Modeling VII

Introduction

- Non-Parametric Classification
- K-Nearest Neighbors (k-NN)
  - Machine Learning Technique
  - Intuitive
  - Non-Parametric
  - Used for Predicting Classes of an Output Variable
- Instructions:
  - Open Supplement File
  - Knit the Document
  - Read the Introduction

Idea Behind k-NN

- Scenario: Will a College Football Player Be Drafted Into the NFL?
- Two Possible Classes
  - Drafted
  - Undrafted
- Known Information
  - Data From All Previous Players Who Entered Draft
  - Whether or Not They Were Drafted
  - Their University and Position
  - Playing Statistics
  - Body Measurements

Idea Behind k-NN

- Current Draft Eligible Player
  - Who? Mike Jones
  - USC and QB
  - Passer Rating = 95
  - 6’4”, 205 lbs.
- Goal: Predict Whether or Not Mike Jones Will Be Drafted
- Base Your Prediction for Mike Jones on the *k*=*5* Most Similar Players From Historical Info

Idea Behind k-NN

- Process
  - Consider Database of Info
  - Find 5 Most Similar Players
    - QB's From USC
    - Similar Passer Ratings
    - Similar Body Types
  - Of the 5, Observe Classes
    - 4 Drafted
    - 1 Undrafted
  - Above Info Acts as Votes
  - Historical Information Leads Us to Conclude Mike Jones is More Likely to Be Drafted
  - Predict Mike Jones Will Be Drafted into the NFL

k-NN Algorithm

- Step 1: Choose a *k*
- Step 2: Select the *k* Most Similar Observations in a Database Which are the “Closest” According to the Input Variables
- Step 3: Find the Most Common Classification Among These
- Step 4: Classify the New Observation Based on What is Category is Known to Occur Most

Pause For Lyrics

Love can touch us one time
And last for a lifetime
And never let go till we're gone

Part 1: Feature Engineering and Visualization

- Titanic Survival Data

```
> library(titanic)
```

  - Response Variable

$$Y = \begin{cases} 1 & if\ \ Survived \\ 0 & if\ \ Did\ Not\ Survive \end{cases}$$

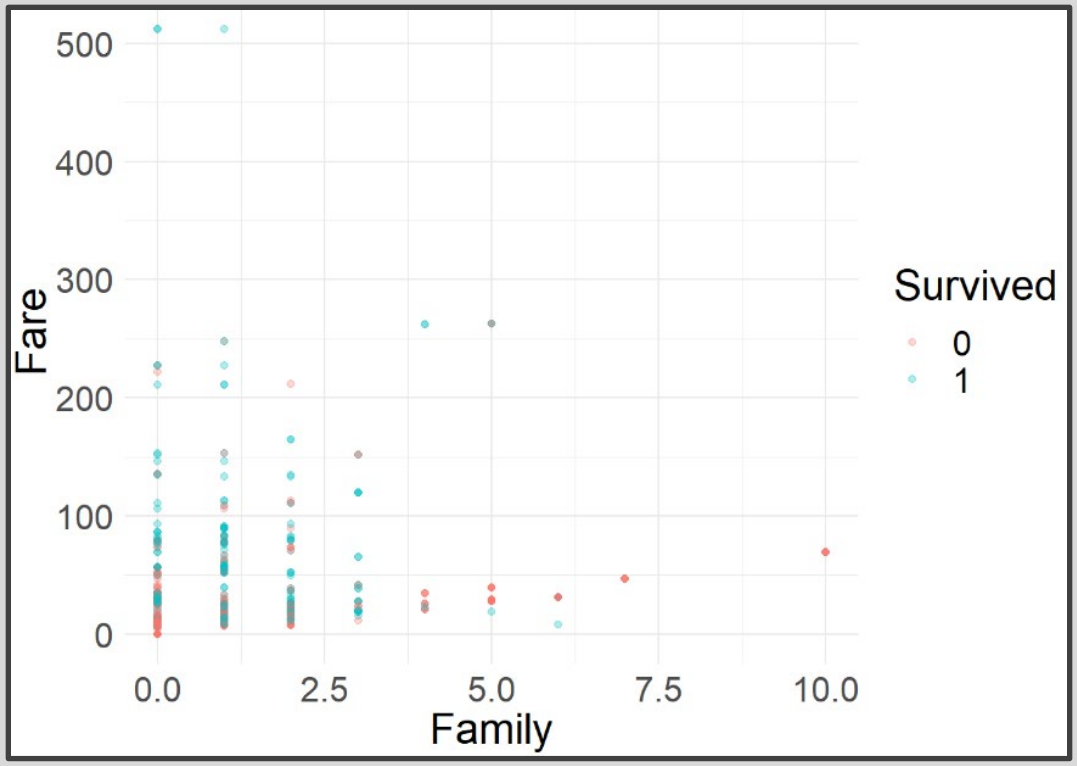
  - Explanatory Variables
    - Siblings/Spouses Aboard
    - Parents/Children Aboard
    - Passenger Fare

