

Lecture 6: Intro to Classifiers

INFO 1998: Introduction to Machine Learning



Apply to Cornell Data Science! 📢

- All subteams are recruiting freshmen this semester!
 - Deadline: **October 17th, 11:59pm**
 - Don't forget to also submit the College of Engineering [application](#).
- Application Link:
<https://cornelldata.science/recruitment>
- If you're enjoying this class...
 - you'll LOVE being on CDS 🧐



Subteam UTea trip!



Agenda

1. What is a Classifier?
2. K-Nearest Neighbors Classifier
3. Review of Underfitting v. Overfitting
4. Confusion Matrices



What are Classifiers?



What are Classifiers?

Classifiers are able to help answer questions like...

- “What species is this?”
- “What major is a student in based on their classes?”
- “Which Hogwarts House do I belong to?”
- “Am I going to pass this class?”



What are Classifiers?

- Classifiers predict the class/category of a set of data points. This class/category is based off of the target variable we are looking at.
- Difference between linear regression and classifiers
 - Linear regression is used to predict the value of a **continuous variable**
 - Classifiers are used to predict **categorical or binary variables**



K-Nearest Neighbors Classifier



What is the KNN Classifier?

- Lazy learner classifier
- Easy to interpret
- Fast to calculate
- Good for coarse analysis



How Does It Work?

Uses the k (a user specified value) nearest data points to predict the unknown one

- A simple assumption: the values **nearest** to a data point are **similar** to it
- k is a **hyperparameter** of the KNN model
 - a parameter which affects the training process



How Does It Work?

Most around me
got an A, maybe I
got an A as well
then.

?

A

B

C

C

B

C

A

A

A

A

B

B

A

A

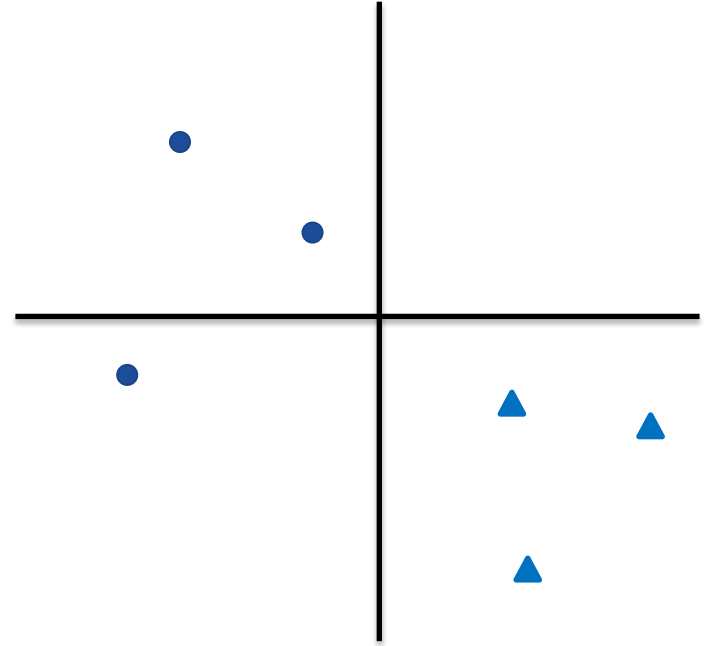
A

C



How Does It Work? (Step-By-Step Example)

