

Machine Learning

Lecture 1 – Introduction to Machine Learning

Dr SHI Lei

Today

- Machine Learning

What is this module about?

- General Module Information

What is Machine Learning?

What is Machine Learning?

ML is a “field of study that gives computers the ability to learn without being explicitly programmed”.

-- Arthur Samuel, 1959

What is Machine Learning?

ML will allow you, as a software engineer, to do 3 things:

1. to reduce the time you spend programming;
2. to customise product, making it better for specific users;
3. to solve problems that you, as a programmer, have no idea how to do by hand.

What is Machine Learning?

Some ML examples...

SECOMMENDATIONS

Netflix taps the streaming history and habits of its millions of users to predict what an individual user may enjoy, by curating its huge collection of movies and TV shows.

Find the single perfect artwork for **Stranger Things** across all Netflix members.



[Source: Netflix Techblog]

RELEVANT TIMELINES

Twitter predicts how interesting and engaging a Tweet would be specifically to an individual user, in order to rank Tweets based on relevance thus provide personalised timelines.



OPTIMISED LOGISTIC

Alibaba uses purchase histories to generate precise order predictions which help online sellers to pre-load their warehouses with certain amounts of inventories.



SELF-DRIVING CARS

Waymo's self-driving cars scan constantly for objects around, and predicts their possible paths to determine the exact trajectory, speed, lane, and steering manoeuvres needed to progress along the route safely.

Machine Learning has great impact potential across industries and use case types

Impact potential
low high

Problem type	Automotive	Manufacturing	Consumer	Finance	Agriculture	Energy	Healthcare	Pharmaceuticals	Public/social	Media	Telecom	Transport and logistics
Real-time												
Strategic optimisation												
Predictive analytics												
Predictive maintenance												
Radical personalisation												
Discover new trends/anomalies												
forecasting												
Process unstructured data												

[Source: Théo Szymkowiak]

7 steps in Machine Learning Lifecycle



Gathering
data

Preparing
data

Choosing
model

Training

Evaluation

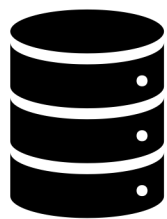
Hyper-
parameter
tuning

prediction

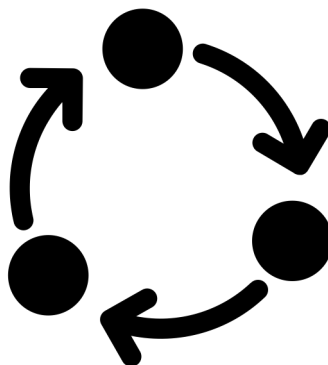
Training

Prediction

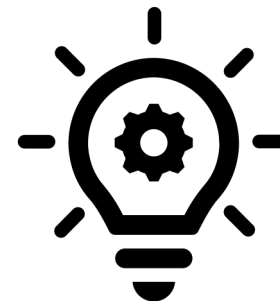
Using data to answer questions



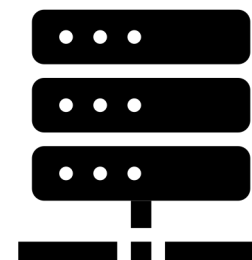
data



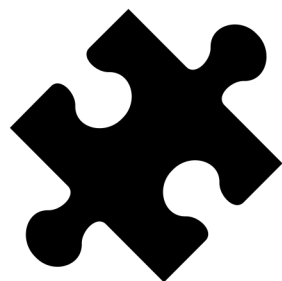
training



model



serve predictions



answer questions

So, how does Machine Learning really work?

Green tea / Oolong tea

Green tea / Oolong tea

1. Gathering the Data

Caffeine (mg)	Acidity (PH level)	Green tea or oolong tea?

Green tea / Oolong tea

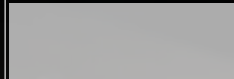
2. Data Preparation

Caffeine (mg)	Acidity (PH level)	Green tea or oolong tea?
70	7.8	Oolong tea
60	6.5	Green tea
50	5.8	Green tea
65	6.2	Oolong tea
40	7.9	Green tea