- Goal: Use k-NN to Predict a Passenger to Survive or to Die a Miserable, Cold Death

Part 1: Feature Engineering and Visualization

- Run Chunk 1
  - Creating a New Variable
  - What Does This Variable Represent?

- Run Chunk 2

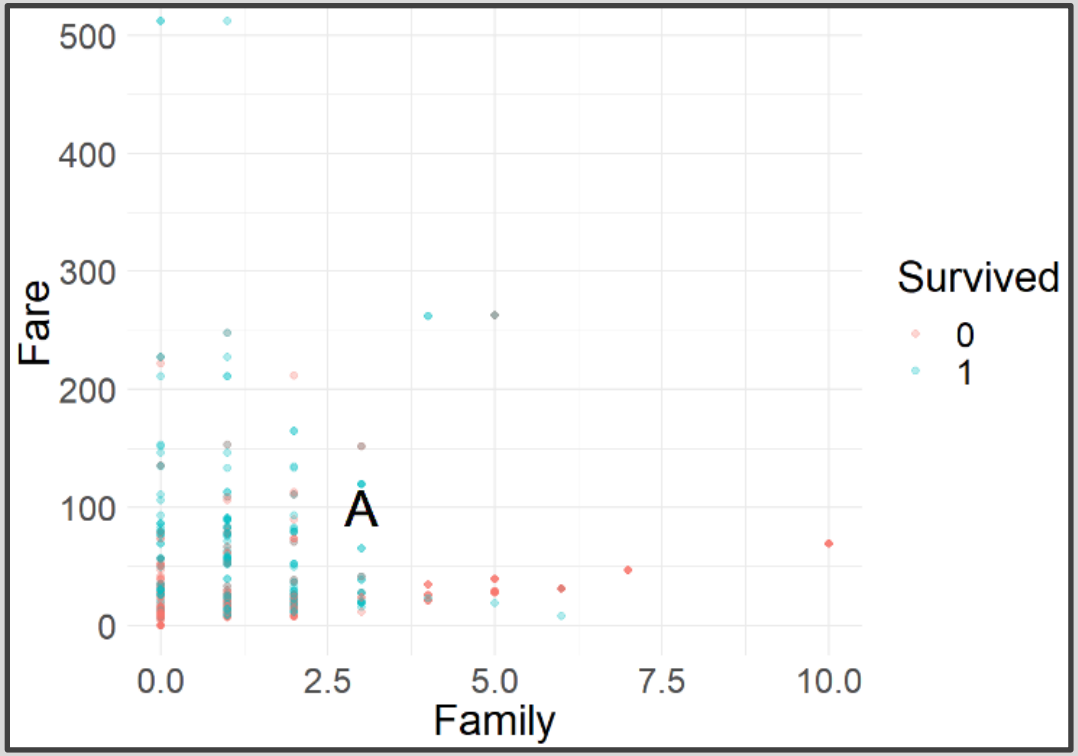


Pause For Lyrics

Love was when I loved you
One true time I hold to
In my life we'll always go on

Part 2: Obtaining Predictions Using k-NN

- New Individual: Alice
  - Had 3 Family Members on Ship
  - Spent $75 on Ticket
  - Survived or Died?
- Run Chunk 1



