RESPONSIBLE ARTIFICIAL INTELLIGENCE LAB (RAIL)

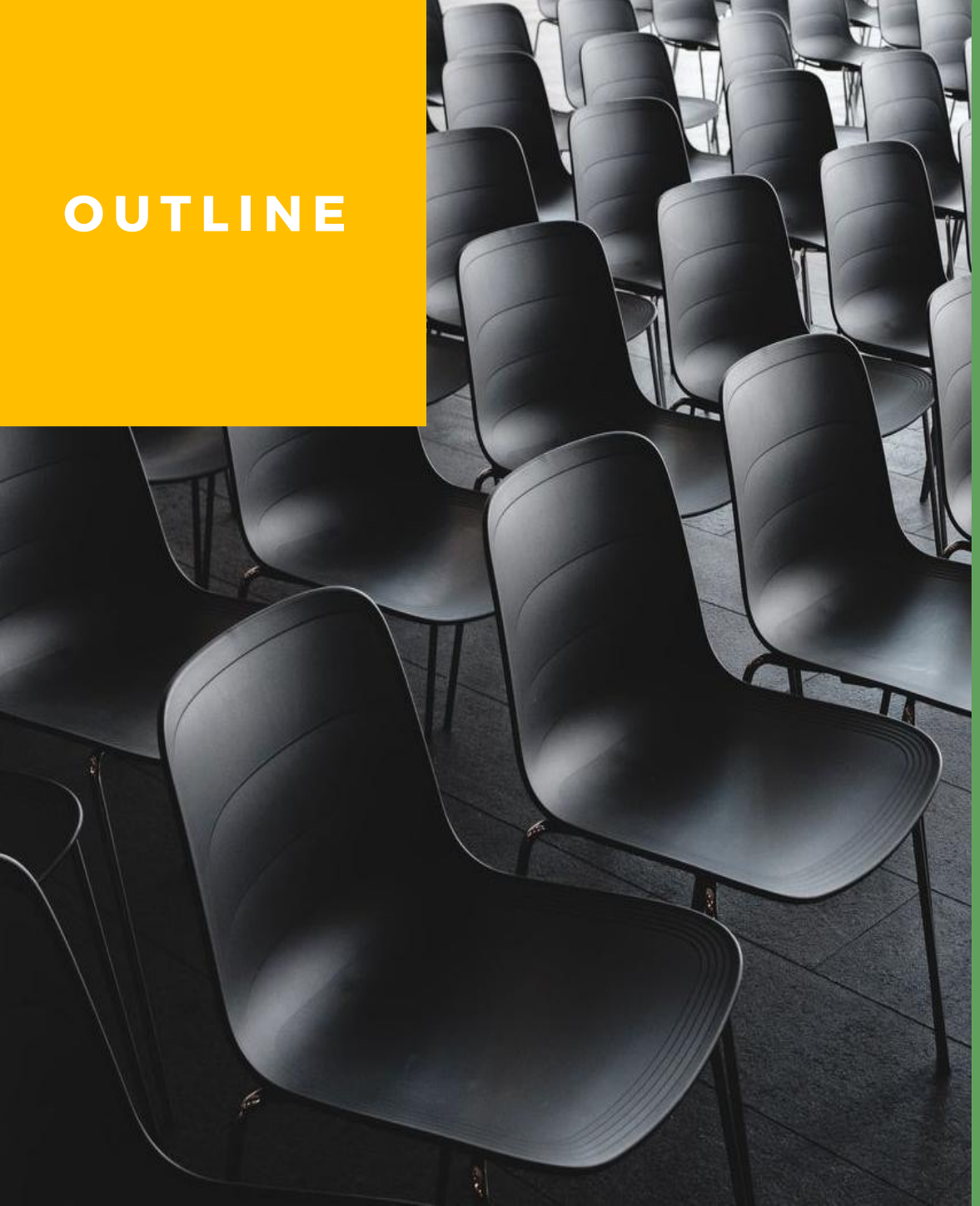
Fundamentals of Machine Learning

ARTIFICIAL INTELLIGENCE FOR DEVELOPMENT AFRICA

RESPONSIBLE ARTIFICIAL INTELLIGENCE LAB

5th December 2022

OUTLINE



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2. What is Machine Learning
3. Applications of ML
4. Essential ML Processes
5. What are ML models
6. Selecting a Model
7. How to Use a Model
8. The Data for Use and Data for Training
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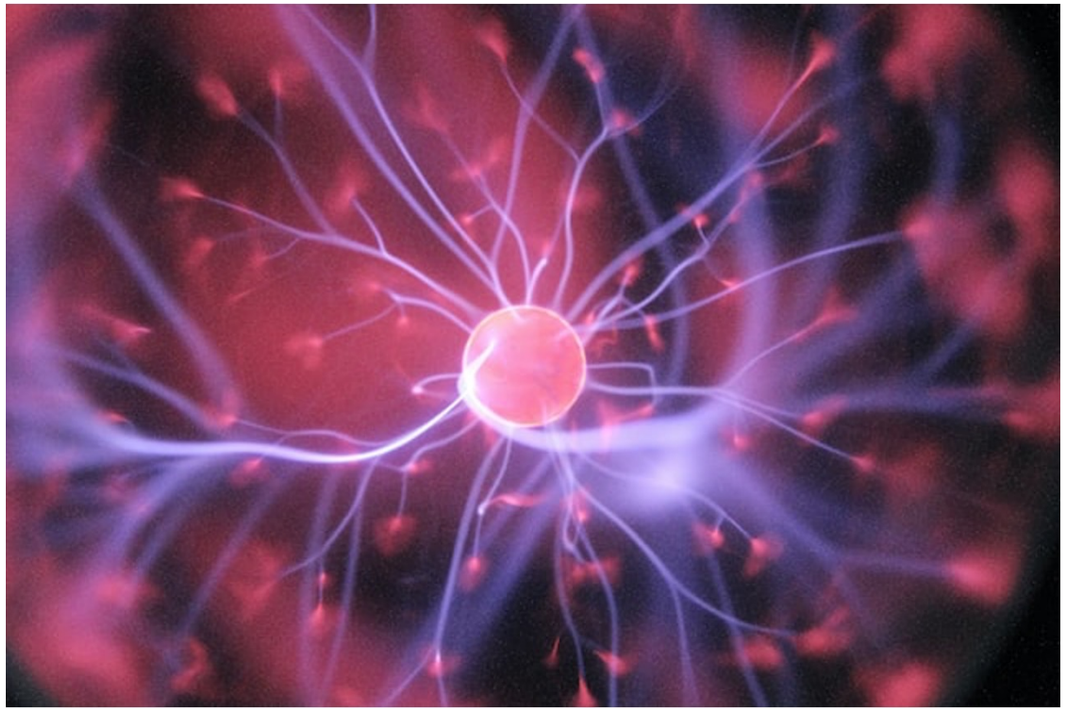
The Human Brain

