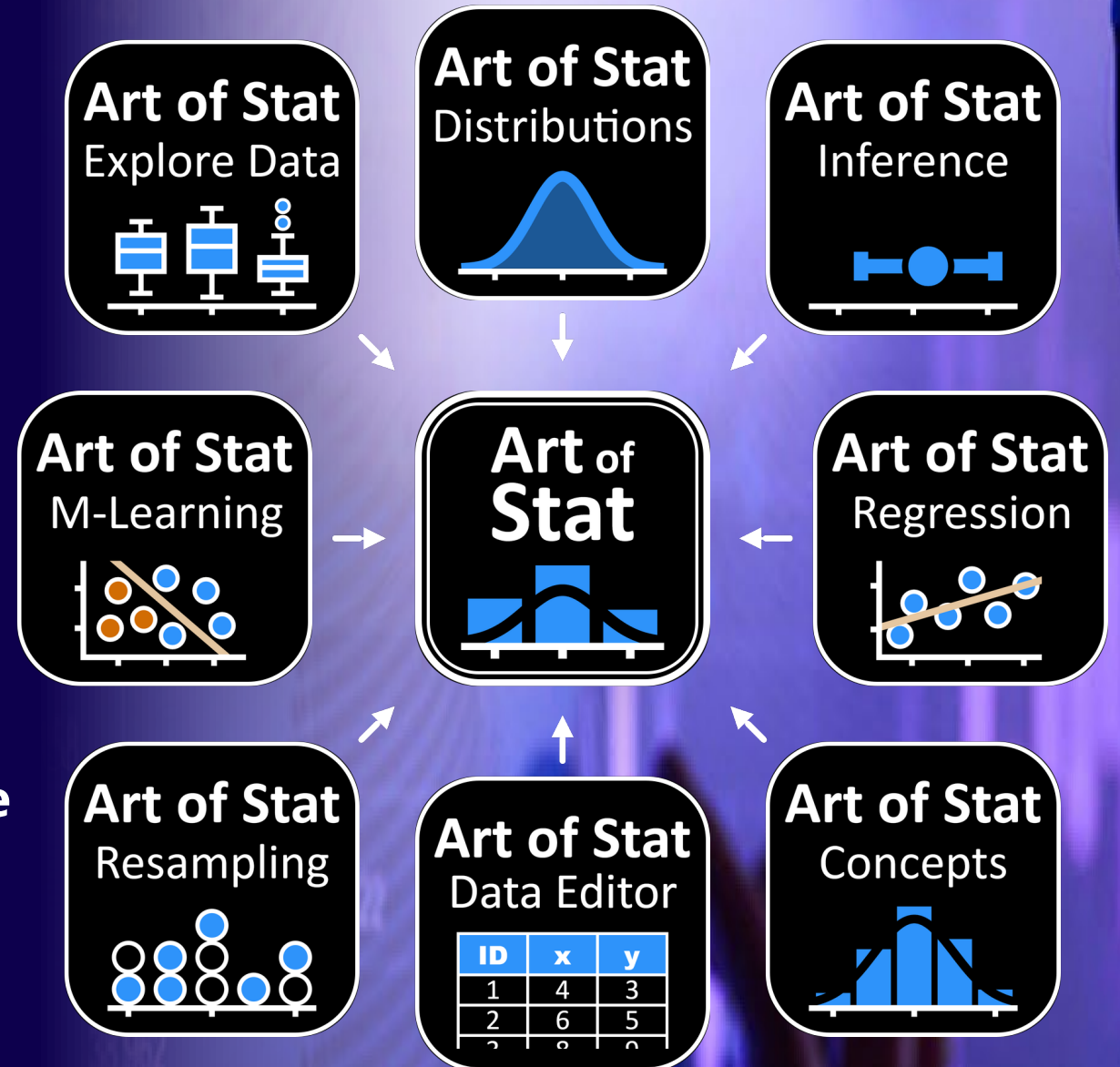


Mobile App for Teaching & Learning Statistics

Bernhard Klingenberg
Director, Masters in Applied Data Science
New College Florida

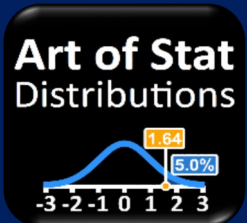
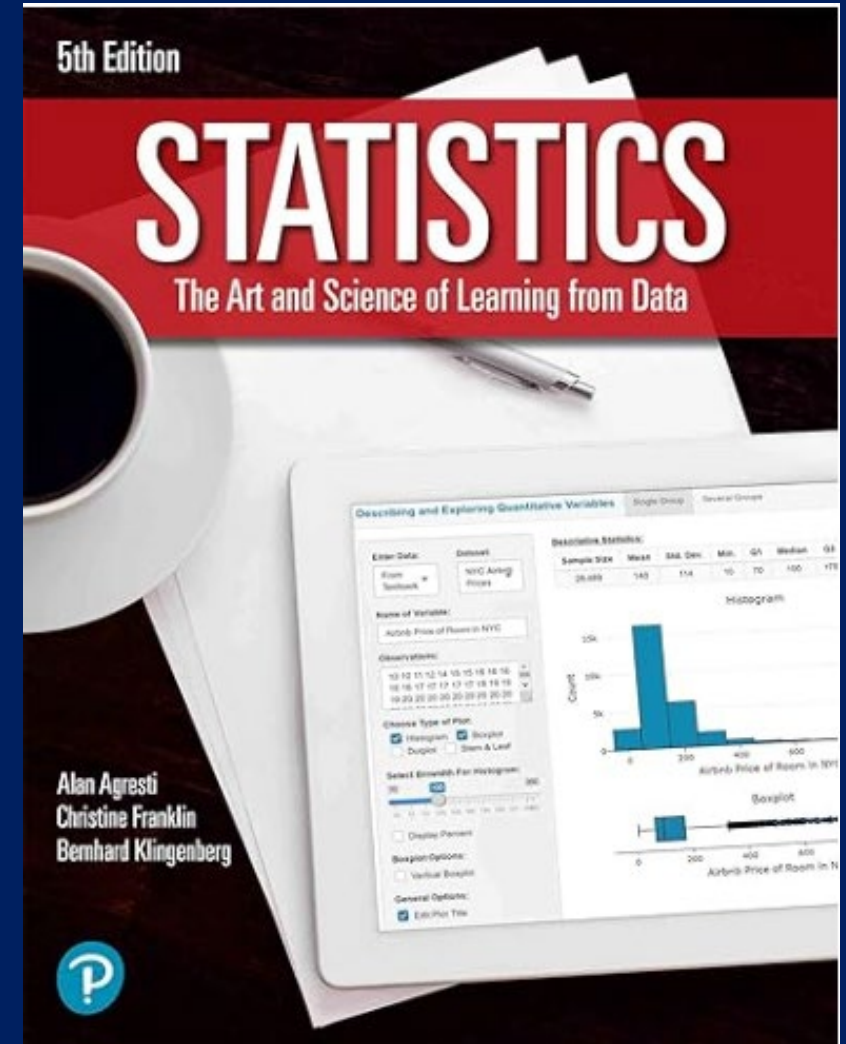
eCots 2026

Electronic Conference on Teaching Statistics

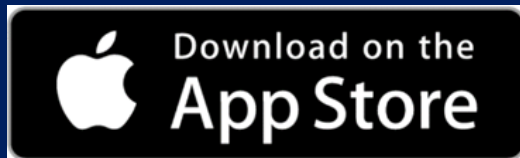


Introduction

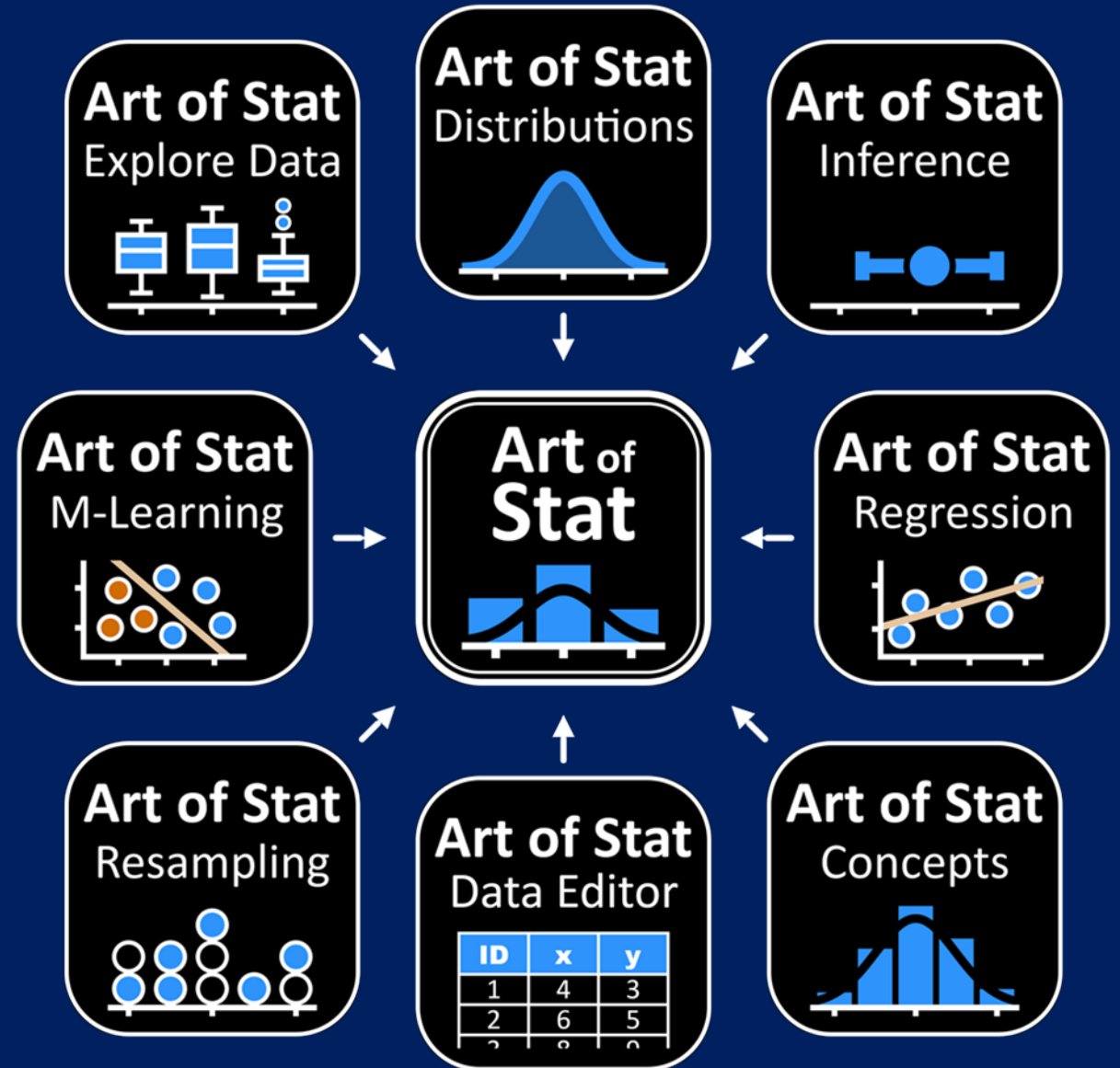
- Ph.D. in Statistics (@UF in 2004)
- Worked at Williams College for 18 years
- Research in Categorical Data Analysis, ML for Solar Flare identification
- Co-author of: “Statistics, the Art & Science of Learning from Data” (with Alan Agresti, Chris Franklin, Pearson 2021)
- Web- and Mobile Apps: “Art of Stat”

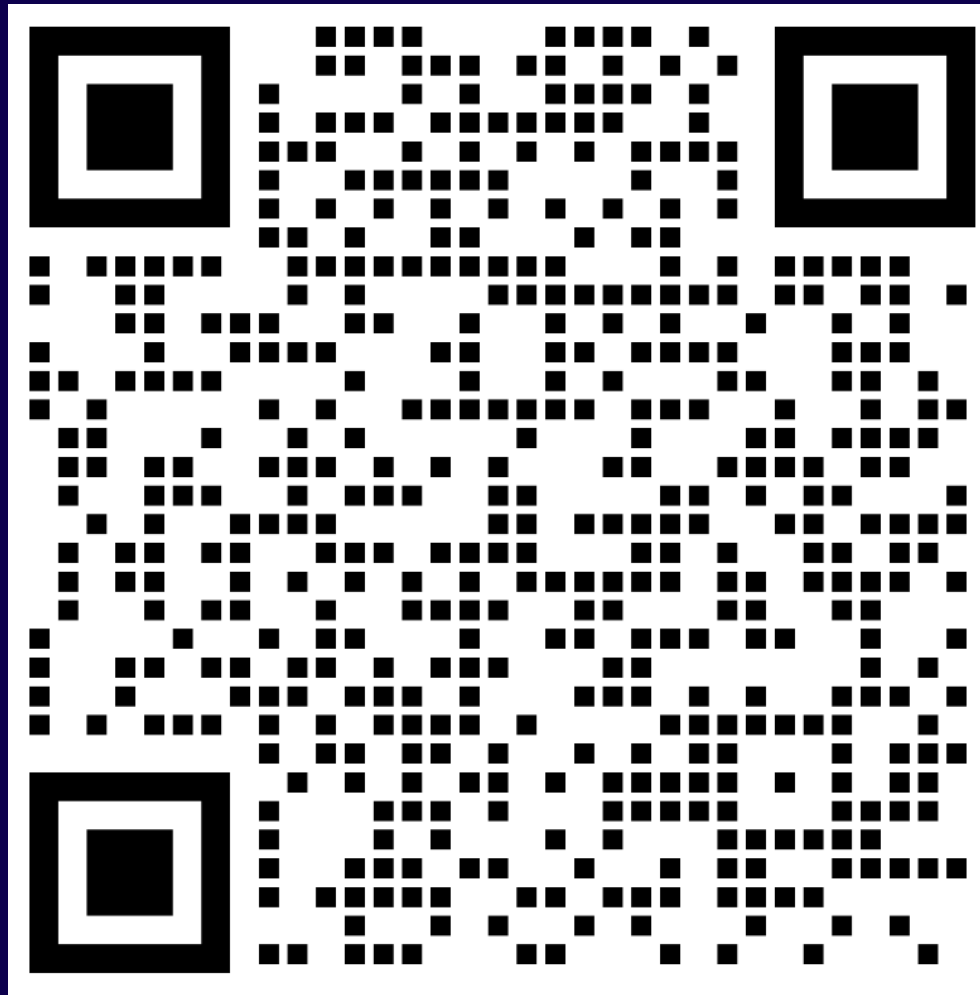


The All-in-One Art of Stat Mobile App



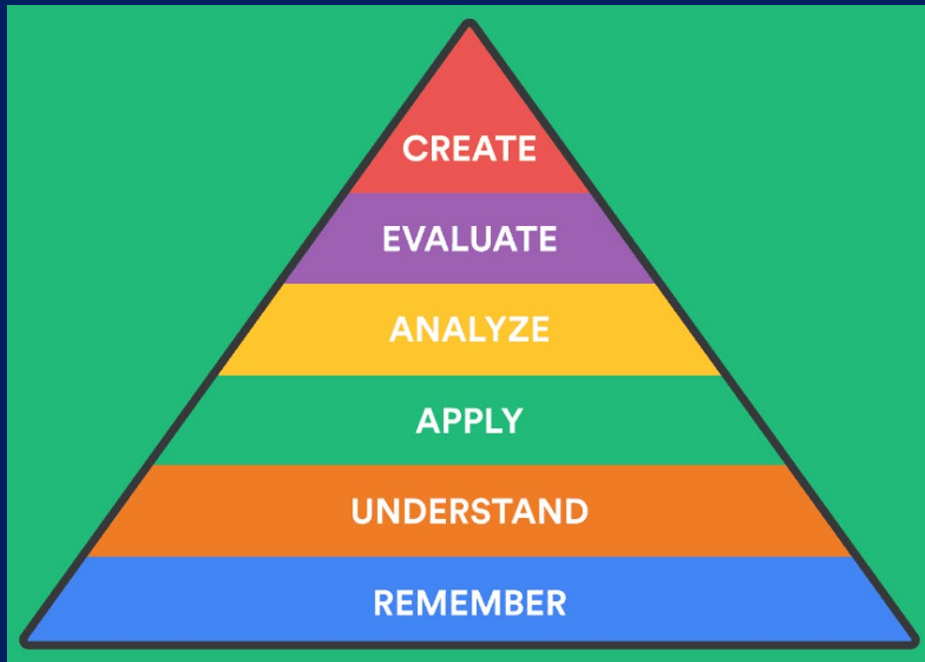
Contains 8 Modules







Why Teaching with Technology (Apps)?



