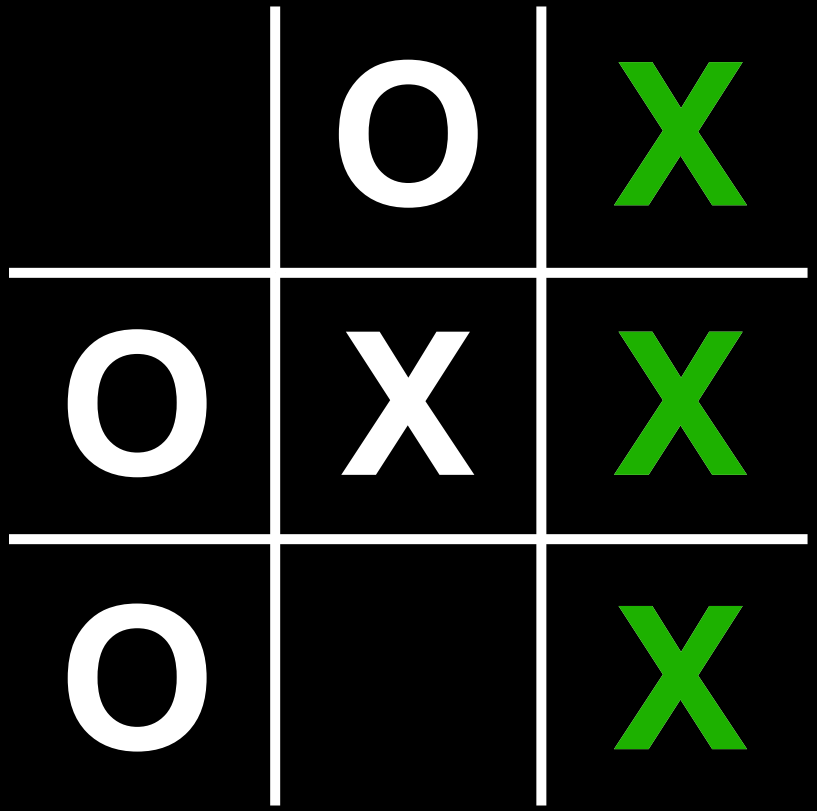
# CS50 for JDs

Artificial Intelligence

"Will AI really replace lawyers?"

