

# INTRO TO CLASSIFICATION

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*DAT<sub>2</sub>*

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## INTRO TO CLASSIFICATION

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# LEARNING OBJECTIVES

- ▶ Define class label and classification
- ▶ Build a K-Nearest Neighbors model using the scikit-learn library
- ▶ Evaluate and tune model by using metrics such as classification accuracy/error

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## PRE-WORK REVIEW

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- ▶ Understand how to optimize for error in a model
- ▶ Understand the concept of iteration to solve problems
- ▶ Know when to use Lasso or Ridge to regularize a model

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**OPENING**

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# INTRO TO CLASSIFICATION

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# INTRO TO CLASSIFICATION

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- ▶ So far, we've worked primarily with regression problems. We've focused on predicting continuous values.
  - ▶ That means we've been able to use distance to measure how accurate our prediction is.
- ▶ For other problems, we need to predict binary responses:
  - ▶ Will a loan default?
  - ▶ Is email spam?

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# ACTIVITY: KNOWLEDGE CHECK

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## ANSWER THE FOLLOWING QUESTIONS



EXERCISE

1. What if we want to build a model to predict a set of values, like a photo color or the gender of a baby?
2. Can we use regression for binary values?
3. Do the same principles apply?

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# WHAT IS CLASSIFICATION?

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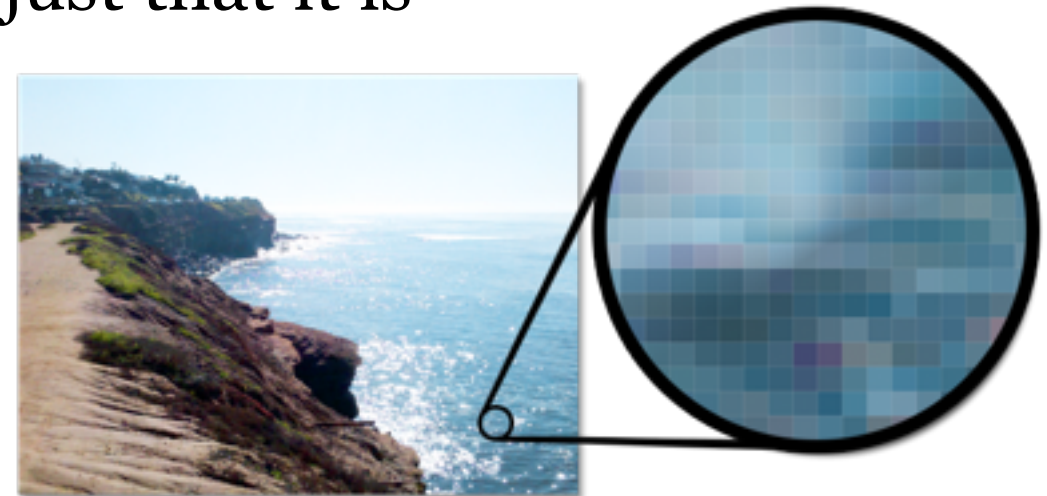
- ▶ Classification is a machine learning approach for solving a set value given the knowledge we have about that value.
- ▶ Many classification problems are trying to predict *binary* values.
- ▶ For example, we may be using patient data (medical history) to predict whether the patient is a smoker or not.

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# WHAT IS CLASSIFICATION?

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- ▶ Some problems don't appear to be binary at first glance. However, you can boil down the response to a *boolean* value.
- ▶ What if you are predicting whether an image pixel will be red or blue?
- ▶ We don't need to predict that a pixel is blue, just that it is not red.
- ▶ Similar to the concept of dummy variables.

