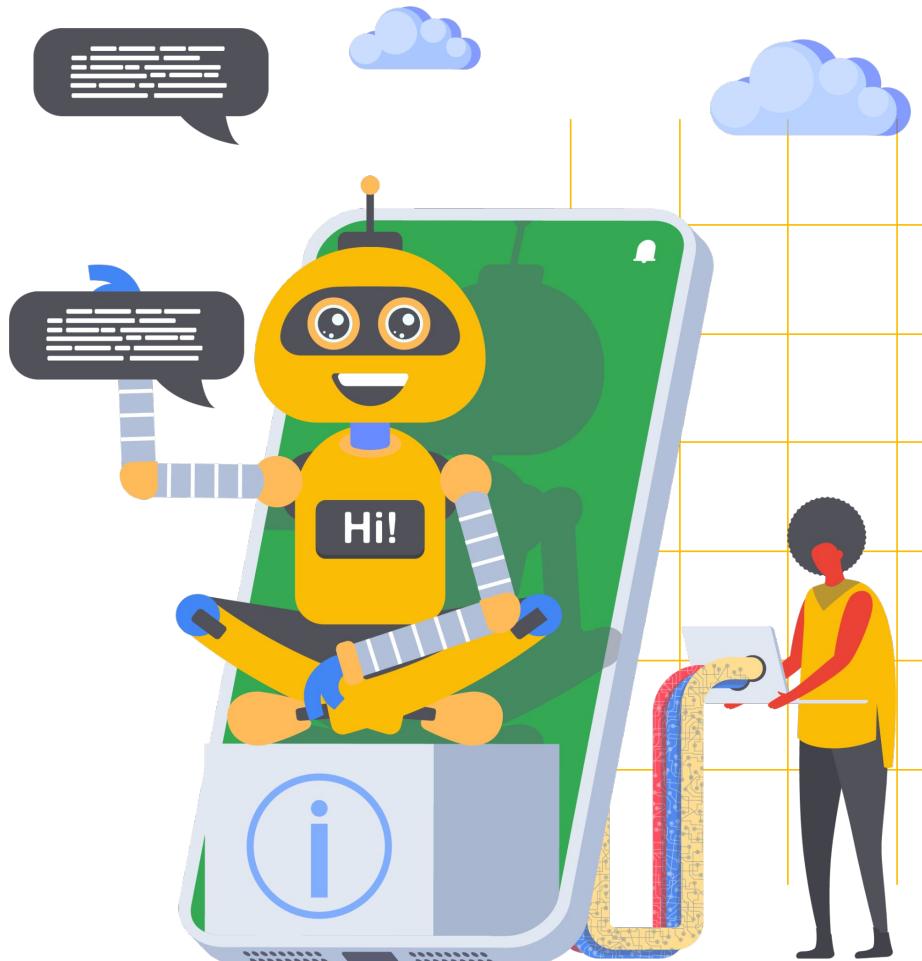


How ML works?

with Professor VJ



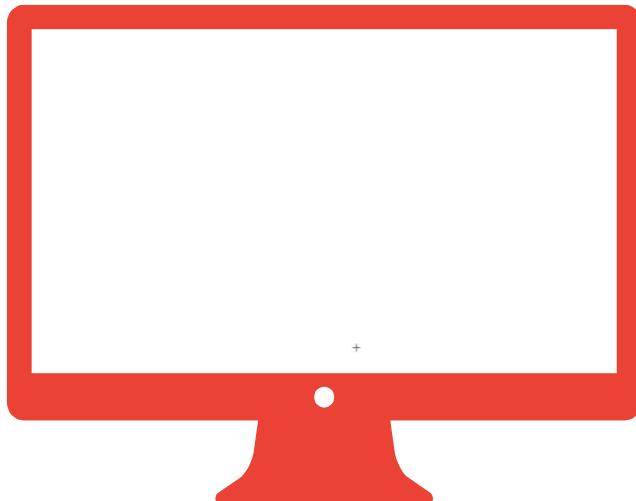


I'm VJ!

I teach Electrical Engineering and
Computer Science at **Harvard**.

Recap from yesterday

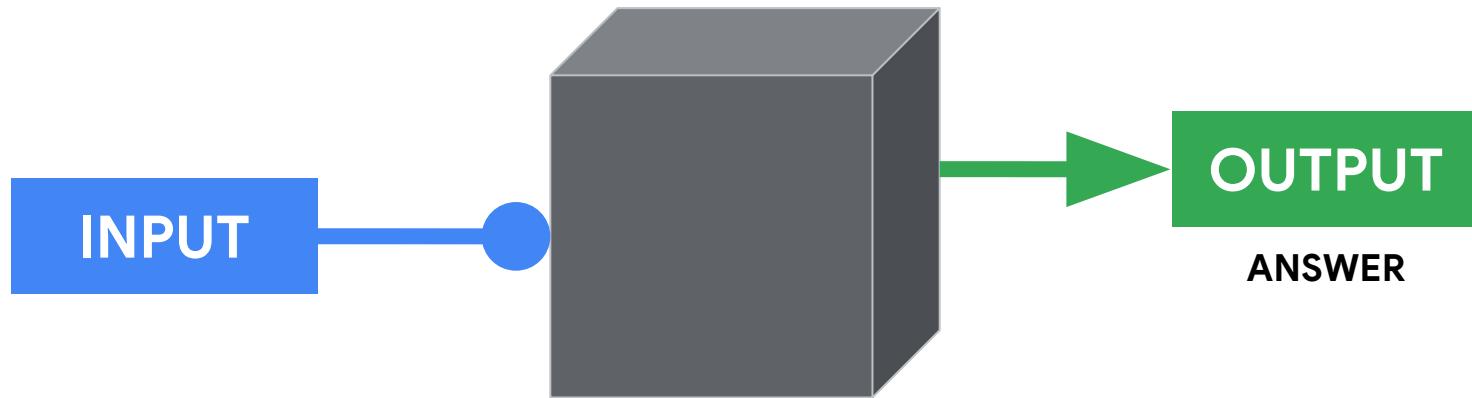
Placeholder, something from
Laurence's intro



Predict your sketch!

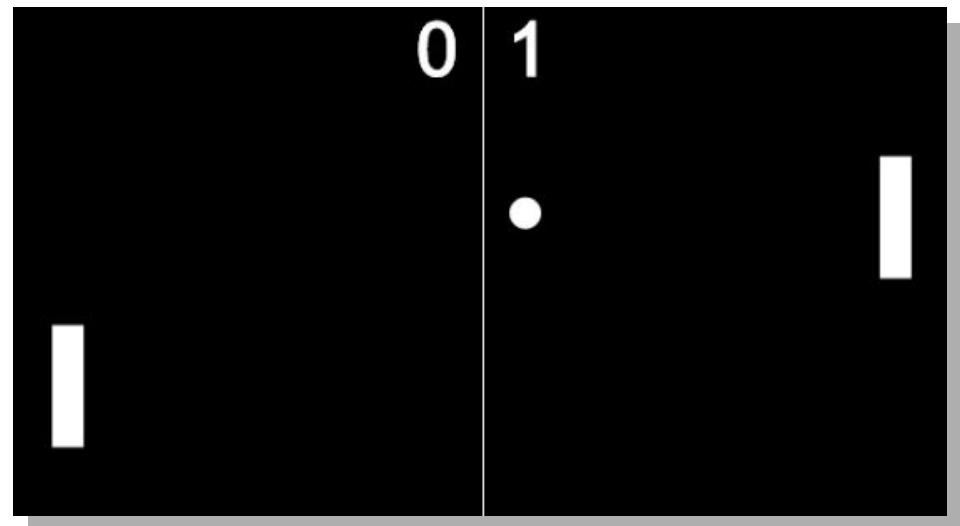


Computer Science



One method: **explicit** coding

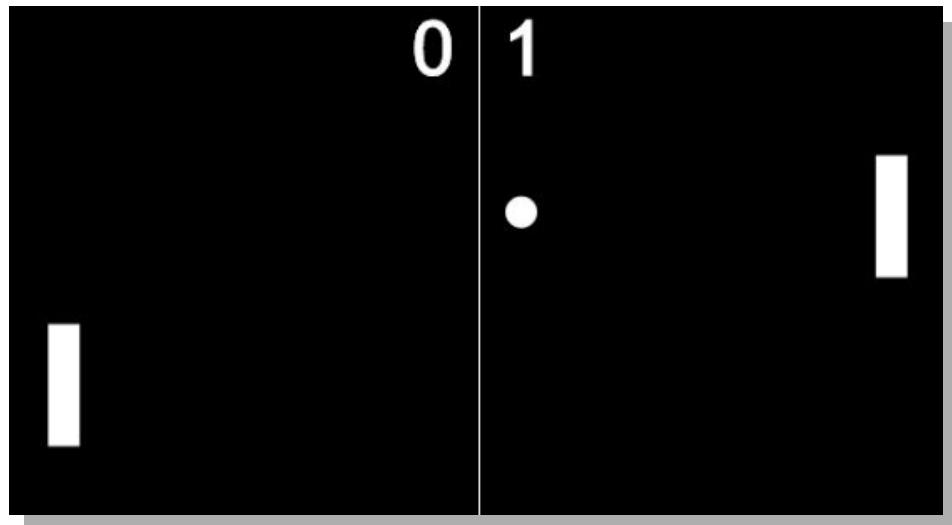
List **all** of the rules:



One method: **explicit** coding

List **all** of the rules:

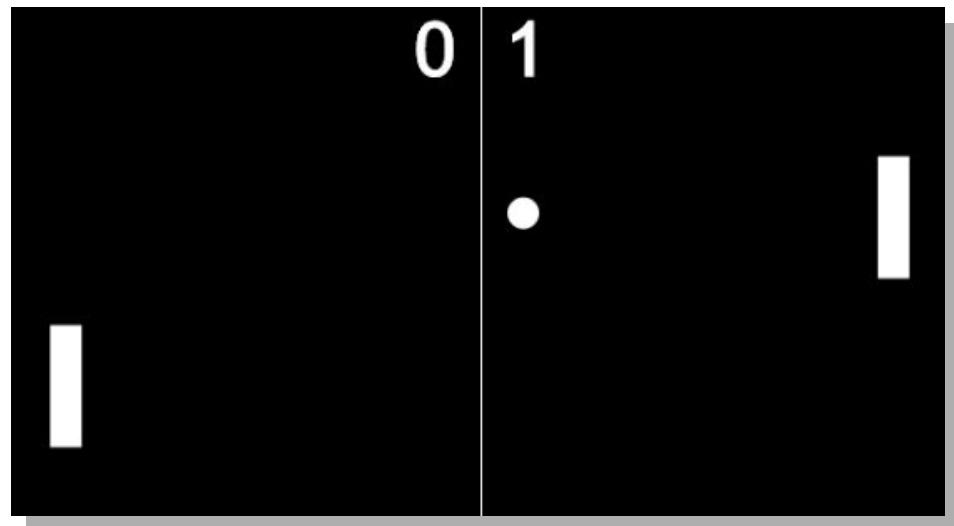
1. What happens when ball hits the paddle?



One method: **explicit** coding

List **all** of the rules:

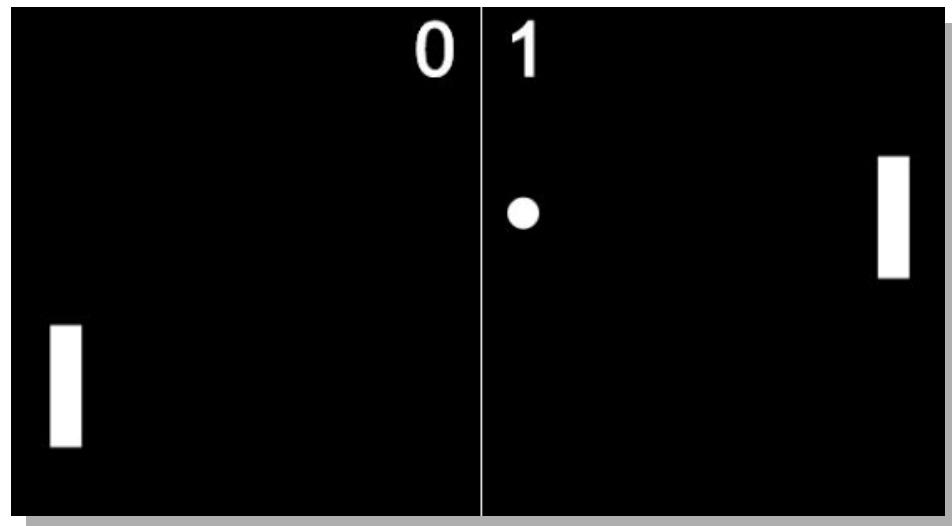
1. What happens when ball hits the paddle?
2. What happens if the ball passes the paddle?



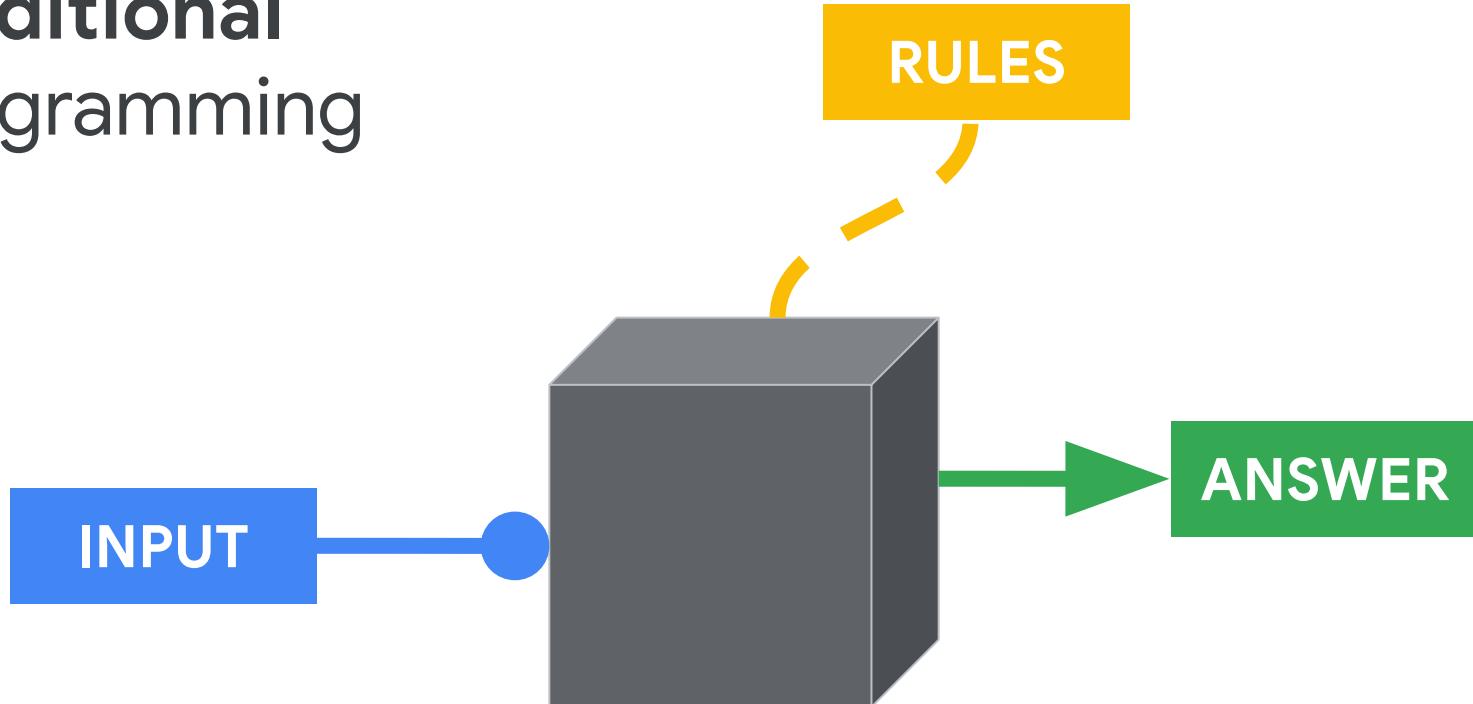
One method: **explicit** coding

List **all** of the rules:

1. What happens when ball hits the paddle?
2. What happens if the ball passes the paddle?
3. Where does the ball restart after one player scored?



Traditional Programming



Let's try to figure out **what** she's doing?



```
if (speed < 4):  
    then walking
```

Let's try to figure out **what** she's doing?



```
if (speed < 4):  
    then walking
```

```
if (speed < 4):  
    then walking  
else:  
    running
```

Let's try to figure out **what** she's doing?



```
if (speed < 4):  
    then walking
```

```
if (speed < 4):  
    then walking  
else:  
    running
```

```
if (speed < 4):  
    then walking  
else if (speed < 12):  
    then running  
else:  
    biking
```

Let's try to figure out **what** she's doing?



