



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 Tutorial 14 Rmd 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

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

- Explanatory Variables

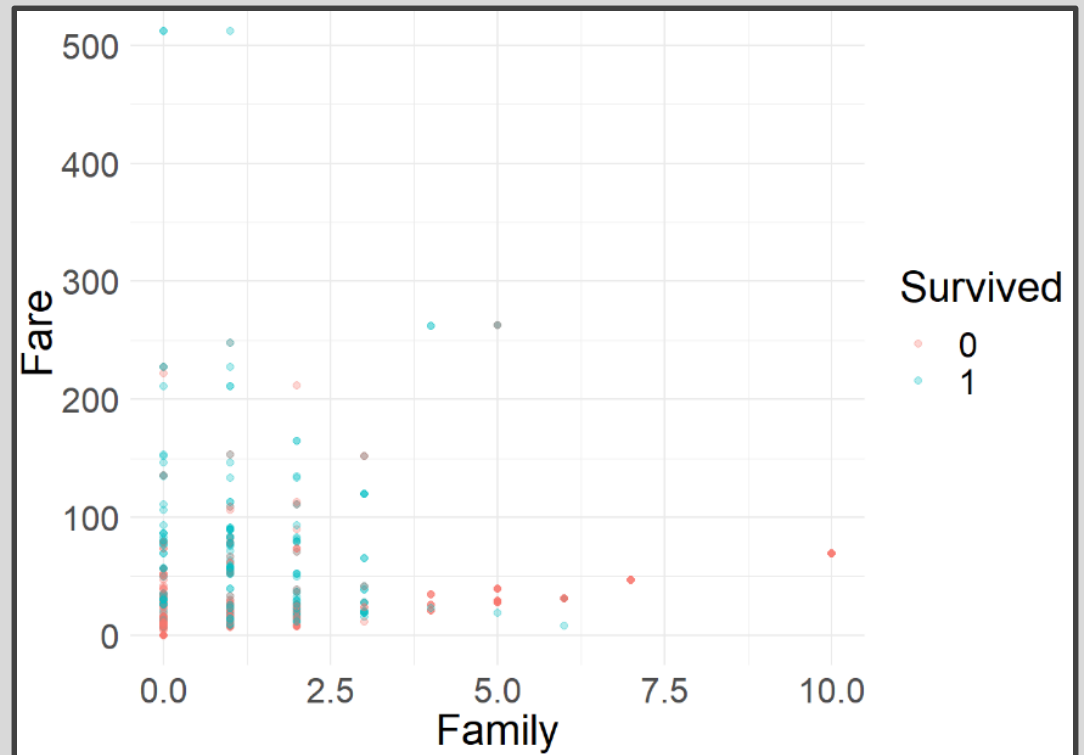
- Siblings/Spouses Aboard
- Parents/Children Aboard
- Passenger Fare