Blooms Taxonomy of effective learning:

Move student from simple recall toward increasingly sophisticated forms of thinking

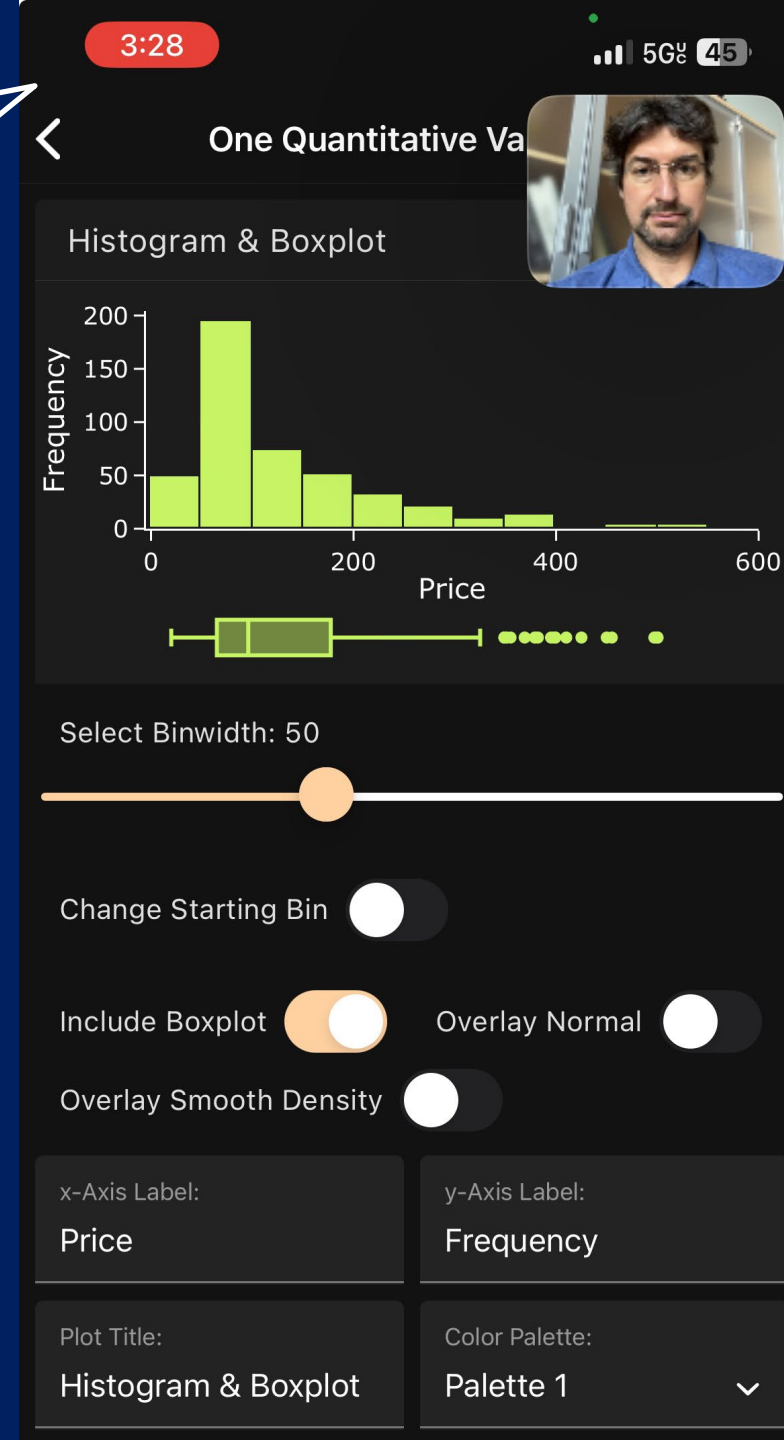
Methods & Concepts in Stats...

- are understood when you can “see” and interact with them.
- become memorable when you can apply them in an activity.
- stay relevant when you can analyze and create insights and knowledge using your own data.

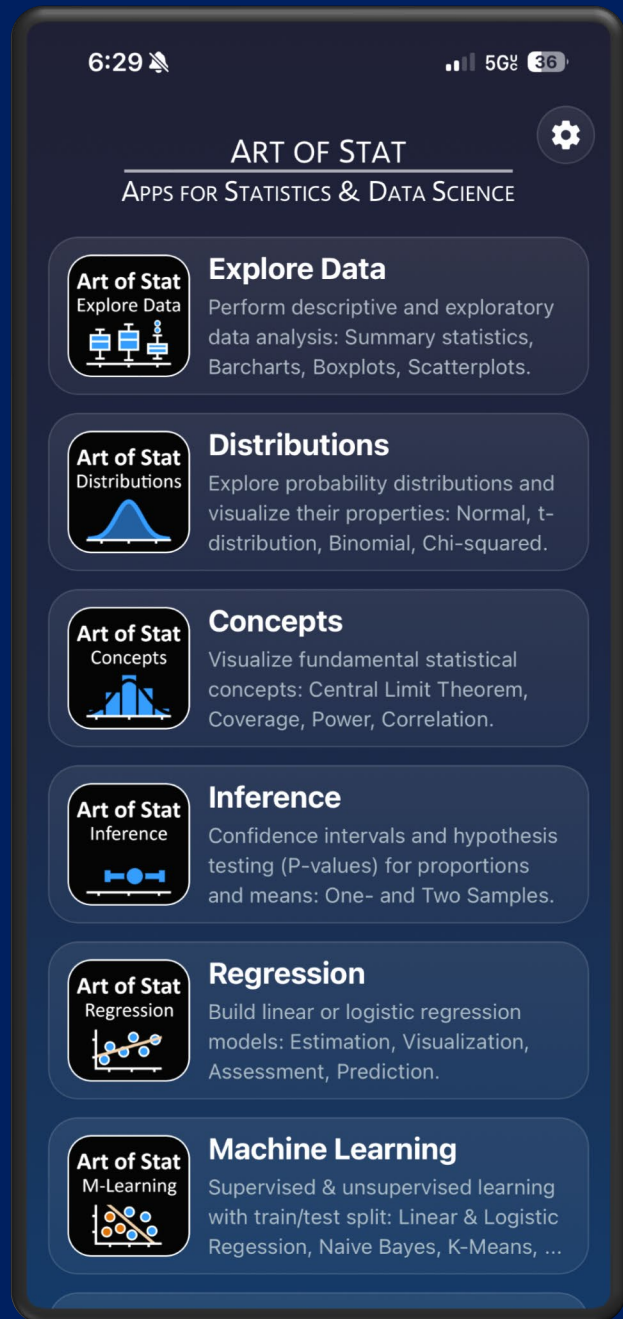
App Technology

Me in a Zoom call sharing my screen with the class

- Connect Phone/Tablet to Screen
- Share Screenshots, Join Zoom Calls
- Screen Recording (Videos)
- Upload your own data (.csv, .xls)
- Available 24/7, no lab needed
- Work Off-Line (Airplane Mode)

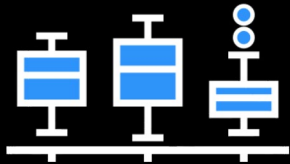


Overview of Modules



Art of Stat

Explore Data



Descriptive Statistics, Plots for Categorical and Quantitative Variables, Scatterplots

1:16 5G 49

ART OF STAT
Explore Data

Categorical Variables:

Barchart

Count

A B C

One Categorical Variable

Side-by-Side Barchart

Percent (%)

Group 1 Group 2

Compare Groups on Categorical Variable

Stacked Barchart

Row 1 Row 2 Row 3

Col 1 Col 2 Col 3

Percent (%)

Relationship Between Two Categorical Variables

Quantitative Variables:

Histogram & Boxplot

Count

Score

One Quantitative Variable

Side-by-Side Boxplots

Score

Group 1 Group 2 Group 3

Compare Groups on Quantitative Variable

ENTER DATA COMPUTE PROPORTIONS BAR CHART

1:17 5G 48

Compare Groups: Categorical Response

Bar Chart of Conditional Distribution: Food, given Sex

Food

Invertebrate Fish Other Reptile Bird

Percent (%)

Male Female

Sex

Stacked Horizontal Labels

x-Axis Label: Sex

y-Axis Label: Percent (%)

Legend Title: Food

Color Palette: Palette 1

Plot Title: Bar Chart of Conditional Distribution: Food,

ENTER DATA COMPUTE PROPORTIONS BAR CHART

1:18 5G 48

One Quantitative Variable

Histogram & Boxplot

Frequency

Self Esteem Appearance

Select Binwidth: 0.5

Change Starting Bin Lower Bound: 1.5

Include Boxplot Overlay Normal

Overlay Smooth Density

x-Axis Label: Self Esteem

y-Axis Label: Frequency

Plot Title: Histogram & Boxplot

Color Palette: Palette 1

ENTER DATA DESCRIPTIVE STATISTICS HISTOGRAM BOXPLOT

Art of Stat Distributions

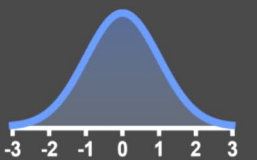



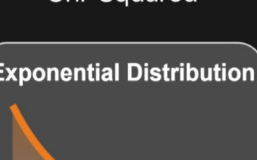
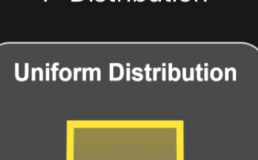
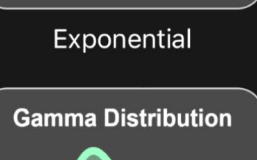
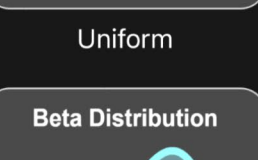


Explore & Visualize Discrete and Continuous Probability Distributions

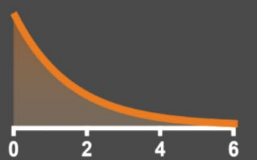
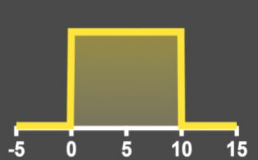


1:27 5G 46

ART OF STAT Distributions



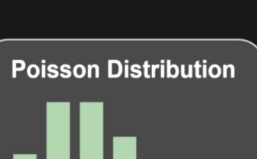
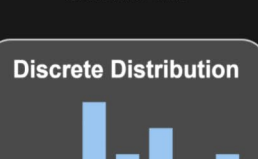
Continuous Distributions:

- Normal Distribution:  Normal
- Student t-Distribution:  t-Distribution
- Chi-Squared Distribution:  Chi-Squared
- F-Distribution:  F-Distribution
- Exponential Distribution:  Exponential
- Uniform Distribution:  Uniform
- Gamma Distribution:  Gamma
- Beta Distribution:  Beta

1:28 5G 46

- Exponential Distribution:  Exponential
- Uniform Distribution:  Uniform
- Gamma Distribution:  Gamma
- Beta Distribution:  Beta

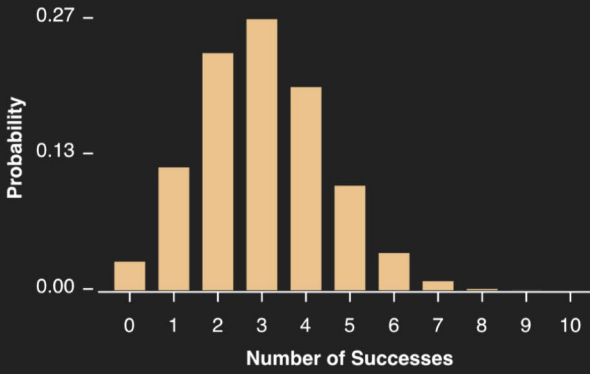
Discrete Distributions:

- Binomial Distribution:  Binomial
- Geometric Distribution:  Geometric
- Poisson Distribution:  Poisson
- Discrete Distribution:  Discrete

1:28 5G 46

The Binomial Distribution

Graph of Distribution: $n = 10, p = 0.3$



Mean: 3, Standard Deviation: 1.449

Number of Bernoulli Trials (n): 10

Probability of Success (p): 0.3

Enter Value for n Enter Value for p

Table of Binomial Probabilities ($n = 10, p = 0.3$)

x	$P(X = x)$	$P(X \leq x)$	$P(X \geq x)$
1	0.0282	0.0282	0.9718
2	0.1209	0.1491	0.8509
3	0.2709	0.4200	0.5790
4	0.3770	0.7970	0.2030
5	0.3770	0.9718	0.0282
6	0.2709	1.0000	0.0000
7	0.1209	1.0000	0.0000

EXPLORE DISTRIBUTION FIND PROBABILITY SIMULATE NUMBERS

Art of Stat Inference



Confidence Intervals, Hypothesis Tests for one, two & paired samples. Inference for Linear Regression

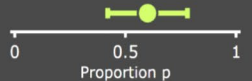
1:36 5G 44%

ART OF STAT Inference

Inference About Proportions:

Single Population Proportion

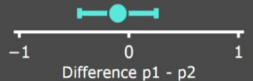
95% Confidence Interval



Proportion p

Difference of Two Population Proportions

95% Confidence Interval

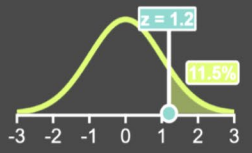


Difference $p_1 - p_2$

Inference for a Population Proportion (One Sample)

Compare Two Population Proportions (Independent Samples)

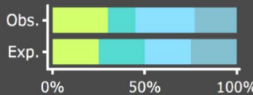
McNemar's Test & CI



$z = 1.2$
11.5%

Chi-Square Test (Goodness of Fit)

Stacked Bar Chart



Obs. -
Exp. -


0% 50% 100%

Compare Two Population Proportions (Dependent Samples)

Chi-Square Test (Goodness of Fit)

Chi-Square Test (Independence/Homogeneity)

Group 1 -
Group 2 -
Group 3 -



0% 50% 100%

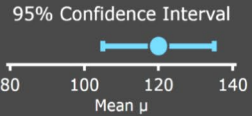
Chi-Square Test (Independence or Homogeneity)

1:36 5G 44%

Inference About Means:

Single Population Mean


95% Confidence Interval



Mean μ

Difference of Two Population Means

95% Confidence Interval

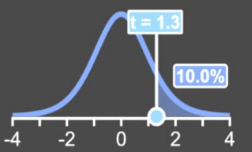


Difference $\mu_1 - \mu_2$

Inference for a Population Mean (One Sample)

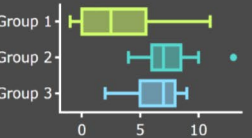
Compare Two Population Means (Independent Samples)

Paired t-Test & CI



$t = 1.3$
10.0%

One-Way ANOVA



Group 1 -
Group 2 -
Group 3 -

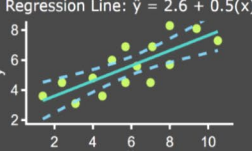
Compare Two Population Means (Dependent Samples)

One-Way ANOVA

Inference in Linear Regression:

Linear Regression

Regression Line: $\hat{y} = 2.6 + 0.5(x)$



y
 x

Inference in Linear Regression

1:37 5G 43%

Inference for Two Means

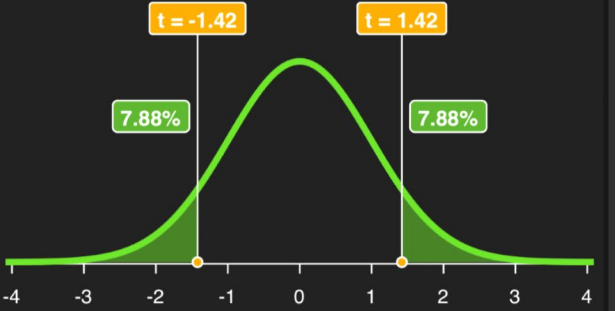
Two-Sided

Hypothesis Test for the Difference $\mu_1 - \mu_2$ Between Two Population Means:

Null Hypothesis	$H_0: \mu_1 - \mu_2 = 0$
Alternative Hypothesis	$H_a: \mu_1 - \mu_2 \neq 0$
Difference Between the Two Sample Means ($\bar{x}_1 - \bar{x}_2$)	0.24
Standard Error (se) of the Difference	0.17
Test Statistic (t , $df = 136.6$)	1.42
P-value	0.1577

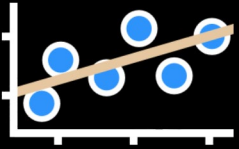
μ_1 and μ_2 are population means for groups Male and Female, respectively.

t-Distribution with $df = 136.6$
Test Statistic: $t = 1.42$, P-value = 0.1577



ENTER DATA CONFIDENCE INTERVAL HYPOTHESIS TEST

Art of Stat Regression



Simple
Linear,
Poisson,
Exponential &
Logistic
Regression.

Multiple
Linear &
Logistic
Regression

2:51 📶 🔋 24

ART OF STAT
Regression

Simple Regression (One Predictor)

Linear Regression

$\hat{y} = 5.2 + 0.23(x)$

Longevity

Gestation

Exponential Regression

$\hat{y} = 4.9 * 1.52^{(x)}$

Population

Days

Logistic Regression

$\hat{y} = 1 / (1 + \exp(7.1 - 0.23x))$

P(Card)

Income

Poisson Regression

$\hat{y} = \exp(0.9 + 1.2x)$

Count

x

Multiple Regression (Several Predictors)

Multiple Linear Regression

x2

y

x1

x2

Multiple Logistic Regression

Prob

x

Multiple Linear

Multiple Logistic

2:01 📶 5G 🔋 40

Simple Linear Regression

Scatterplot

Regression Line: $\hat{y} = 5.11 + 0.2286 * x$

Longevity (yrs)

Gestation (days)

Bobcat

Show Linear Regression Line

Show Residuals

Confidence Band for Mean

Prediction Band for New Response

Confidence Level: 95% − + Confidence & prediction intervals available on 3rd tab.

