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We are learning on Noongar land

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CITS 5506
The Internet of Things
Lecture 10 (Part 2)
Tiny Machine Learning

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Lecture Overview

Machine Learning (Definition And Applications)

Machine Learning Paradigm

Basic Concepts of Machine Learning

Ethical AI & Machine Learning

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Machine Learning
Definition & Applications

Human Intelligence & Artificial Intelligence

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Human Intelligence

- Solve problems
- Achieve goals
- Analyse & reason
- Communicate
- Collaborate & influence
- Consciousness
- Emotions, Intuition, Imagination

Artificial Intelligence

The ability for machines to simulate & enhance (human) intelligence.

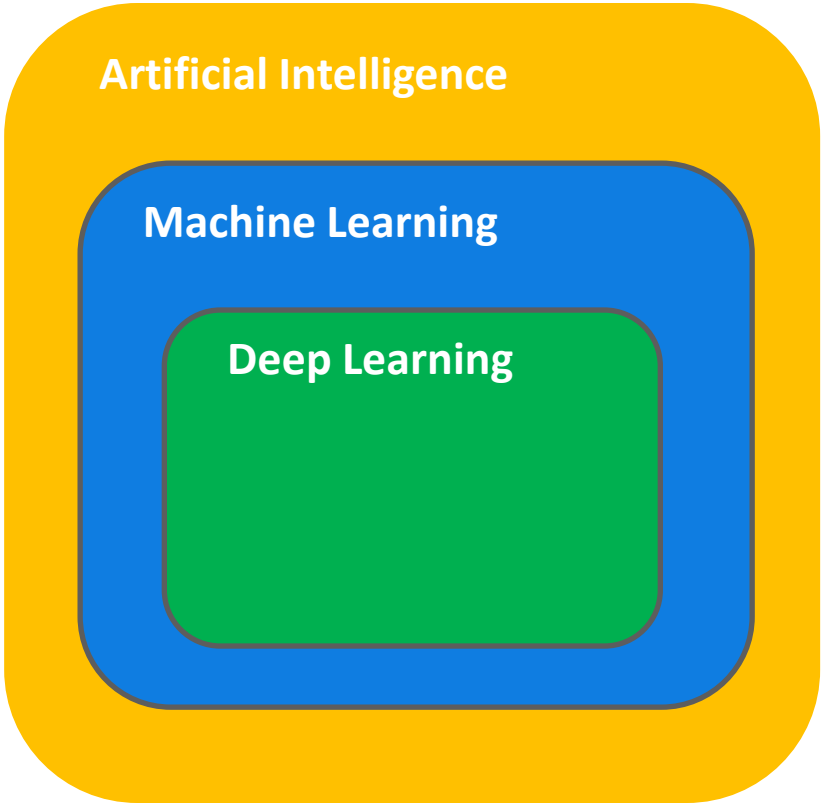
AI Definition (Academic)

The designing and building of intelligent agents that receive precepts from the environment and take actions that affect that environment.

Artificial Intelligence: A Modern Approach, 4th US ed.
By Stuart Russell & Peter Norvig,

What is Machine Learning

1. **Machine Learning** is a subfield of **Artificial Intelligence** focused on developing algorithms that learn to **solve problems by analysing data for patterns.**
2. **Deep Learning** is a type of Machine Learning that leverages **Neural Networks** and **Big Data**



Applications of Machine Learning

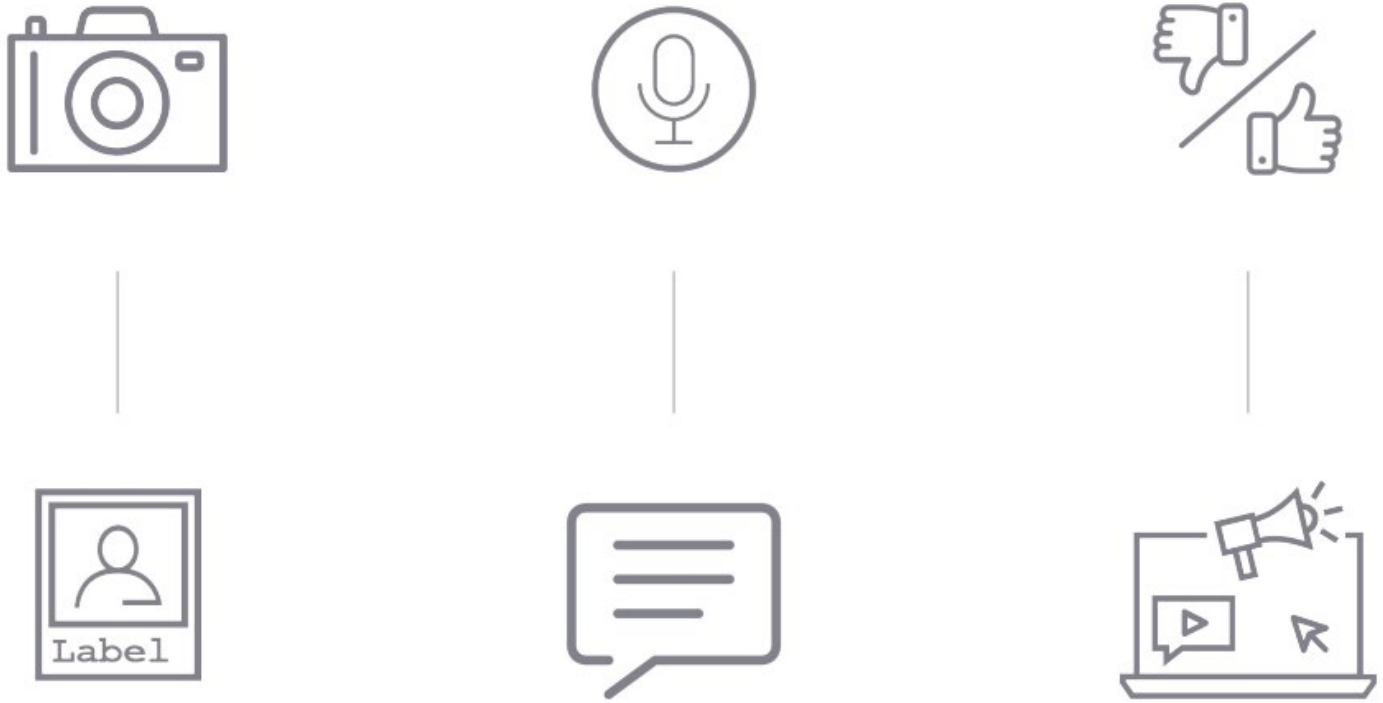
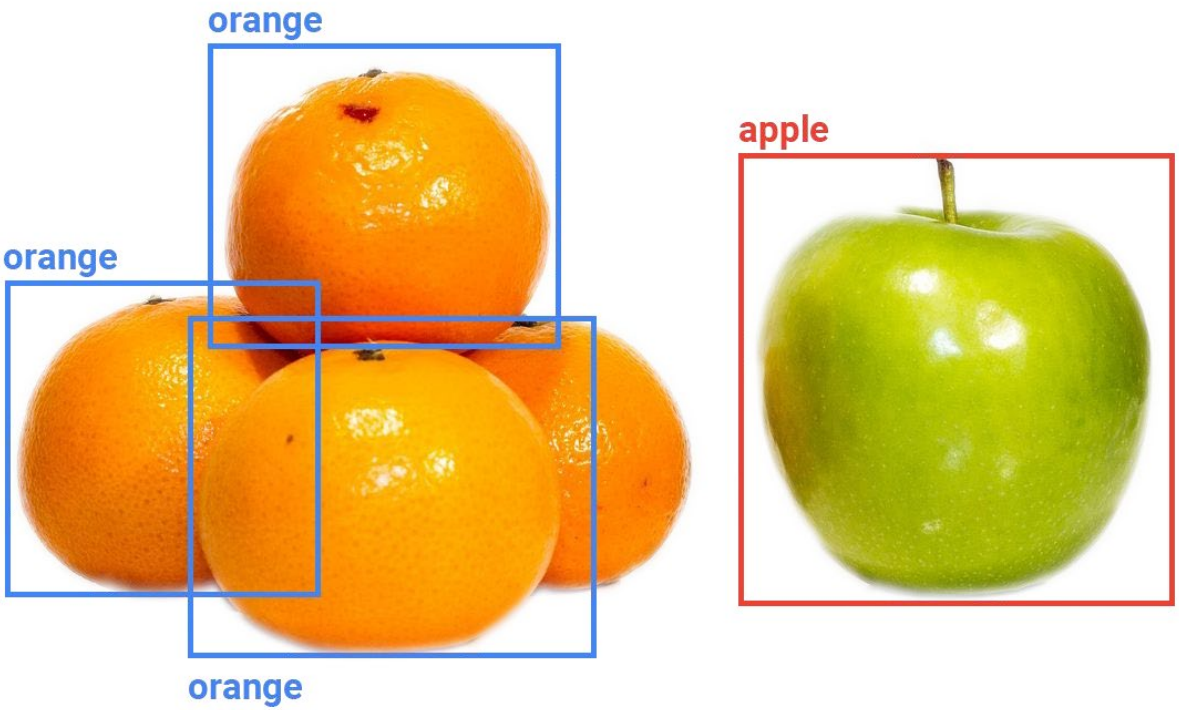
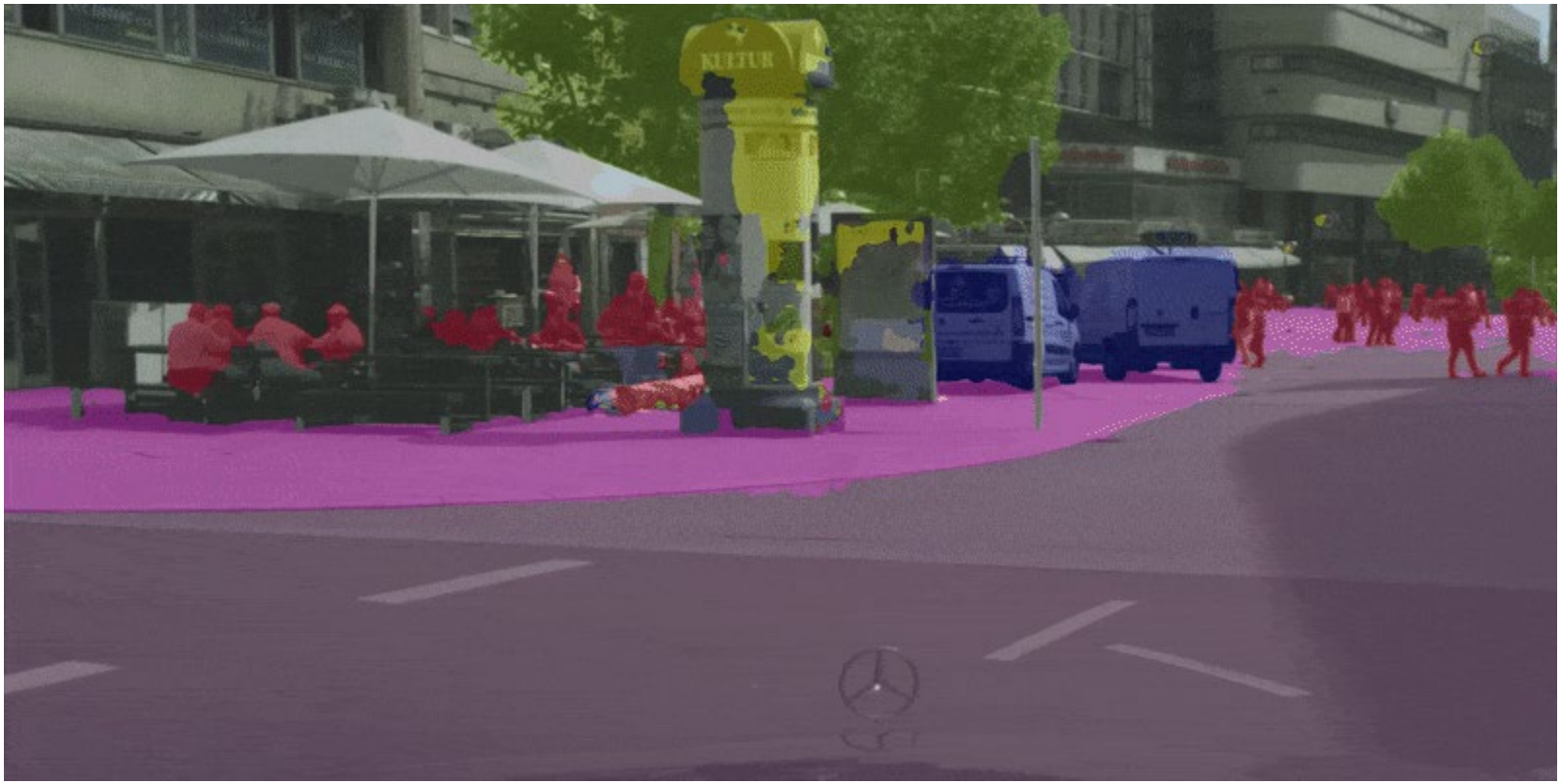