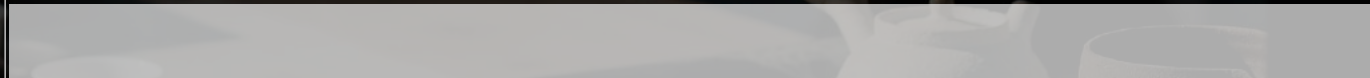
Green tea / Oolong tea

2. Data Preparation

Green tea



Oolong tea

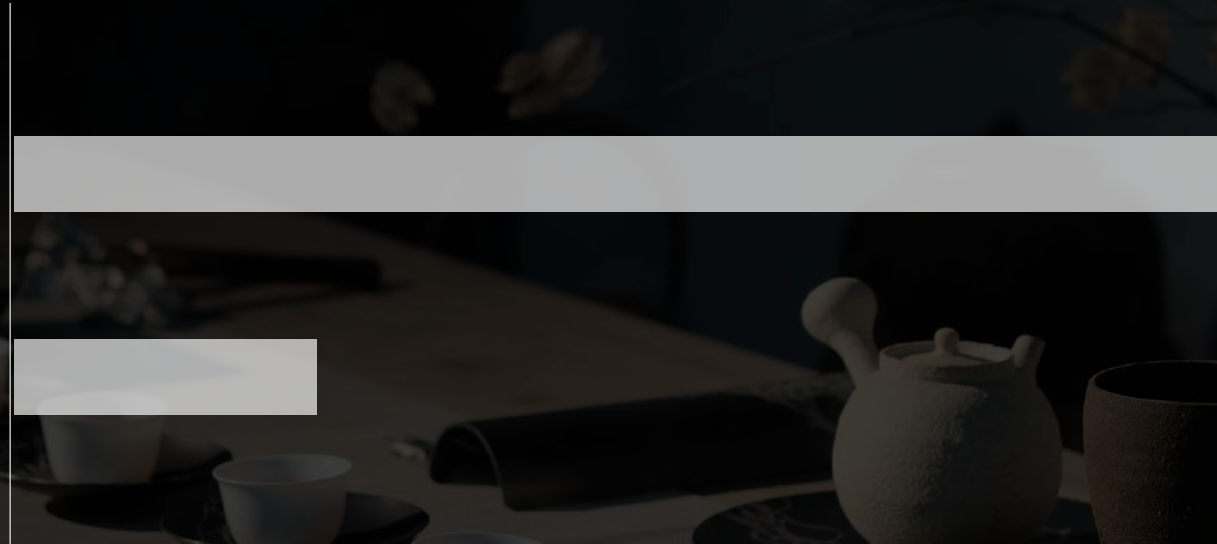


Green tea / Oolong tea

2. Data Preparation

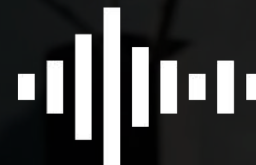
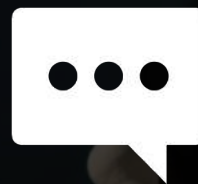
Training

