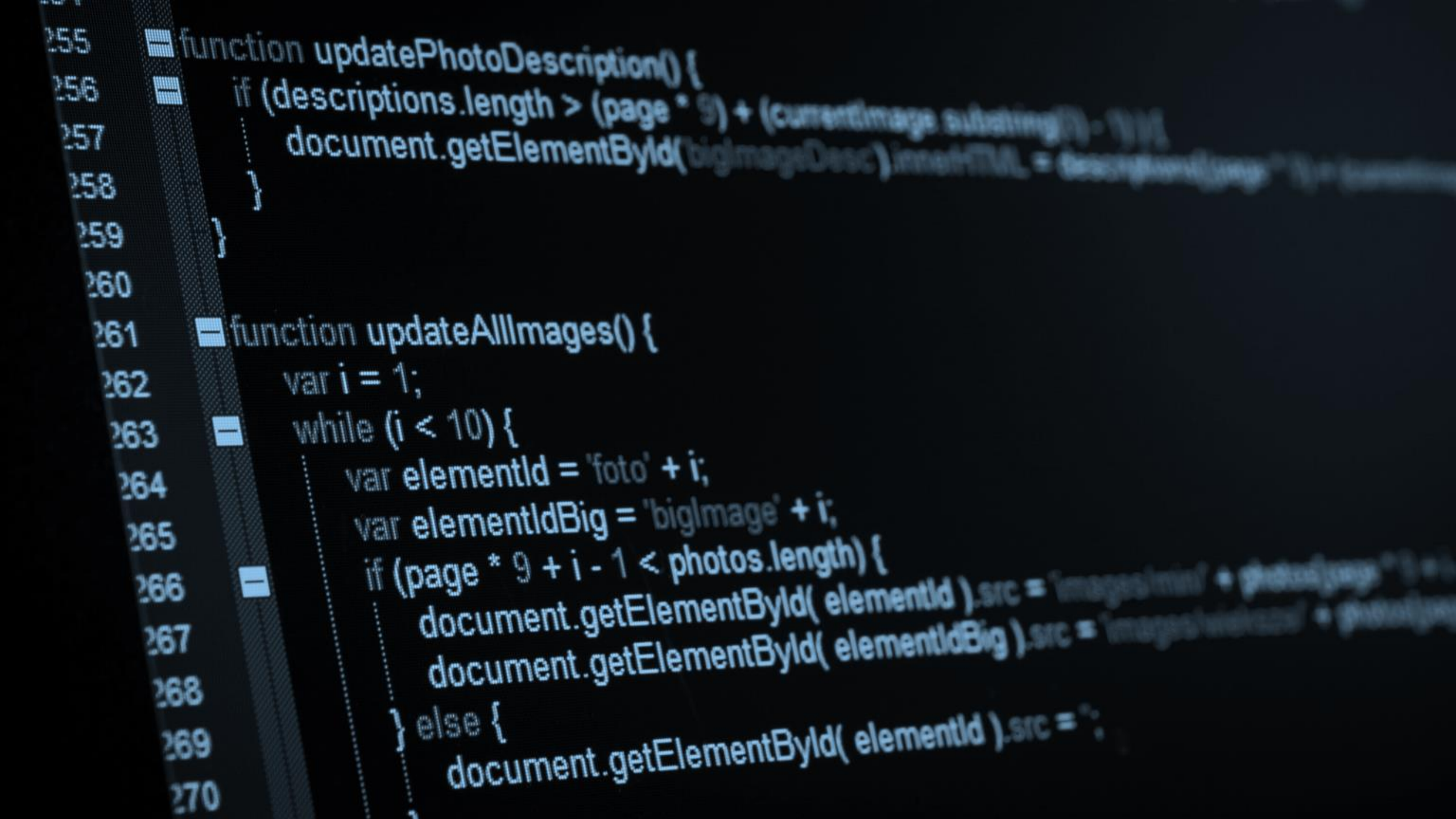
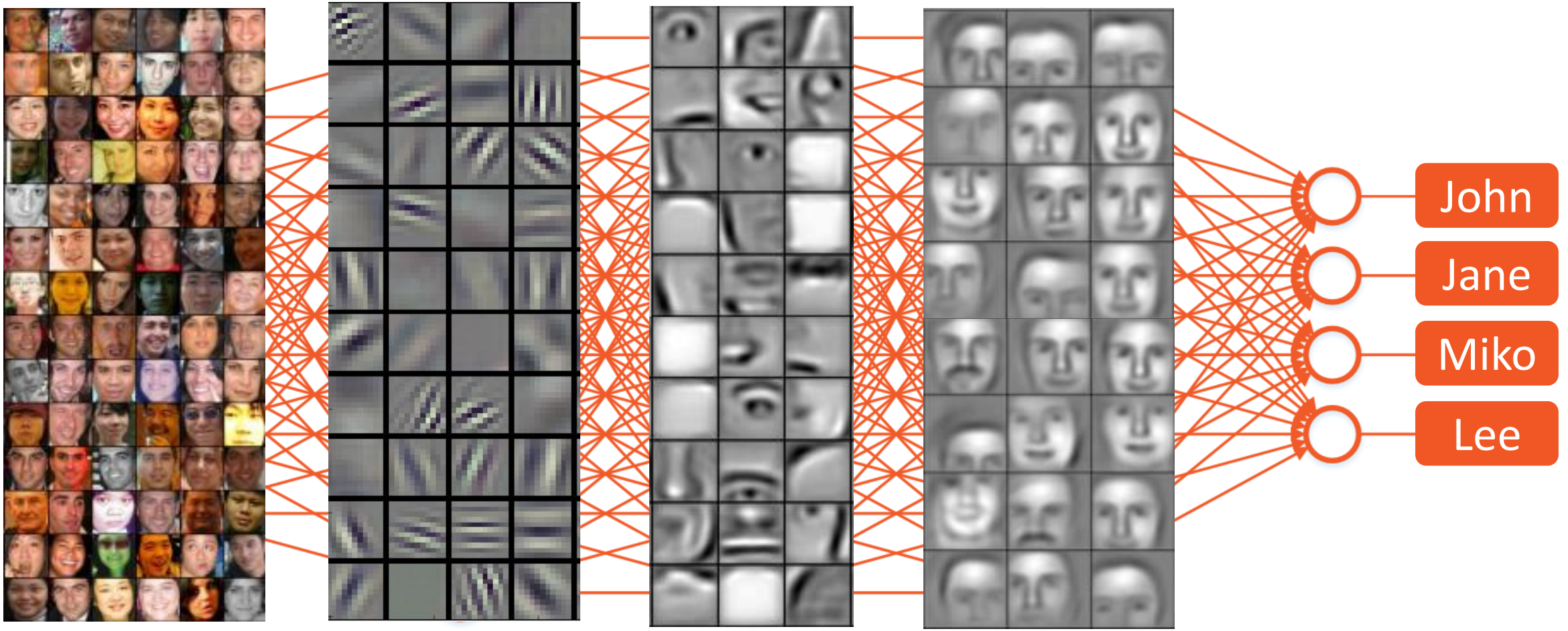
Machine Learning with R

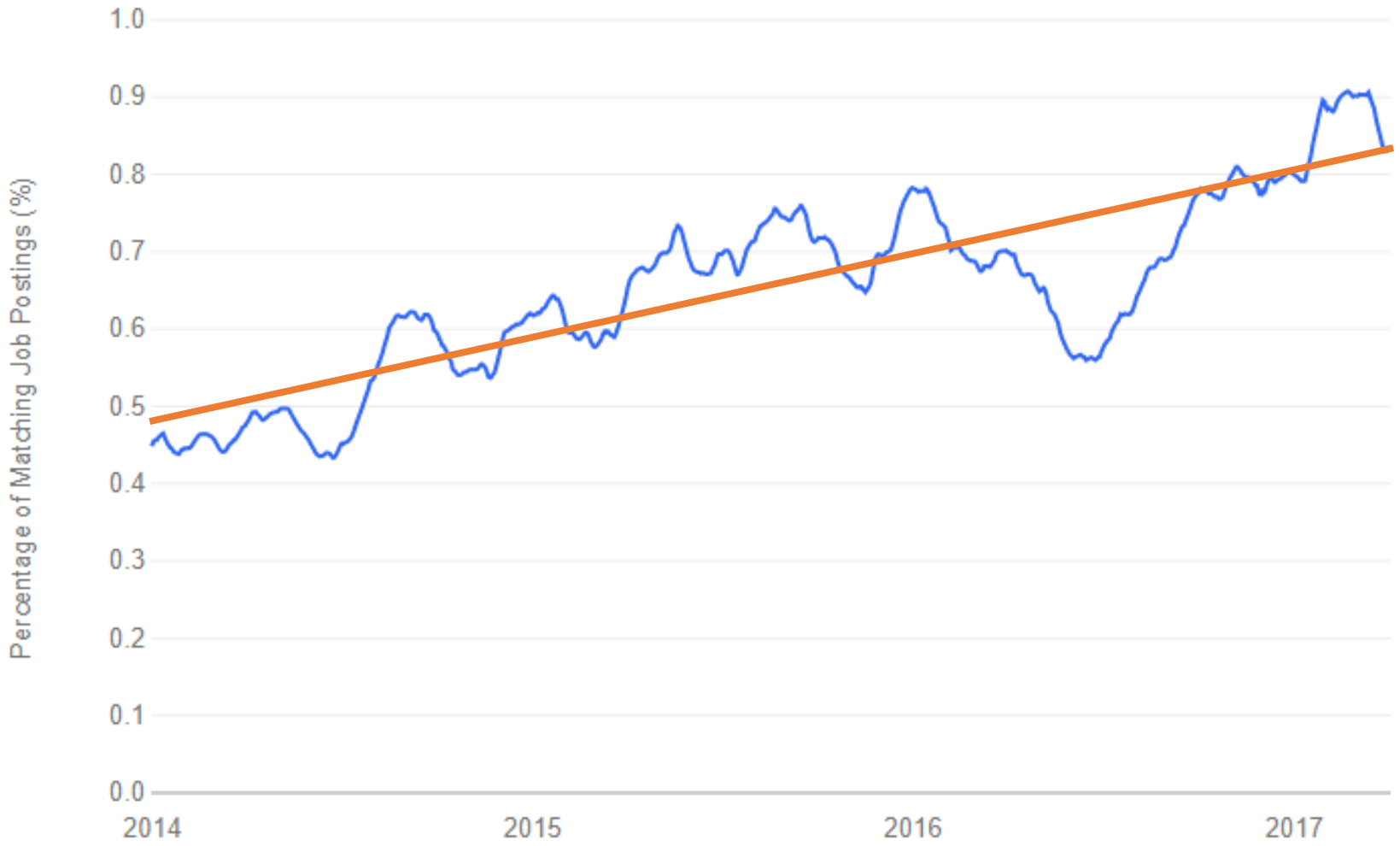
@MatthewRenze

@netcorebcn


255 function updatePhotoDescription() {
256 if (descriptions.length > (page * 9) +
257 document.getElementById(
258 }
259 }
260
261 function updateAllImages() {
262 var i = 1;
263 while (i < 10) {
264 var elementId = 'foto' + i;
265 var elementIdBig = 'bigImage' + i;
266 if (page * 9 + i - 1 < photos.length) {
267 document.getElementById(elementId).
268 document.getElementById(elementIdBig).
269 } else {
270 document.getElementById(elementId).src = '';

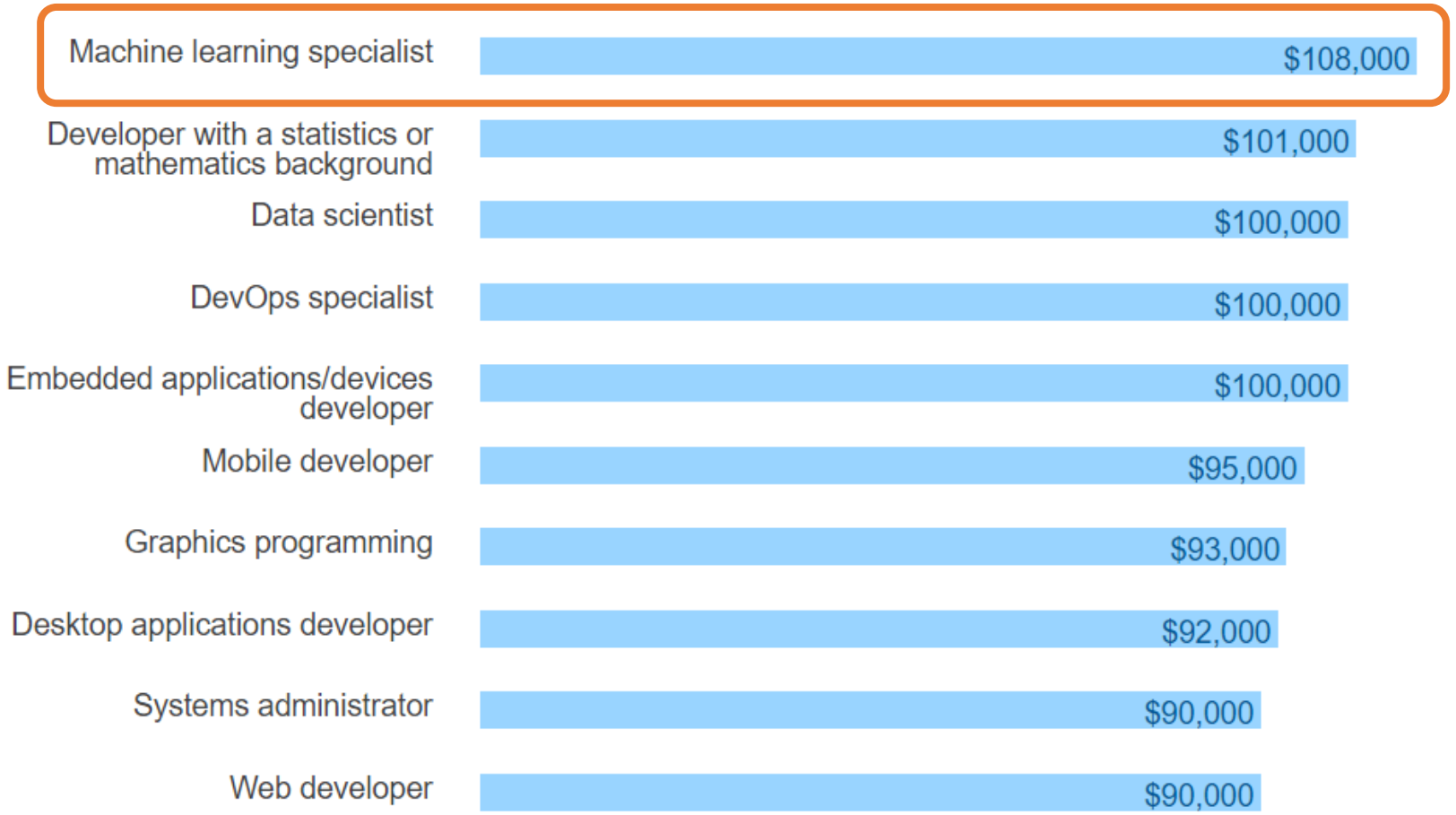

John
Jane
Miko
Lee

Job Postings for Machine Learning



Source: Indeed.com

Average Salary by Job Type (USA)



Source: Stack Overflow 2017

Overview

1. Introduction to ML
2. Introduction to R
3. Classification
4. Regression
5. Beyond the Basics

About Me

Data Science Consultant

Education

- B.S. in Computer Science
- B.A. in Philosophy

Community

- Public Speaker
- Pluralsight Author
- Microsoft MVP
- ASPInsider
- Open-source Software

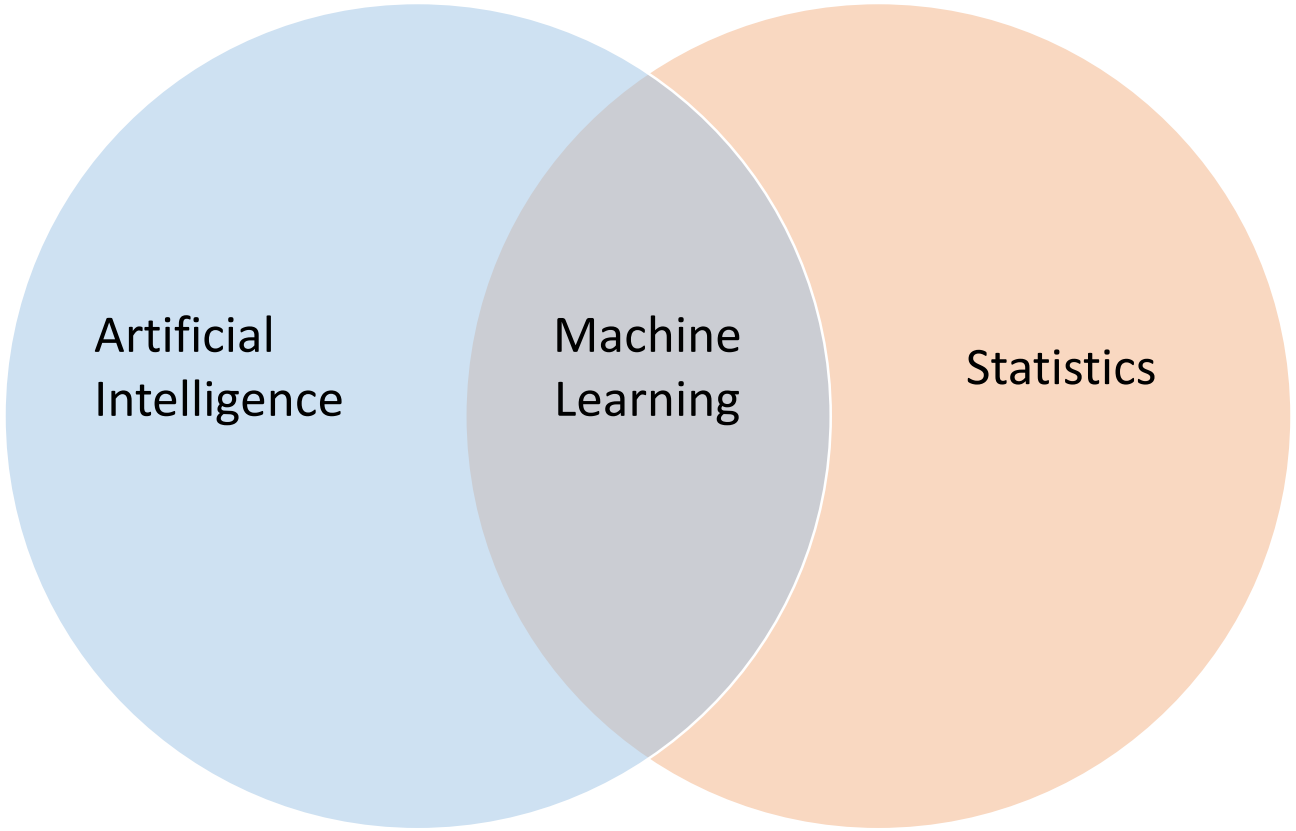
How Does This Apply to Me?

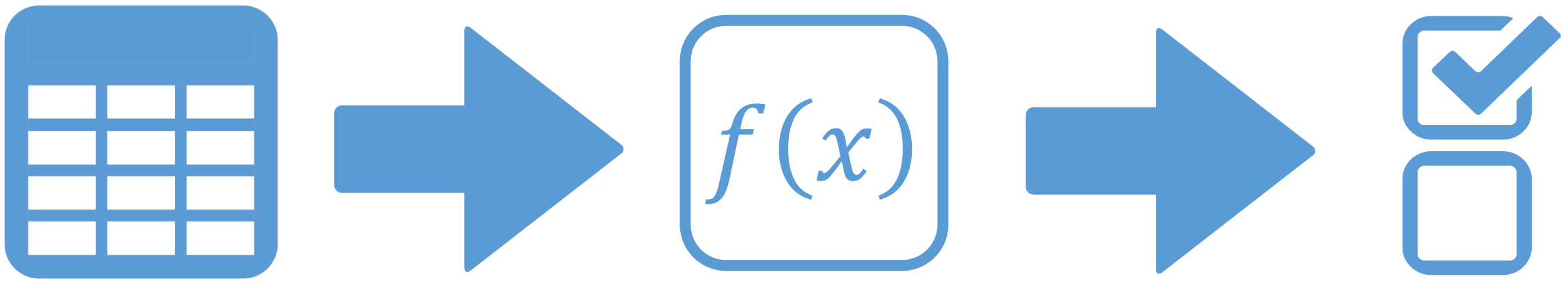
- ☑ Make decisions using data
- ☑ Make predictions using data
- ☑ Make recommendations using data
- ☑ Find patterns of interest in data
- ☑ Find anomalies in data
- ☑ Write code that does all these things

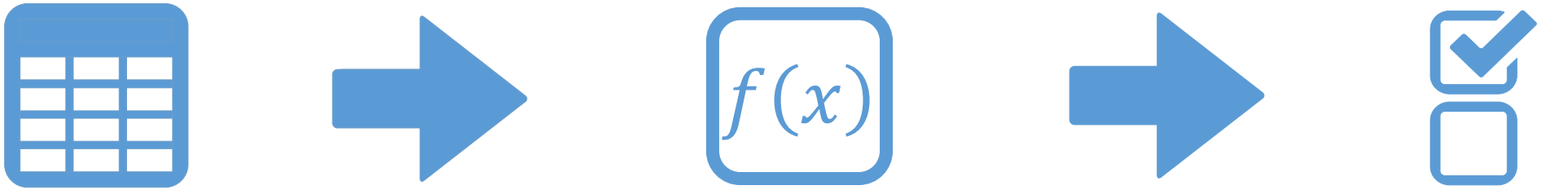

IDEAL
MODEL SMALL
STACK 100h
DATASEG
HW DB "Danger", 13, 10, '$'
CODESEG
Begin:
MOV AX, @data
MOV DS, AX
MOV DX, OFFSET HW
MOV AH, 09H
INT 21H
MOV AX, 4C00H
INT 21H
END Begin
MOV AX,1234H
PUSH AX
MOV AH,09
INT 21H
POP AX
model small
stack
data
message db "Connecting..."
inline int call host1(int sys
asm ("int \$0x80\n"
"=a" (sys)
"0" (sys), "b" (parm)
return sys;

Introduction to Machine Learning

What is Machine Learning?


Artificial
Intelligence
Machine
Learning
Statistics

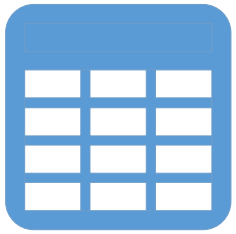

f(x)



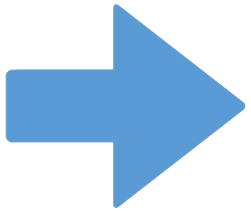
Data

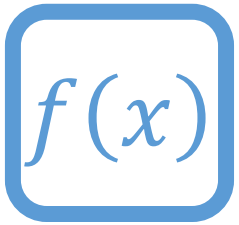
Function

Prediction

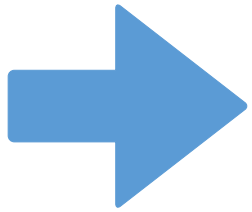


Data

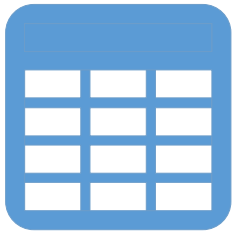




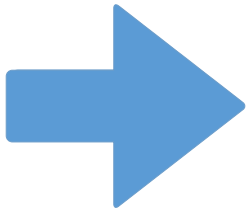
Function

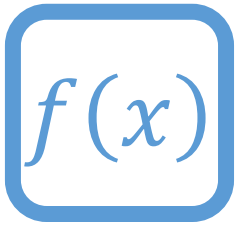


Prediction

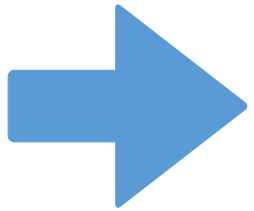


Data





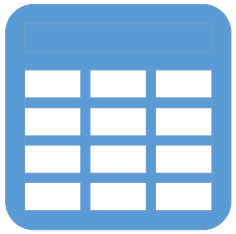
Function



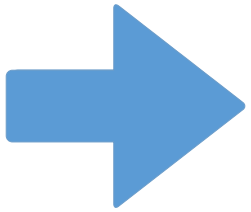
Prediction

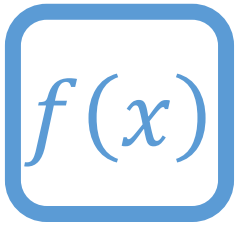
Cat

Dog

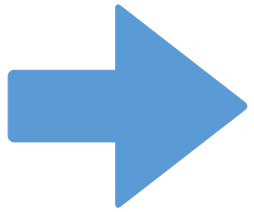


Data





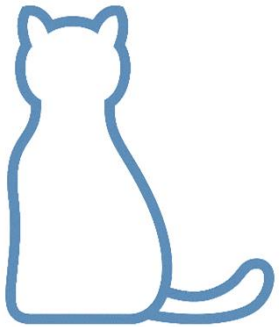
Function

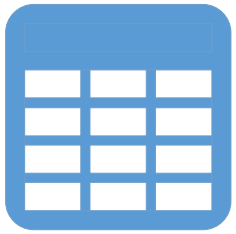


Prediction

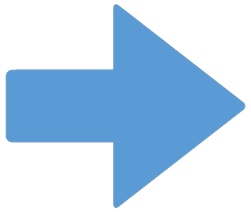
Cat

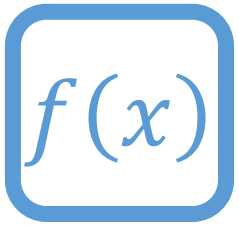
Dog





Data





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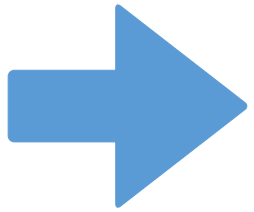
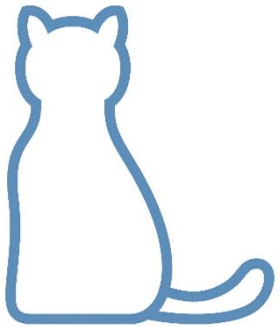


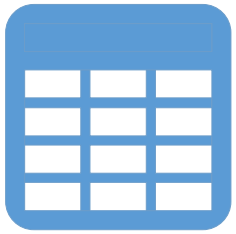
Prediction

Cat

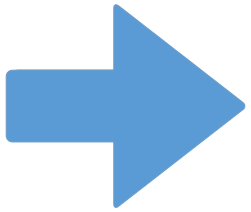
Dog

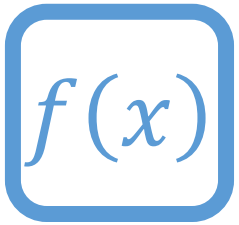


Is cat?



Data





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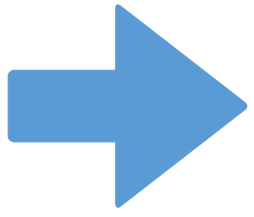
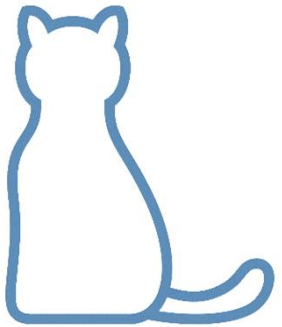


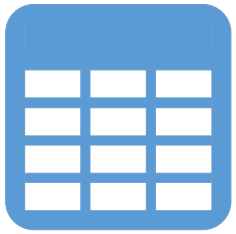
Prediction

Cat

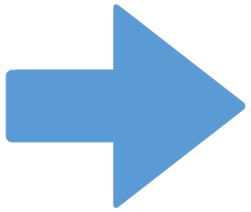
Dog

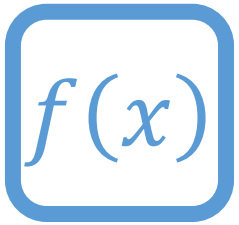


Is cat?