Part 2: Obtaining Predictions Using k-NN

- Finding Similar Passenger
  - Out-of-Sample Passenger
    - $X_{11} = Family\ Onboard$
    - $X_{12} = Fare$
  - Passenger in Training Data
    - $X_{21} = Family\ Onboard$
    - $X_{22} = Fare$
  - Geometric Distance Formula

$$d = \sqrt{(x_{11} - x_{21})^2 + (x_{12} - x_{22})^2}$$

  - Two Scenarios
    - Distance is Small
    - Distance is Large

Part 2: Obtaining Predictions Using k-NN

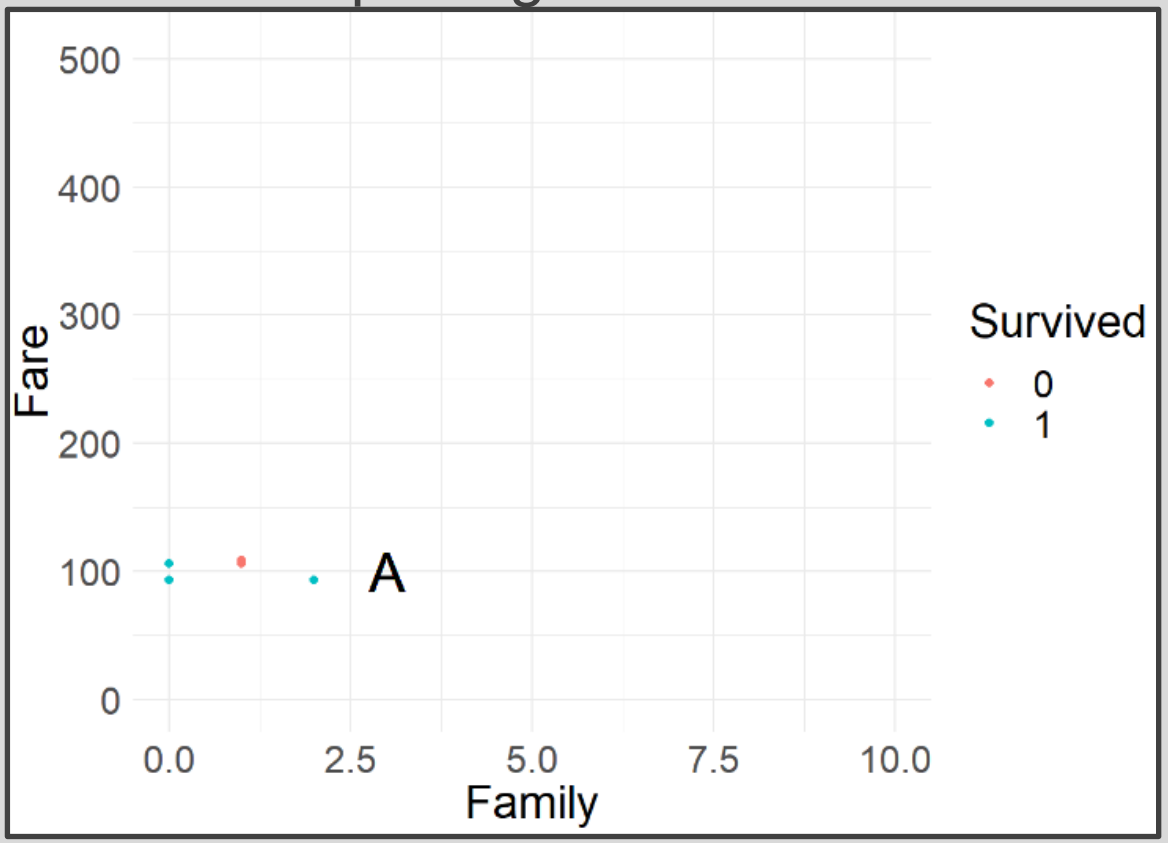
- Run Chunk 2
  - Suppose k=5
  - Five Most Similar Passengers

Survived	Fare	Family	d
1	93.500	2	6.576473
0	106.425	1	6.729088
1	106.425	0	7.090883
1	93.500	0	7.158911
1	108.900	1	9.121952
0	108.900	1	9.121952

  - Why are There Six?
  - Did Alice Survive or Die?

Part 2: Obtaining Predictions Using k-NN

- Run Chunk 3
  - Output Figure



- What Did You Expect to See?
- Are You Surprised?