Evaluation



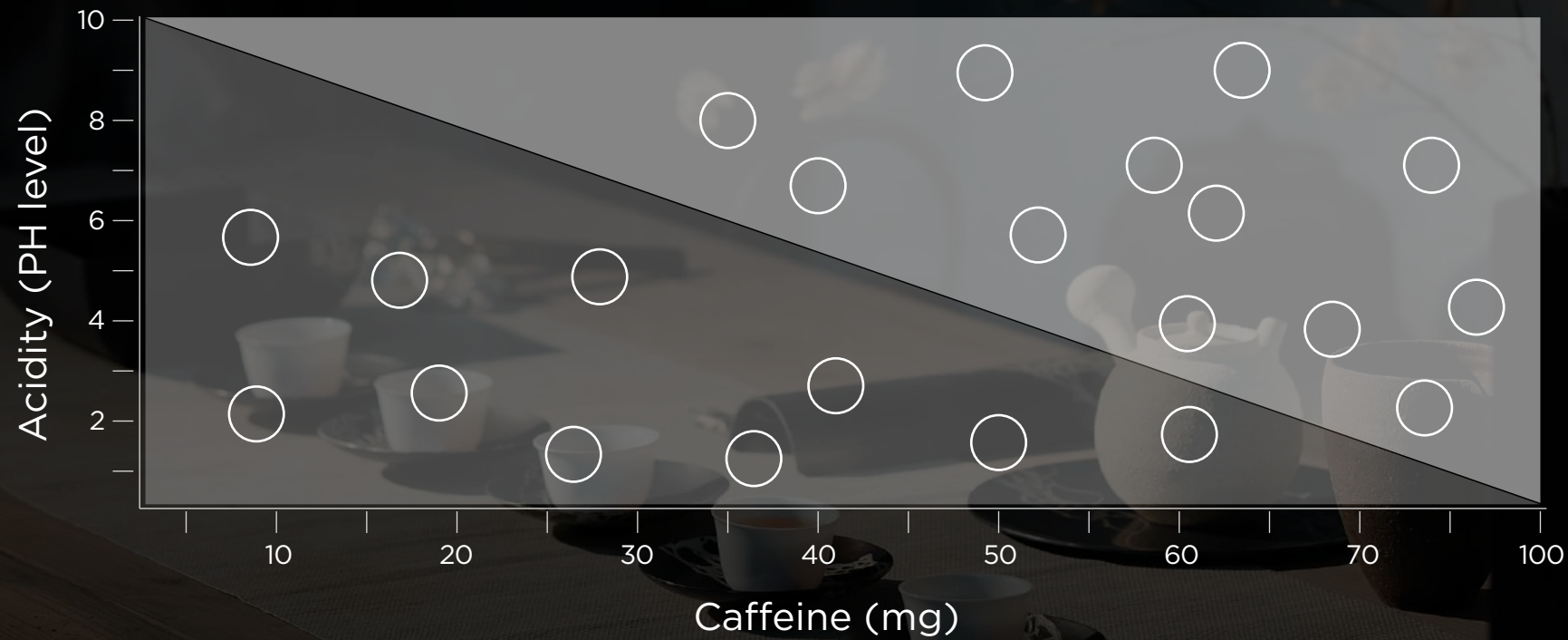
Green tea / Oolong tea

3. Choosing a Model



Green tea / Oolong tea

3. Choosing a Model



Green tea / Oolong tea

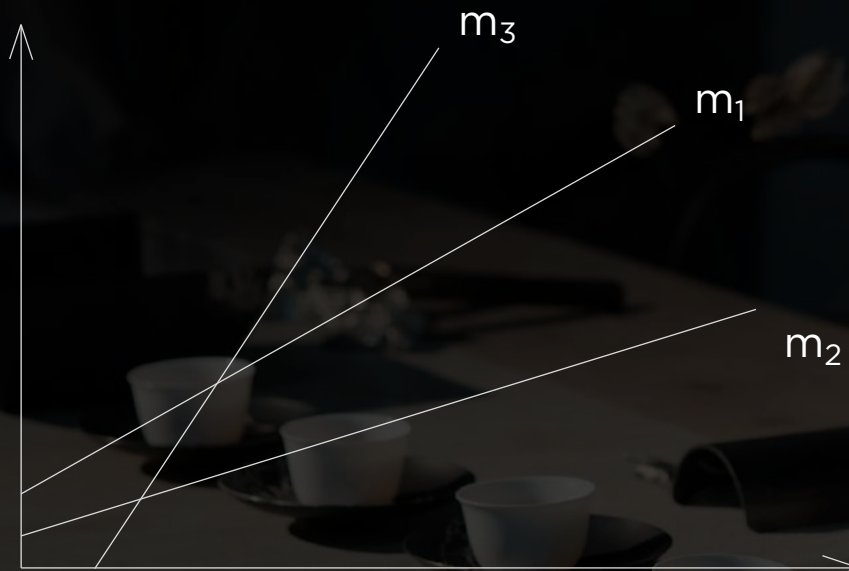
4. Training



model

Green tea / Oolong tea

4. Training



$$y = m \times x + b$$

output slope input y-intercept

Green tea / Oolong tea

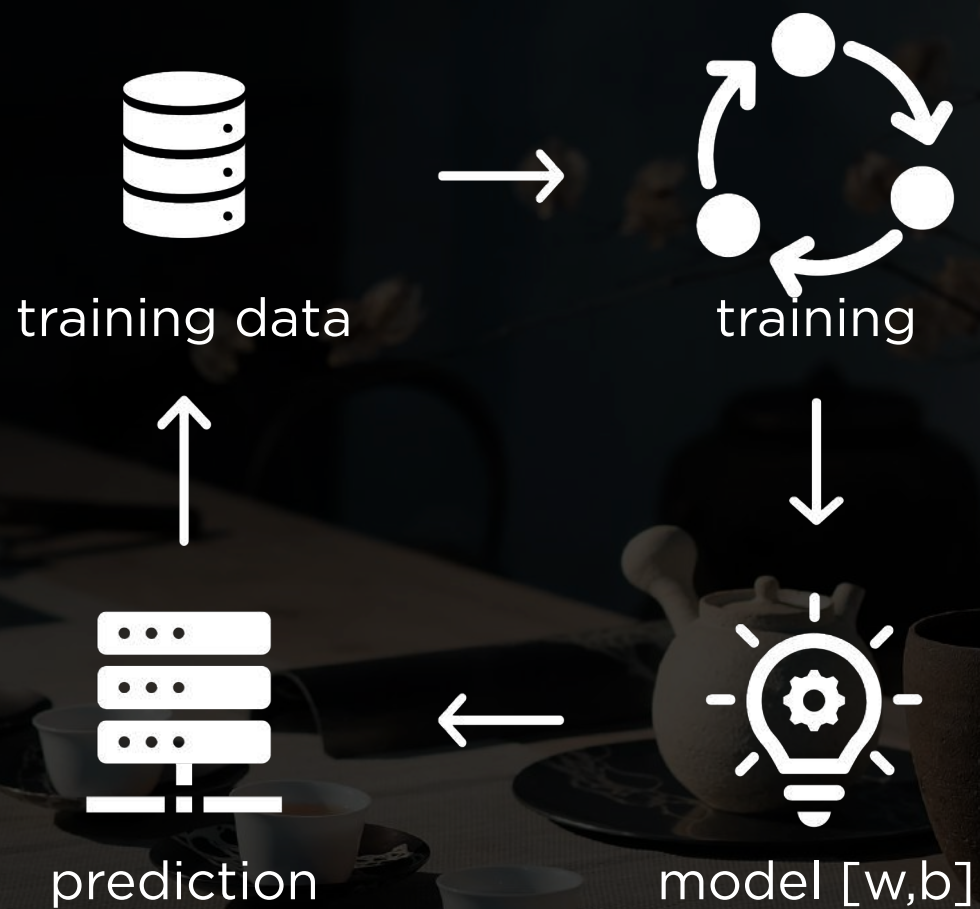
4. Training

$$\text{weights} = \begin{bmatrix} \mathbf{m}_{1,1} & \mathbf{m}_{1,2} \\ \mathbf{m}_{2,1} & \mathbf{m}_{2,2} \\ \mathbf{m}_{2,1} & \mathbf{m}_{2,2} \end{bmatrix}$$

$$\text{biases} = \begin{bmatrix} \mathbf{b}_{1,1} & \mathbf{b}_{1,2} \\ \mathbf{b}_{2,1} & \mathbf{b}_{2,2} \\ \mathbf{b}_{2,1} & \mathbf{b}_{2,2} \end{bmatrix}$$