- 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

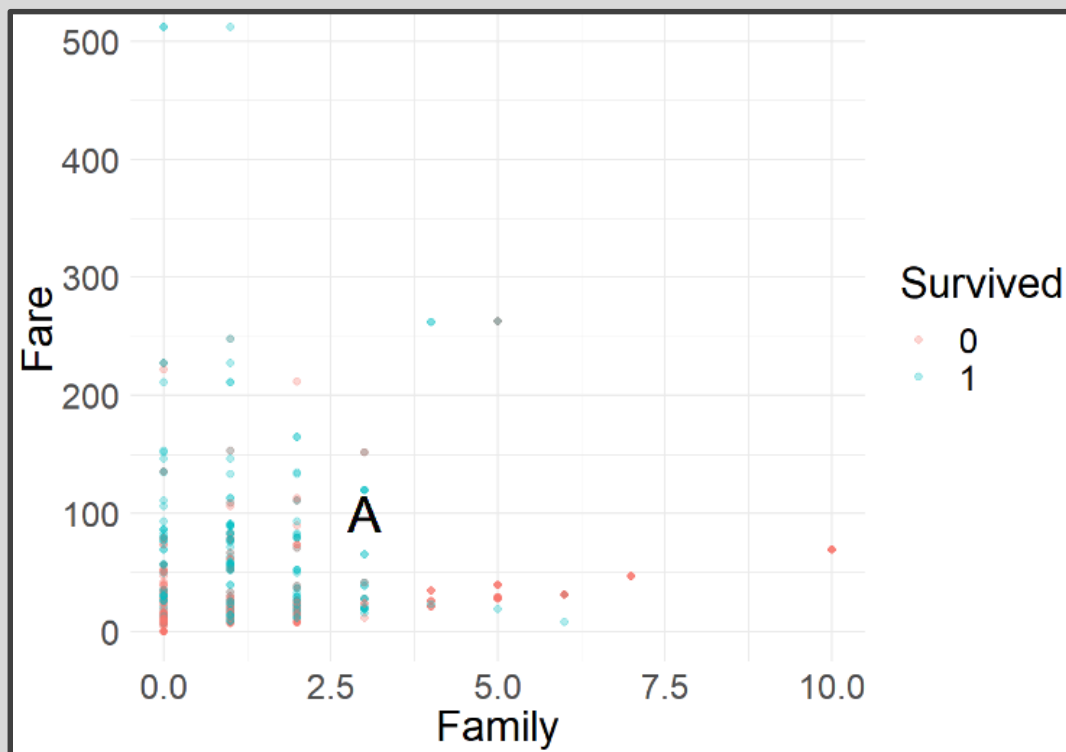


Love was when I loved you
One true time I hold to
In my life we'll always go on

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
 - $X_{11} = \textit{Family Onboard}$
 - $X_{12} = \textit{Fare}$
 - Passenger in Training Data
 - $X_{21} = \textit{Family Onboard}$
 - $X_{22} = \textit{Fare}$
 - 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

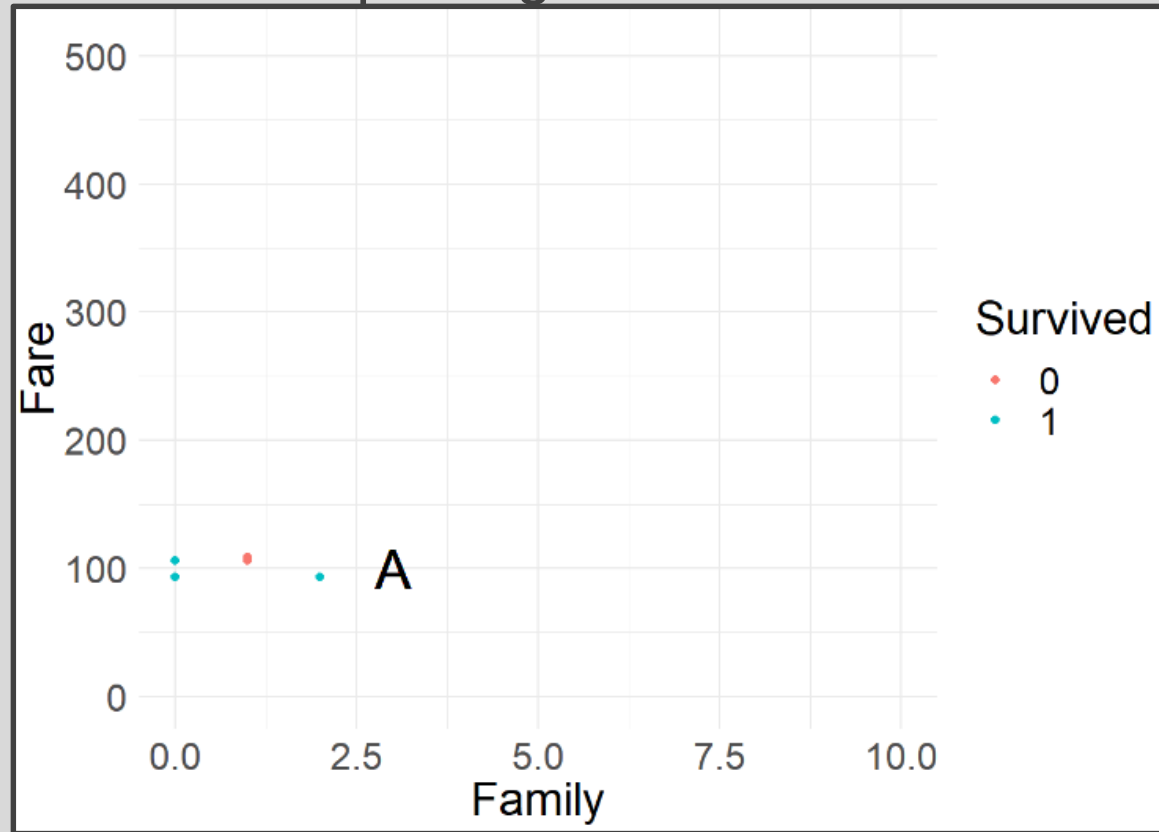
| Survived | Fare | Family | d |
|----------|---------|--------|----------|
| 1 | 93.500 | 2 | 6.576473 |
| 0 | 106.425 | 1 | 6.729088 |
| 1 | 106.425 | 0 | 7.090883 |
| 1 | 93.500 | 0 | 7.158911 |
| 1 | 108.900 | 1 | 9.121952 |
| 0 | 108.900 | 1 | 9.121952 |