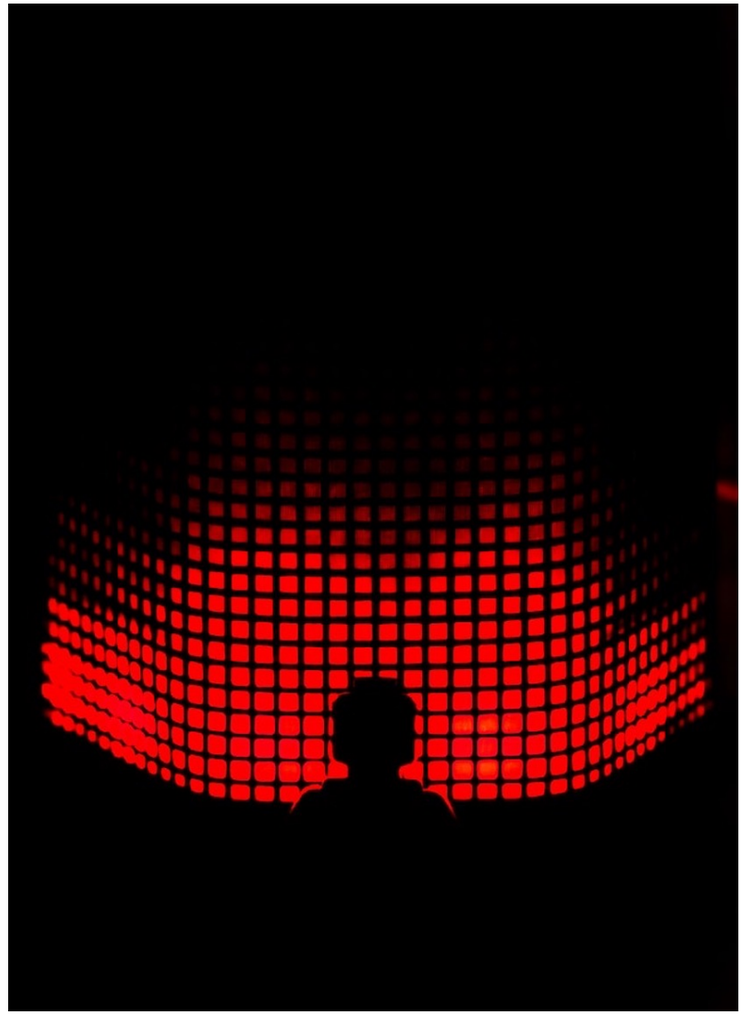
- The human brain **perceives** things from the real world, **processes** the perceived information, **makes rational decisions**, and performs **specific actions** based on circumstances.
  - This is what we call behaving intelligently.
- When we program a facsimile of the **intelligent behavioural process** to a **machine**, it is called **artificial intelligence** (AI).



What is Machine Learning?

- Machine learning is one of the most popular and frequently used terms today.

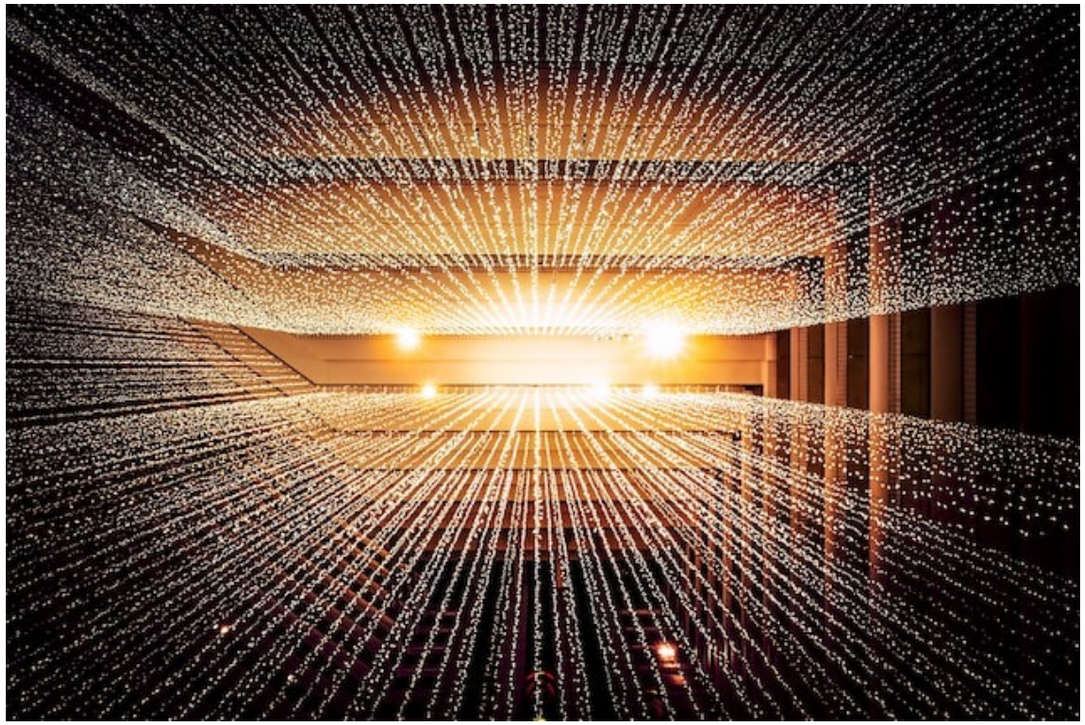
- However, the mechanics of machine learning are a mystery to most people.



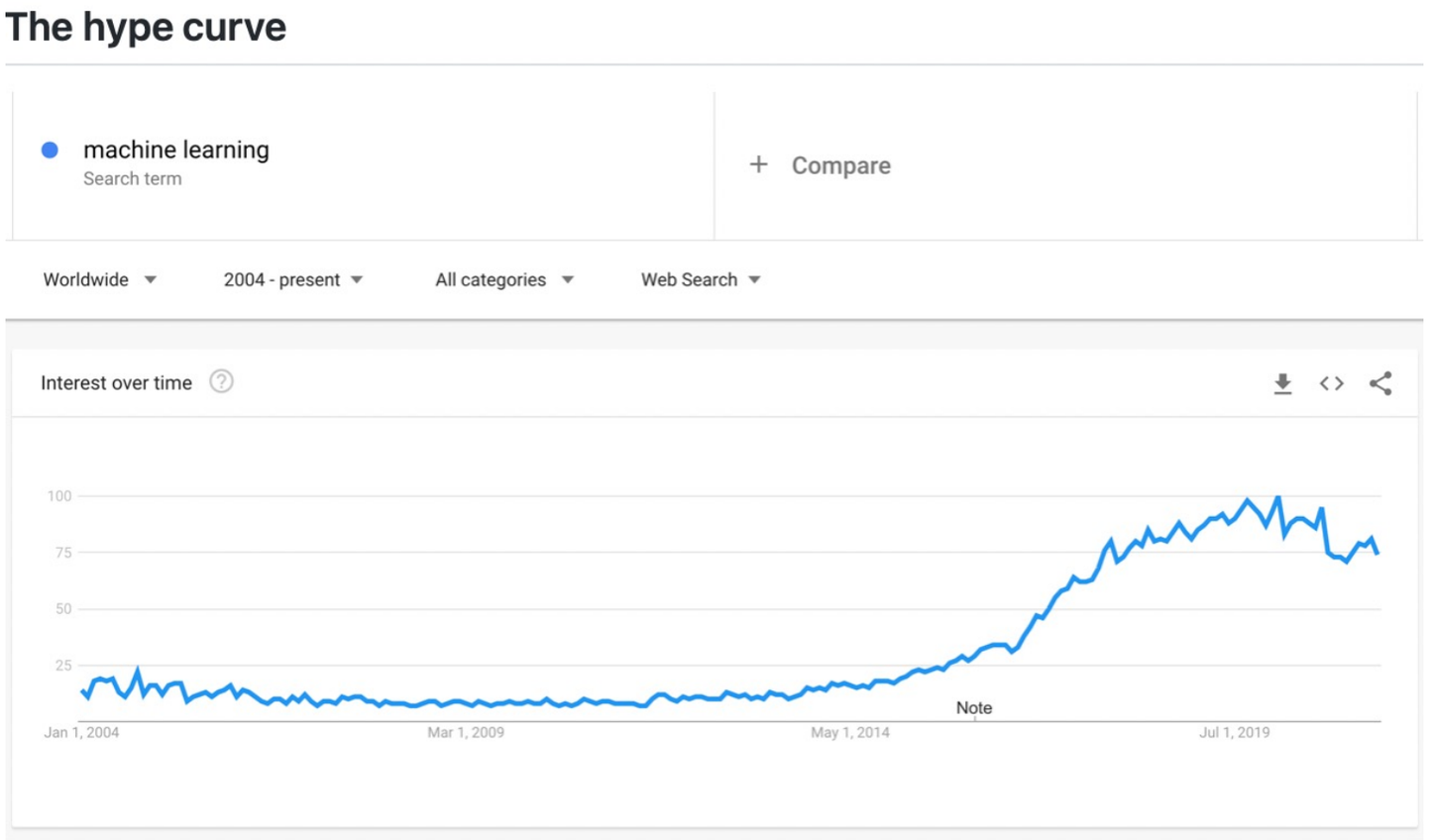
What is Machine Learning?