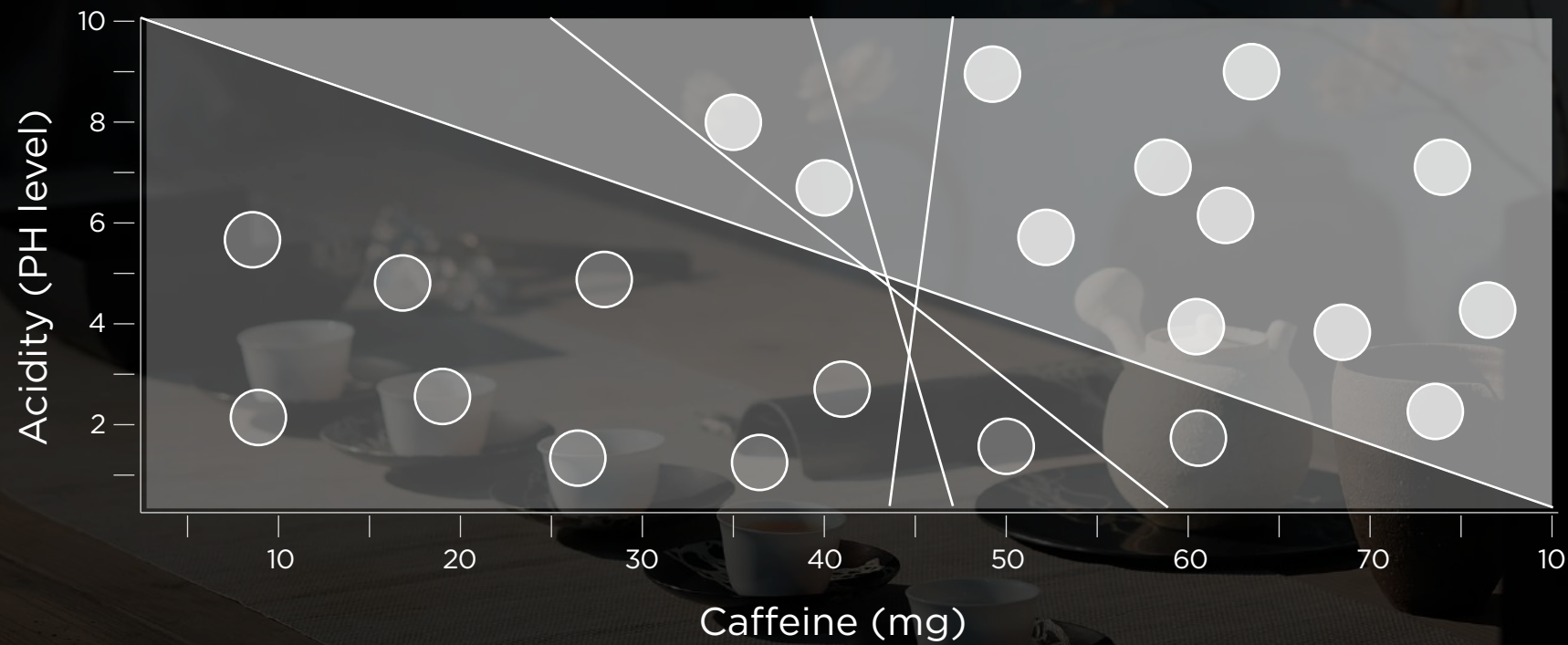
Green tea / Oolong tea

4. Training



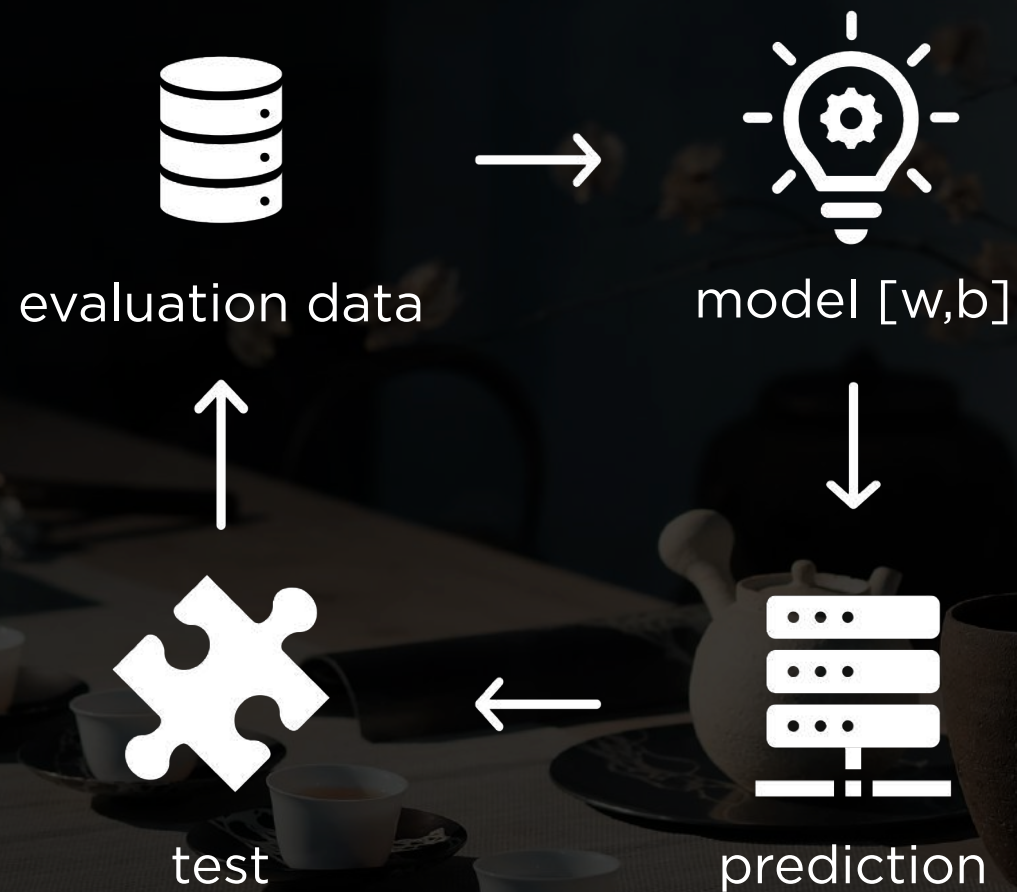
Green tea / Oolong tea

4. Training



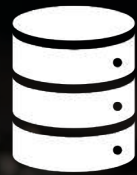
Green tea / Oolong tea

5. Evaluation



Green tea / Oolong tea

5. Evaluation



training data

80% / 70%



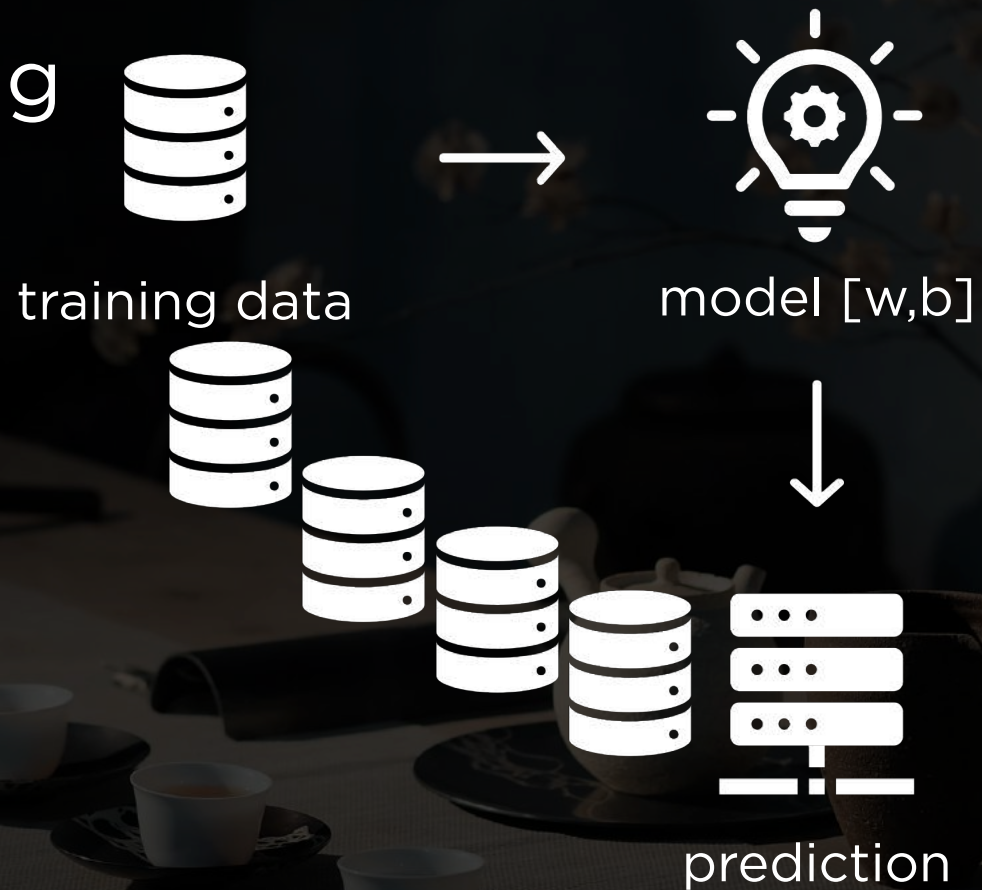
evaluation data

20% / 30%

The training-evaluation split depends on the size of dataset

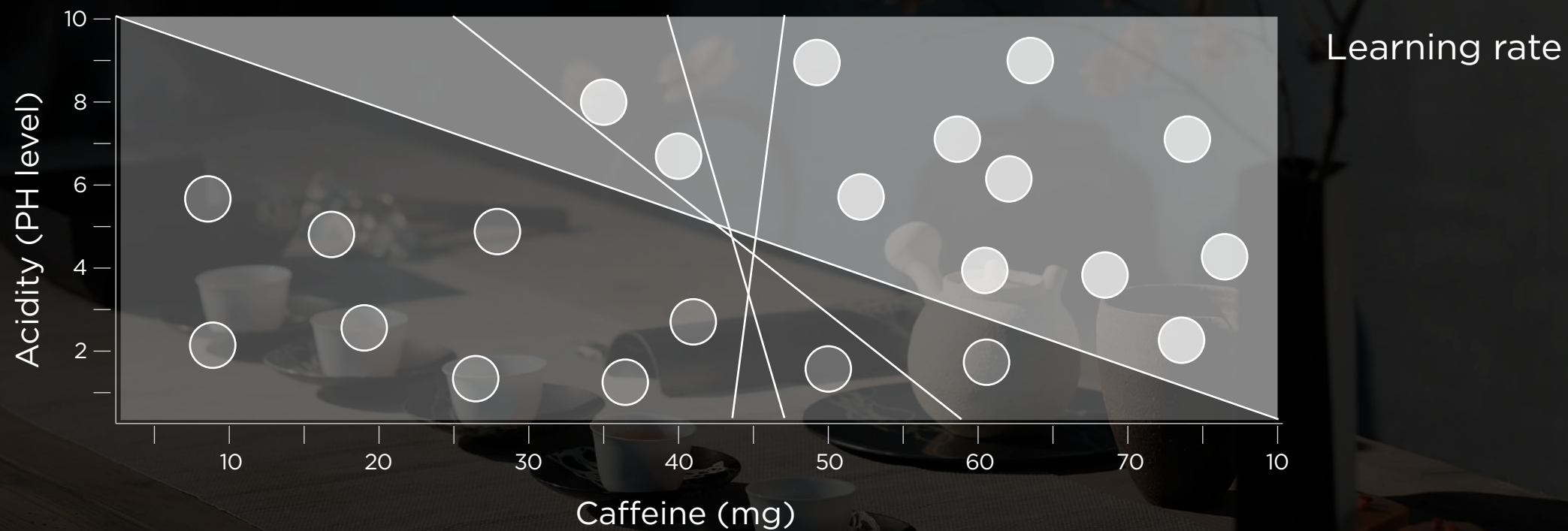
Green tea / Oolong tea

6. Parameter Tuning



Green tea / Oolong tea

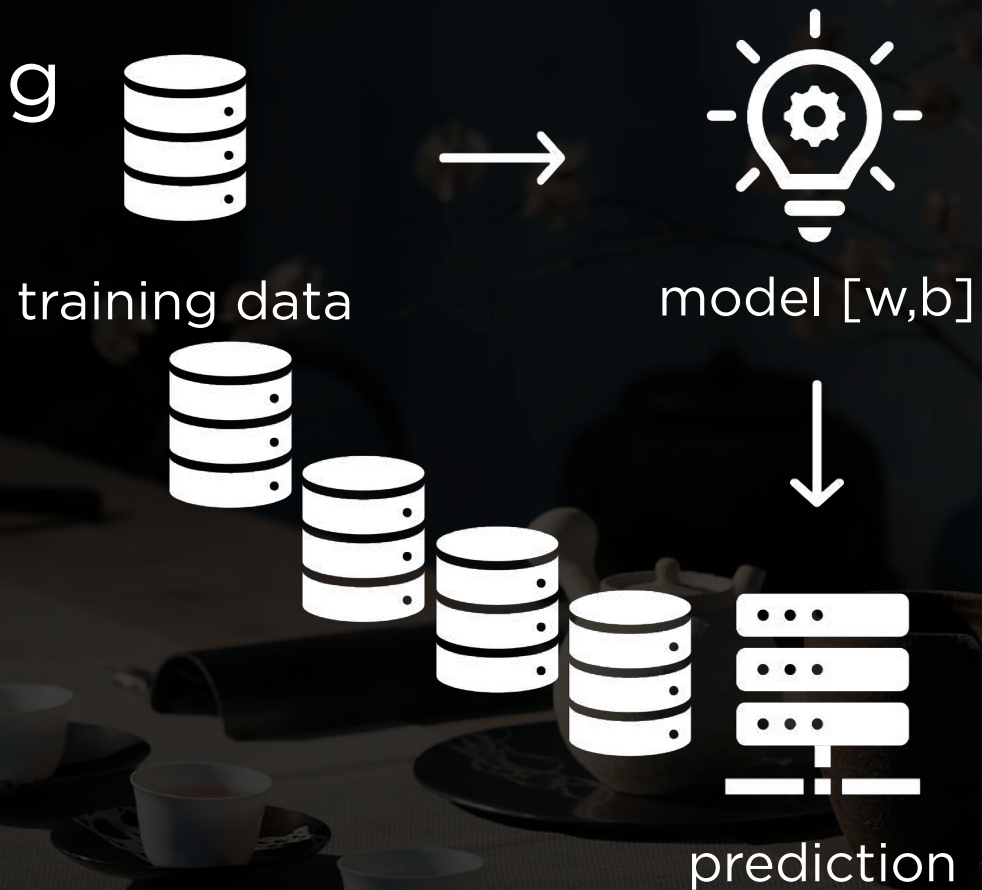
6. Parameter Tuning



Green tea / Oolong tea

6. Parameter Tuning

(hyperparameters)



Green tea / Oolong tea

7. Prediction

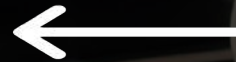
Caffeine: 60 mg
Acidity: 7.2



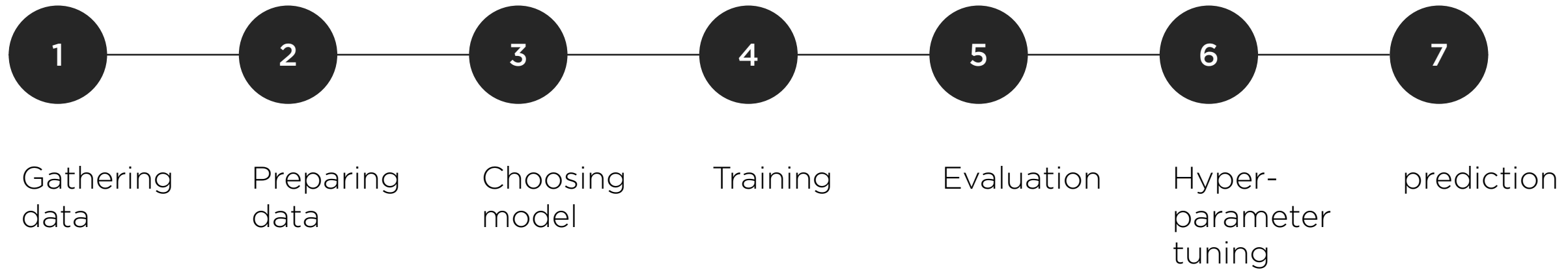