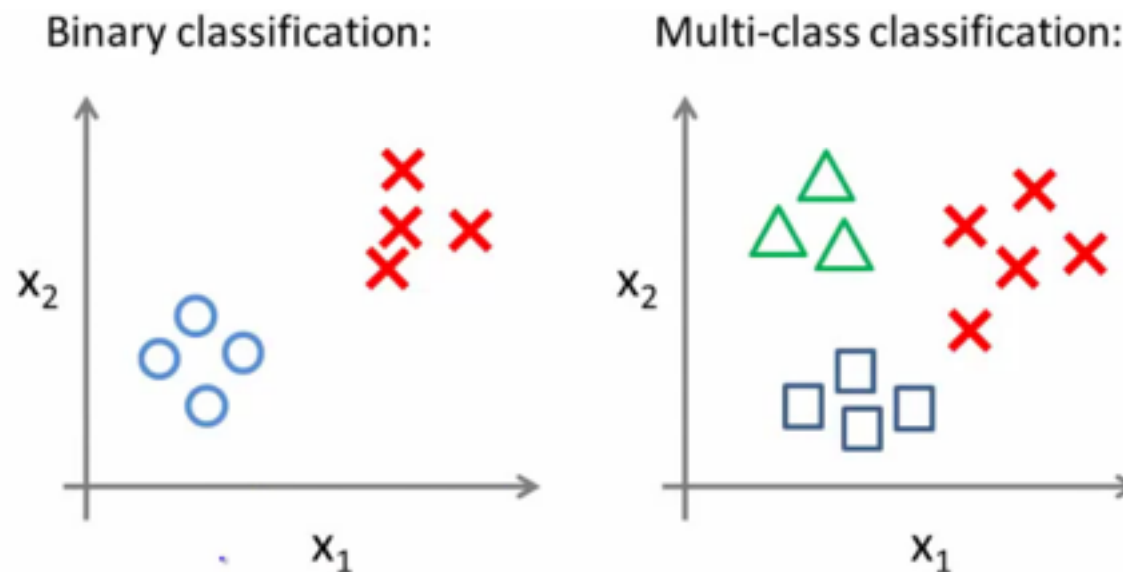




# WHAT IS CLASSIFICATION?

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- ▶ Binary classification is the simplest form of classification.
- ▶ However, classification problems can have multiple *class labels*.
- ▶ Instead of predicting whether the pixel is red or blue, you could predict whether the pixel is red, blue, or green.



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# WHAT IS A CLASS LABEL?

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- ▶ A **class label** is a representation of what we are trying to predict: our *target*.
- ▶ Examples of class labels:

<b>Data Problem</b>	<b>Class Labels</b>
Patient data problem	is smoker, is not smoker
pixel color	red, blue, green

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# DETERMINING REGRESSION OR CLASSIFICATION

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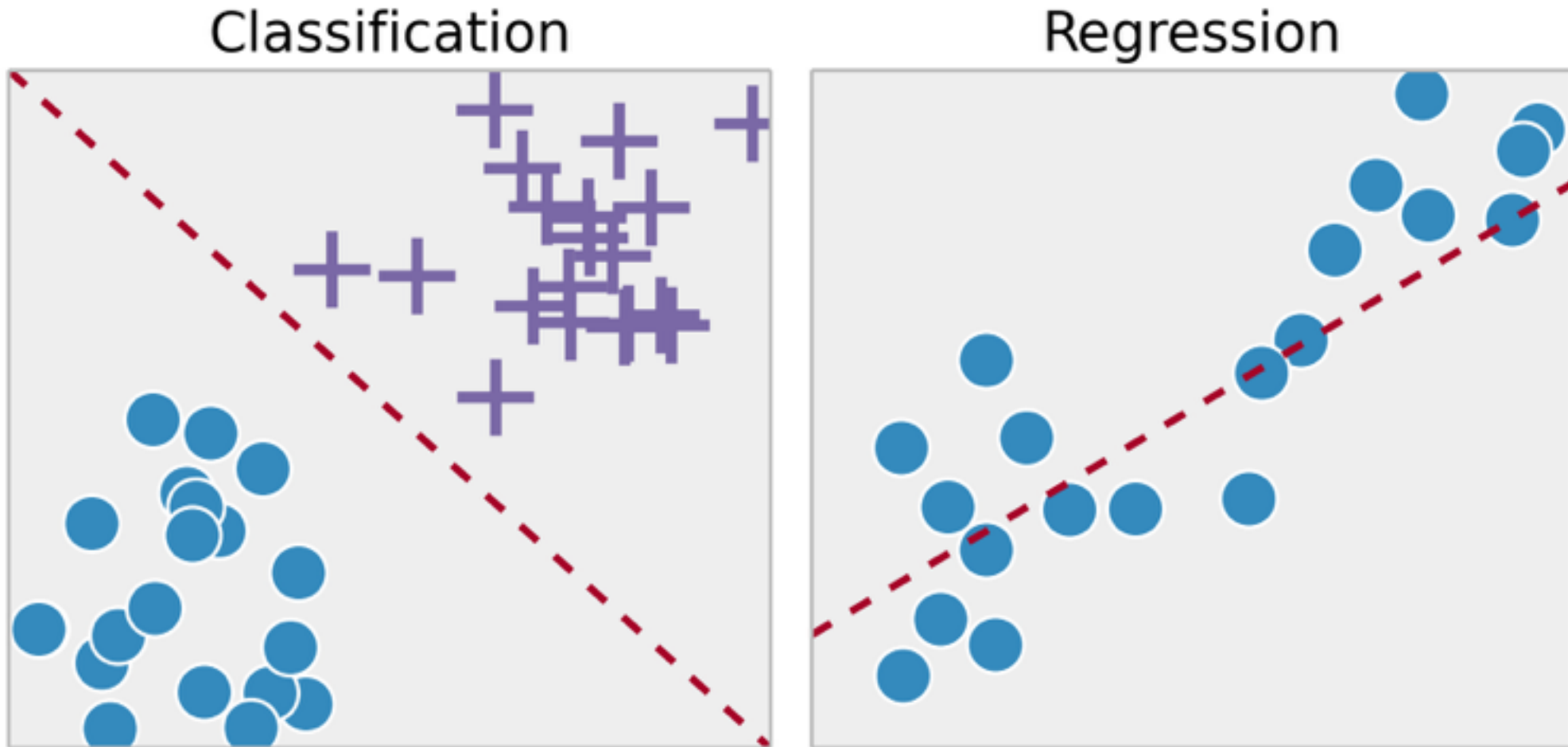
- ▶ One of the easiest ways to determine if a problem is regression or classification is to determine if our *target* variable can be ordered mathematically.
- ▶ For example, if predicting company revenue, \$100MM is greater than \$90MM. This is a *regression* problem because the target can be ordered.
- ▶ However, if predicting pixel color, red is not inherently greater than blue. Therefore, this is a *classification* problem.