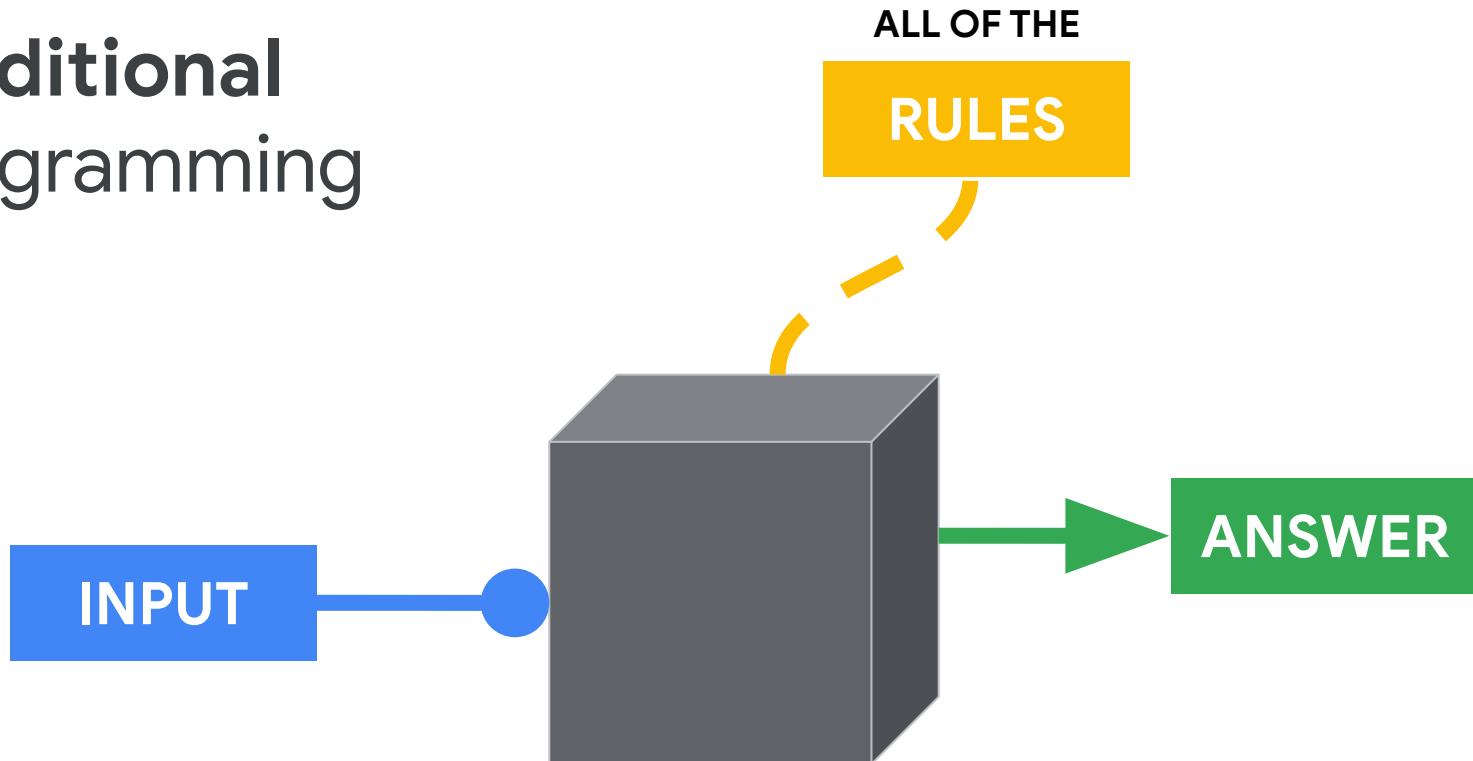
```
if (speed < 4):  
    then walking
```

```
if (speed < 4):  
    then walking  
else:  
    running
```

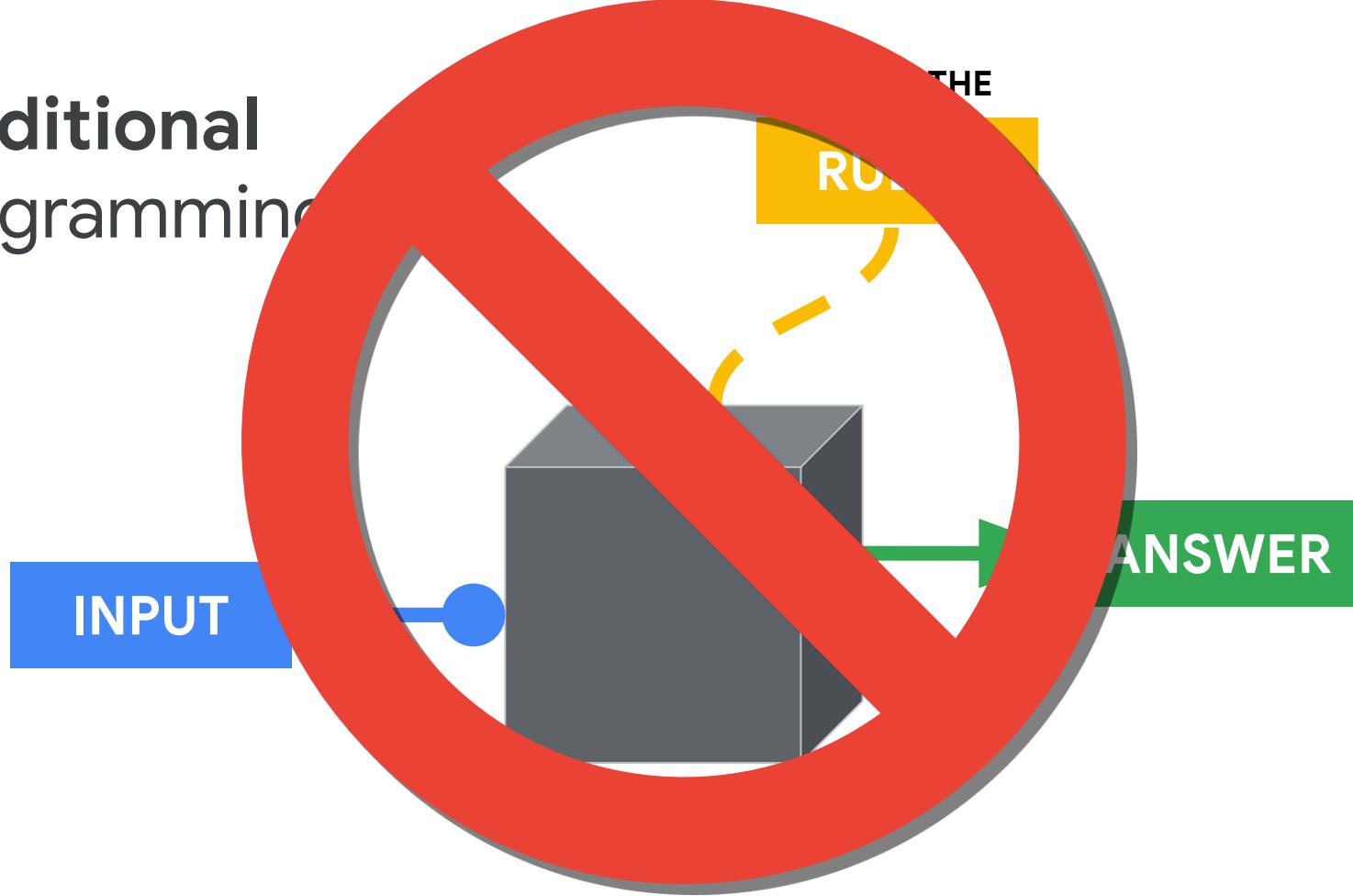
```
if (speed < 4):  
    then walking  
else if (speed < 12):  
    then running  
else:  
    biking
```

?? **WHAT IS THIS ??**

Traditional Programming



Traditional Programming



A New Method

Machine Learning



Machine Learning



Let's try to figure out **what** she's doing?



01010101001000110101
01010100101001001010
10101011010100101001

11110101001001010101
01010010100101010100
11010110010101001111

00001110101110101101
01010111101011010101
11010111111001001011

01111110101110101010
10101110101011010101
1111111100100001110

walking

running

biking

golfing

Let's try to figure out **what** she's doing?



01010101001000110101
01010100101001001010
1010101101010010**1001**

11110101001001010101
01010010100101010100
11010110010101001111

00001110101110101101
01010111101011010101
11010111111001001011

01111110101110101010
10101110101011010101
1111111100100001110

walking

running

biking

golfing

Let's try to figure out **what** she's doing?



