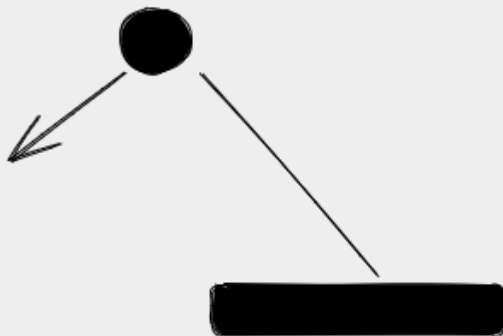




Embedded.ai Machine Learning Fundamentals

Ivanovitch Silva
ivanovitch.silva@ufrn.br

What is Machine Learning?



```
if (ball.collide(brick)){  
    removeBrick();  
    ball.dx = 1.1*(ball.dx);  
    ball.dy = -1*(ball.dy);  
}
```

Rules



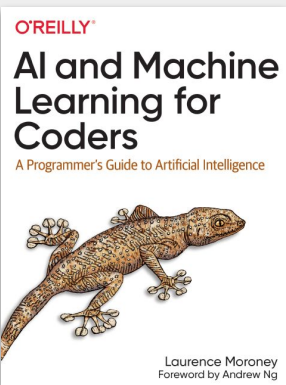
Data



Traditional
Programming



Answers



Limitations of traditional programming

<activity detection>



```
if (speed < 4){  
    status = WALKING;  
}
```



```
if (speed < 4){  
    status = WALKING;  
} else {  
    status = RUNNING;  
}
```



```
if (speed < 4){  
    status = WALKING;  
} else if (speed < 12) {  
    status = RUNNING;  
} else {  
    status = BIKING;  
}
```



// ????

Rules →

Data →

Traditional
Programming

→ Answers

From coding to ML

<gathering and label data>



```

010111100001110101
111010101010111000
111010101010101010
000000000111001111
  
```

Label = WALKING



```

010111100011101110
000111010101011011
000111101010111000
000000000000001111
  
```

Label = RUNNING



```

111101110010101011
110101110101011011
111110101110010101
000111111001101111
  
```

Label = BIKING

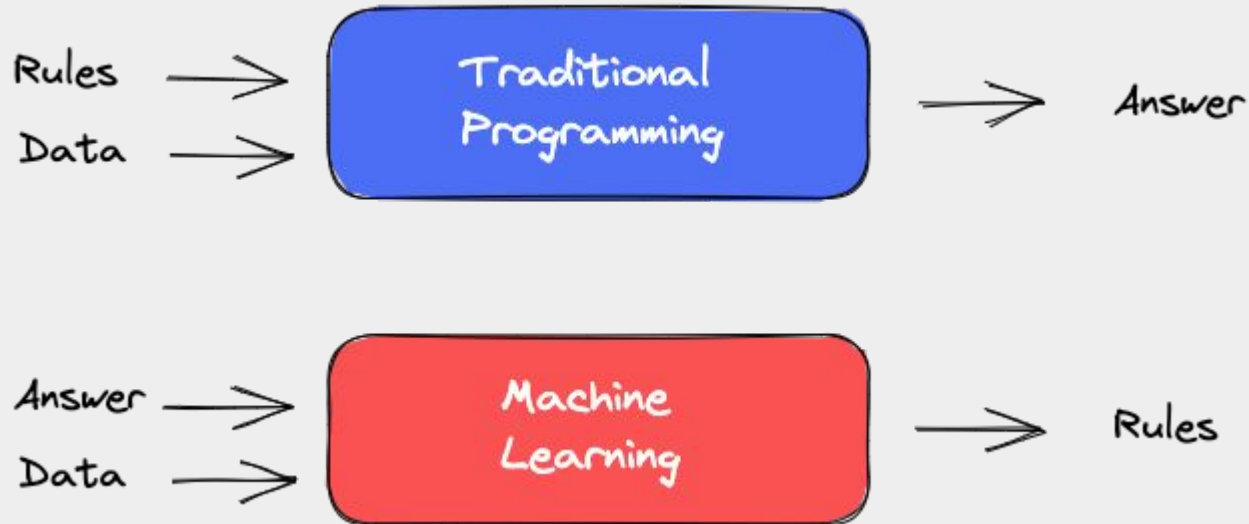


```

100000000010101011
111111111000011001
000000011100111101
111111111100000001
  
```

Label = GOLFING

From programming to learning



What is Machine Learning?

Machine Learning (ML): a subset of AI that often uses statistical techniques to give machines the ability to "learn" from data without being explicitly given the instructions for how to do so. This process is known as "training" a "model" using a learning "algorithm" that progressively improves models performance on a specific task.