Show Smooth Trend Line

x-Axis Label: Gestation (days)

y-Axis Label: Longevity (yrs)

ENTER DATA SCATTERPLOT AND REGRESSION MODEL FITTED VALUES AND RESIDUALS

2:03 📶 5G 🔋 39

Multiple Linear Regression

Scatterplot

Species: — Adelie — Chinstrap — Gentoo

Bill Depth (mm)

Bill Length (mm)

Color Points Regression Line

Fitted Regression Model:

Predicted Bill Depth (mm) = 10.5922
 − 1.9332 * I(Species = Chinstrap)
 − 5.1060 * I(Species = Gentoo)
 + 0.19989 * Bill Length (mm)

Estimated Regression Parameters:

	Estimate	Standard Error
Intercept	10.5922	0.6830
Species (Chinstrap)	−1.9332	0.2242

ENTER DATA FITTED MODEL AND PLOTS FITTED VALUES AND RESIDUALS

Art of Stat Concepts



Central Limit Theorem, Correlation, Regression, Coverage & Power

2:09 ART OF STAT Concepts

Central Limit Theorem

Distribution of the Sample Mean \bar{x}

CLT for Means

Distribution of the Sample Proportion \hat{p}

CLT for Proportions

Correlation and Regression

Guess Correlation

Explore Correlation

Explore Regression

Explore Regression

Coverage, Errors and Power

Explore Coverage

Explore Coverage of

Errors and Power

Explore Type I & II

2:10 CLT for Means

Population Distribution: $\mu = 36,844$, $\sigma = 17,139$

Cost of Attendance (\$)

Distribution of Sample: $n = 25$, $\bar{x} = 39,730$, $s = 14,465$

Cost of Attendance (\$)

Sampling Distribution of \bar{x} (2904 Simulations)
Mean = 36,865, Std. Dev. = 3,358

Sample Mean (\bar{x})

Sample Size n: 25

Draw 1 Sample

Draw 100 Samples

Reset

Normal Distribution Zoom In

POPULATION DISTRIBUTION DRAW SAMPLES SAMPLING DISTRIBUTION

2:11 Errors & Power

Null Value (p_0): 0.4

True Pop. Proportion (p): 0.6

Testing: $H_0: p = 0.4$ vs. $H_a: p > 0.4$

Sampling Distribution of \hat{p}

Null: $P(\text{Type I}) = 5\%$ Alternative: $P(\text{Type II}) = 10.7\%$

Sample Size n: 50

Significance Level α : 5%

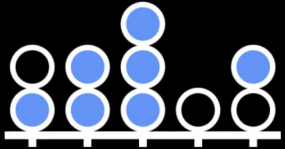
Type I Type II Power

Alternative Hypothesis: Larger

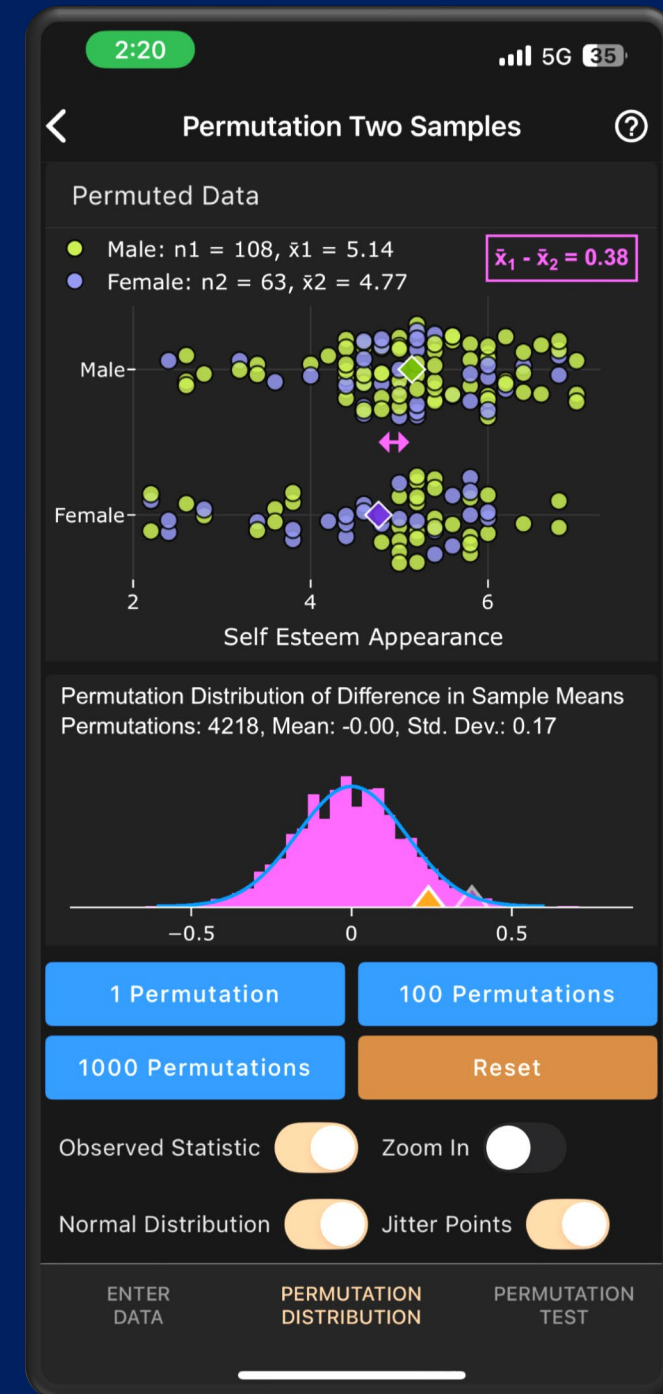
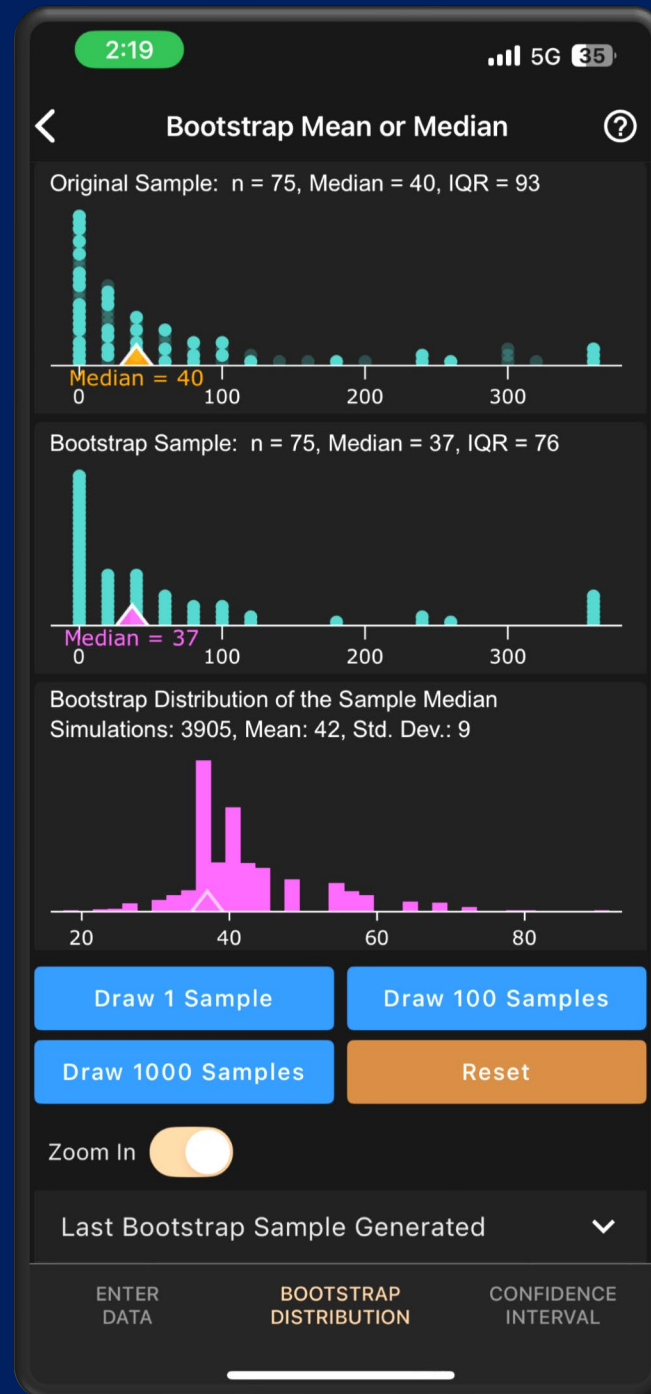
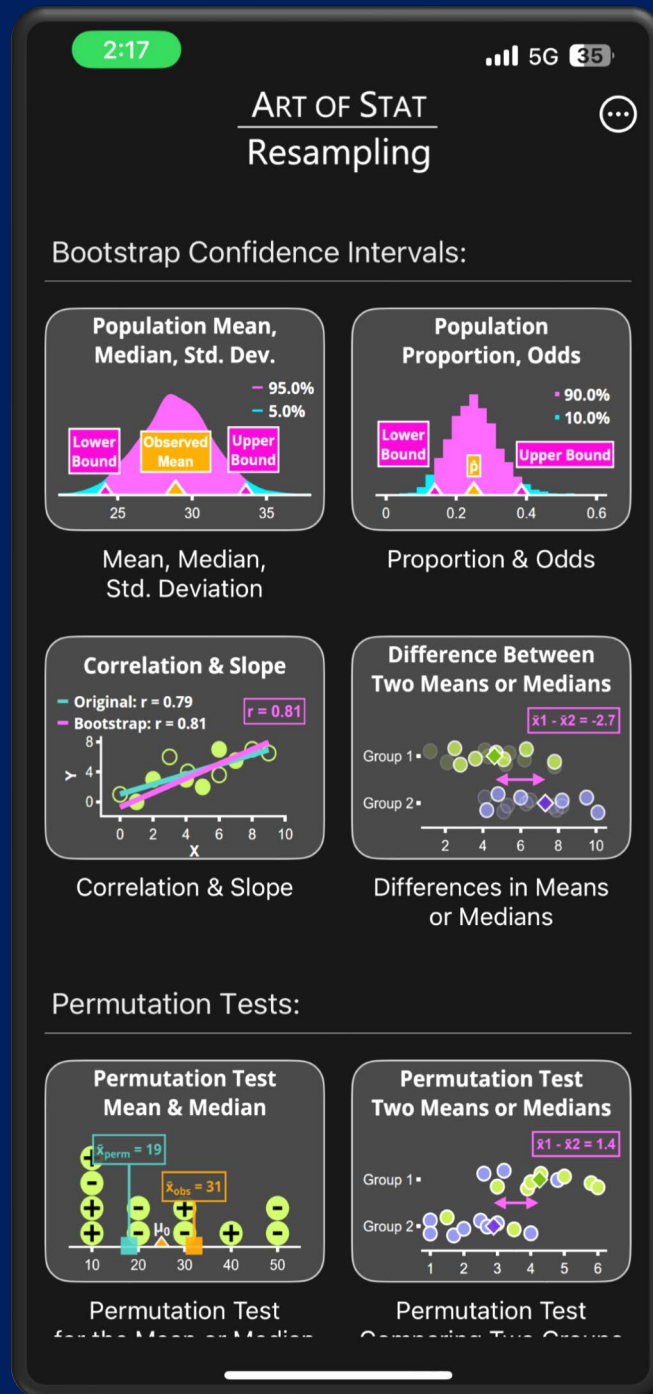
Color Palette: Palette 1

TEST FOR A PROPORTION TEST FOR A MEAN

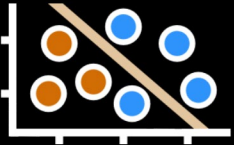
Art of Stat Resampling



Bootstrap Confidence Intervals.
Permutation Tests.
For One & Two Samples.
Chi-Squared Test.



Art of Stat M-Learning



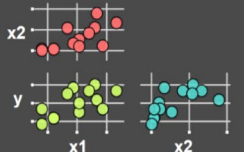
Classical Methods for Supervised & Unsupervised Learning

4:26 5G% 64

ART OF STAT
Machine Learning

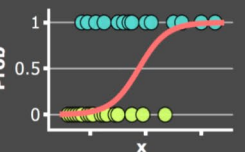
Supervised Learning

Linear Regression



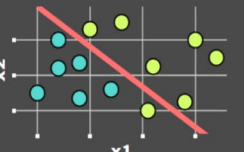
Multiple Linear Regression

Logistic Regression




Multiple Logistic Regression

Linear LDA




Linear Discriminant Analysis

Quadratic LDA



Quadratic Discriminant Analysis

Naive Bayes



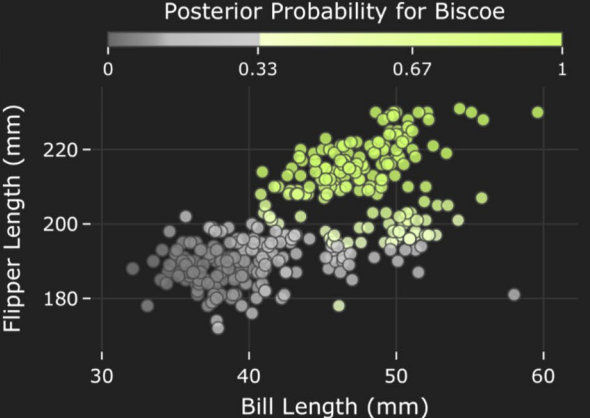
Naive Bayes Classifier

ENTER DATA PLOTS AND CLASSIFICATIONS ACCURACY & PREDICTIONS

3:03 60

Naive Bayes

Plot of Training Data (Observed Labels)



Flipper Length (mm)

Bill Length (mm)

Posterior Probability for Biscoe

Jitter Points Plot Test Data

Predicted Labels

Posterior Probabilities

Class: Biscoe

Uniform Color Scale

Heatmap (Biscoe)

Heatmap of Posterior Probabilities

Class Means Normal Contours

Prior Class Probabilities:

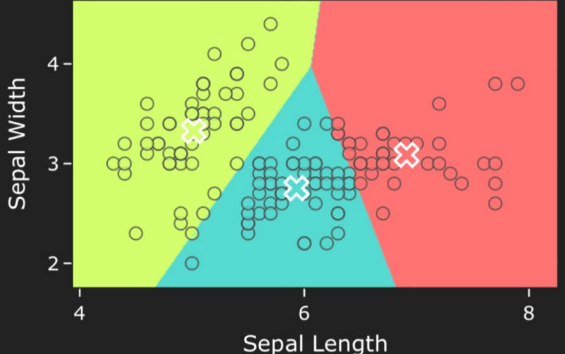
ENTER DATA PLOTS AND CLASSIFICATIONS ACCURACY & PREDICTIONS

3:05 60

K-Means Clustering

Scatterplot (K = 3 Clusters)

Cluster 1 Cluster 2 Cluster 3



Sepal Width

Sepal Length

Number of Clusters: 3

Run Automatically

Reset

Update Centroids

Update Assignments

Show Centroids Show Test Data

Heatmap of Cluster Regions

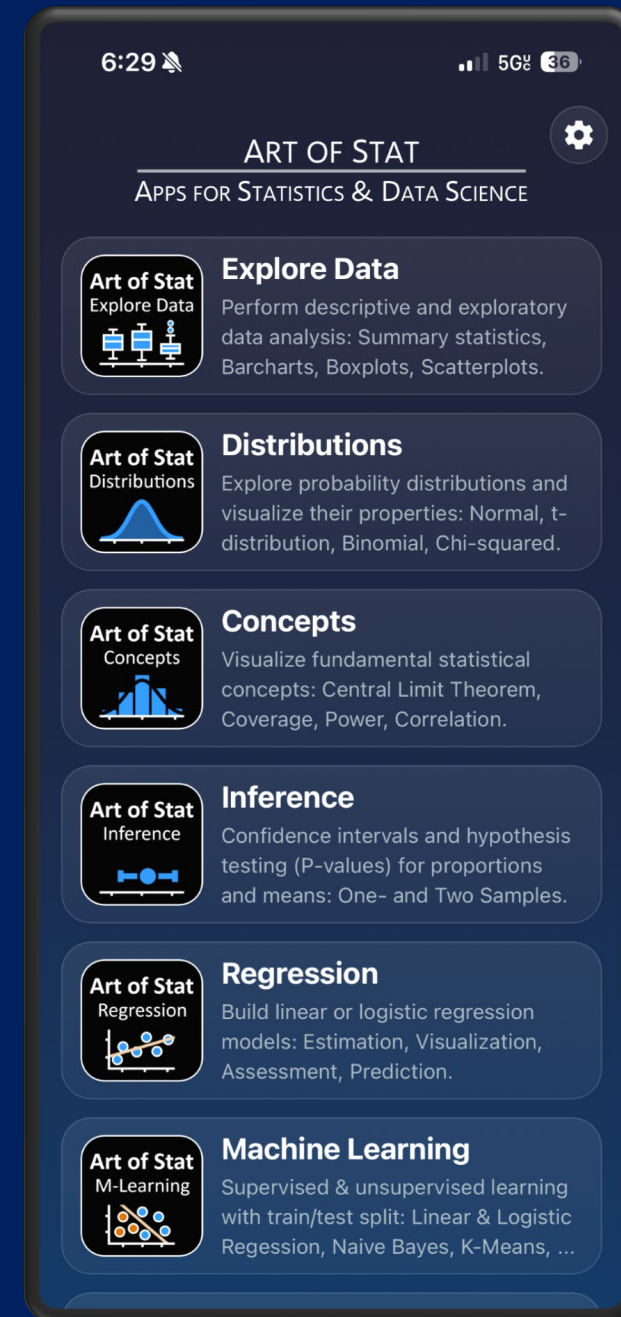
Find Best Possible Clusterings for K = 1 to 10