01010101001000110101
01010100101001001010
1010101101010010**1001**

11110101001001010101
01010010100101010100
1101011001010100**1111**

00001110101110101101
01010111101011010101
1101011111100100**1011**

01111110101110101010
10101110101011010101
111111110010000**1110**

walking

running

biking

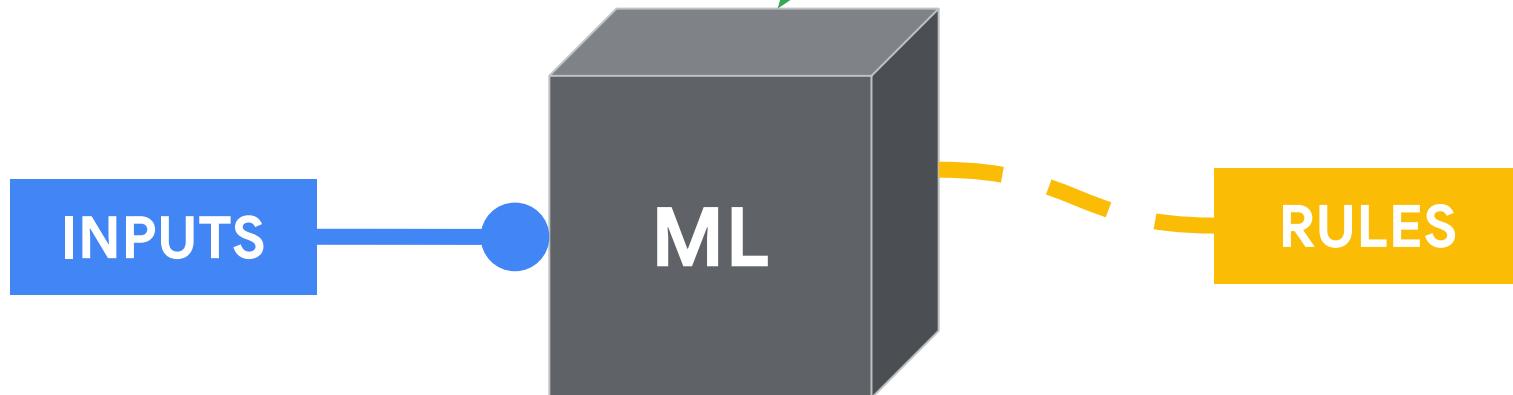
golfing

Training the machine



WE PROVIDE

ANSWERS

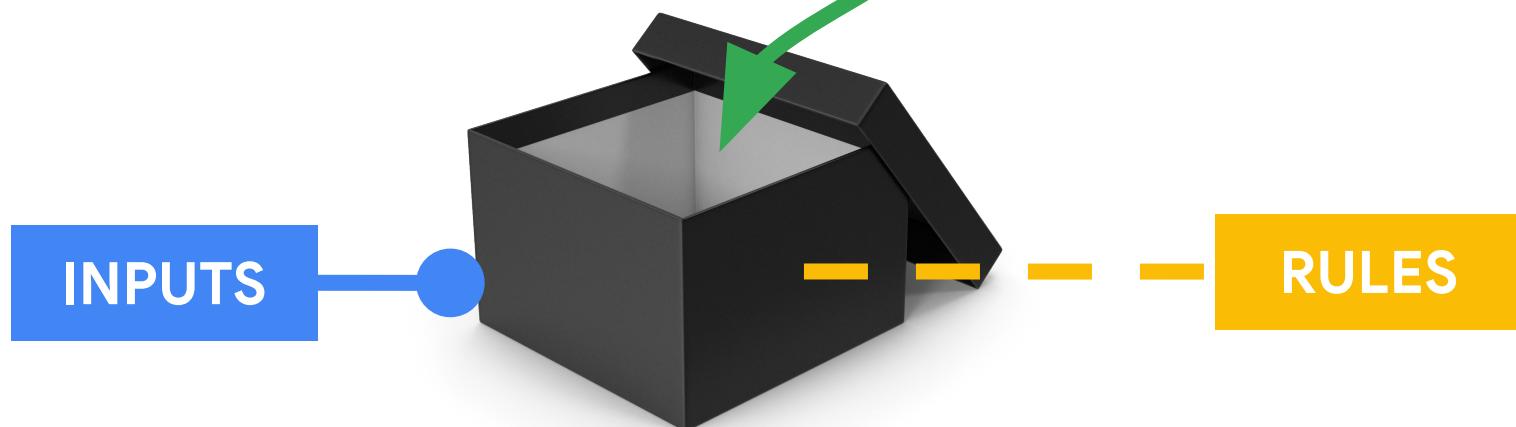


Training the machine



WE PROVIDE

ANSWERS

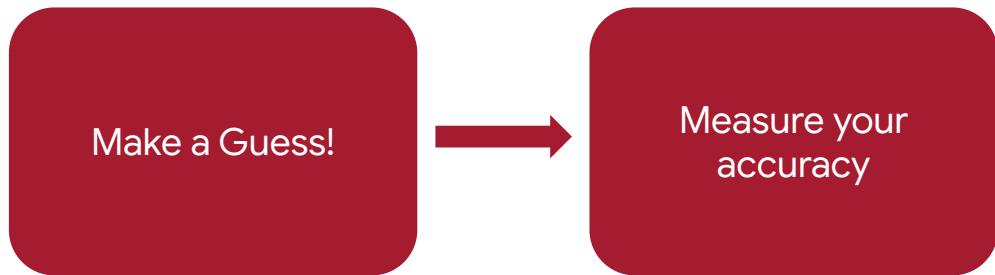


STILL A WORK IN PROGRESS

The Machine Learning Paradigm

Make a Guess!