Image Classification

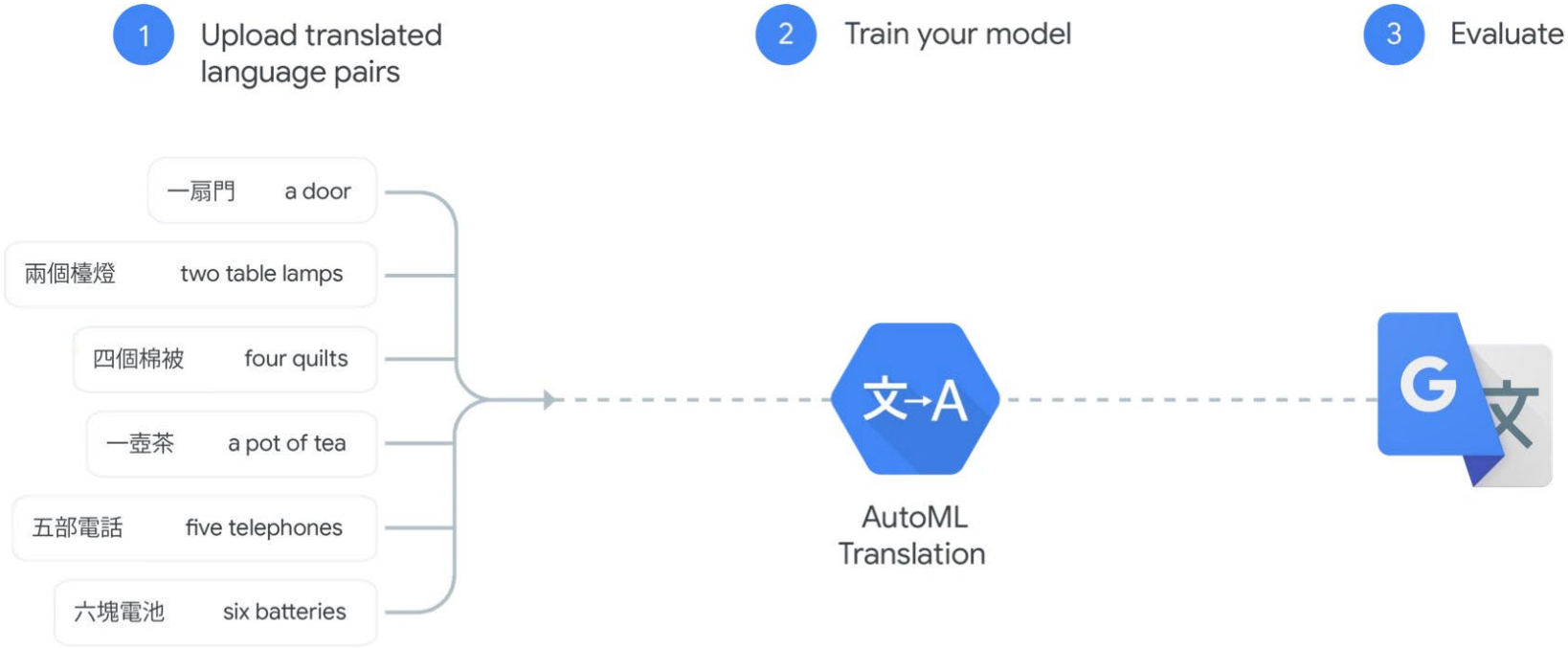
Object Detection



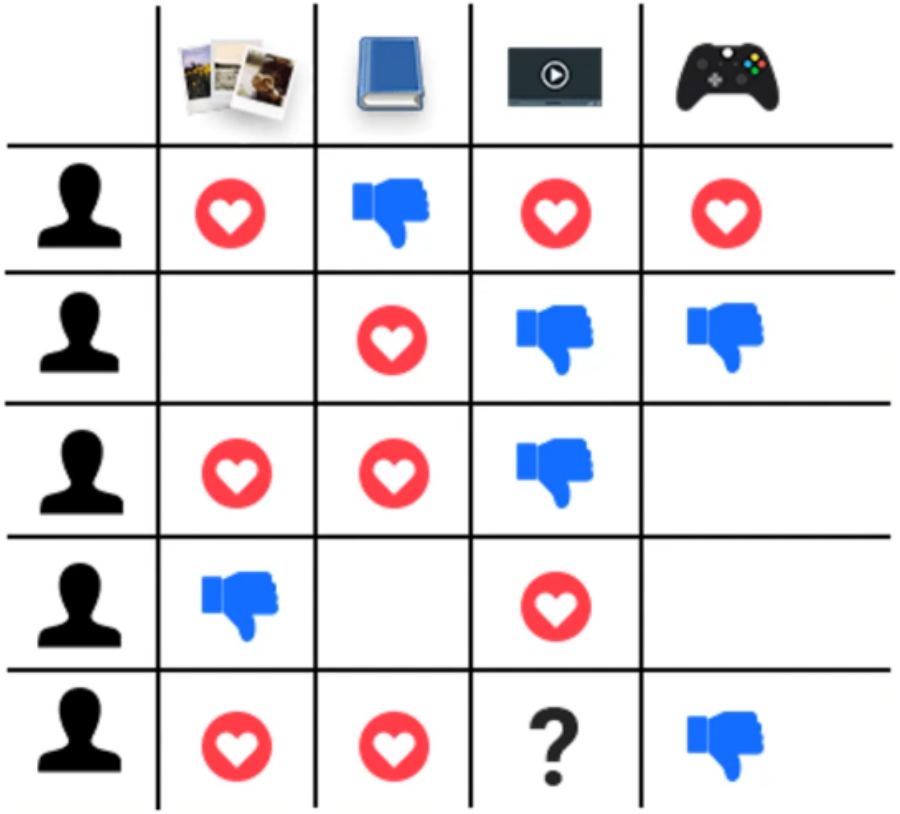
Segmentation



Machine Translation



Recommendations



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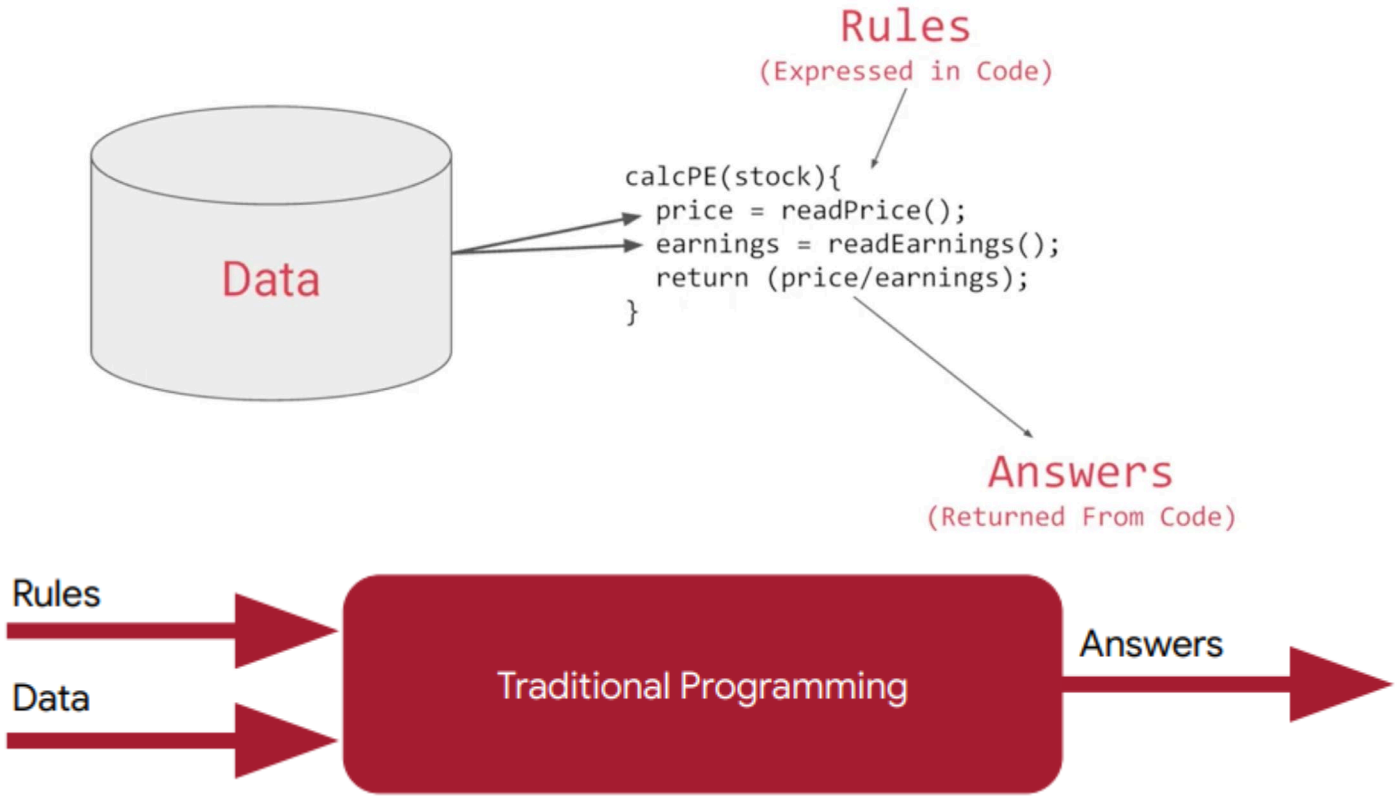
The Machine Learning Paradigm

The Traditional Programming Paradigm



Activity Recognition

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

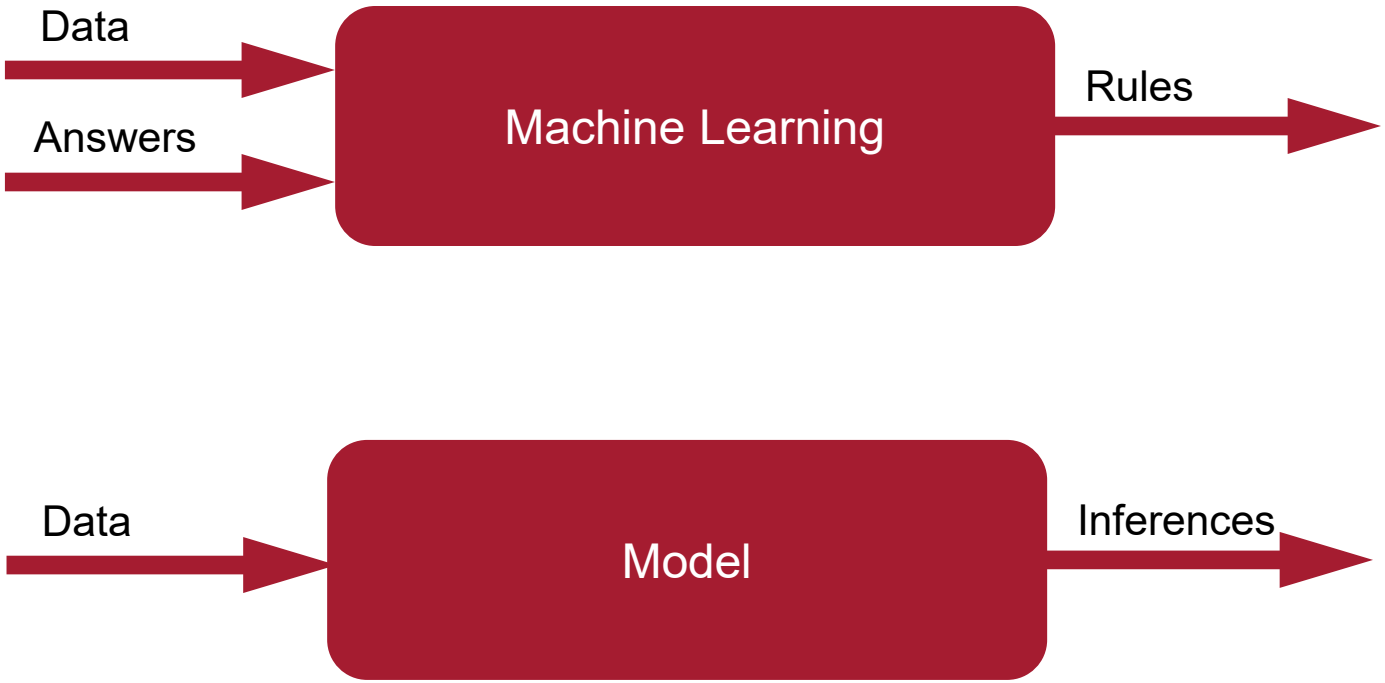
```
if(speed<4){
    status=WALKING;
} else {
    status=RUNNING;
}
```