model $[w, b]$



prediction



7 steps in Machine Learning Lifecycle



- to determine how to differentiate between oolong tea and green tea using our model rather than using human judgement and manual rules.
- We can extrapolate the ideas to other problem domain as well, where the same principles apply – 7 steps...

What is Machine Learning?

Definition

"A computer program is said to **learn** from experience E with respect to some class of tasks T and performance measure P if its performance at tasks in T, as measured by P, improves with experience E."

-- Tom M. Mitchell, 1997

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"A computer program is said to **learn** from experience E with respect to some class of tasks T and performance measure P if its performance at tasks in T , as measured by P , improves with experience E ."

-- Tom M. Mitchell, 1997

Machine learning is the study of algorithms that

- improve their performance P
- at some task T
- with experience E

A well-defined learning task is given by $\langle P, T, E \rangle$.

What is Machine Learning?

Exercise: how to define the learning task in our Tea Example?

- improve their performance P
- at some task T
- with experience E

supervised learning

To learn the **mapping** (the rules) between a set of **inputs** and **outputs**.

The tea example --



Goal: to learn the mapping that describes the relationship between feature of tea (caffeine & acidity) and type of tea (oolong tea / green tea).

Labelled data is provided of past input & output pairs during the learning process to train the model how it should behave.

So, **“supervised” learning**.