# Artificial Intelligence

# Artificial Intelligence




# Game Playing

Deep Blue versus Garry Kasparov, 1997

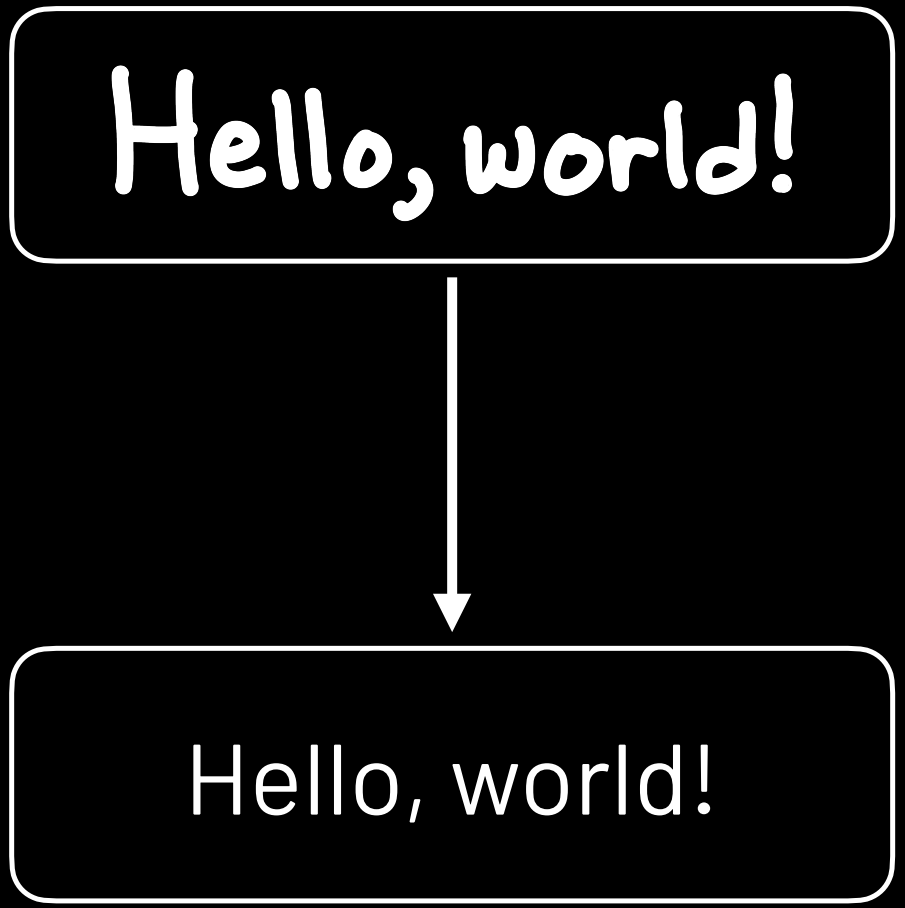
# Game Playing

Source: *Encyclopedia Brittanica*

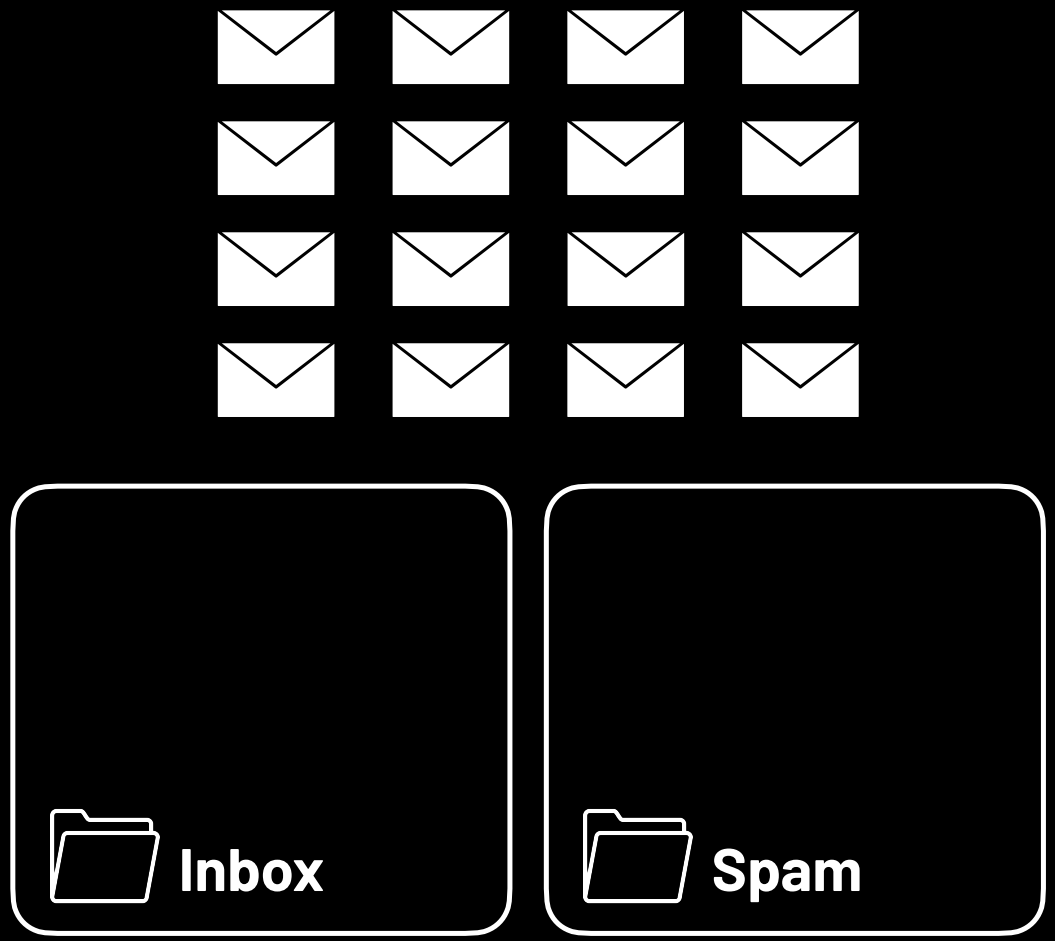
AlphaGo versus Lee Sedol, 2016

# Game Playing

Source: *The Keyword — Google*

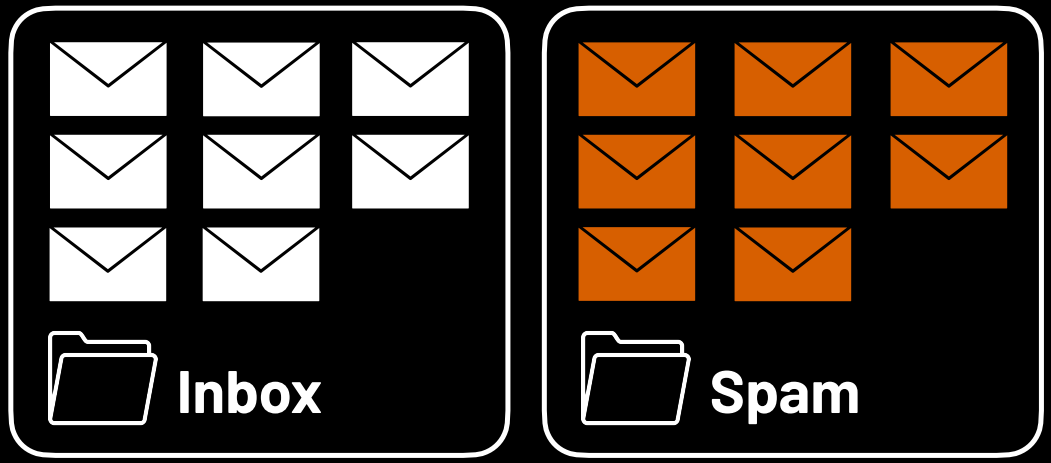


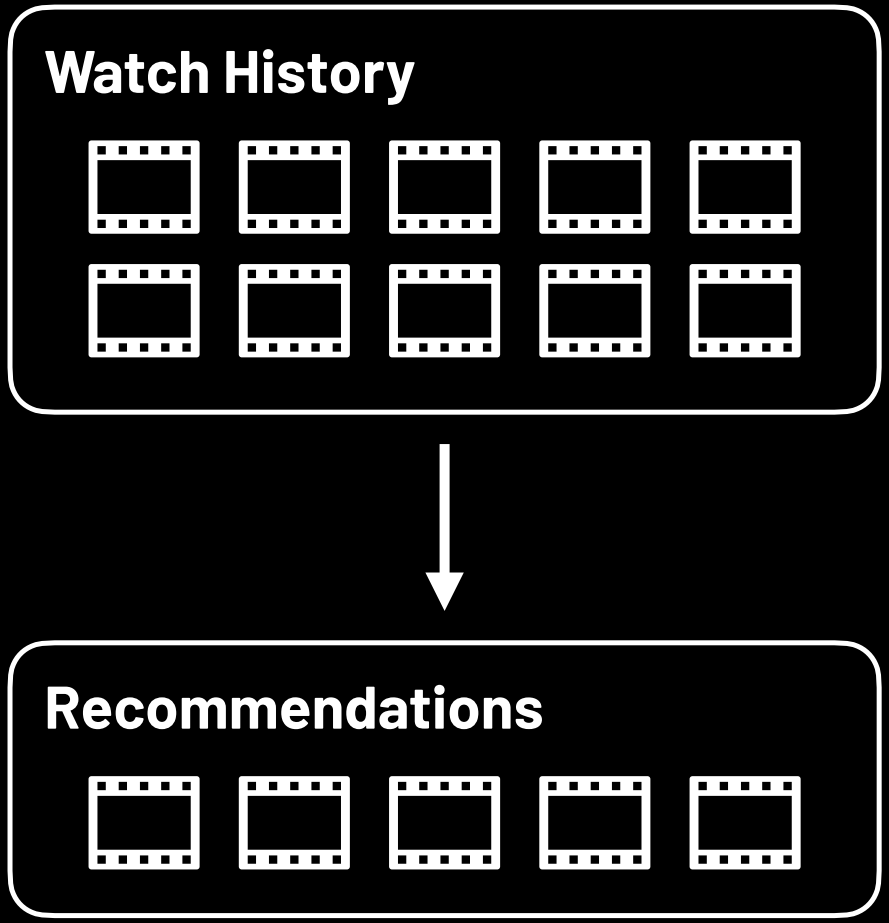

**Handwriting Recognition**




# Spam Filtering

# Spam Filtering

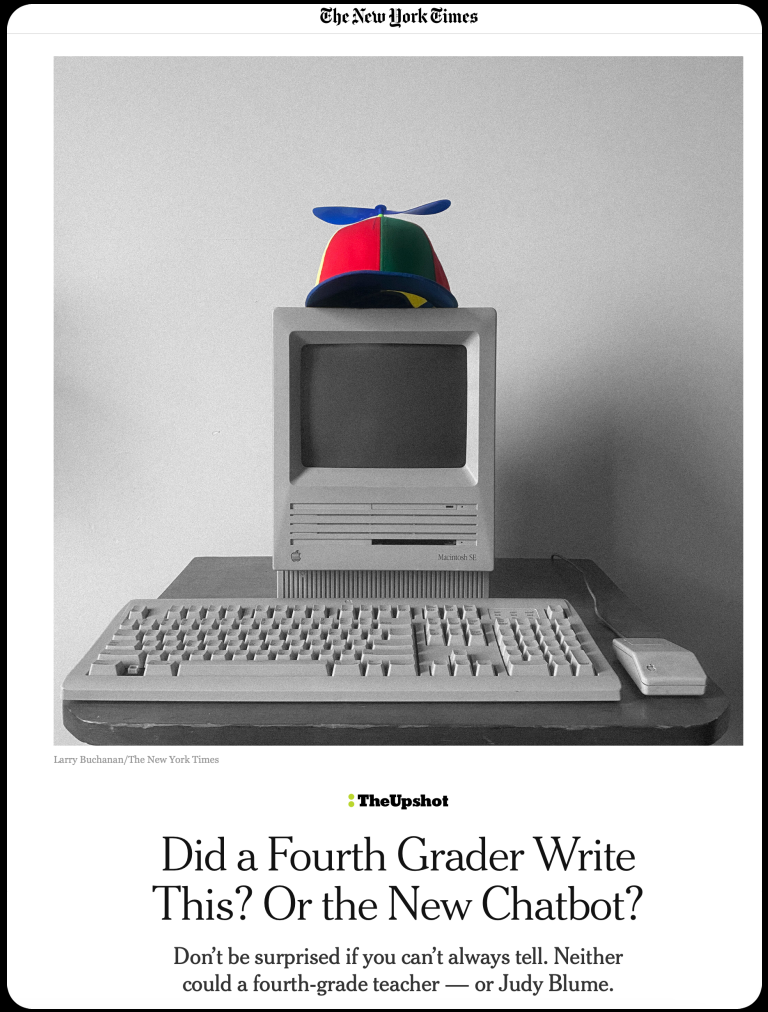





# Recommendation Systems

# Question Answering

Source: *The Verge*


The New York Times

Larry Buchanan/The New York Times

TheUpshot

Did a Fourth Grader Write This? Or the New Chatbot?