Show SSD Show Scree Plot

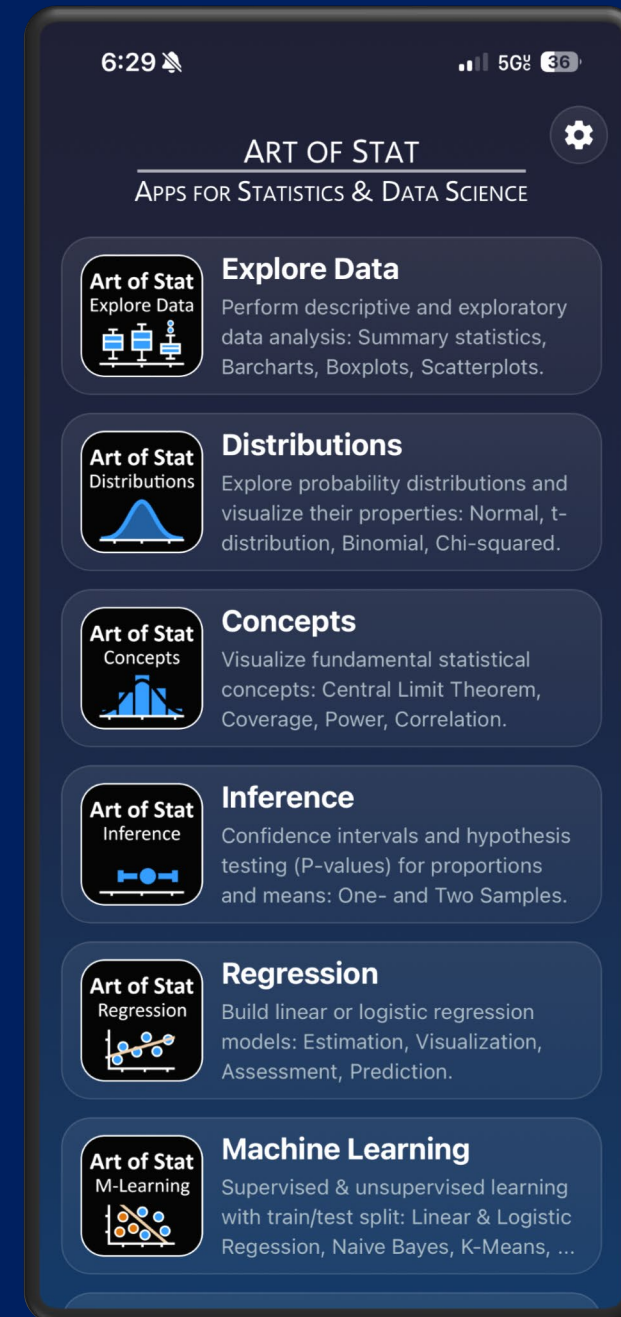
Cluster Summary Statistics

ENTER DATA CLUSTERING & VISUALIZATION ANALYSIS & PREDICTION

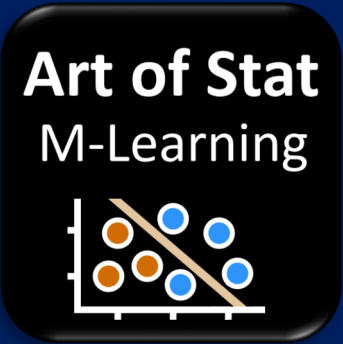
Is there
anything you
want to see?
(Go Live)



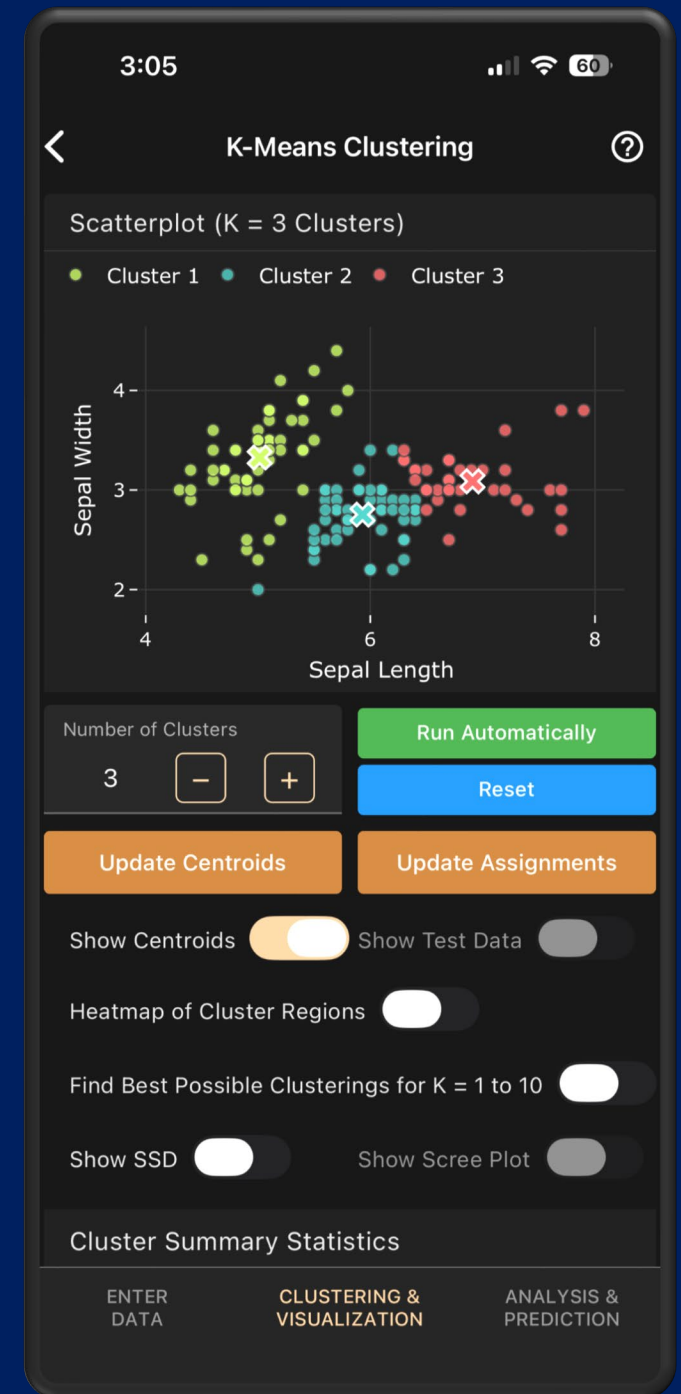
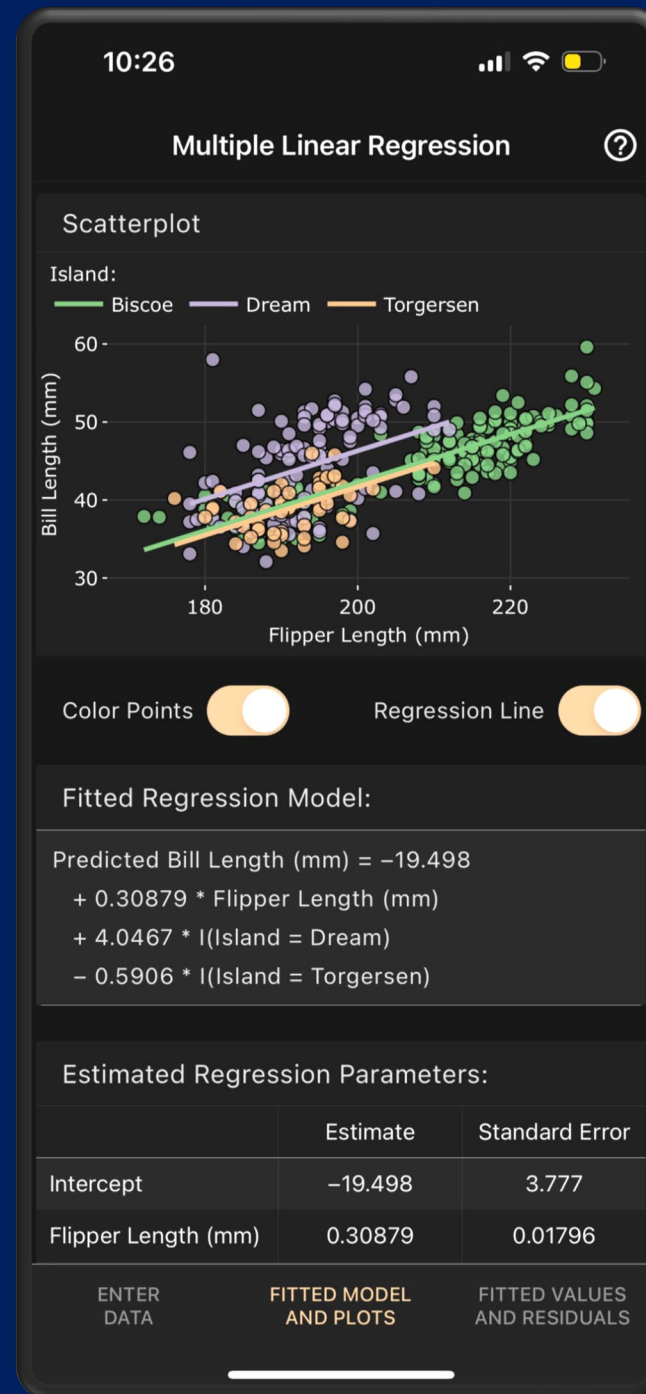
Run-Through of the Naïve Bayes App



Art of Stat: Machine Learning



- **Supervised Learning**
 - Regression (Linear, Logistic)
 - Discriminant Analysis
 - Naïve Bayes
 - K-Nearest Neighbors
 - Trees, Random Forests
- **Unsupervised Learning**
 - K-Means Clustering



6:29

5G% 65

ART OF STAT



APPS FOR STATISTICS & DATA SCIENCE



Explore Data

Perform descriptive and exploratory data analysis: Summary statistics, Barcharts, Boxplots, Scatterplots.



Distributions

Explore probability distributions and visualize their properties: Normal, t-distribution, Binomial, Chi-squared.



Concepts

Visualize fundamental statistical concepts: Central Limit Theorem, Coverage, Power, Correlation.



Inference

Confidence intervals and hypothesis testing (P-values) for proportions and means: One- and Two Samples.



Regression

Build linear or logistic regression models: Estimation, Visualization, Assessment, Prediction.



Machine Learning

Supervised & unsupervised learning with train/test split: Linear & Logistic Regression, Naive Bayes, K-Means, ...

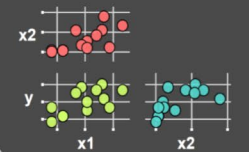
4:26

5G% 64

ART OF STAT Machine Learning

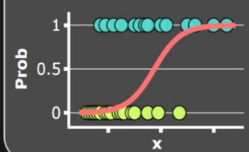
Supervised Learning

Linear Regression



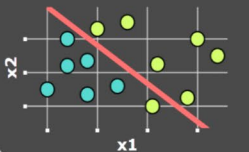
Multiple Linear Regression

Logistic Regression



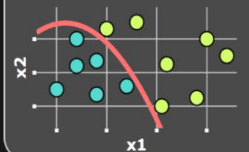
Multiple Logistic Regression

Linear LDA



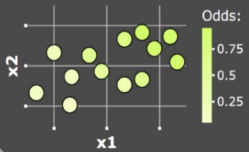
Linear Discriminant Analysis

Quadratic LDA



Quadratic Discriminant Analysis

Naive Bayes



Naive Bayes Classifier

5:10

5G% 61

Naive Bayes

Data Source:

Open Example Datasets

Choose from several example datasets. Then, select the response (=target) variable which provides the labels and the explanatory variables (=features) you want to include in the naive bayes classification.

Select Dataset:

Palmer Penguins

Penguin	Species	Island	Bill Length (mm)
1	Adelie	Torgersen	39.1
2	Adelie	Torgersen	39.5
3	Adelie	Torgersen	40.3
4	Adelie	Torgersen	36.7
5	Adelie	Torgersen	39.3

Showing all 342 rows, and all 8 columns (swipe left).

Response Variable (Class Labels):

Species

Two Features Selected:

Bill Length (mm)

Flipper Length (mm)

Split into Train and Test Data

ENTER DATA

PLOTS AND CLASSIFICATIONS

ACCURACY & PREDICTIONS

5:12

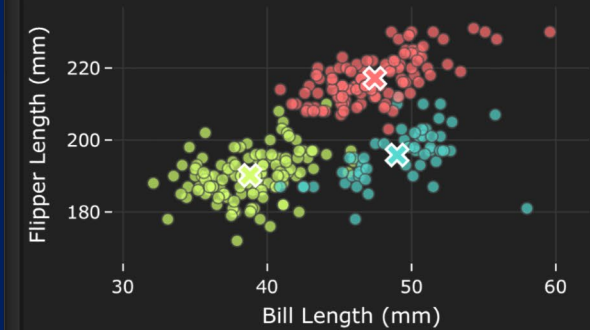
5G% 61

Naive Bayes

Plot of Training Data (Observed Labels)

Species:

Adelie Chinstrap Gentoo



Jitter Points



Plot Test Data



Predicted Labels



Posterior Probabilities



Heatmap of Posterior Probabilities



Class Means



Normal Contours



Prior Class Probabilities:

Species	Prior Probabilities
Adelie	43.8%
Chinstrap	19.3%

ENTER DATA

PLOTS AND CLASSIFICATIONS

ACCURACY & PREDICTIONS

Naïve Bayes

- Classification method, trying to predict class membership based on some features (supervised learning)
- Uses Bayes Theorem and “naïve” independence assumption about joint distribution of features x_1 and x_2
- Finds **Posterior Probability** for observation falling in class k :

$$\begin{aligned} P(\text{Class } k \mid x_1, x_2) &\propto P(x_1, x_2 \mid \text{Class } k) * P(\text{Class } k) \\ &= P(x_1 \mid \text{Class } k) * P(x_2 \mid \text{Class } k) * P(\text{Class } k) \end{aligned}$$

- Need **prior** class probabilities $P(\text{Class } k)$ and distribution of feature in a given class $P(x_1 \mid \text{Class } k)$
- Predicted class is the one with largest posterior probability

Example: Naïve Bayes

Tab 1:

- Load Data
- Select Target
- Select Predictors
- Train/Test Split
- Descriptive Stats

Naive Bayes

Data Source:
Open Example Datasets

Choose from several example datasets. Then, select the response (=target) variable which provides the labels and the explanatory variables (=features) you want to include in the naive bayes classification.

Select Dataset:
Palmer Penguins

Penguin	Species	Island	Bill Length (mm)
1	Adelie	Torgersen	39.1
2	Adelie	Torgersen	39.5
3	Adelie	Torgersen	40.3
4	Adelie	Torgersen	36.7
5	Adelie	Torgersen	39.3

Showing all 342 rows, and all 8 columns (swipe left).

Response Variable (Class Labels):
Species

Two Features Selected:

Bill Length (mm) Flipper Length (mm)

Split into Train and Test Data

ENTER DATA PLOTS AND CLASSIFICATIONS ACCURACY & PREDICTIONS

Pick a Data Source:

- Pre-Implemented Examples
- Upload your own CSV/Excel
- Data Editor

Pick the particular dataset

Scroll through the dataset

Pick target variable

Select Features:

- continuous
- categorical

Split into testing & training set

Tab 1

ENTER DATA

PLOTS AND CLASSIFICATIONS

ACCURACY & PREDICTIONS

Example: Naïve Bayes

Tab 1:

- Load Data
- Select Target
- Select Predictors
- **Train/Test Split**
- Descriptive Stats

Naive Bayes

Split into Train and Test Data

Percent Training Samples: 80%

Frequency Table of Labels (Training Data):

Species	Count	Percent
Adelie	120	43.8%
Chinstrap	53	19.3%
Gentoo	101	36.9%
Total	274	100.0%

Frequency Table of Labels (Test Data):

Species	Count	Percent
Adelie	31	45.6%
Chinstrap	15	22.1%
Gentoo	22	32.4%
Total	68	100.0%

Class Means & Standard Deviations for Continuous Features (Training Set):

Species	Sample Size	Mean x1	Std. Dev. x1

Generate 80/20 split by pressing button

See distribution of labels in training set

See distribution of labels in test set

Tab 1

ENTER DATA

PLOTS AND CLASSIFICATIONS

ACCURACY & PREDICTIONS

Example: Naïve Bayes

Tab 1:

- Load Data
- Select Target
- Select Predictors
- Train/Test Split
- Descriptive Stats

The screenshot shows the 'Naive Bayes' app interface. At the top, there is a title 'Naive Bayes' with a back arrow and a help icon. Below the title, the text reads 'Class Means & Standard Deviations for Continuous Features (Training Set):'. This is followed by a table with columns 'Species', 'Sample Size', 'Mean x1', and 'Std. Dev. x1'. The table contains three rows: 'Adelie' (Sample Size: 120, Mean: 38.8, Std. Dev.: 2.8), 'Chinstrap' (Sample Size: 53, Mean: 49.0, Std. Dev.: 3.3), and 'Gentoo' (Sample Size: 101, Mean: 47.4, Std. Dev.: 3.2). Below the table, it says 'x1 = Bill Length (mm), x2 = Flipper Length (mm)'. There is a toggle switch for 'Show Overall Descriptive Statistics' which is currently turned on. Below this, the text reads 'Descriptive Statistics of Features (Training Data):'. This is followed by another table with columns 'Bill Length (mm)' and 'Flipper Length (mm)'. The table contains seven rows: 'Sample Size (n)' (274, 274), 'Mean (\bar{x})' (44.0, 201.2), 'Standard Deviation (s)' (5.5, 14.0), 'Minimum' (32.1, 172.0), 'First Quartile (Q1)' (39.2, 190.0), and 'Median' (44.5, 197.0). At the bottom of the app, there are three tabs: 'ENTER DATA', 'PLOTS AND CLASSIFICATIONS', and 'ACCURACY & PREDICTIONS'. The 'ENTER DATA' tab is highlighted with a red box and a red callout bubble.

Species	Sample Size	Mean x1	Std. Dev. x1
Adelie	120	38.8	2.8
Chinstrap	53	49.0	3.3
Gentoo	101	47.4	3.2

x1 = Bill Length (mm), x2 = Flipper Length (mm)

Show Overall Descriptive Statistics

	Bill Length (mm)	Flipper Length (mm)
Sample Size (n)	274	274
Mean (\bar{x})	44.0	201.2
Standard Deviation (s)	5.5	14.0
Minimum	32.1	172.0
First Quartile (Q1)	39.2	190.0
Median	44.5	197.0

ENTER DATA | PLOTS AND CLASSIFICATIONS | ACCURACY & PREDICTIONS

Mean and standard deviation for each continuous predictor, stratified by label.

If we had categorical predictors (e.g., Sex or Island), app would show distribution of categories for each label.