Computer Vision

 Semantic Segmentation 📊 203 benchmarks 2300 papers with code	 Image Classification 📊 279 benchmarks 1989 papers with code	 Object Detection 📊 264 benchmarks 1737 papers with code	 Image Generation 📊 169 benchmarks 771 papers with code	 Denoising 📊 100 benchmarks 739 papers with code
---	---	---	--	---

Natural Language Processing

 Language Modelling 📊 27 benchmarks 1513 papers with code	 Machine Translation 📊 73 benchmarks 1366 papers with code	 Question Answering 📊 103 benchmarks 1307 papers with code	 Sentiment Analysis 📊 69 benchmarks 836 papers with code	 Text Generation 📊 84 benchmarks 649 papers with code
--	---	---	---	--

Medical

 Medical Image Segmentation 📊 86 benchmarks 244 papers with code	 Drug Discovery 📊 14 benchmarks 151 papers with code	 Lesion Segmentation 📊 6 benchmarks 104 papers with code	 Brain Tumor Segmentation 📊 10 benchmarks 69 papers with code	 COVID-19 Diagnosis 📊 4 benchmarks 59 papers with code
---	---	---	--	---




Graphs

 Link Prediction 📊 69 benchmarks 463 papers with code	 Node Classification 📊 77 benchmarks 370 papers with code	 Graph Embedding 📊 2 benchmarks 252 papers with code	 Graph Classification 📊 54 benchmarks 209 papers with code	 Community Detection 📊 11 benchmarks 156 papers with code
--	--	---	---	--




Time Series

 Time Series 📊 2 benchmarks 1127 papers with code	 EEG 📊 8 benchmarks 177 papers with code	 Imputation 📊 10 benchmarks 160 papers with code
--	---	---




Speech

 Speech Recognition 📊 121 benchmarks 575 papers with code	 Speech Synthesis 📊 3 benchmarks 142 papers with code	 Dialogue Generation 📊 10 benchmarks 108 papers with code
--	--	--

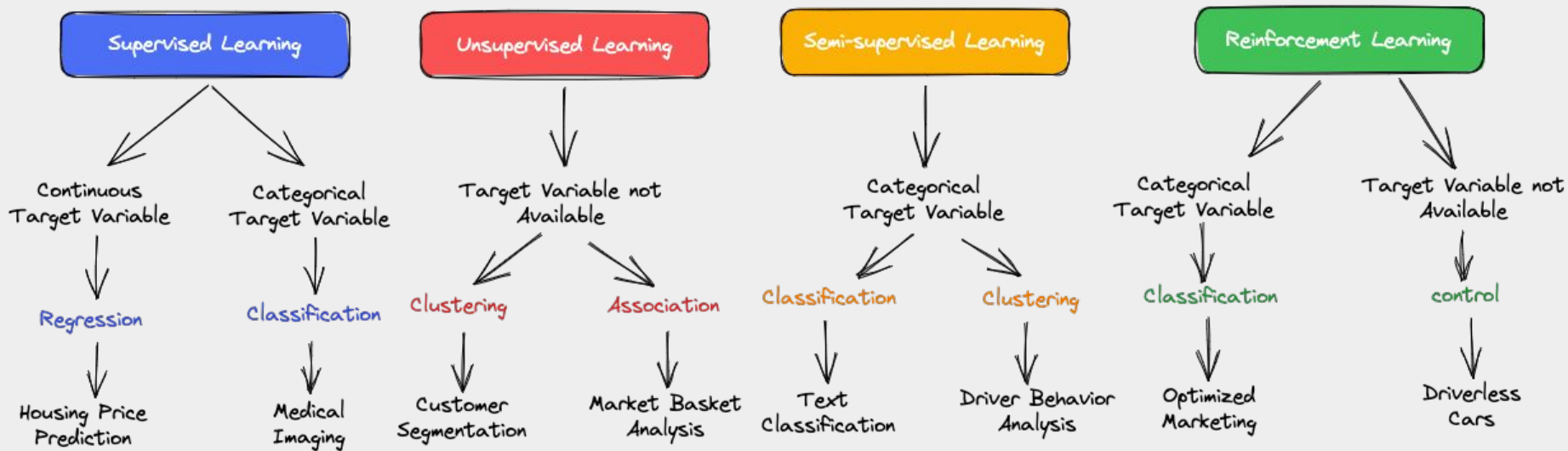
Playing Games

 Continuous Control 📊 76 benchmarks 242 papers with code	 Atari Games 📊 65 benchmarks 213 papers with code	 OpenAI Gym 📊 9 benchmarks 112 papers with code
---	--	--

Music

 Music Generation 60 papers with code	 Music Information Retrieval 55 papers with code	 Music Source Separation 📊 3 benchmarks 31 papers with code
---	--	--