Pause For Lyrics

Near, far, wherever you are
I believe that the heart does go on
Once more you open the door
And you're here in my heart
And my heart will go on and on

Part 3: Transform and Revisit k-NN

- Consider Standardization
  - Multiple Methods
  - Classic Formula

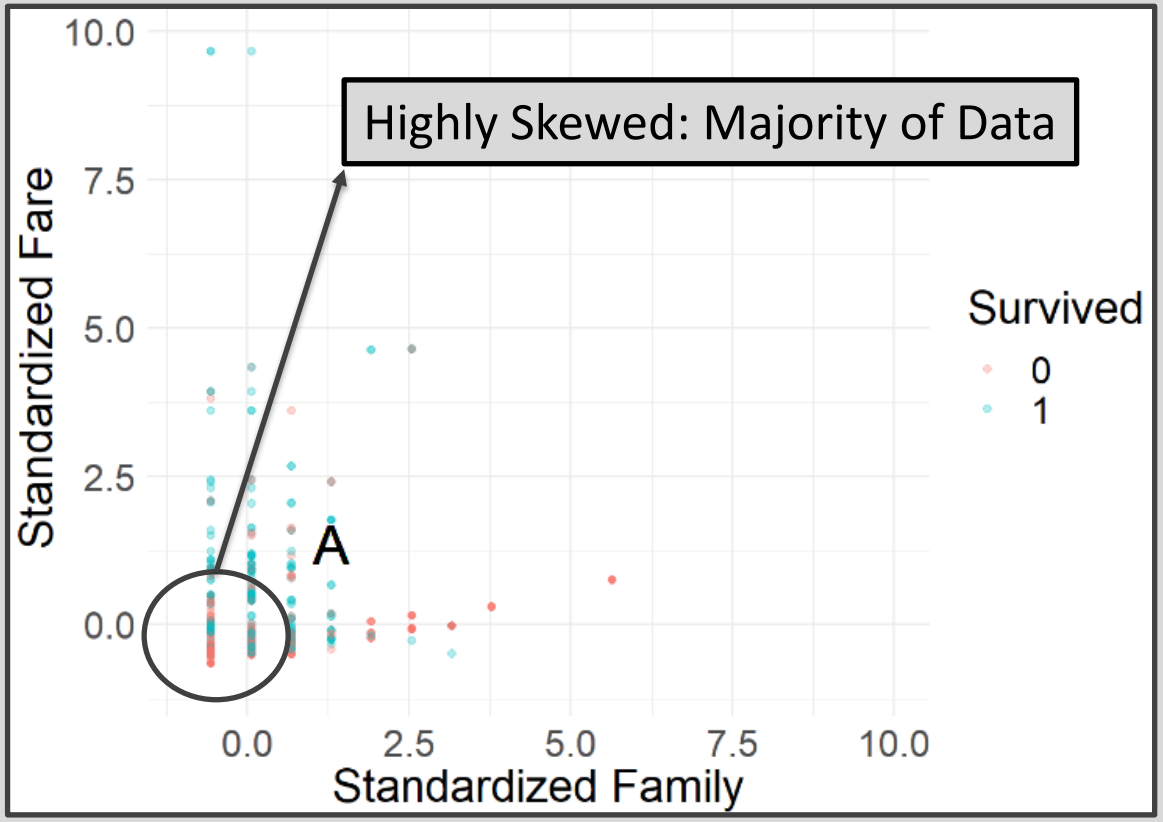
$$Z = \frac{X - \mu}{\sigma_x}$$

  - Use $\bar{x}$ and s_x
  - What We are Doing
    - Centering Data
    - Scaling Data

```
> scale(x,center=T,scale=T)
```

Part 3: Transform and Revisit k-NN

- Run Chunk 1
  - Units: Standard Deviations
  - Alice: Above Average Family Size and Fare