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# DETERMINING REGRESSION OR CLASSIFICATION

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- Classification and regression differ in what you are trying to predict.



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# ACTIVITY: REGRESSION OR CLASSIFICATION?

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## DIRECTIONS (20 minutes)

Review the following situations and decide if each one is a regression problem, classification problem, or neither:



### EXERCISE

1. Using the total number of explosions in a movie, predict if the movie is by JJ Abrams or Michael Bay.
2. Determine how many tickets will be sold to a concert given who is performing, where, and the date and time.
3. Given the temperature over the last year by day, predict tomorrow's temperature outside.
4. Using data from four cell phone microphones, reduce the noisy sounds so the voice is crystal clear to the receiving phone.
5. With customer data, determine if a user will return or not in the next 7 days to an e-commerce website.

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## INDEPENDENT PRACTICE

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**BUILD A  
CLASSIFIER!**

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# ACTIVITY: BUILD A CLASSIFIER!

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## DIRECTIONS (20 minutes)



### EXERCISE

1. Explore the iris dataset and build a program that classifies each data point. Use if-else statements and Pandas functions.
2. Measure the *accuracy* of your classifier using the math of “total correct” over “total samples”.
3. Your classifier should be able to:
  - a. Get one class label 100% correct (one type of iris is easily distinguishable from the other two).
  - b. Accurately predict the majority of the other two classes with some error (hint: make sure to *generalize*).

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# ACTIVITY: BUILD A CLASSIFIER!

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## DIRECTIONS



### EXERCISE

1. How simple could the if-else classifier be while remaining *relatively* accurate?
2. How complicated could our if-else classifier be and remain *completely* accurate?
3. How many if-else statements would you need, or nested if-else statements, in order to get the classifier 100% accurate? (The above uses a count of 2).
4. Which if-else classifier would work better against iris data that it hasn't seen? Why is that the case?



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## INTRODUCTION

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# K NEAREST NEIGHBORS

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# WHAT IS K NEAREST NEIGHBORS?