Machine Learning Types



Supervised Learning

Classification Problem

Chest Pain	Blocked Arteries	Patient Weight	Heart Disease
Yes	Yes	205	Yes
No	Yes	180	Yes
Yes	No	210	Yes
Yes	Yes	167	Yes
No	Yes	156	No
No	Yes	125	No
Yes	No	168	No
Yes	Yes	172	No

Chest Pain	Blocked Arteries	Patient Weight
Yes	No	200

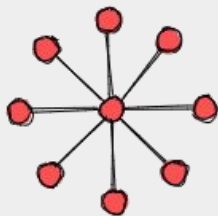
Supervised Learning

Regression Problem

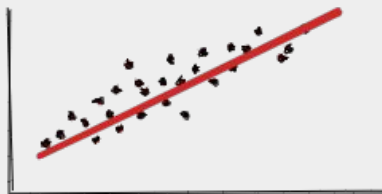
Height (m)	Favorite Color	Gender	Weight (kg)
1.6	Blue	Male	88
1.6	Green	Female	76
1.5	Blue	Female	56
1.8	Red	Male	73
1.5	Green	Male	77
1.4	Blue	Female	57

Height (m)	Favorite Color	Gender
1.83	Yellow	Male

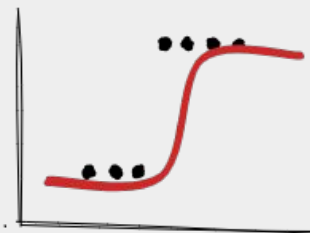
K-Nearest Neighbors (KNN)



Linear Regression



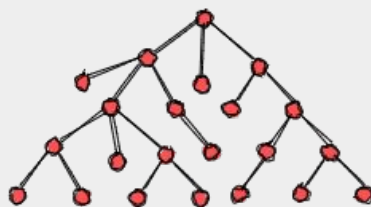
Logistic Regression



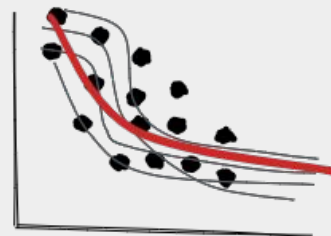
Support Vector Machines (SVM)