Part 3: Transform and Revisit k-NN

- Run Chunk 2
  - Recall: Alice
    - Family Size of 3
    - $100 Ticket

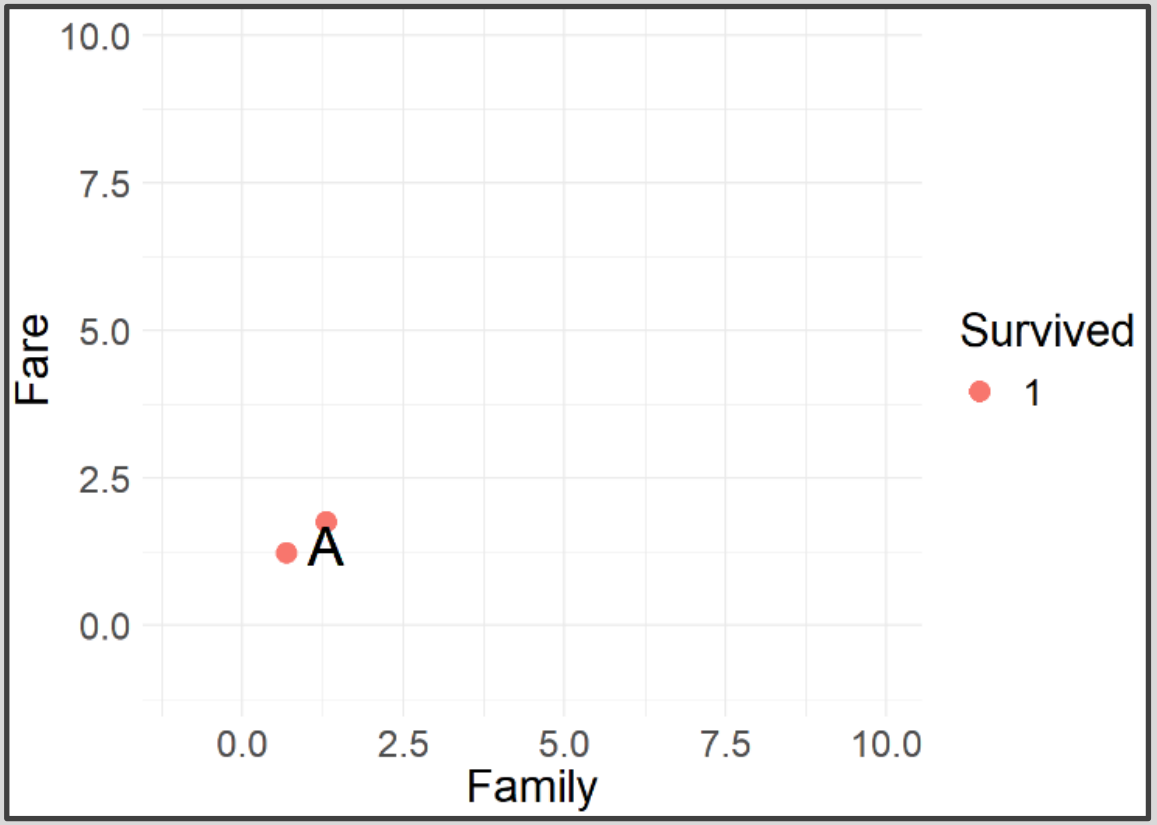
  - Before & After Standardization

Survived	Fare	Family	d
1	93.500	2	6.576473
0	106.425	1	6.729088
1	106.425	0	7.090883
1	93.500	0	7.158911
1	108.900	1	9.121952
0	108.900	1	9.121952

Survived	Fare	Family	d
1	120.0	3	0.4024677
1	120.0	3	0.4024677
1	120.0	3	0.4024677
1	120.0	3	0.4024677
1	93.5	2	0.6334387

Part 3: Transform and Revisit k-NN

- Chunk 2 Continued
  - Both Before and After Standardization We Would Predict Alice to Survive
  - Updated Figure