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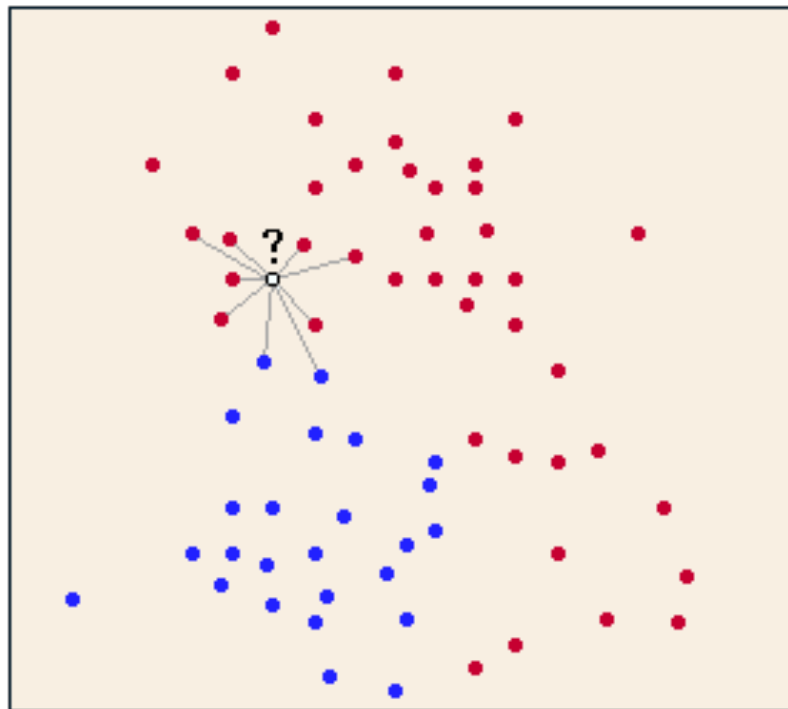
- ▶ **K Nearest Neighbors (KNN)** is a classification algorithm that makes a prediction based upon the closest data points.
- ▶ The KNN algorithm:
  - ▶ For a given point, calculate the distance to all other points.
  - ▶ Given those distances, pick the  $k$  closest points.
  - ▶ Calculate the probability of each class label given those points.
  - ▶ The original point is classified as the class label with the largest probability (“votes”).

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# WHAT IS K NEAREST NEIGHBORS?

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- ▶ KNN uses distance to predict a class label. This application of distance is used as a measure of similarity between classifications.
- ▶ We're using shared traits to identify the most likely class label.



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# WHAT IS K NEAREST NEIGHBORS?

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- ▶ Suppose we want to determine your favorite type of music. How might we determine this without directly asking you?
- ▶ Generally, friends share similar traits and interests (e.g. music, sports teams, hobbies, etc). We could ask your five closest friends what their favorite type of music is and take the majority vote.
- ▶ This is the idea behind KNN: we look for things similar to (or close to) our new observation and identify shared traits. We can use this information to make an educated guess about a trait of our new observation.

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# KNN IN ACTION

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► The following code demonstrates using KNN via sklearn.

```
from sklearn import datasets, neighbors, metrics
import pandas as pd
```

```
iris = datasets.load_iris()
# n_neighbors is our option in KNN. We'll tune this value to attempt to
improve our prediction.
knn = neighbors.KNeighborsClassifier(n_neighbors=5, weights='uniform')
knn.fit(iris.data[:,2:], iris.target)
print knn.predict(iris.data[:,2:])
print iris.target
print knn.score(iris.data[:,2:], iris.target)
```

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## WHAT HAPPENS IN TIES?

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- ▶ What happens if two classes get the same number of votes?
- ▶ This could happen in binary classification if we use an even number for  $k$ .
- ▶ This could also happen if there are multiple class labels.
- ▶ In sklearn, it will choose the class that it first saw in the *training set*.

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## WHAT HAPPENS IN TIES?

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- ▶ We could implement a *weight*, taking into account the distance between the point and its neighbors.
- ▶ This can be done in sklearn by changing the `weights` parameter to "distance".
- ▶ Try changing the `weights` parameter. How does this affect accuracy?

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## WHAT HAPPENS IN HIGH DIMENSIONALITY?

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- ▶ Since KNN works with distance, higher dimensionality of data (i.e. more features) requires *significantly* more samples in order to have the same predictive power.
- ▶ Consider this: with more dimensions, points tend toward equidistance.
  - ▶ This causes significant issues for KNN.
- ▶ Keep the feature space limited and exclude extraneous features when using KNN.