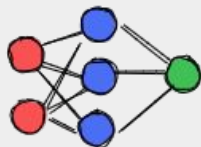
Decision Trees



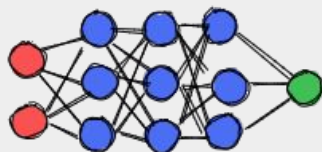
Ensemble



Neural Networks



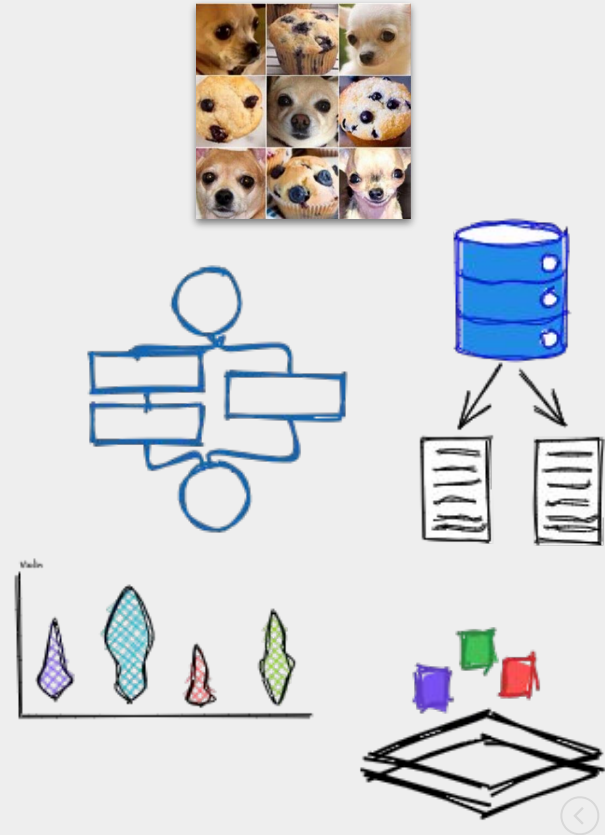
Deep Learning



Bosting

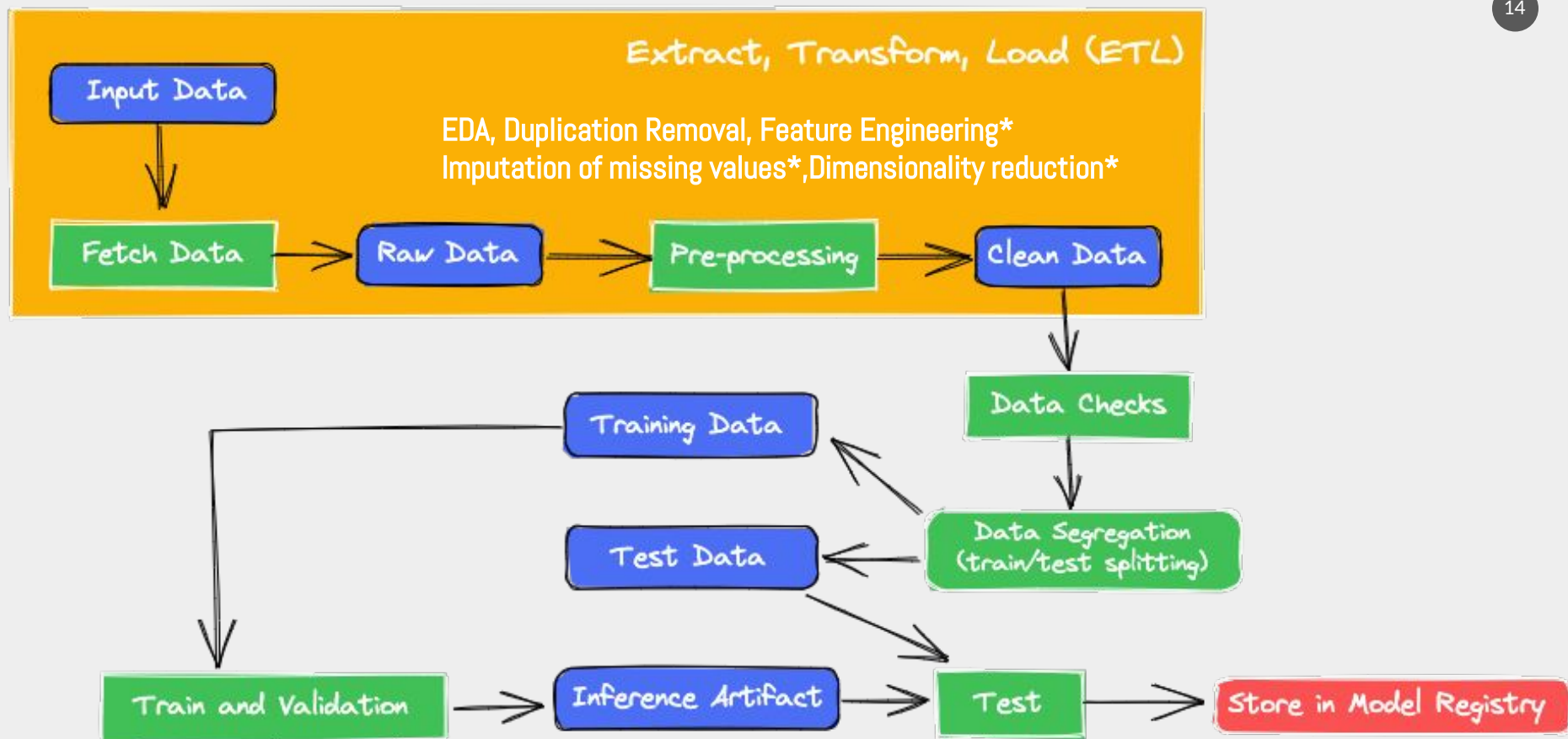