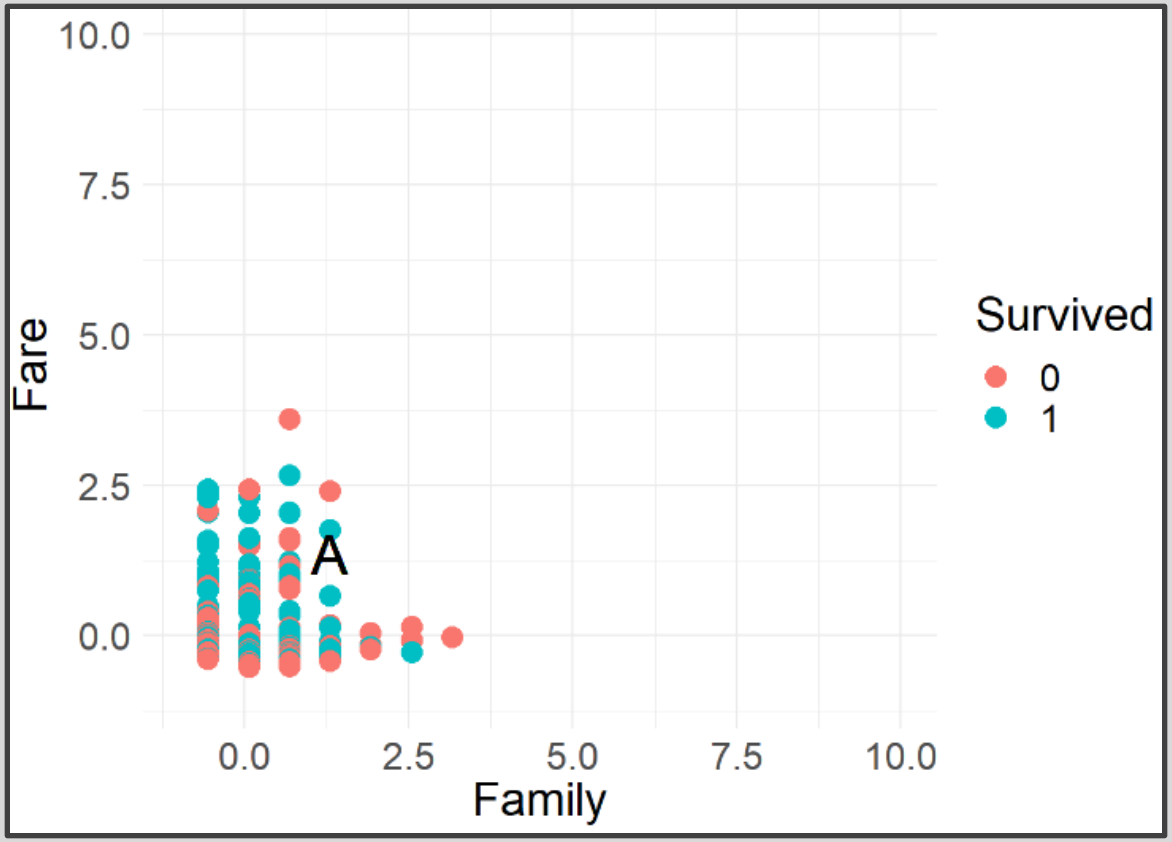


Pause For Lyrics

You're here, there's nothing I fear
And I know that my heart will go on

Part 4: Tuning k for k-NN

- Run Chunk 1
  - Suppose k is Large (k=500)



Part 4: Tuning k for k-NN

- Chunk 1 Continued
  - Votes From Neighbors

```
KNN.PREDICT=table(ST5$Survived)
print(KNN.PREDICT)
```

```
##
##   0   1
## 258 251
```