Don't be surprised if you can't always tell. Neither could a fourth-grade teacher — or Judy Blume.

# Text Generation

Source: *The New York Times*

**Essay 1**

... I like to bring a yummy sandwich and a cold juice box for lunch, and sometimes I'll even pack a tasty piece of fruit or a bag of crunchy chips. As we eat, we chat and laugh and catch up on each other's day. ...

**Essay 2**

... My mother packs me a sandwich, a drink, fruit, and a treat. When I get in the lunchroom I find an empty table and sit there, and eat my lunch. My friends come and sit down with me. ...

# Text Generation

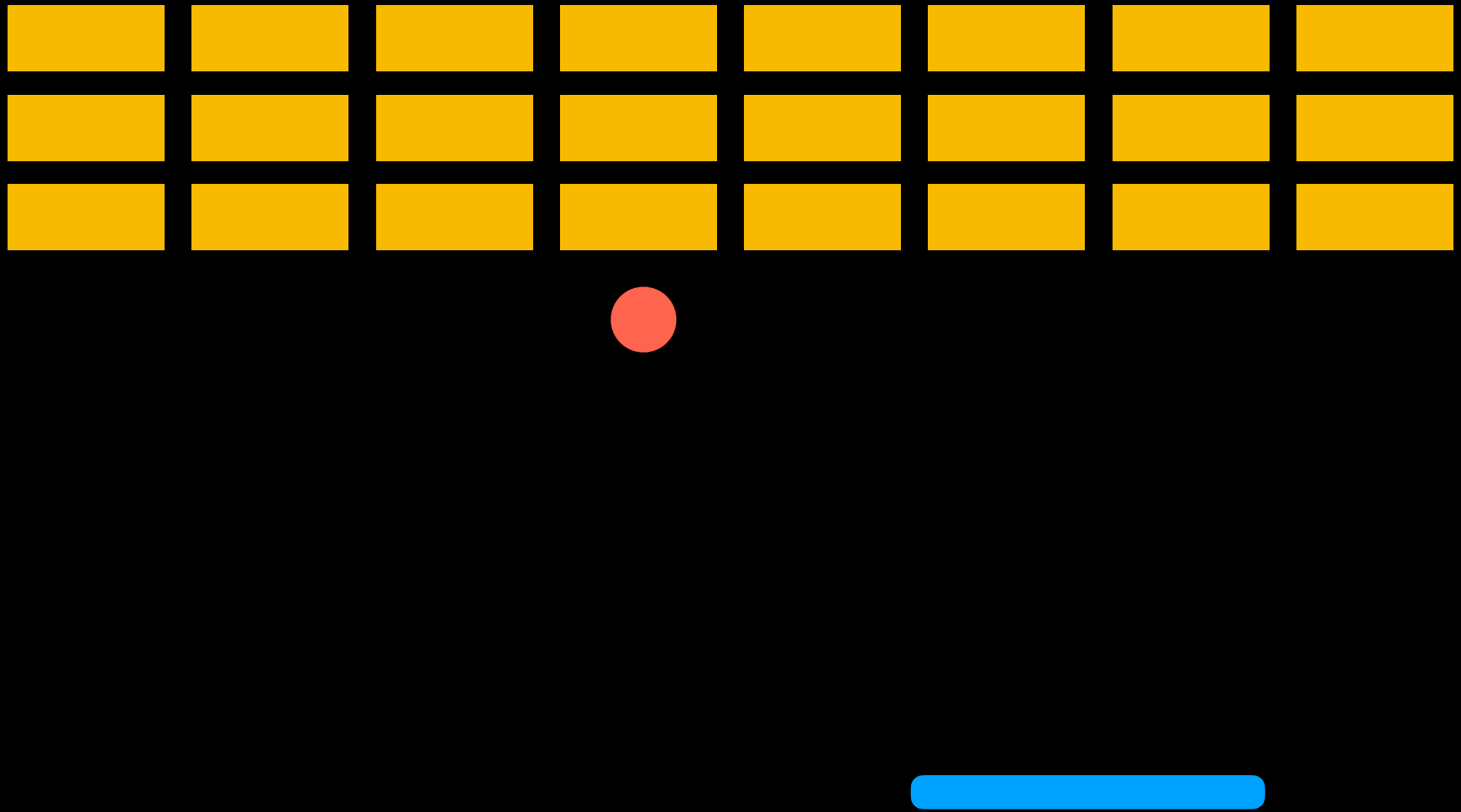
Source: *The New York Times*

Image 1

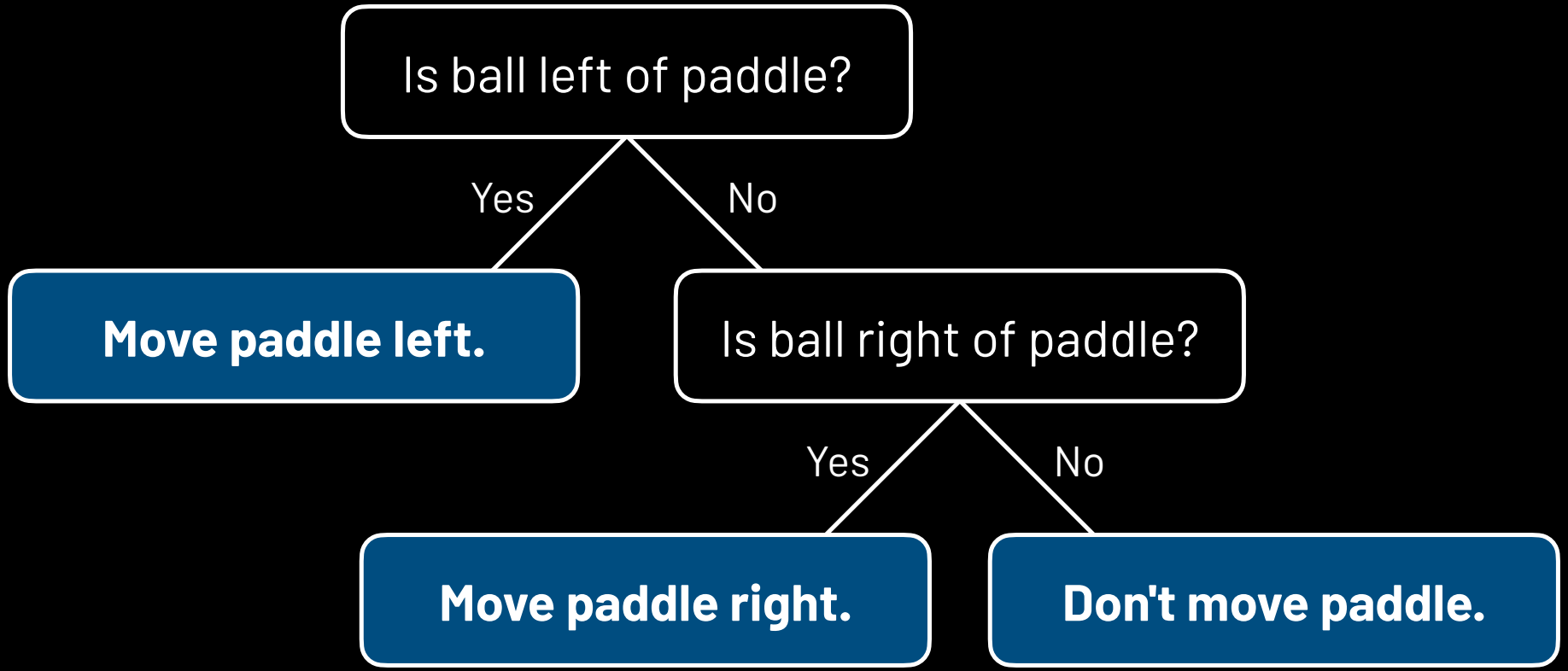
Image 2