The Machine Learning Paradigm



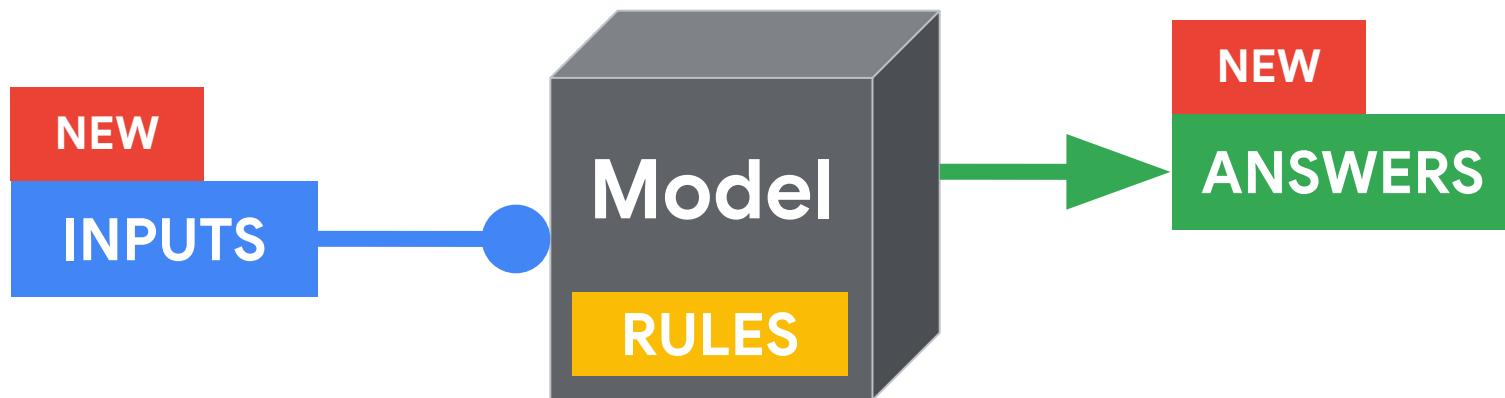
The Machine Learning Paradigm



The Machine Learning Paradigm



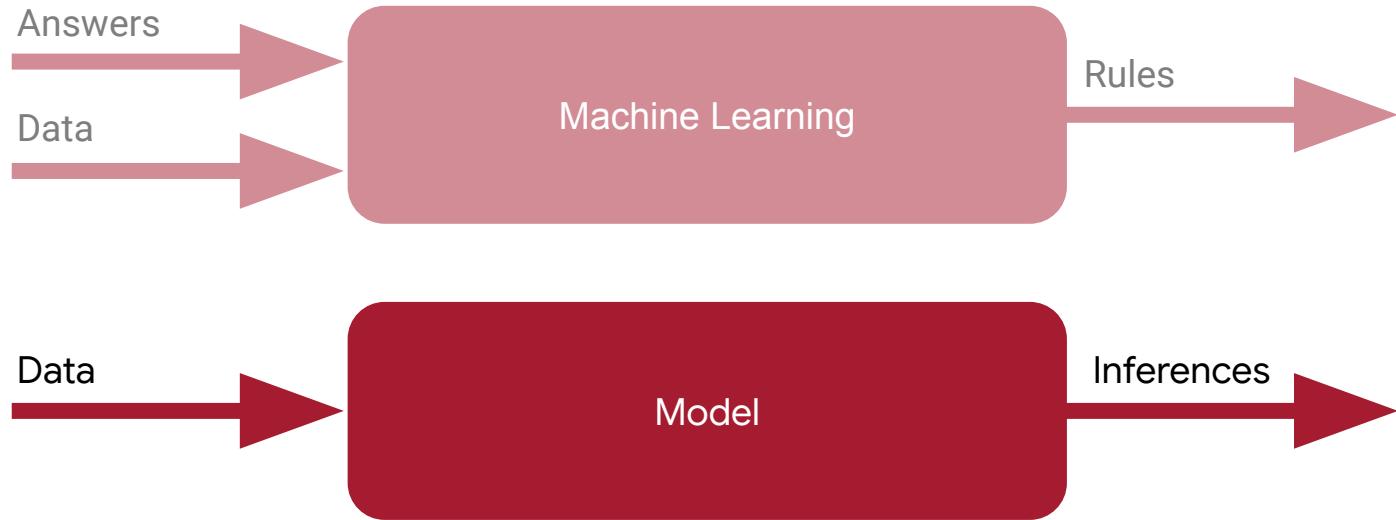
After it's learned:



The Machine Learning Paradigm



The Machine Learning Paradigm



What is (tiny) Machine Learning?

What is Machine Learning?

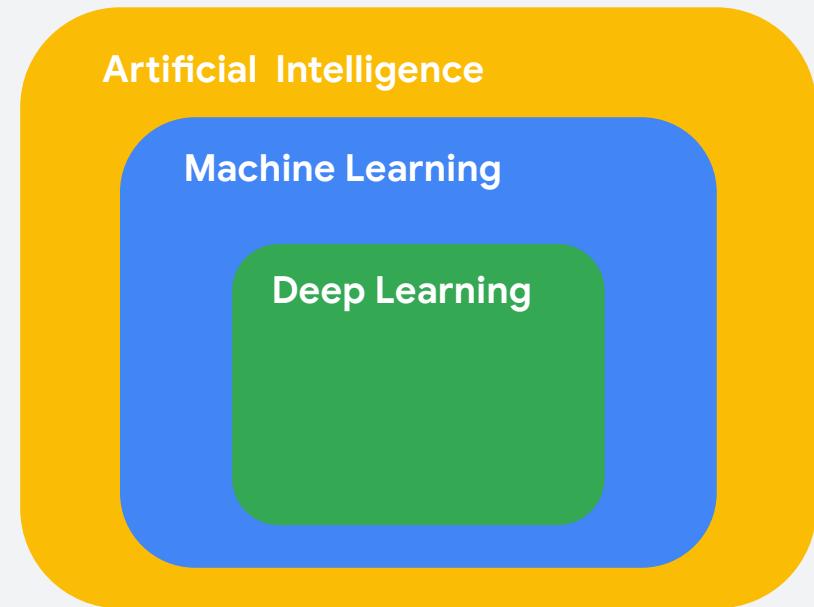
1. **Machine Learning** is a subfield of **Artificial Intelligence** focused on developing algorithms that learn to **solve problems by analyzing data for patterns**

Artificial Intelligence

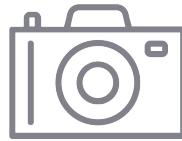
Machine Learning

What is (Deep) Machine Learning?

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



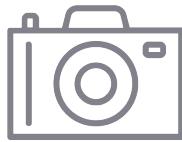
Applications of Machine Learning



↓



Applications of Machine Learning



Applications of Machine Learning

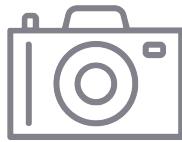
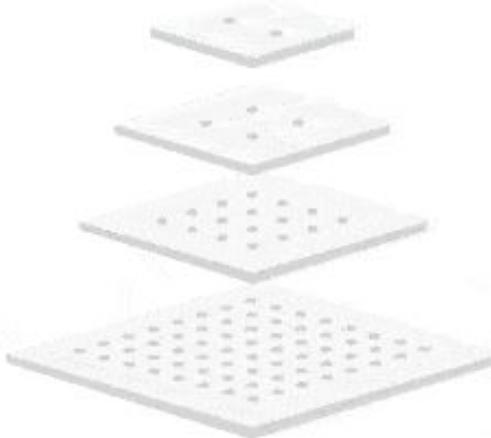