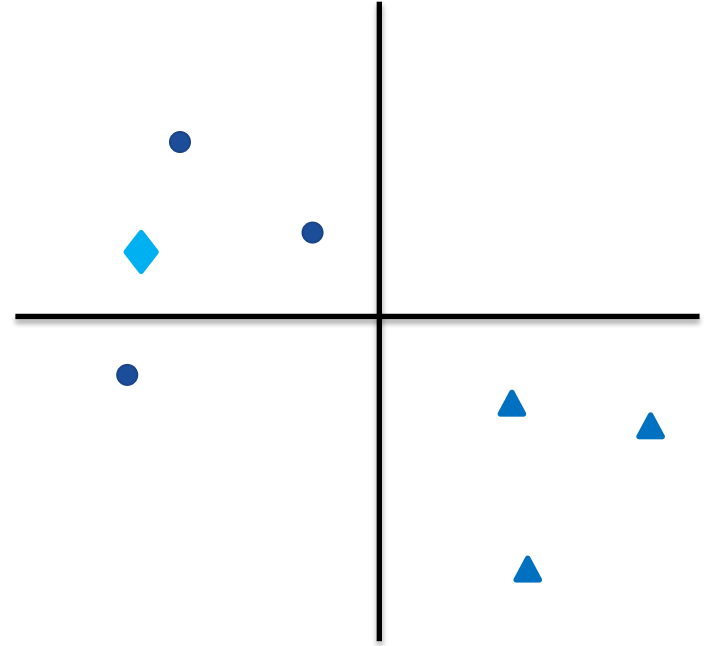
Define a k value (in this case $k = 3$)



How Does It Work? (Step-By-Step Example)

Define a k value (in this case $k = 3$)

Pick a point to predict (blue diamond)

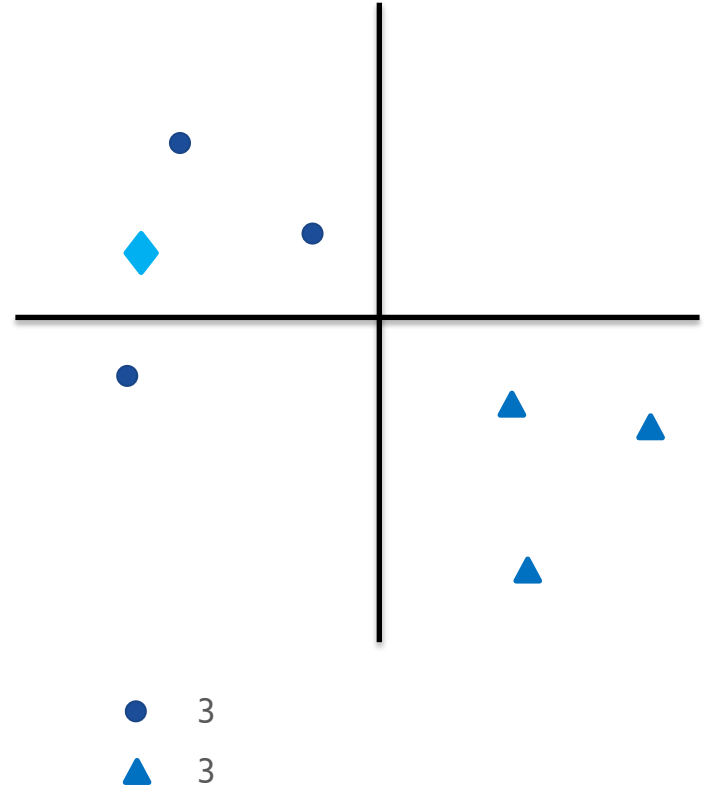


How Does It Work? (Step-By-Step Example)

Define a k value (in this case $k = 3$)

Pick a point to predict (blue diamond)

Count the number of closest points



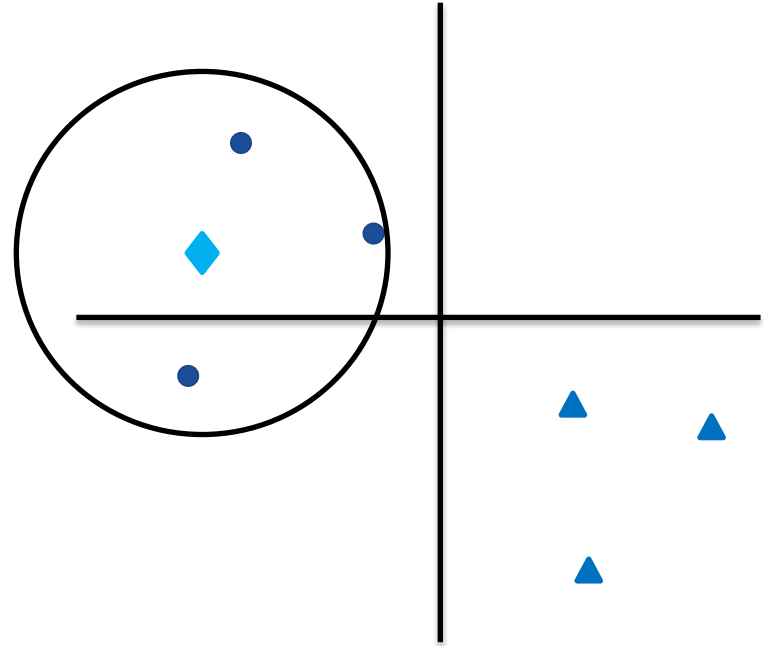
How Does It Work? (Step-By-Step Example)