# Image Generation

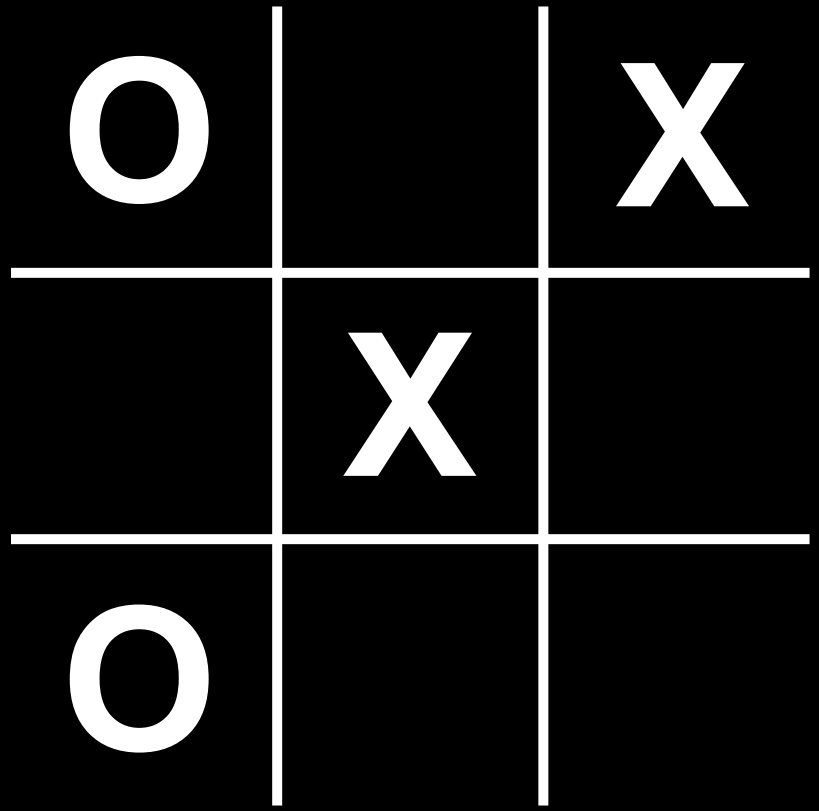
# Artificial Intelligence

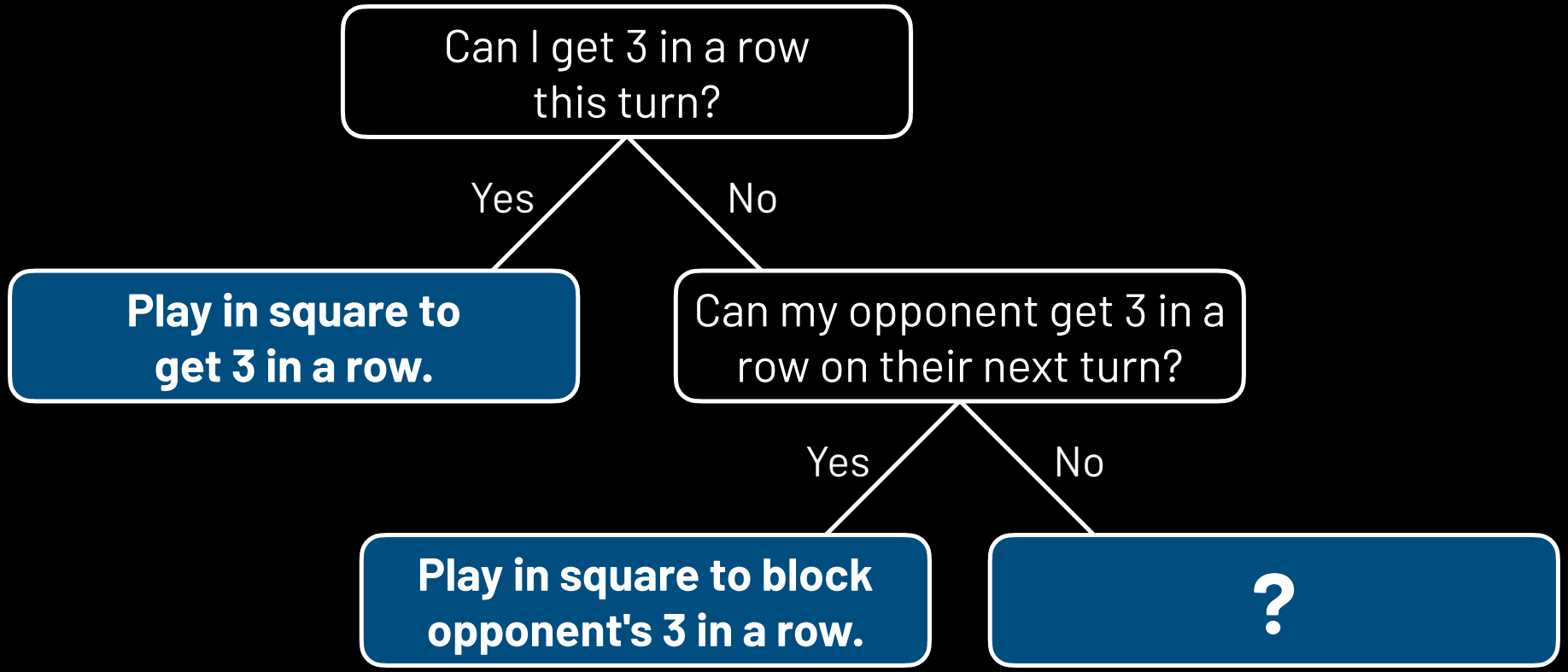


# Decision Trees


Is ball left of paddle?
Yes
No
Move paddle left.
Is ball right of paddle?
Yes
No
Move paddle right.
Don't move paddle.

```
while game is ongoing:
    if ball left of paddle:
        move paddle left
    else if ball right of paddle:
        move paddle right
    else:
        don't move paddle
```

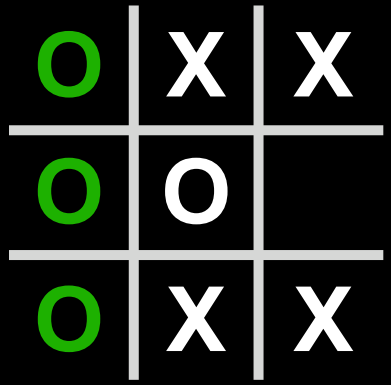

O
X
X
O


Can I get 3 in a row this turn?
Yes
No
Play in square to get 3 in a row.
Can my opponent get 3 in a row on their next turn?
Yes
No
Play in square to block opponent's 3 in a row.
?

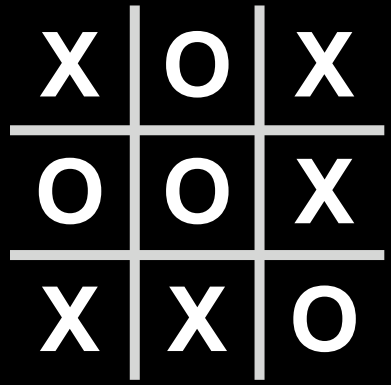
# Minimax

MAX (X) aims to maximize score.

