UFRN
UNIVERSIDADE FEDERAL DO RIO GRANDE DO NORTE

NE 4.0

Aprendizado de Máquina

Fundamentos

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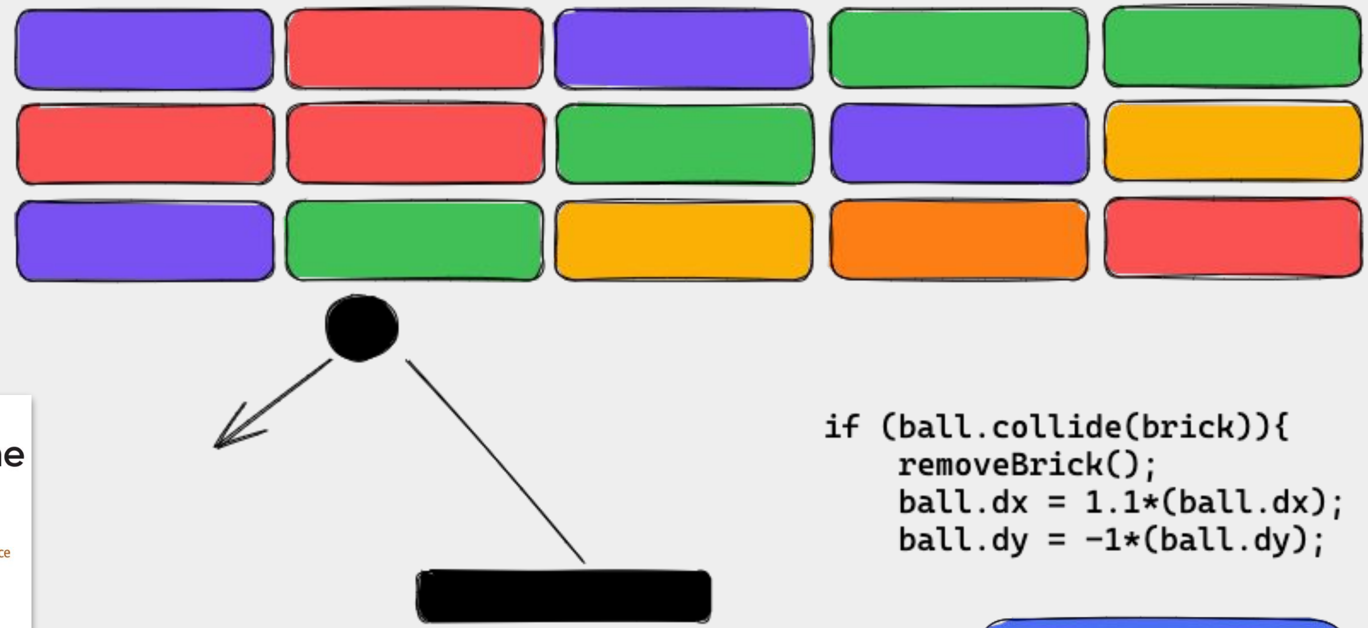
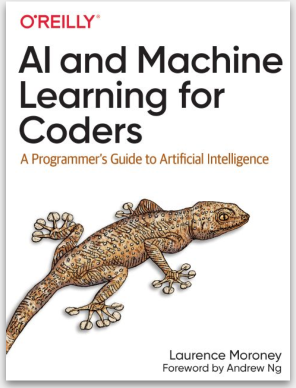
What is Machine Learning?



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



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;
}
```

```
// ????
```

From coding to ML

<gathering and label data>

```
010111100001110101
111010101010111000
111010101010101010
000000000111001111
```

Label = WALKING

```
010111100011101110
000111010101011011
000111101010111000
000000000000001111