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

```
// ???
```

The Machine Learning Paradigm

The Machine Learning Paradigm



Activity Recognition with Machine Learning

```
01010010101001010101
10010101010010111101
01001010100101001001
01010010101001010101
```

Label = WALKING

```
10101001010010101010
01010100100100010001
00100111110101011111
10101001001111010111
```

Label = RUNNING

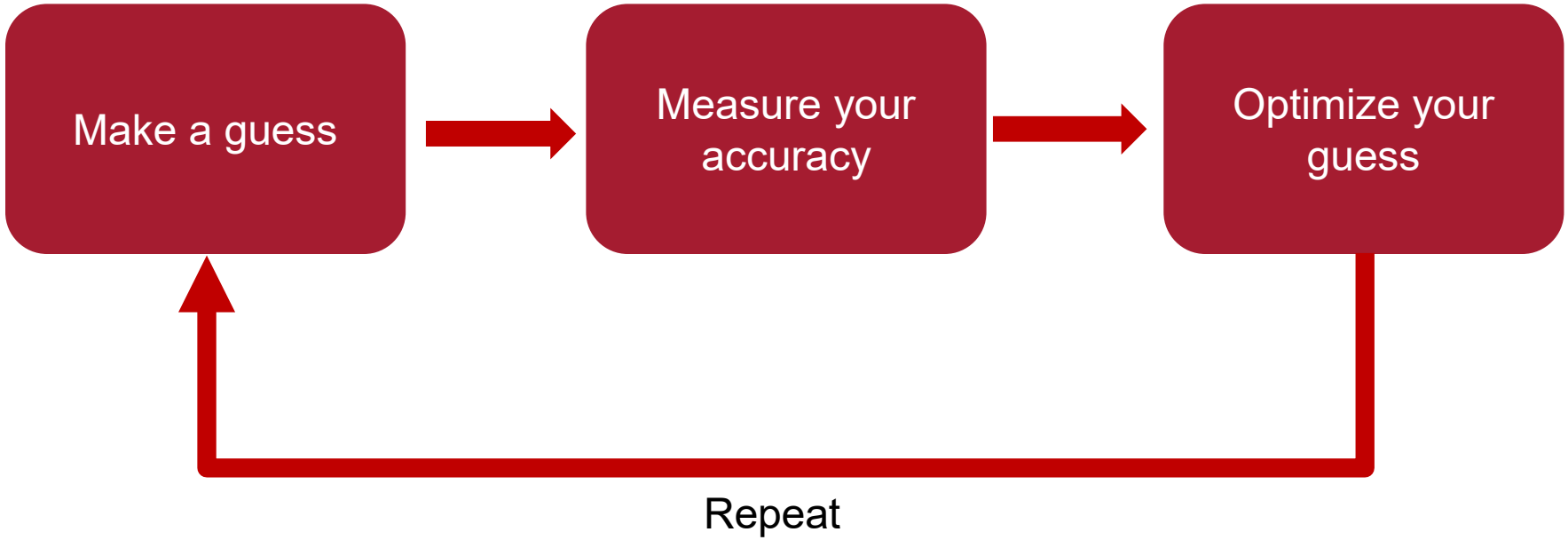
```
10010100111110101010
11010101110101011110
10101011110101001011
11111100011110101010
```

Label = BIKING

```
11111111110100111010
00111111010111110101
01011101010101011110
10101010101001111110
```

Label = GOLFING

The Basic Procedure of Machine Learning



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Basic Concepts of Machine Learning With Example of Linear Regression

Matching X to Y

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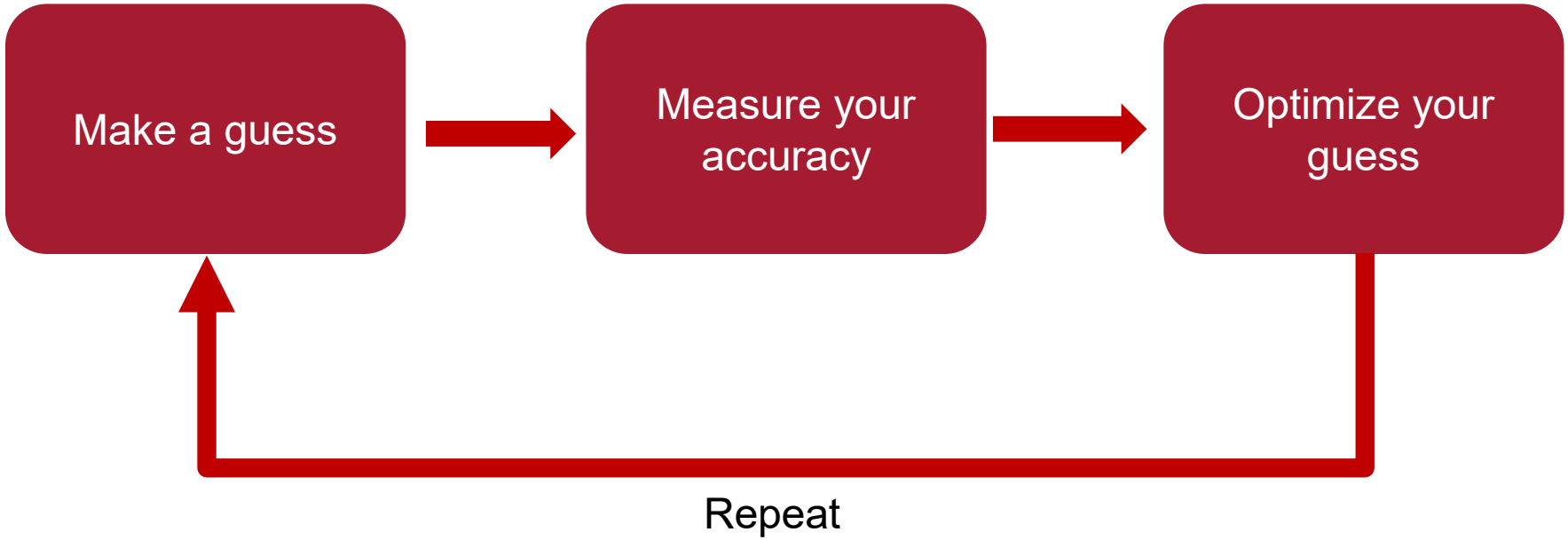
```
X = -1,  0, 1, 2, 3, 4
Y = -3, -1, 1, 3, 5, 7
```

Model: $h_\theta(x) = \theta_0 + \theta_1 x$

θ_i : model parameters

Question: how to choose these θ_i

The Basic Procedure of Machine Learning



Make a Guess: $\theta_0 = -1, \quad \theta_1 = 3$

Y = 3X - 1

X = { -1, 0, 1, 2, 3, 4 }

Y = { -4, -1, 2, 5, 8, 11 }

How good is the guess?