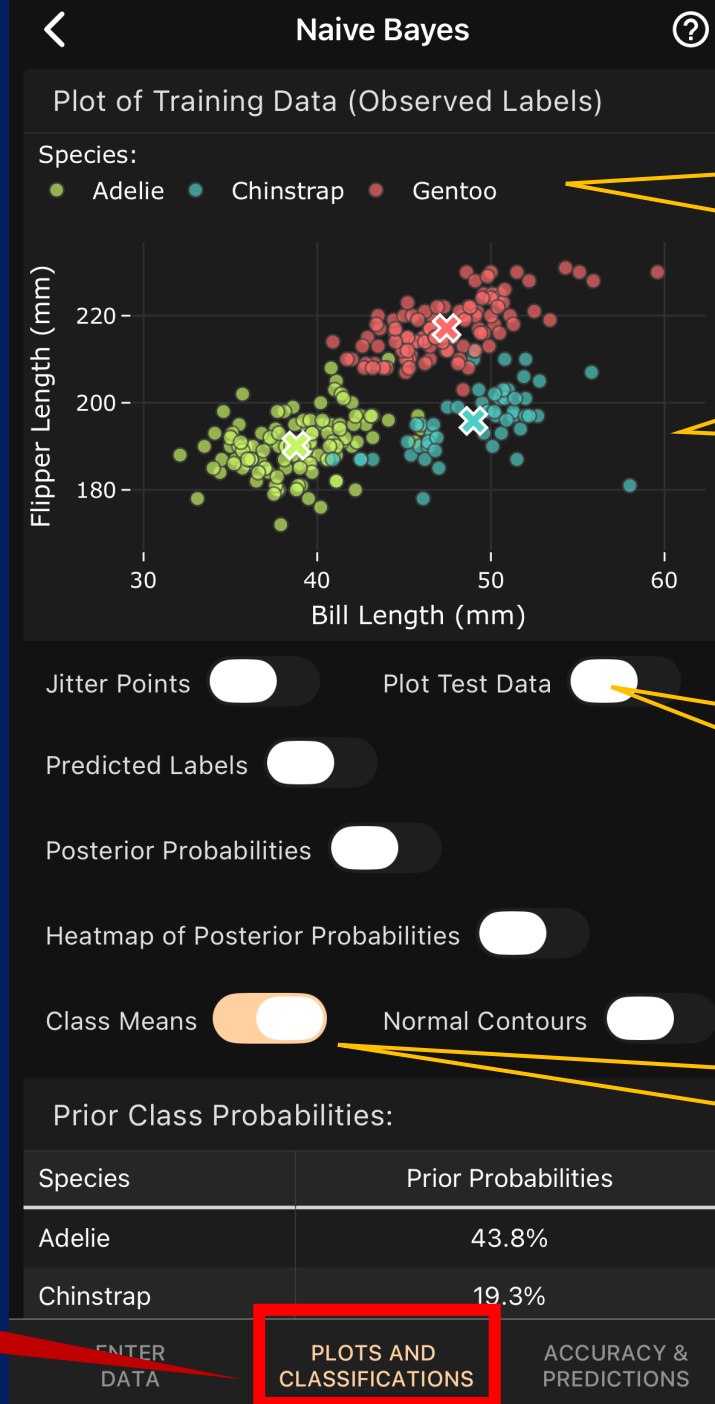
See descriptive stats for each continuous predictor (not stratified)

Tab 1

Example: Naïve Bayes

Tab 2:

- Scatterplot
- Class Means
- Posterior Odds
- Predictions
- Heatmap
- Contours



Different target labels are represented by different colors (plot interactive)

Scatterplot with the two features on the x - and y-axis

Request to plot test data instead of training data

Show the mean for each target label

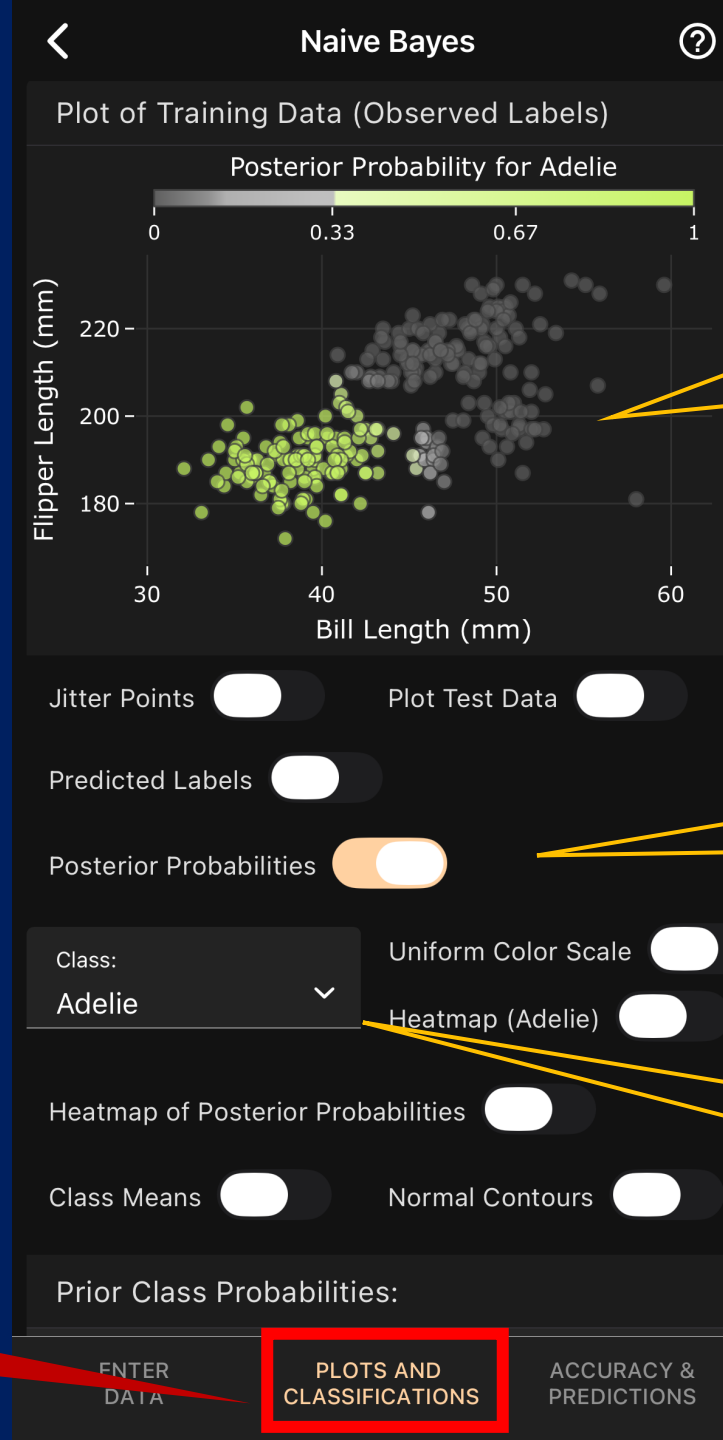
Tab 2

PLOTS AND CLASSIFICATIONS

Example: Naïve Bayes

Tab 2:

- Scatterplot
- Class Means
- **Posterior Odds**
- Predictions
- Heatmap
- Contours



Dots colored by their posterior probability of belonging to species "Adelie"

Request to show posterior odds of class membership

Select which class you want to show posterior odds for

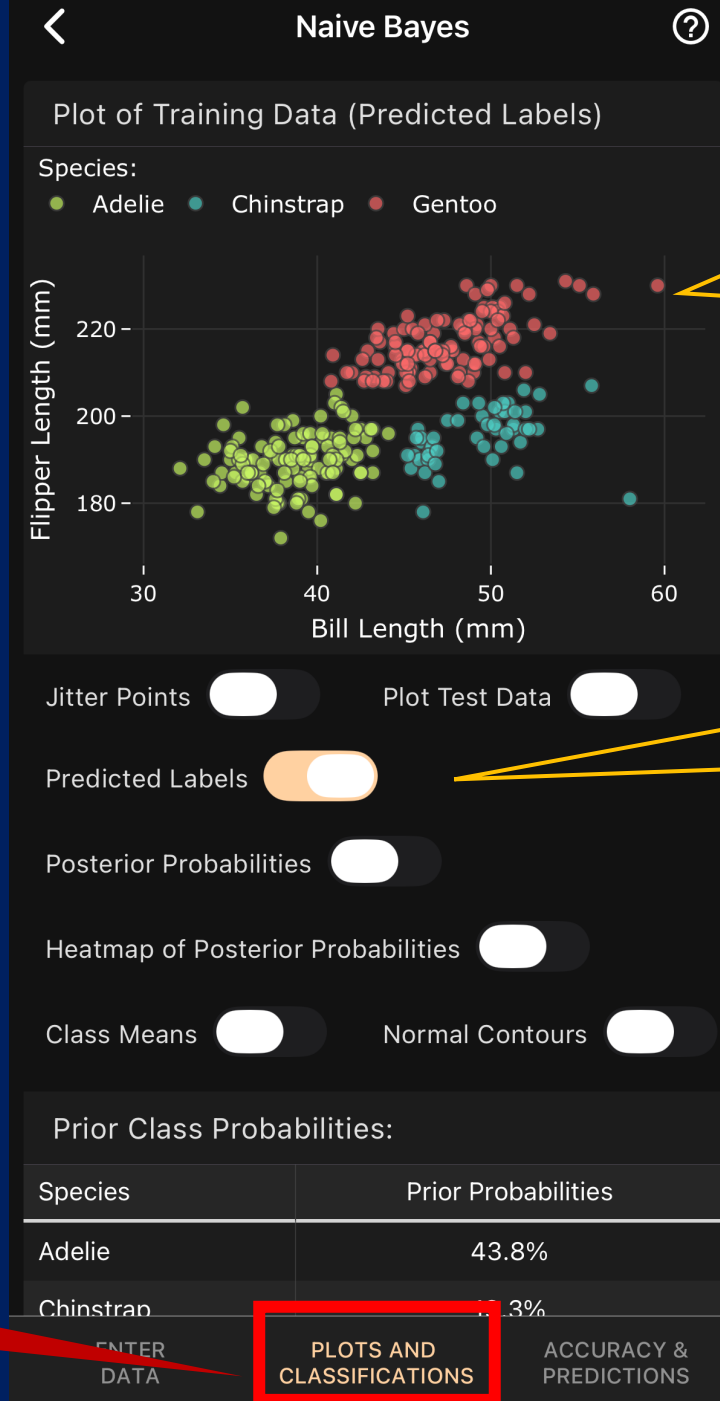
Tab 2

PLOTS AND CLASSIFICATIONS

Example: Naïve Bayes

Tab 2:

- Scatterplot
- Class Means
- Posterior Odds
- Predictions
- Heatmap
- Contours



Scatterplot with points colored by predicted label (training set)

Switch to show the predicted label, based on maximum posterior odds

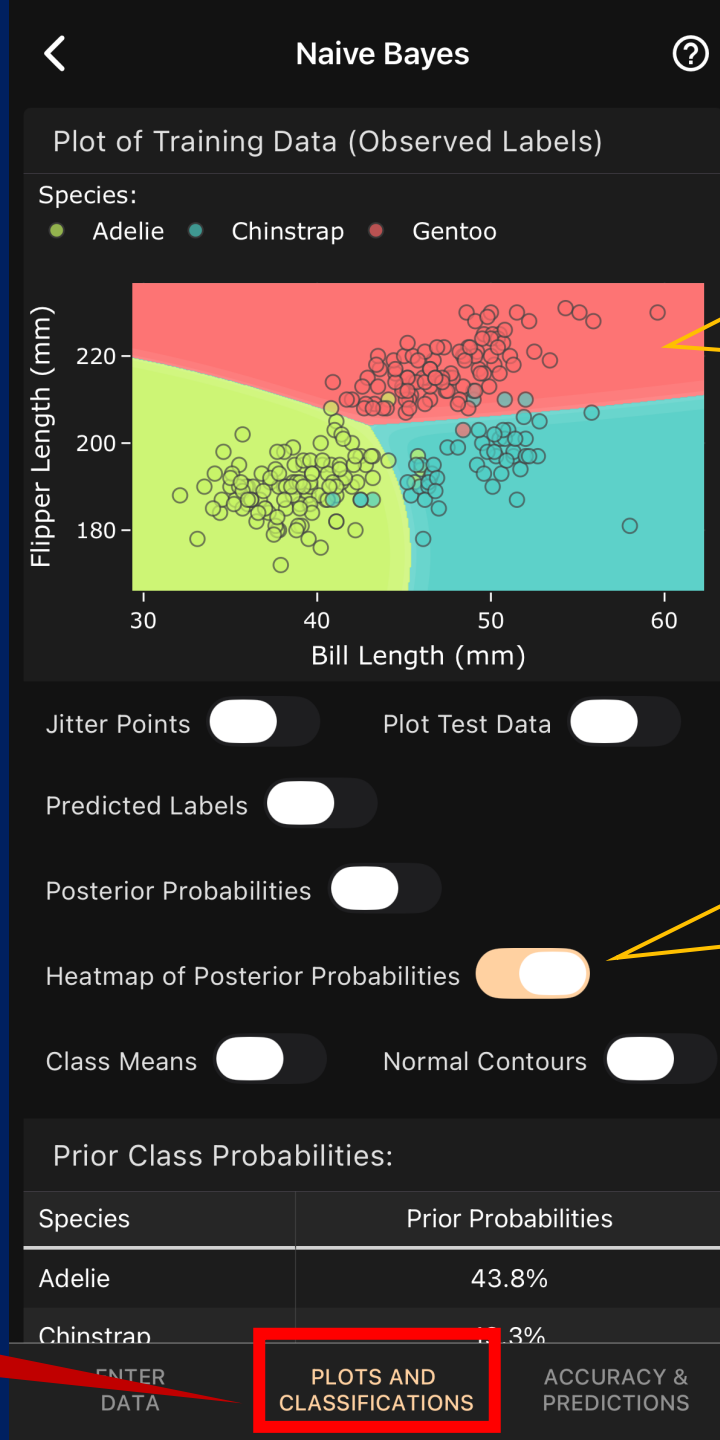
Tab 2

PLOTS AND CLASSIFICATIONS

Example: Naïve Bayes

Tab 2:

- Scatterplot
- Class Means
- Posterior Odds
- Predictions
- **Heatmap**
- Contours



Scatterplot with points colored by original label but area colored by predicted label. (Training set)

Switch to show heatmap of posterior odds. (Works when there are only continuous features.)

Tab 2

Example: Naïve Bayes

Tab 3:

- Dataset with predictions, posterior probs and odds (not shown)
- Find Prediction
- Confusion Matrix
- Performance

The screenshot shows the 'Naive Bayes' app interface. At the top, there is a back arrow and a help icon. Below is a table with columns for index, bill length, flipper length, and species. A blue button labeled 'Download Dataset of Predictions' is visible. A toggle switch for 'Find Predicted Class for New Observation' is turned on. Below this, there are input fields for 'Bill Length (mm)' (40) and 'Flipper Length (mm)' (200). The predicted class is 'Adelie'. A table shows 'Prior and Posterior Probabilities' for Adelie, Chinstrap, and Gentoo. At the bottom, there is a 'Confusion Matrix (Counts)' table and a navigation bar with three tabs: 'ENTER DATA', 'PLOTS AND CLASSIFICATIONS', and 'ACCURACY & PREDICTIONS'.

Index	Bill Length (mm)	Flipper Length (mm)	Species
3	40.3	195	Adelie
4	26.7	182	Adelie

Scroll left to reveal more columns

Download Dataset of Predictions

Find Predicted Class for New Observation

Select Values for Features:

Bill Length (mm)	Flipper Length (mm)
40	200

Predicted Class: **Adelie**

Prior and Posterior Probabilities:

Species	Prior Probability	Posterior Probability
Adelie	43.8%	97.3%
Chinstrap	19.3%	2.2%
Gentoo	36.9%	0.4%

Confusion Matrix (Counts):

Observed Class	Predicted Class			Total
	Adelie	Chinstrap	Gentoo	
Adelie				
Chinstrap				
Gentoo				

ENTER DATA PLOTS AND CLASSIFICATIONS ACCURACY & PREDICTIONS

Dataset (train and test) with posterior probabilities and odds (only shown partially in this screenshot)

Ask for class prediction of new observation

Enter values for features

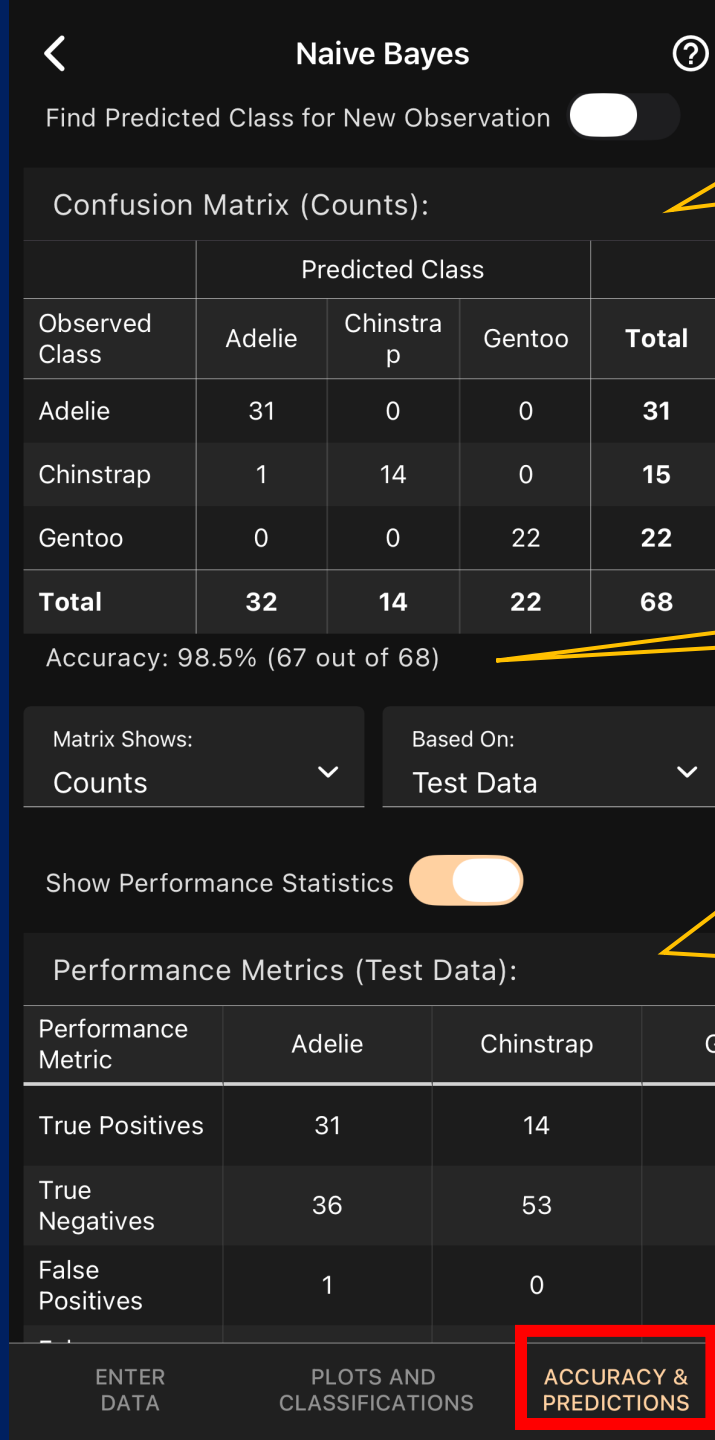
Table showing, for each class, the posterior probabilities for each class, based on the supplied feature values

Tab 3

Example: Naïve Bayes

Tab 3:

- Dataset with predictions, posterior probs. and odds
- Find Prediction
- Confusion Matrix
- Performance



3x3 Confusion Matrix comparing observed and predicted labels

Overall test accuracy

Table showing, for each class, true positives, true negatives, false positives and false negatives, sensitivity, specificity, precision, recall and F1 score.