- 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

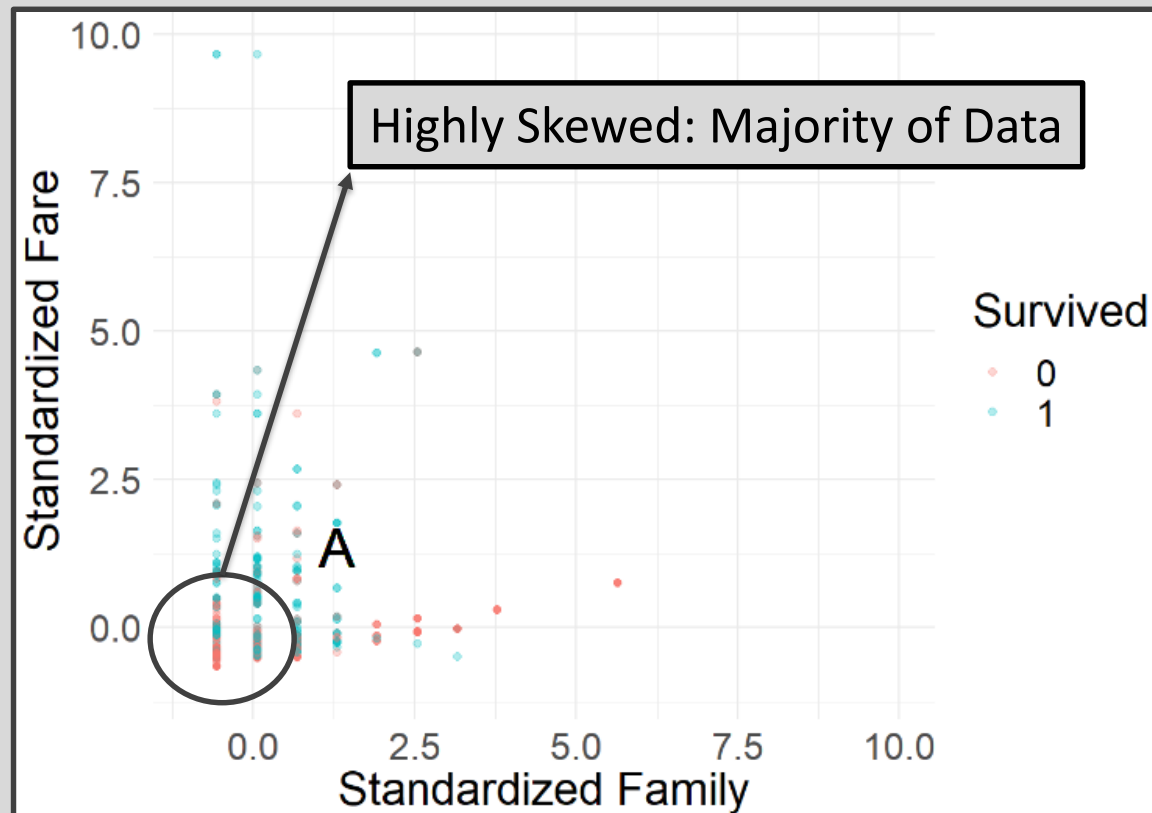
- Centering Data
 - Scaling Data

```
> 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

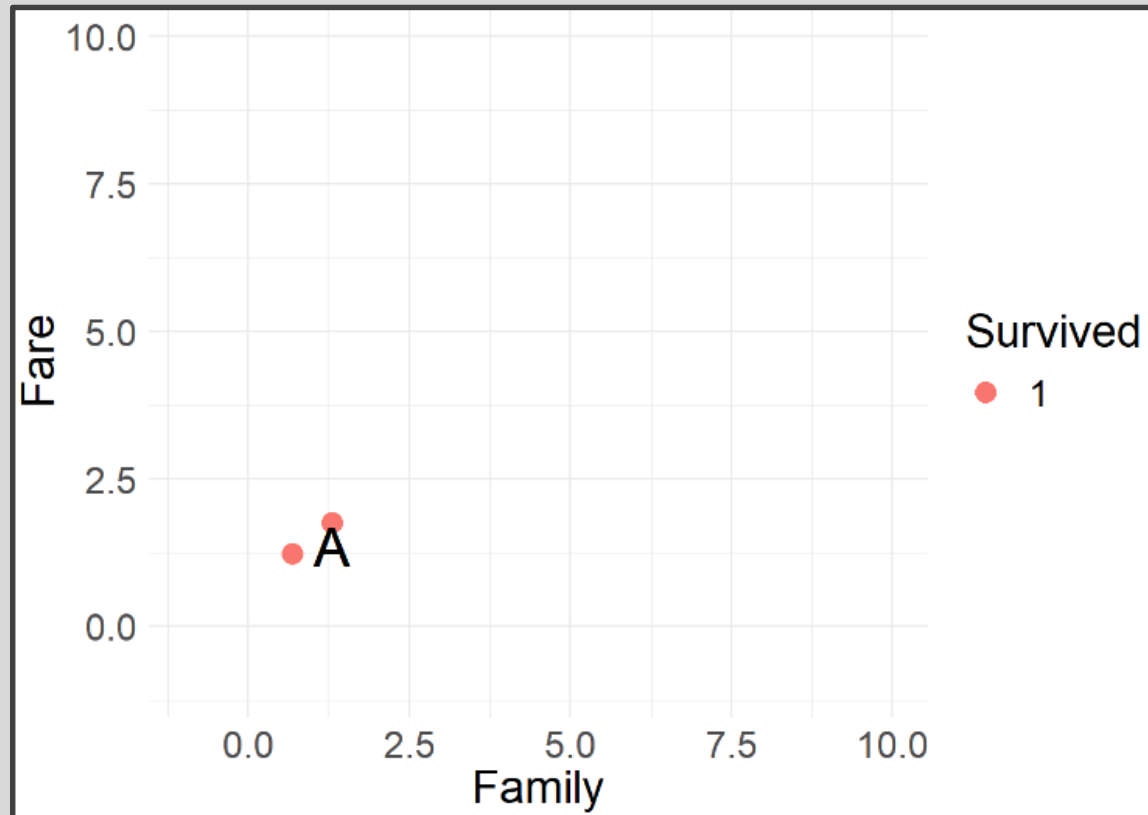
| Survived | Fare | Family | d |