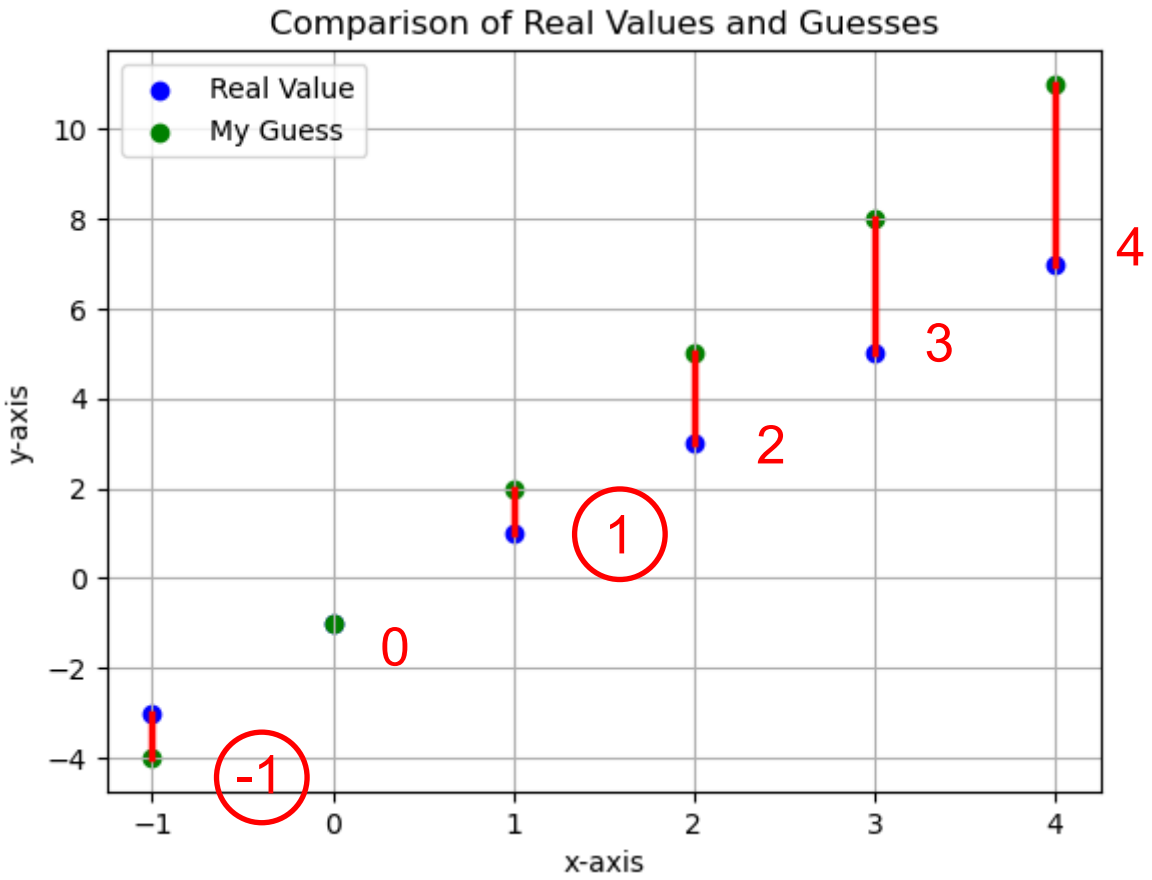
Y = 3X - 1

X = { -1, 0, 1, 2, 3, 4 }

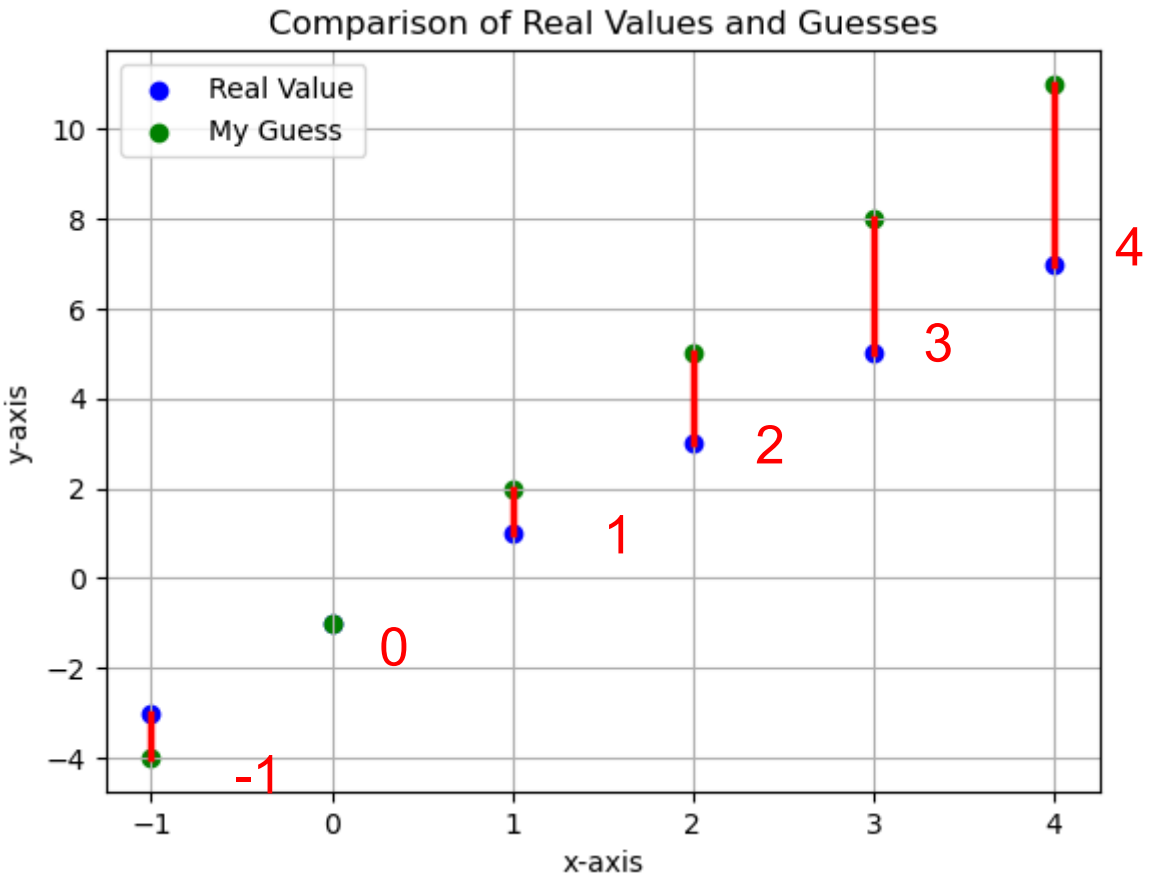
My Y = { -4, -1, 2, 5, 8, 11 }

Real Y = { -3, -1, 1, 3, 5, 7 }

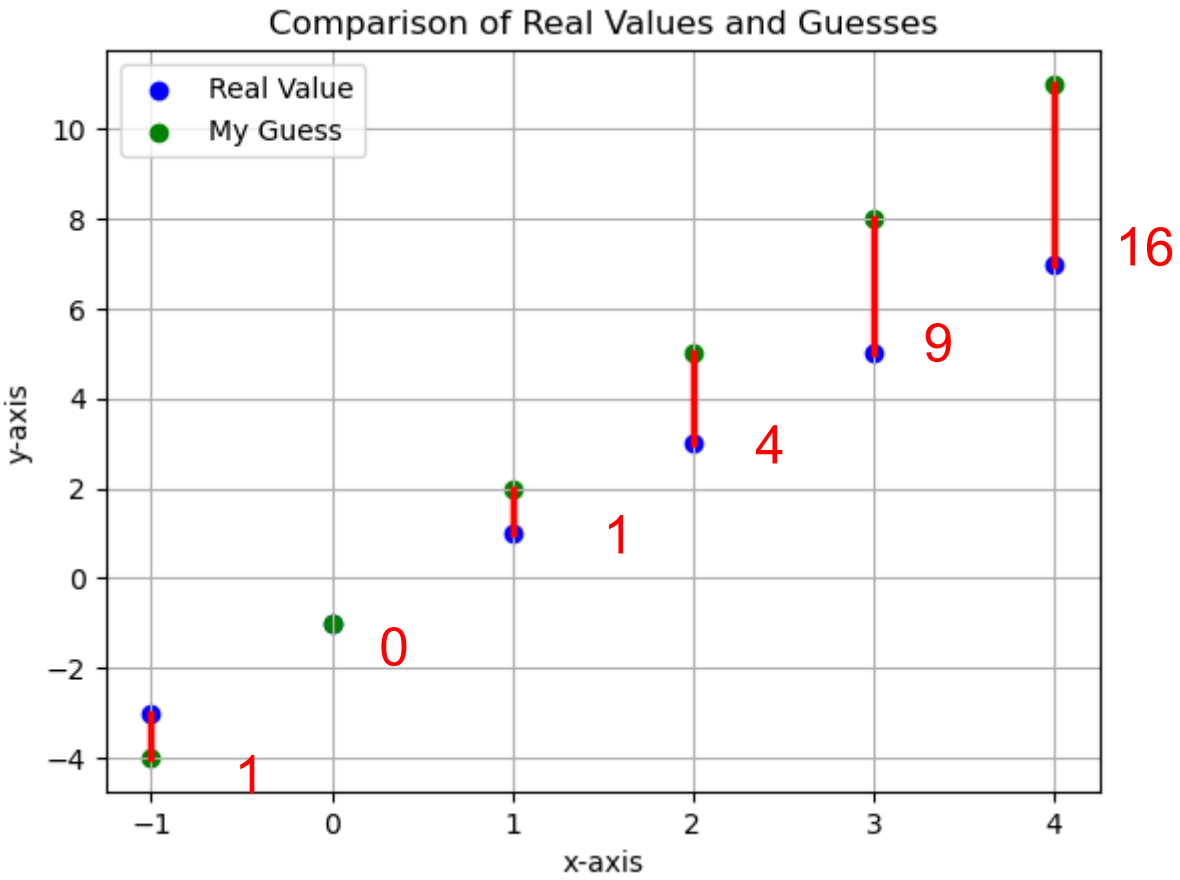
Let's measure it!