```

Label = RUNNING

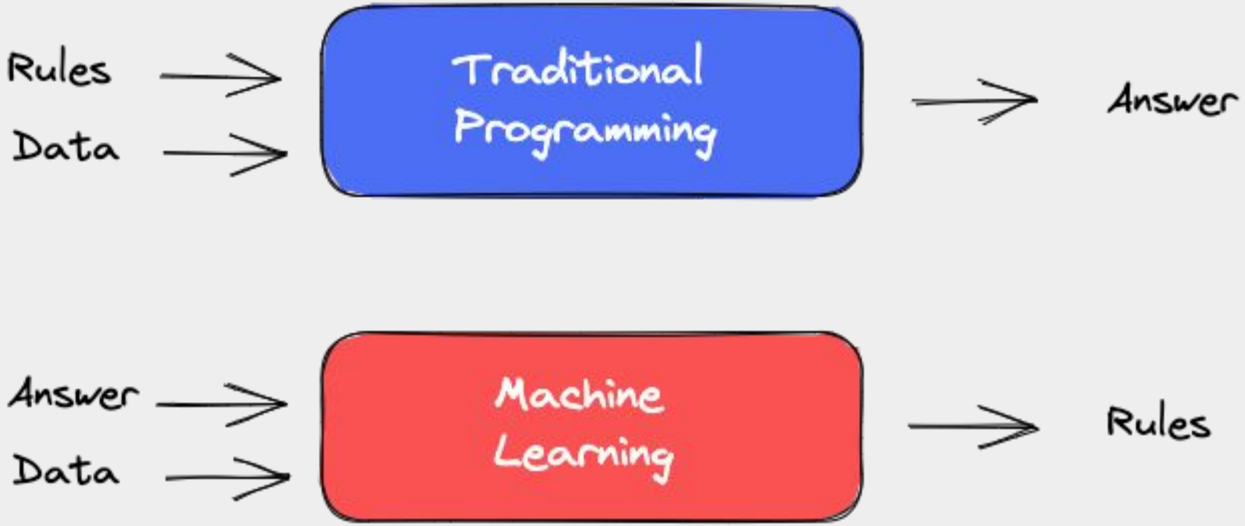
```
111101110010101011
110101110101011011
111110101110010101
000111111001101111
```

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 begging 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

Task	Benchmarks	Papers with code
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

Time Series

Task	Benchmarks	Papers with code
Time Series	2 benchmarks	1127 papers with code
EEG	8 benchmarks	177 papers with code
Imputation	10 benchmarks	160 papers with code

Natural Language Processing

Task	Benchmarks	Papers with code