Define a k value (in this case $k = 3$)

Pick a point to predict
(blue diamond)

Count the number of closest points

Increase the radius until the number of points in circle adds up to 3



● 3/3
▲ 0/3



How Does It Work? (Step-By-Step Example)

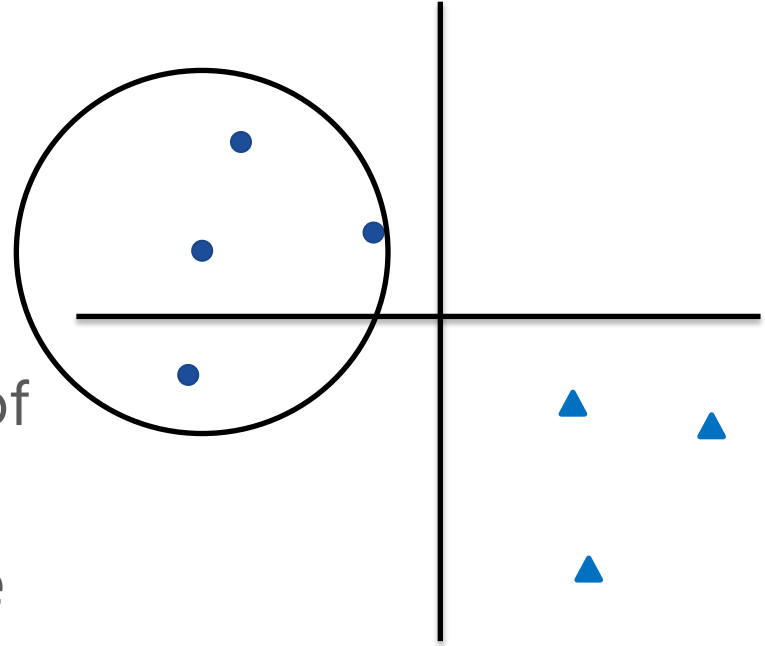
Define a k value (in this case $k = 3$)

Pick a point to predict (blue diamond)

Count the number of closest points

Increase the radius until the number of points within the radius adds up to 3

Predict the blue diamond to be a blue circle!