What if we square them?



What if we square them?



Loss Function

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Mean Square Error (MSE):

$$J(\theta_0, \theta_1) = \frac{1}{2m} \sum_{i=1}^{m} \left(h_\theta(x^{(i)}) - y^{(i)} \right)^2$$

Loss for our first guess:

$$Loss = \frac{(1 + 0 + 1 + 4 + 9 + 16)}{2 \times 6} \approx 2.583$$

What is the next guess?

Loss Function:

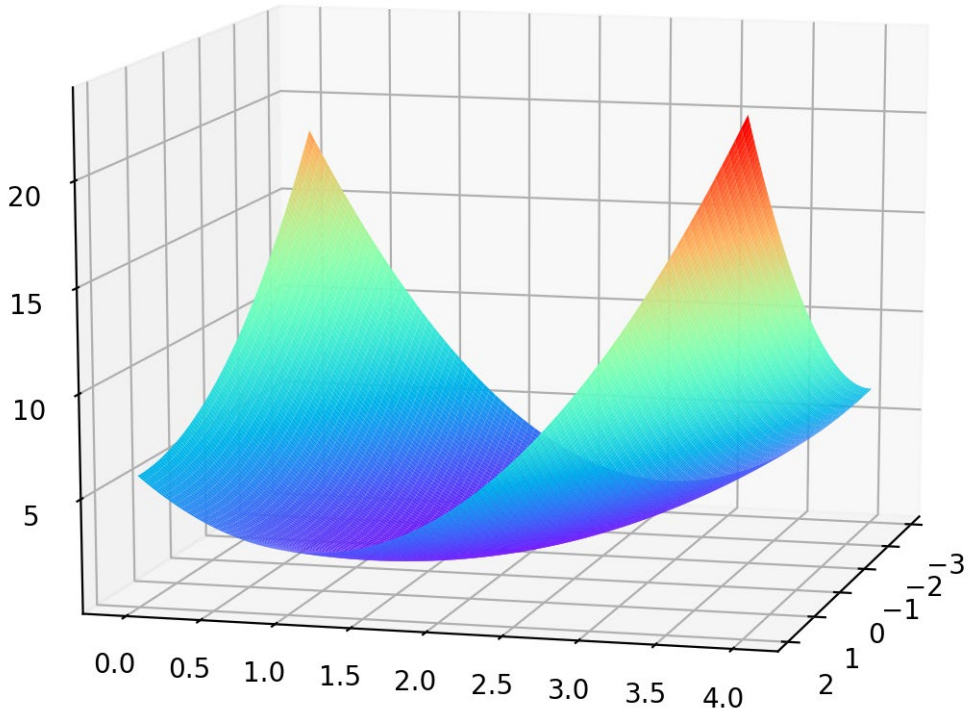
$$J(\theta_0, \theta_1) = \frac{1}{2m} \sum_{i=1}^{m} \left(h_\theta(x^{(i)}) - y^{(i)} \right)^2$$

Goal:

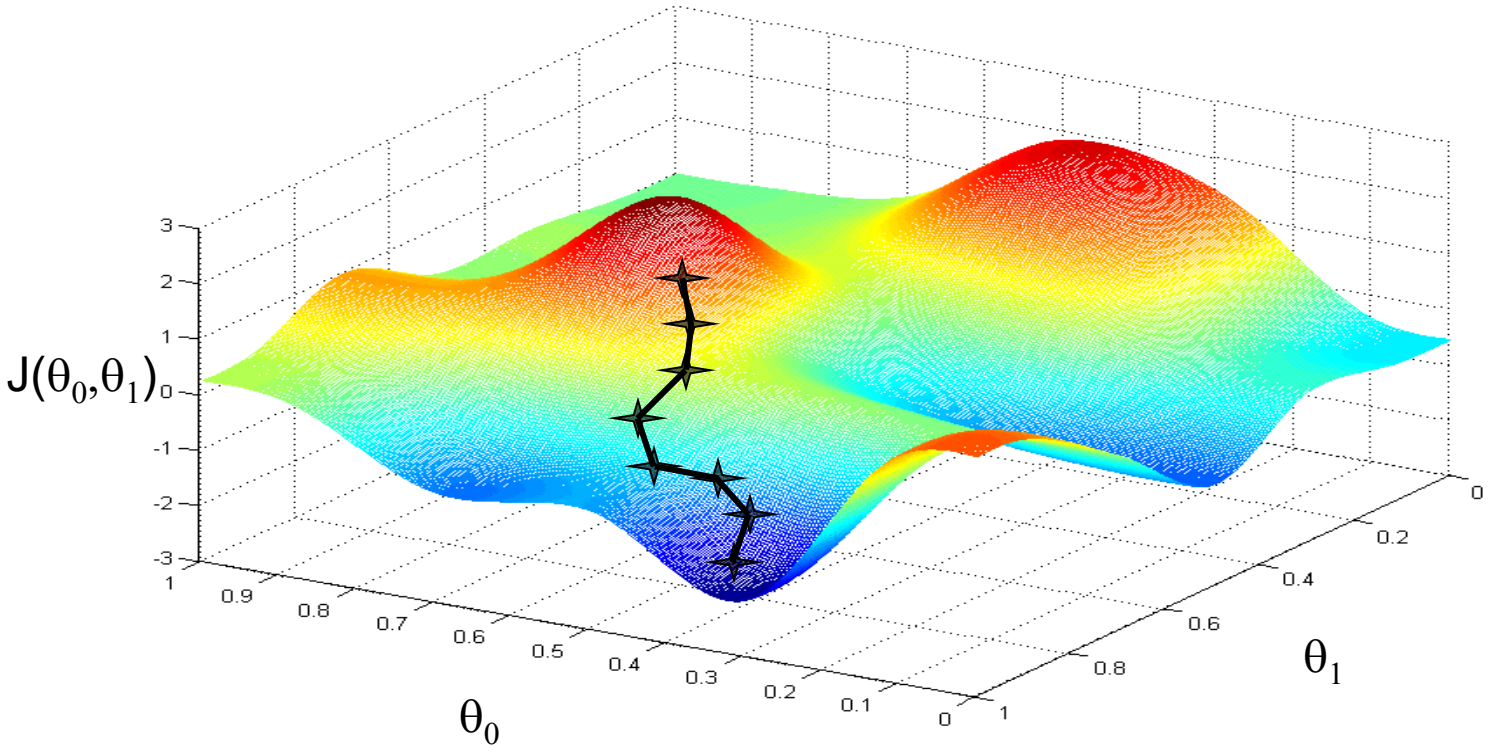
$$\underset{\theta_0, \theta_1}{\text{minimize}}\ J(\theta_0, \theta_1)$$

Method:

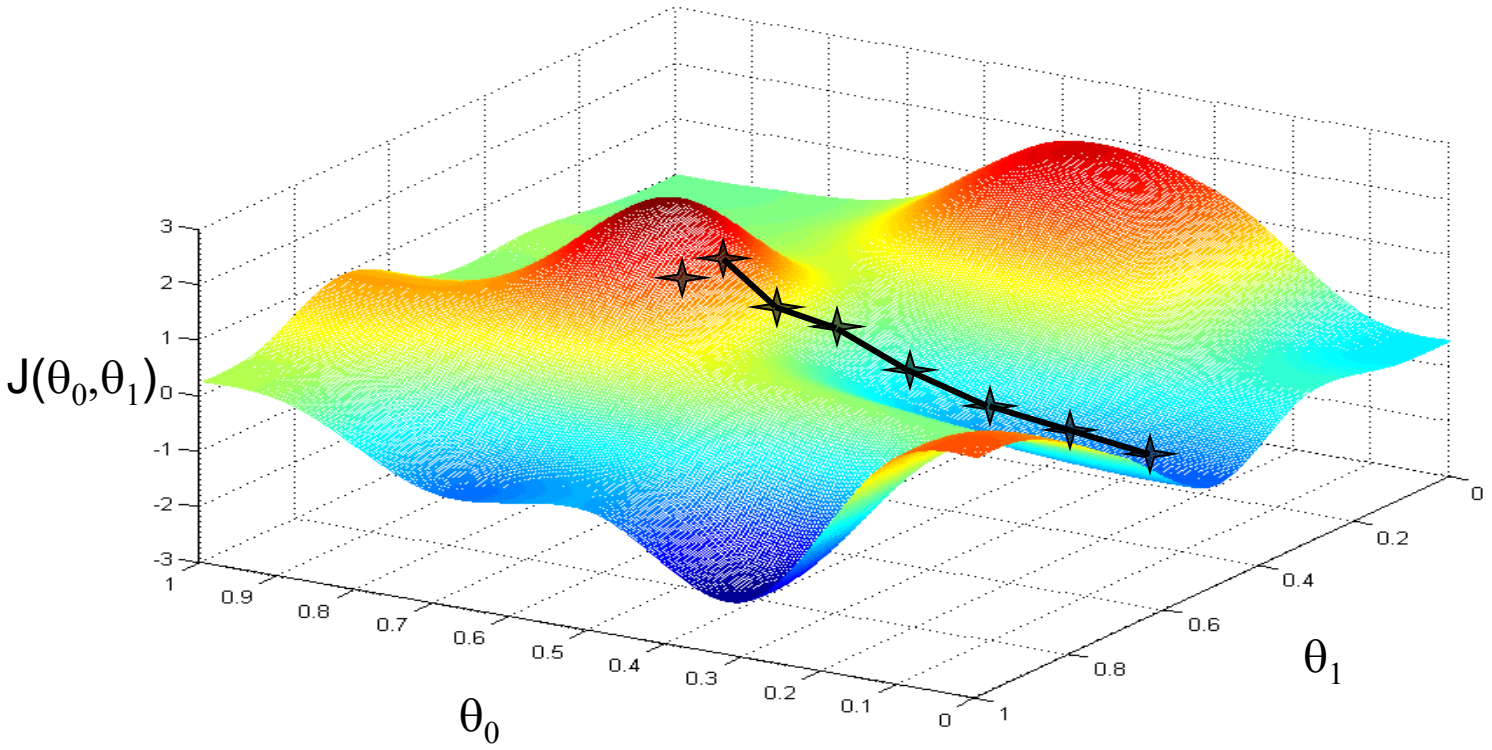
Gradient Decent



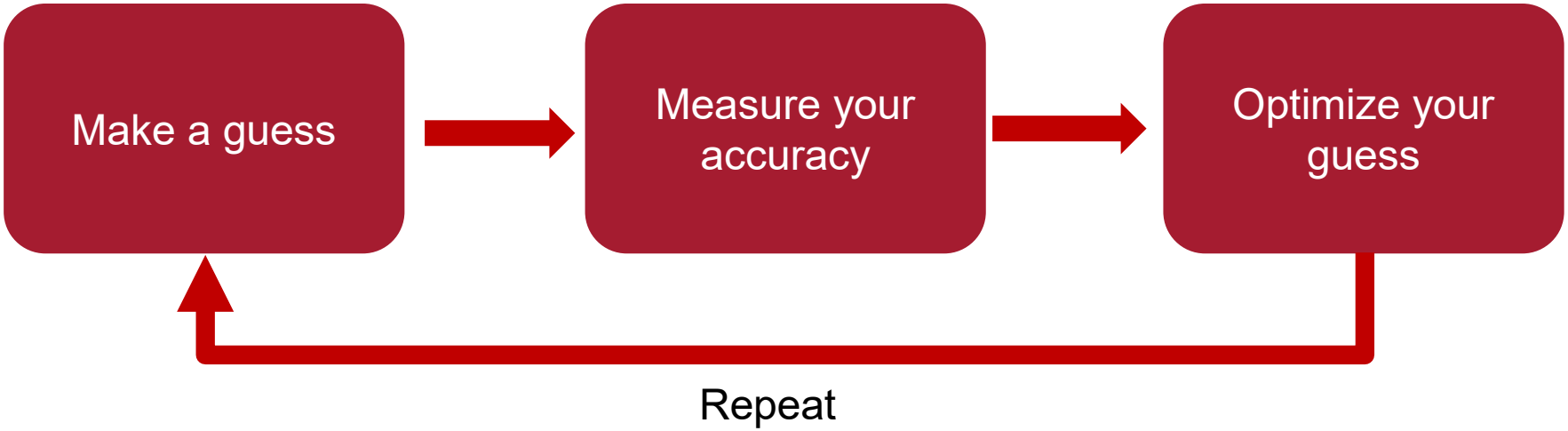
Gradient Descent



Gradient Descent

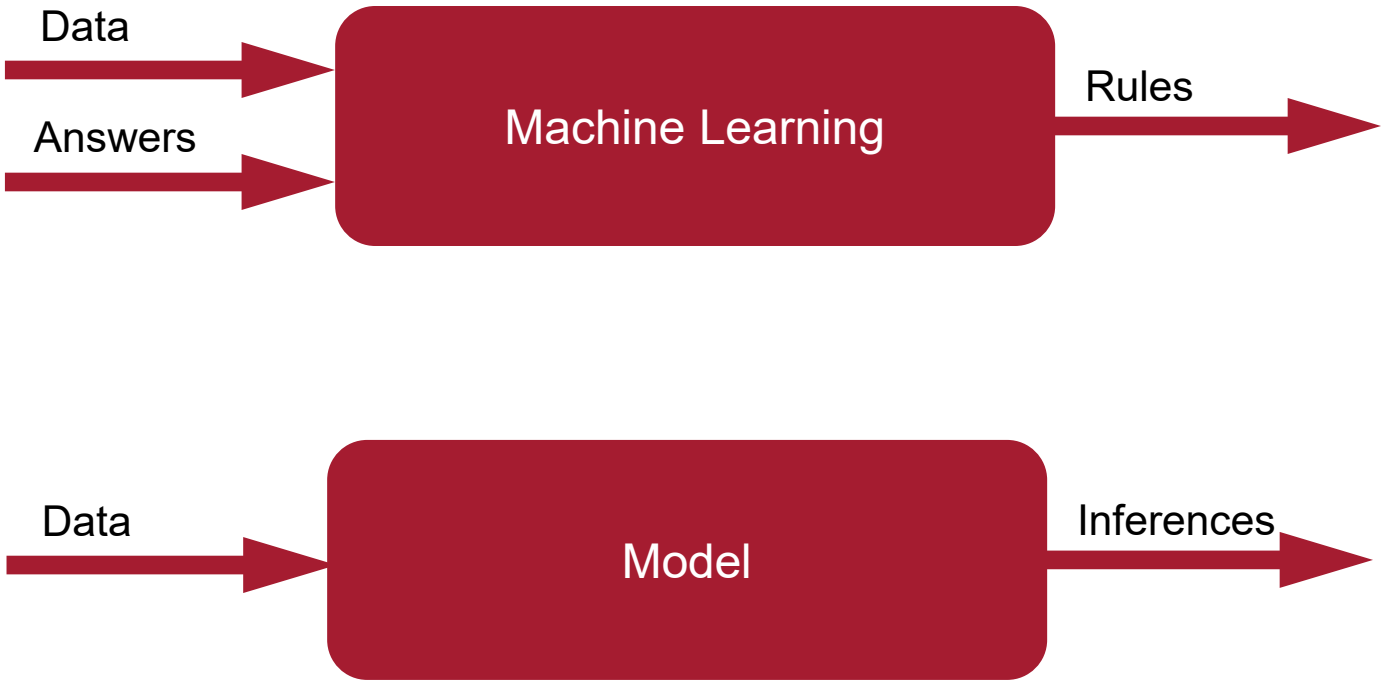


Summary

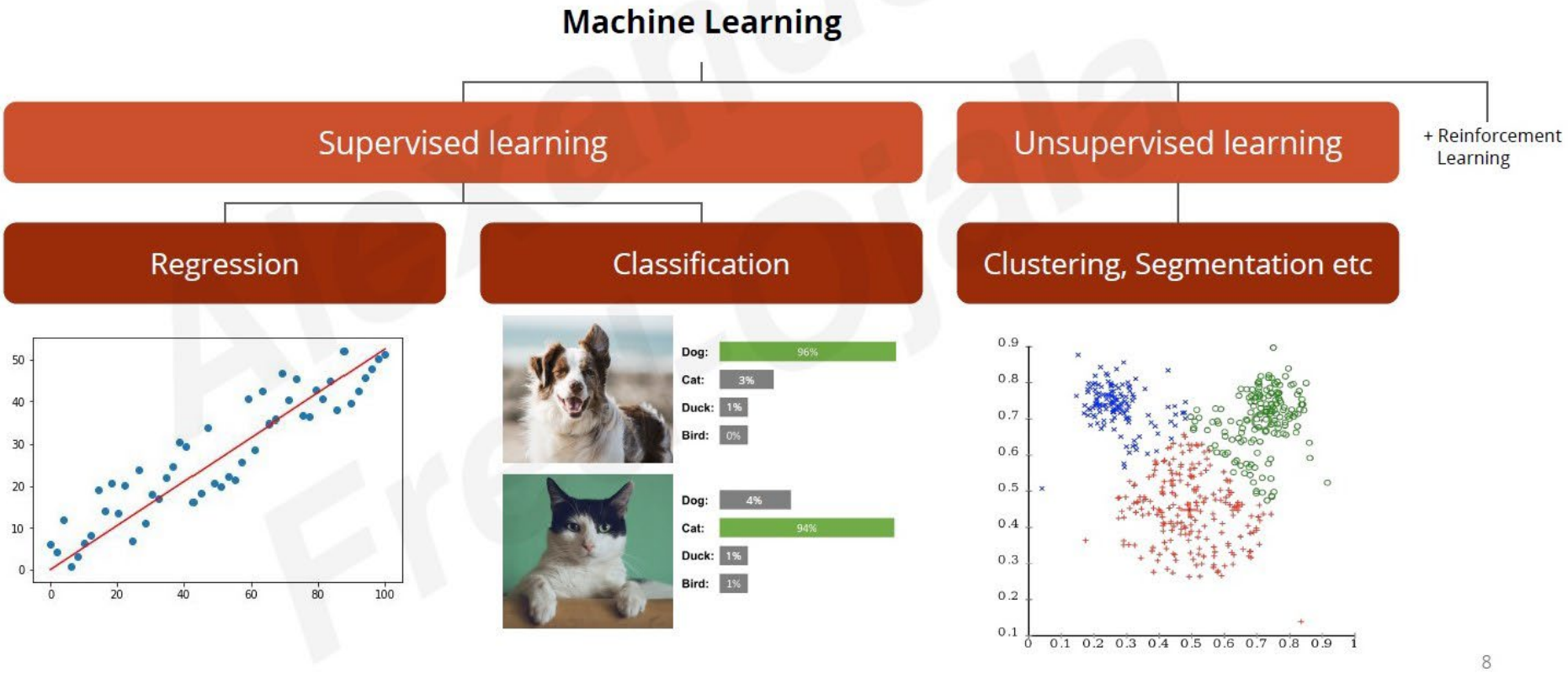


- Randomly Initialization: initial guess
- Loss Function: measure your accuracy
- Optimization: minimize the loss by gradient descent
  - Learning rate: Step size during optimization
- Epochs: repeat times

The Machine Learning Paradigm



Categories of Machine Learning



Reinforcement Learning

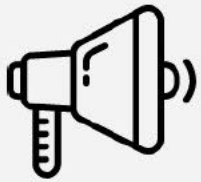
- The agent has a task to perform
- It takes some actions in the environment
- It gets feedback telling it how well it did on performing the task
- The agent gets positive reinforcement for tasks done well
- The agent gets negative reinforcement for tasks done poorly

Ethical AI & Machine Learning

Desire:

Ethical, responsible and trustworthy AI

AI Enablers

1. 
   Data availability
2. 
   Computational power
3. 
   Algorithm advancements
4. 
   Broad public interest

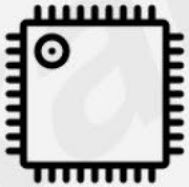
Flip side of AI Enablers

1

Data availability

Violate privacy & data integrity

2



Computational power

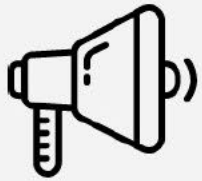
Energy & capital intensive

3

Algorithm advancements

Introduction of biases & opacity

4

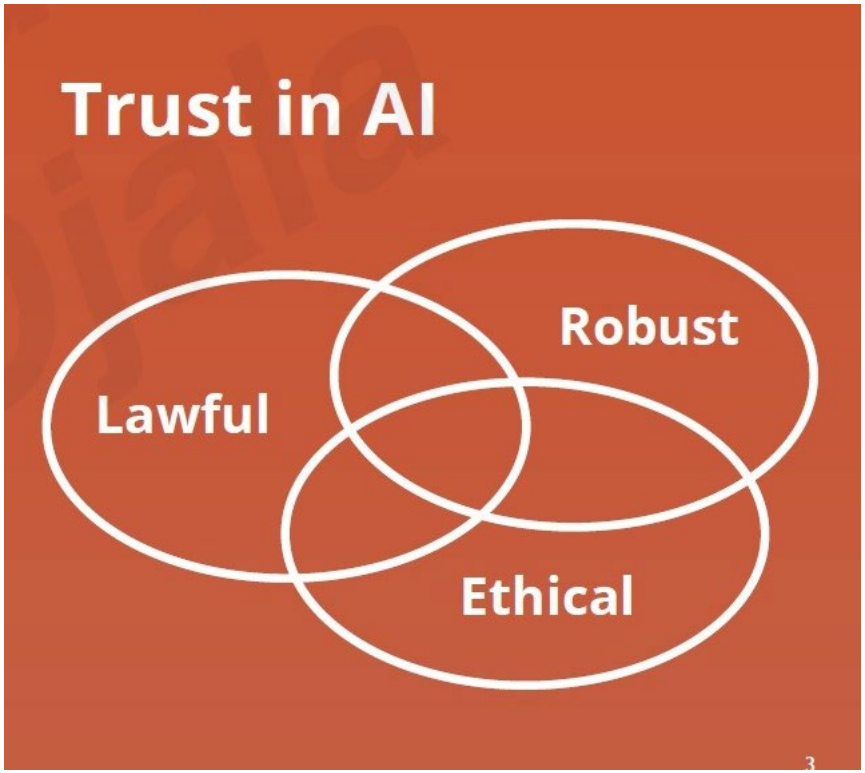


Broad public interest

Hype vs reality

Trust in Humans vs Trust In AI

- Morals & Ethics
- Character
- Societal Laws
- Cultural Laws
- Compassion



EU Ethics guidelines for trustworthy AI

- Human agency & oversight
- Technical robustness & safety
- Privacy & data governance
- Transparency
- Diversity, fairness & non-discrimination
- Societal & environmental wellbeing
- Accountability

https://digital-strategy.ec.europa.eu/en/library/ethics-guidelines-trustworthy-ai

Human Agency and Oversight

AI systems should empower human beings, allowing them to make informed decisions and fostering their fundamental rights. At the same time, proper oversight mechanisms need to be ensured, which can be achieved through human-in-the-loop, human-on-the-loop, and human-in-command approaches.

Technical Robustness and safety