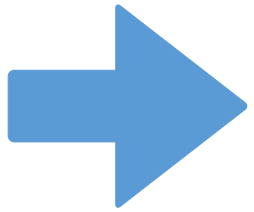


Data





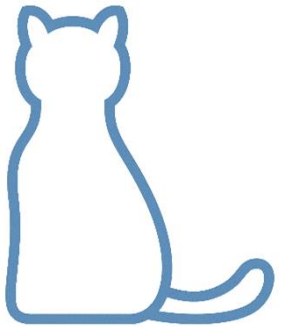
Function



Prediction

Cat

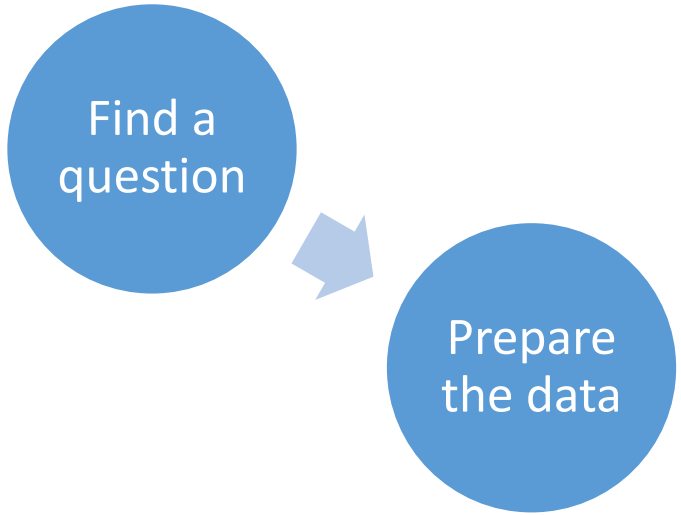
Dog

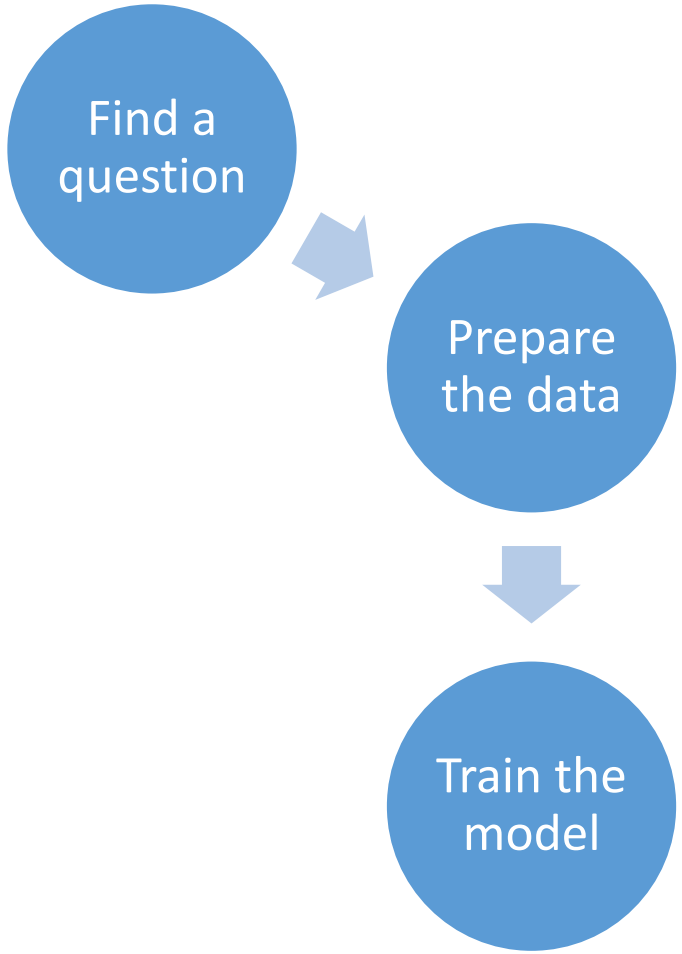


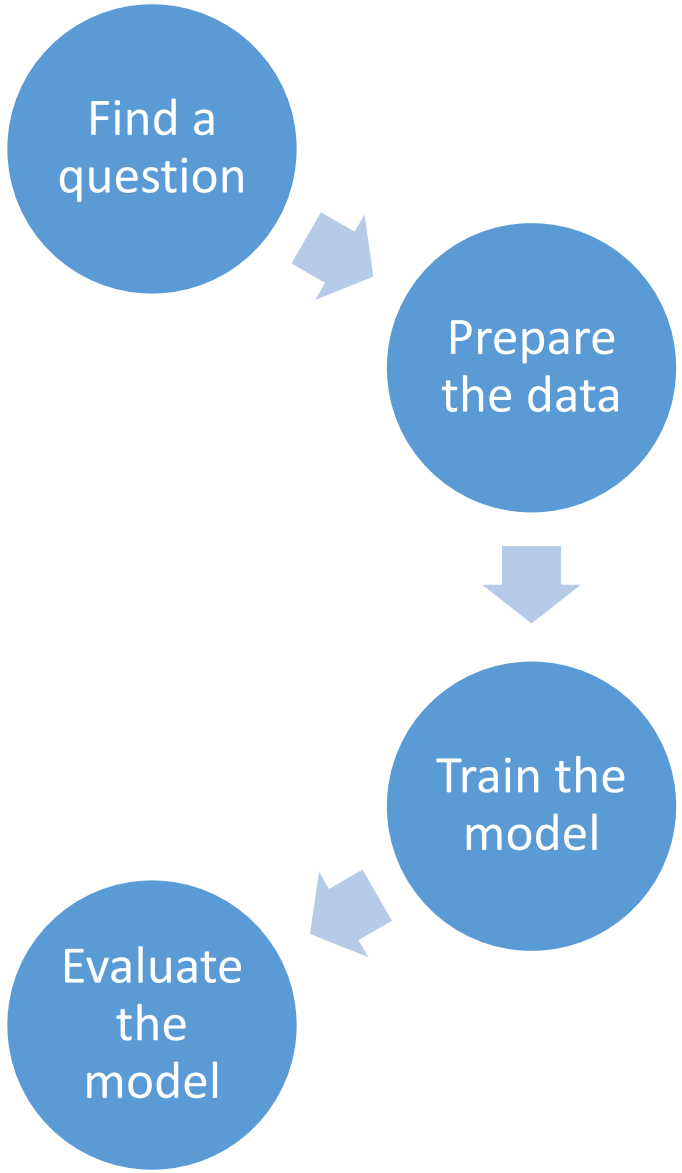
Is cat?

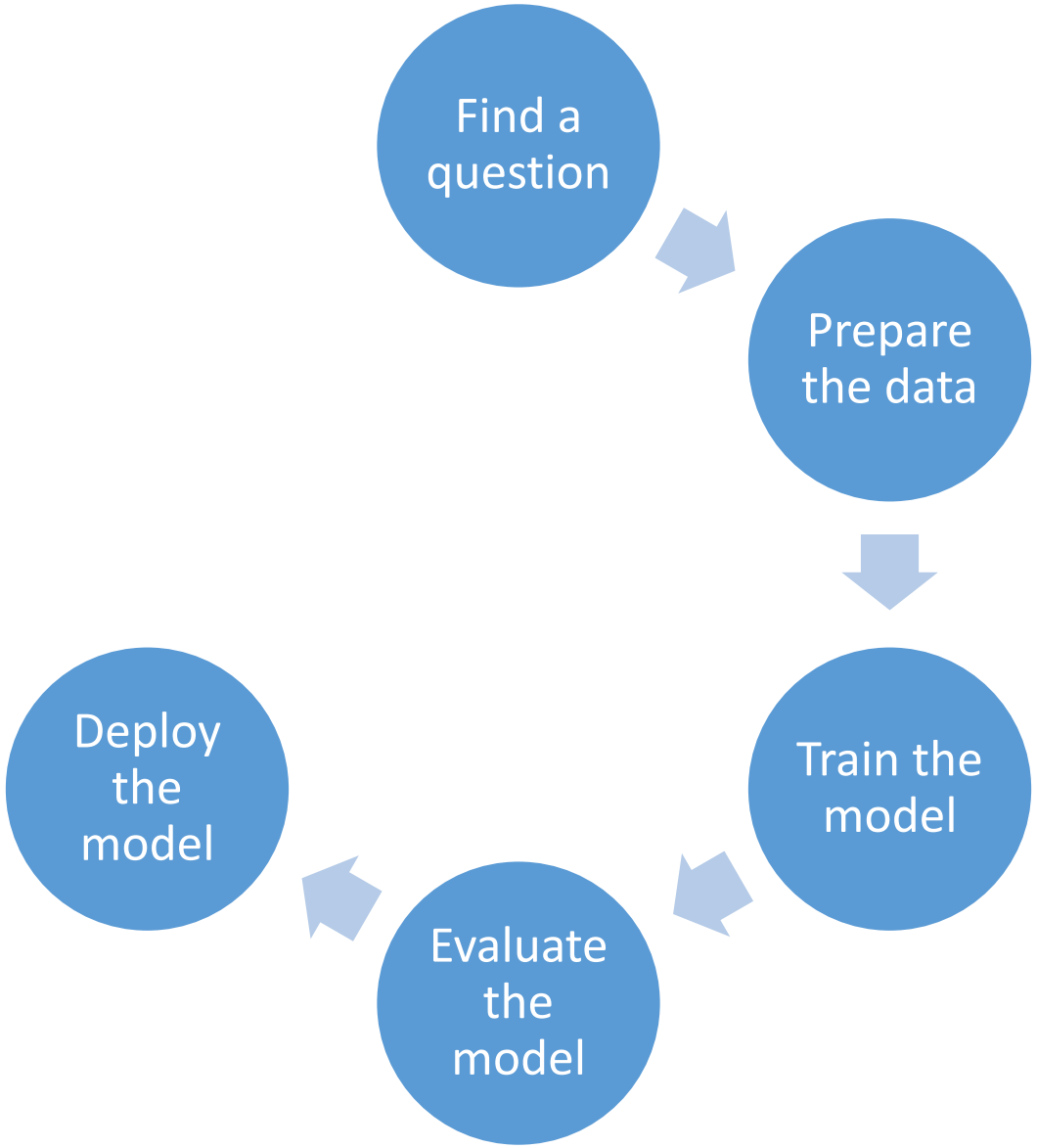
Yes

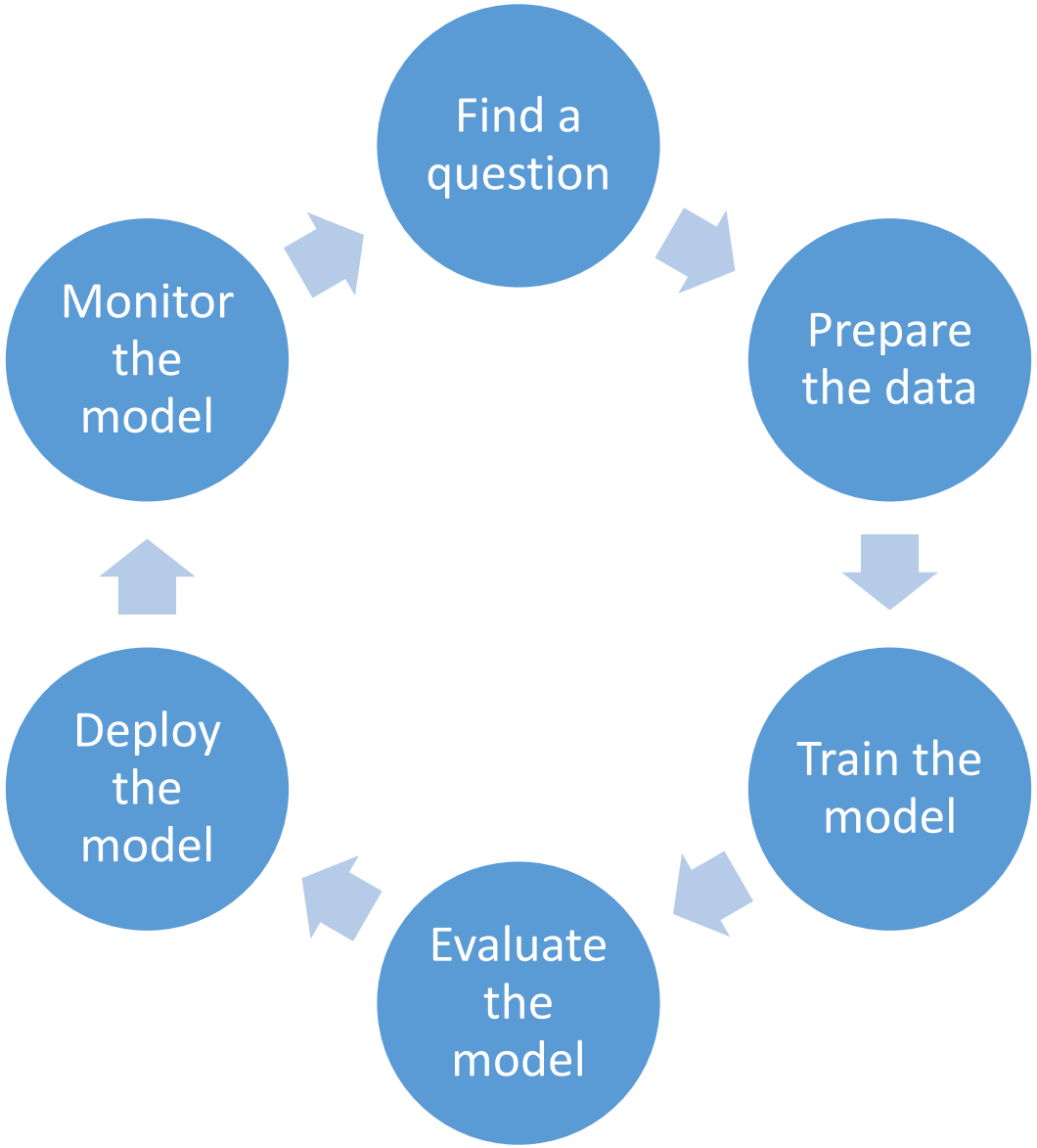
Find a question

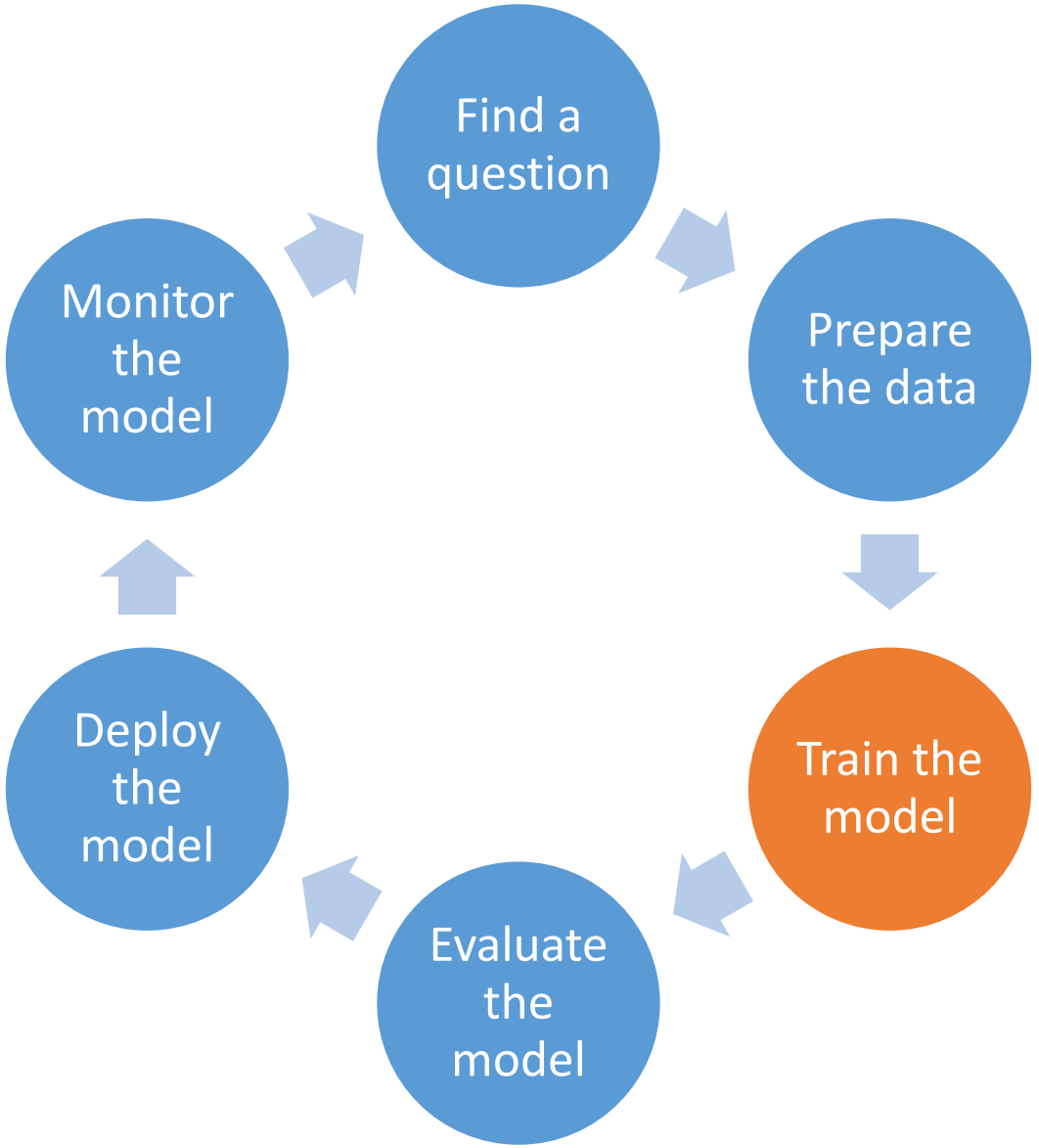

Find a question
Prepare the data

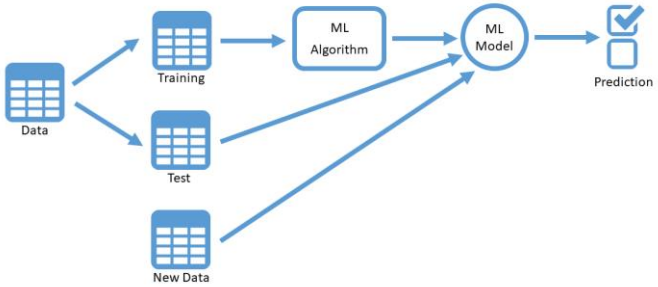

Find a question
Prepare the data
Train the model

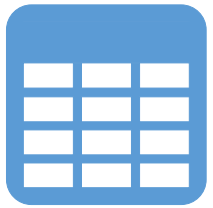

Find a question
Prepare the data
Train the model
Evaluate the model


Find a question
Prepare the data
Train the model
Evaluate the model
Deploy the model

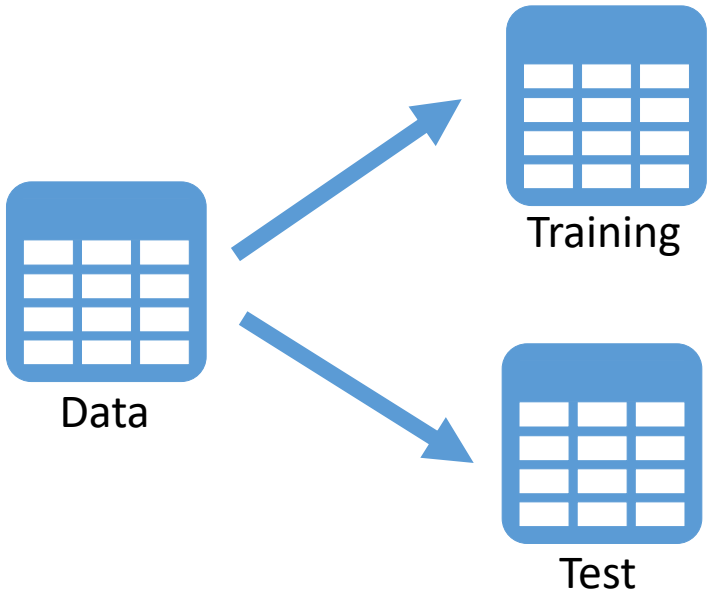

Find a question
Prepare the data
Train the model
Evaluate the model
Deploy the model
Monitor the model

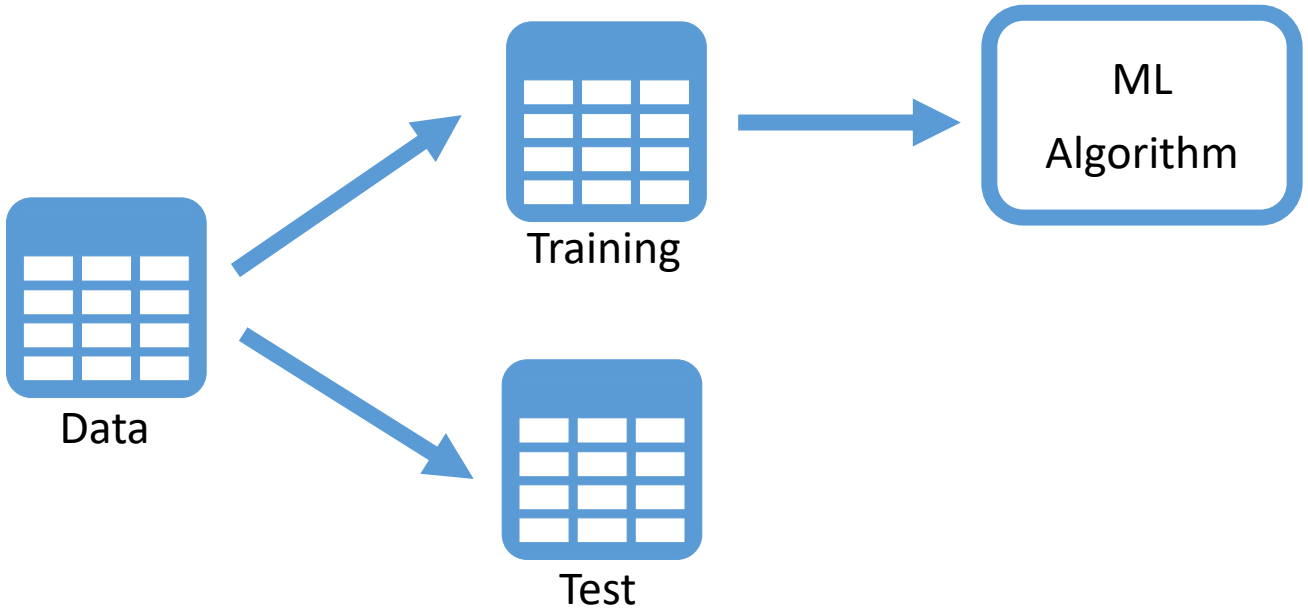

Find a question
Prepare the data
Train the model
Evaluate the model
Deploy the model
Monitor the model