- For a machine learning beginner, the subject can sometimes feel overwhelming.

- Therefore, it is essential to understand what machine learning is and learn about it through practical examples.



What is Machine Learning?

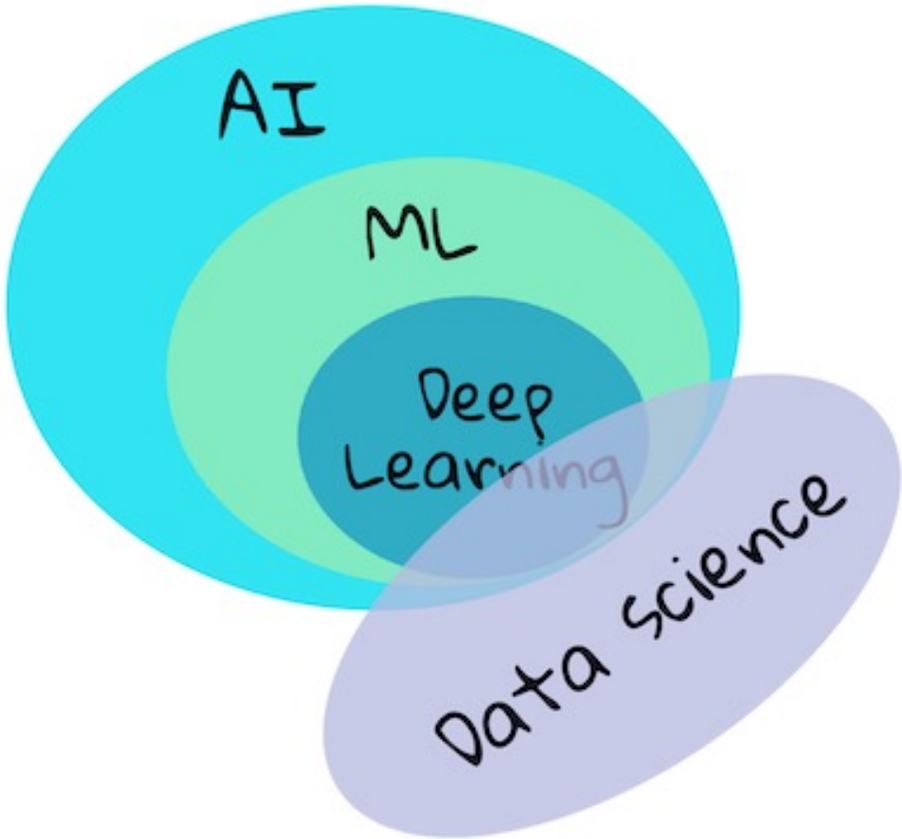


Google Trends shows the recent 'hype curve' of the term 'machine learning'

AI, ML, Deep Learning

- Although the terms can be confused, machine learning (ML) is an essential subset of artificial intelligence.

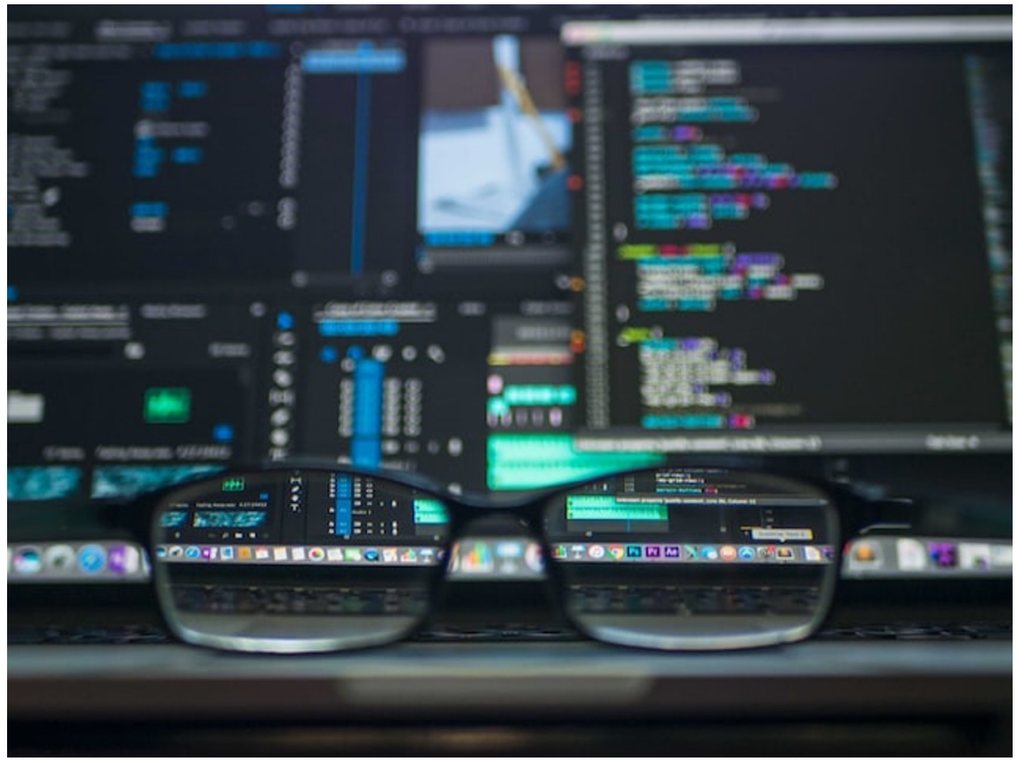
- ML uses specialised algorithms to uncover meaningful information and hidden patterns from perceived data to corroborate rational decision-making.