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

Speech

Task	Benchmarks	Papers with code
Speech Recognition	121 benchmarks	575 papers with code
Speech Synthesis	3 benchmarks	142 papers with code
Dialogue Generation	10 benchmarks	108 papers with code

Medical

Task	Benchmarks	Papers with code
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

Playing Games

Task	Benchmarks	Papers with code
Continuous Control	76 benchmarks	242 papers with code
Atari Games	65 benchmarks	213 papers with code
OpenAI Gym	9 benchmarks	112 papers with code

Graphs

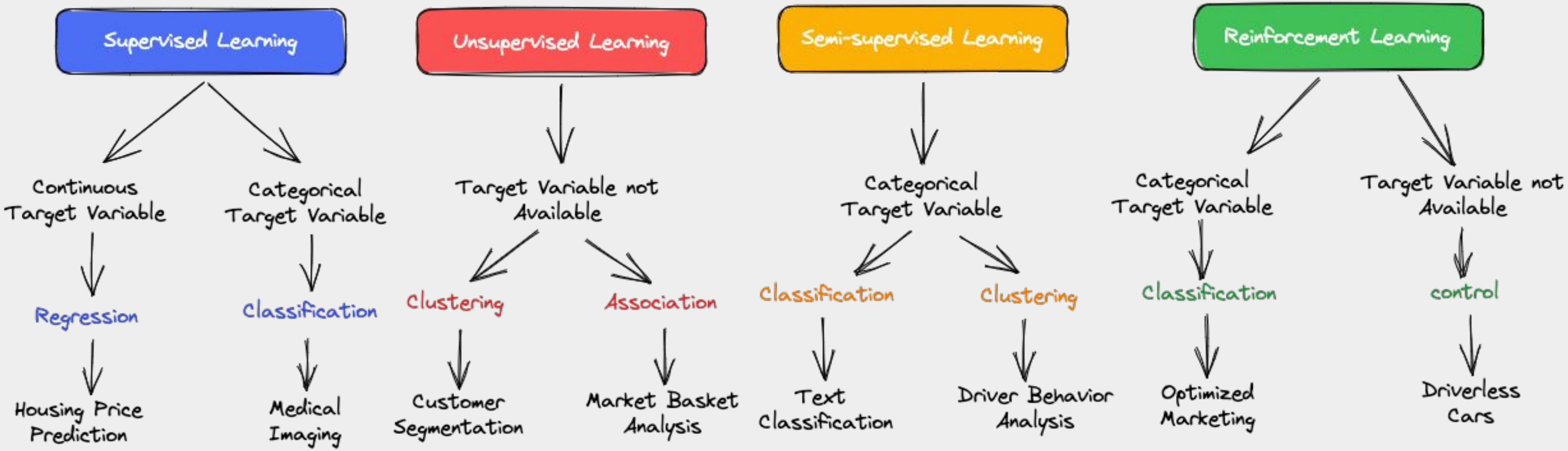
Task	Benchmarks	Papers with code