Main Challenges Of Machine Learning

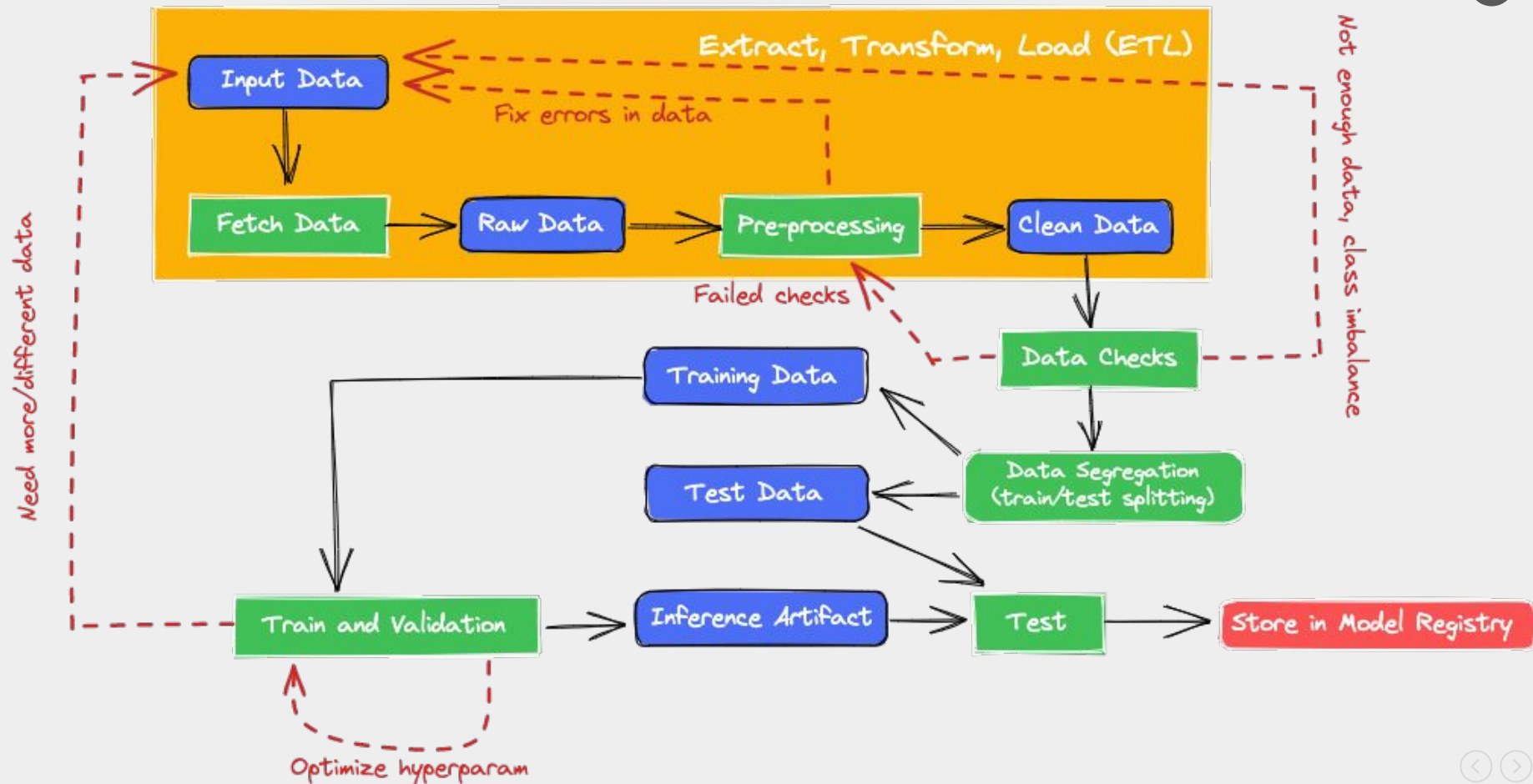


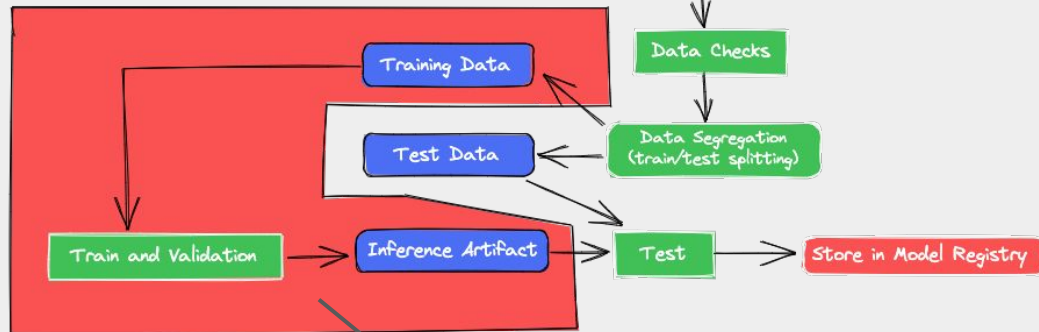
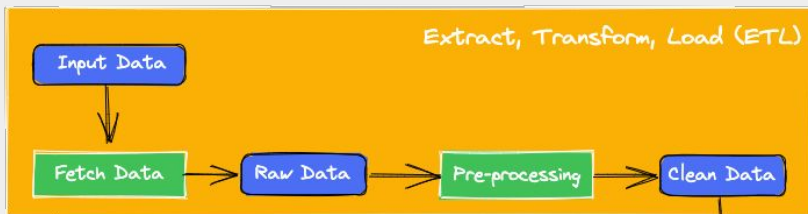
Titanic: Machine Learning from Disaster