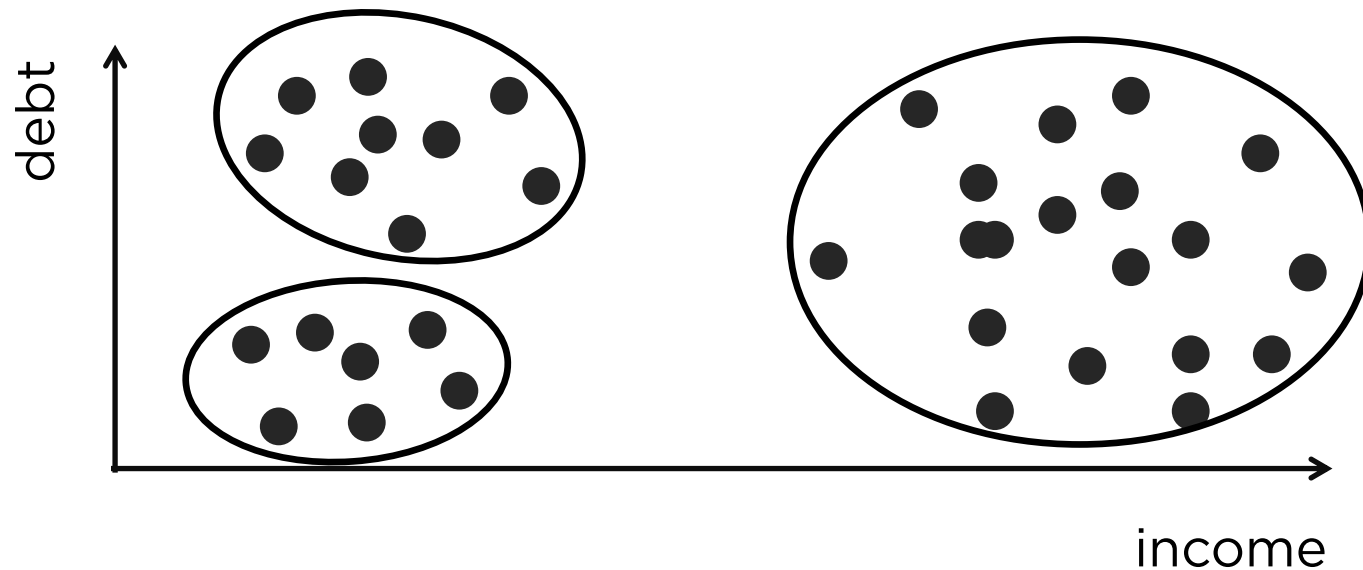
unsupervised learning

To learn the **hidden pattern** (the rules) from a set of **inputs (no output)**.

Unlabelled data is provided of past input (not a input & output pair) during the learning process to train the model how it should behave.

So, “unsupervised” learning.

An example --



Goal: clustering a set of examples in such a way that the examples in the same group (called cluster) are more similar (in some sense or another) to each other than to those in other groups (clusters).

reinforcement learning

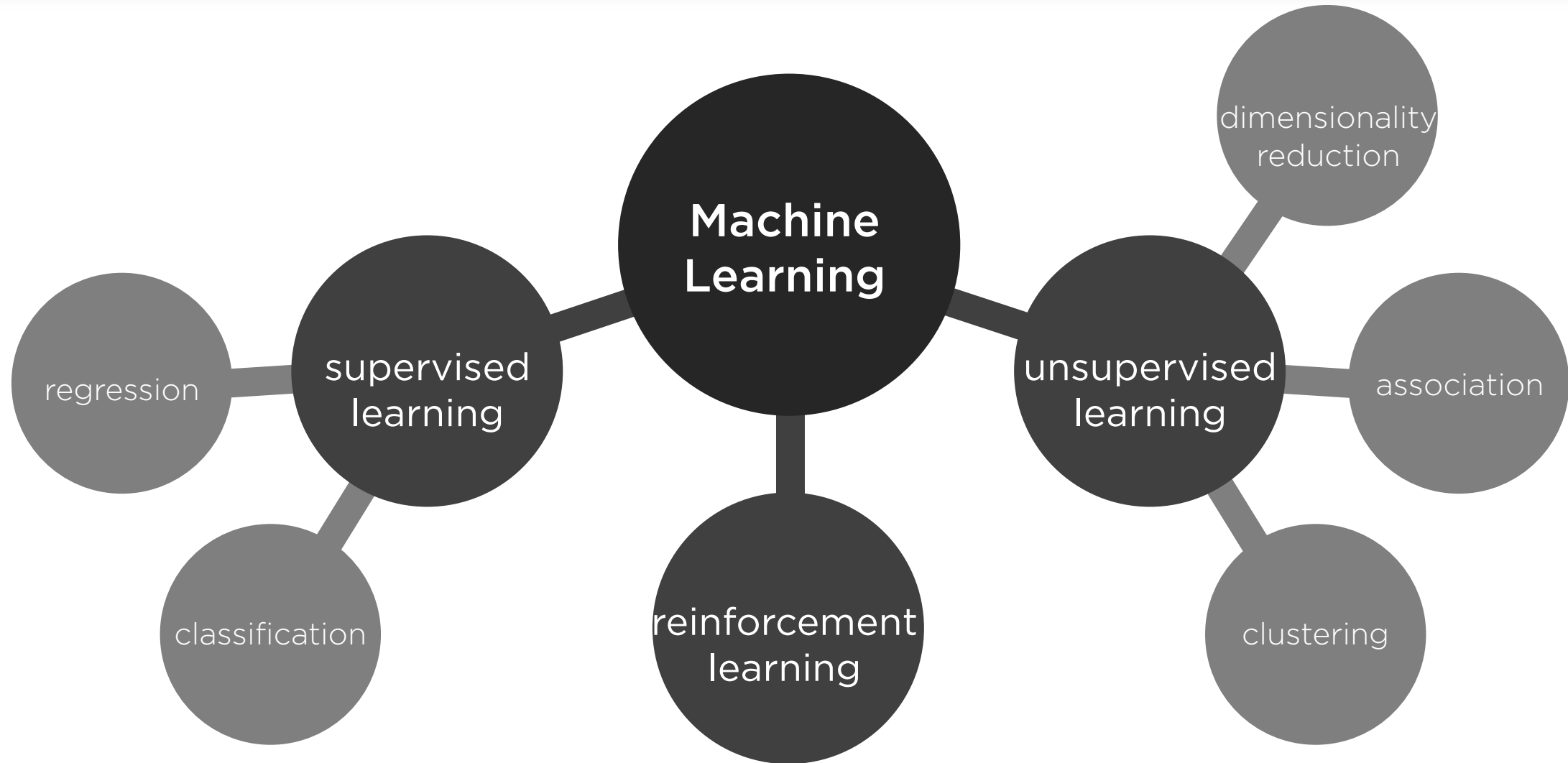
Occasional **positive** and **negative** feedback is used to **reinforce** behaviours.