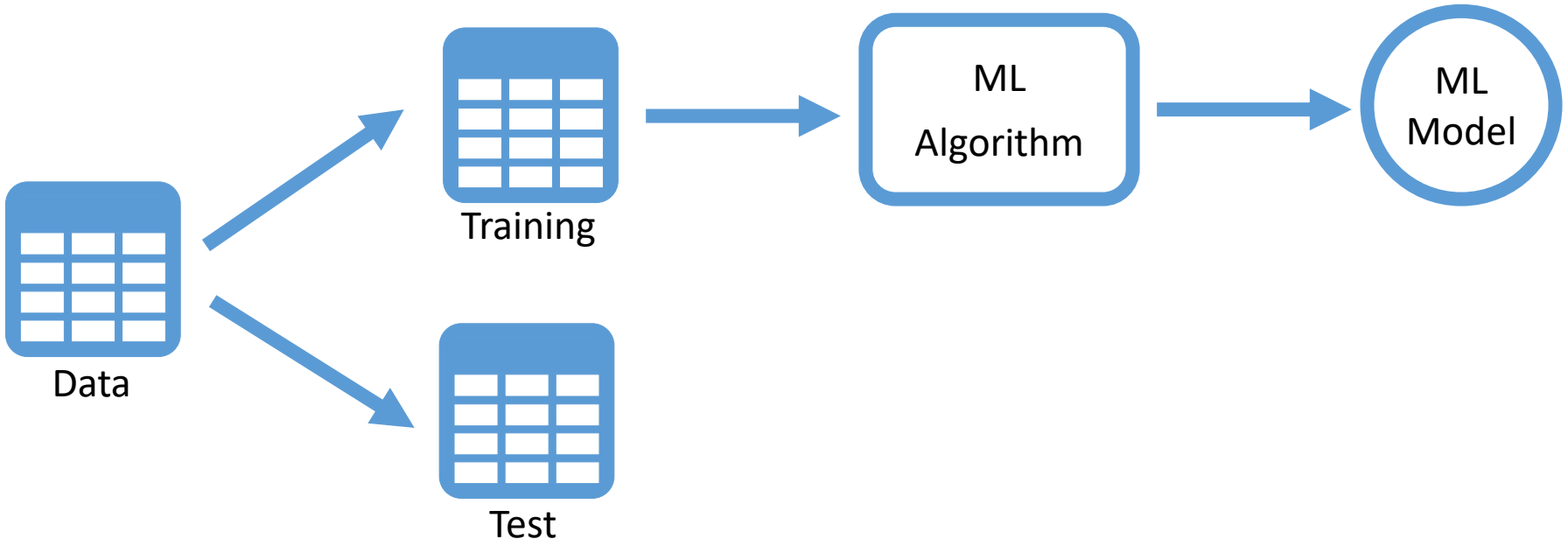

Data
Training
Test
New Data
ML Algorithm
ML Model
Prediction

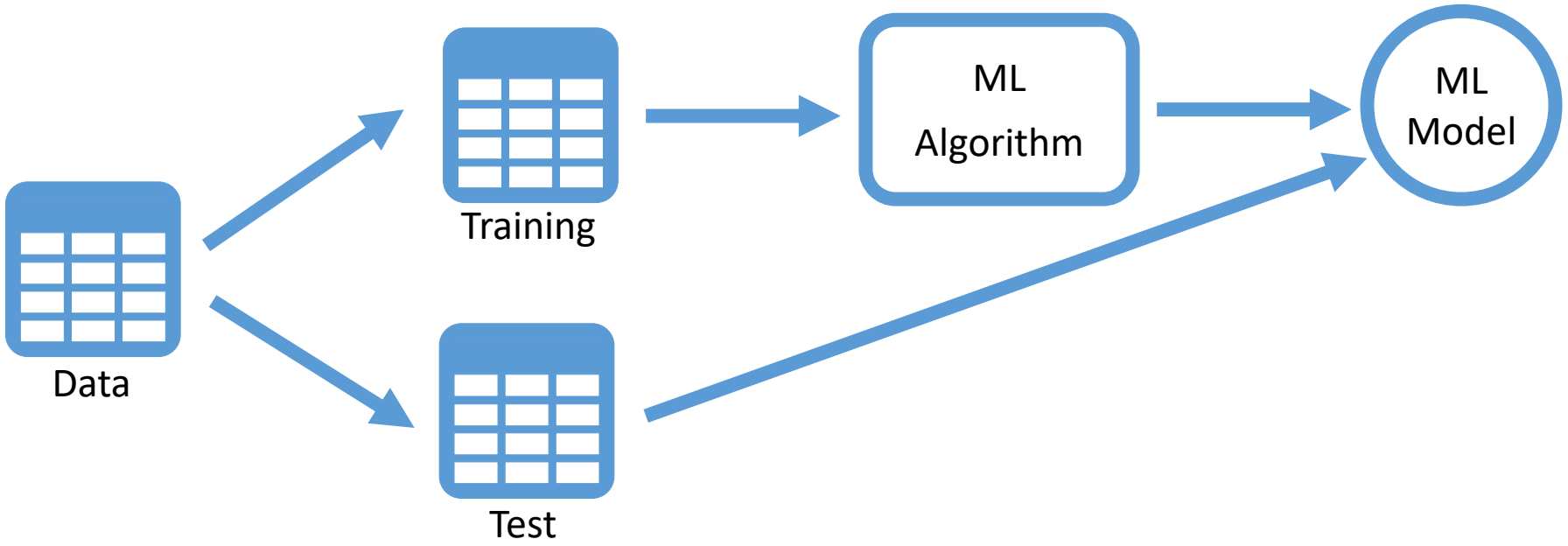


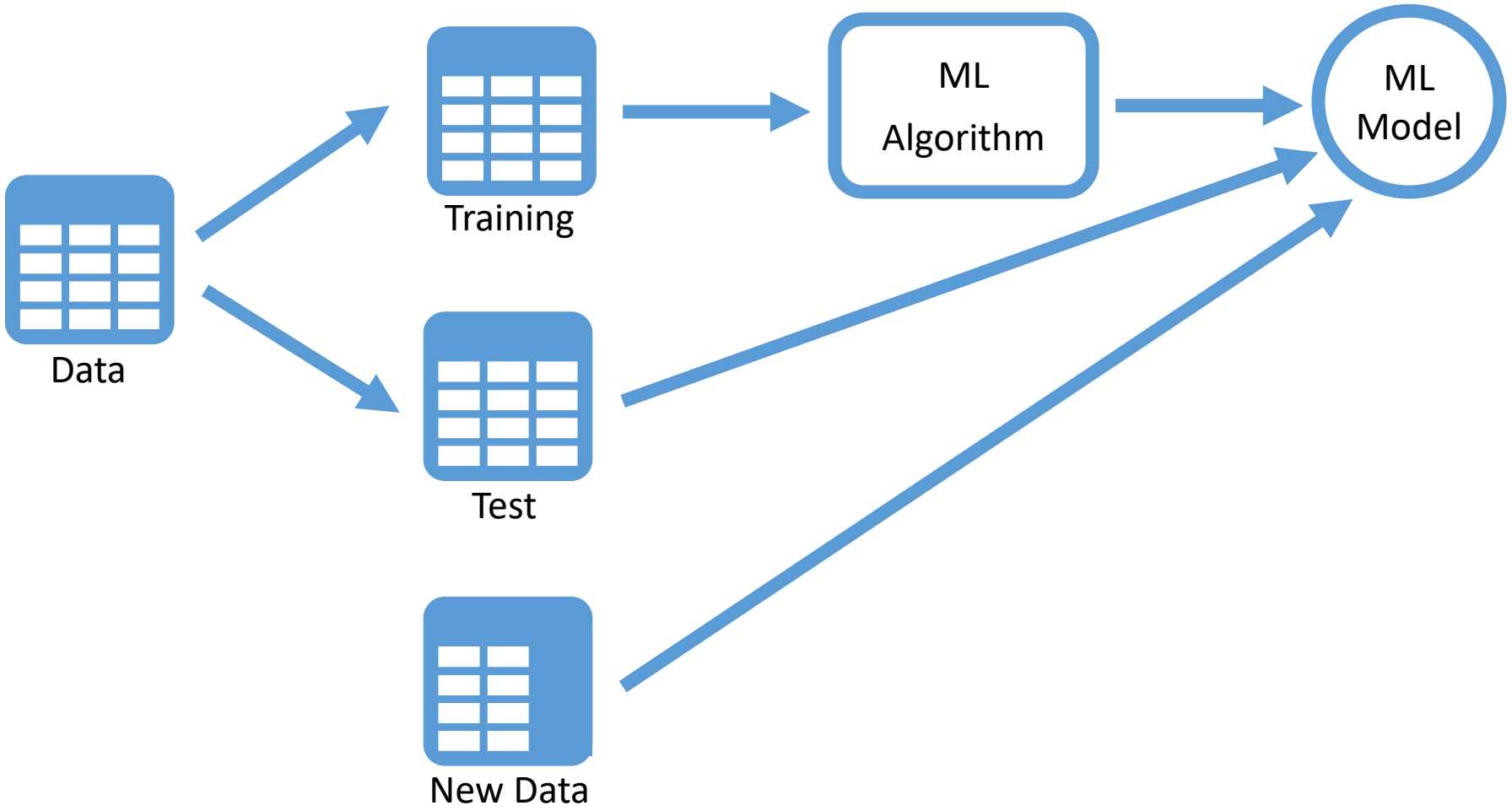
Data

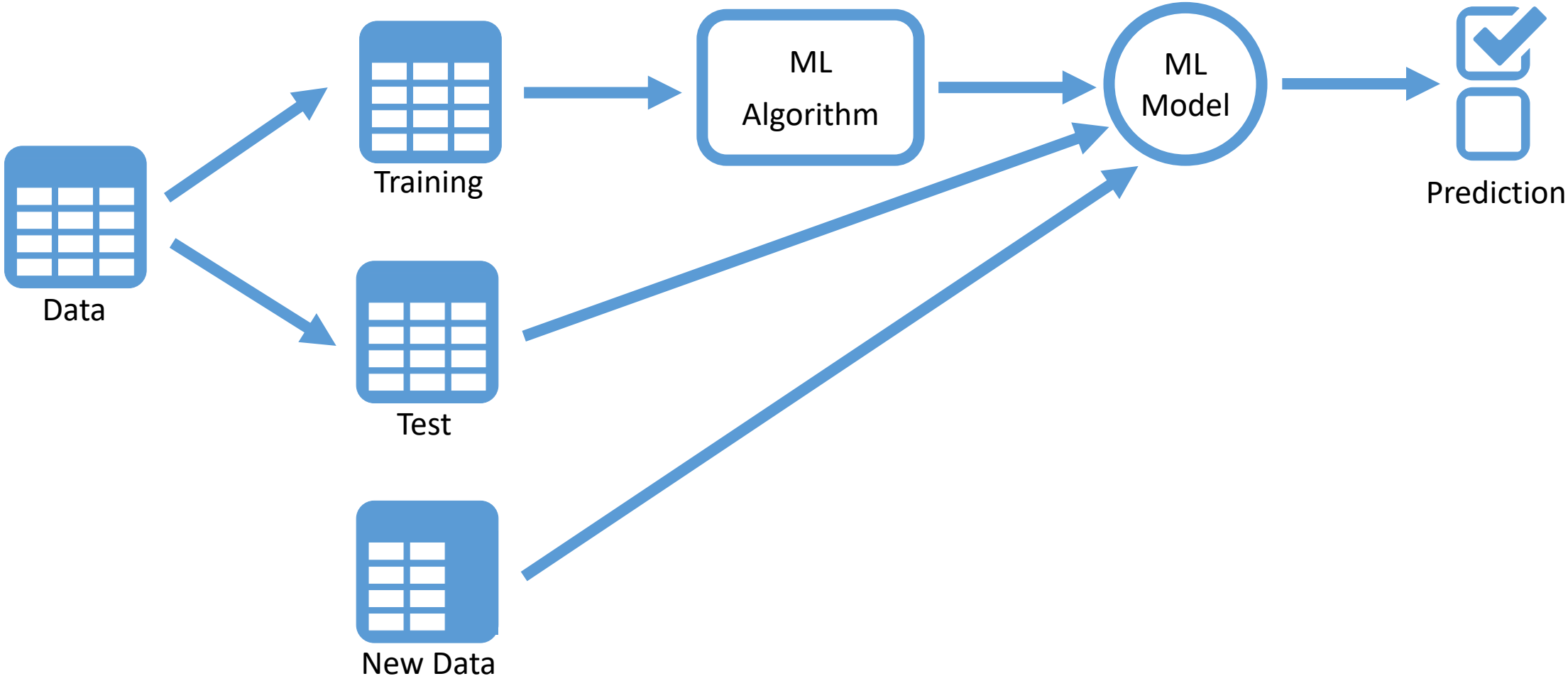

Training
Data
Test


Data
Training
Test
ML
Algorithm

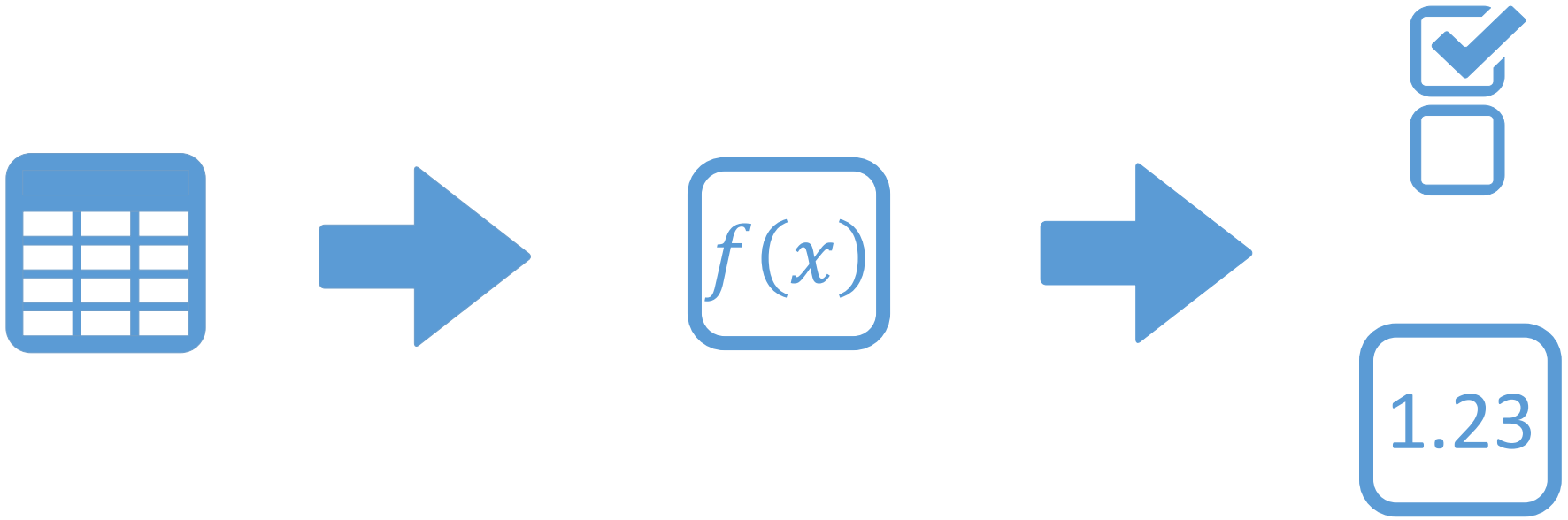

Data
Training
Test
ML
Algorithm
ML
Model

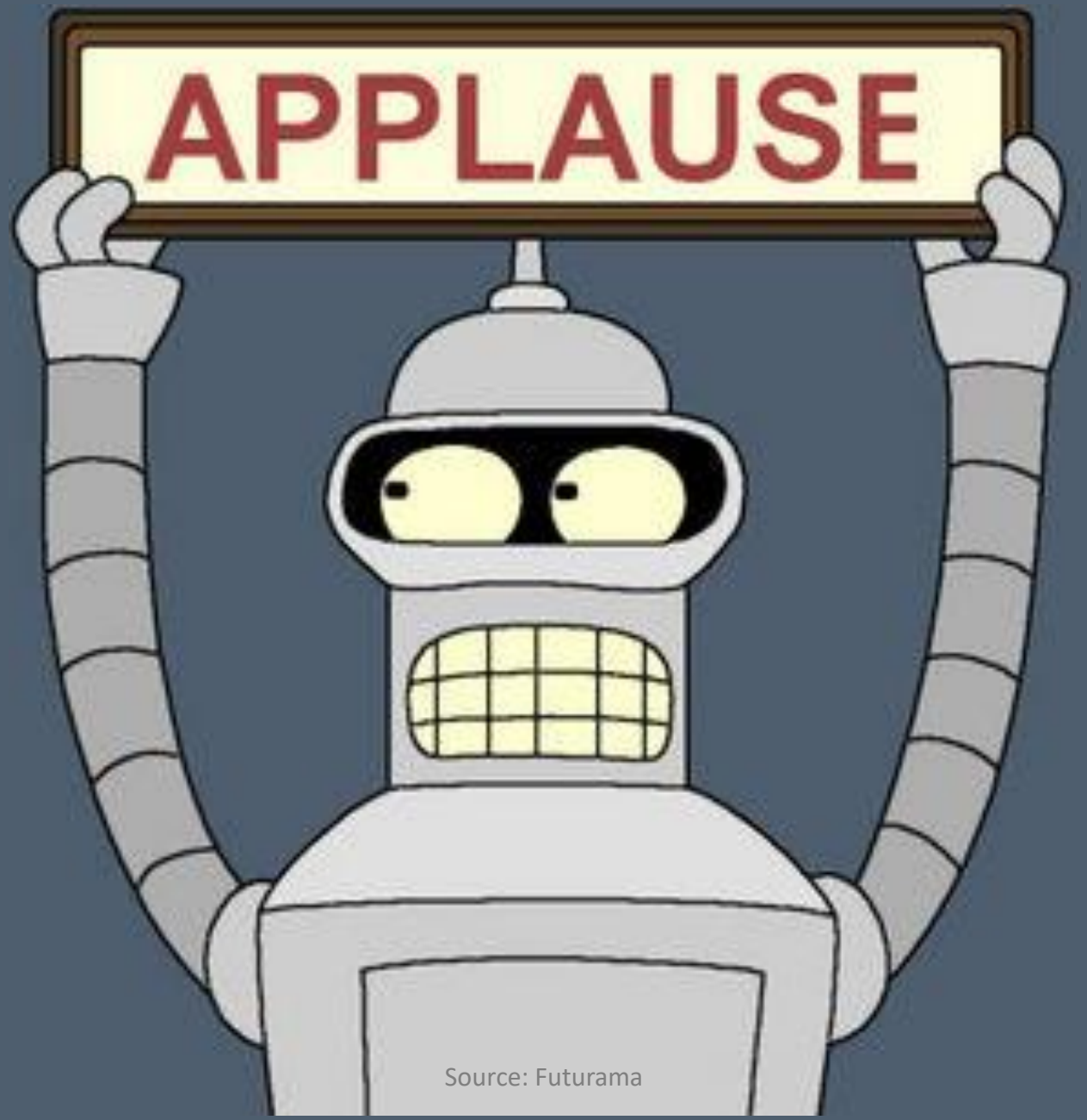

Data
Training
Test
ML
Algorithm
ML
Model


Data
Training
Test
New Data
ML
Algorithm
ML
Model


Data
Training
Test
New Data
ML
Algorithm
ML
Model
Prediction

What Can Machine Learning Do?


$f(x)$
1.23



Source: Futurama

Introduction to R

What is R?

Open source

Language and environment

Numerical and graphical analysis

Cross platform

What is R?

Active development

Large user community

Modular and extensible

9000+ extensions


FREE


FREE

RGui (64-bit)

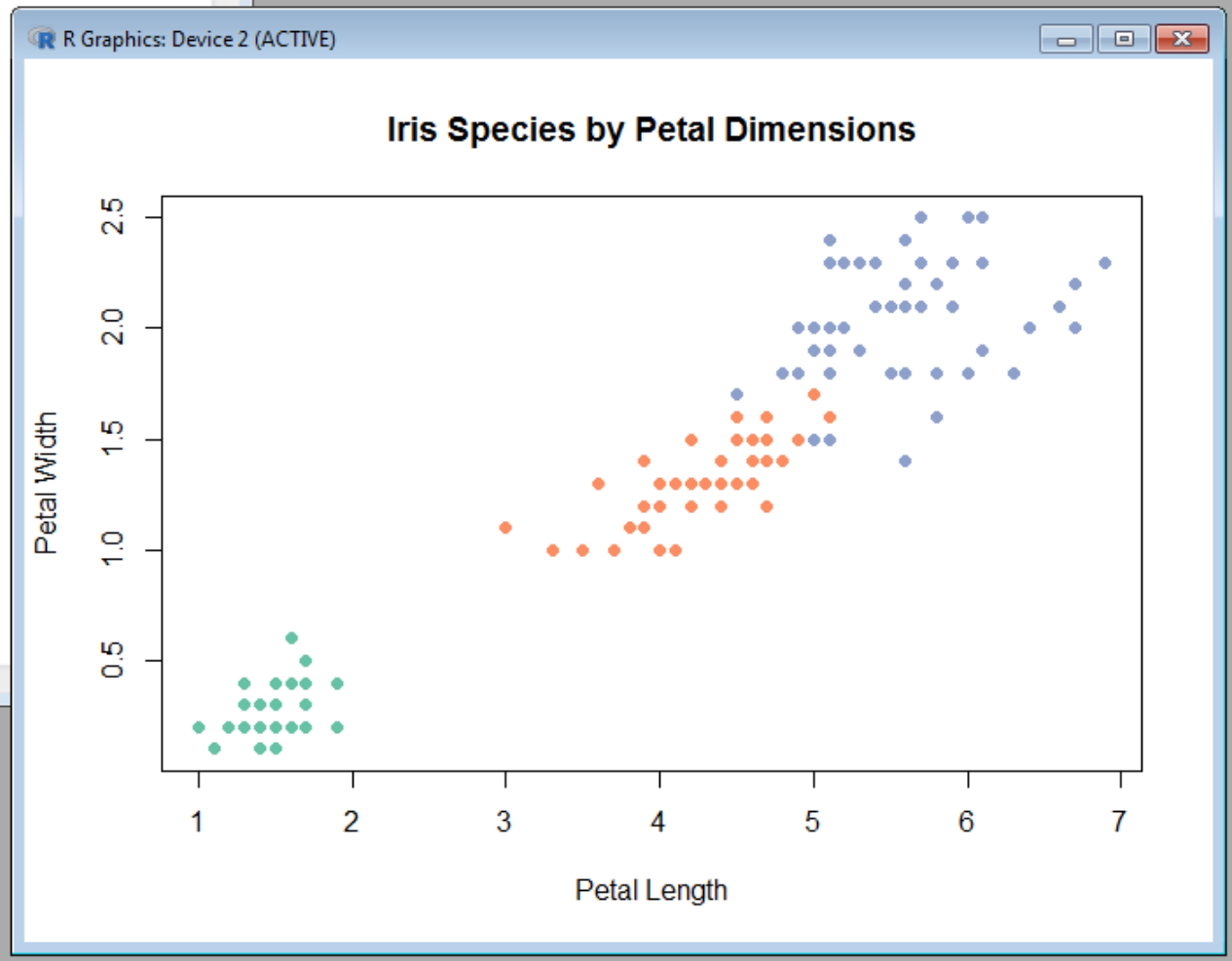
File History Resize Windows

R Console

```
> # Create a plot of species by dimension
> plot(
+     x = iris$Petal.Length,
+     y = iris$Petal.Width,
+     pch = 19,
+     col = palette[as.numeric(iris$Species)],
+     main = "Iris Species by Petal Dimensions",
+     xlab = "Petal Length",
+     ylab = "Petal Width")
>
> # Create a frequency table of species
> table(iris$Species)

    setosa versicolor  virginica
        50         50         50
>
> # Get the average petal length
> mean(iris$Petal.Length)
[1] 3.758
>
> # Get the correlation coefficient
> cor(
+     x = iris$Petal.Length,
+     y = iris$Petal.Width)
[1] 0.9628654
```

R Graphics: Device 2 (ACTIVE)



RStudio

File Edit Code View Plots Session Build Debug Tools Help

Go to file/function | Addins | Project: (None)

Script.R

Source on Save | Run | Source

```
16 # Create a frequency table of species
17 table(iris$Species)
18
19 # Get the average petal length
20 mean(iris$Petal.Length)
21
22 # Get the correlation coefficient
23 cor(
24     x = iris$Petal.Length,
25     y = iris$Petal.Width)
```

21:1 (Top Level) R Script

Console ~/

```
> table(iris$Species)

    setosa versicolor  virginica
        50         50         50
> # Get the average petal length
> mean(iris$Petal.Length)
[1] 3.758
> # Get the correlation coefficient
> cor(
+ x = iris$Petal.Length,
+ y = iris$Petal.Width)
[1] 0.9628654
>
```

Environment History

Import Dataset | List

Global Environment

Data

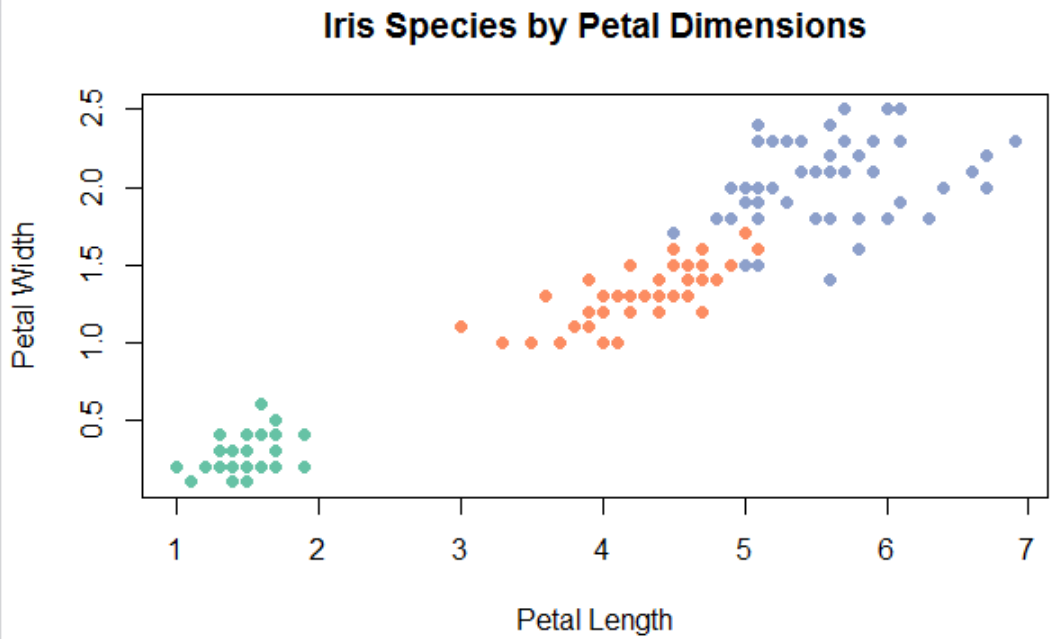
iris	150 obs. of 5 variables

Values

palette	chr [1:3] "#66C2A5" "#FC8D62" "#8DA0C…

Files Plots Packages Help Viewer

Zoom | Export | Publish



Script.R - Microsoft Visual Studio

File Edit View NCrunch Project Debug Team Tools Architecture Test ReSharper R Tools Analyze Window Help

Matthew Renze

Quick Launch (Ctrl+Q)

Attach...

Script.R

```
        main = "Iris Species by Petal Dimensions",
        xlab = "Petal Length",
        ylab = "Petal Width")

# Create a frequency table of species
table(iris$Species)

# Get the average petal length
mean(iris$Petal.Length)

# Get the correlation coefficient
cor(
    x = iris$Petal.Length,
    y = iris$Petal.Width)
```

100 %

R Interactive

Attach Debugger

```
> # Create a frequency table of species
> table(iris$Species)

    setosa versicolor  virginica
        50         50         50
> # Get the average petal length
> mean(iris$Petal.Length)
[1] 3.758
> # Get the correlation coefficient
> cor(
+     x = iris$Petal.Length,
+     y = iris$Petal.Width)
[1] 0.9628654
>
```

100 %

Variable Explorer

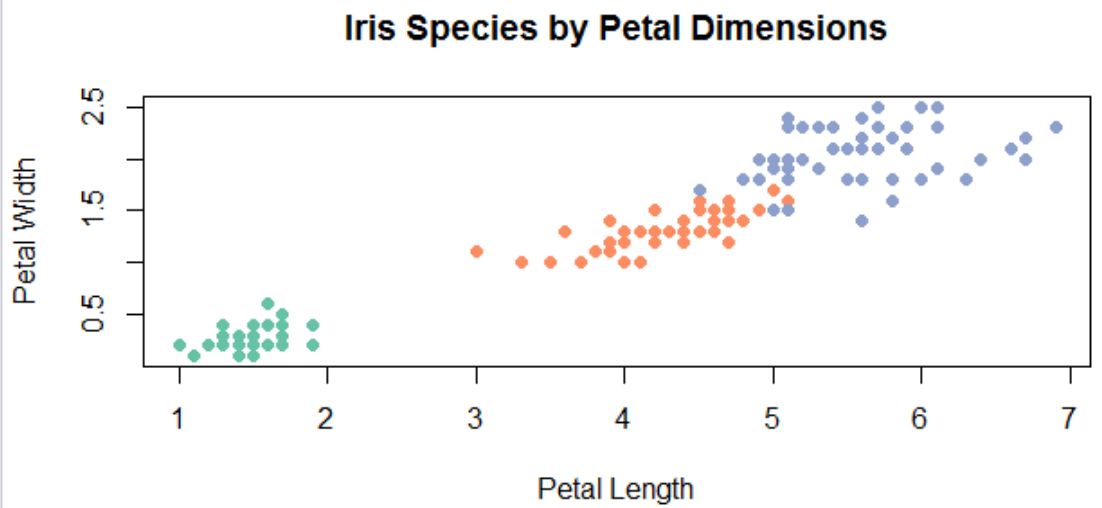
Search

.GlobalEnv

Name	Value	Class	Type
iris	150 obs. of 5 variables	data.frame	list
palette	chr [1:3] "#66C2A5" "#FC8D62" "#8DA0CB"	character	character

Variable Explorer | R History

R Plot



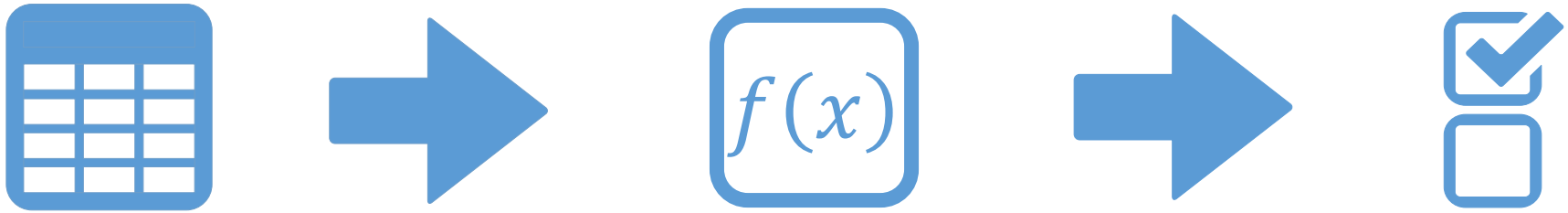
Solution Explorer | R Plot | R Package Manager | R Help

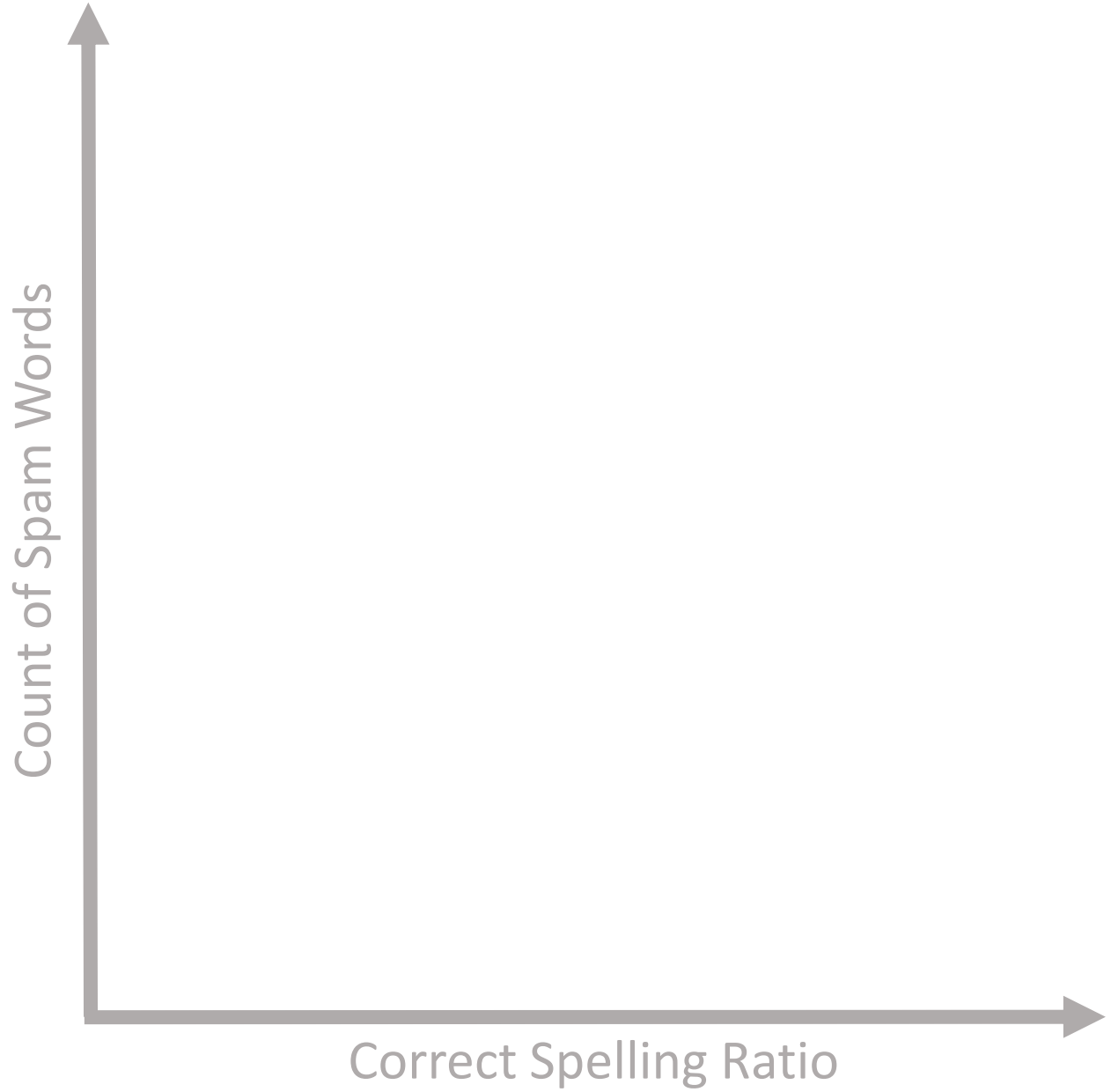
Error List | Output | Azure App Service Activity

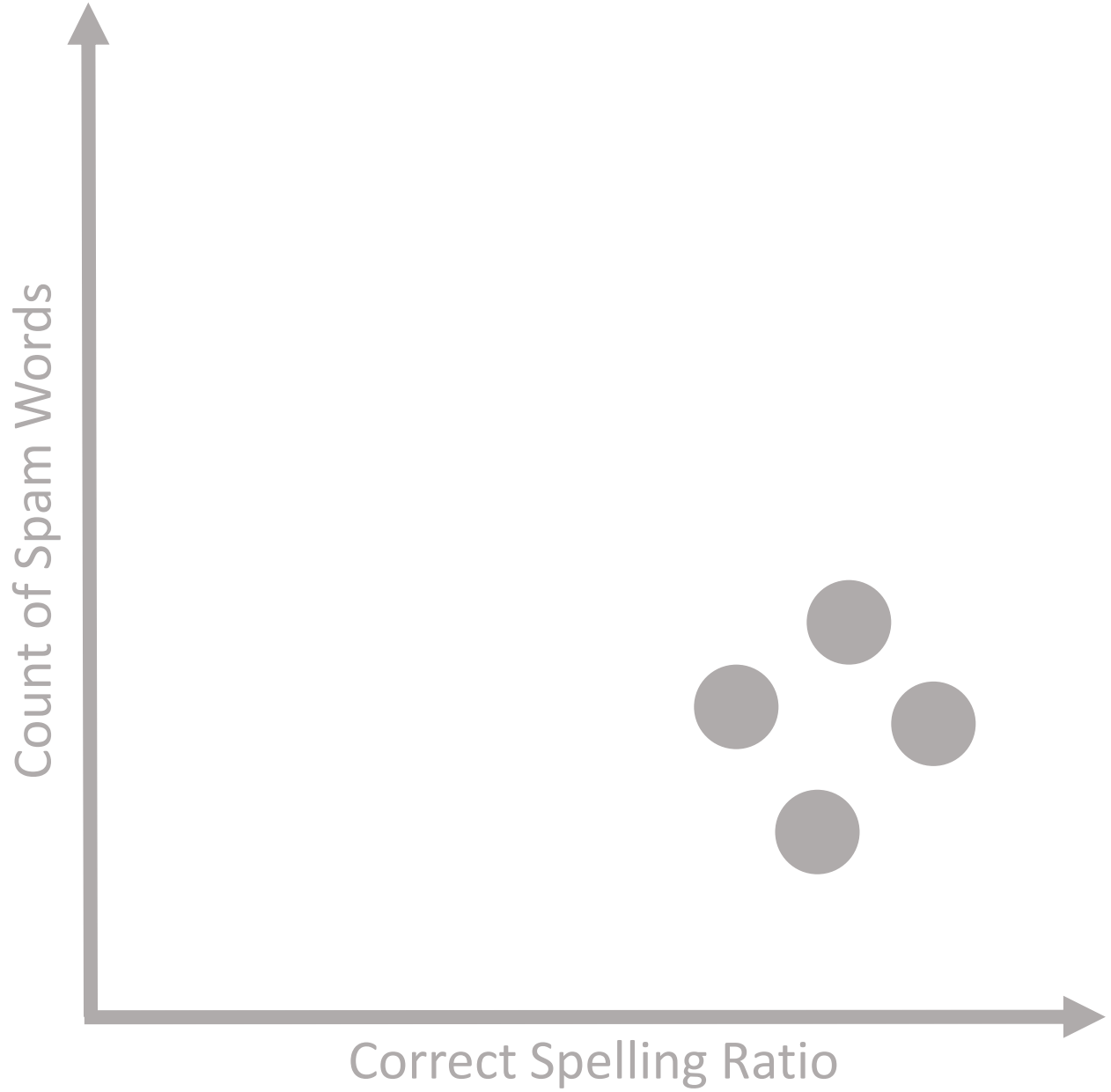
Ready | Ln 30 | Col 1 | Ch 1 | INS | 7 | 0 | Root | master