Link Prediction	69 benchmarks	463 papers with code
Node Classification	77 benchmarks	370 papers with code
Graph Embedding	2 benchmarks	252 papers with code
Graph Classification	54 benchmarks	209 papers with code
Community Detection	11 benchmarks	156 papers with code

Music

Task	Benchmarks	Papers with code
Music Generation		60 papers with code
Music Information Retrieval		55 papers with code
Music Source Separation	3 benchmarks	31 papers with code

https://paperswithcode.com/sota

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

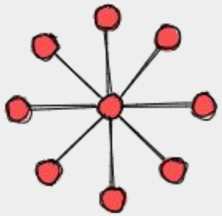
Supervised Learning

Regression Problem

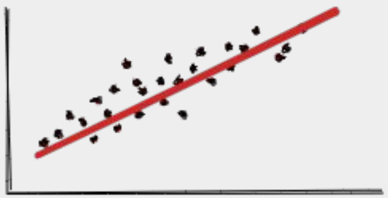
Height (m)	Favorite Color	Gender	Weight (kg)
1.6	Blue	Male	88
1.6	Green	Famale	76
1.5	Blue	Female	56
1.8	Red	Male	73
1.5	Green	Male	77
1.4	Blue	Female	57

Height (m)	Favorite Color	Gender
1.83	Yellow	Male

K-Neighrest Neighbors (KNN)



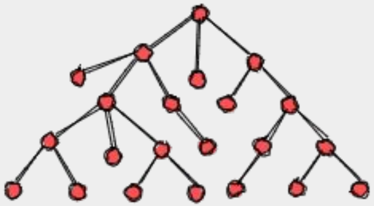
Linear Regression



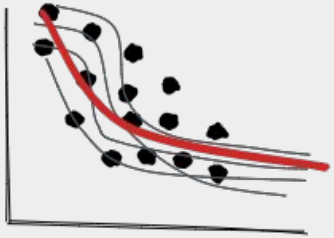
Logistic Regression

Support Vector Machines (SVM)

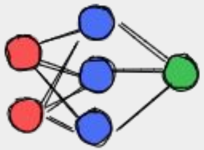
Decision Trees



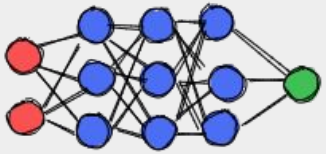
Ensemble



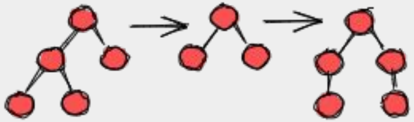
Neural Networks