Applications of Machine Learning

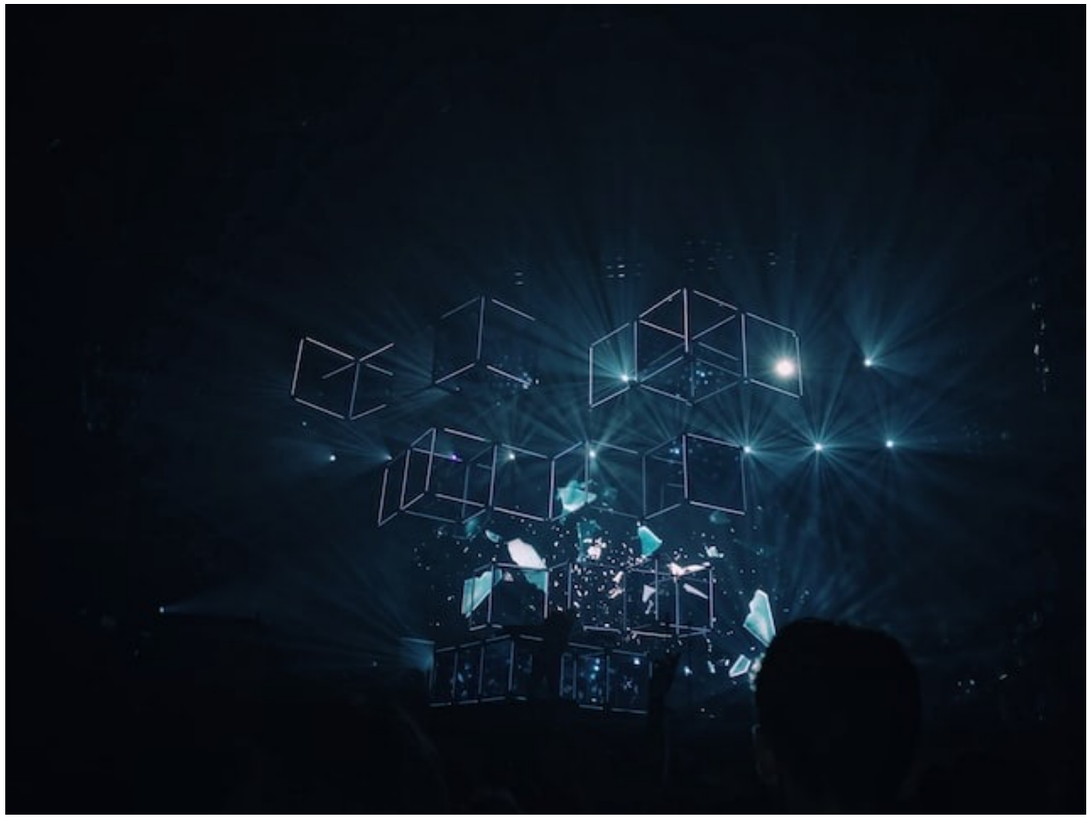
- Applications of machine learning are now almost everywhere.
  - and are as ubiquitous as the data that is flowing around our societies.

- ML has been exploring the capability to solve multi-dimensional and multi-disciplinary real-life problems with excellent positive outcomes.



Examples of Applied Machine Learning

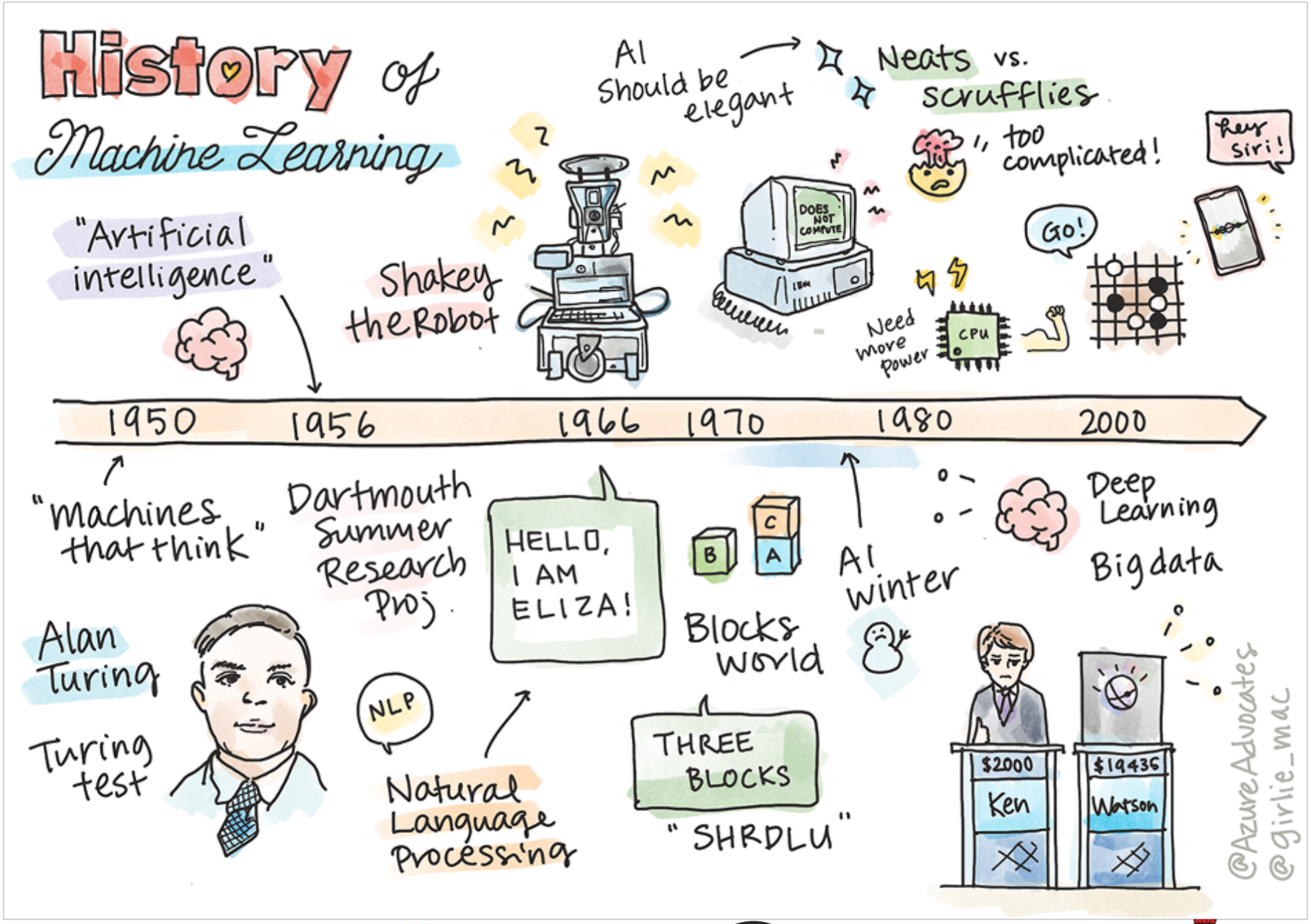
- You can use machine learning in many ways:
  - To predict the likelihood of disease from a patient's medical history or reports.
  - To leverage weather data to predict weather events.
  - To understand the sentiment of a text.
  - To detect fake news to stop the spread of propaganda.



Others: Finance, economics, earth science, space exploration, biomedical engineering, cognitive science, and even fields in the humanities have adapted machine learning to solve their domain's arduous, data-processing-heavy problems.

Breather…

- Machine Learning algorithms are meant to simulate
  - Intelligent machines
  - The human brain
  - Orangutans
- What is an example of a classical ML technique?
  - Natural Language processing
  - Deep learning
  - Neural networks
- Why should everyone learn the basics of ML?
  - Learning ML is fun and accessible to everyone.
  - ML strategies are being used in many industries and domains
  - Both of the above


History of Machine Learning
AI Should be elegant
Neats vs. scrufflies
too complicated!
Hey Siri!
"Artificial intelligence"
Shakey the Robot
DOES NOT COMPUTE
IBM
Need more power
CPU
GO!
1950
1956
1966
1970
1980
2000
"Machines that think"
Dartmouth Summer Research Proj
HELLO, I AM ELIZA!
Blocks World
AI winter
Deep Learning
Big data
Alan Turing
Turing test
NLP
Natural Language Processing
THREE BLOCKS
"SHRDLU"
$2000
Ken
$19436
Watson
@AzureAdvocates
@girlie_mac

Essential ML Processes

- An ML process is comprised of the following steps:
  - Decide on the question
  - Collect and prepare data
  - Choose the training method
  - Training the model
  - Evaluate the model
  - Parameter tuning
  - Predict

What are ML models

The model is the core component of machine learning and, ultimately, what we are trying to build.