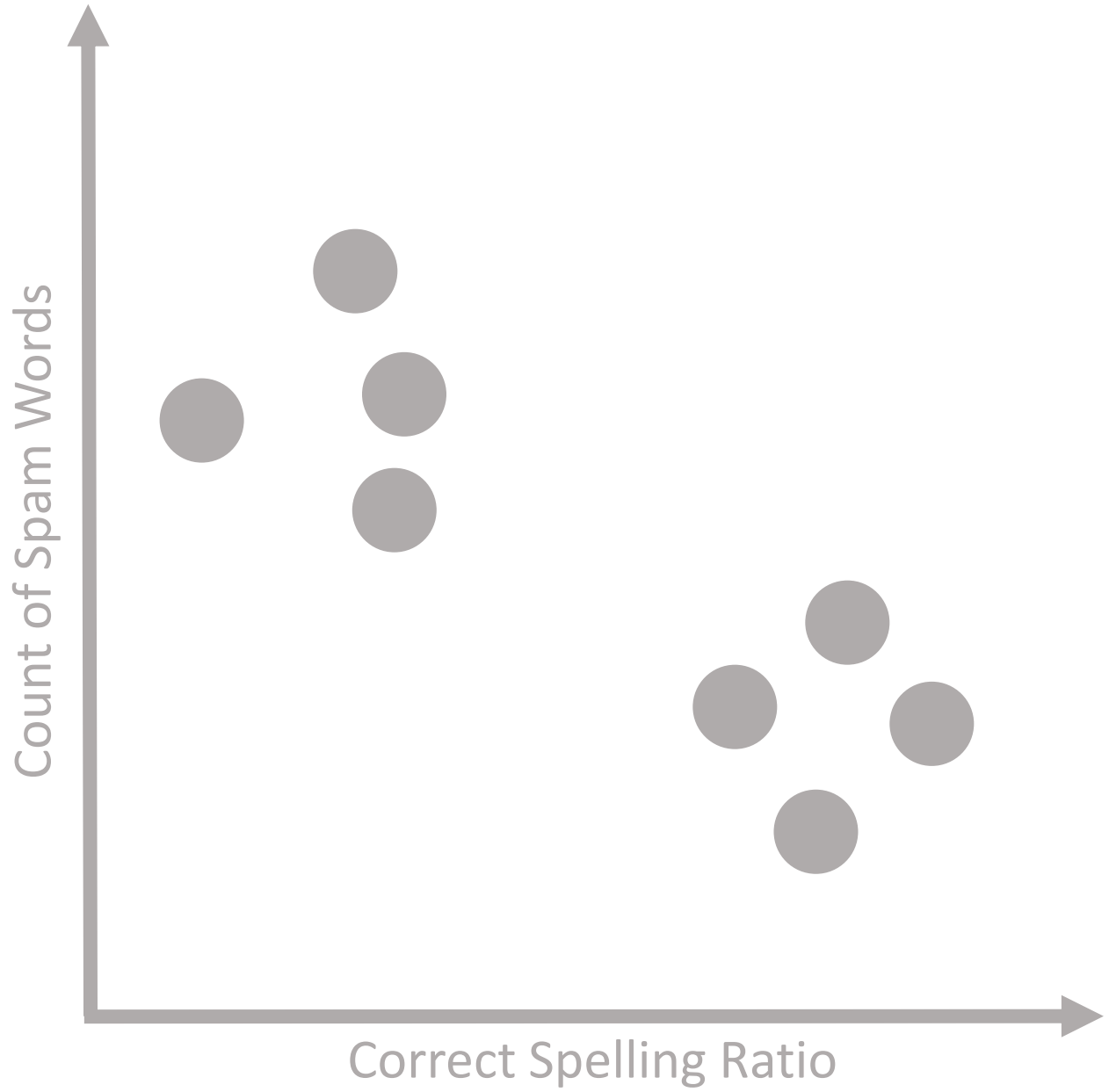
Code Demo

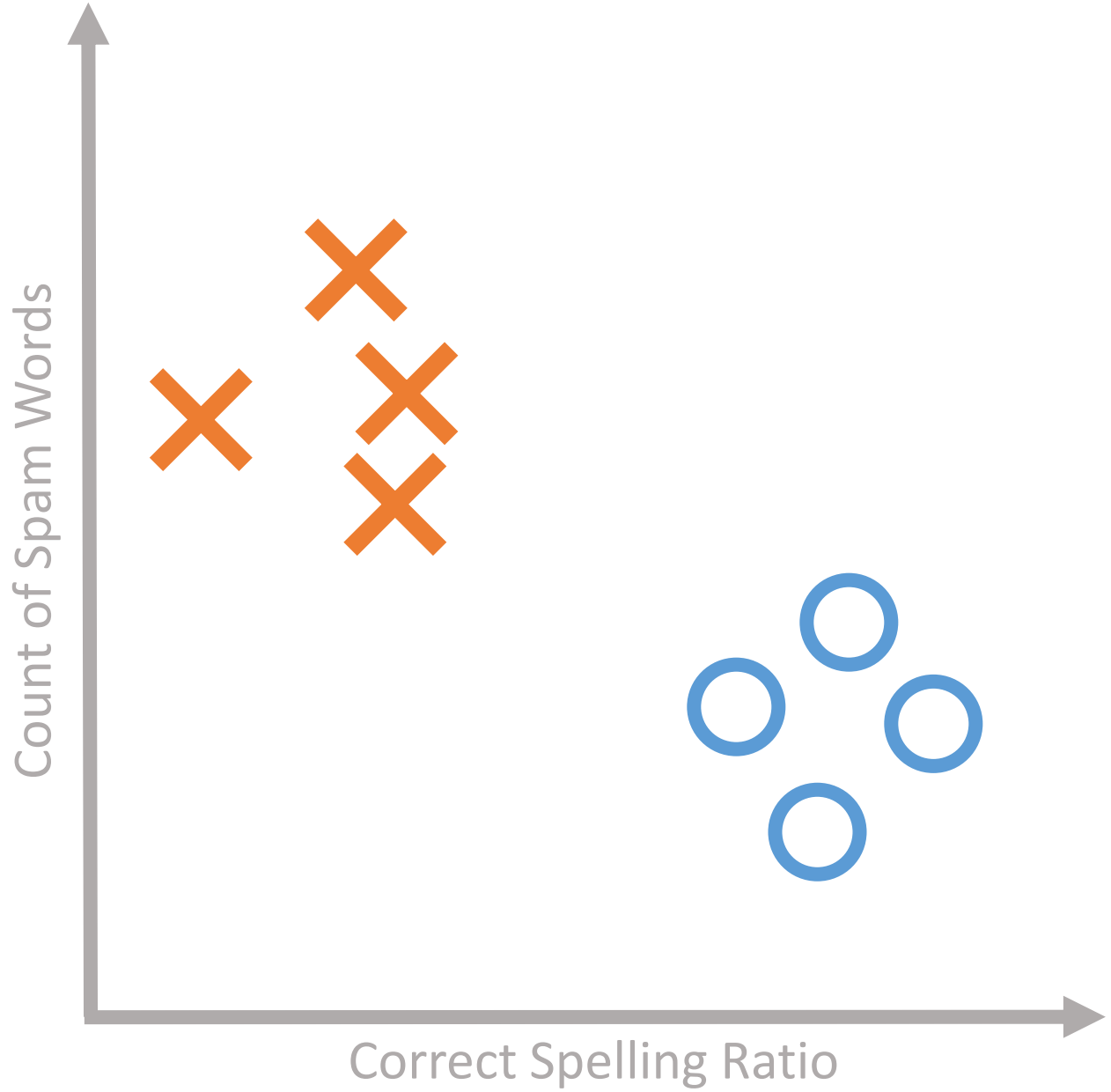
Classification

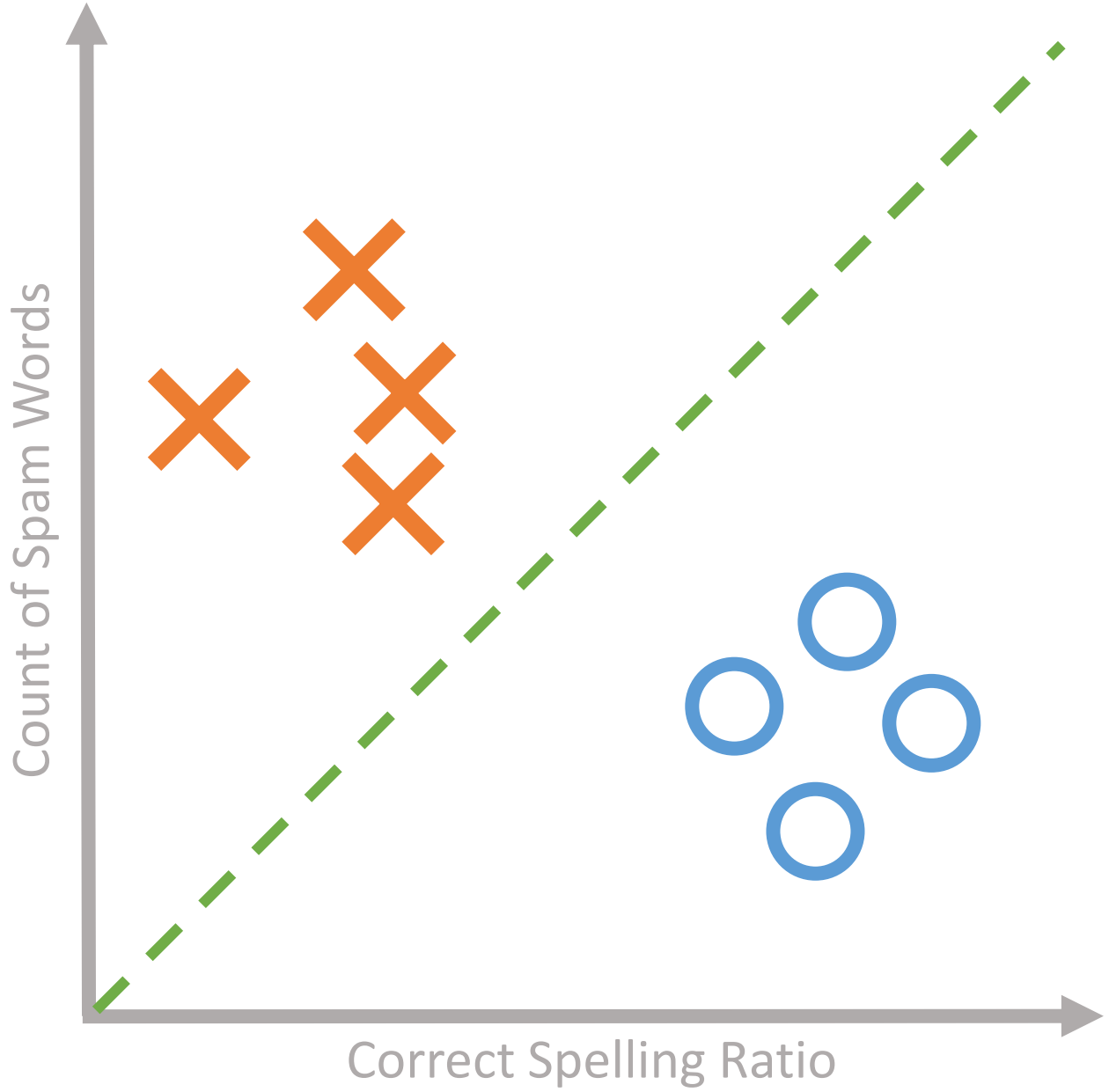

$f(x)$

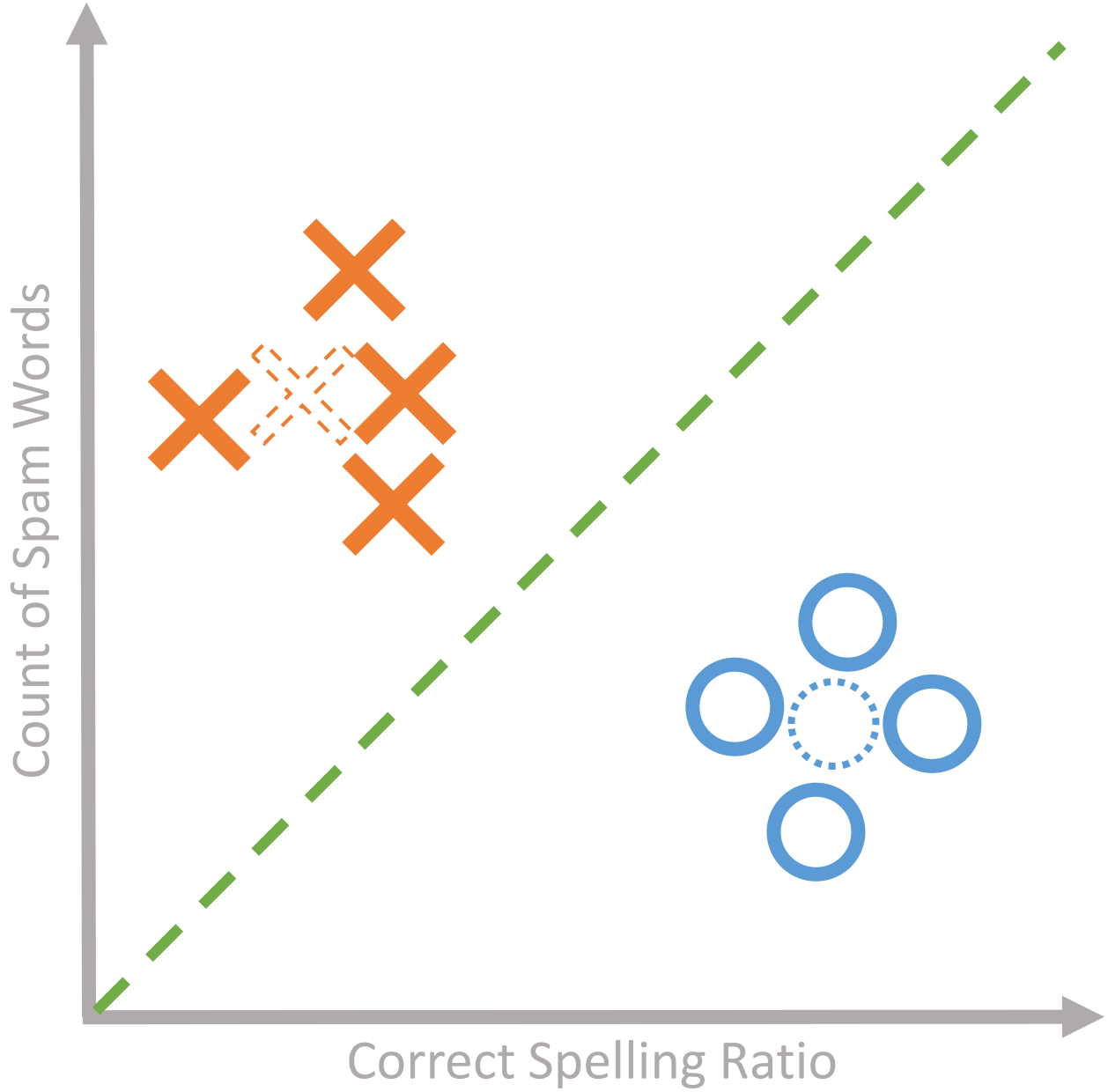

Count of Spam Words
Correct Spelling Ratio


Count of Spam Words
Correct Spelling Ratio


Count of Spam Words
Correct Spelling Ratio


Count of Spam Words
Correct Spelling Ratio


Count of Spam Words
Correct Spelling Ratio


Count of Spam Words
Correct Spelling Ratio

Classification Algorithms

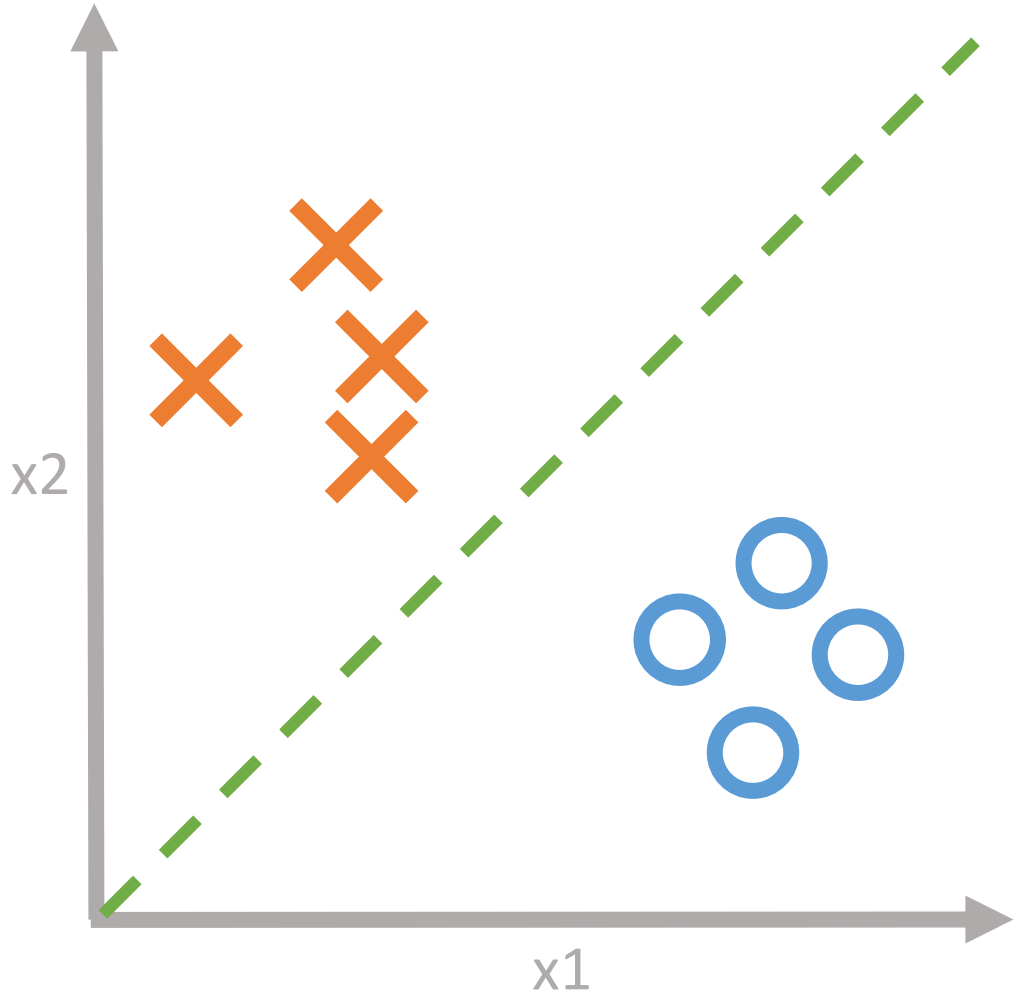
k-Nearest Neighbor Classifier

Decision Tree Classifier

Naïve Bayes Classifier

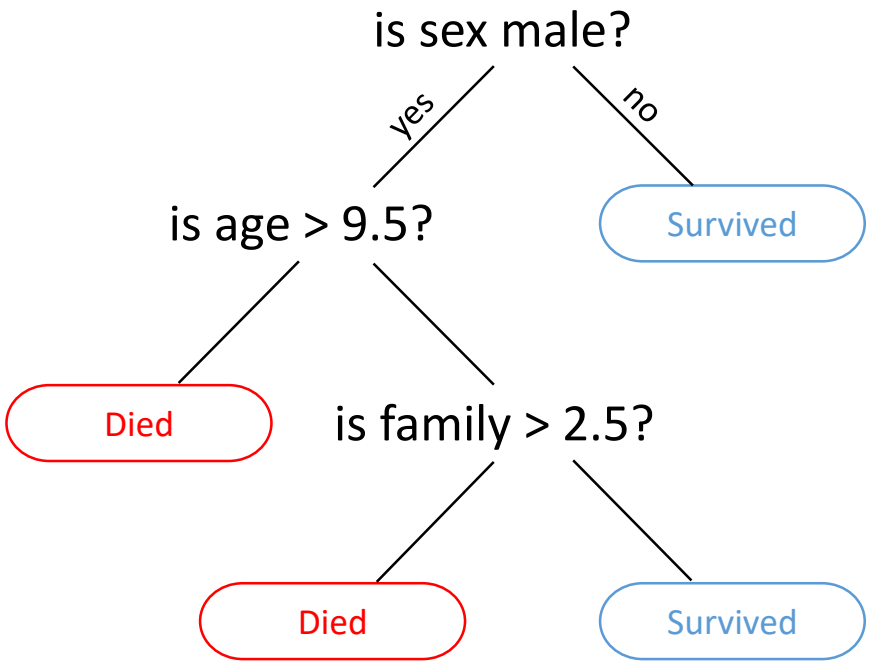
Support Vector Machine

Neural Network Classifier



Decision Tree Classifier

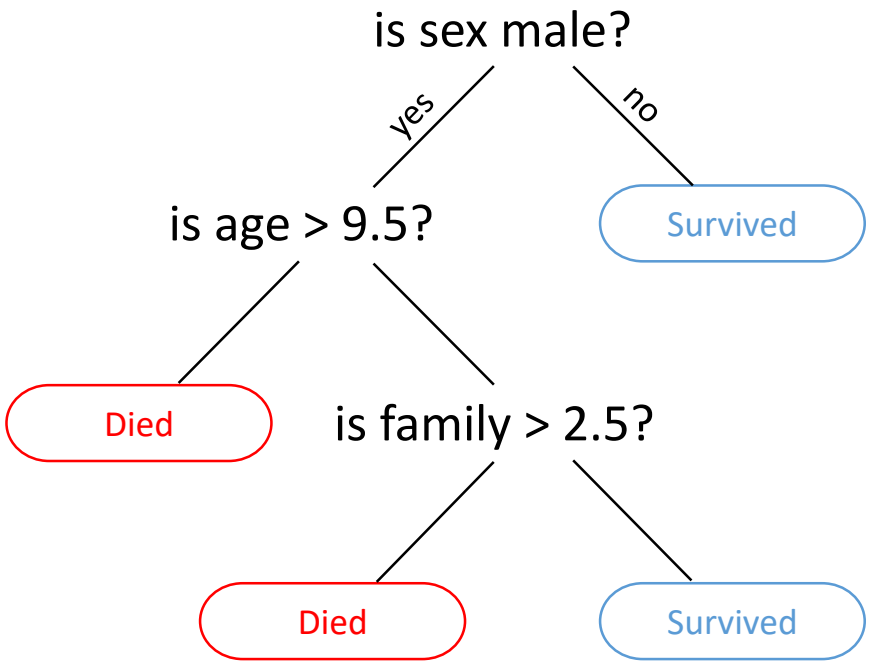
Supervised learning



Decision Tree Classifier

Supervised learning

Tree of decisions

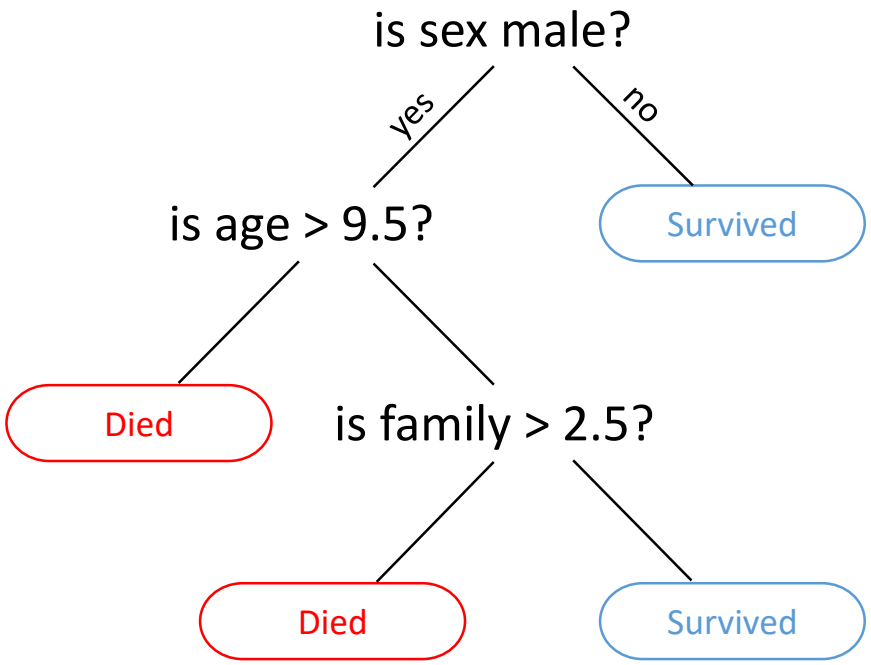


Decision Tree Classifier

Supervised learning

Tree of decisions

Information gain



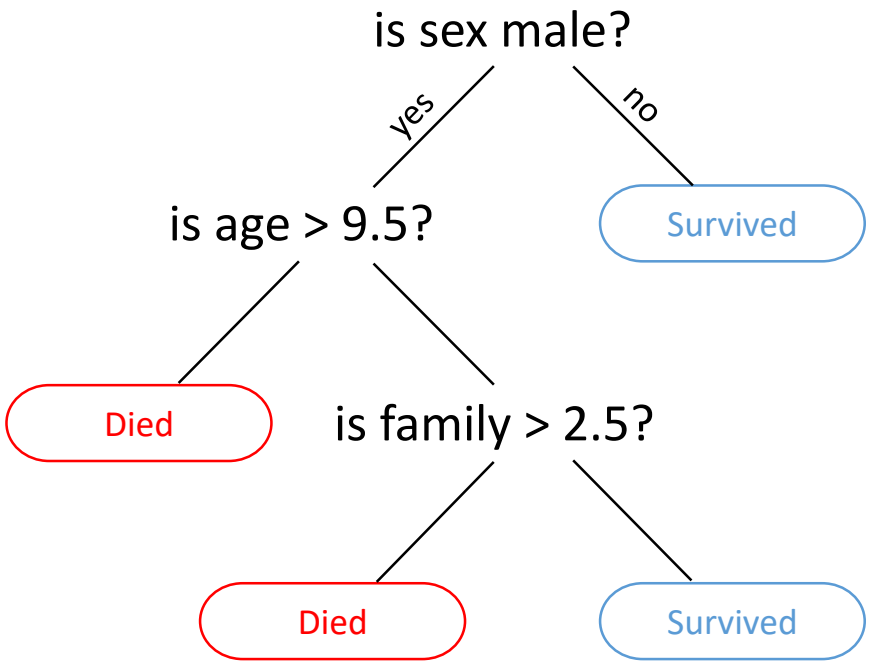
Decision Tree Classifier

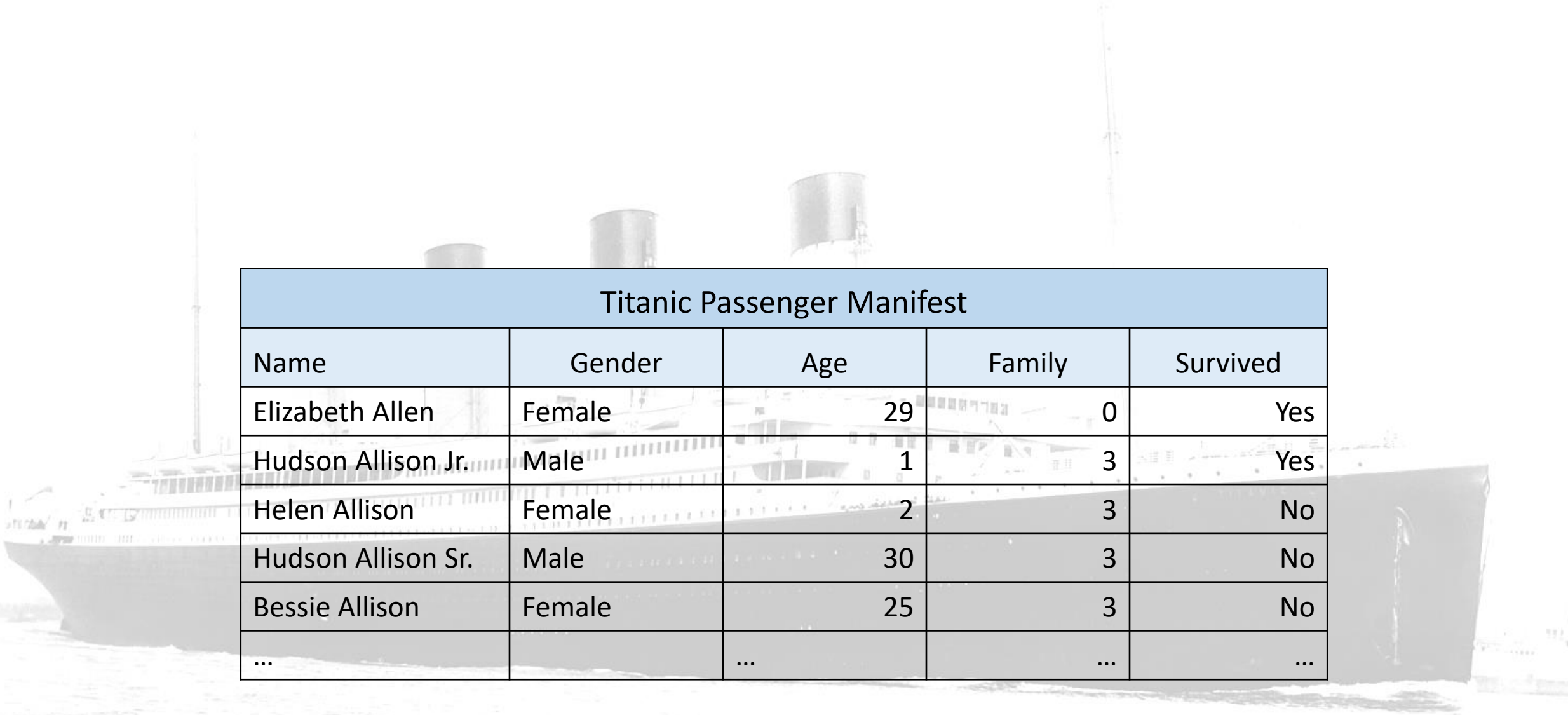
Supervised learning

Tree of decisions

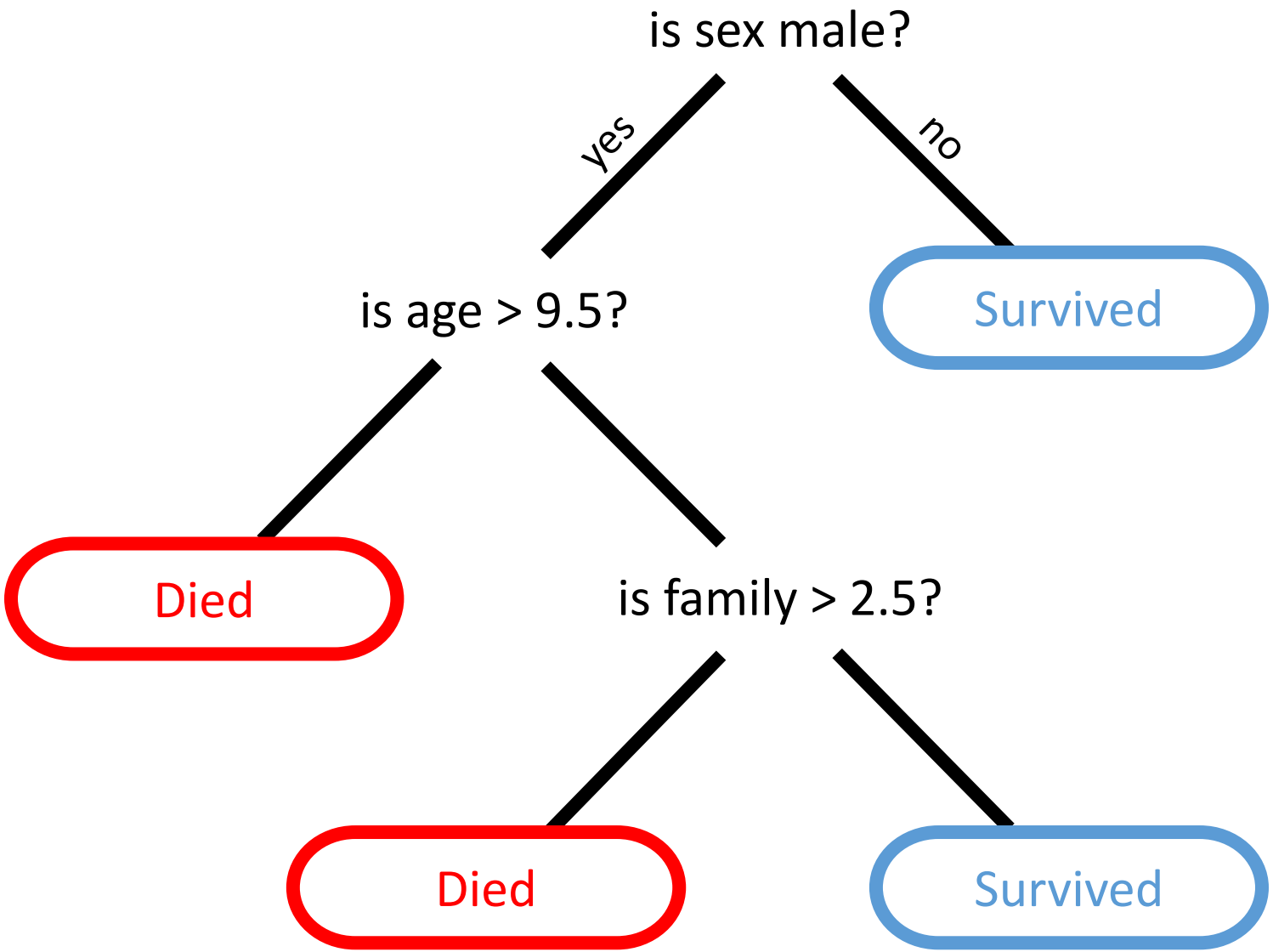
Information gain

Simple and easy



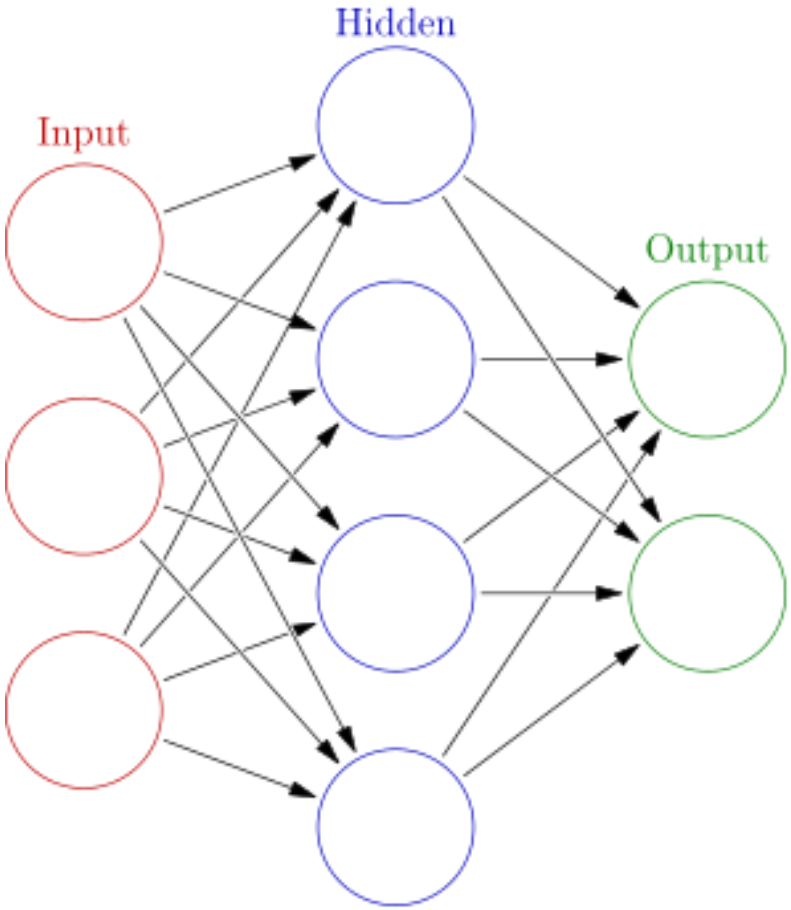


Titanic Passenger Manifest				
Name	Gender	Age	Family	Survived
Elizabeth Allen	Female	29	0	Yes
Hudson Allison Jr.	Male	1	3	Yes
Helen Allison	Female	2	3	No