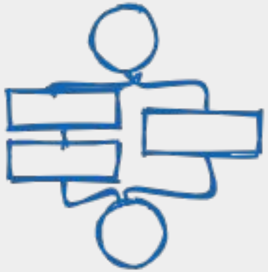
Deep Learning

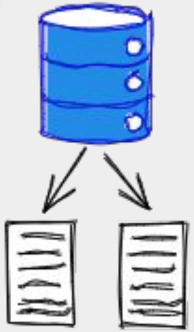


Bosting



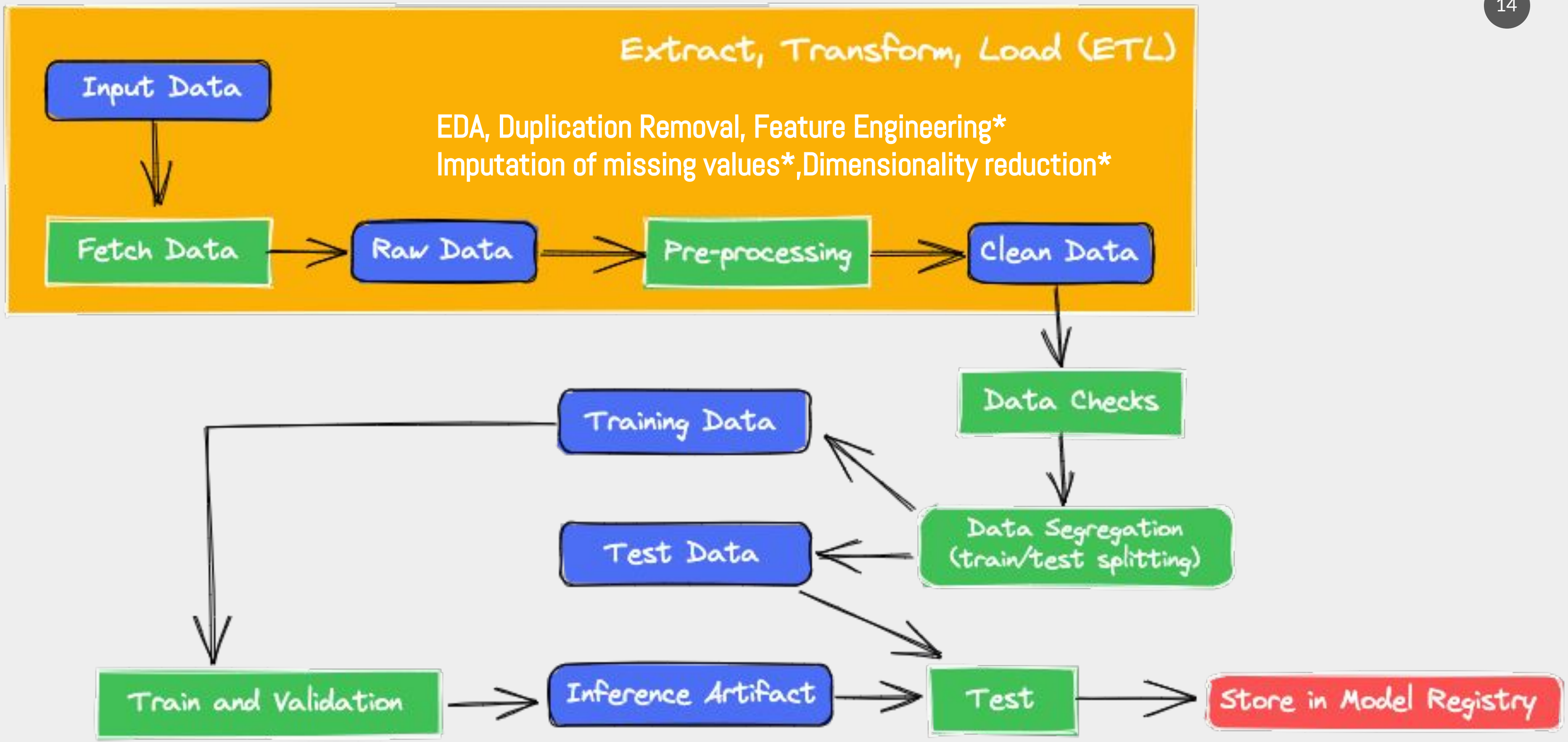
Main Challenges Of Machine Learning



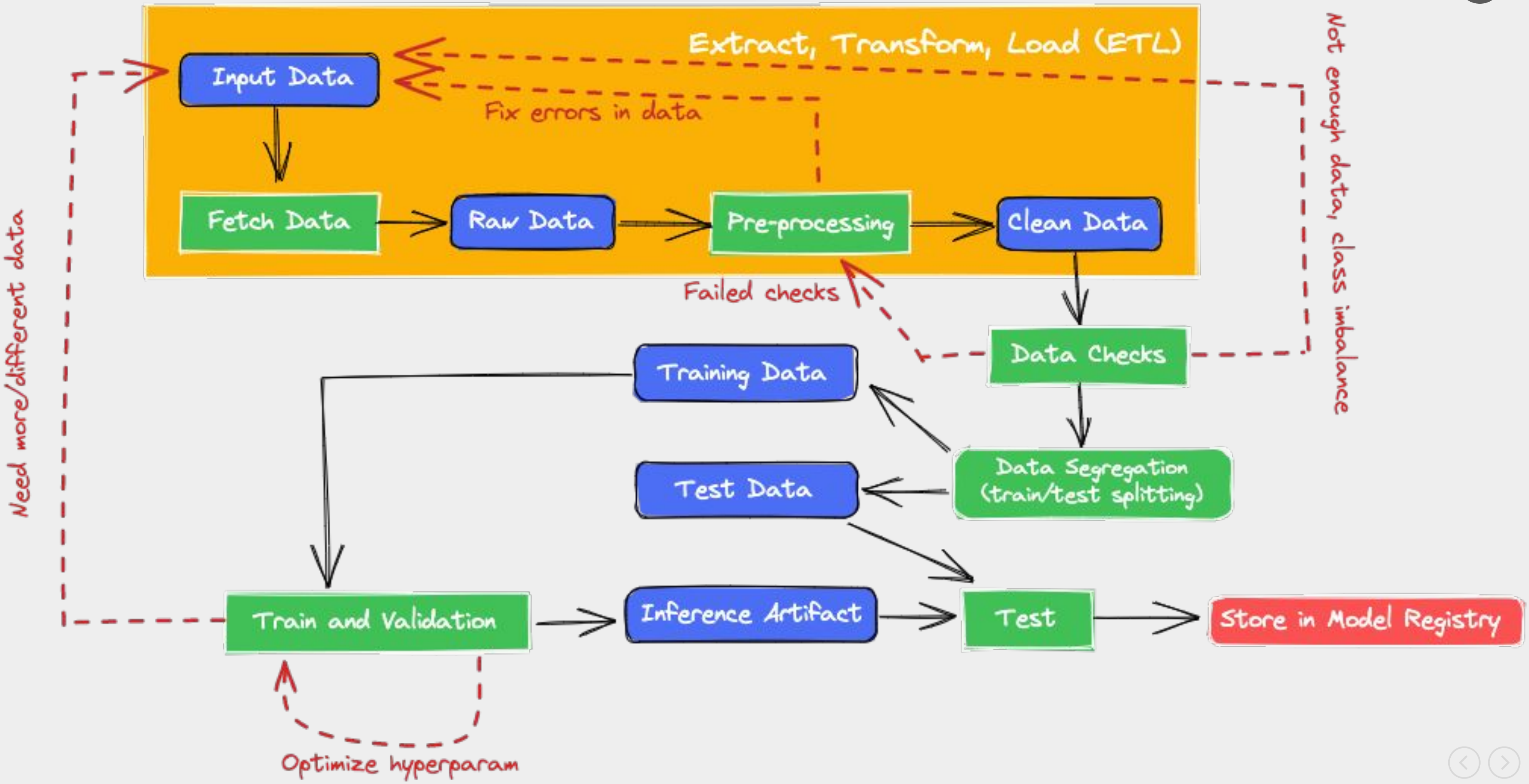


Titanic: Machine Learning from Disaster

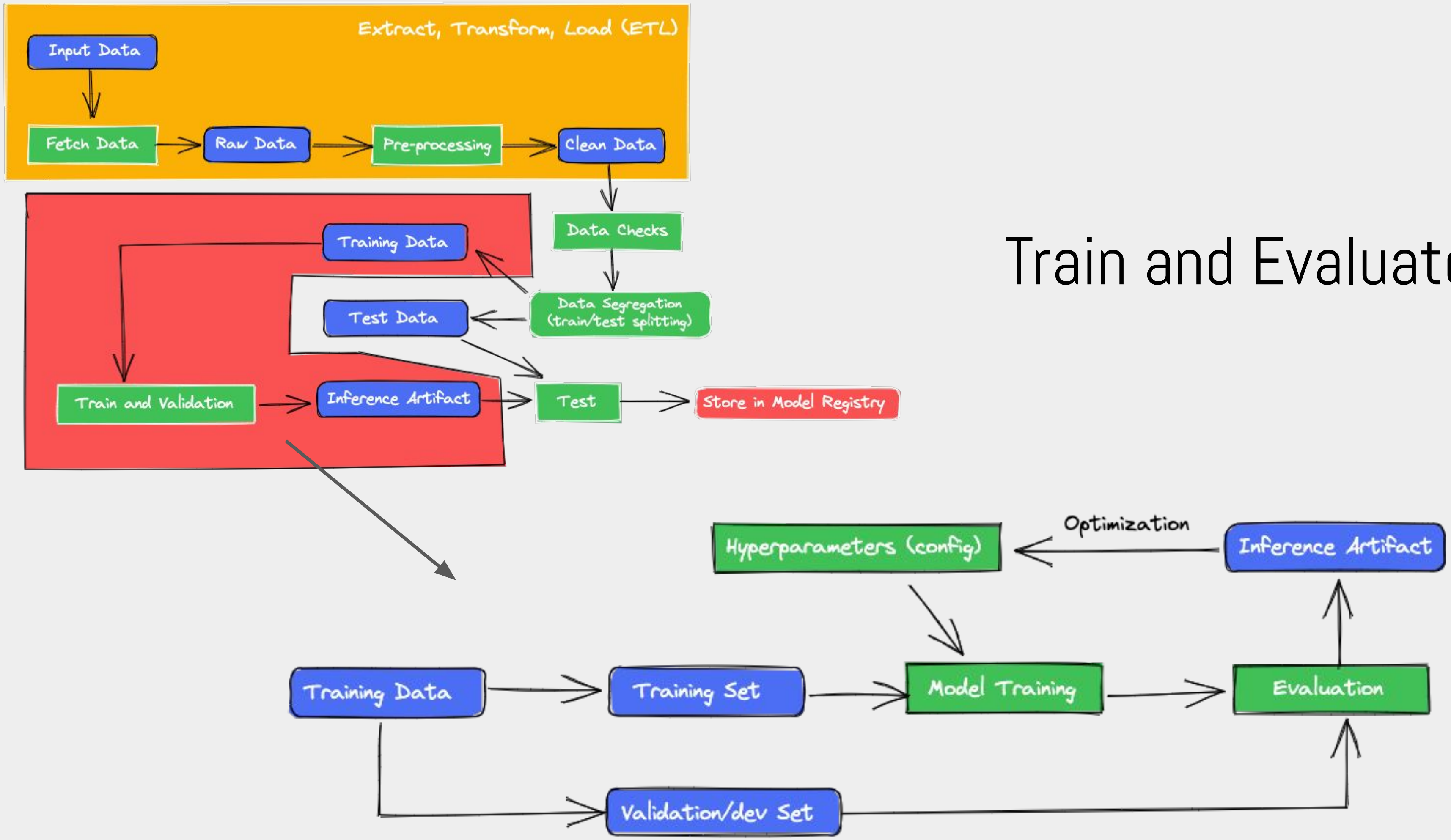
Survived	Pclass	Name	Sex	Age	Ticket	Cabin	Embarked
0	3	Braund, Mr. Owen	Male	22	A/5 21171	NaN	S
1	1	Cummings, Mrs John	Female	38	PC 17599	C85	C
1	3	Heikkinen, Ms Laina	Female	26	STON/02	NaN	S
1	1	Futrelle, Mrs Jacques	Female	35	113803	C123	S
0	3	Allen, Mr. William	Male	35	373450	NaN	S