|----------|---------|--------|----------|
| 1 | 93.500 | 2 | 6.576473 |
| 0 | 106.425 | 1 | 6.729088 |
| 1 | 106.425 | 0 | 7.090883 |
| 1 | 93.500 | 0 | 7.158911 |
| 1 | 108.900 | 1 | 9.121952 |
| 0 | 108.900 | 1 | 9.121952 |

| 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

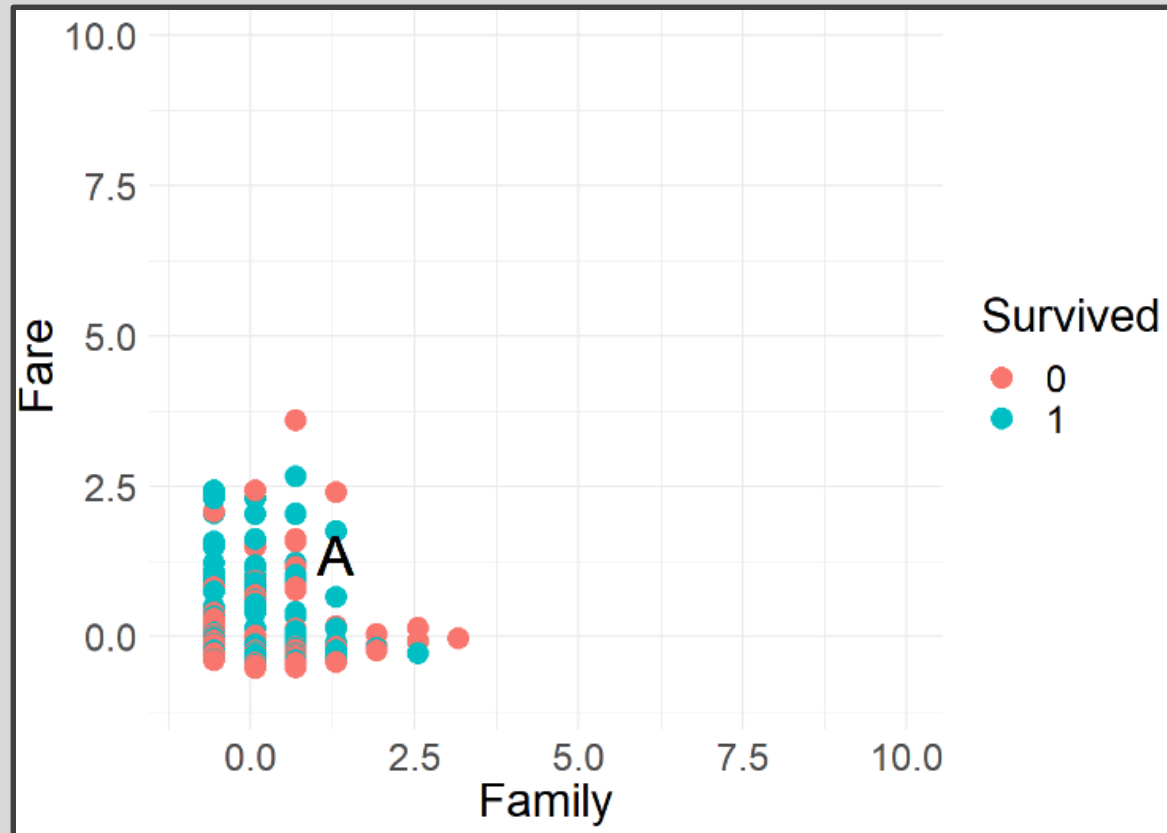


You're here, there's nothing I fear
And I know that my heart will go on

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

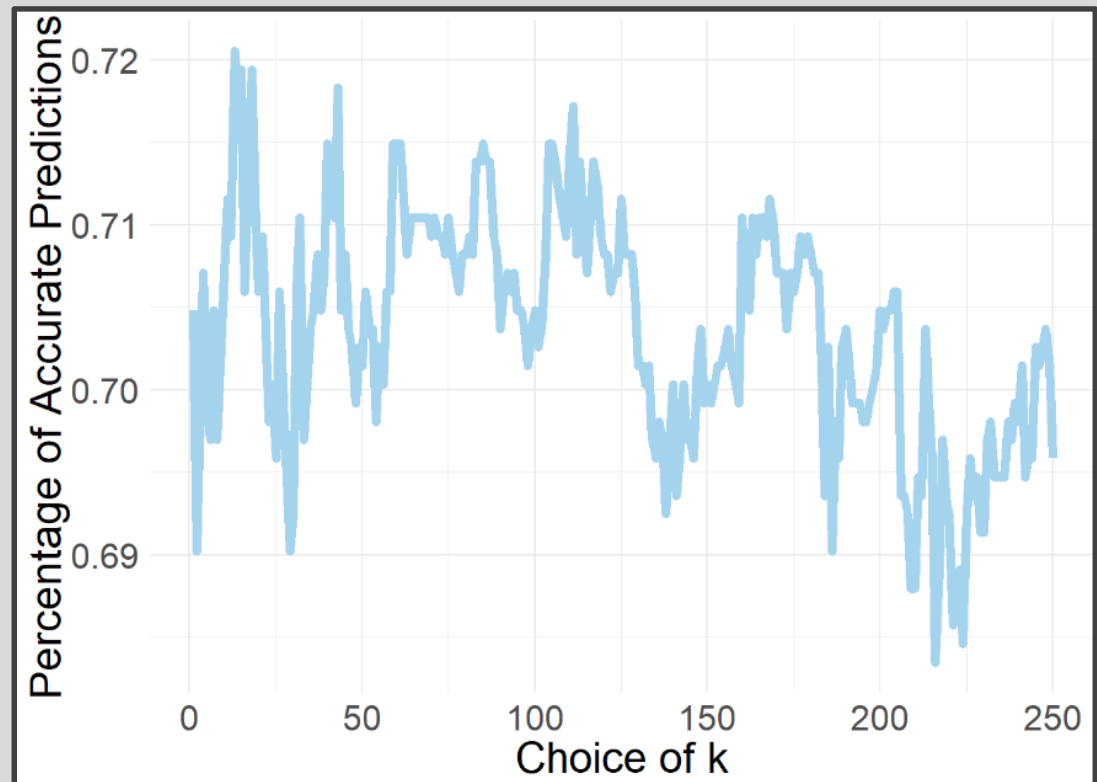
```
> library(class)
```
 - Install the R Package
 - Helpful Functions
 - Performing k-NN