Hudson Allison Sr.	Male	30	3	No
Bessie Allison	Female	25	3	No
…		…	…	…


is sex male?
yes
no
is age > 9.5?
Survived
Died
is family > 2.5?
Died
Survived

Neural Network Classifier

Supervised learning

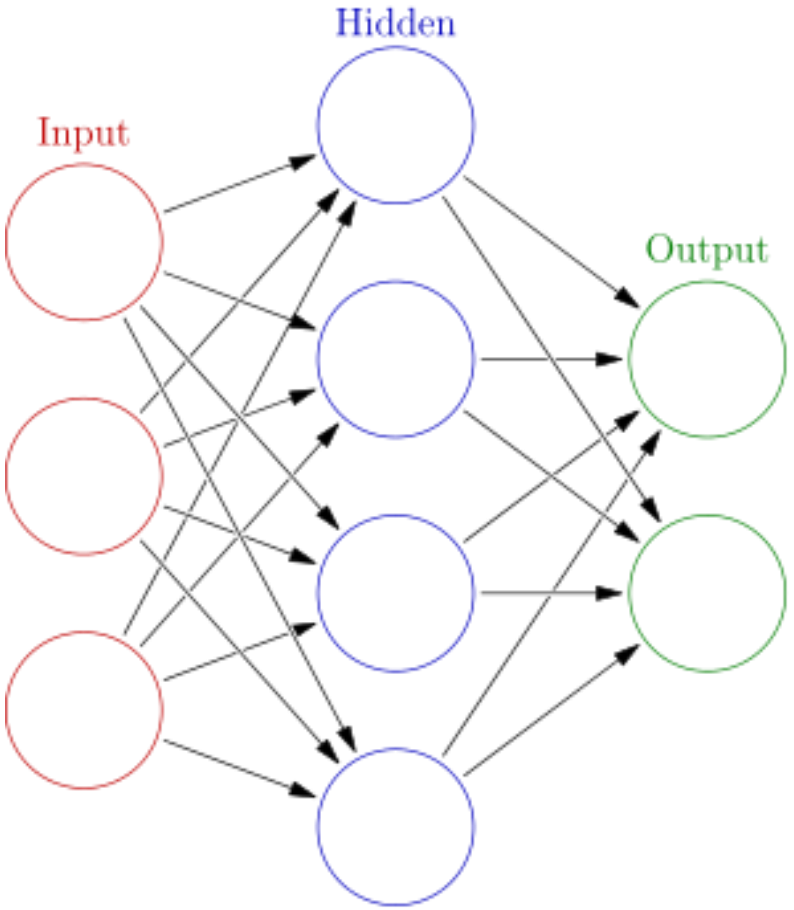


Source: Wikipedia

Neural Network Classifier

Supervised learning

Neurons in a brain



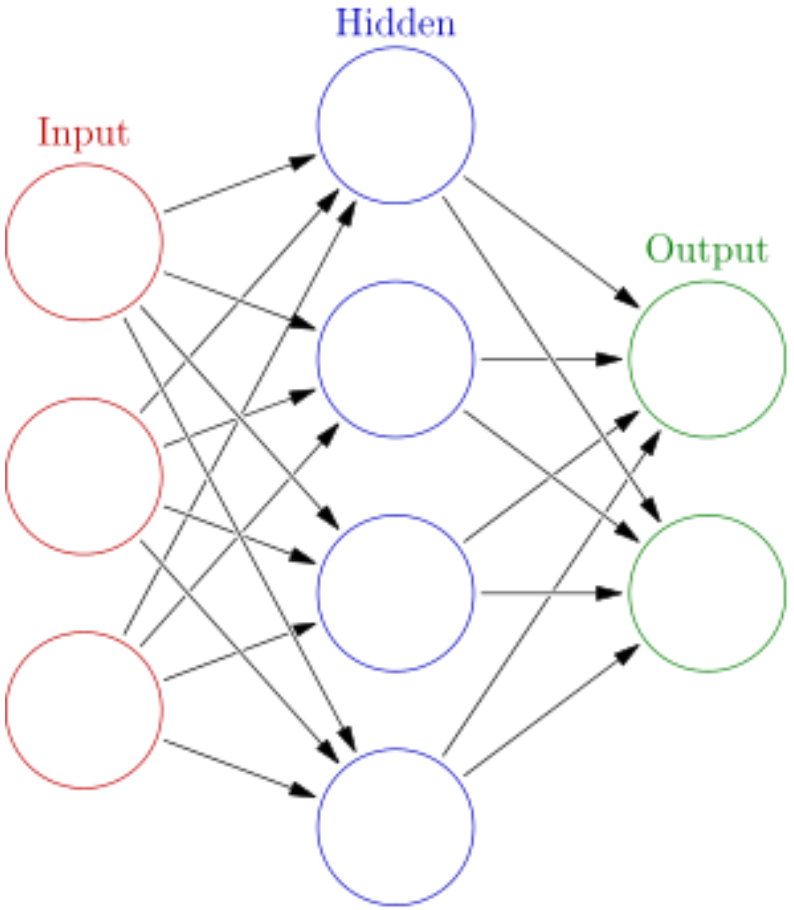
Source: Wikipedia

Neural Network Classifier

Supervised learning

Neurons in a brain

Complex



Source: Wikipedia

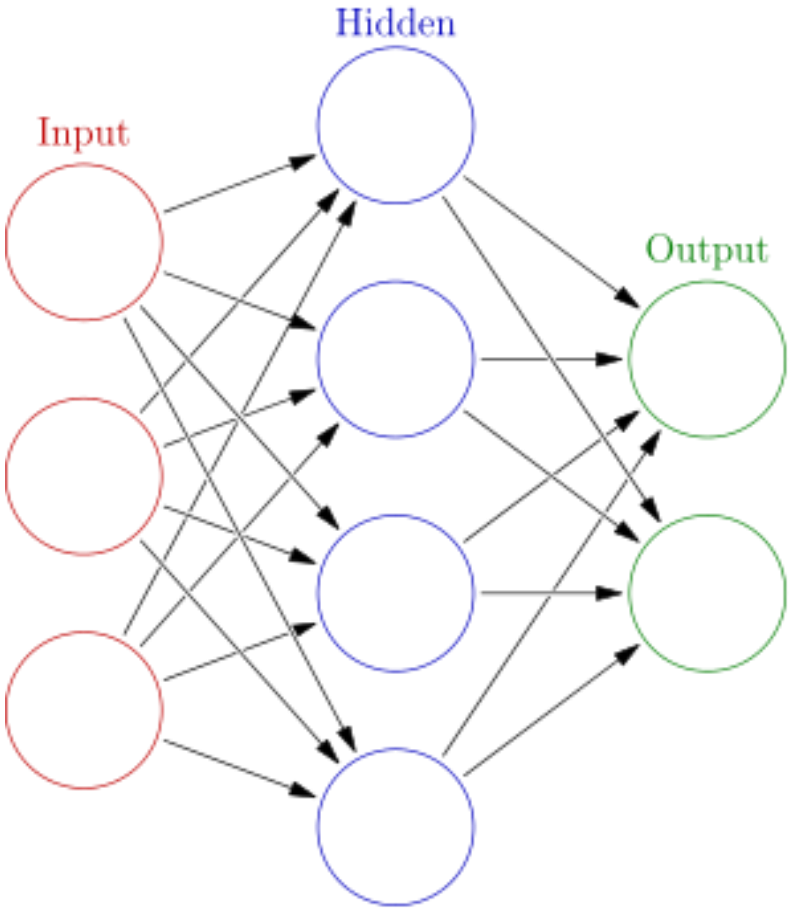
Neural Network Classifier

Supervised learning

Neurons in a brain

Complex

Not transparent



Source: Wikipedia

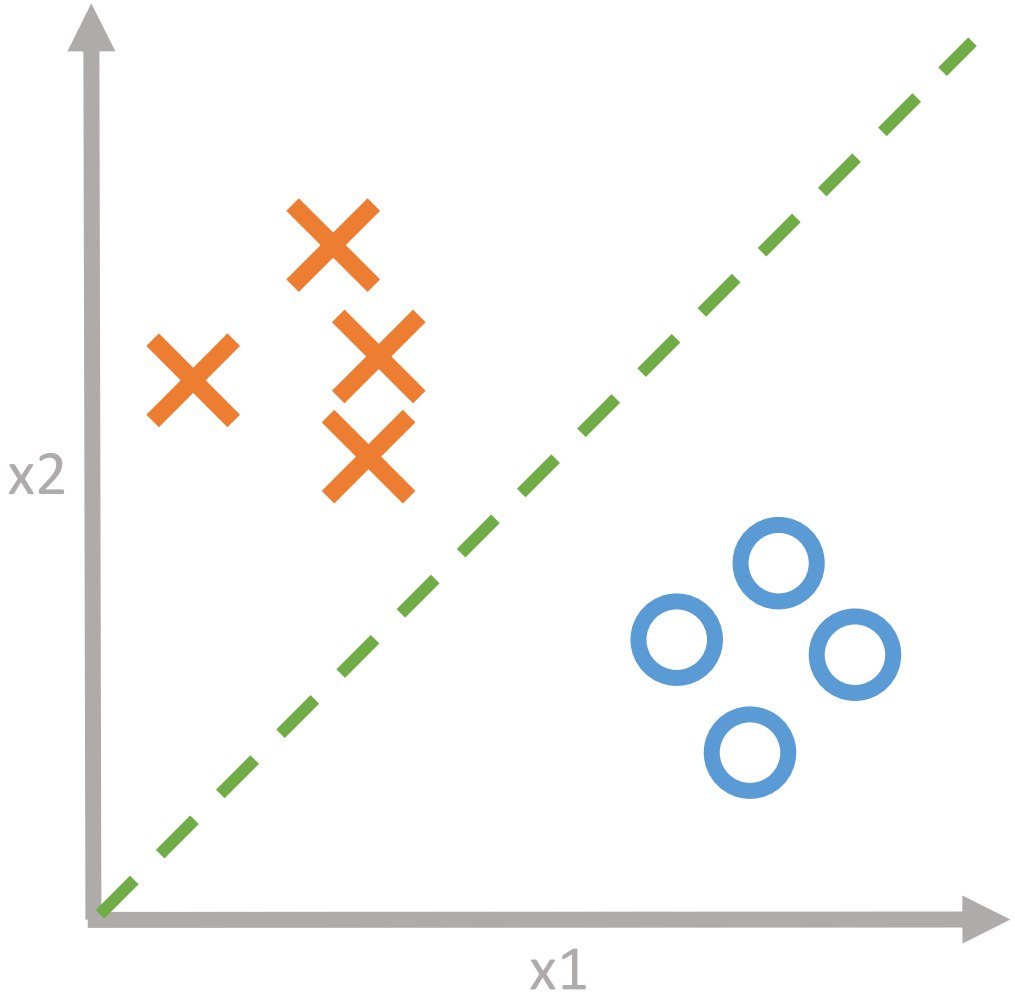
Real-World Examples

Should we approve this loan?

Will this customer buy from us?

Should we replace this part?

Does this person have cancer?



Iris Data Set

Iris Setosa

Iris Versicolor

Iris Virginica

Photos by Radomił Binek, Danielle Langlois, and Frank Mayfield

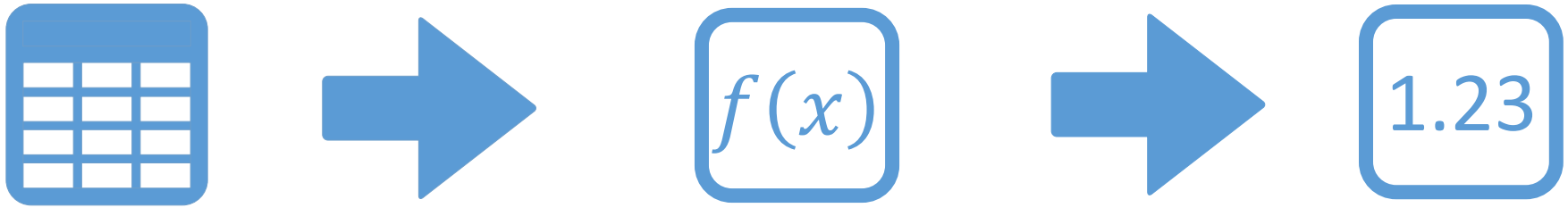
Iris Data Set

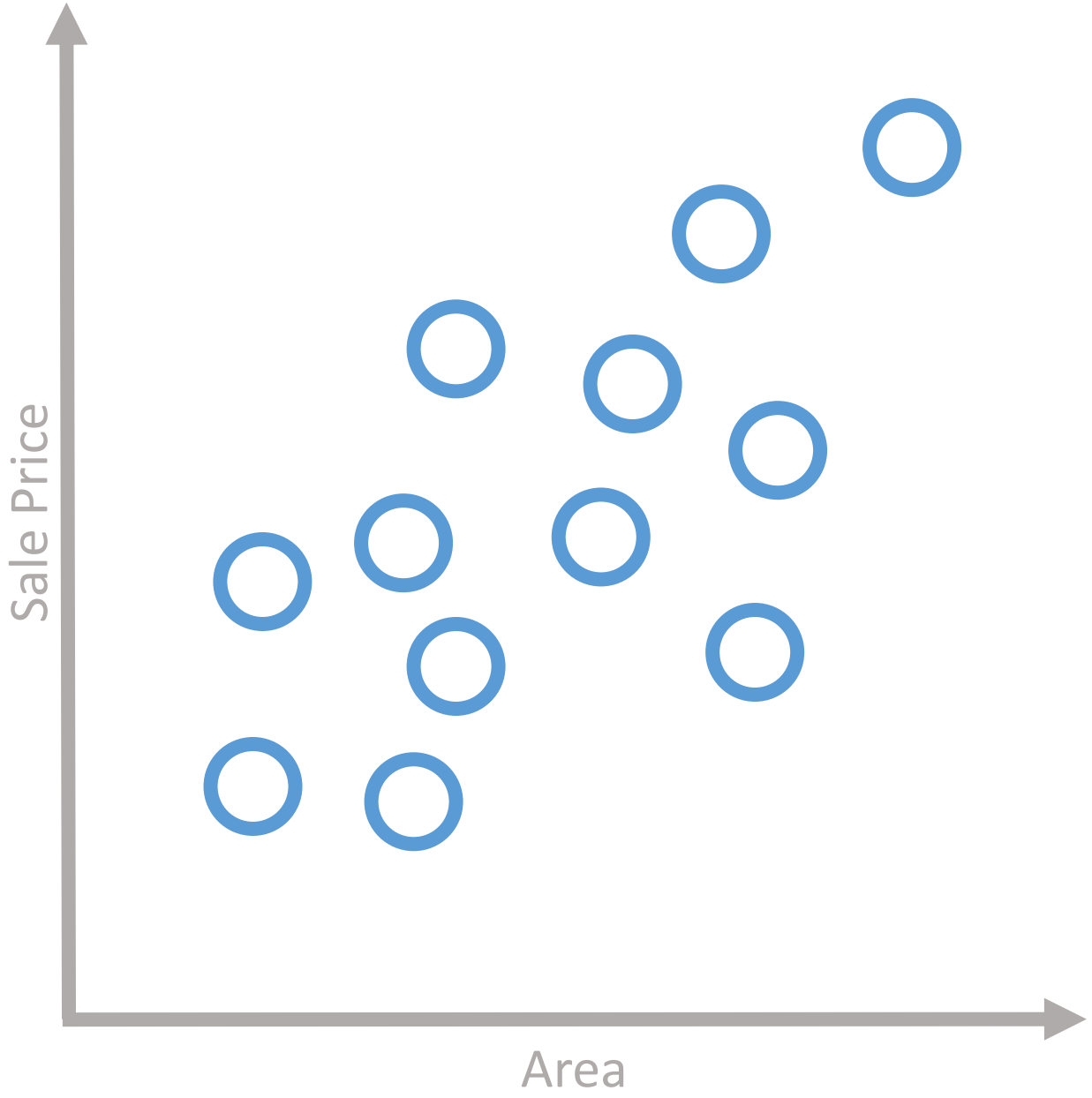
Fisher's Iris Data				
Species	Petal Length	Petal Width	Sepal Length	Sepal Width
setosa	1.1	0.1	4.3	3
setosa	1.4	0.2	4.4	2.9
setosa	1.3	0.2	4.4	3
setosa	1.3	0.2	4.4	3.2
setosa	1.3	0.3	4.5	2.3
…		…	…	…

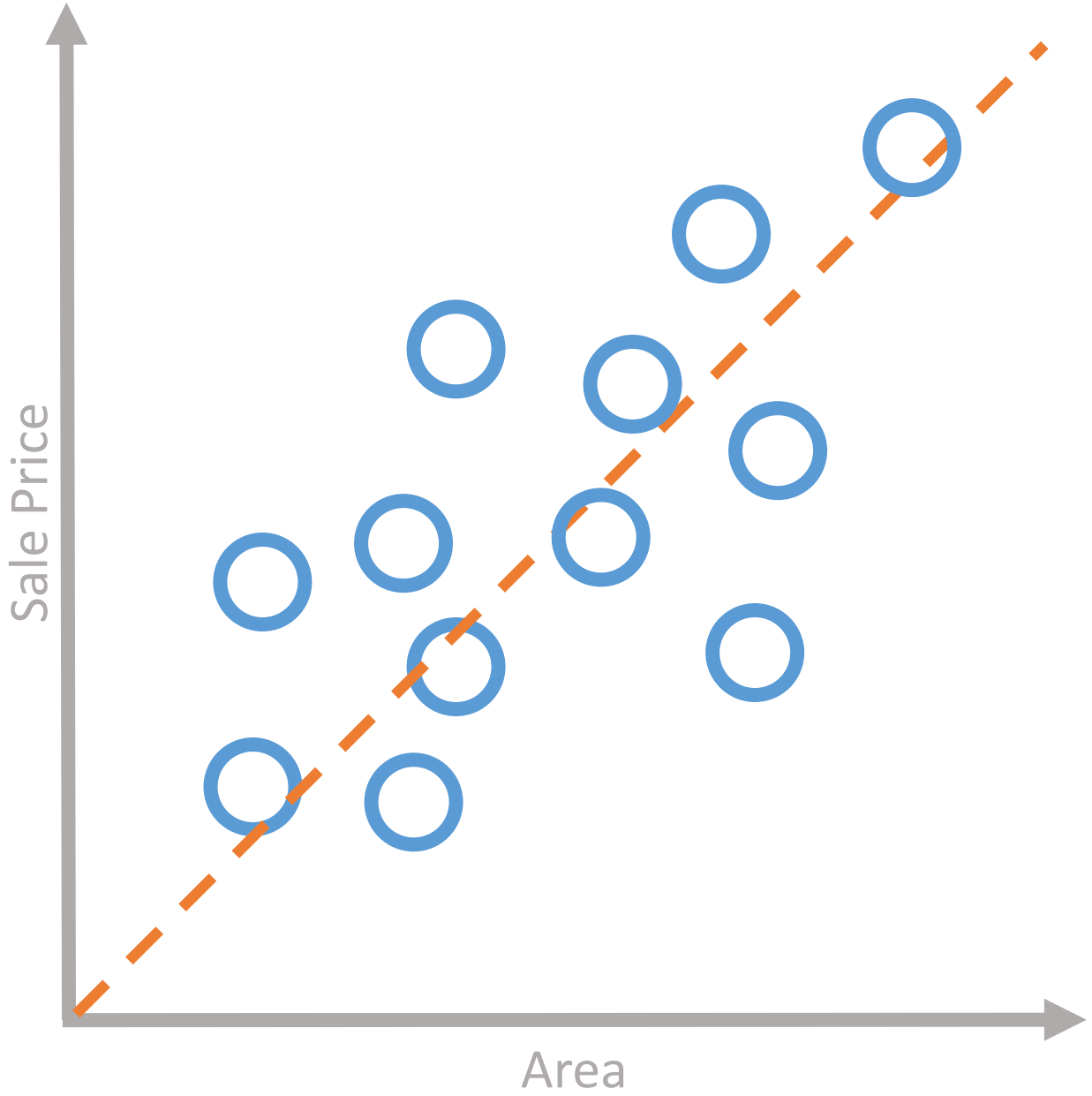
Classification Demo

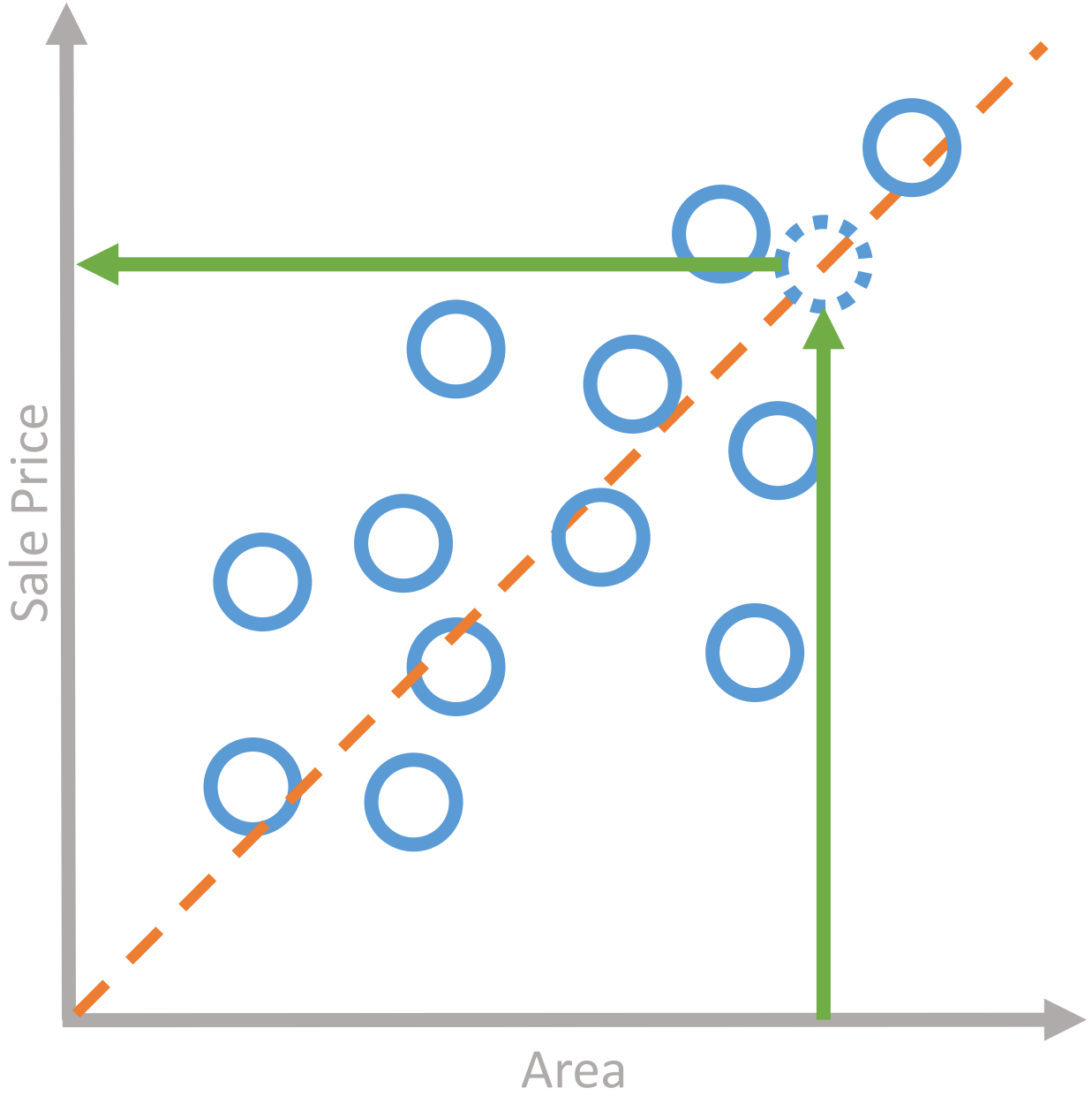
Goal: Predict species based on petal and sepal measurements