Survived	Pclass	Name	Sex	Age	Ticket	Cabin	Embarked
0	3	Braund, Mr. Owen	Male	22	A/5 21171	NaN	S
1	1	Cummings, Mrs John	Female	38	PC 17599	C85	C
1	3	Heikkinen, Ms Laina	Female	26	STON/O2	NaN	S
1	1	Futrelle, Mrs Jacques	Female	35	113803	C123	S
0	3	Allen, Mr. William	Male	35	373450	NaN	S

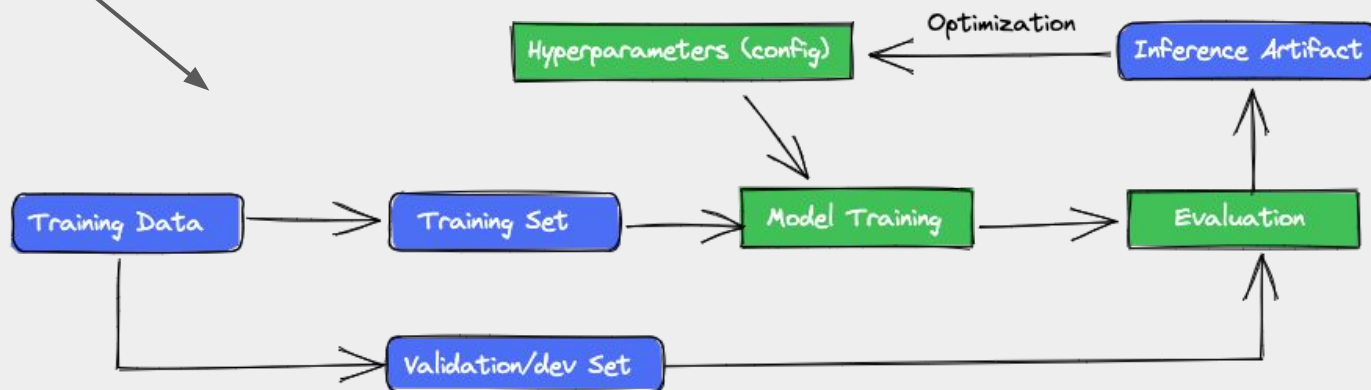


Feature Store, Categorical encoding missing values imputation, Dimensionality Reduction





Train and Evaluate



Controlled Chaos



Assume you are going to iterate A LOT



Nothing is lost
You learn something with every experiment



Give yourself time within the project deadlines



Perfection is the enemy of good
Be clear on your objective and stop once you reach it



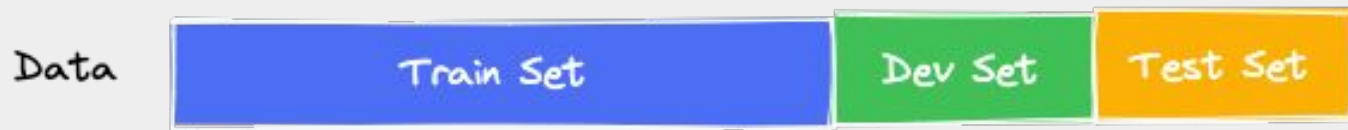
Be systematic
Normally, change one thing at the time



Nothing is fixed
data, code and hyperparameters

Train - Dev - Test Sets

Making good choices in how you set up your training, development, and test sets can make a huge difference in helping you quickly find a good high performance neural network.



Previous ML era

- 70/30
- 60/20/20

Big Data era

- 98/1/1
- 99.5/0.25/0.25
- 99.5/0.4/0.1

Holdout
Cross-Validation
Validation
Development

Mismatched train/test distribution

Scenario: say you are building a cat-image classifier application that determines if an image is of a cat or not. The application is intended for users in rural areas who can take pictures of animals by their mobile devices for the application to classify the animals for them.