Feature Store, Categorical encoding missing values imputation, Dimensionality Reduction


Extract, Transform, Load (ETL)
Input Data
Fix errors in data
Fetch Data
Raw Data
Pre-processing
Clean Data
Failed checks
Data Checks
Not enough data, class imbalance
Need more/different data
Training Data
Test Data
Data Segregation (train/test splitting)
Train and Validation
Inference Artifact
Test
Store in Model Registry
Optimize hyperparam

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
Normaly, 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

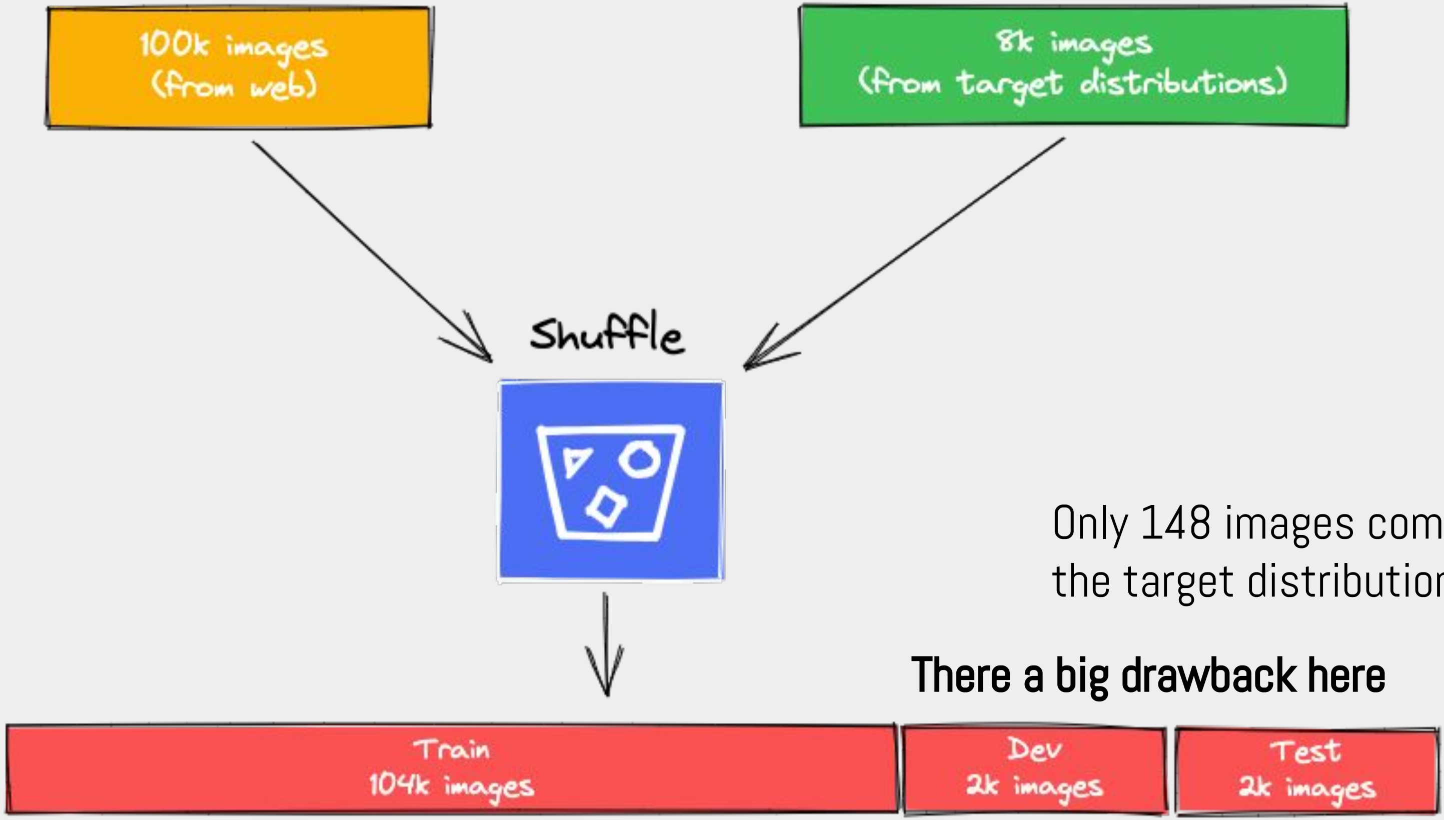
Mismatched train/test distribution