Regression


$f(x)$
1.23


Sale Price
Area


Sale Price
Area


Sale Price
Area

Regression Algorithms

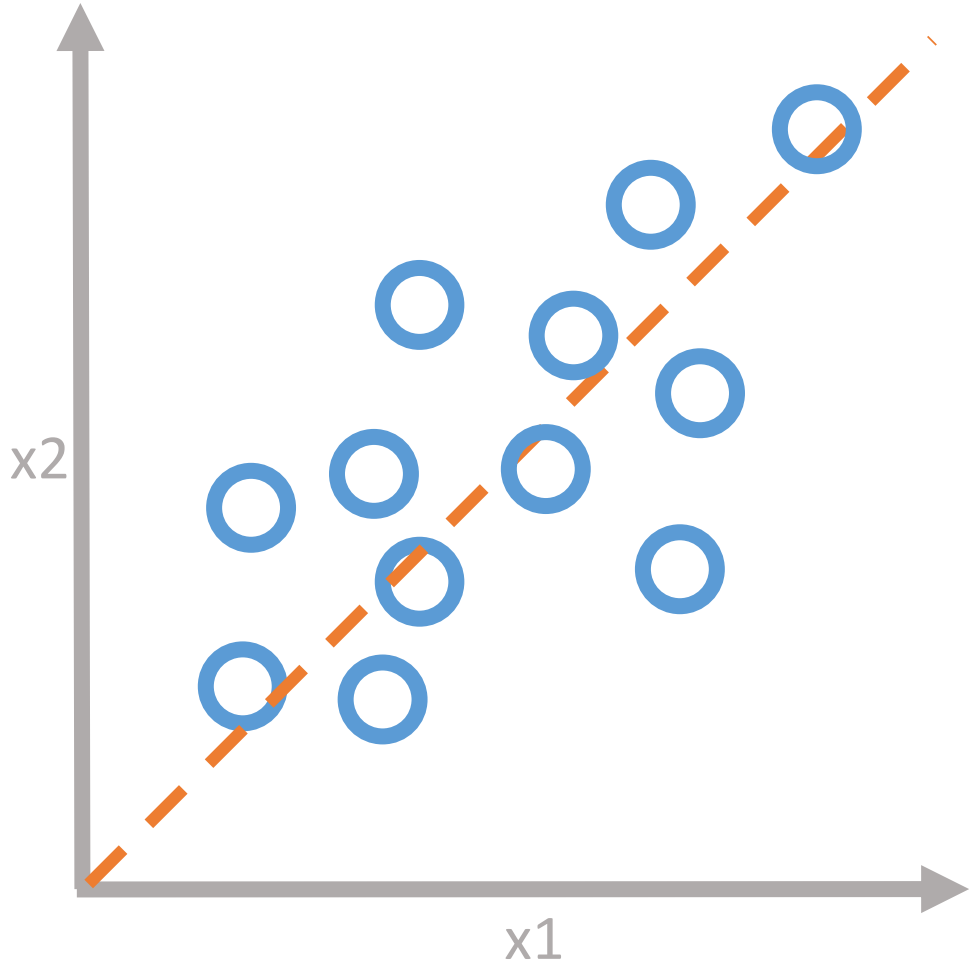
Linear Regression

Polynomial Regression

Lasso Regression

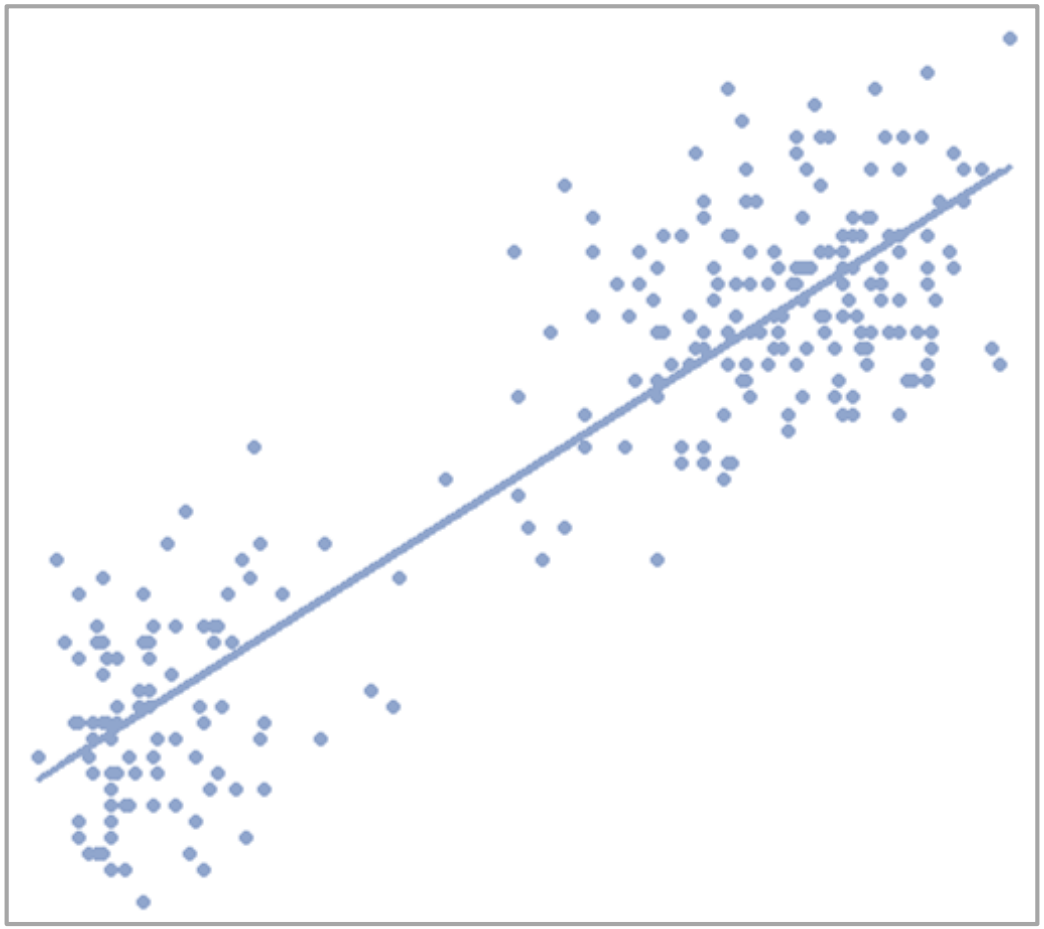
ElasticNet Regression

Neural Network Regression



Simple Linear Regression

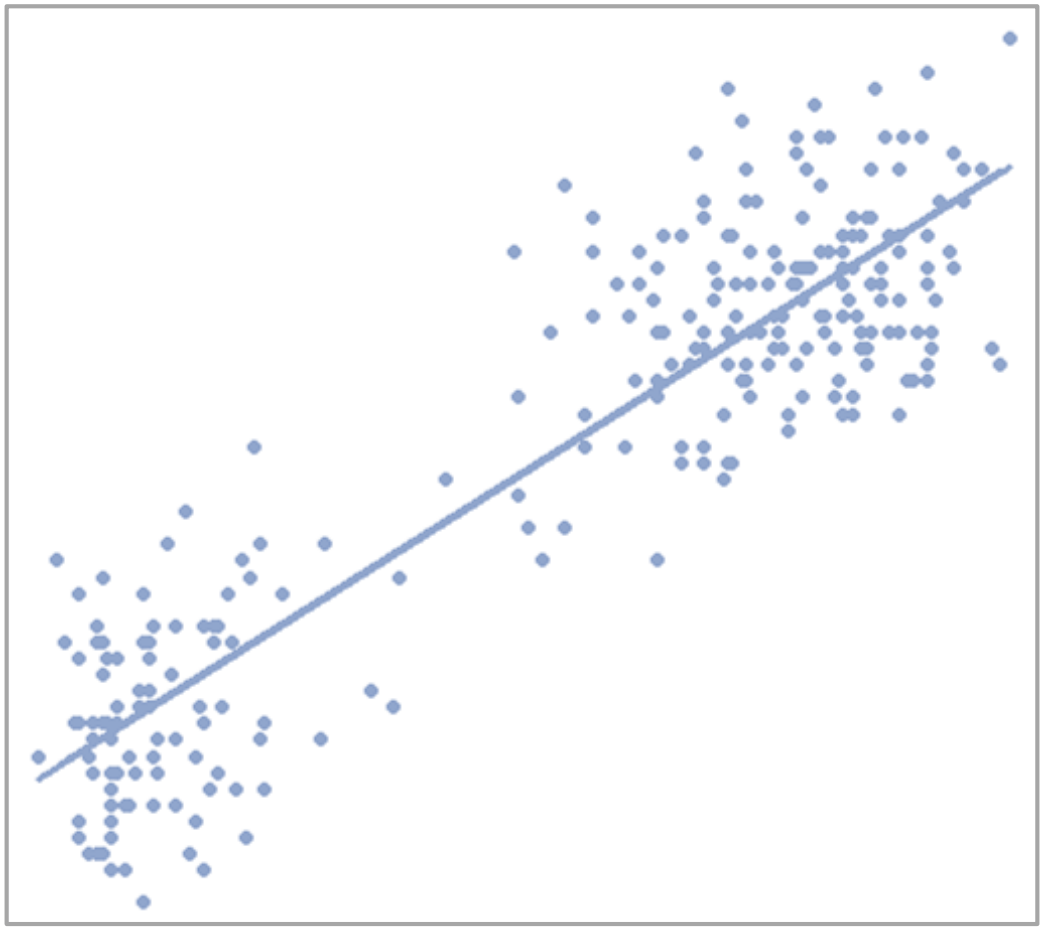
Relationship



Simple Linear Regression

Relationship

Linear model

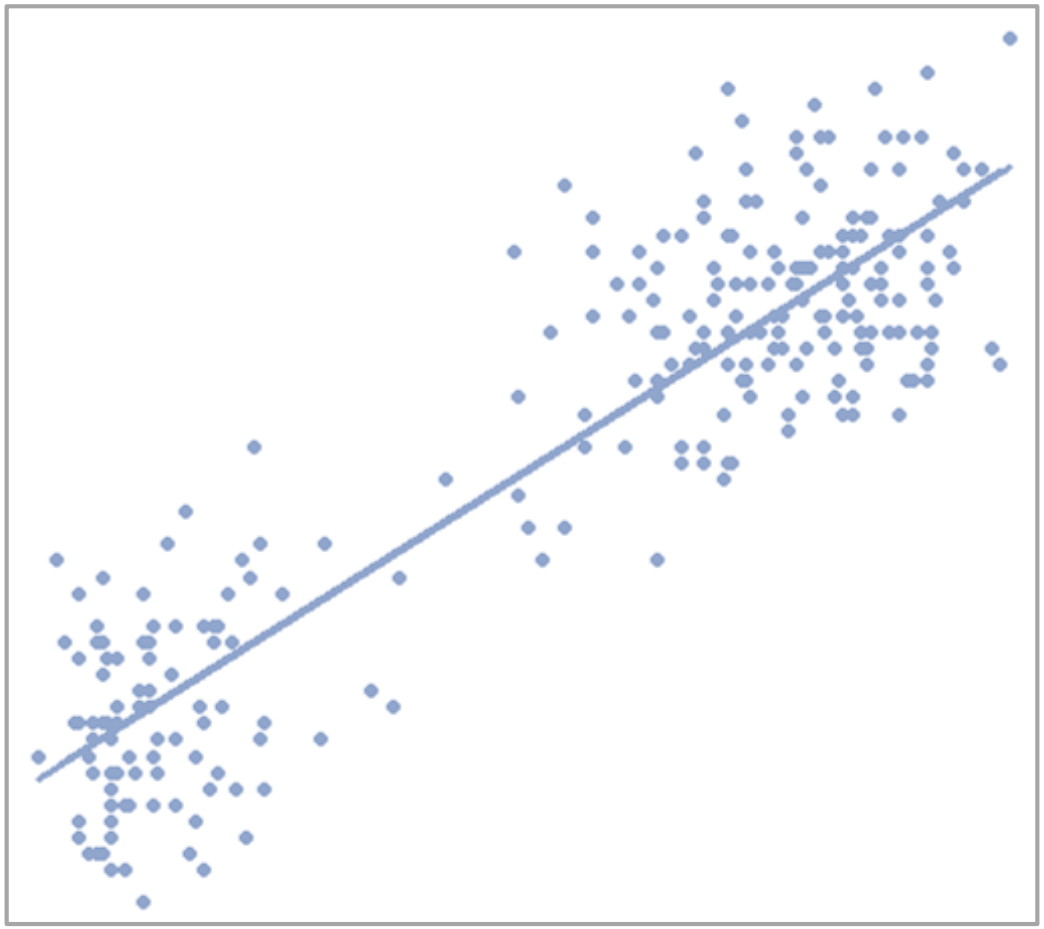


Simple Linear Regression

Relationship

Linear model

Explanatory variable



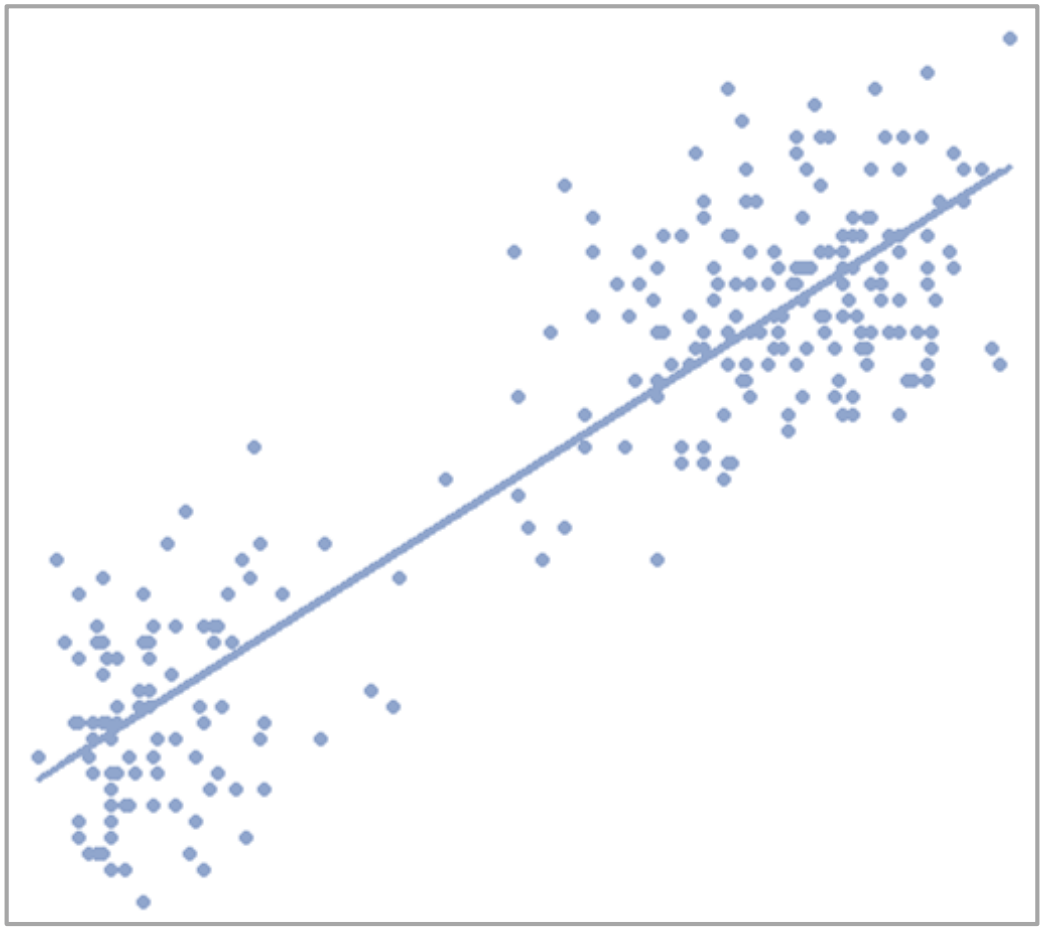
Simple Linear Regression

Relationship

Linear model

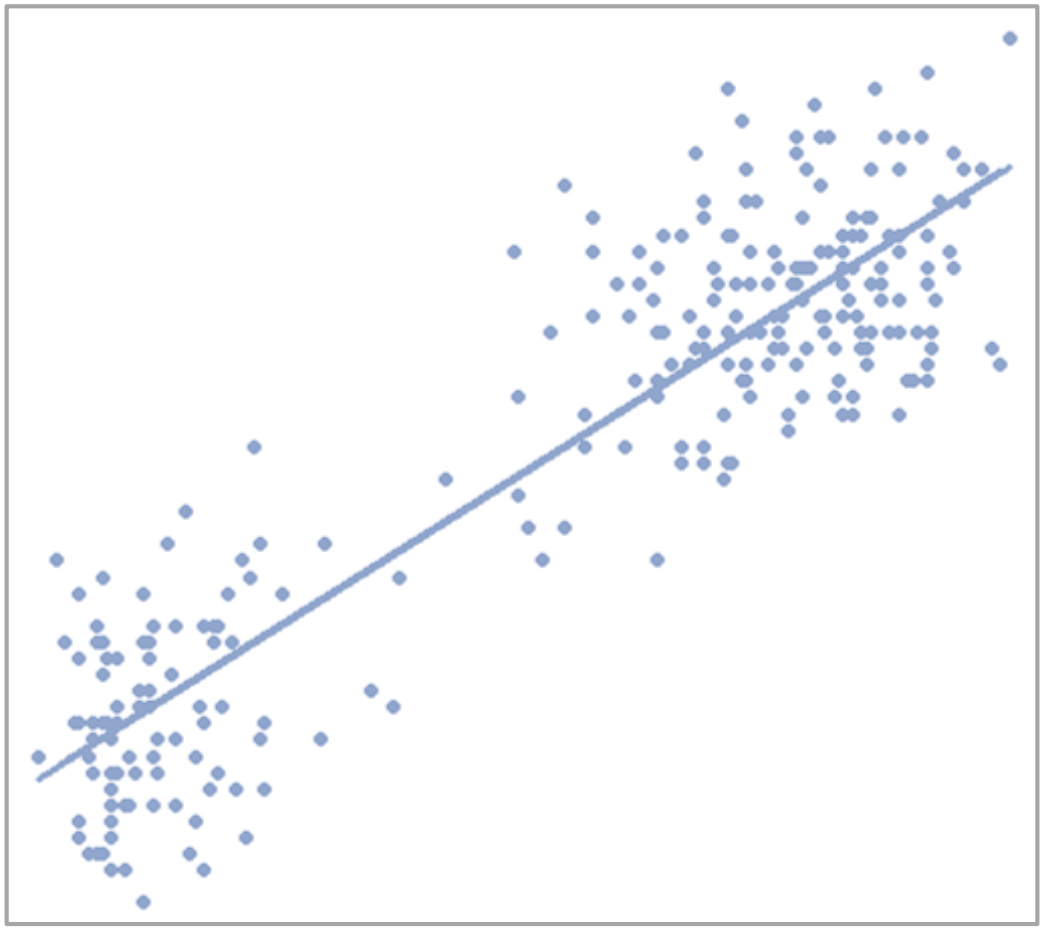
Explanatory variable

Outcome variable



Simple Linear Regression

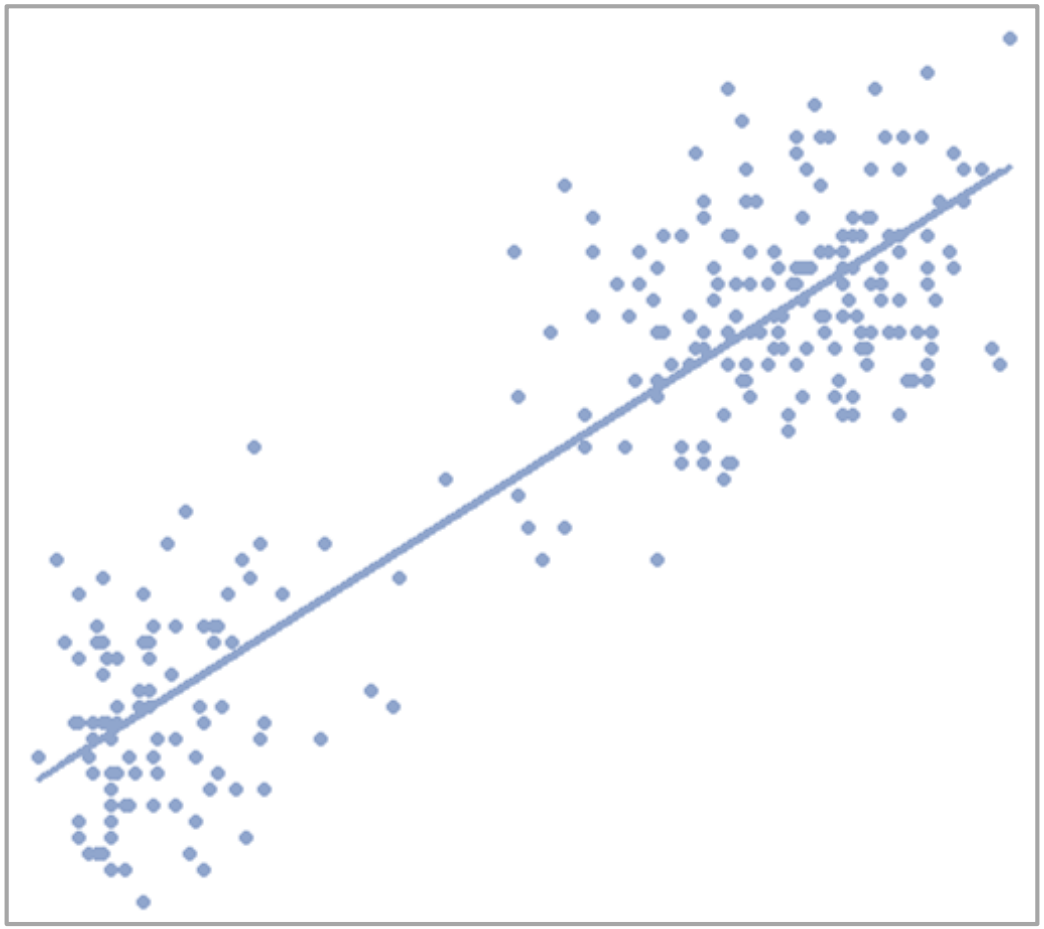
Linear predictor function



Simple Linear Regression

Linear predictor function

$y = m \cdot x + b$

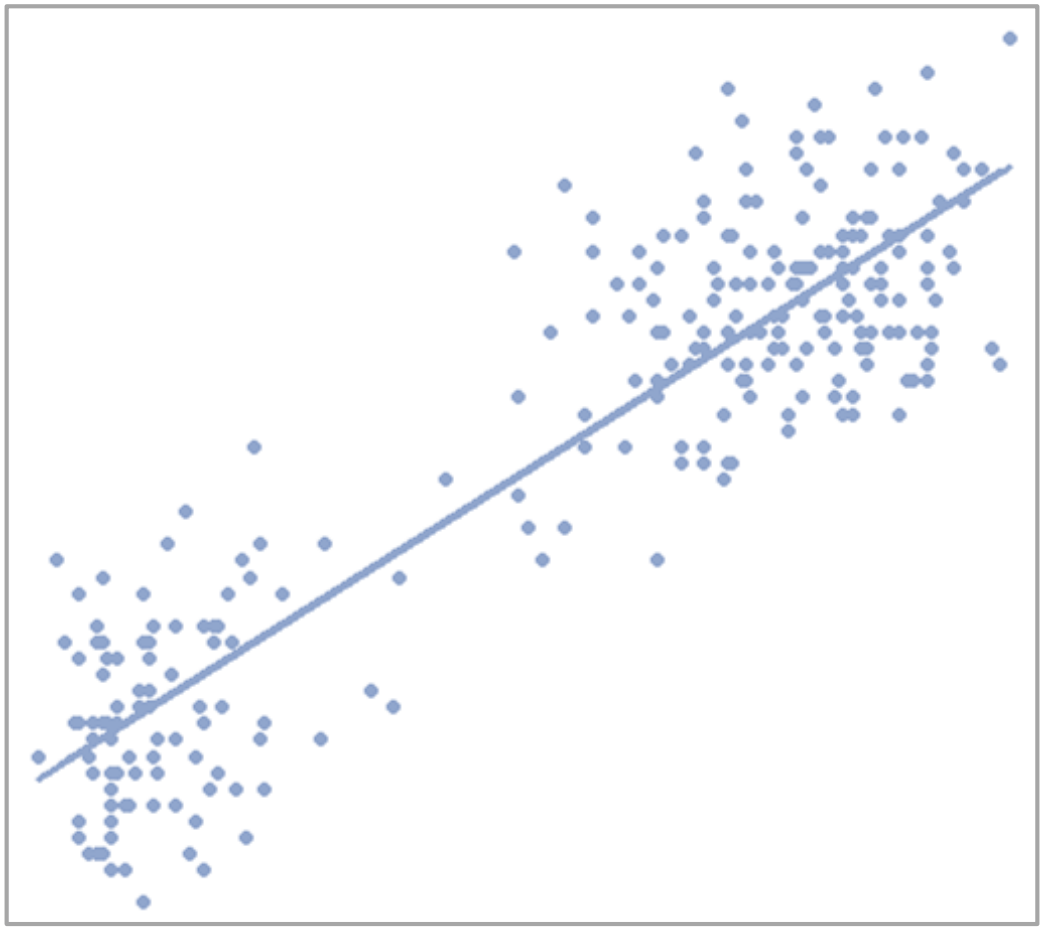


Simple Linear Regression

Linear predictor function

$y = m \cdot x + b$