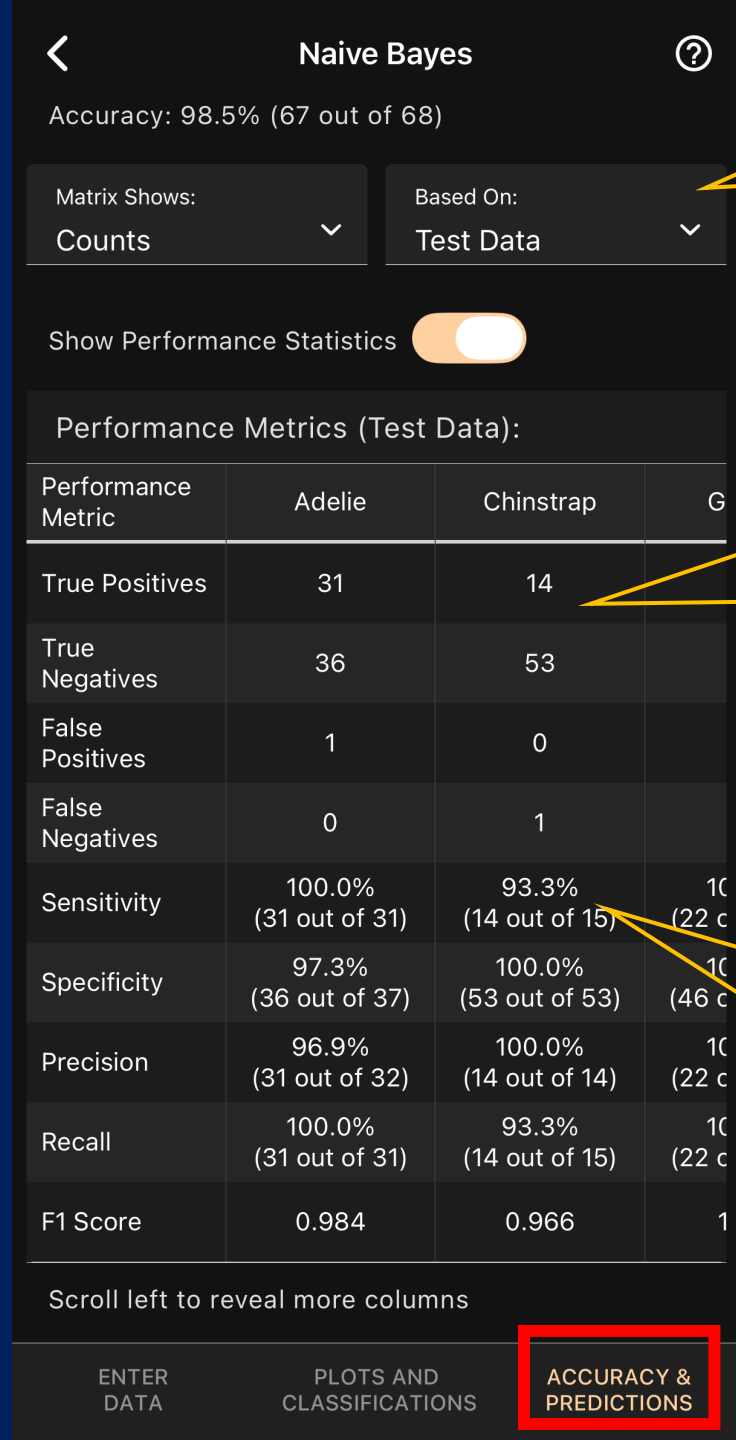
Tab 3

ACCURACY & PREDICTIONS

Example: Naïve Bayes

Tab 3:

- Dataset with predictions, posterior probs. and odds
- Find Prediction
- Confusion Matrix
- Performance



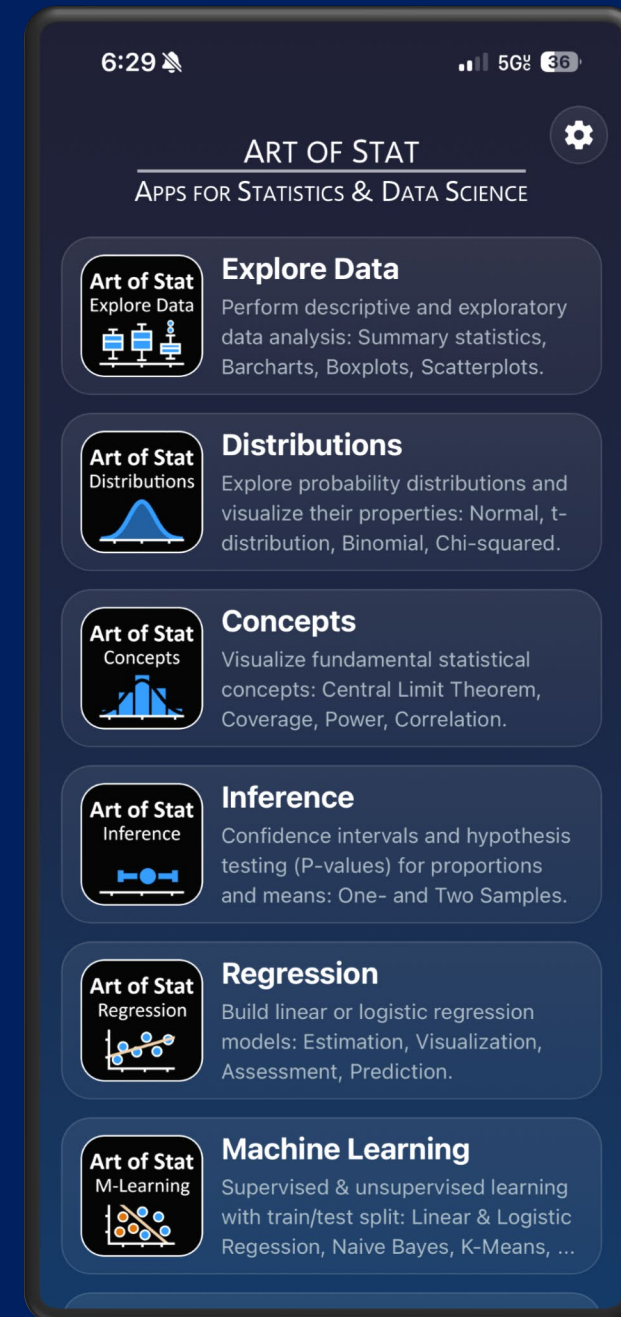
Requested performance statistics for test data

Table showing, for each class, true positives, true negatives, false positives and false negatives.

Also showing resulting sensitivity, specificity, precision, recall and F1 score.

Third tab

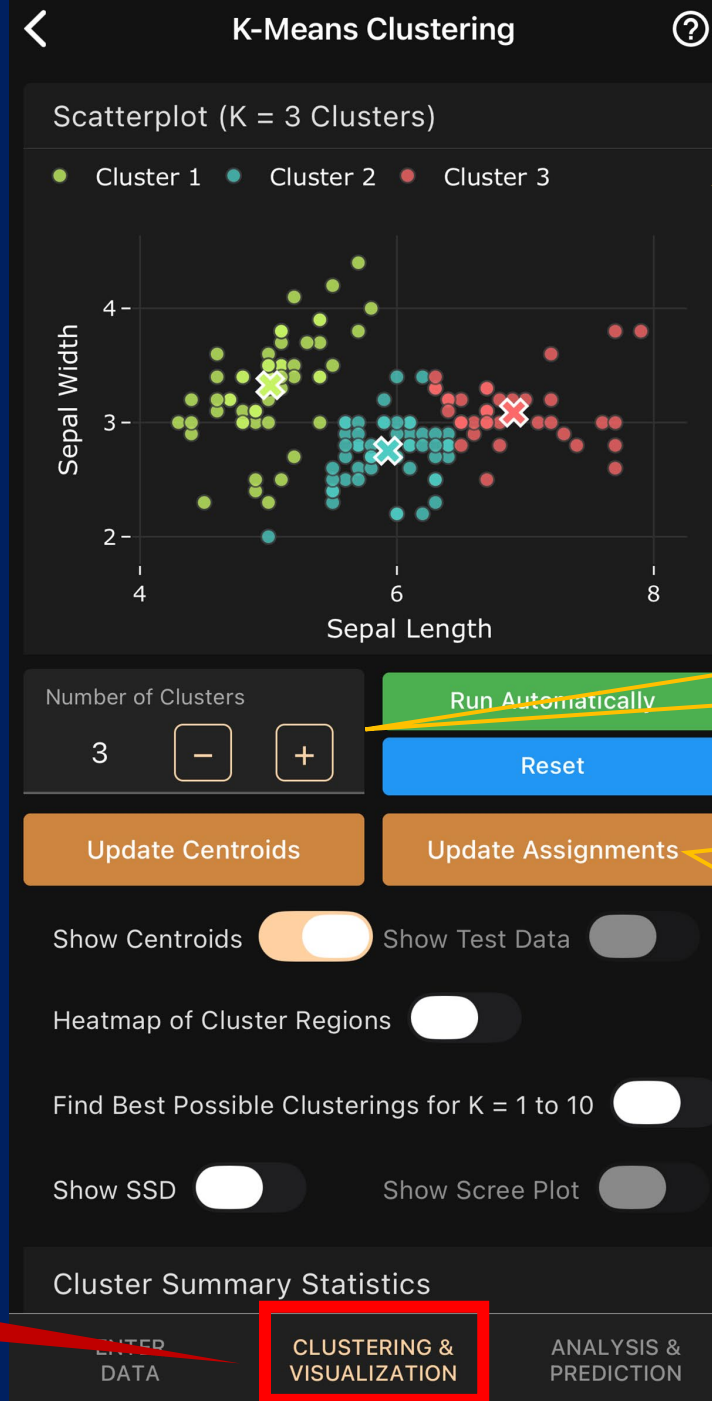
Run-Through of the K-Means Clustering App (Go Live)



Example: K-Means Clustering

Tab 2:

- Scatterplot
- Select K
- Carry out clustering
- Heatmap
- Screeplot
- Cluster Summaries



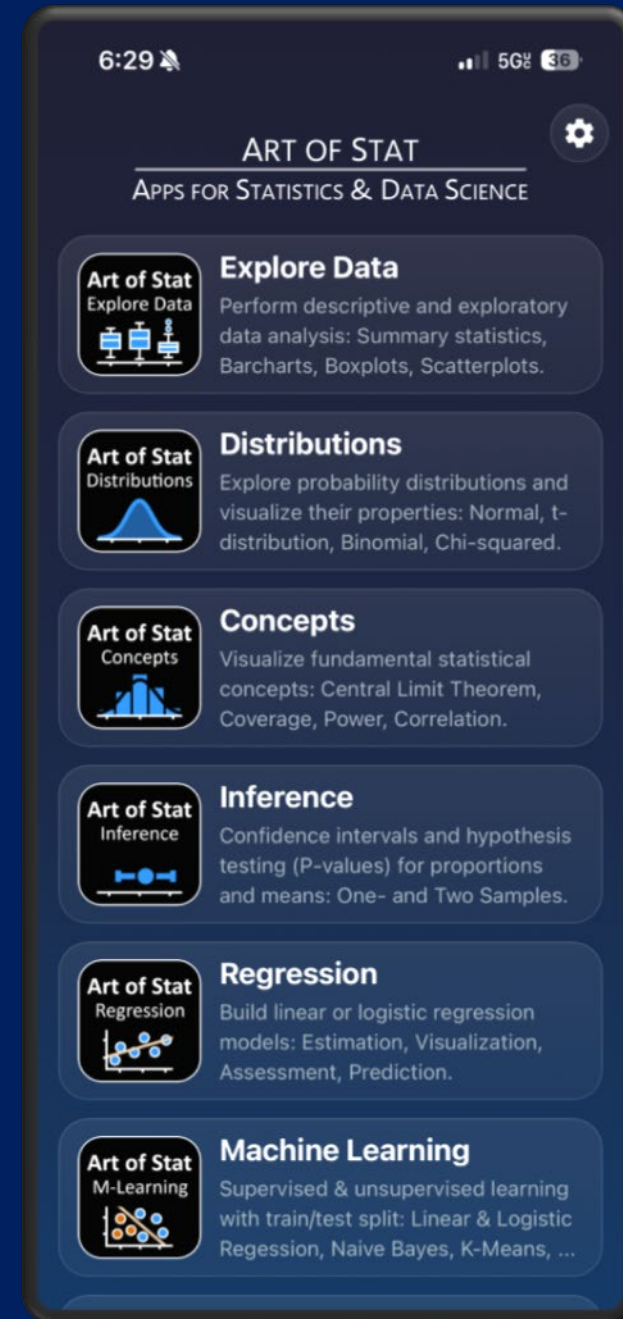
Scatterplot of two features to be clustered on

Select the number of clusters (K)

Step through clustering step by - step, iterating between finding centroids and then updating assignment.

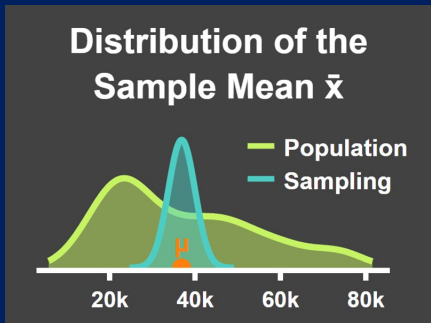
Tab 2

Run-Through of the Concepts App (Go Live)



Art of Stat: Concepts

Central Limit Theorem for Means



7:52

CLT for Means

Select Population Distribution:
US Colleges: Attendance Cost

Population Distribution

Population Description

The population consists of 1,829 public & private U.S. colleges offering a bachelor's degree. The variable measured for each college is the average cost of attendance (in USD) for academic year 2019/20, ranging from \$5,663 to \$81,531.