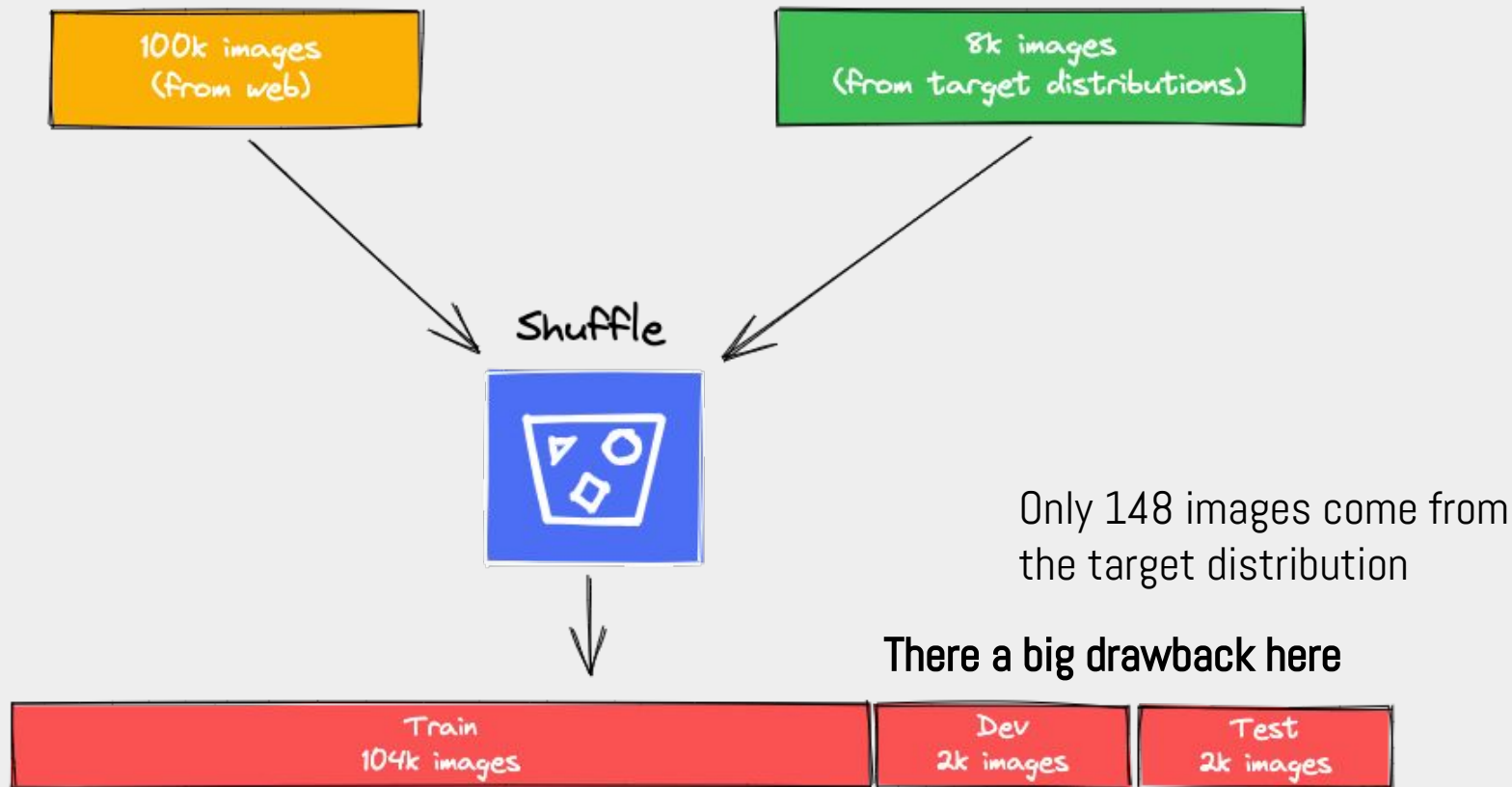


Scraped from Web Pages
100k images

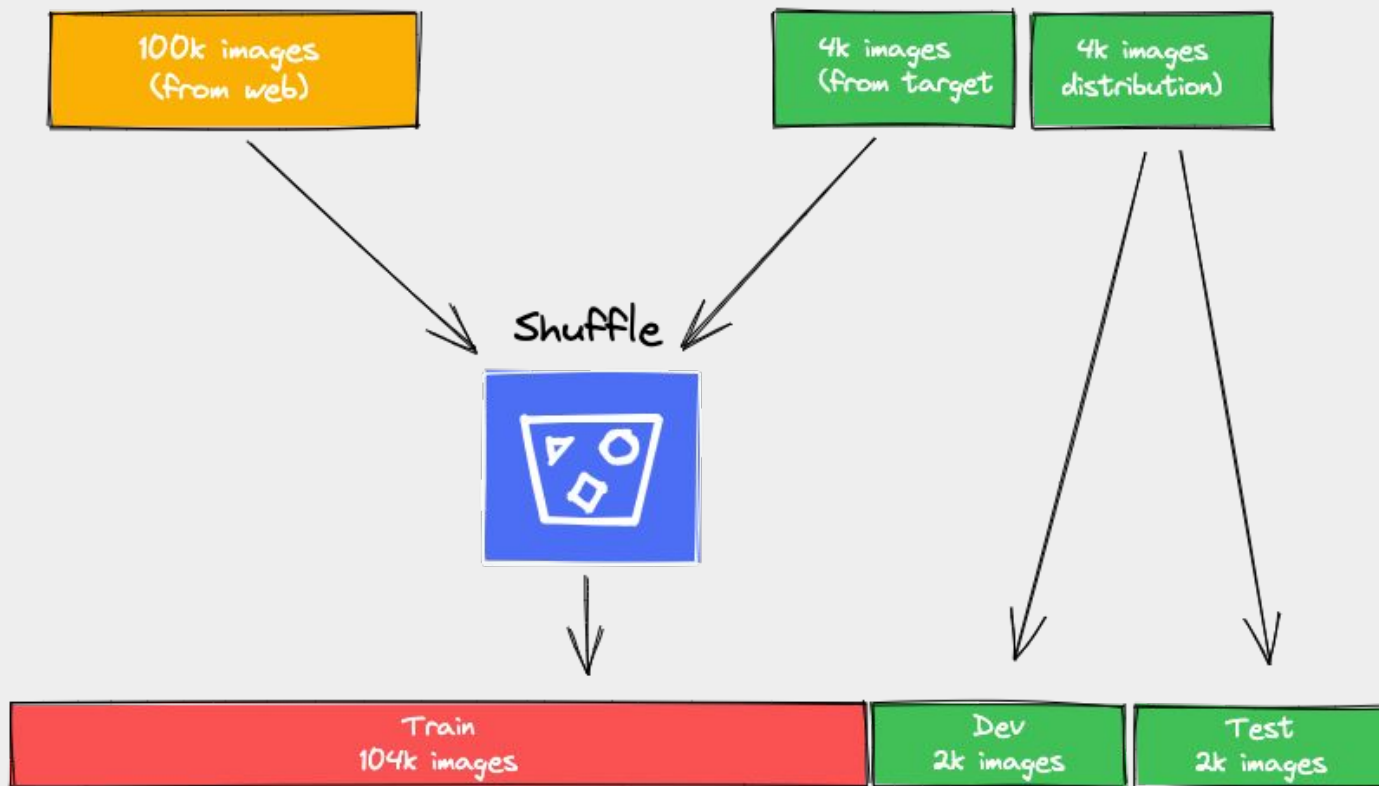


Collected from Mobile Devices
<<target distribution>>
8k images

A possible option: shuffling the data



A better option



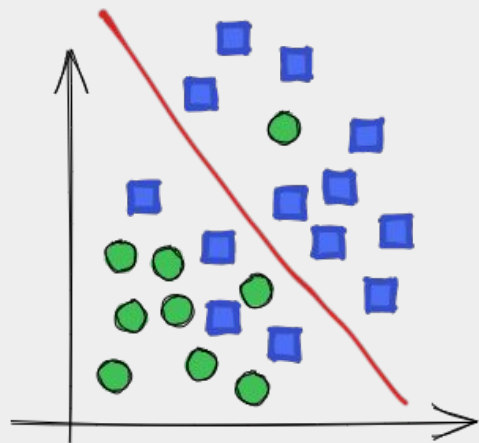
Rule of the thumb

>> make sure that the dev and test sets come from the same distribution

Not having a test set might be okay. (Only dev set)