● 3/3

▲ 0/3



Demo



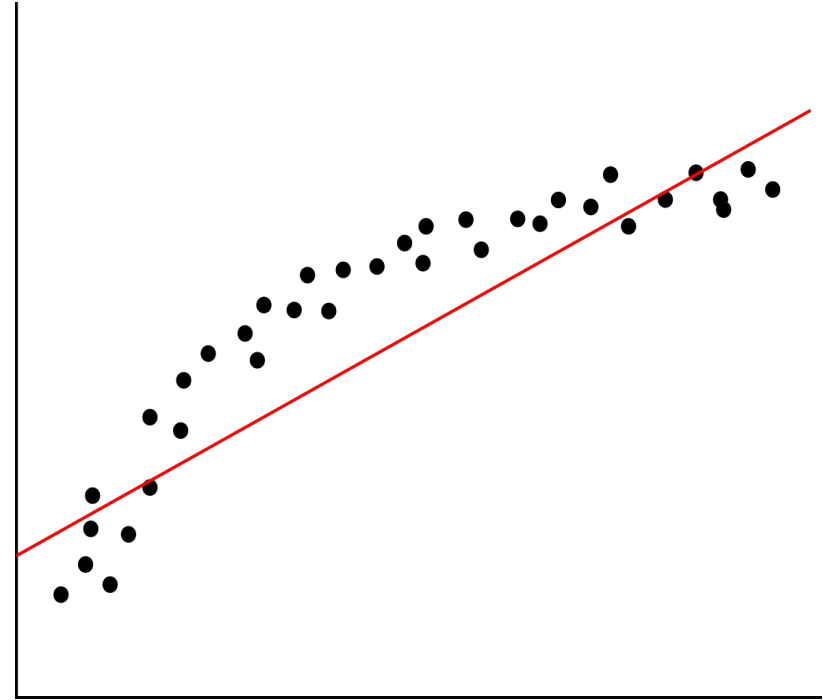
Underfitting v. Overfitting



Underfitting

Underfitting means we have high bias and low variance.

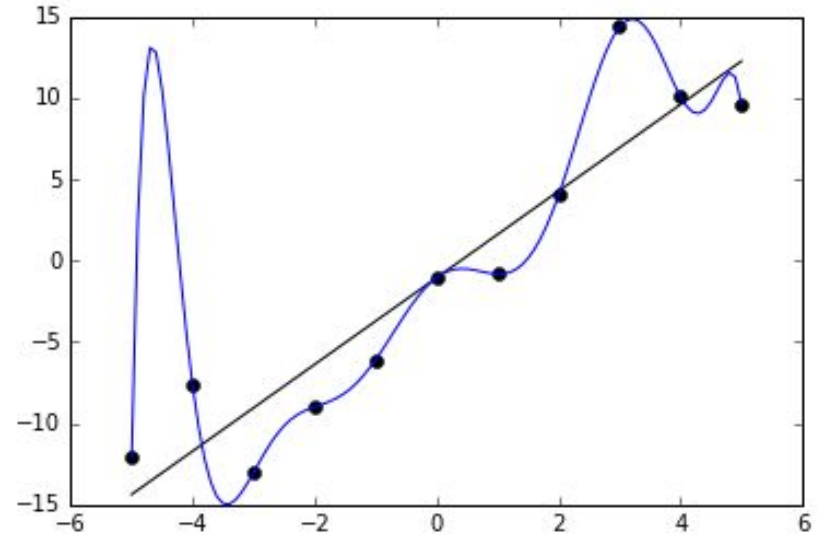
- Lack of relevant variables/factor
- Imposing limiting assumptions
 - Linearity
 - Assumptions on distribution
 - Wrong values for parameters



Overfitting

Overfitting means we have low bias and high variance.

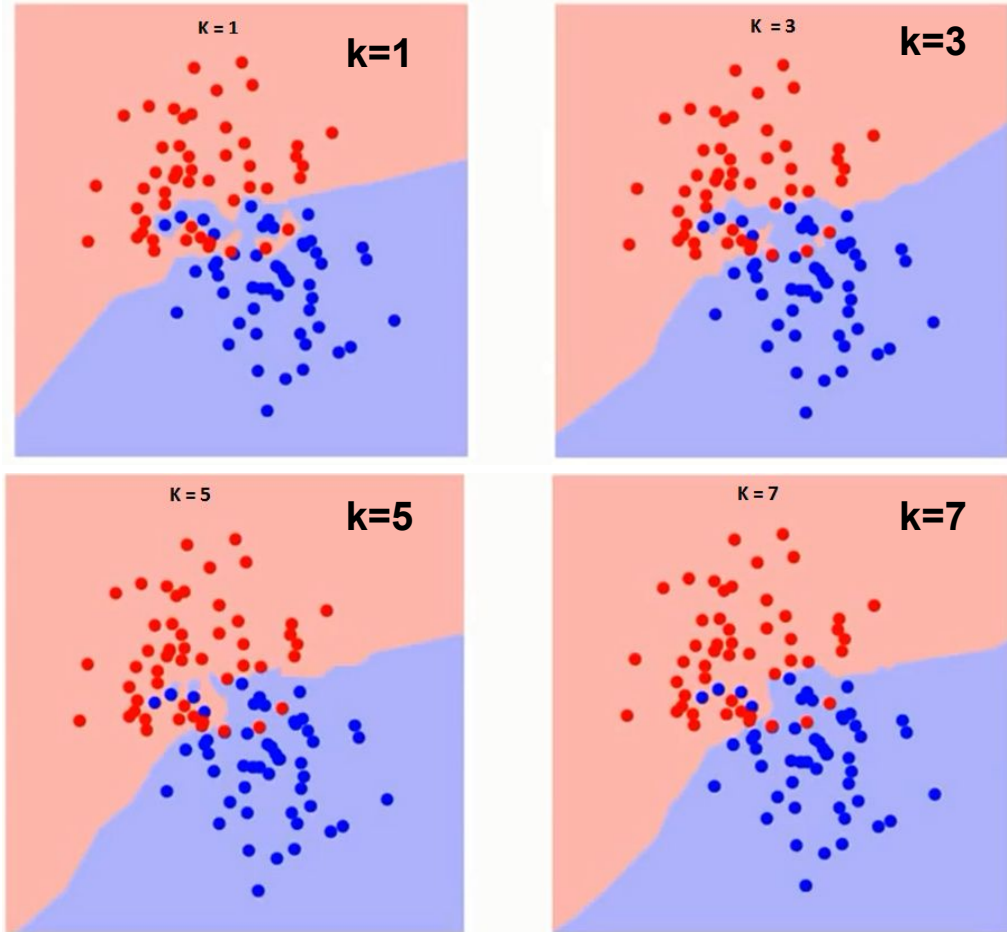
- Model fits too well to specific cases
- Model is over-sensitive to sample-specific noise
- Model introduces too many variables/complexities than needed