Population Parameters

Population Size	1,829
Population Mean (μ)	36,844
Population Standard Deviation (σ)	17,139
Population First Quartile (Q1)	22,827
Population Median	32,776
Population Third Quartile (Q3)	48,844

POPULATION DISTRIBUTION DRAW SAMPLES SAMPLING DISTRIBUTION

7:54

CLT for Means

Population Distribution: $\mu = 36,844, \sigma = 17,139$

Distribution of Sample: $n = 25, \bar{x} = 34,304, s = 13,408$

Sampling Distribution of \bar{x} (5633 Simulations)
Mean = 36,801, Std. Dev. = 3,409

Sample Size n: 25 Draw 1 Sample Draw 100 Samples Reset

Normal Distribution Zoom In

POPULATION DISTRIBUTION DRAW SAMPLES SAMPLING DISTRIBUTION

9:49

CLT for Means

Population Distribution: $\mu = 36,844, \sigma = 17,139$

Distribution of Sample: $n = 100, \bar{x} = 34,135, s = 15,933$

Sampling Distribution of \bar{x} (5633 Simulations)
Mean = 36,843, Std. Dev. = 1,721

Sample Size n: 100 Draw 1 Sample Draw 100 Samples Reset

Normal Distribution Zoom In

POPULATION DISTRIBUTION DRAW SAMPLES SAMPLING DISTRIBUTION

7:56

CLT for Means

Sampling Distribution of \bar{x} ($n = 80$)

Histogram of Simulated Sample Means Simulated Sampling Distribution of \bar{x} (smooth) Sampling Distribution of \bar{x} (if CLT applies) Population Distribution

Distribution of the Sample Mean \bar{x} ($n = 80$)

Statistic	Population Distribution	Theoretical Distribution*	Simulated Distribution**
Mean	36,844	36,844	36,845
Std. Dev.	17,139	1,916	1,910
Q1	22,827	35,552	35,537
Median	32,776	36,844	36,817
Q3	48,844	38,136	38,150

POPULATION DISTRIBUTION DRAW SAMPLES SAMPLING DISTRIBUTION

- Screens:
- Population Distribution
 - Draw Samples
 - Sampling Distribution

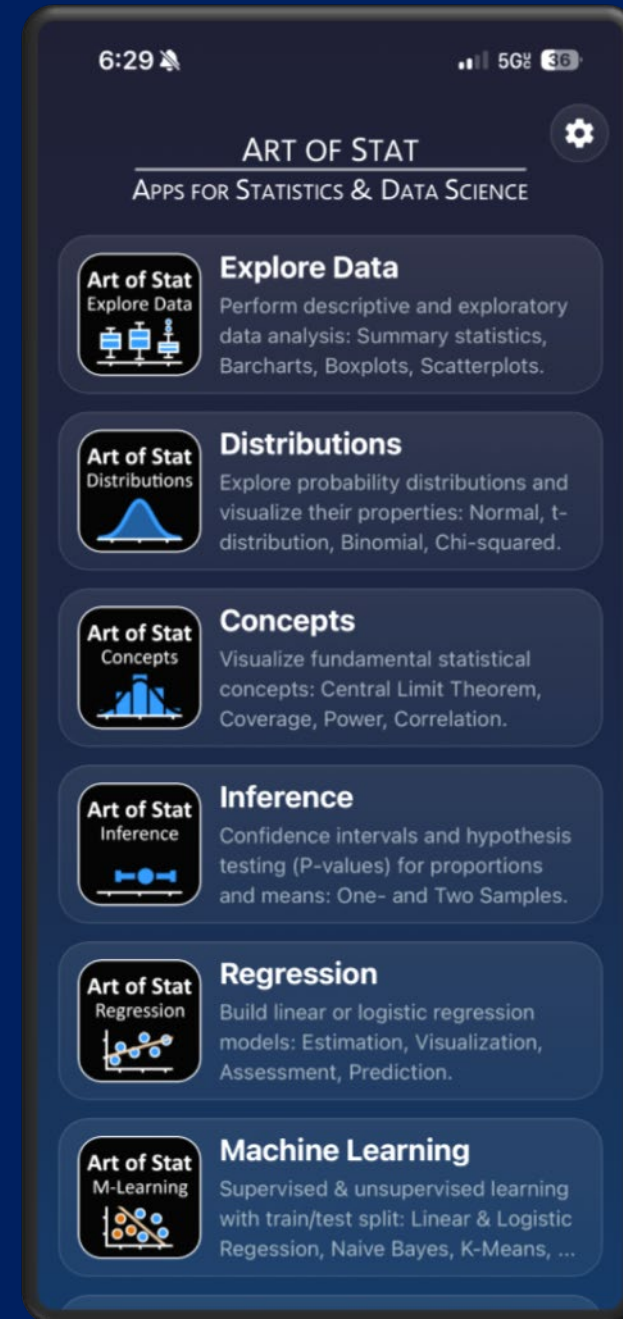
Explore real population distribution, and its parameters (mean, standard deviation).

Draw samples of a given size from this population distribution, and keep track of the sample means

See what happens as the sample size increases

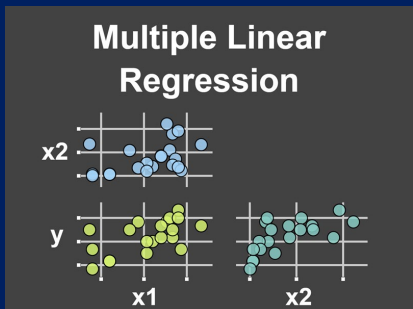
Show (simulated) sampling distribution, compare to population distribution

Run-Through of the Multiple Linear Regression App (Go Live)

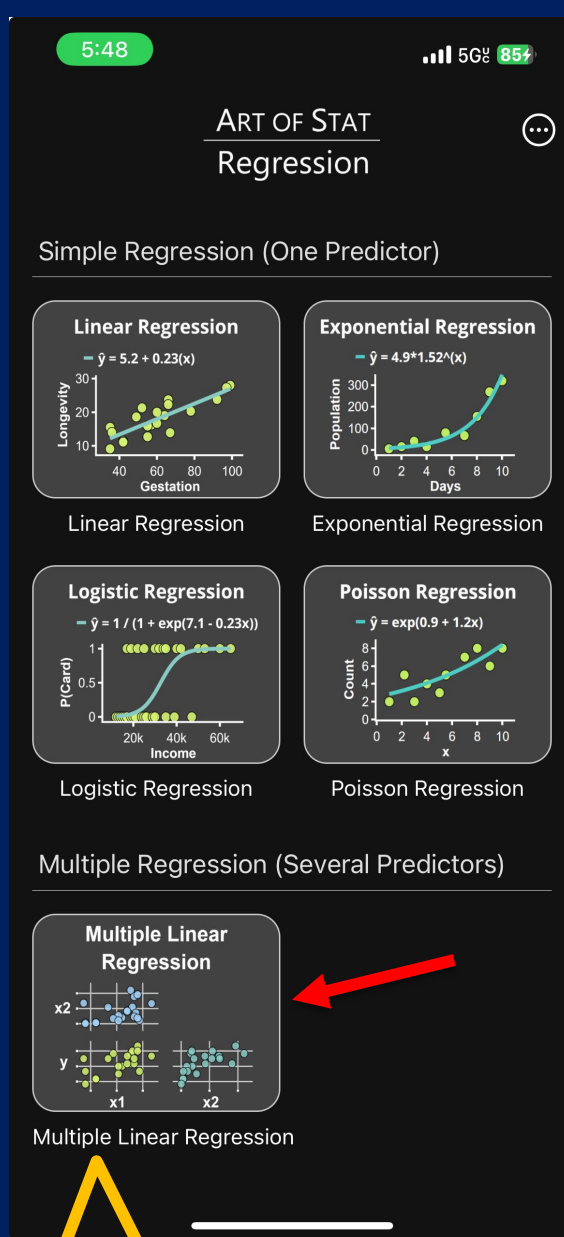


Art of Stat: Regression

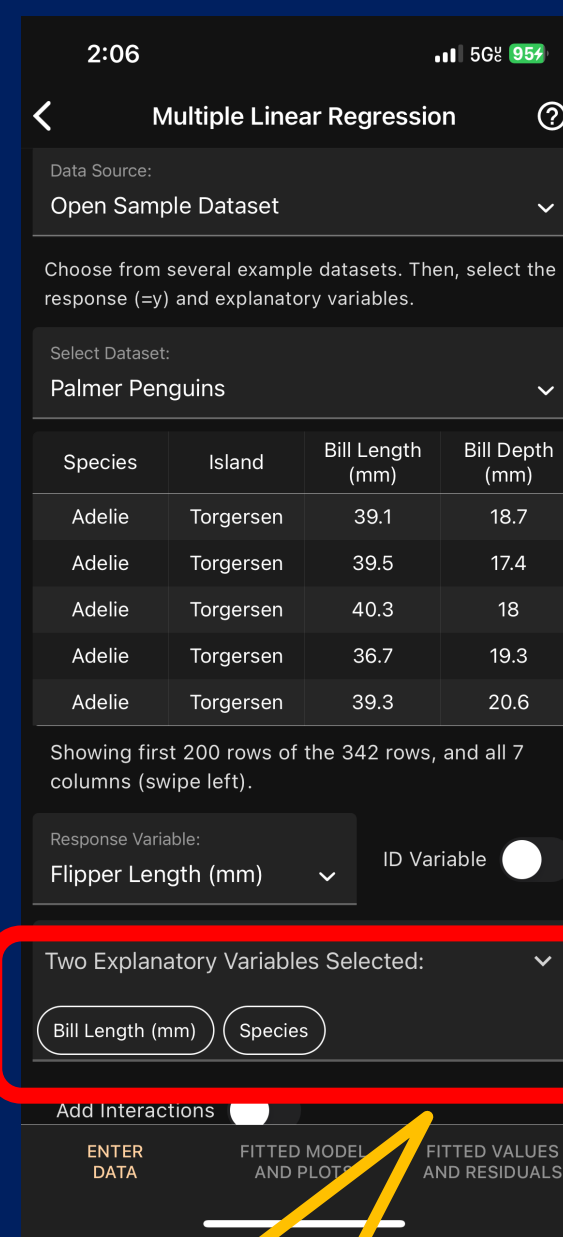
Multiple Linear Regression



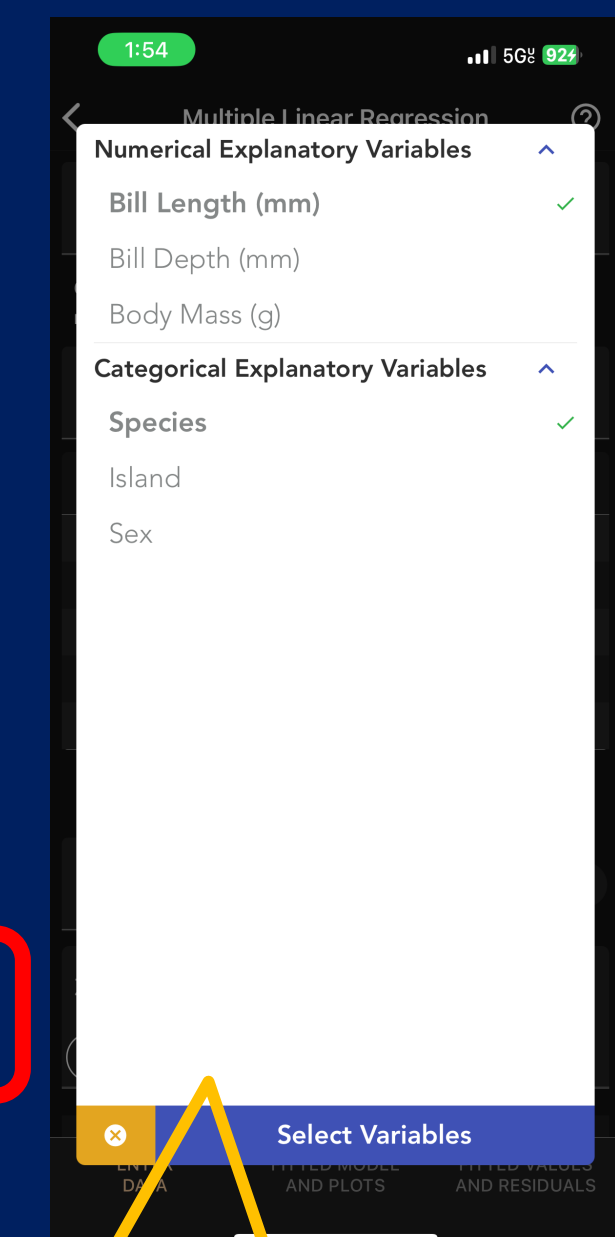
- Screens:
- Enter Data
 - Fitted Model & Plots
 - Fitted Values, Residuals



Select Multiple Linear Regression



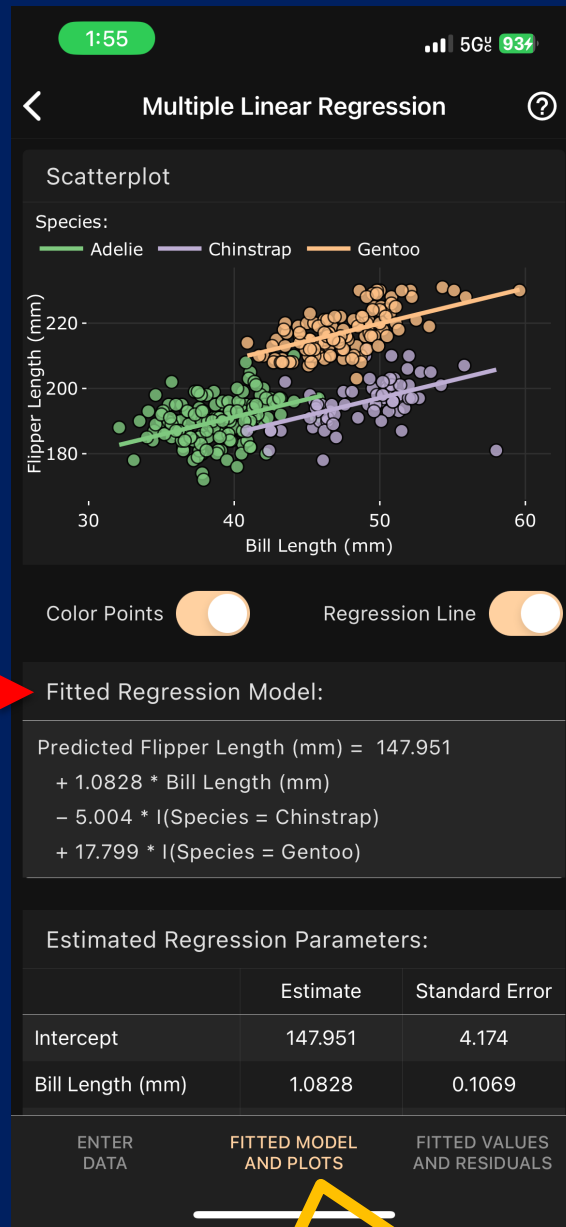
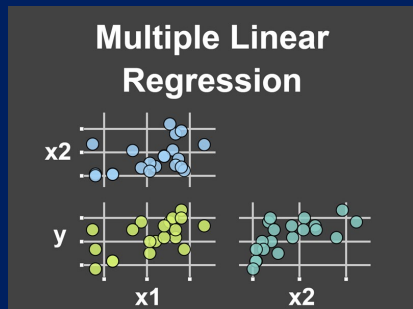
Select response & explanatory variables



Click on variables you want to select, continuous or categorical

Art of Stat: Regression

Multiple Linear Regression



Three separate lines, and equation for fitted model

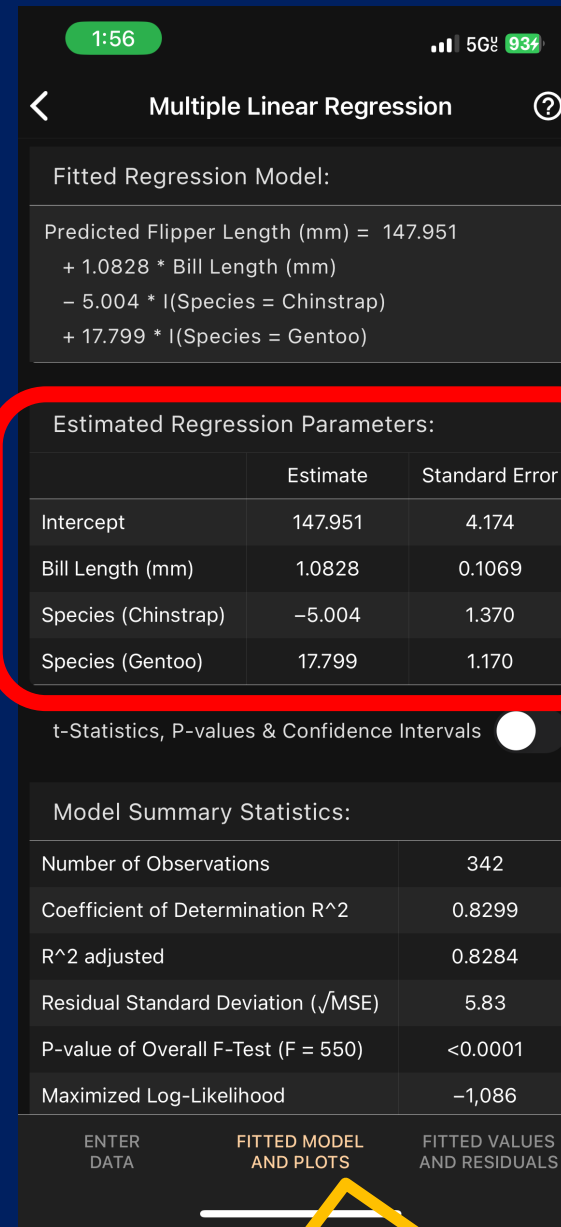
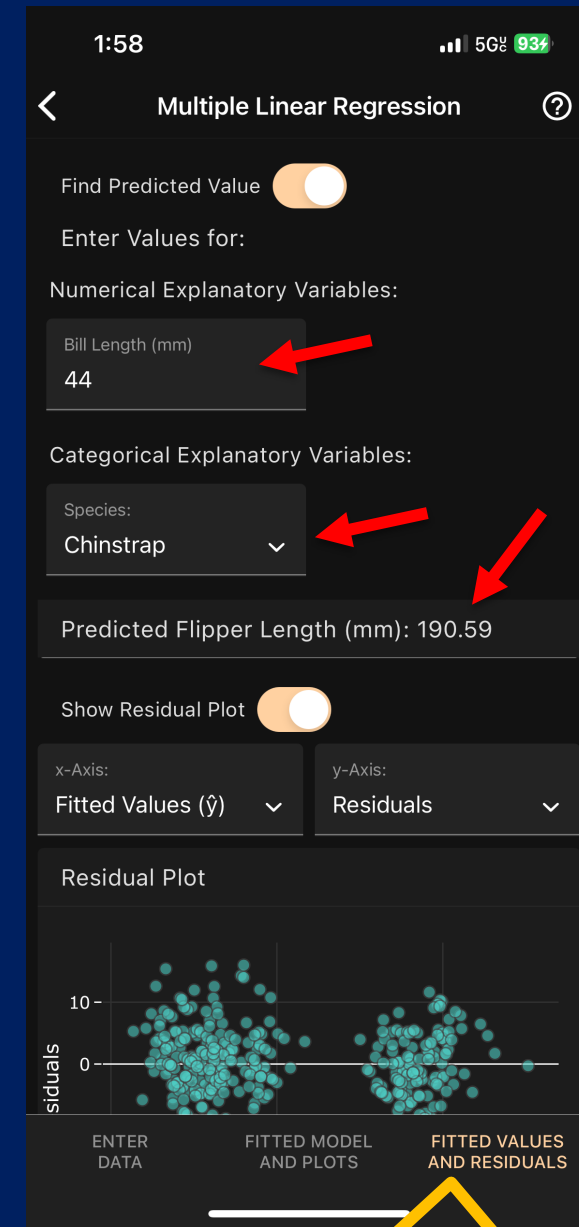


Table of regression coefficient, plus std. errors and P-values

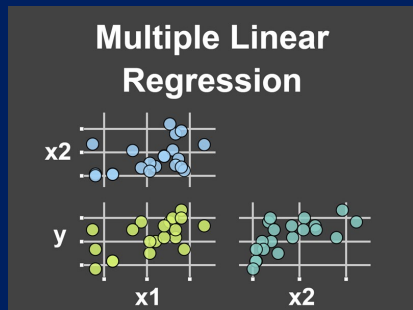


Prediction: drop-downs for categorical predictors

- Screens:
- Enter Data
 - Fitted Model & Plots
 - Fitted Values, Residuals

Art of Stat: Regression

Multiple Linear Regression



- Screens:
- Enter Data
 - Fitted Model & Plots
 - Fitted Values, Residuals

1:59 5G 94%

Multiple Linear Regression

Select Dataset: Palmer Penguins

Species	Island	Bill Length (mm)	Bill Depth (mm)
Adelie	Torgersen	39.1	18.7
Adelie	Torgersen	39.5	17.4
Adelie	Torgersen	40.3	18
Adelie	Torgersen	36.7	19.3
Adelie	Torgersen	39.3	20.6

Showing first 200 rows of the 342 rows, and all 7 columns (swipe left).