A model might estimate how old a person is from a photo, predict what you might like to see on social media or decide where a robotic arm should move.

What are ML models

- In our scenario, we want to build a model that can estimate the best boot size for a dog based on its harness size.

- Models can be built in many ways. For example, a traditional model that simulates how an aeroplane flies is built by people using knowledge of physics and engineering.

- Machine-learning models are unique; rather than being edited by people so that they work well, they are shaped by data.

- They learn from experience.

How to Think of a Model

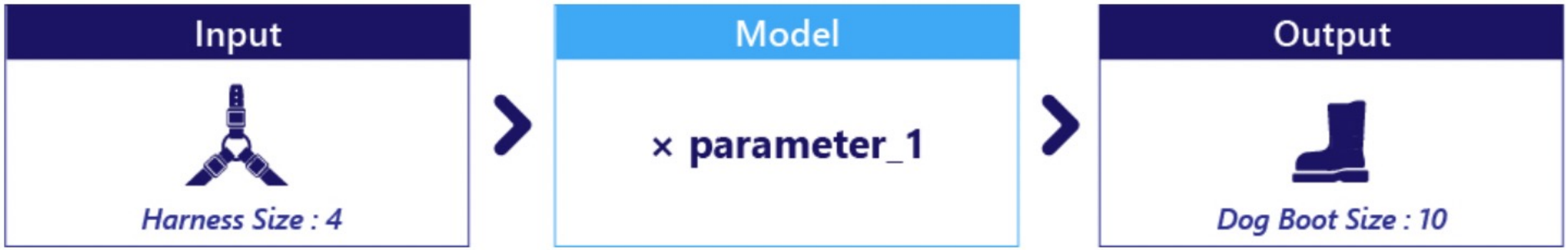
- You can think of a model as a function that accepts data as an input and produces an output.
- More specifically, a model uses input data to estimate something else.

- NB: Harness and Dog Boot Size are not part of the model

Models are often Simple Code

- Models are often not meaningfully different from simple functions you're already familiar with.
- Like other codes, they contain logic and parameters.

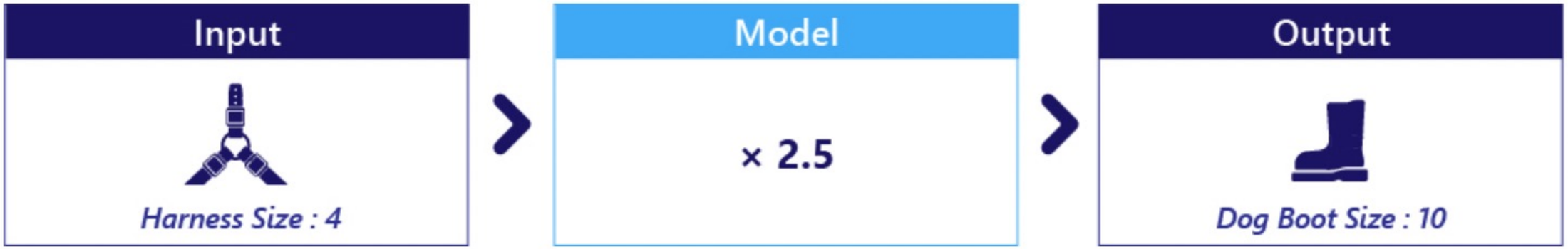
- For example, the logic might be “multiply the harness size by parameter_1”:



Models are often Simple Code

- Models are often not meaningfully different from simple functions you're already familiar with.
- Like other codes, they contain logic and parameters.

- If parameter_1 here was 2.5, our model would multiply harness size by 2.5 and return the result:



Selecting a Model

- There are many model types, some simple and some complex.

- Like all code,
  - simpler models are often the most reliable and easy to understand
  - while complex models can potentially perform impressive feats.

- Which kind of model you should choose depends on your goal.

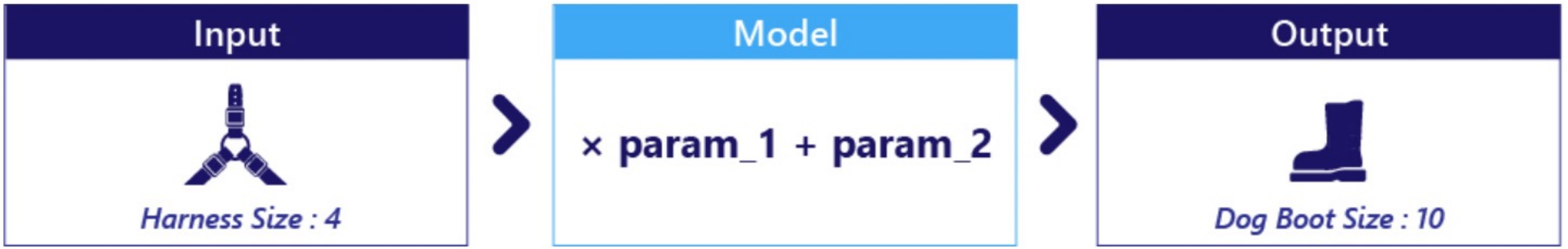
- For example,
  - medical scientists often work with relatively simple models because they are reliable and intuitive.

- By contrast, AI-based robots typically rely on very complex models.

Selecting a Model

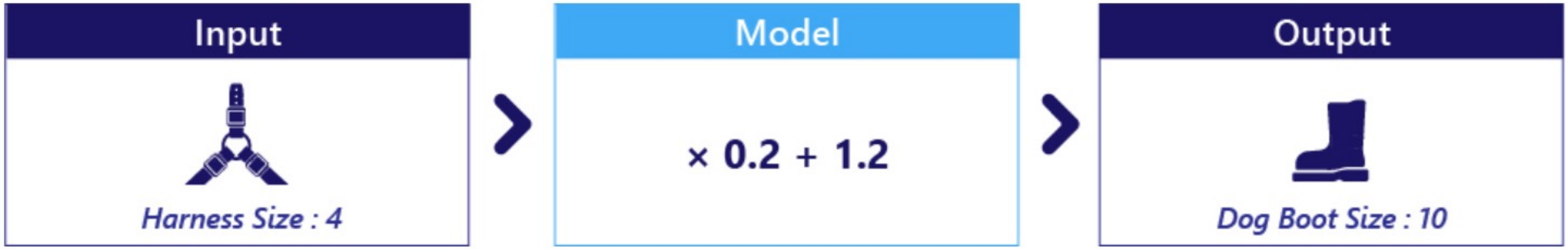
- The first step in machine learning is selecting the kind of model that you'd like to use.
- This means we're choosing a model based on its internal logic.