MIN (O) aims to minimize score.




-1

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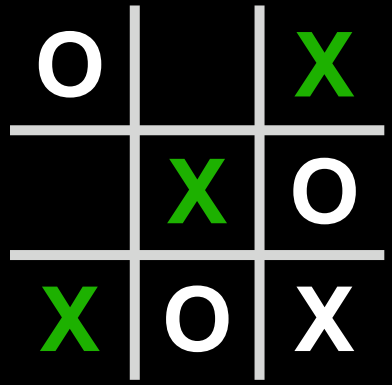


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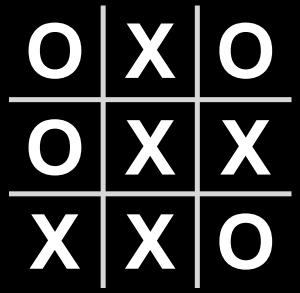
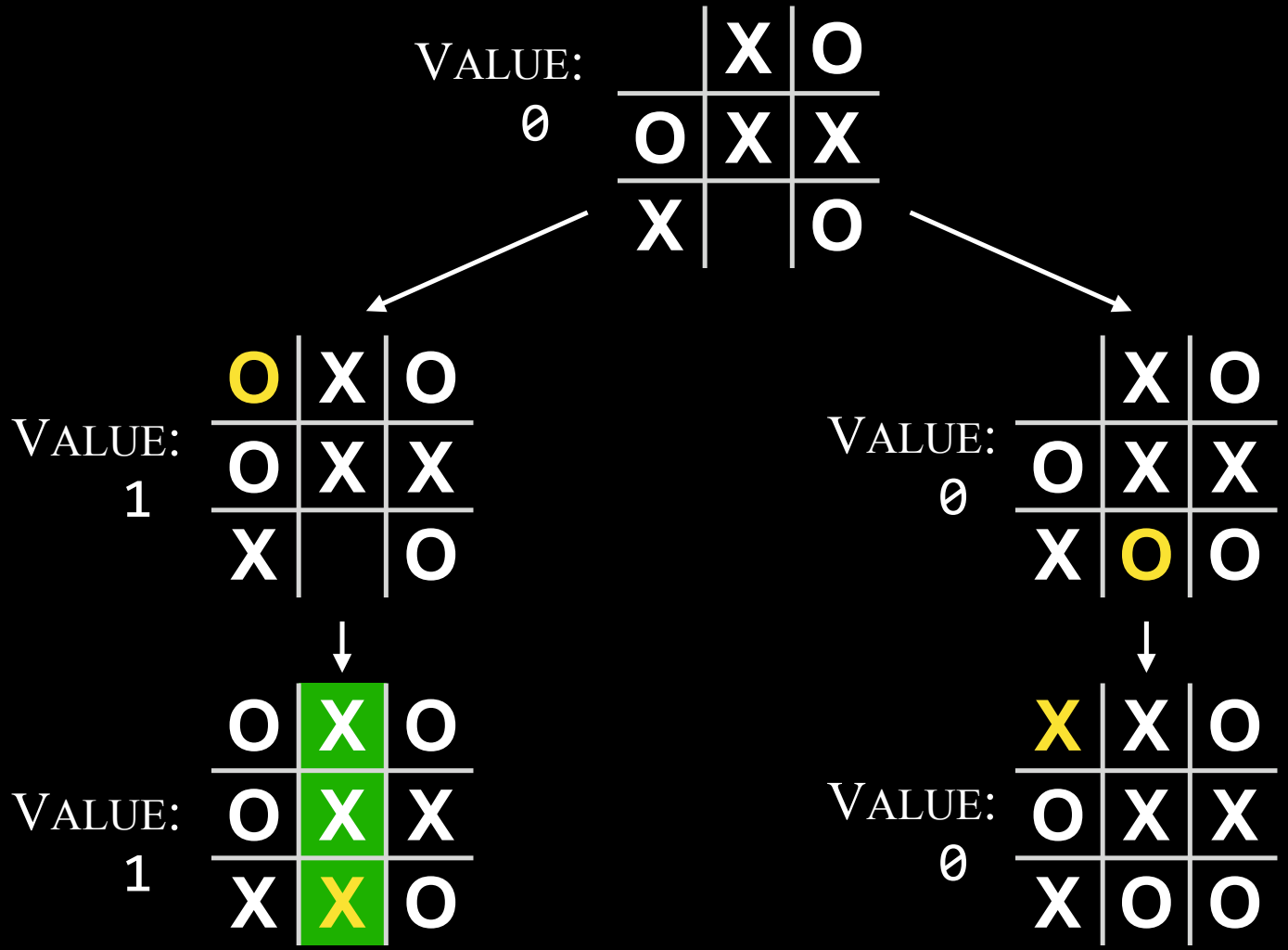
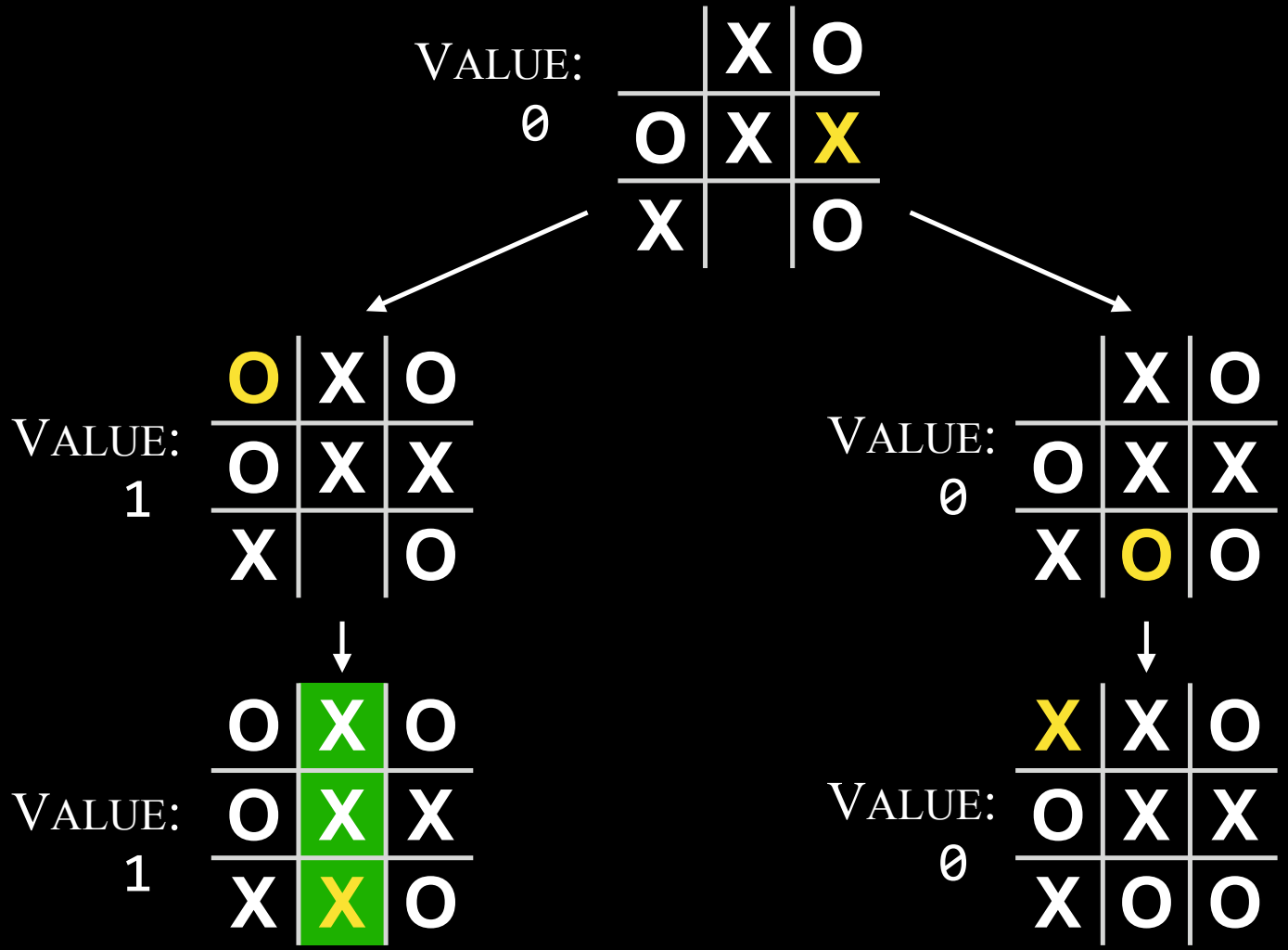