Relationship Between k and Fit

The k value you use has a relationship to the fit of the model

A higher k gives a smoother line, but too large of a k and it is the average of all the data (or the label that is most common/likely)



Confusion Matrix



What is a Confusion Matrix?

Table used to describe the performance of a classifier on a set of binary test data for which the true values are known

	p' (Predicted)	n' (Predicted)
p (Actual)	True Positive	False Negative
n (Actual)	False Positive	True Negative



Sensitivity

Called the **true positive rate**

Tells us how many positives are correctly identified as positives

Optimize for: Initial diagnosis of fatal disease

	p' (Predicted)	n' (Predicted)
P (Actual)	True Positive	False Negative
n (Actual)	False Positive	True Negative

$$\text{Sensitivity} = \text{True Positive} / (\text{True Positive} + \text{False Negative})$$



Specificity

Called the **true negative rate**

Tells us how many negatives are correctly identified as negatives

Optimize for: testing for a disease with a risky treatment

	p' (Predicted)	n' (Predicted)
p (Actual)	True Positive	False Negative
n (Actual)	False Positive	True Negative

$$\text{Specificity} = \frac{\text{True Negative}}{\text{True Negative} + \text{False Positive}}$$



Question

Which is an example of when you would want **higher specificity**?

- A. DNA tests for a death penalty case
- B. Deciding which iPhone to buy
- C. Airport security



Attendance!



Overall Accuracy

Proportion of correct predictions

	p' (Predicted)	n' (Predicted)
p (Actual)	True Positive	False Negative
n (Actual)	False Positive	True Negative

$$\text{Accuracy} = \frac{\text{True Positive} + \text{True Negative}}{\text{Total}}$$



Overall Error Rate

Proportion of incorrect predictions

	p' (Predicted)	n' (Predicted)
p (Actual)	True Positive	False Negative
n (Actual)	False Positive	True Negative

$$\text{Error} = (\text{False Positive} + \text{False Negative}) / \text{Total}$$



Precision

Proportion of correct positive predictions among all positive predictions

	p' (Predicted)	n' (Predicted)
p (Actual)	True Positive	False Negative
n (Actual)	False Positive	True Negative

$$\text{Precision} = \text{True Positive} / (\text{True Positive} + \text{False Positive})$$



Coming Up

- **Assignment 5:** Due **Friday 10/18** at 11:59pm!
- **Assignment 6:** Due next Wednesday 10/23
- **Mid-Semester Check-In:** Details on ED! Complete by Wednesday 10/23.
- **Next Lecture:** Supervised Learning Pt. 1