- For example, we might select a two-parameter model to estimate dog boot size from harness size:



Discovering Parameters During Training

- The human designer doesn't select parameter values.
- Instead, parameter values are set to an initial guess and then adjusted during an automated learning process called training.
- Given our selection of a two-parameter model (previous slide), we'll now provide random guesses for our parameters:

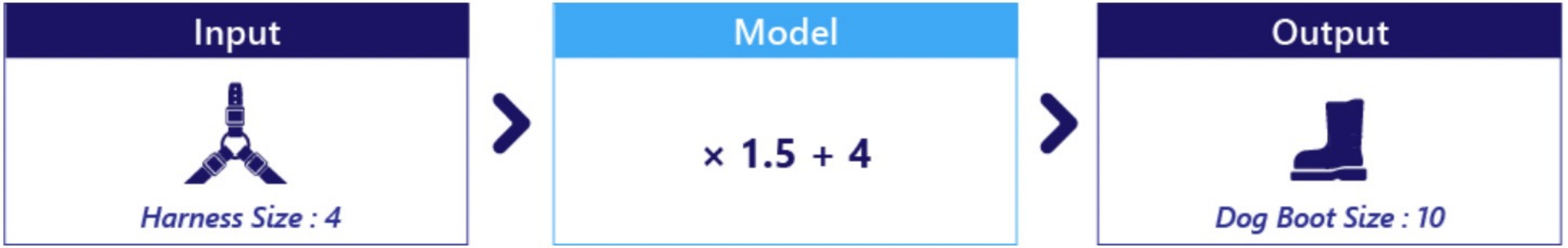


Discovering Parameters During Training

- These random parameters will mean the model isn't good at estimating boot size, so we'll perform training.

- During training, these parameters are automatically changed to two new values that give better results:

- We'll progressively explain how this process works throughout your learning journey.



Activity: Train and Run First Model

- Go through the Jupyter notebook on Train and Run First Model.

- Click on Image to Open the File

The Objective

- The objective is what we want the model to be able to do. For example, our scenario's objective is to estimate a dog's boot size based on its harness size.

- So that a computer can understand our objective, we need to provide our goal as a code snippet called an objective function (also known as a cost function)

- Objective functions judge whether the model is doing a good job (estimating boot size well) or a bad job (estimating boot size poorly).

- We'll cover objective functions in more depth in later learning material.

The Data

- Data refers to the information we provide the model (also known as inputs).
- In our scenario, this is harness size.
- Data also refers to information that the objective function might need.
- For example, if our objective function reports whether the model guessed the boot size correctly, it will need to know the correct boot size.
- This is why our previous exercise provided both harness sizes and the correct answers to the training code.

We will practice working with data in the next exercise.

The Optimiser

- During training, the model makes a prediction, and the objective function calculates how well it performed.

- The optimiser is code that then changes the model's parameters so the model will do a better job next time.

- How an optimizer does this is complex.
- Don't be intimidated, though; we don't normally write our own optimizers,
  - we use open-source frameworks where the hard work has been done for us.

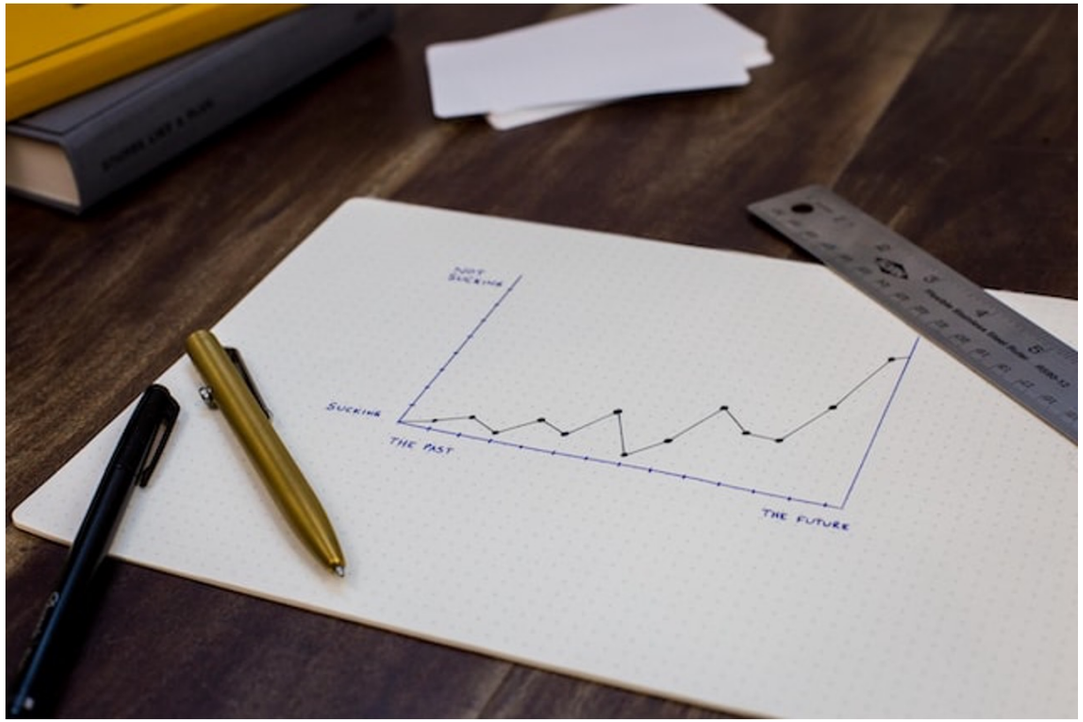
We will practice working with data in the next exercise.

- It's important to remember that the objective, data, and optimiser are simply a means to train the model.
- They are not needed once training is complete.
- It's also important to remember that training only changes the parameter values inside a model.
- It does not change what model is used.

Activity: Visualize Inputs and Outputs

- Go through the Jupyter notebook on visializing inputs and outputs.

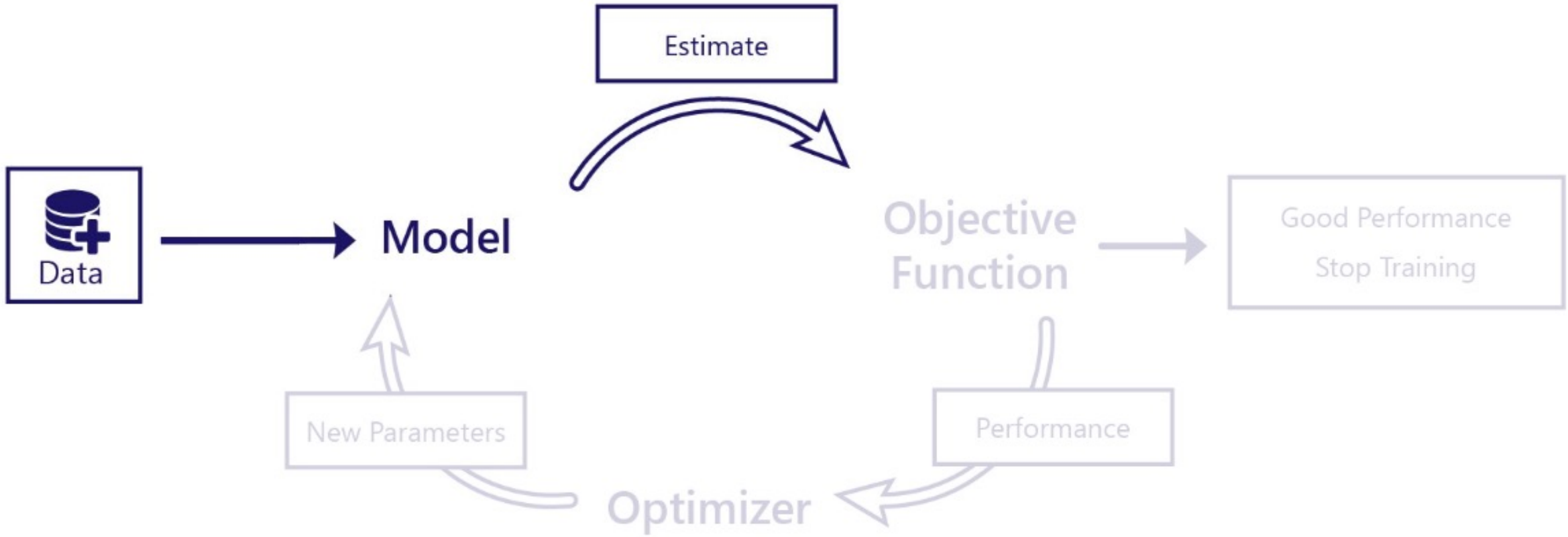
- Click on Image to Open the File



How to Use a Model

- Let’s revise how these parts fit together to train a model.
- Training versus using a model
- It's essential to make a distinction between training and using a model.
- Using a model means providing inputs and receiving an estimation or prediction.
- We do this when we're training our model and when our customers or we use it in the real world.
- Using a model typically takes less than a few seconds.