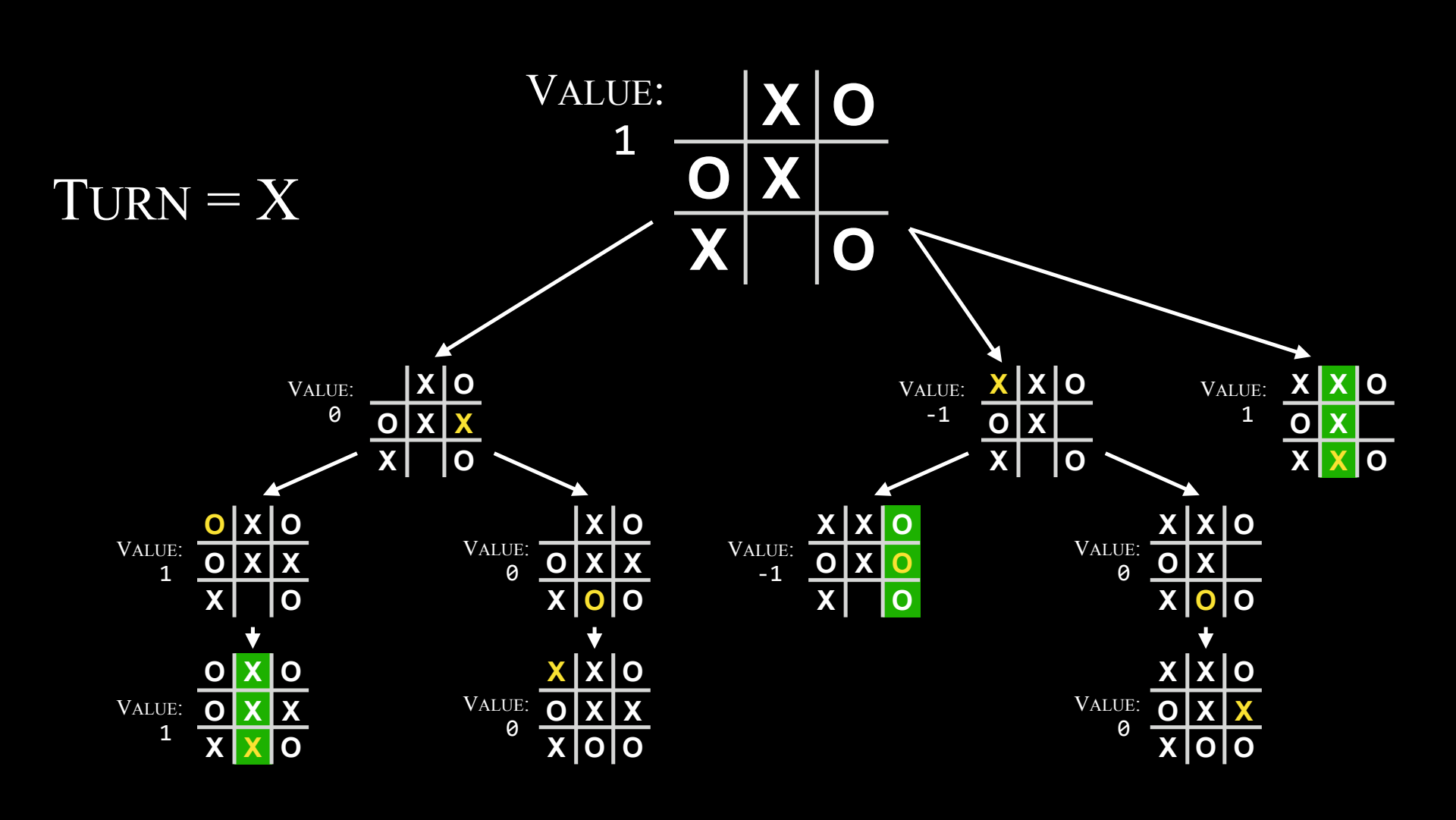

VALUE: 1

Turn = O



Turn = O




Turn = X
Value: 1
Value: 0
Value: -1
Value: 1
Value: 1
Value: 0
Value: -1
Value: 0
Value: 1
Value: 0
Value: 0

# Minimax

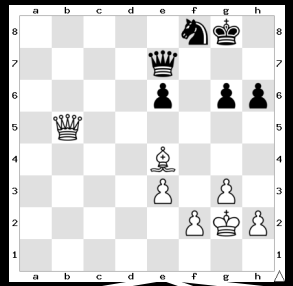
```
if player is X:
    for all possible moves:
        calculate score for board
    choose move with highest score

else:
    for all possible moves:
        calculate score for board
    choose move with lowest score
```

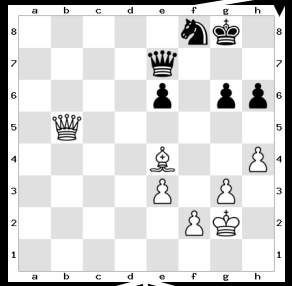
| | Possibilities |
| --- | --- |
| **Tic-Tac-Toe**<br>All possible games | 255,168 |
| **Chess**<br>First 4 moves only | 288 million |
| **Go**<br>First 4 moves only | 266 quintillion |

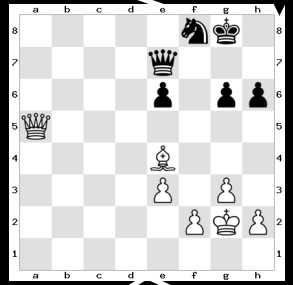
# Depth-Limited Minimax

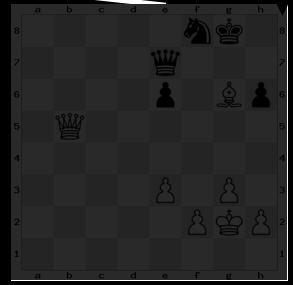
# evaluation function

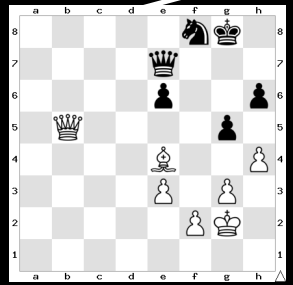
function that estimates the expected utility of the game from a given state