AI systems need to be resilient and secure. They need to be safe, ensuring a fall back plan in case something goes wrong, as well as being accurate, reliable and reproducible. That is the only way to ensure that also unintentional harm can be minimized and prevented.

Privacy and data governance

Besides ensuring full respect for privacy and data protection, adequate data governance mechanisms must also be ensured, taking into account the quality and integrity of the data, and ensuring legitimised access to data.

Transparency

The data, system and AI business models should be transparent. Traceability mechanisms can help achieving this.

Moreover, AI systems and their decisions should be explained in a manner adapted to the stakeholder concerned. Humans need to be aware that they are interacting with an AI system and must be informed of the system's capabilities and limitations.

Diversity, Non-discrimination and Fairness

- Unfair bias must be avoided, as it could have multiple negative implications, from the marginalization of vulnerable groups, to the exacerbation of prejudice and discrimination.

- Fostering diversity, AI systems should be accessible to all, regardless of any disability, and involve relevant stakeholders throughout their entire life circle.

Societal and environmental well-being

AI systems should benefit all human beings, including future generations. It must hence be ensured that they are sustainable and environmentally friendly. Moreover, they should take into account the environment, including other living beings, and their social and societal impact should be carefully considered.

Accountability

Mechanisms should be put in place to ensure responsibility and accountability for AI systems and their outcomes.

Auditability, which enables the assessment of algorithms, data and design processes plays a key role therein, especially in critical applications. Moreover, adequate and accessible redress should be ensured.

Limitations

- The Limitations of Machine Learning

https://towardsdatascience.com/the-limitations-of-machine-learning-a00e0c3040c6

- The Limitations of Deep Learning

https://blog.keras.io/the-limitations-of-deep-learning.html

- The Future of AI; Bias Amplification & Algorithmic Determinism

https://digileaders.com/future-ai-bias-amplification-algorithmic-determinism/