How to Use a Model



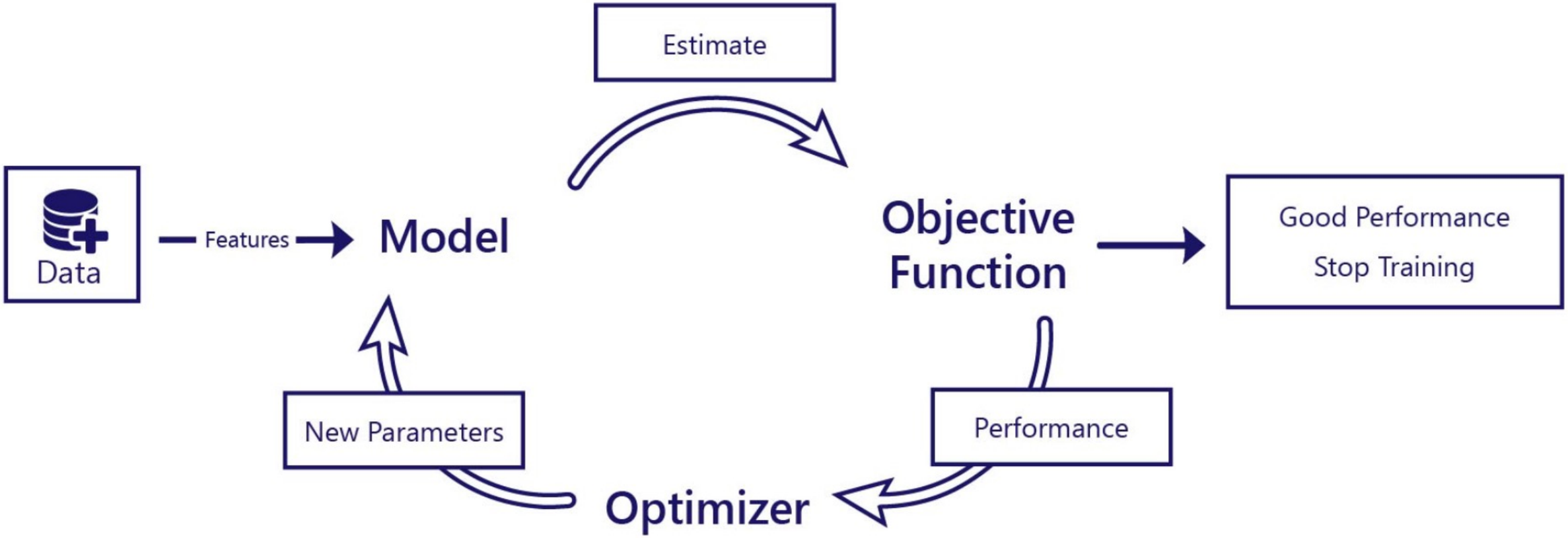
How to Use a Model

- By contrast, training a model is the process of improving how well a model works.

- Training requires that we use the model, as well as the objective function and optimizer, in a special loop.

- This can take minutes or days to complete.
  - Usually, we only train a model once.
  - Once it's trained, we can use it as many times as we like without making further changes.

How to Use a Model



The Data

- Collect data.
  - Collect your data with care.
  - Be aware of the sources of this data, and any inherent biases it might have, and document its origin.
- Prepare data.
  - There are several steps in the data preparation process. You might need to collate data and normalise it if it comes from diverse sources.
  - You can improve the data's quality and quantity through various methods, such as converting strings to numbers.

The Data

- An essential aspect of the data scientist's toolkit is the power to visualise data using several excellent libraries such as **Seaborn** or **MatPlotLib**.

- Visualising your data might reveal hidden correlations that you can leverage.

- Your visualisations might also help you to uncover biased or unbalanced data

- You might also generate new data based on the original (as in Classification).

- You can clean and edit the data.

- Finally, depending on your training techniques, you might also need to randomise and shuffle it.

Data for Use, Data for Training

- When we use our model, we only need the column(s) of data the model accepts as input.
  - These columns are called features.
- Before training, you must split your dataset into two or more parts of unequal size that still represent the data well.
  - Training, Testing, Validation
- In our scenario, if our model accepts harness size and estimates boot size, our feature is harness size.
- During training, the objective function usually needs to know both the model's output and the correct answer.

Data for Use, Data for Training

- These are called labels. In our scenario, if our model predicts boot size, boot size is our label.

- This means that to use a model, we only need features, while during training, we usually need both features and labels.

- During training in our scenario, we need both our harness-size feature and our boot-size label (target).

- When we use our model on our website, we only need to know the harness-size feature; our model will then estimate the boot size for us to use.