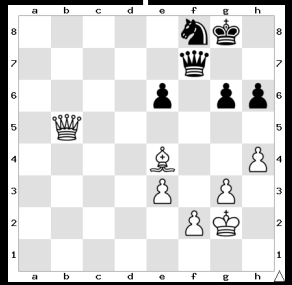


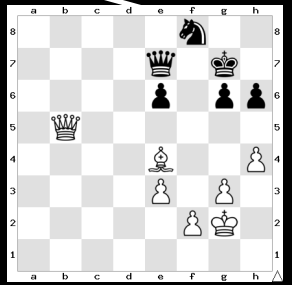


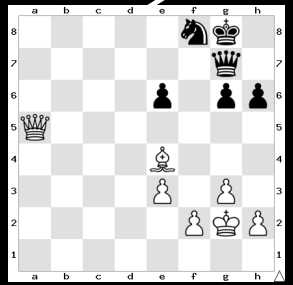


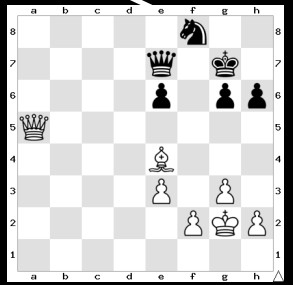












Deep Blue versus Garry Kasparov, 1997

# Chess

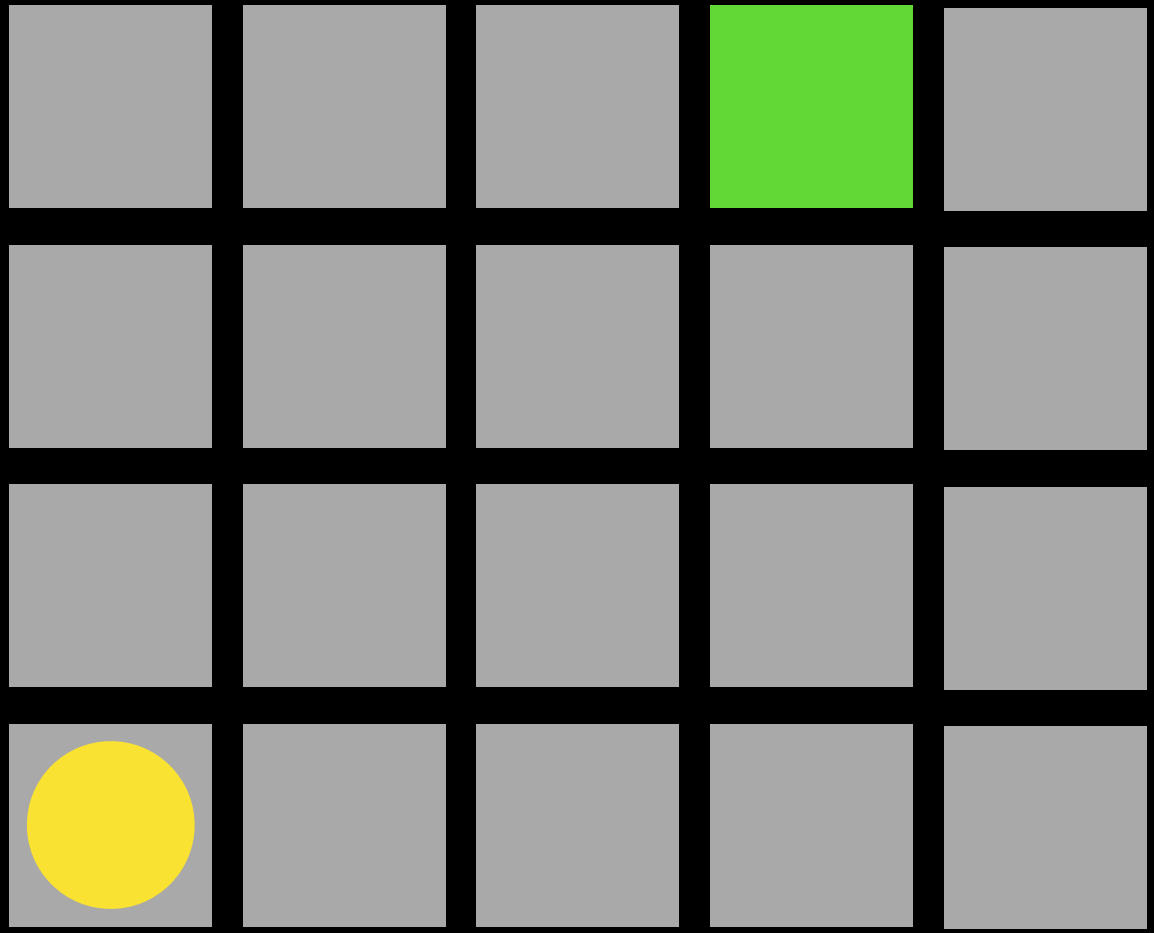
Source: *Encyclopedia Brittanica*