Image Classification

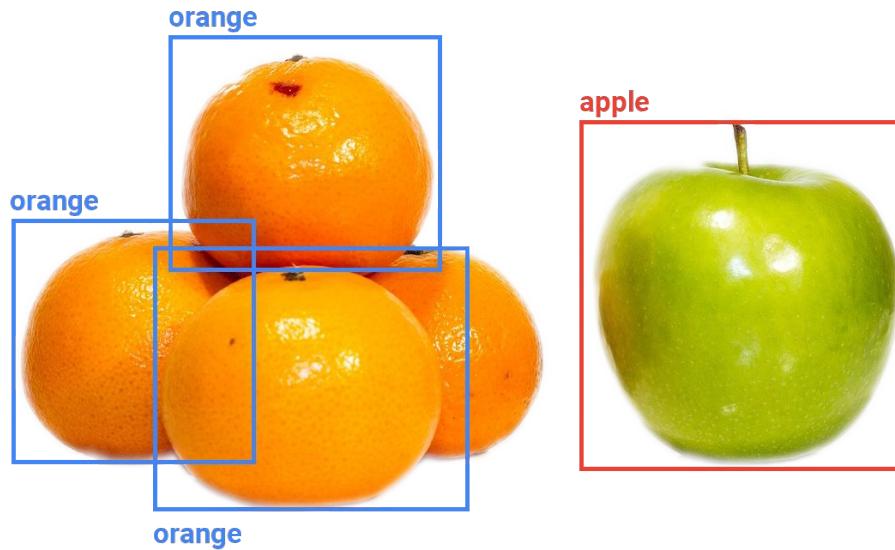


CAT

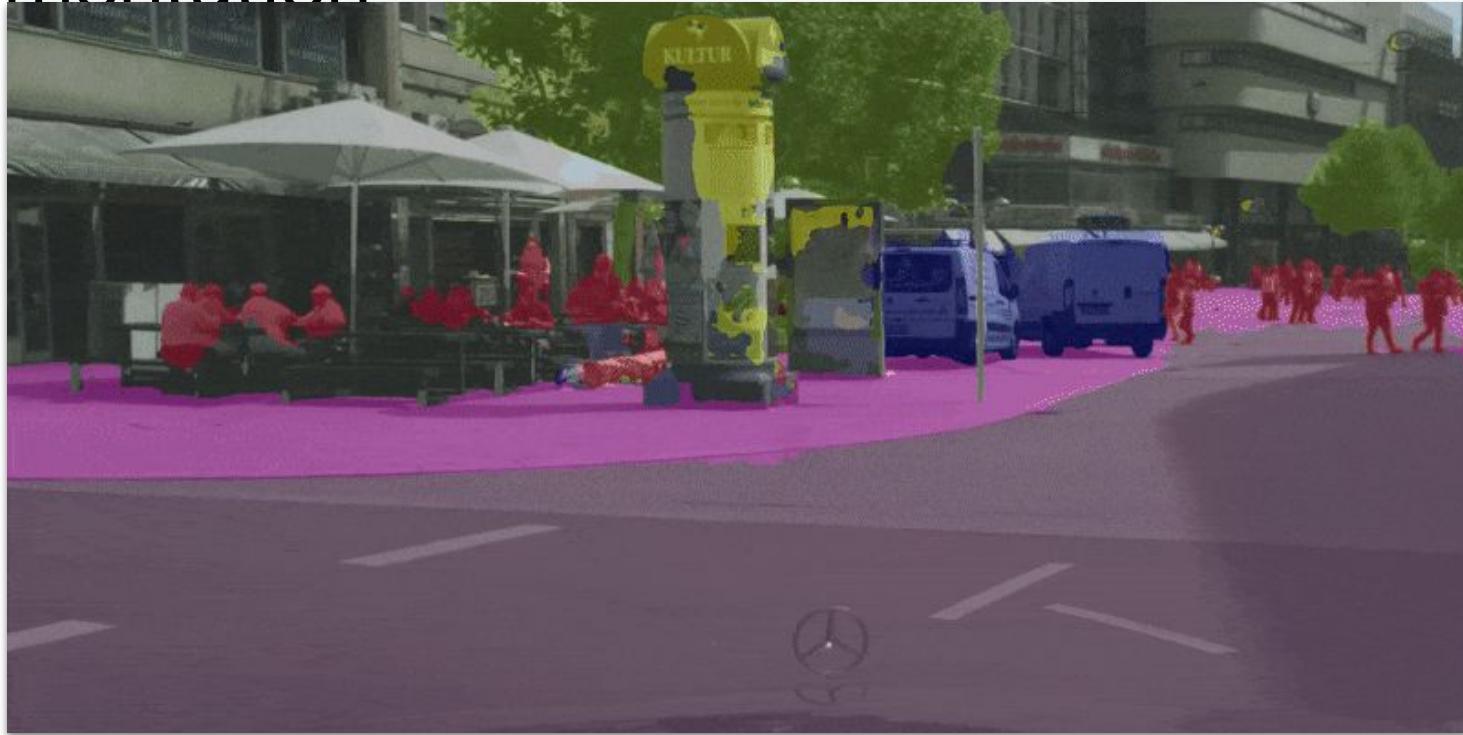
DOG



Object Detection

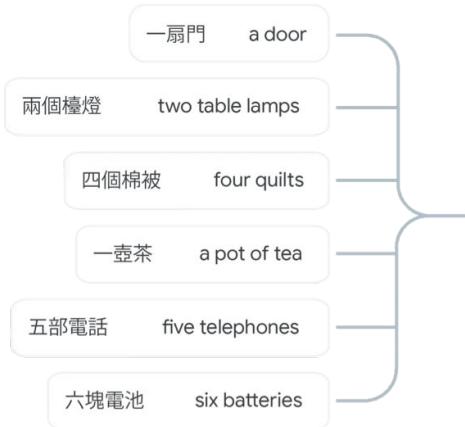


Segmentation



Machine Translation

- 1 Upload translated language pairs



- 2 Train your model

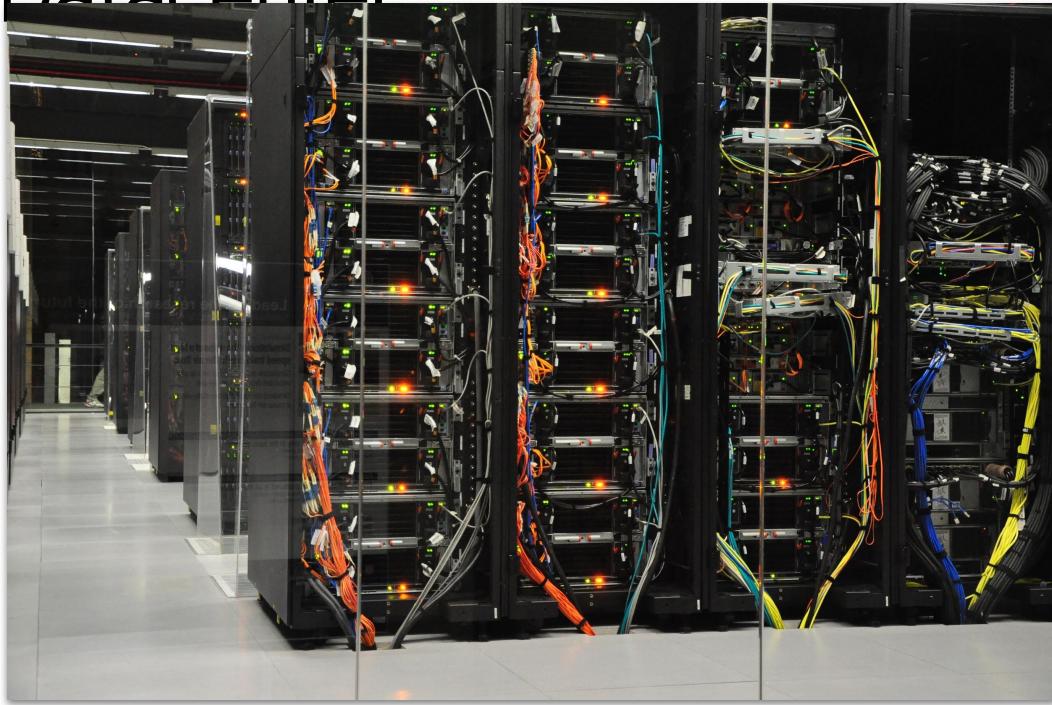


- 3 Evaluate

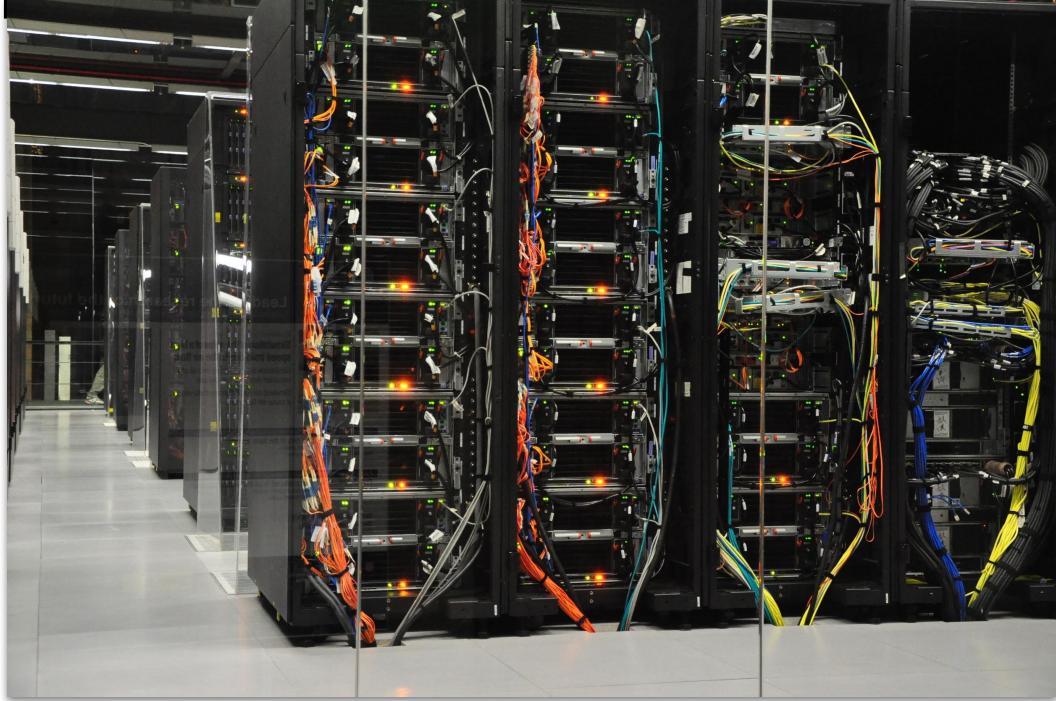


Recommendations

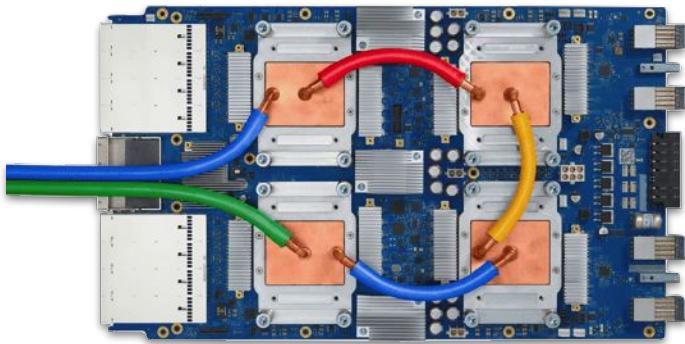
Datacenter



Datacenter

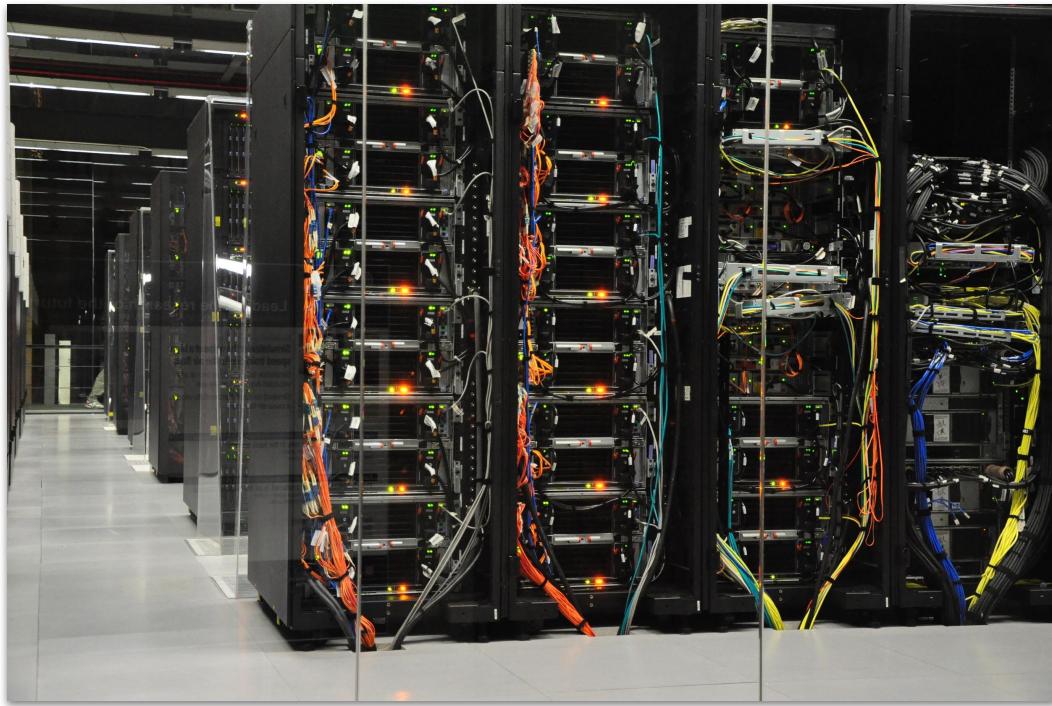


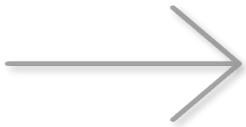
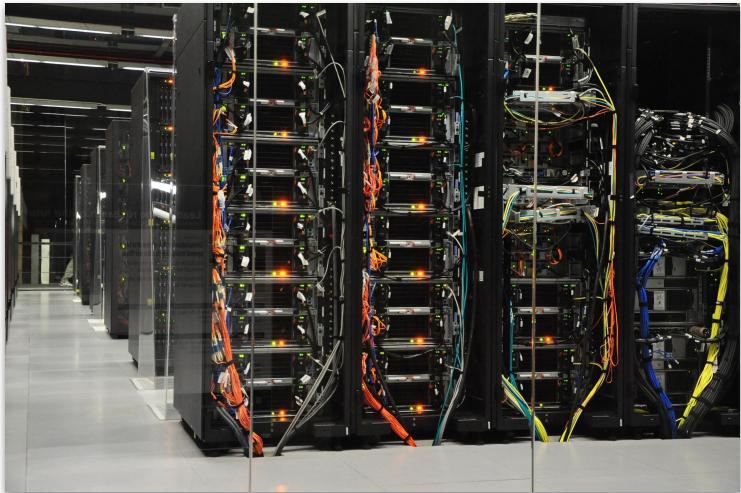