```
> 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

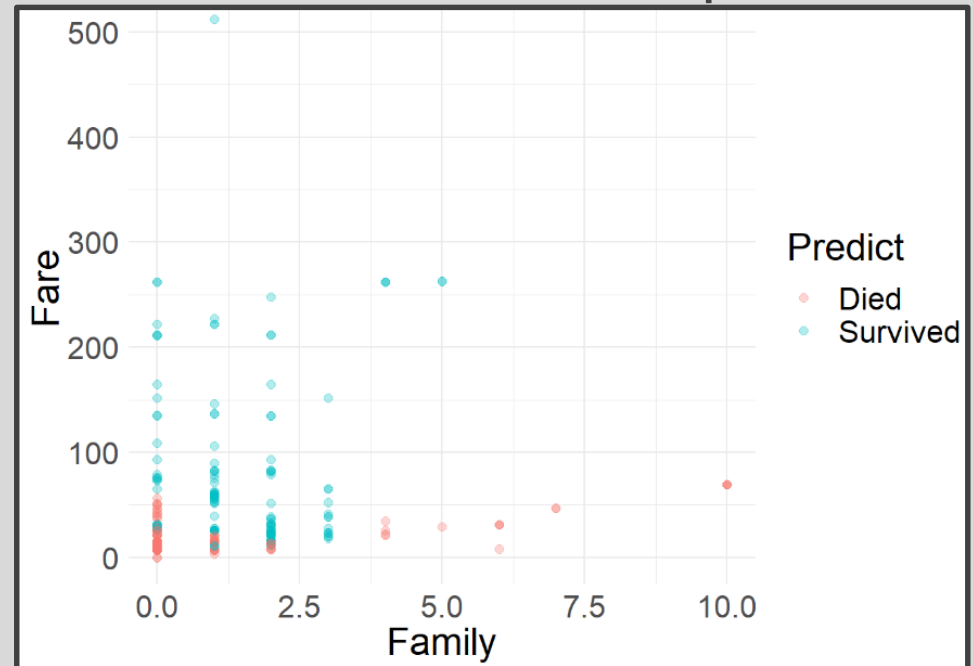
- Run Chunk 2
 - Consider $k=1,2,3,\dots,250$
 - Use CV, to Generate Out-of-Sample Predictions for Each k
 - Calculate Overall Accuracy Percentage



Part 4: Tuning k for k-NN



- ```
> titanic_test
```



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



Closing



Disperse  
and Make  
Reasonable  
Decisions