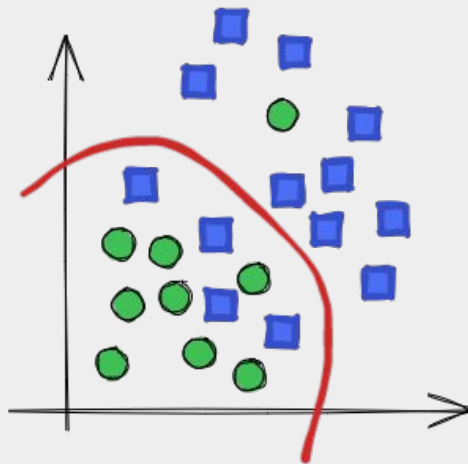


Bias vs Variance

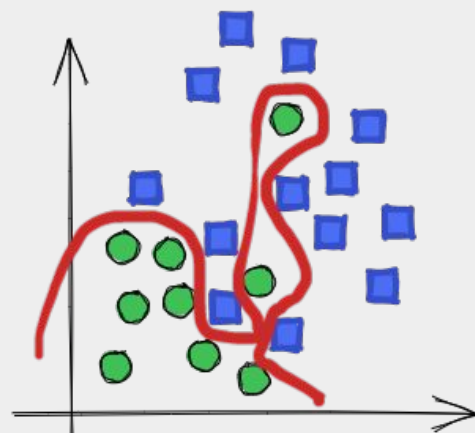


High Bias

Underfitting



Just Right



High Variance

Overfitting

Bias vs Variance

Cat Classification



	Scenario #01	Scenario #02	Scenario #03	Scenario #04
Train Set Error	1%	15%	15%	0.5%
Dev Set Error	16%	16%	30%	1%
	Low Bias High Variance	High Bias Low Variance	High Bias High Variance	Low Bias Low Variance

Basic Recipe for Machine Learning