TPUs/GPUs



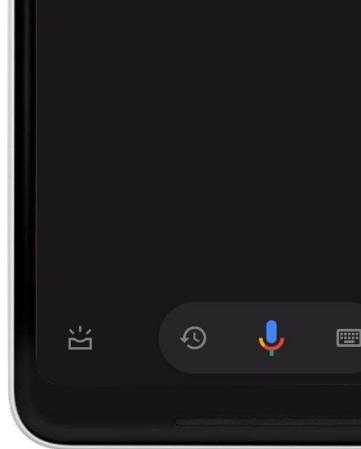
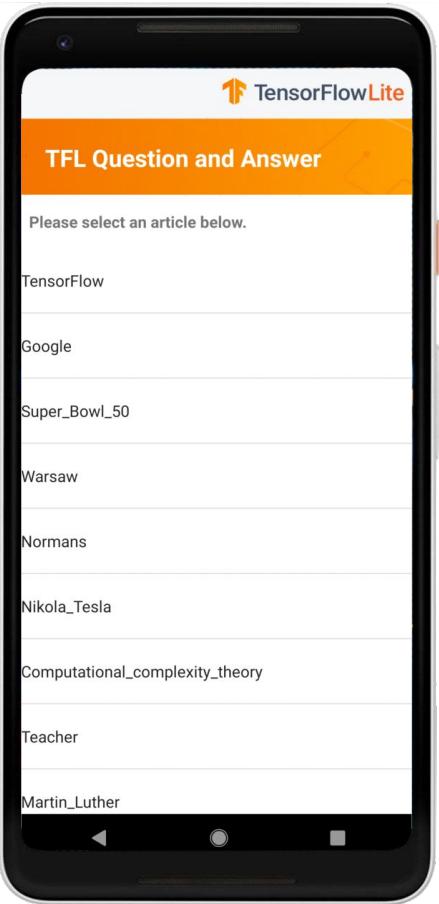


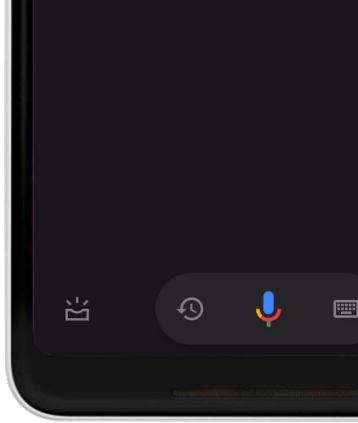
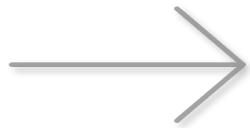
Bigger Is Not
Always Better.









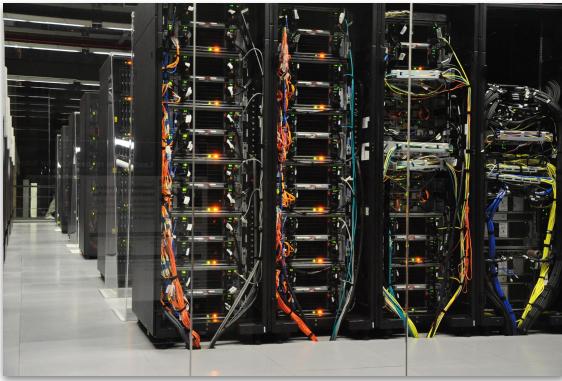


TensorFlow

TFL Question and Answer

Please select an article below.

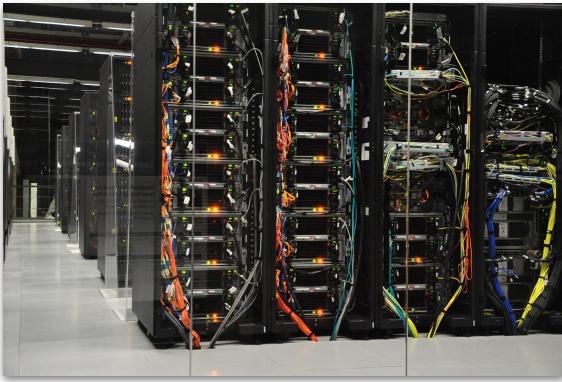
- TensorFlow
- Google
- Super_Bowl_50
- Warsaw
- Normans



Why?

High power



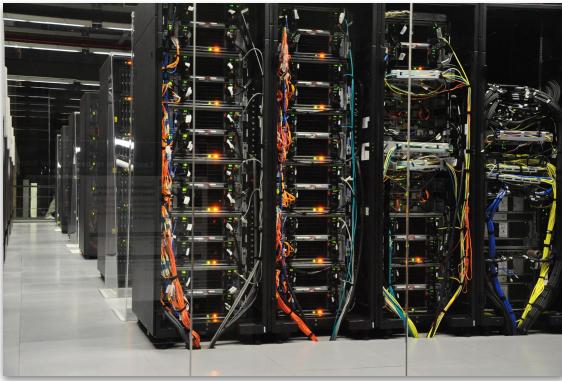


Why?

High power



Low power

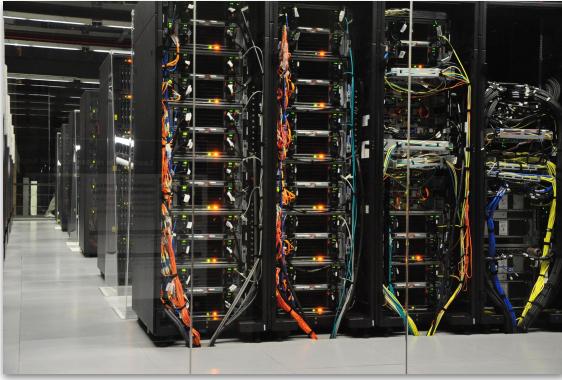


Why?

