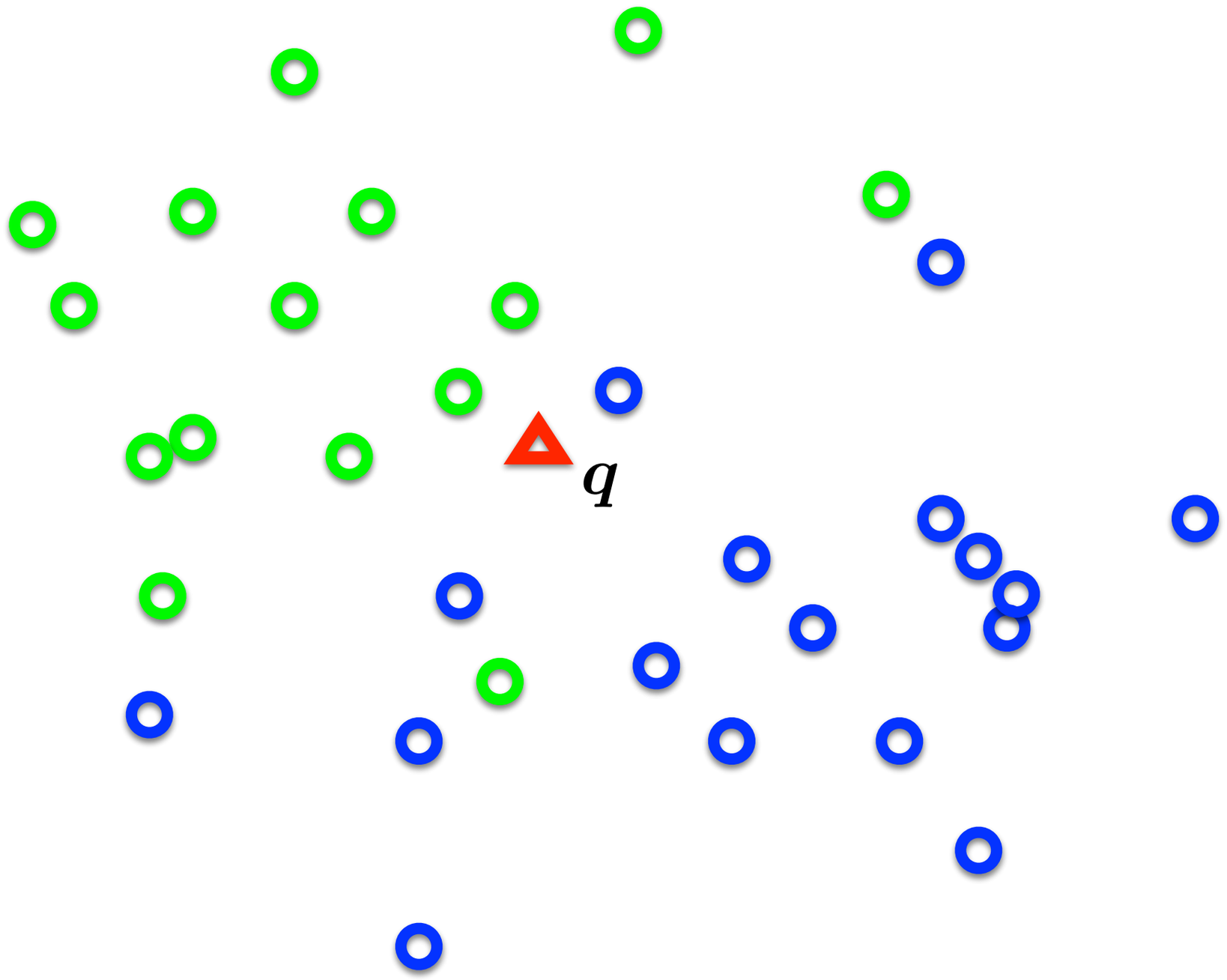


Support Vector Machine

Distribution of data from two classes

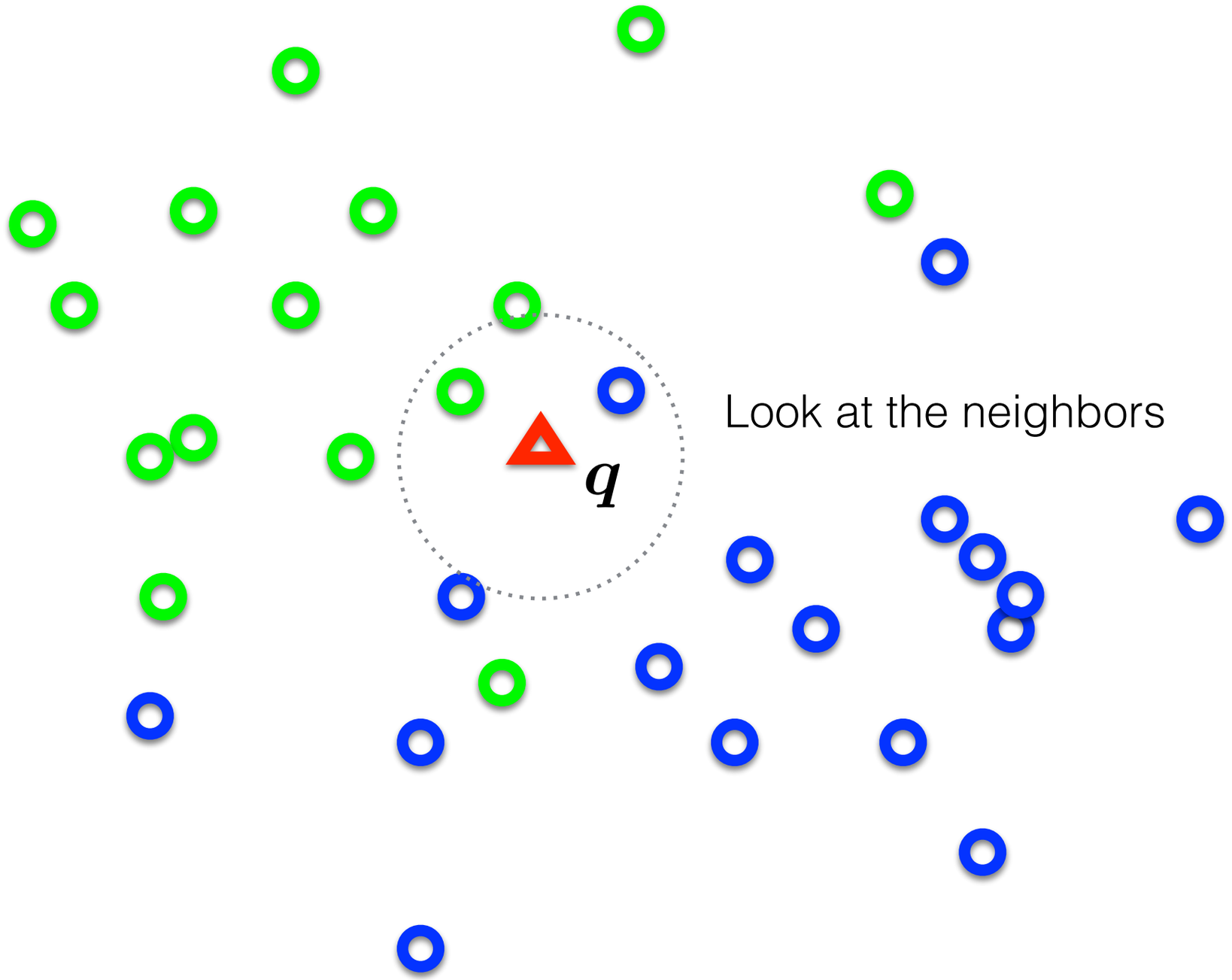


Distribution of data from two classes



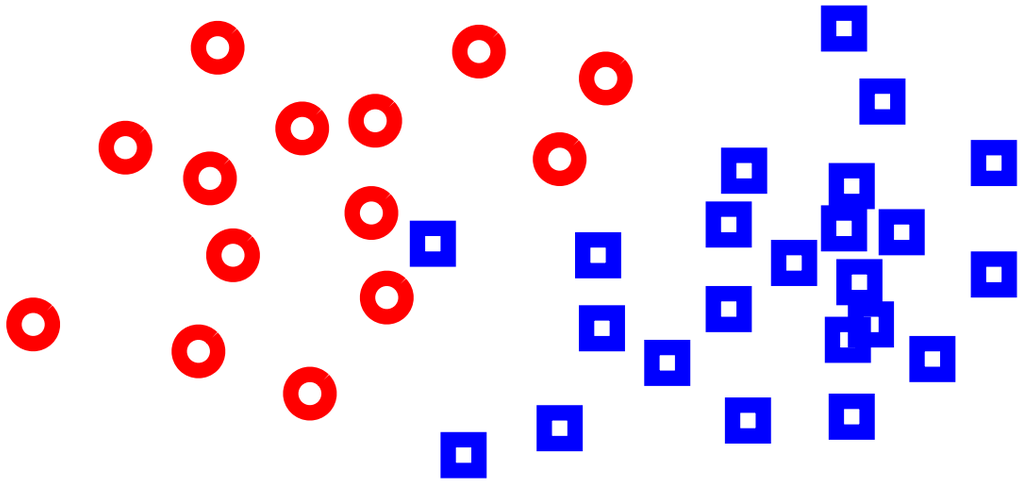
Which class does q belong too?

Distribution of data from two classes



K-nearest neighbor

K-Nearest Neighbor (KNN) Classifier

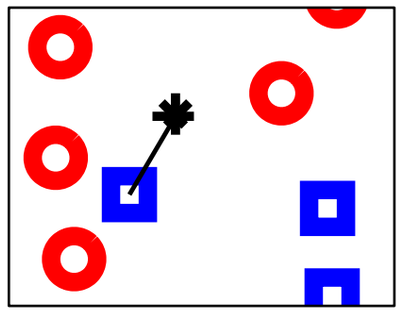


Non-parametric pattern classification approach

Consider a two class problem where each sample consists of two measurements (x,y).

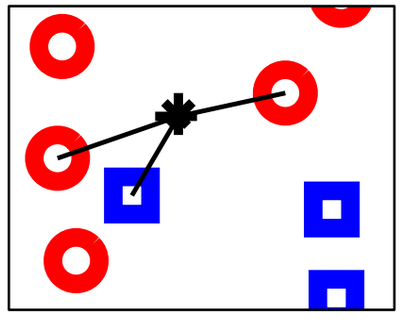
For a given query point q, assign the class of the nearest neighbor

k = 1



Compute the k nearest neighbors and assign the class by majority vote.