Response Variable: Flipper Length (mm) ID Variable

Two Explanatory Variables Selected:

Bill Length (mm) Species

Add Interactions

Interactions Selected:

Bill Length (mm) * Species

ENTER DATA FITTED MODEL AND PLOTS FITTED VALUES AND RESIDUALS

Multivariate Thinking also means understanding Interactions

2:02 5G 94%

Multiple Linear Regression

Scatterplot

Species: Adelie Chinstrap Gentoo

Color Points Regression Line

Fitted Regression Model:

$$\text{Predicted Flipper Length (mm)} = 158.924 + 0.7999 * \text{Bill Length (mm)} - 12.29 * I(\text{Species} = \text{Chinstrap}) - 7.83 * I(\text{Species} = \text{Gentoo}) + 0.2073 * \text{Bill Length (mm)} * I(\text{Species} = \text{Chinstrap}) + 0.5913 * \text{Bill Length (mm)} * I(\text{Species} = \text{Gentoo})$$

Estimated Regression Parameters:

ENTER DATA FITTED MODEL AND PLOTS FITTED VALUES AND RESIDUALS

Now we have different slopes: different effects

2:03 5G 94%

Multiple Linear Regression

Estimated Regression Parameters:

	Estimate	Standard Error
Intercept	158.924	6.904
Bill Length (mm)	0.7999	0.1776
Species (Chinstrap)	-12.29	12.46
Species (Gentoo)	-7.83	10.64
Bill Length (mm) * Species (Chinstrap)	0.2073	0.2765
Bill Length (mm) * Species (Gentoo)	0.5913	0.2459

t-Statistics, P-values & Confidence Intervals

Model Summary Statistics:

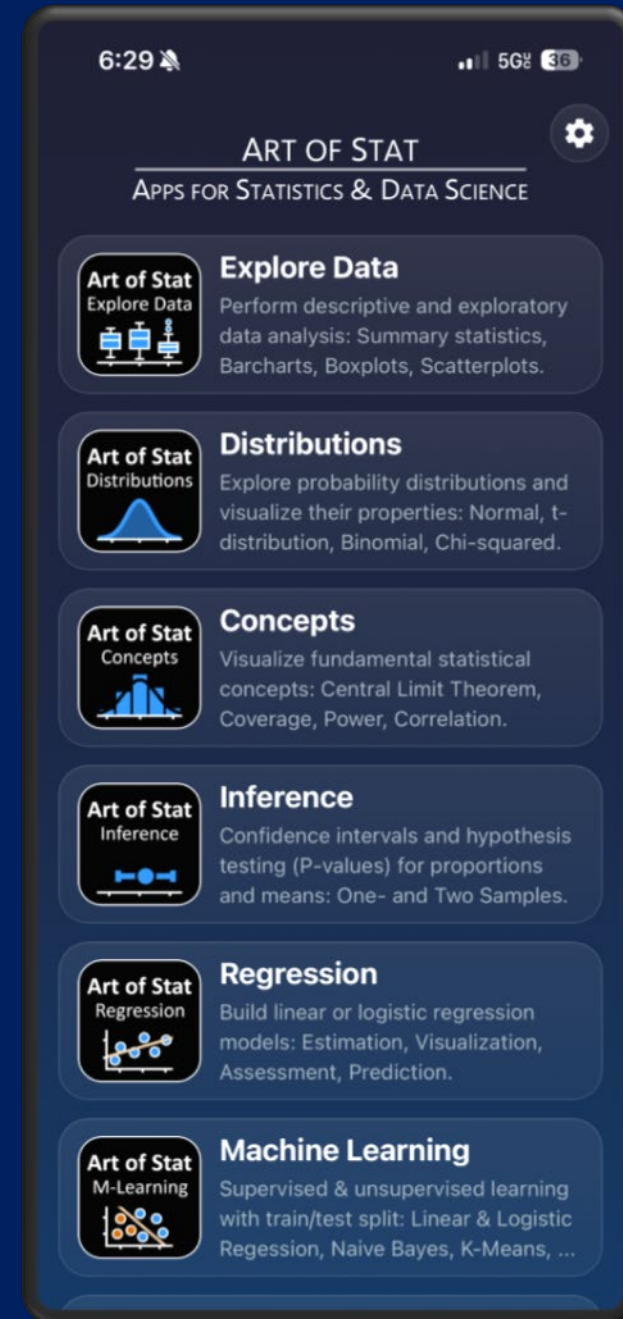
Number of Observations	342
Coefficient of Determination R ²	0.8328
R ² adjusted	0.8303
Residual Standard Deviation ($\sqrt{\text{MSE}}$)	5.79
P-value of Overall F-Test (F = 335)	<0.0001
Maximized Log-Likelihood	-1,083
Number of Parameters (including σ)	7

Regression Anova Table

ENTER DATA FITTED MODEL AND PLOTS FITTED VALUES AND RESIDUALS

Regression coefficient table easy to read

Homework Assignment Examples



STAT 161: HW2

Reading: Read Chapter 2, Sections 2.1 to 2.4.

1. Eyewitness testimony

Read [this story](#), which ran on NPR in January 2016. The original article can be found at [this link](#). Under Supporting Information, the article gives a link to the [data](#) used for this article.

- a. Download these data and save the data (as a .csv file) to your computer. (Nothing to turn in.)
- b. Open the data set in Excel, Google Sheets or some other spreadsheet program to take an initial look at the data. Clean the data as you see fit. For instance, it is a very good idea to delete the first row and any special characters! Save the cleaned data as a .csv file. (Nothing to turn in.)
- c. **Choose one categorical variable from this dataset.** (Nothing to turn in.)
- d. **Email** the cleaned csv file to yourself (then download it from your email to your device) **or** put the cleaned csv file on your **Google Drive/iCloud**. Open the Art of Stat app, go to Explore Data and from there open an appropriate procedure to describe the distribution of the variable.

What to turn in:

- i. **A description of the distribution of the variable**, including an appropriate graph, table and a short paragraph. Use screenshots from the app to include in your description.
- e. Now, turn to the internet or, better, generative AI and ask *“How to open a .csv file in Stata”*. I tried this with chatGPT and got very useful answers I pasted below, but I rather have you try on

RESEARCH ARTICLE

The Novel New Jersey Eyewitness Instruction Induces Skepticism but Not Sensitivity

Athan P. Papailiou¹*, David V. Yokum^{1,2}, Christopher T. Robertson¹

¹ James E. Rogers College of Law, University of Arizona, Tucson, Arizona, United States of America,

² Department of Psychology, University of Arizona, Tucson, Arizona, United States of America

* These authors contributed equally to this work.

* athan@email.arizona.edu

Abstract

In recent decades, social scientists have shown that the reliability of eyewitness identifications is much worse than laypersons tend to believe. Although courts have only recently begun to react to this evidence, the New Jersey judiciary has reformed its jury instructions to notify jurors about the frailties of human memory, the potential for lineup administrators to nudge witnesses towards suspects that they police have already identified, and the advantages of alternative lineup procedures, including blinding of the administrator. This experiment tested the efficacy of New Jersey's jury instruction. In a 2x2 between-subjects design, mock jurors ($N = 335$) watched a 35-minute murder trial, wherein identification quality was either "weak" or "strong" and either the New Jersey or a "standard" instruction was delivered. Jurors were more than twice as likely to convict when the standard instruction was used ($OR = 2.55$; $95\% CI = 1.37-4.89$, $p < 0.001$). The New Jersey instruction, however, did *not* improve juror's ability to discern quality; rather, jurors receiving those instructions indiscriminately discounted "weak" and "strong" testimony in equal measure.



CrossMark
click for updates

OPEN ACCESS

Citation: Papailiou AP, Yokum DV, Robertson CT (2015) The Novel New Jersey Eyewitness Instruction Induces Skepticism but Not Sensitivity. PLoS ONE 10 (12): e0142695. doi:10.1371/journal.pone.0142695

Editor: Francesco Di Russo, University of Rome,

One Student Solution:

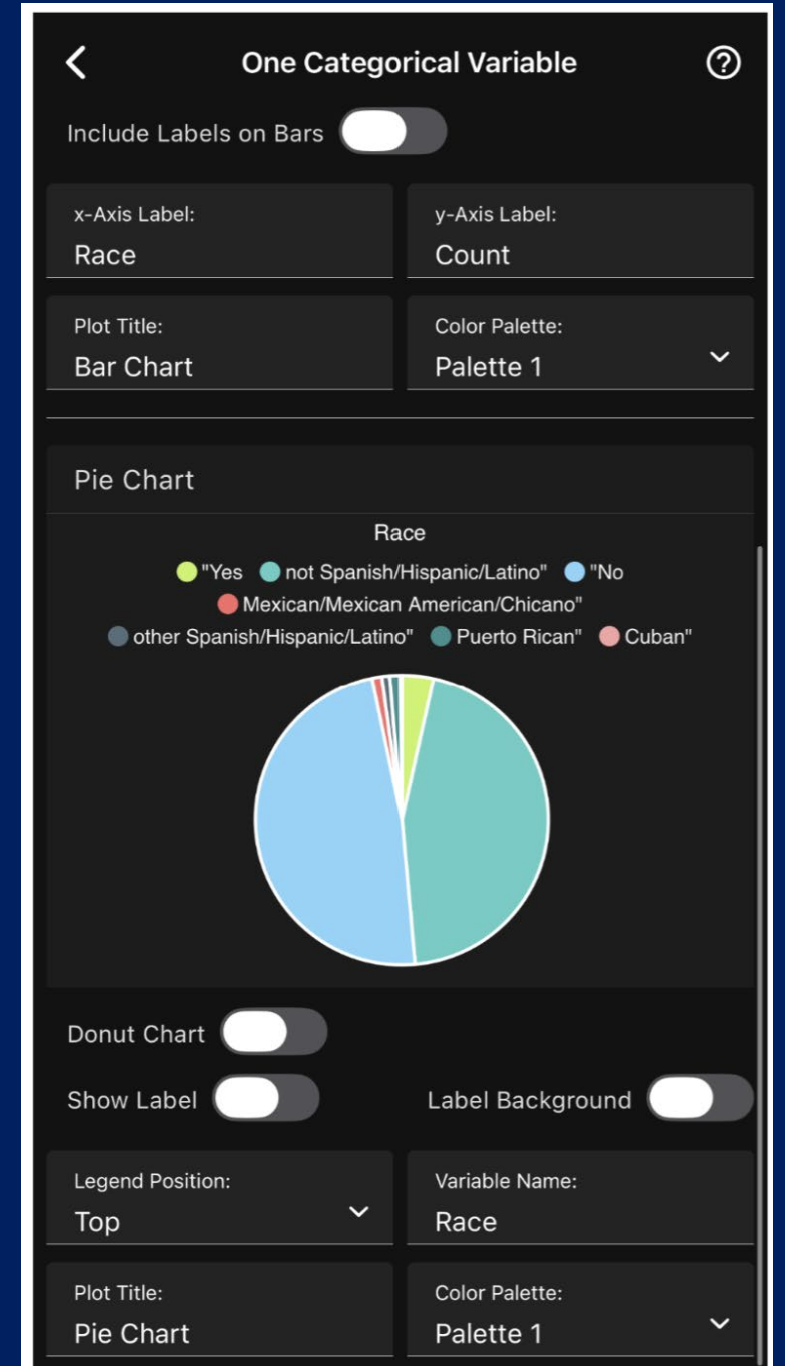
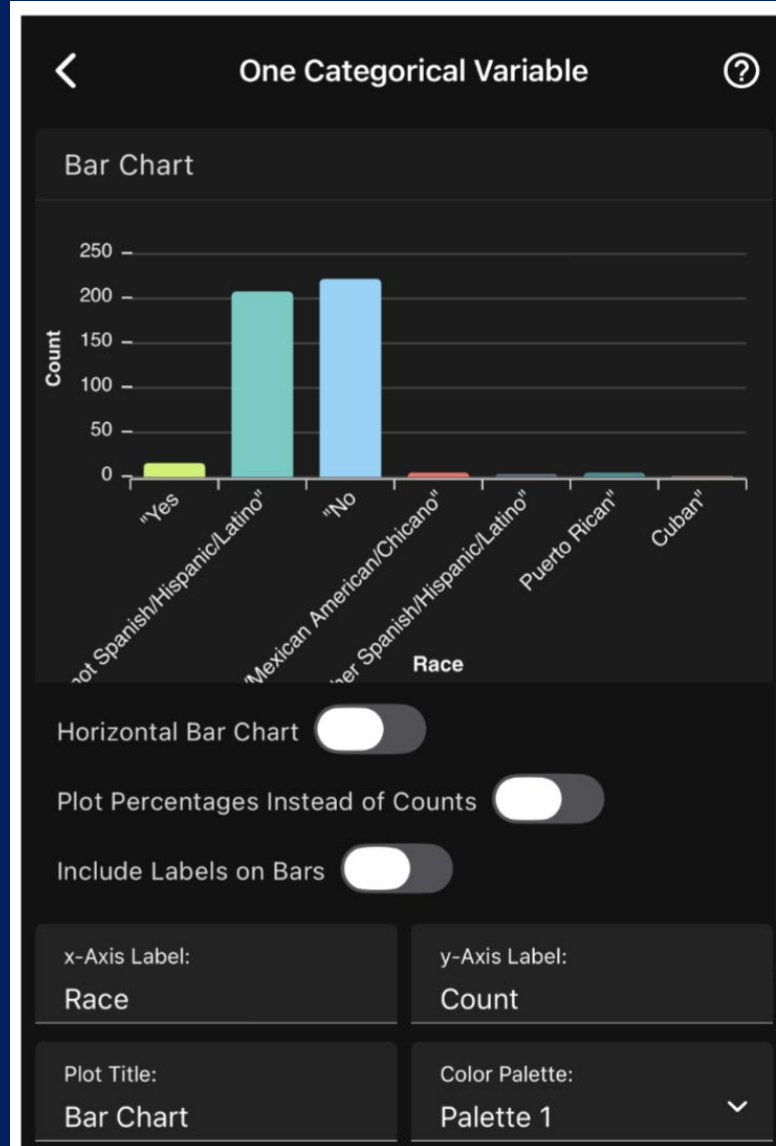
One Categorical Variable

Frequency Table:

Race	Count	Proportion	Percent
"Yes	16	0.0347	3.5%
not Spanish/Hispanic/Latino"	208	0.4512	45.1%
"No	222	0.4816	48.2%
Mexican/Mexican American/Chicano"	5	0.0108	1.1%
other Spanish/Hispanic/Latino"	4	0.0087	0.9%
Puerto Rican"	5	0.0108	1.1%
Cuban"	1	0.0022	0.2%
Total	461	1.0000	100.0%

Sort Categories: As Entered

Adjust Number of Digits

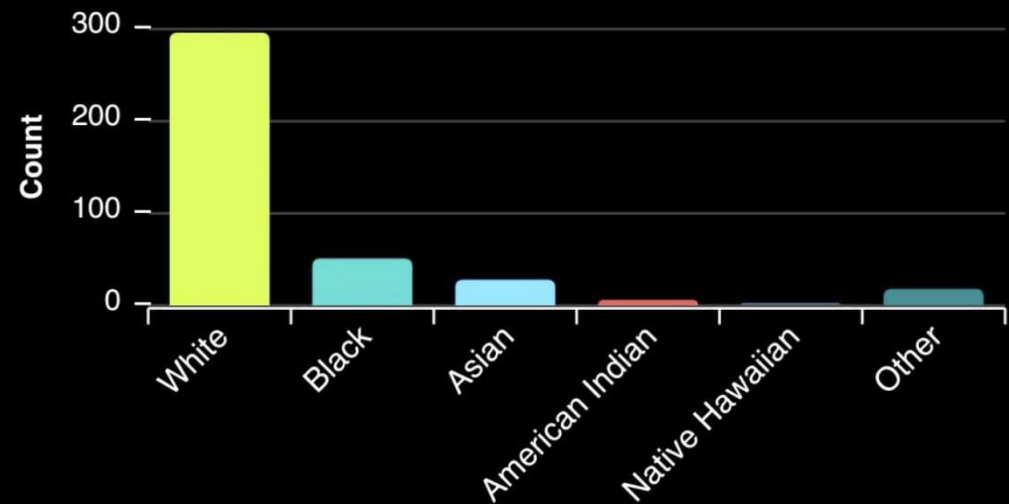


Another Student Solution:

Frequency Table:

Variable	Count	Proportion	Percent
White	296	0.7363	73.6%
Black	51	0.1269	12.7%
Asian	28	0.0697	7.0%
American Indian	6	0.0149	1.5%
Native Hawaiian	3	0.0075	0.7%
Other	18	0.0448	4.5%
Total	402	1.0000	100.0%

Bar Chart



Thank you!

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