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# WHAT HAPPENS IN HIGH DIMENSIONALITY?

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- ▶ Consider two different examples: classifying users of a newspaper and users of a particular toothpaste.
- ▶ The features of the newspapers are very broad and there are many: sections, topics, types of stories, writers, online vs print, etc.
- ▶ However, the features of a toothpaste are more narrow: has fluoride, controls tartar, etc.
- ▶ For which problem would KNN work better?

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## INTRODUCTION

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# CLASSIFICATION METRICS

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# INTRODUCTION TO CLASSIFICATION METRICS

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- ▶ Metrics for regression do **not** apply to classification.
- ▶ We *could* measure the distance between the probability of a given class and an item being in that class.
  - ▶ Guessing 0.6 for a 1 is a 0.4 error.
- ▶ But this overcomplicates our goal: understanding binary classification, whether something is black or white, right or wrong.
- ▶ Instead, measure “correctness” or “incorrectness”.

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# INTRODUCTION TO CLASSIFICATION METRICS

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- ▶ We'll use two primary metrics: *accuracy* and *misclassification rate*.
- ▶ **Accuracy** is the number of *correct* predictions out of all predictions in the sample. This is a value we want to *maximize*.
- ▶ **Misclassification rate** is the number of *incorrect* predictions out of all predictions in the sample. This is a value we want to *minimize*.
- ▶ These two metrics are directly opposite of each other.
  - ▶  $1 - \text{misclassification rate} = \text{accuracy}$

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# INTRODUCTION TO CLASSIFICATION METRICS

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- ▶ **WARNING:** You cannot use regression evaluation metrics for a classification problem, or vice versa. This is a common mistake.
- ▶ sklearn will not intuitively understand if you are doing regression or classification, so make sure to manually review your metrics.

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# ACTIVITY: SOLVING FOR K

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## DIRECTIONS (35 minutes)

One of the primary challenges of KNN is solving for  $k$  - how many neighbors do we use?

Use the lesson 8 starter code and the iris data set to answer the following questions:

1. What is the accuracy for  $k=1$ ?
2. What is the accuracy for  $k=n-1$ ?
3. Using cross validation, what value of  $k$  optimizes model accuracy. Create a plot with  $k$  as the x-axis and *accuracy* as the y-axis (called a “fit chart”) to help find the answer.



EXERCISE

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# ACTIVITY: SOLVING FOR K

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## DIRECTIONS

### Bonus Questions:



EXERCISE

1. By default, the KNN classifier in sklearn uses the *Minkowski metric* for distance.
  - a. What *type* of data does this metric work best for?
  - b. What *type* of data does this distance metric not work for?
  - c. You can read about distance metrics in [the sklearn documentation](#).
2. It is possible to use KNN as a regression estimator. Determine the following:
  - a. Steps that KNN Regression would follow
  - b. How it predicts a regression value

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**CONCLUSION**

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# TOPIC REVIEW



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# REVIEW

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- ▶ What are class labels? What does it mean to classify?
- ▶ How is a classification problem different from a regression problem?
- ▶ How does the KNN algorithm work?
- ▶ What primary parameters are available for tuning a KNN estimator?
- ▶ How do you define accuracy and misclassification?

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**COURSE**

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**BEFORE NEXT  
CLASS**

**Admissions: Part 3**

# PROJECT DUE DATES

Unit	Project	Assigned	Deadline
Unit 1	Project 1	Assigned Lesson 1	Due Lesson 3
Unit 1	Project 2	Assigned Lesson 3	Due Lesson 5
Unit 2	Final Project, pt 1	Assigned Lesson 1	Due Lesson 8
Unit 2	Project 3	Assigned Lesson 5	Due Lesson 9
Unit 2	Project 4	Assigned Lesson 9	Due Lesson 11
Unit 3	Final Project, pt 2	Assigned Lesson 8	Due Lesson 14
Unit 3	Final Project, pt 3	Assigned Lesson 14	Due Lesson 16
Unit 3	Final Project, pt 4	Assigned Lesson 16	Due Lesson 18
Unit 3	Final Project, pt 5	Assigned Lesson 18	Due Lesson 20

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# LESSON

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Q & A

## LESSON

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# EXIT TICKET

**DON'T FORGET TO FILL OUT YOUR EXIT  
TICKET**