k = 3



Nearest Neighbor is competitive

MNIST Digit Recognition

- Handwritten digits
- 28x28 pixel images: d = 784
- 60,000 training samples
- 10,000 test samples

Yann LeCunn

	Test Error Rate (%)
Linear classifier (1-layer NN)	12.0
K-nearest-neighbors, Euclidean	5.0
K-nearest-neighbors, Euclidean, deskewed	2.4
K-NN, Tangent Distance, 16x16	1.1
K-NN, shape context matching	0.67
1000 RBF + linear classifier	3.6
SVM deg 4 polynomial	1.1
2-layer NN, 300 hidden units	4.7
2-layer NN, 300 HU, [deskewing]	1.6
LeNet-5, [distortions]	0.8
Boosted LeNet-4, [distortions]	0.7

Pros

- simple yet effective

Cons

- search is expensive (can be sped-up)
- storage requirements
- difficulties with high-dimensional data

What is the best distance metric between data points?

- Typically Euclidean distance
- Locality sensitive distance metrics
- Important to normalize.
  Dimensions have different scales

How many K?

- Typically k=1 is good
- Cross-validation (try different k!)

Distance metrics

$$D(\boldsymbol{x}, \boldsymbol{y}) = \sqrt{(x_1 - y_1)^2 + \cdots + (x_N - y_N)^2}$$ Euclidean

$$D(\boldsymbol{x}, \boldsymbol{y}) = \frac{\boldsymbol{x} \cdot \boldsymbol{y}}{\|\boldsymbol{x}\|\|\boldsymbol{y}\|} = \frac{x_1 y_1 + \cdots + x_N y_N}{\sqrt{\sum_n x_n^2}\sqrt{\sum_n y_n^2}}$$ Cosine

$$D(\boldsymbol{x}, \boldsymbol{y}) = \frac{1}{2}\sum_n \frac{(x_n - y_n)^2}{(x_n + y_n)}$$ Chi-squared