Parameters estimated



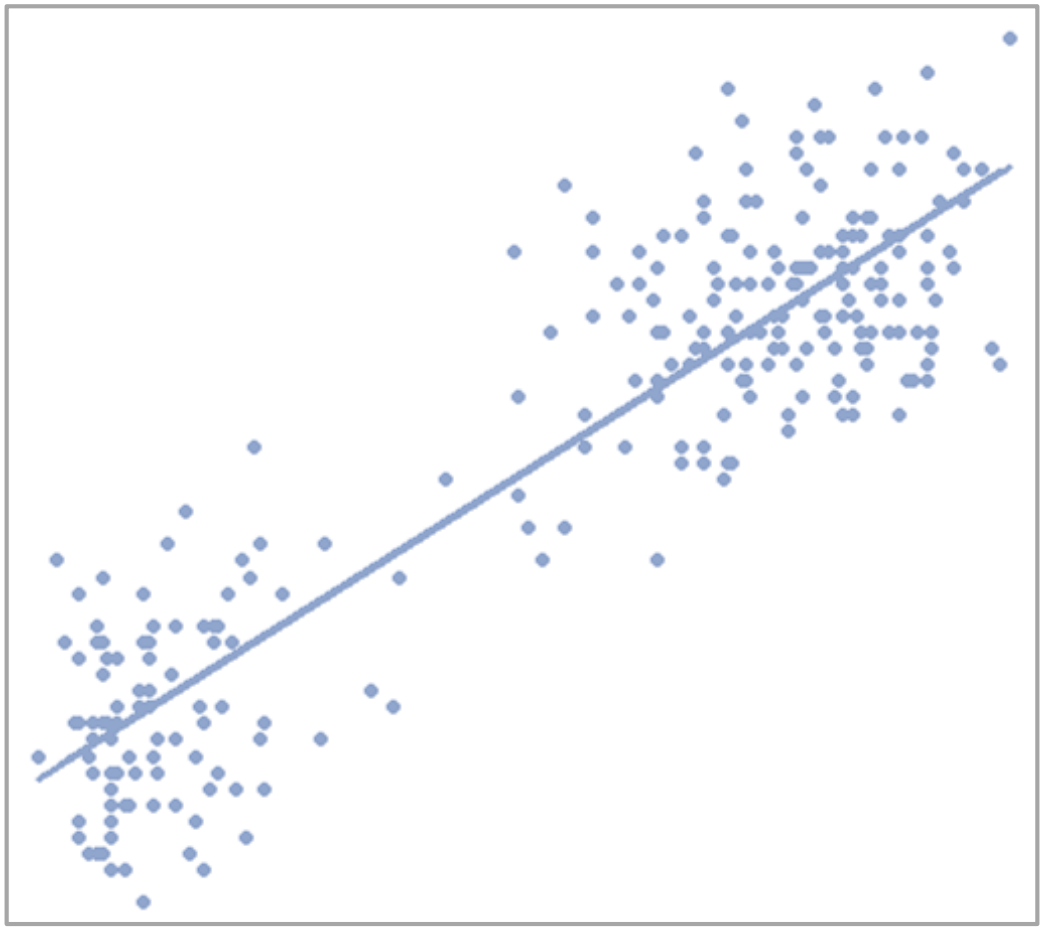
Simple Linear Regression

Linear predictor function

$y = m \cdot x + b$

Parameters estimated

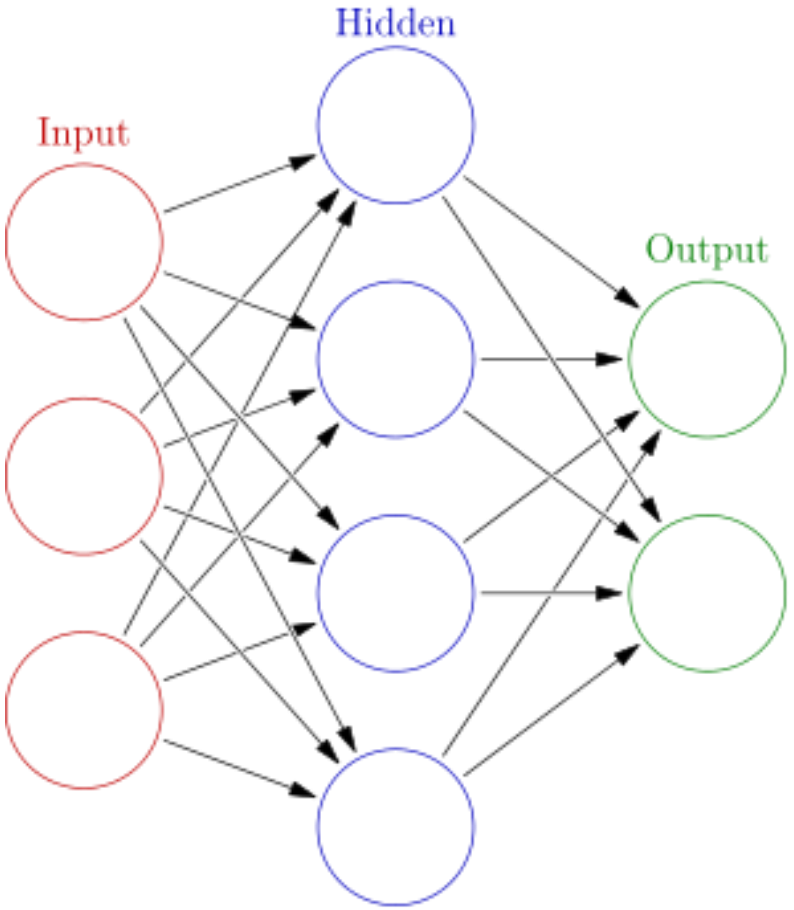
Relies on assumptions



Neural Network Regression

Same as before

Numeric vs. Categorical



Source: Wikipedia

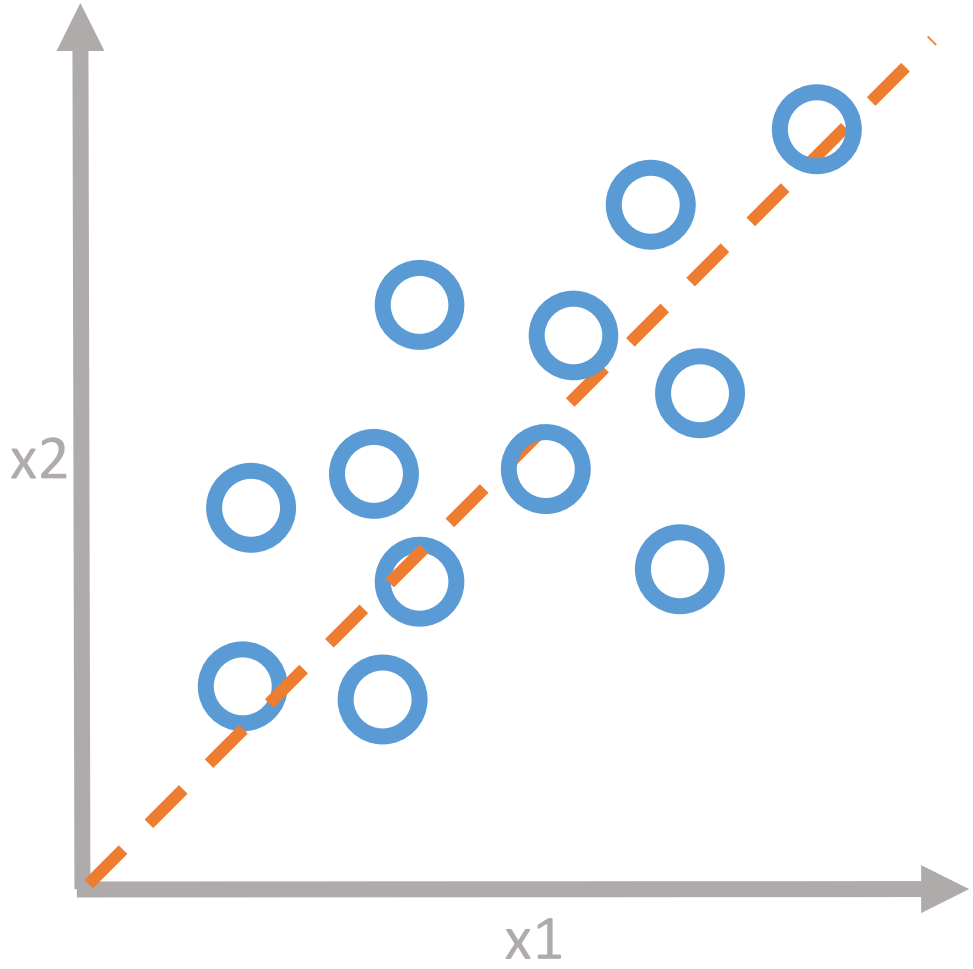
Real-World Examples

How much profit will we make?

What will the price be tomorrow?

How many will this person buy?

How long until this part fails?

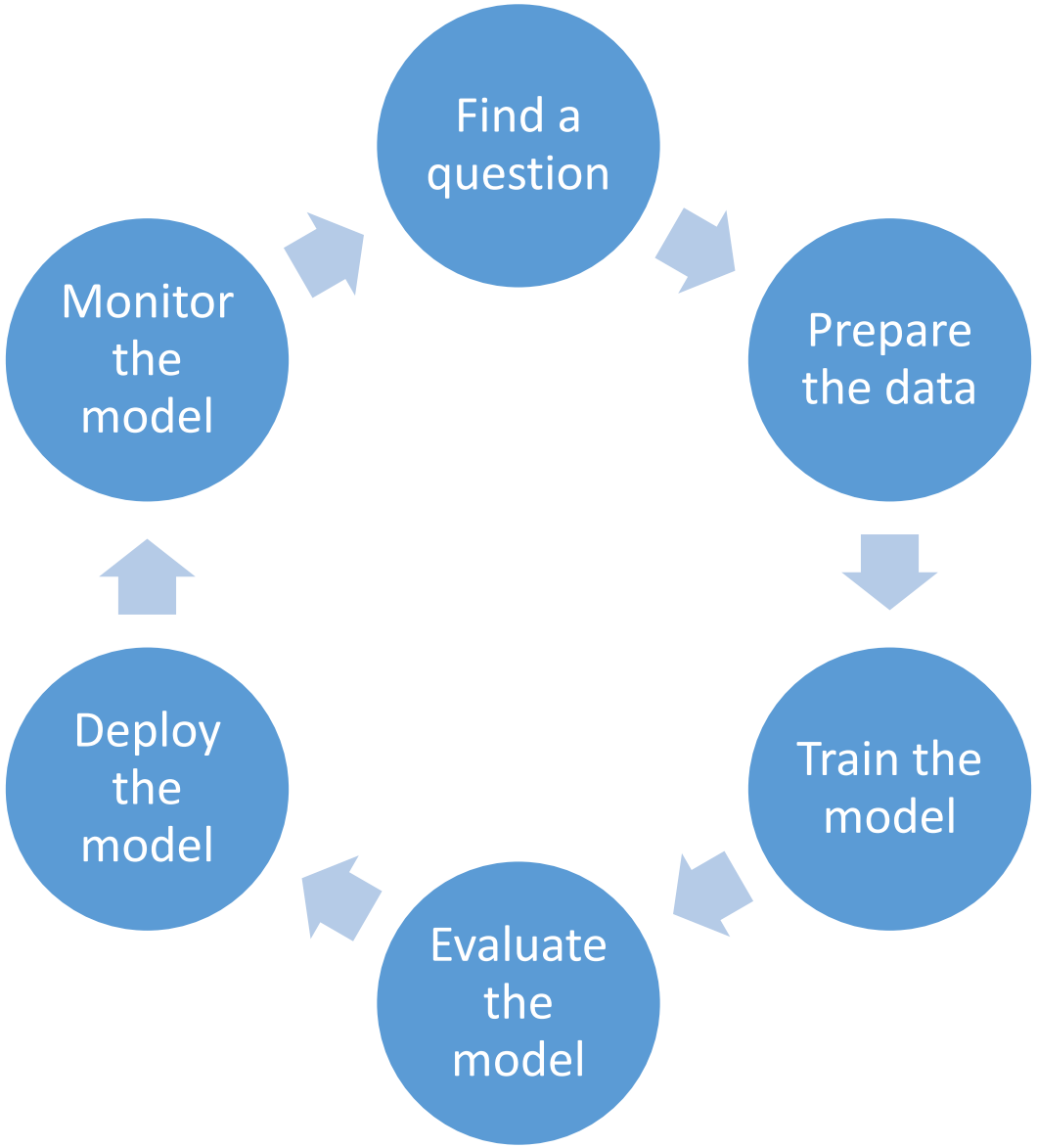


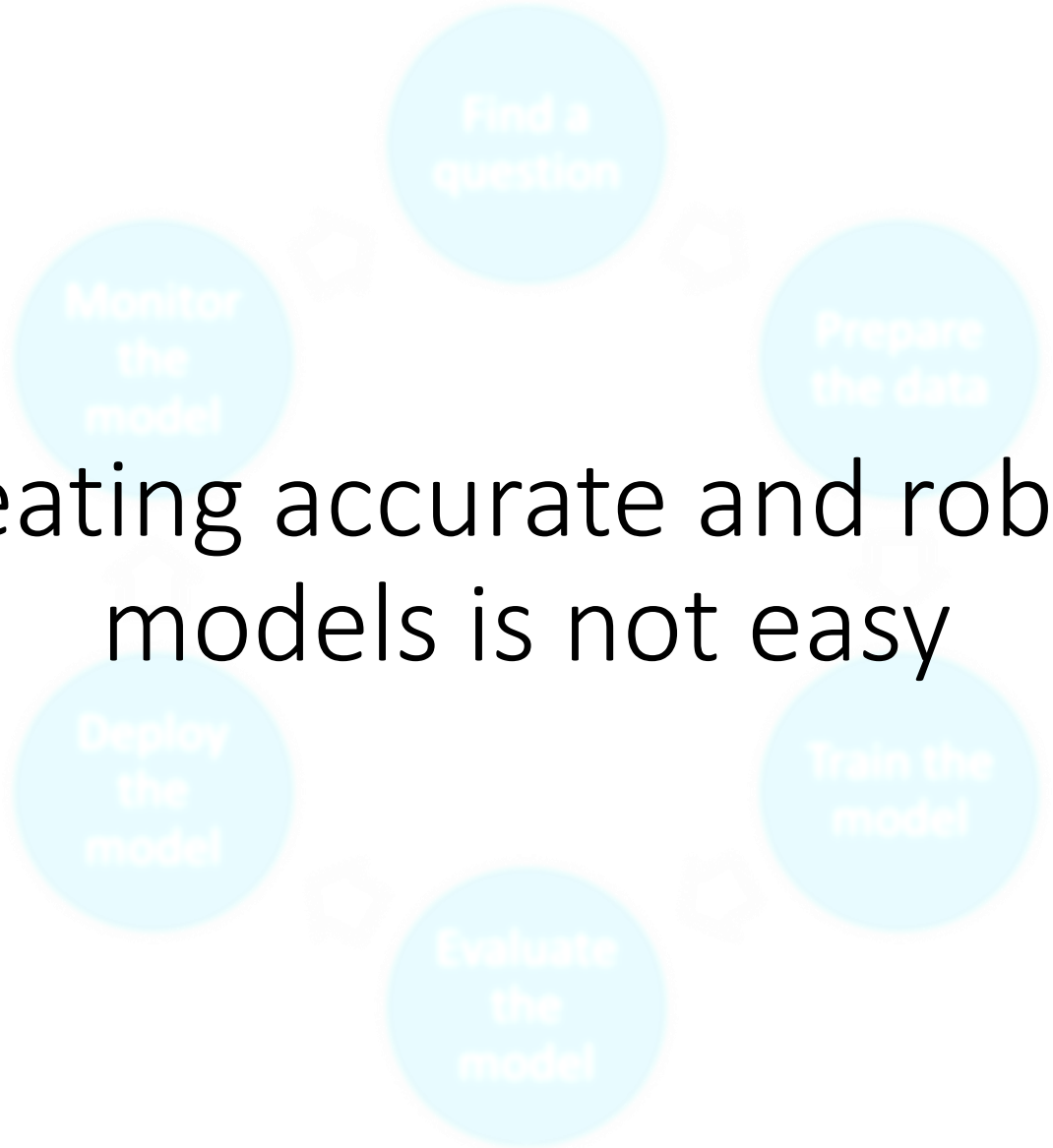
Regression Demo

Goal: Predict petal width
of Iris flowers

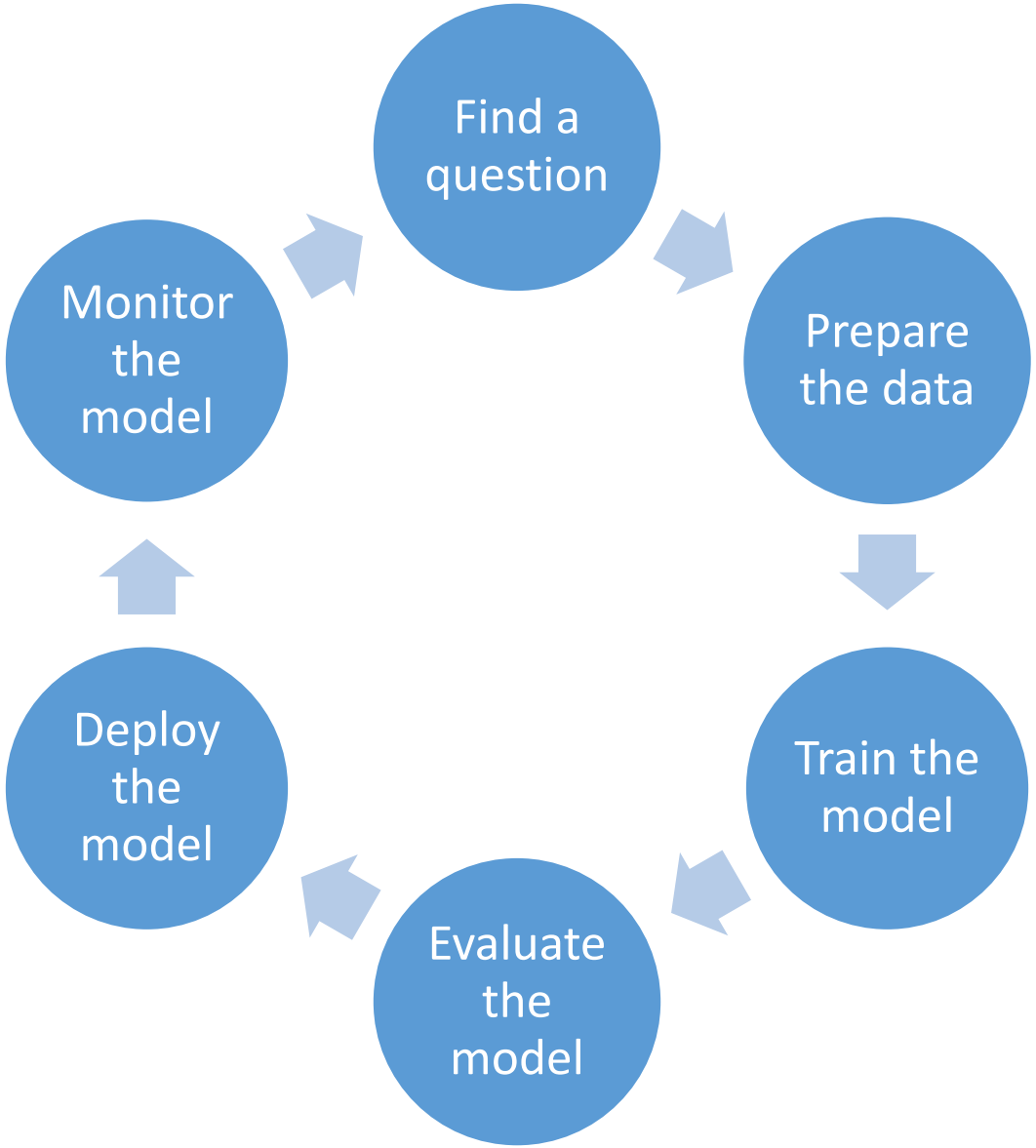
Beyond the Basics


This is just the tip of the iceberg!


Find a question
Prepare the data
Train the model
Evaluate the model
Deploy the model
Monitor the model



Creating accurate and robust models is not easy


Find a question
Prepare the data
Train the model
Evaluate the model
Deploy the model
Monitor the model