High power
High bandwidth



Low power

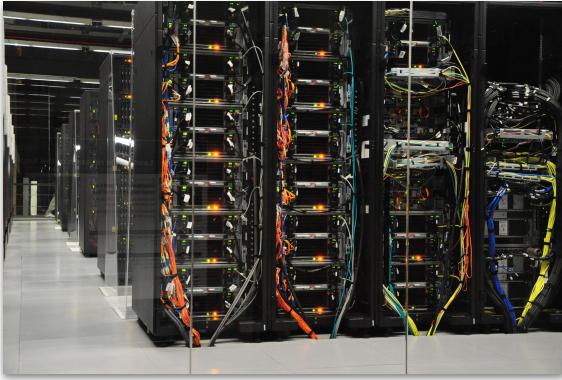


Why?

High power
High bandwidth



Low power
Low bandwidth

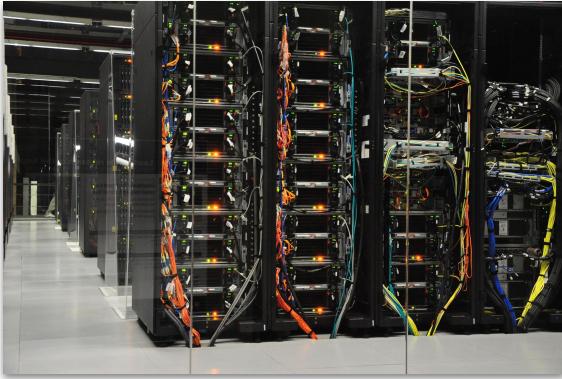


Why?

High power
High bandwidth
High latency



Low power
Low bandwidth

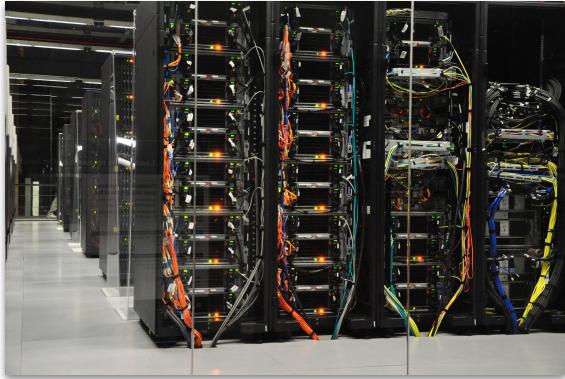


Why?

High power
High bandwidth
High latency



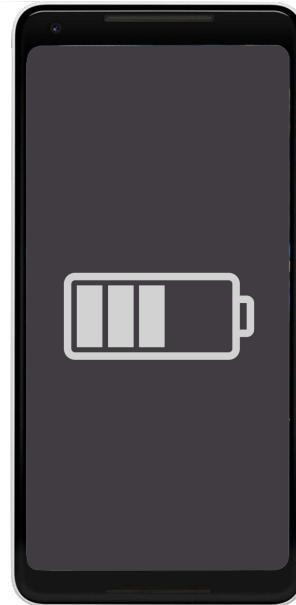
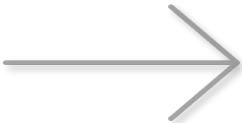
Low power
Low bandwidth
Low latency

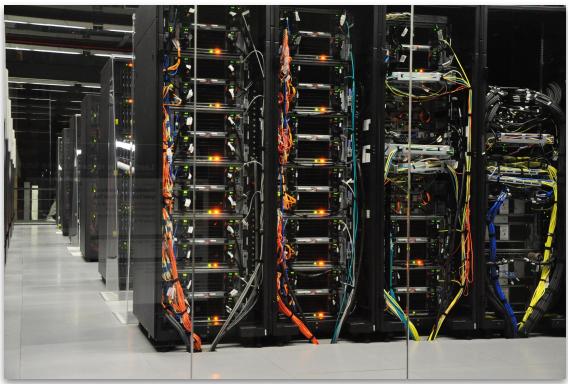


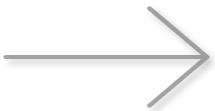
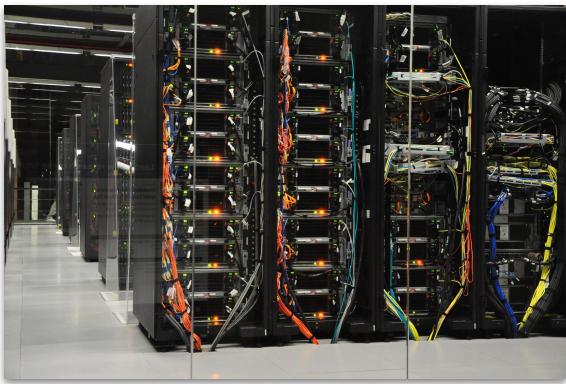
High power
High bandwidth
High latency

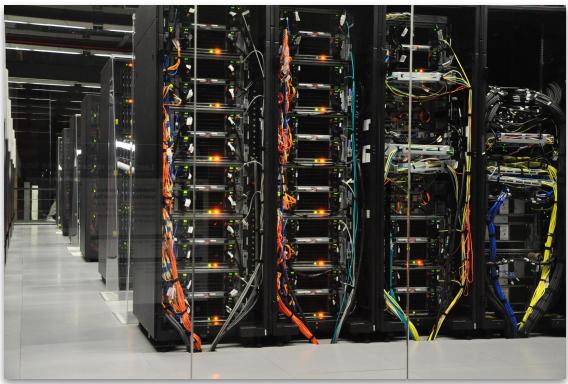


Low power
Low bandwidth
Low latency









Google Assistant



Endpoint Devices



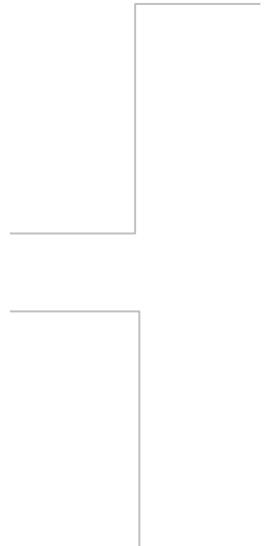
Google Assistant



Endpoint Devices



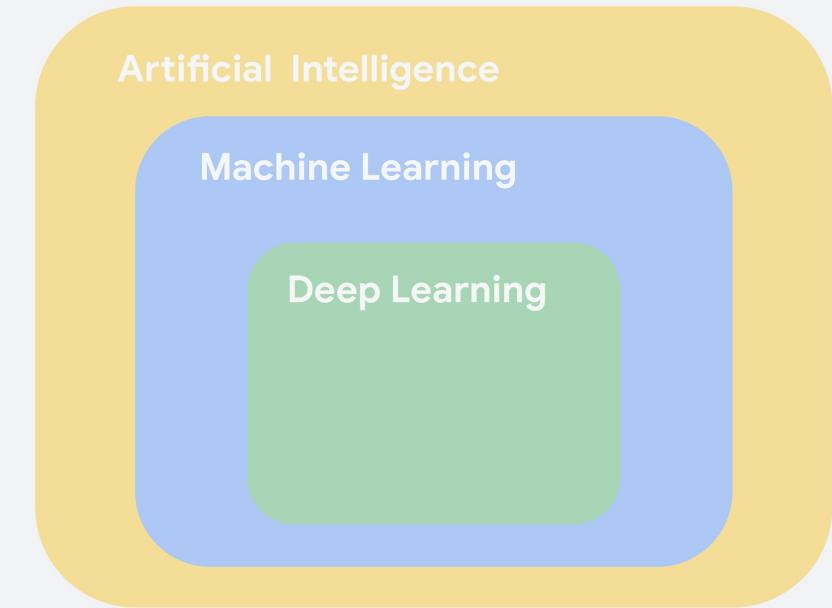
Google Assistant



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

Big Data



No Good Data Left Behind

5 Quintillion

bytes of data produced
every day by IoT

<1%

of unstructured data is
analyzed or used at all

Summary

- ML has several diverse applications in the real-world
- ML is increasingly moving from the cloud to endpoint devices
- Endpoint devices are everywhere around us

Half-screen. Show presenter.

Fullscreen. Show presenter.