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

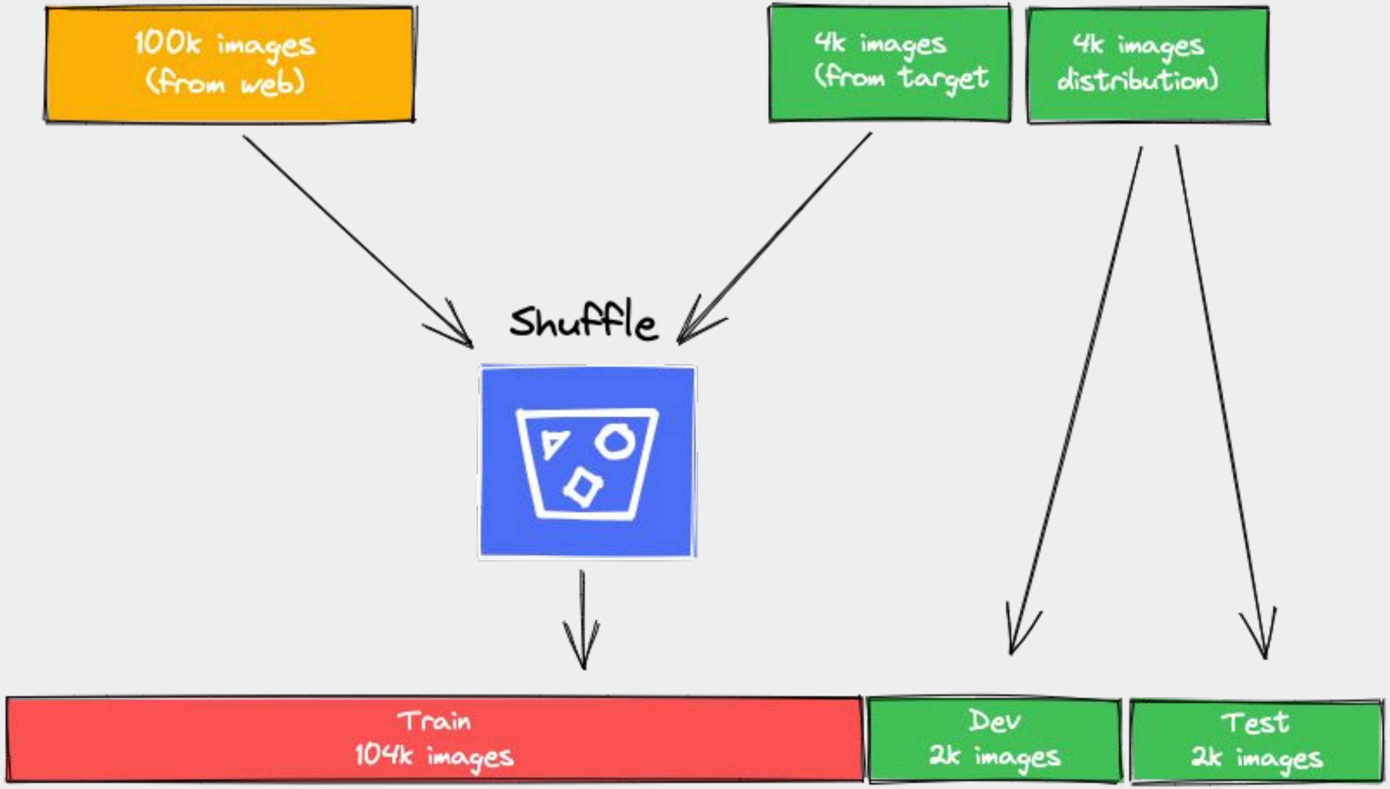
A possible option: shuffling the data



Only 148 images come from the target distribution

There a big drawback here

A better option

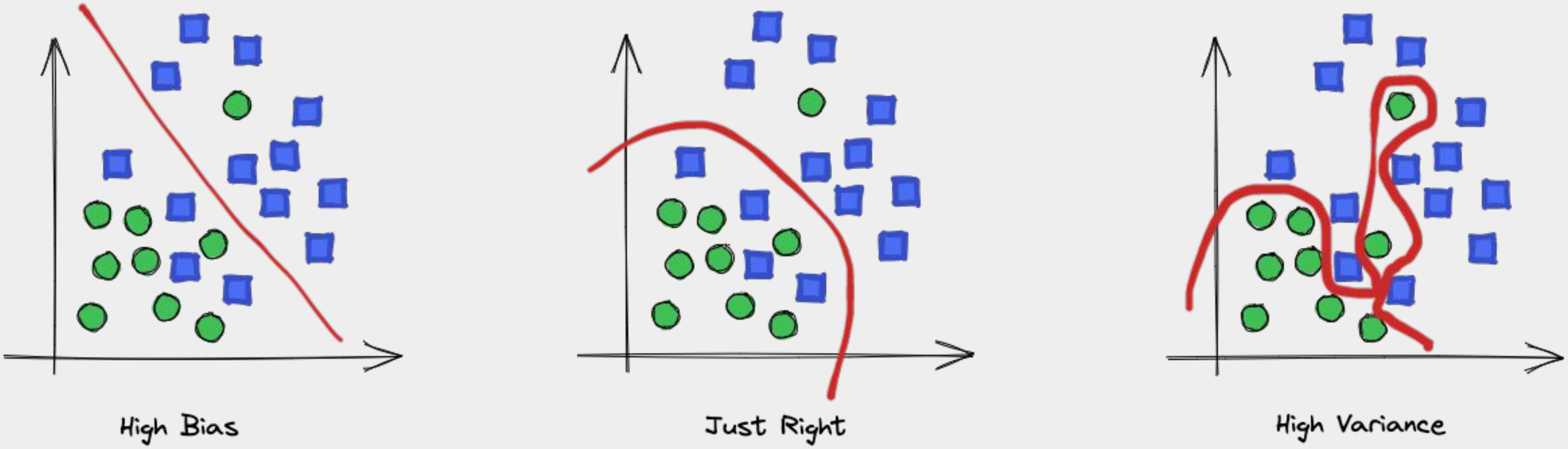


Rule of the thumb

>> 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



Underfitting

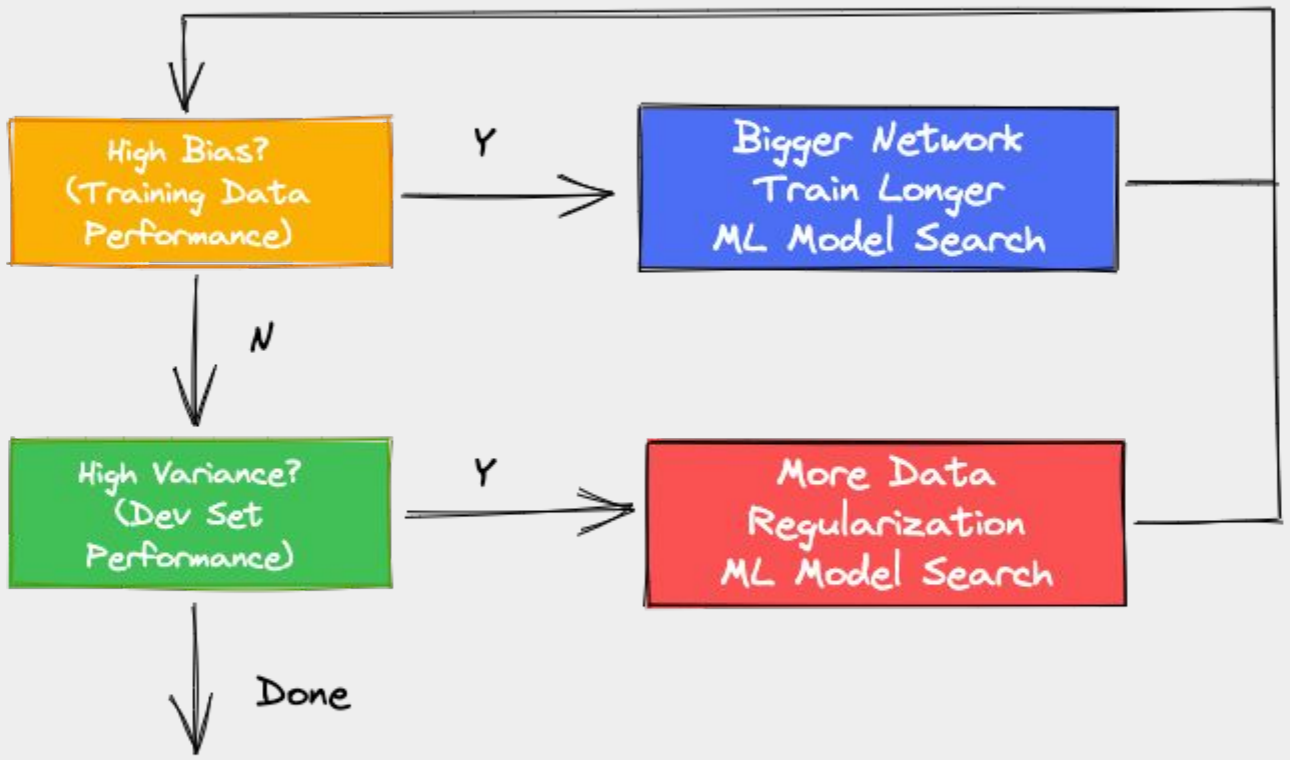
Overfitting

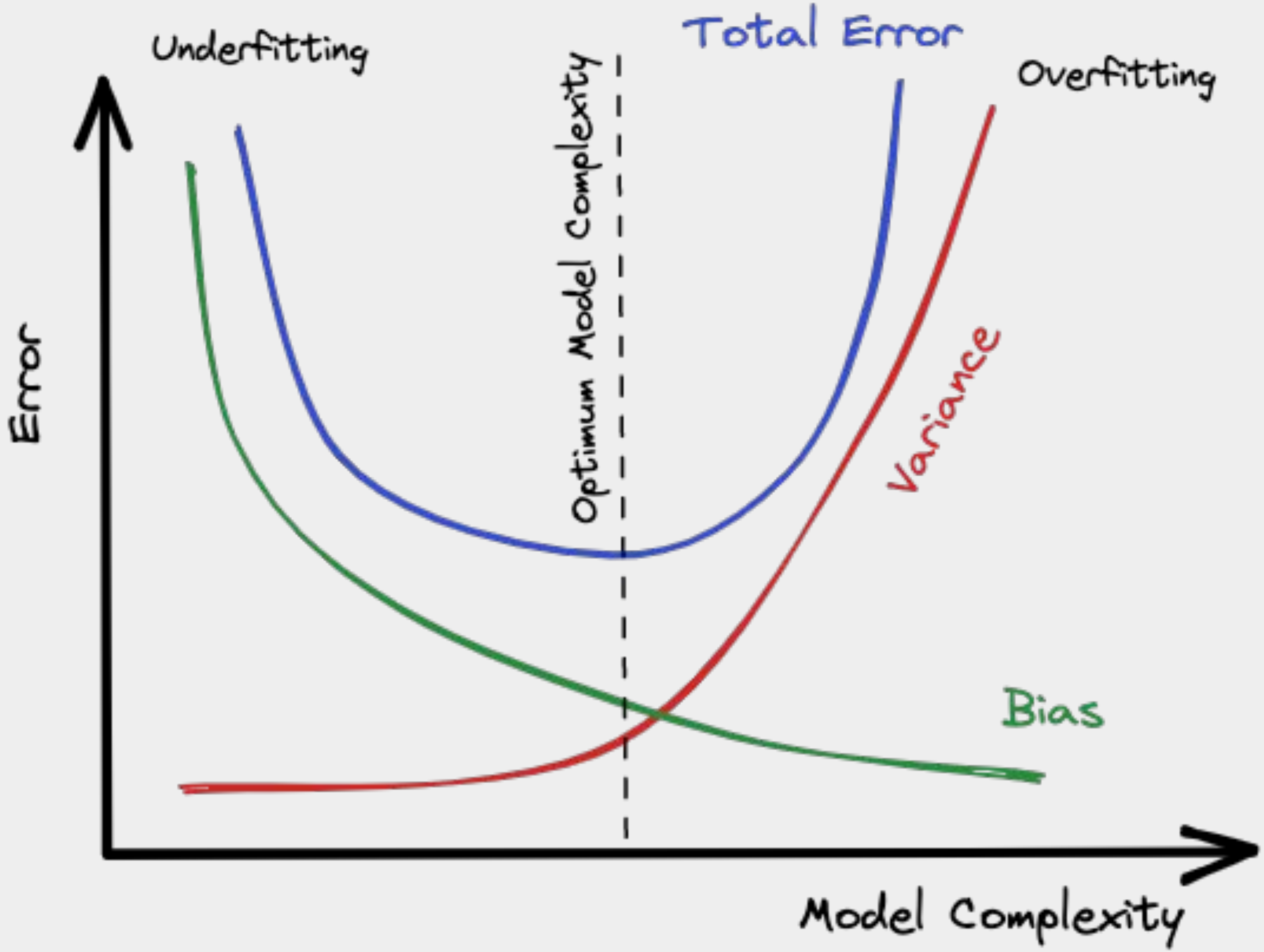
Bias vs Variance

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




Underfitting
Total Error
Overfitting
Optimum Model Complexity
Error
Variance
Bias
Model Complexity