Cleaning and Transforming Data

Data are messy

Cleaning and Transforming Data

Data are messy

80% of work

Cleaning and Transforming Data

Data are messy

80% of work

R helps a lot

Cleaning and Transforming Data

Data are messy

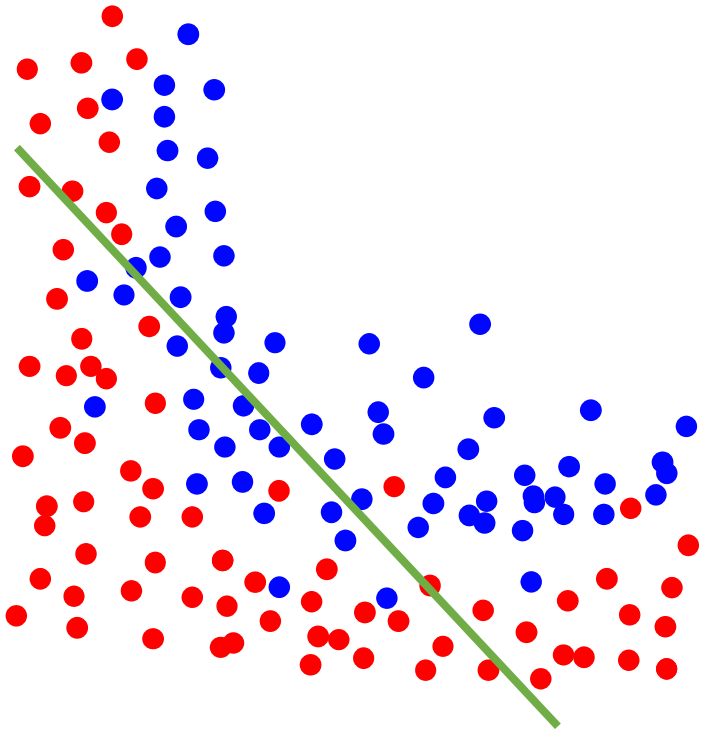
80% of work

R helps a lot

Record all steps

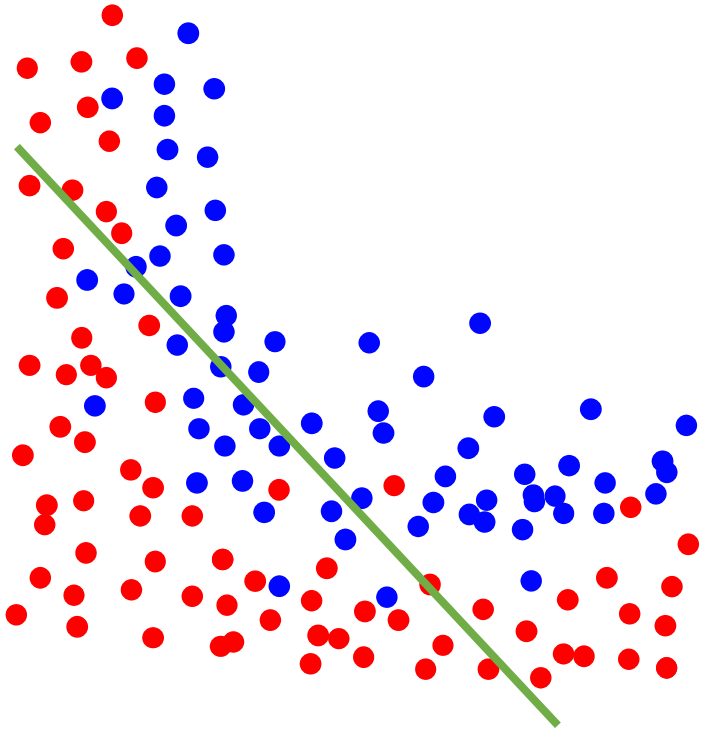
Goodness of Fit

Goodness of Fit

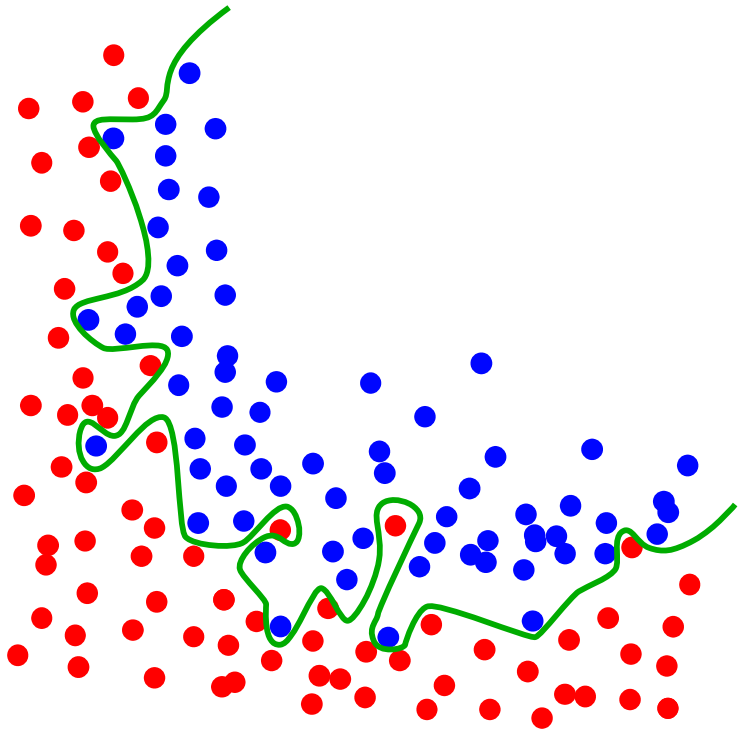


Underfit

Goodness of Fit

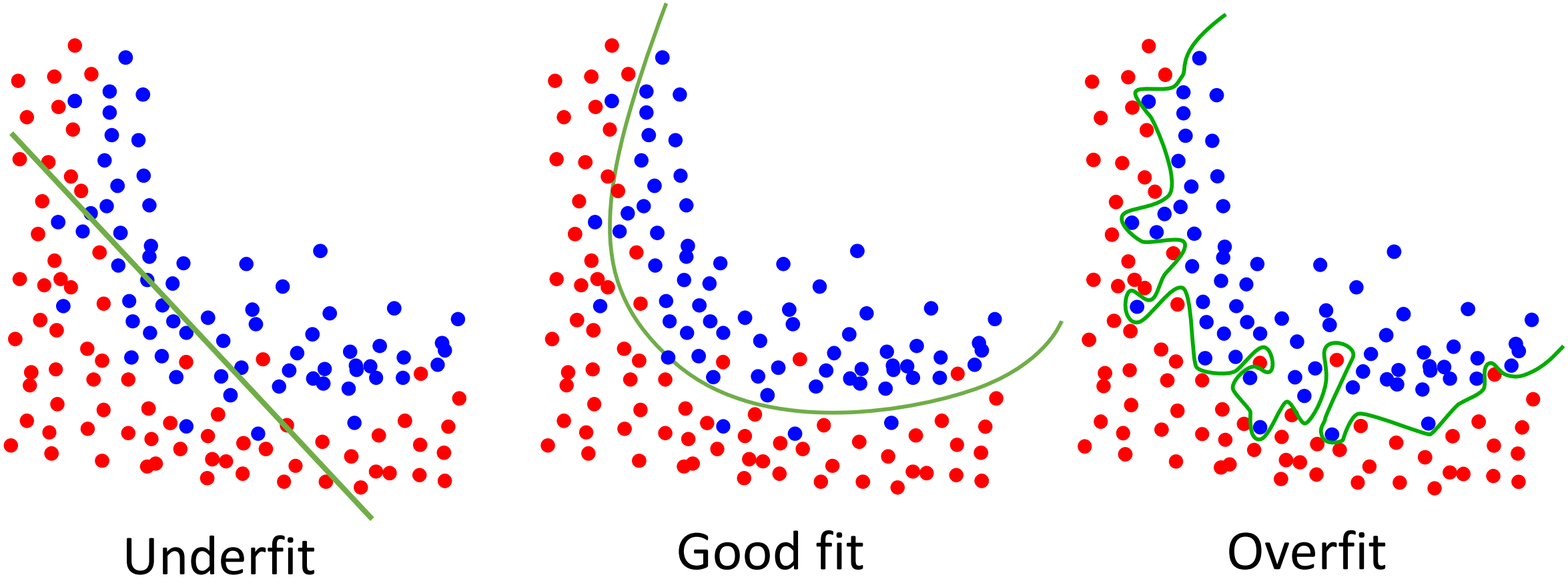


Underfit



Overfit

Goodness of Fit

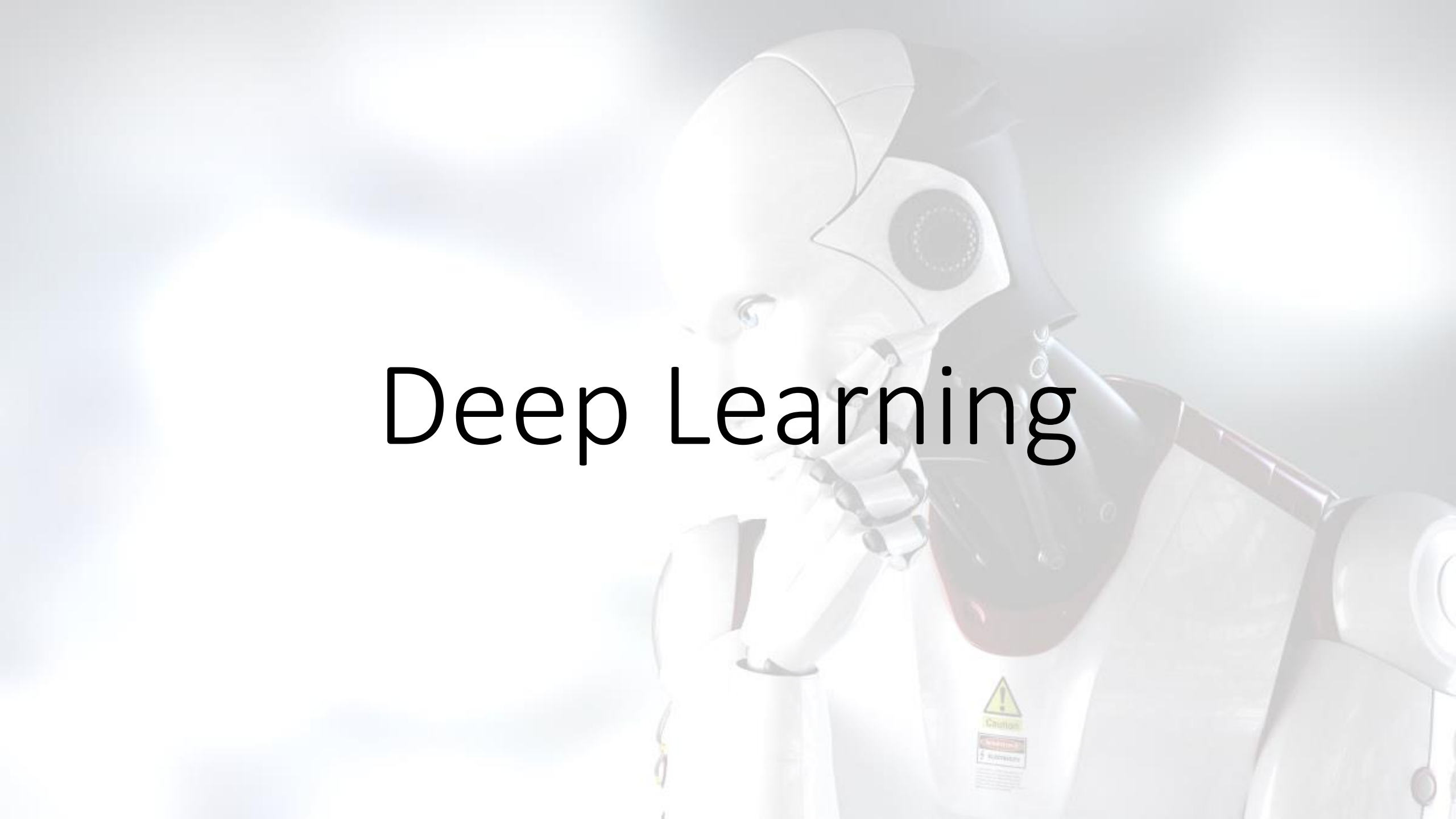


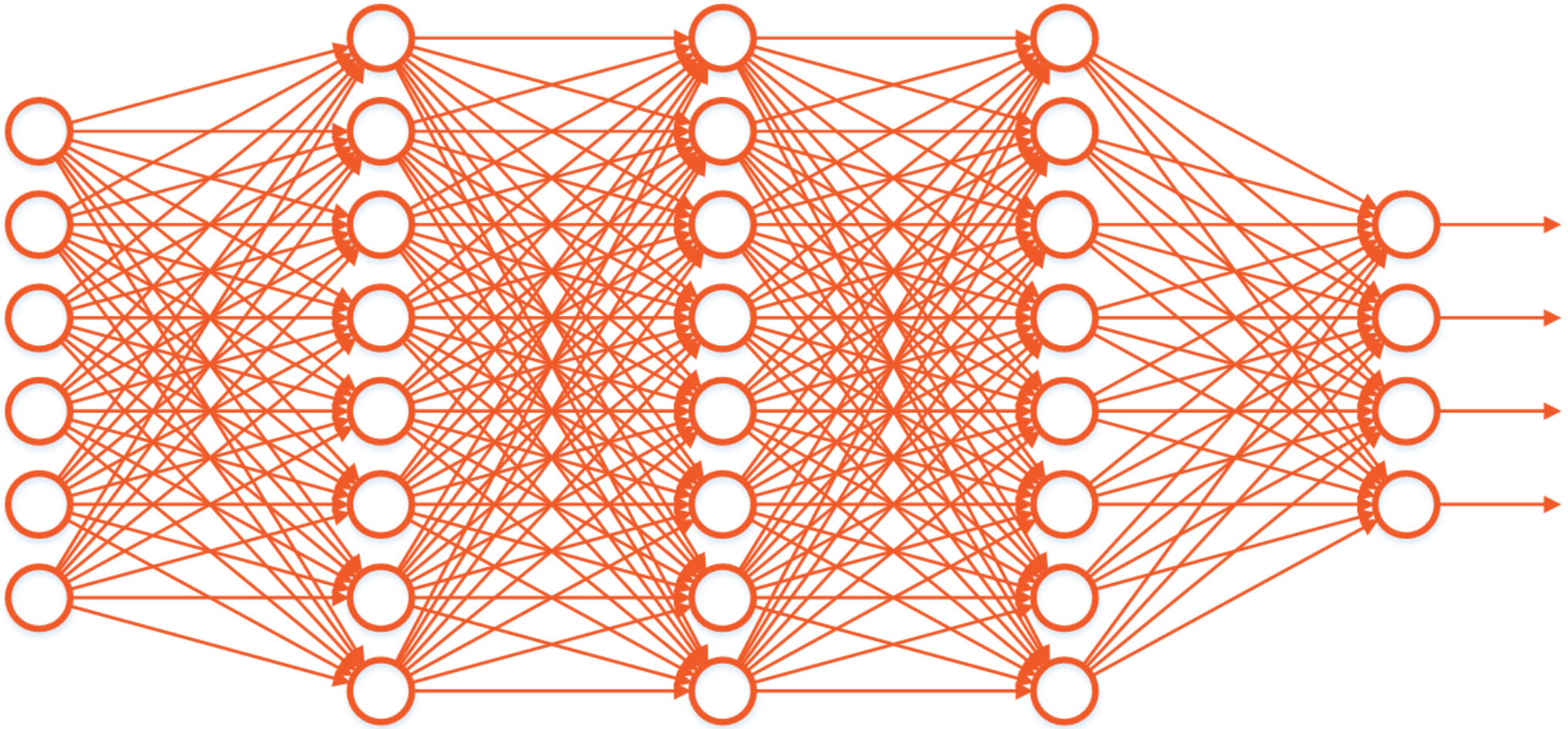
Underfit

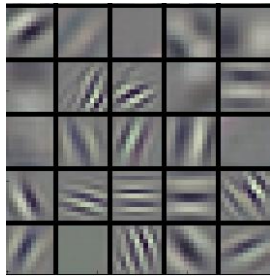
Good fit

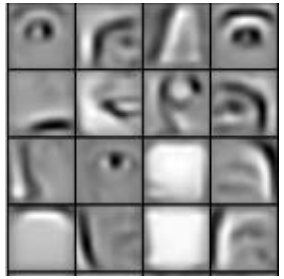
Overfit

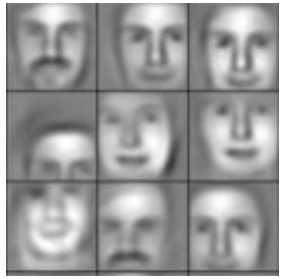
Deep Learning





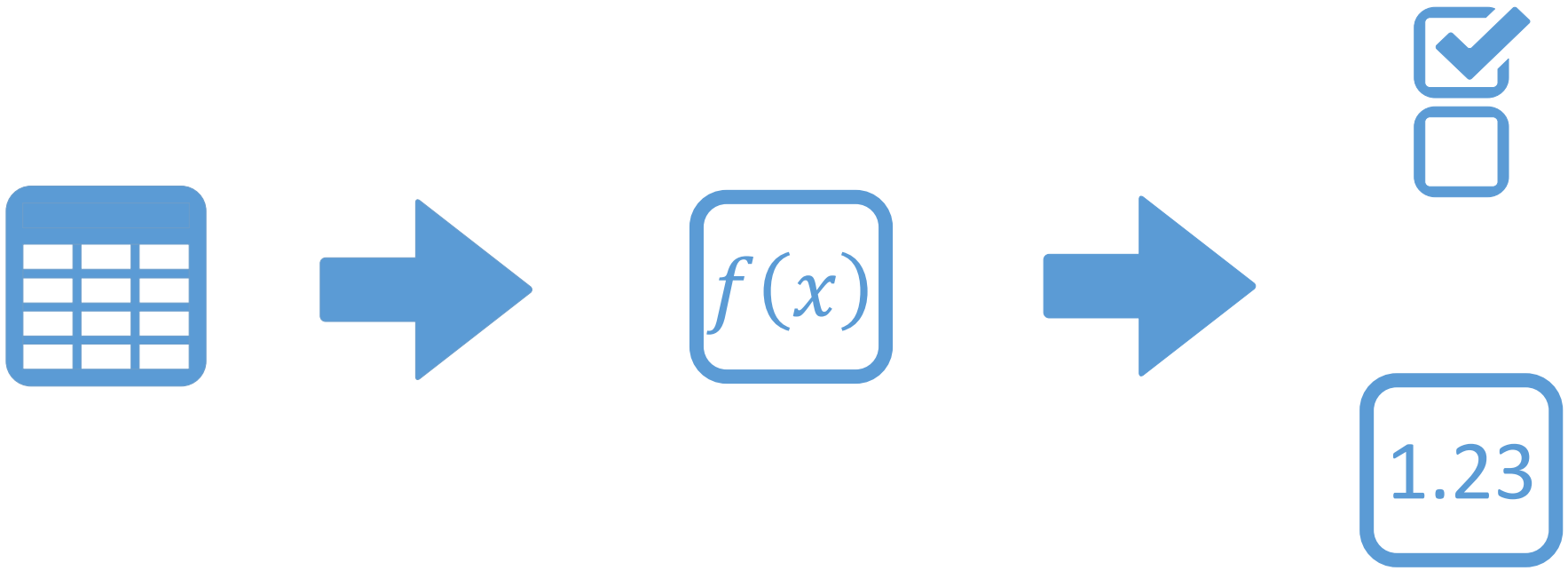


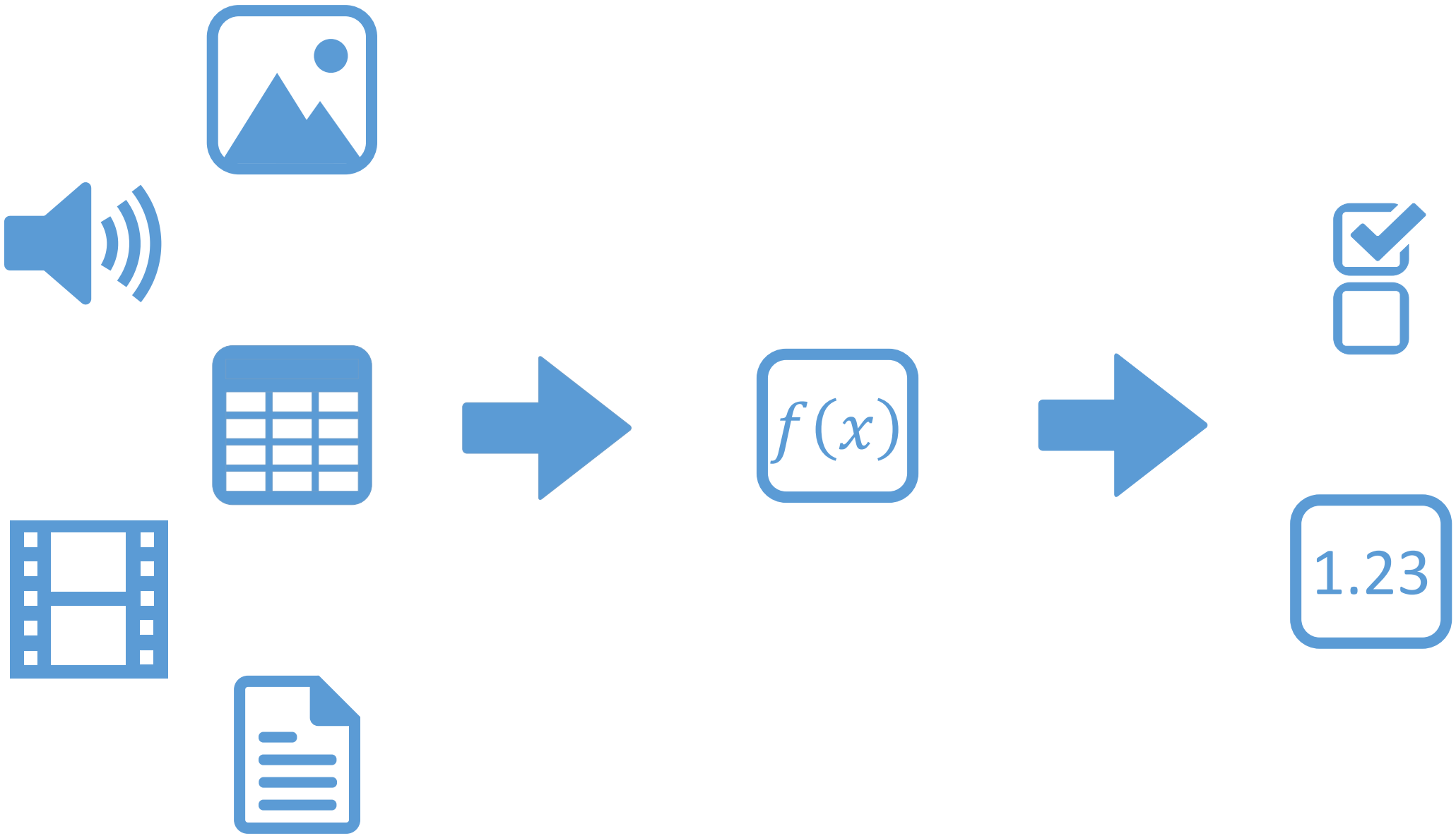


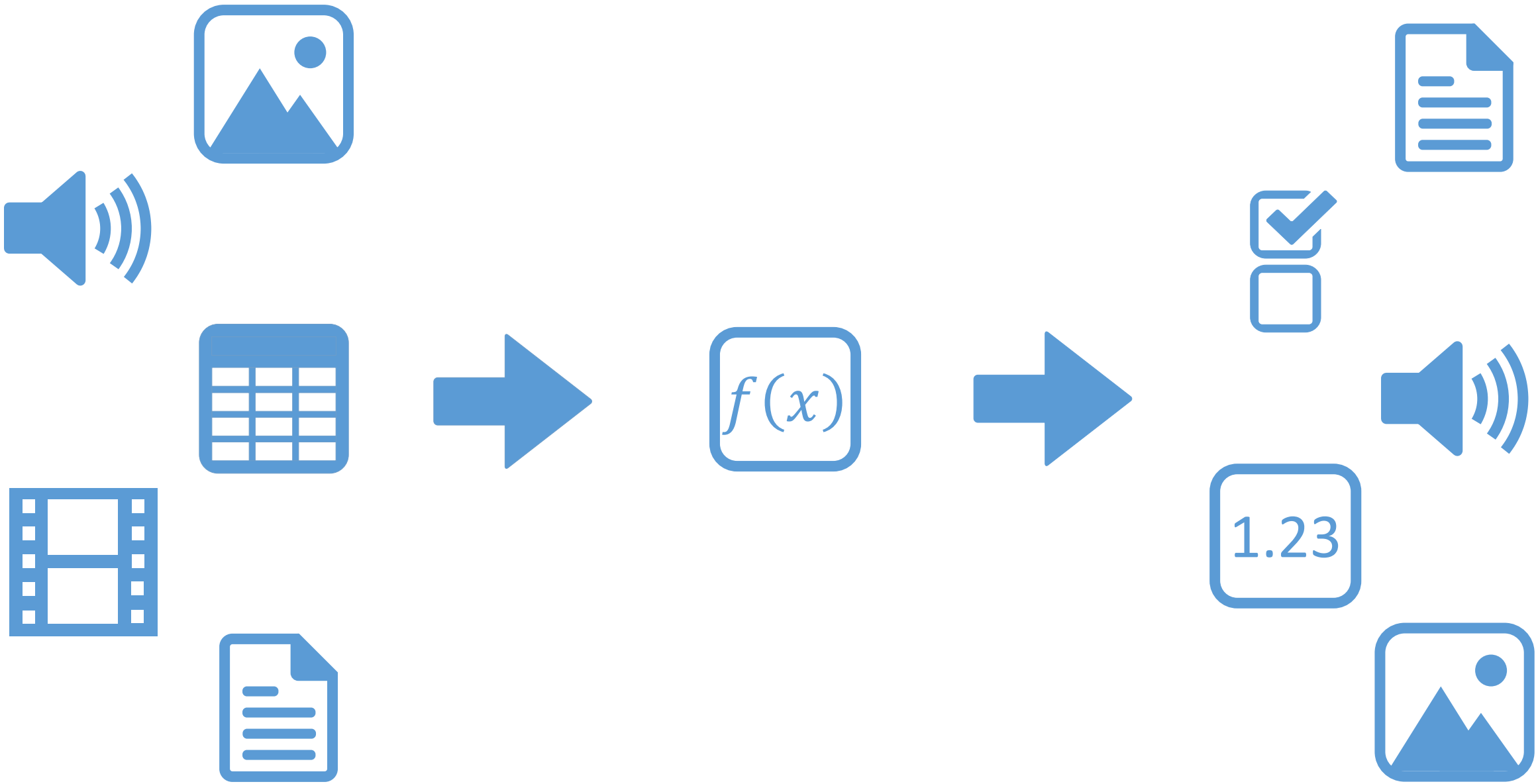


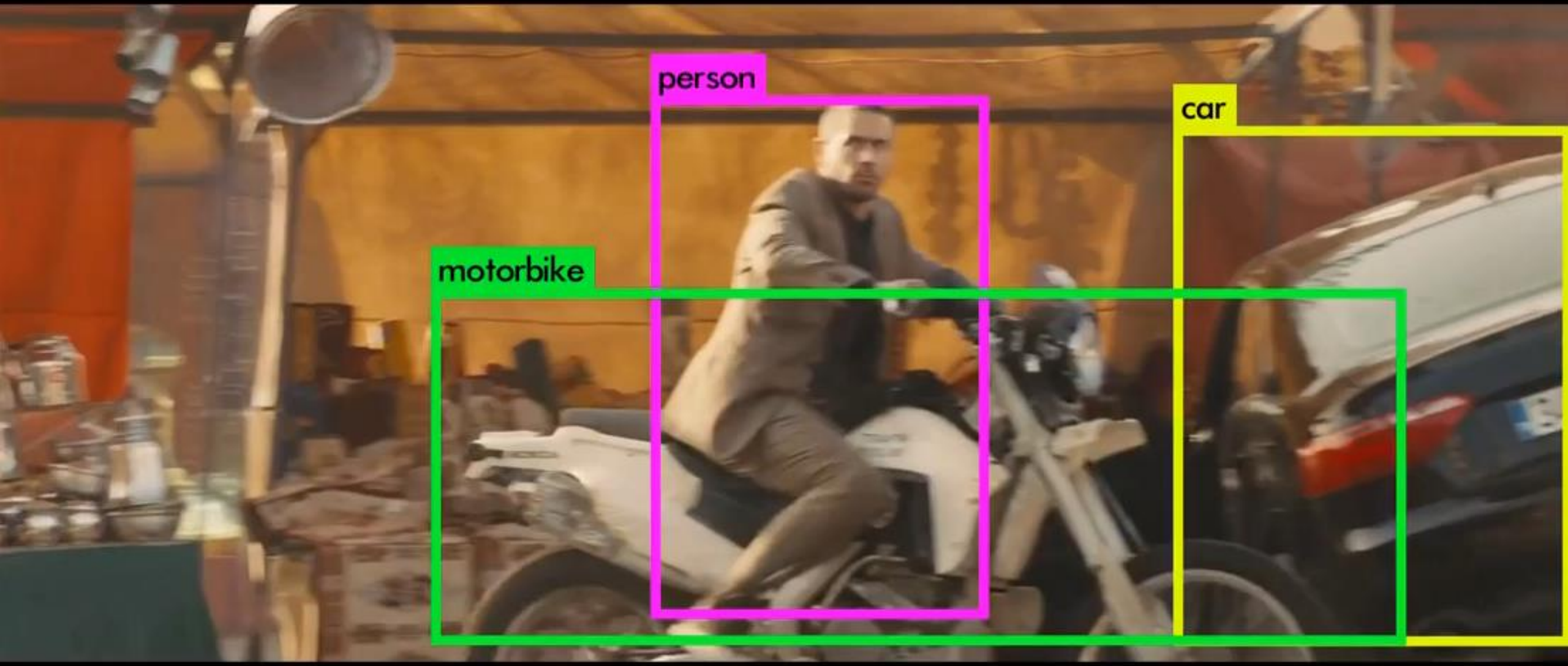

John
Miko
Jane
Lee


Caution
WARNING
ELECTRICITY


$f(x)$
1.23


$f(x)$
1.23


$f(x)$
1.23

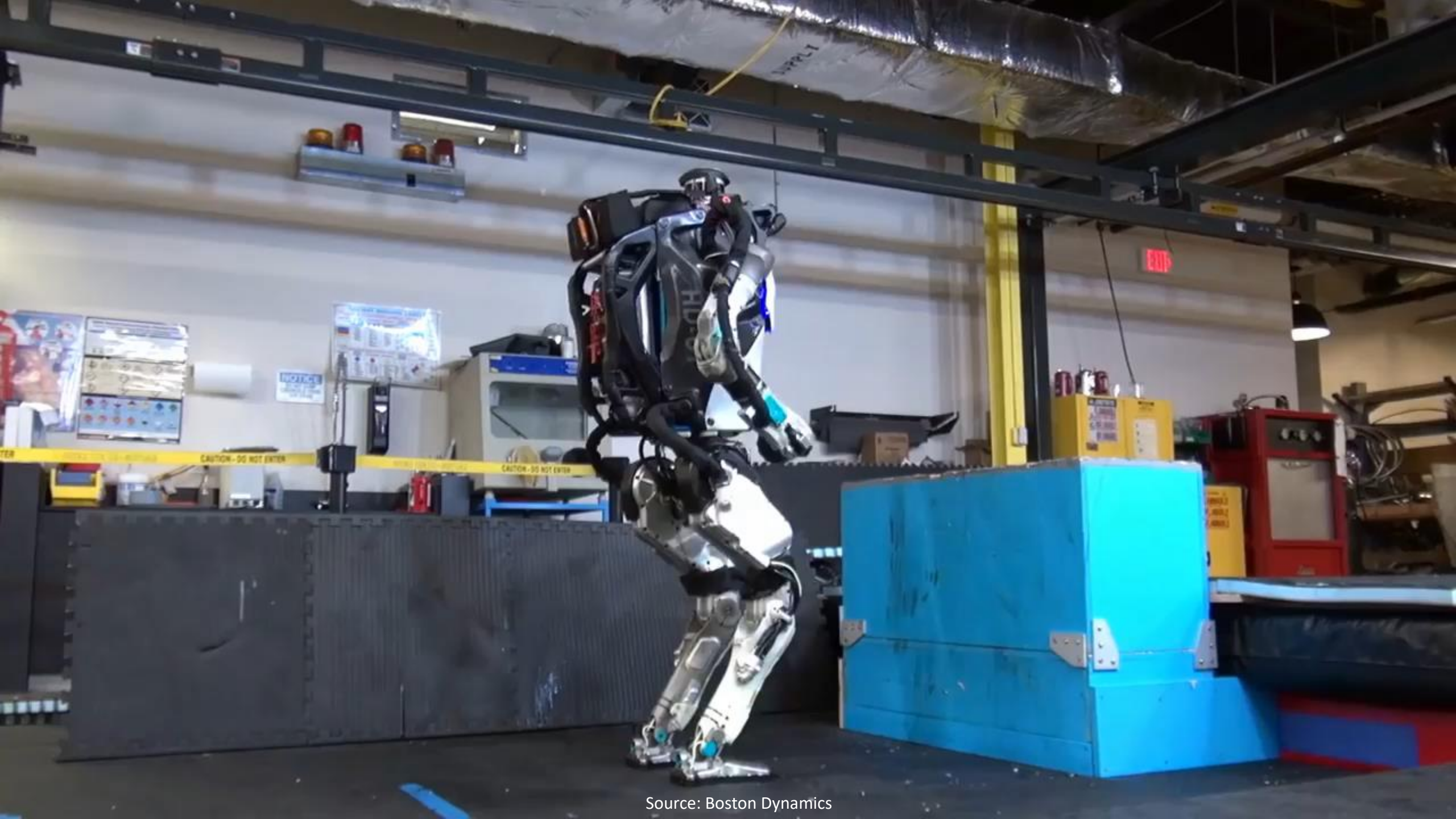


Source: YOLO: Real-Time Object Detection


Source: Nvidia

Source: http://grail.cs.washington.edu/projects/AudioToObama/

Source: Google Deep Mind



Source: Boston Dynamics

Practical Demo

Goal: Predict who will survive the Titanic

Conclusion

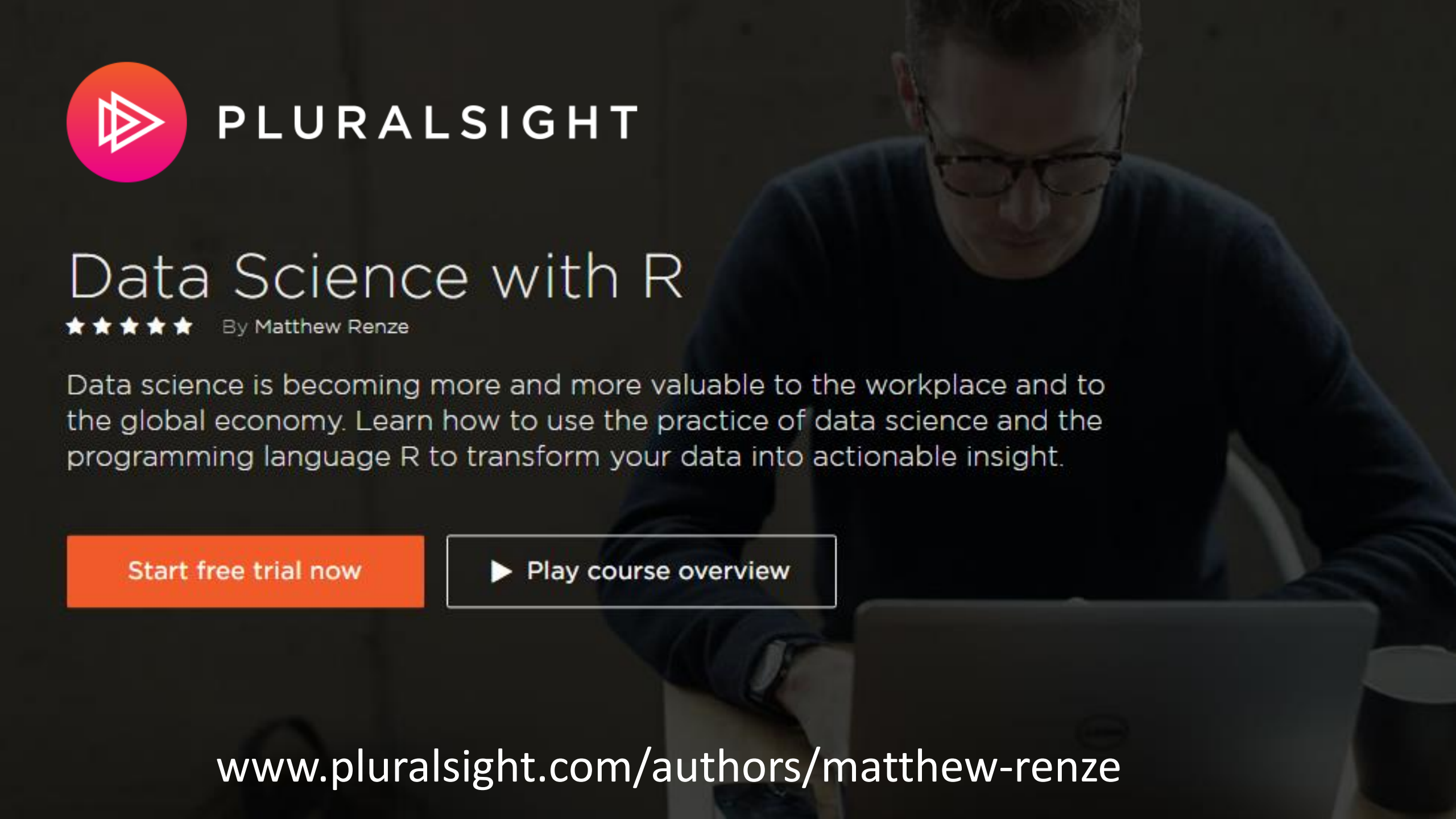
Where to Go Next

Pluralsight: https://www.pluralsight.com

Data Camp: https://www.datacamp.com

Coursera: https://www.coursera.org

Tensorflow: http://playground.tensorflow.org



www.pluralsight.com/authors/matthew-renze

Matthew Renze

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News

2017-08-25 - Invitation to Speak at Devoxx Morocco

Very excited to announce that I've been invited to give a keynote in Casablanca at Devoxx Morocco in November. My keynote presentation will be on Artificial Intelligence.

2017-08-16 - Invitation to Speak at Microsoft Ignite

I've been invited to speak at Microsoft Ignite in Orlando, Florida in September. This will be my first time speaking at Ignite. Talks will include both Data Science and Machine Learning with R.

2017-08-14 - Dev on Fire Interview

Matthew is a data science consultant, author for Pluralsight, international public speaker, a Microsoft MVP, ASPInsider, and open-source software contributor.

www.matthewrenze.com

Feedback

Very important to me!

What did you like?

What could I improve?

Conclusion

1. Introduction to ML
2. Introduction to R
3. Classification
4. Regression
5. Beyond the Basics

Are you prepared?

Is your organization?

Is our world prepared?

Contact Info

Matthew Renze

Data Science Consultant

Renze Consulting

Twitter: @matthewrenze

Email: info@matthewrenze.com

Website: www.matthewrenze.com

Thank You! :)