- **Good** behaviours are **rewarded** with a treat and become more common.
- **Bad** behaviours are **punished** and become less common.

A Reinforcement Learning algorithm just aims to maximise its rewards by playing the game over and over again.

Three Categories of Machine Learning



Key ML Terminology

Key ML Terminology

- **Label** is the variable that we are predicting
typically represented by the variable y
- **Features** are input variables that describe our data
typically represented by the variables $\{x_1, x_2, x_3, \dots, x_n\}$

Key ML Terminology

- **Example** is a particular instance of data, \mathbf{x}
 - **Labelled example** has {features, label}: (\mathbf{x}, y)
used to train the model
 - **Unlabelled example** has {feature, ?}: $(\mathbf{x}, ?)$
used for making prediction on new data

Key ML Terminology

- **Model** maps examples to predict labels: \hat{y}
defined by internal parameters, which are learned
- **Training** - creating or learning the model.
- **Inference** - applying the trained model to unlabelled examples.

What to cover in the module?

Lectures (tentative)

1. Introduction to Machine Learning
2. Linear Regression, Training and Loss
3. Generalisation, Training Test Set, Representation
4. Binary Classifier, Performance Measurement
5. Odds, Log(odds), Logistic Regression
6. Decision Trees and Forests
7. Support Vector Machines
8. Clustering
9. Neural Networks, Deep Learning, and Bias in AI
10. ML Applications

General Module Information

Contact



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E231

Submodule Delivery

Ten one-hour Lectures

Time: Mondays 12-1 PM, Weeks 11-20

Room: D110

Five two-hour Labs

Time: Weeks 2, 4, 6, 8, 10

Room: E216A-B

Assessment

Assignment

Hand out: 31 January

Hand in: 20 March

Hand back: 04 May

Revision

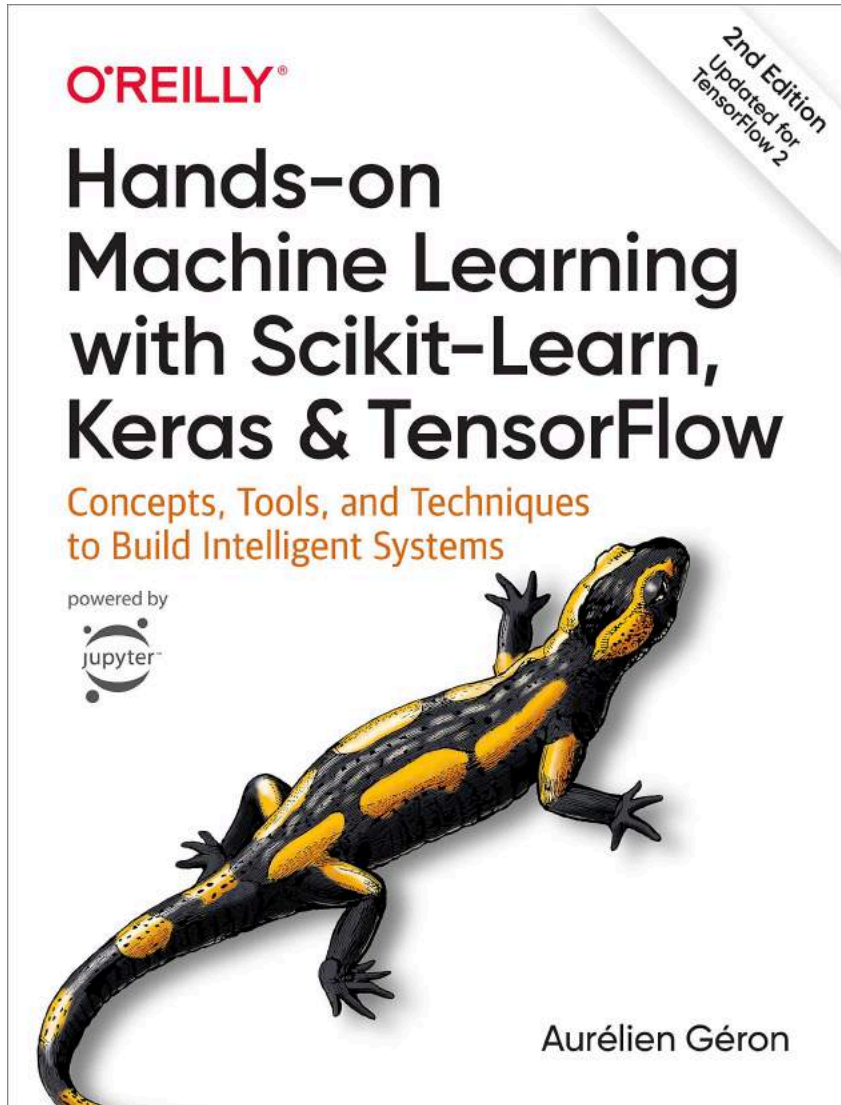
Time: 04 May 12:00-12:45

Room: D110

Exam

May 2020 (TBD)

Reading & Practising



Aurélien Géron, Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow, 2nd Edition, O'Reilly Media, Inc. Sep 2019

Summary

Today

- What is Machine Learning (ML)
 - Definition
 - Lifecycle
 - Types of ML Systems
 - Key Terminologies
- General Module Information

Homework

- On DUO – The Machine Learning Landscape

Next Lecture

- Linear Regression
- Training and Loss