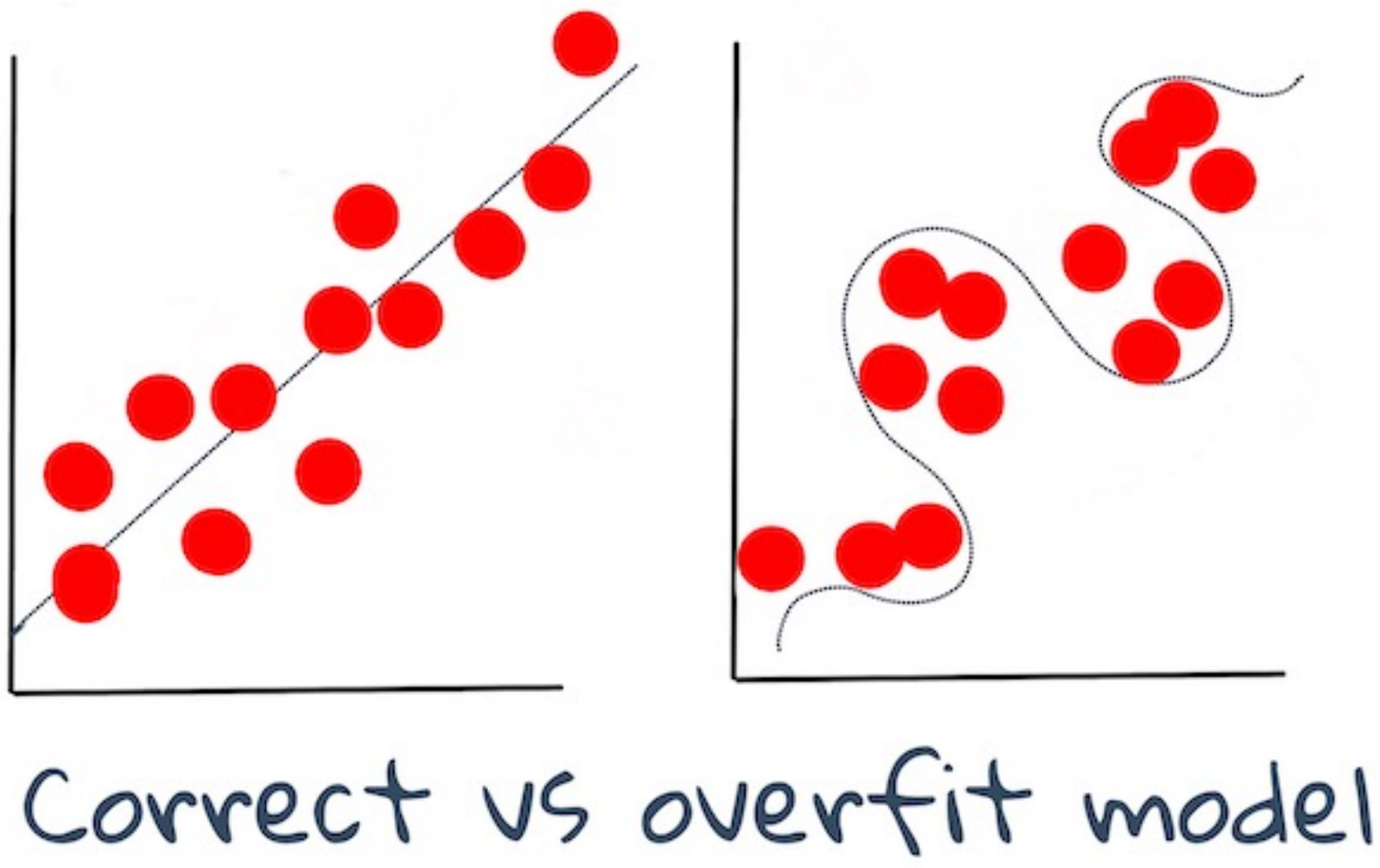
Decide on Training Method

- Depending on your experience, you might have to try several different methods to build the best model.
- You are likely to go through a process whereby data scientists evaluate the performance of a model by feeding it unseen data, checking for accuracy, bias, and other quality-degrading issues, and selecting the most appropriate training method for the task at hand.

Train and Evaluate

- Armed with your training data, you can '**fit**' it to create a model.
- You will notice that in many ML libraries, you will find the code '**model.fit**'.
- You send in your feature variable as an array of values (usually '**X**') and a target variable (usually '**y**').
- Once the training process is complete, you will be able to **evaluate** the model's quality by using test data to gauge its performance.
- . You can print out a table of metrics about your model's quality.

Model Fitting



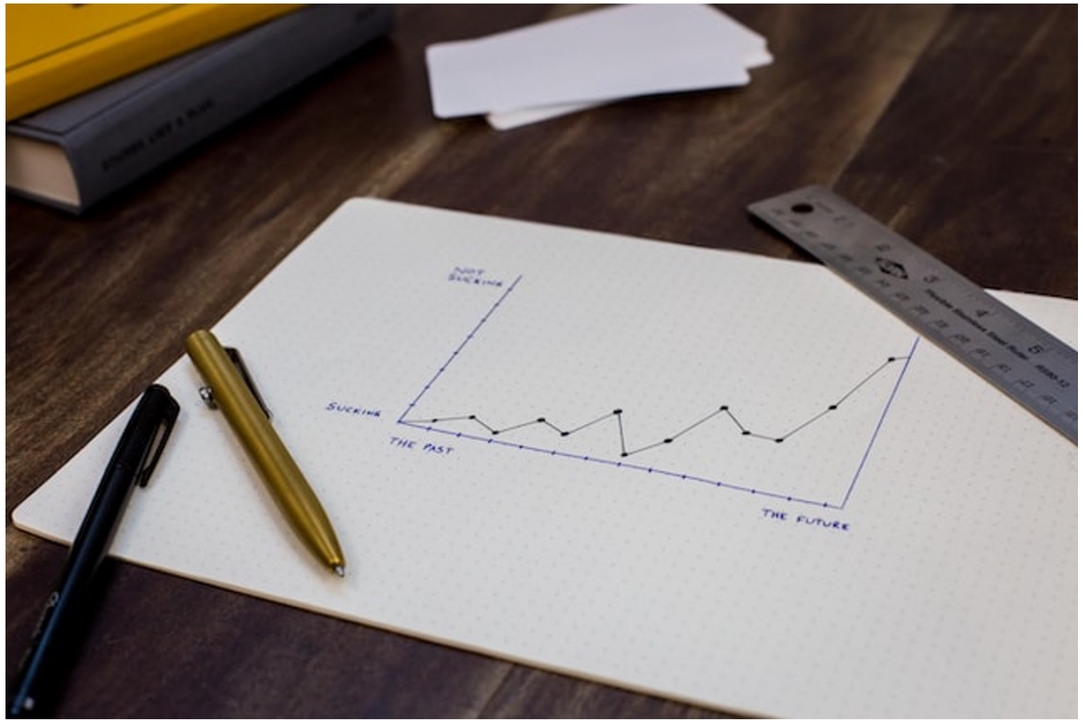
Done Training, What Next?

- Once a model has finished training, you can save it to a file by itself.
- We no longer need the original data, the objective function, or the model updater.
- When we want to use the model, we can load it from disk, provide it with new data, and get back a prediction.
- In our next exercise, we'll practice saving a model, loading it from disk, and using it like we would in the real world.

Activity: Using a Trained Model on New Data

- Go through the Jupyter notebook on visializing inputs and outputs.

- Click on Image to Open the File



Knowledge Check - 1

- What makes ML algorithms different from traditional algorithms?

A. Machine Learning algorithms are always more complicated to build than traditional algorithms.

B. Machine Learning algorithms must be trained every time they are used.

C. Data shape Machine Learning algorithms as part of the development. Traditional Algorithms are based almost entirely on the theory or opinions of the person writing the code.

Knowledge Check - 2

- When do we want to perform training?

A. Whenever we want to use a model

B. Only when we want to improve the model

C. Every time we load a model

Knowledge Check - 3

- What is the relationship between a model, an objective, and training data?

A. The training data is used to make changes to the model. These changes help the model get better at achieving the objective.

B. The training data is used to make changes to the objective. These changes help the objective be more like the model.

C. The model is used to make changes to the training data. These changes help the training data get better at achieving the objective.

Knowledge Check - 4

- You should visualise you data because

A. You can discover outliers.

B. You can discover a potential cause for bias.

C. Both of these

Knowledge Check - 5

- Split you data into:

A. Training and turing sets

B. Training and Test sets.

C. Validation and evaluation sets

Knowledge Check - 6

- A typical command to start the training process in various ML libraries is?

A. Model.travel

B. Model.train

C. Model.fit

Summary

- The goal of machine learning is to find patterns in data and use these patterns to make estimates.

- Machine learning differs from normal software development in that we use special code, rather than our intuition, to improve how well the software works.

- The learning process conceptually uses four components:
- Data about the topic we're interested in.
  - A model which makes estimates.
  - An objective the model is trying to achieve.
  - An optimiser which is the extra code that changes the model depending on its performance.

Summary

- Data can be thought of as features and labels. Features correspond to potential model inputs, while labels correspond to model outputs or desired model outputs.

- Pandas and Plotly are powerful tools for exploring datasets in Python.

- Once we have a trained model, we can save it to disk for later use.

THANK YOU FOR YOUR TIME

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