- Based on k-NN When k=500
  - 258 Neighbors Died
  - 251 Neighbors Survived

- Predict Alice is Food for Fish

Part 4: Tuning k for k-NN

- Leave-on-Out Cross Validation
  - Helpful Package for k-NN

    ```
    > library(class)
    ```

  - Install the R Package
  - Helpful Functions
    - Peforming k-NN

      ```
      > knn(train, test, cl, k = 1)
      ```

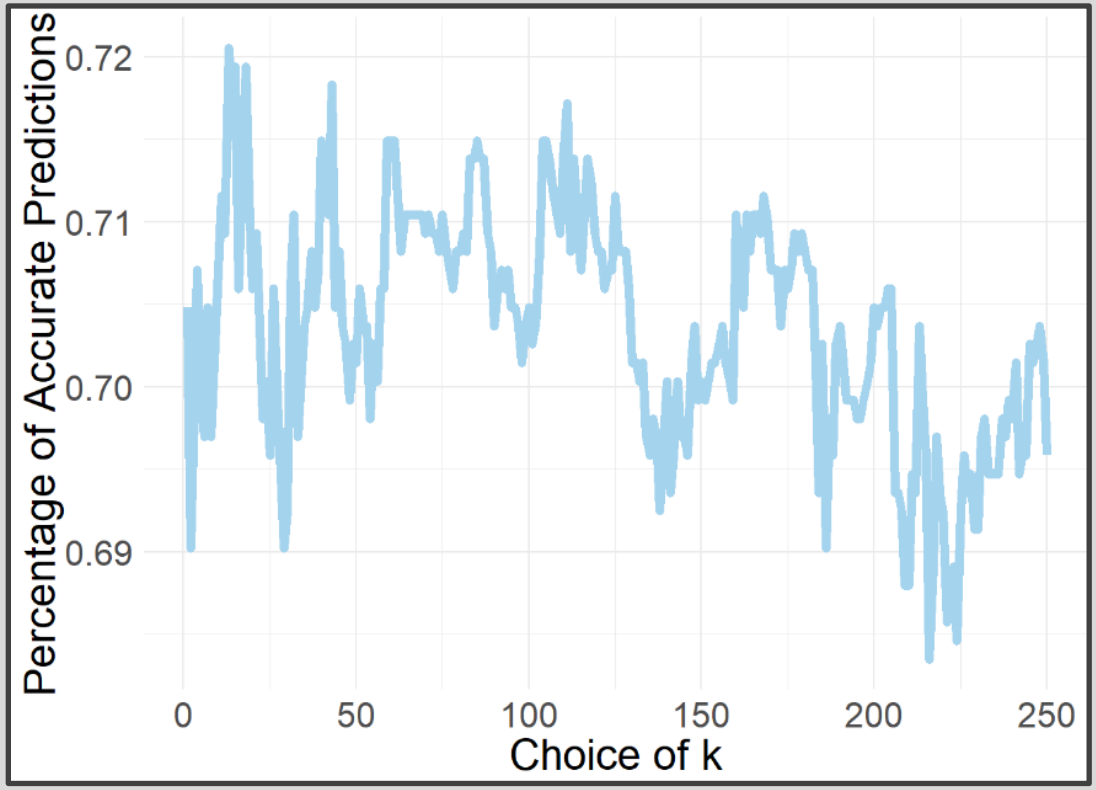
    - LOOCV

      ```
      > knn.cv(train, cl, k = 1)
      ```

  - For Other Important Arguments, See Documentation

Part 4: Tuning k for k-NN

- Run Chunk 2
  - Consider k=1,2,3,…,250
  - Use CV, to Generate Out-of-Sample Predictions for Each k
  - Calculate Overall Accuracy Percentage

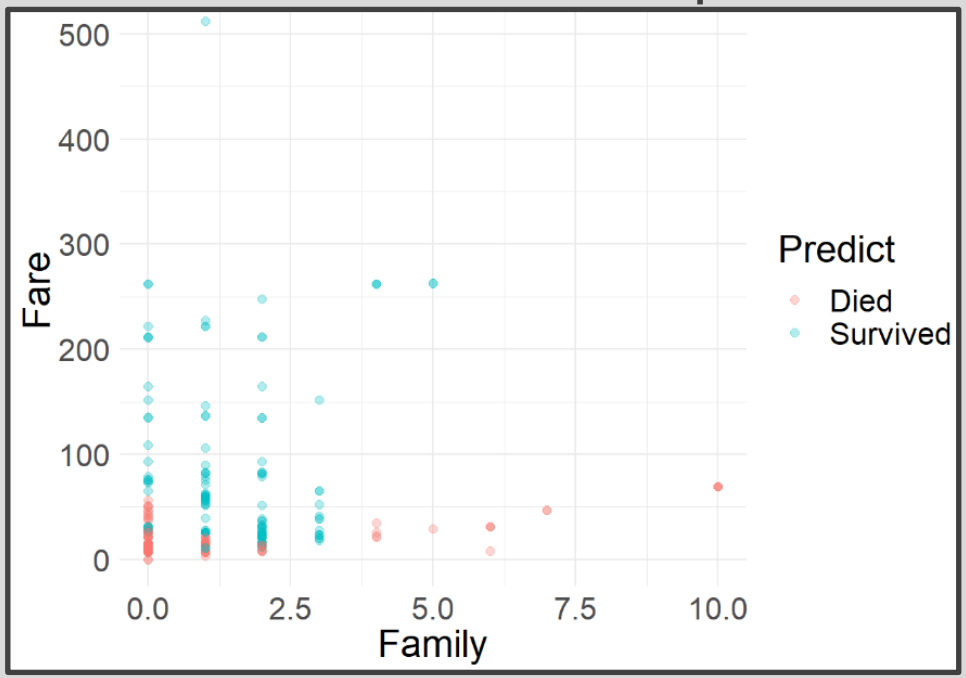


Part 4: Tuning k for k-NN

- Run Chunk 3
  - Identify Best Choice for k (k=18)
  - Use k to Generate Predictions on Future Data With Unknown Survival

```
> titanic_test
```

  - Figure Illustrating Predictions on Test Set for Competition



Pause For Lyrics

We'll stay forever this way
You are safe in my heart and
My heart will go on and on

In Memoriam

RIP

Jack Dawson

Unknown – 1912

Closing

Disperse and Make Reasonable Decisions