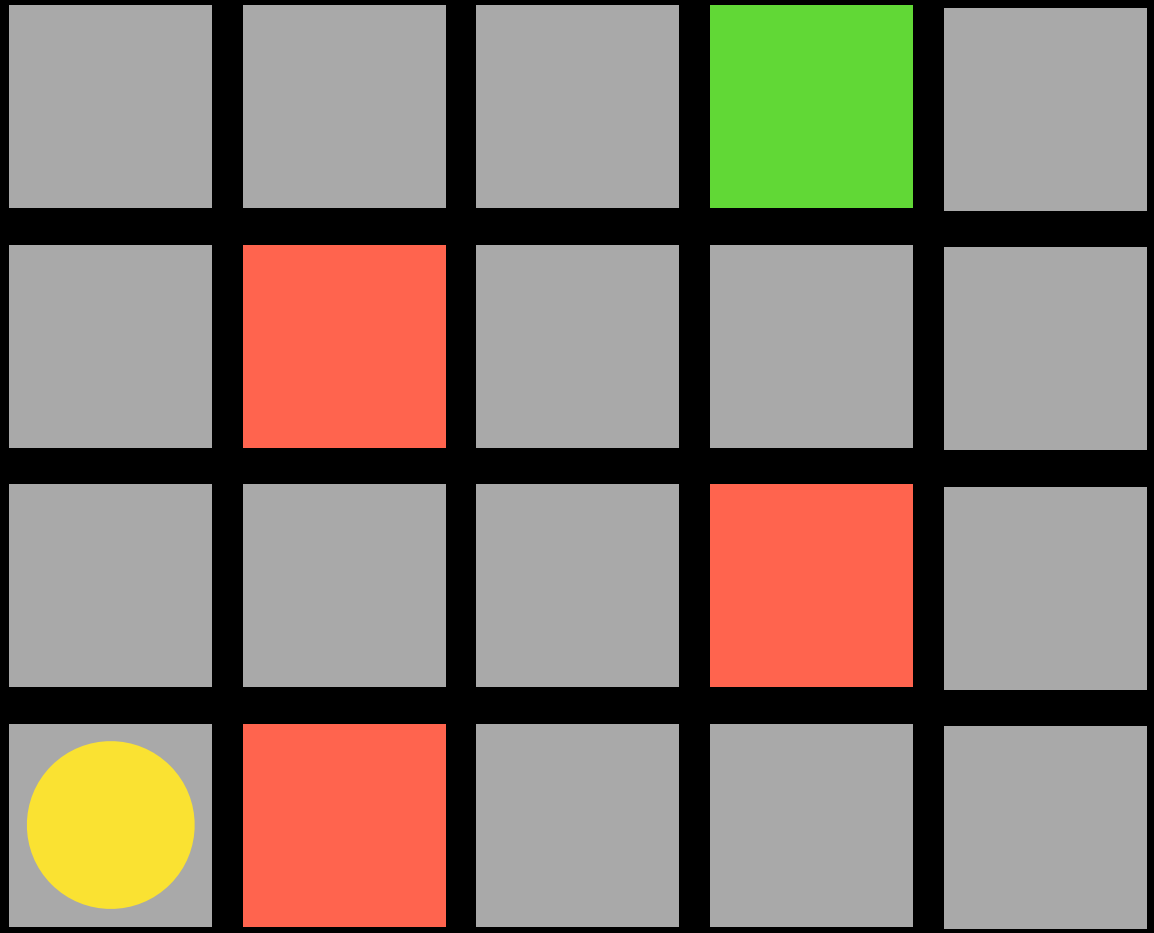
# Why AI is Good at Games

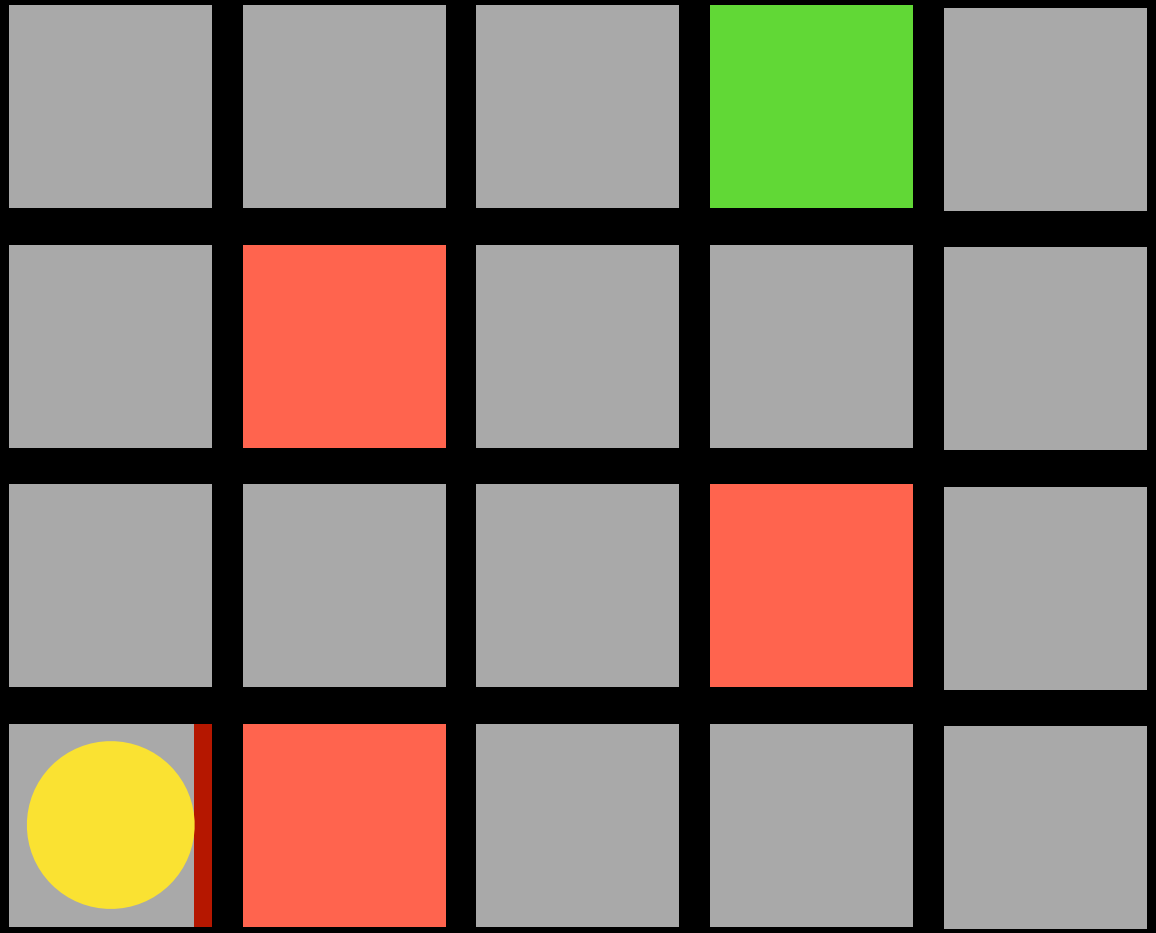
**Inputs and outputs** that can be **represented mathematically**.

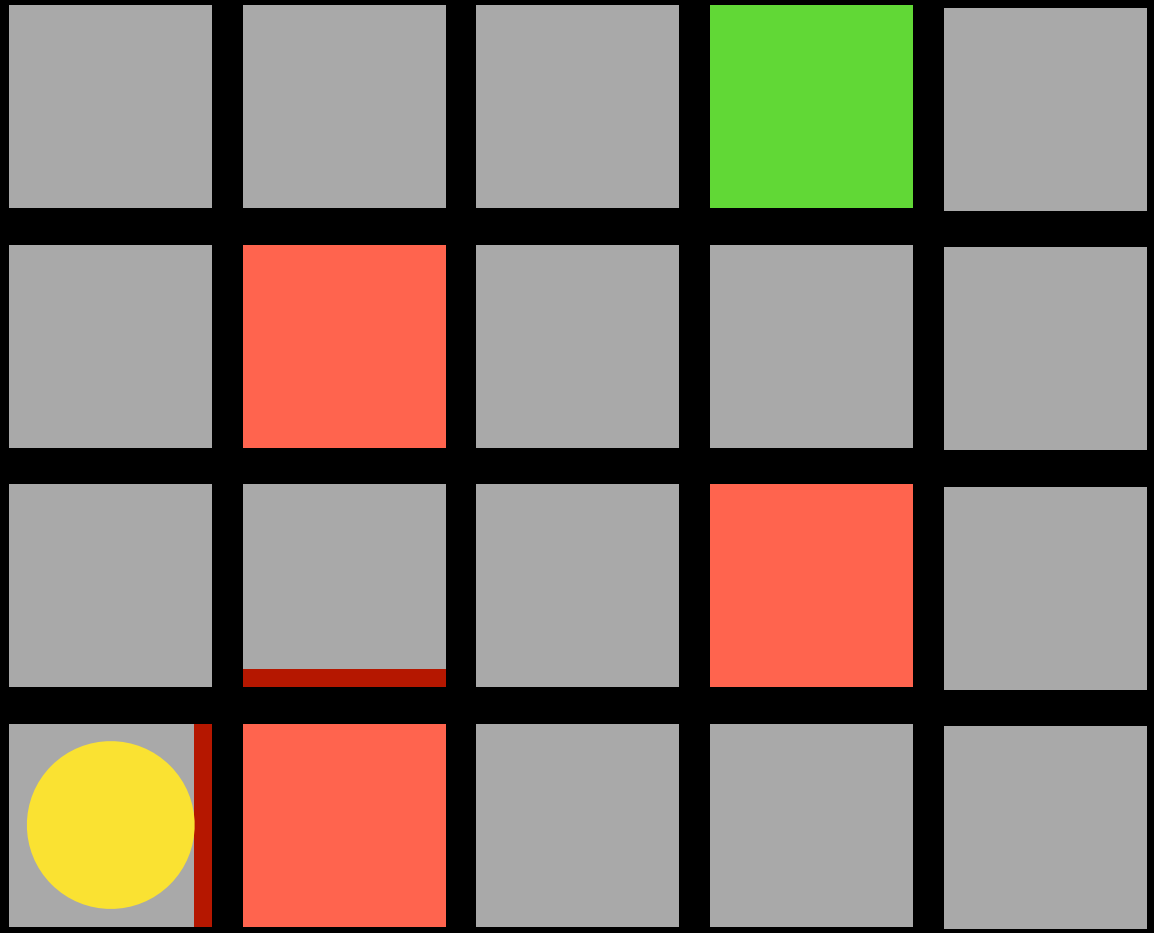
A **goal** in the form of a **function to maximize/minimize**.

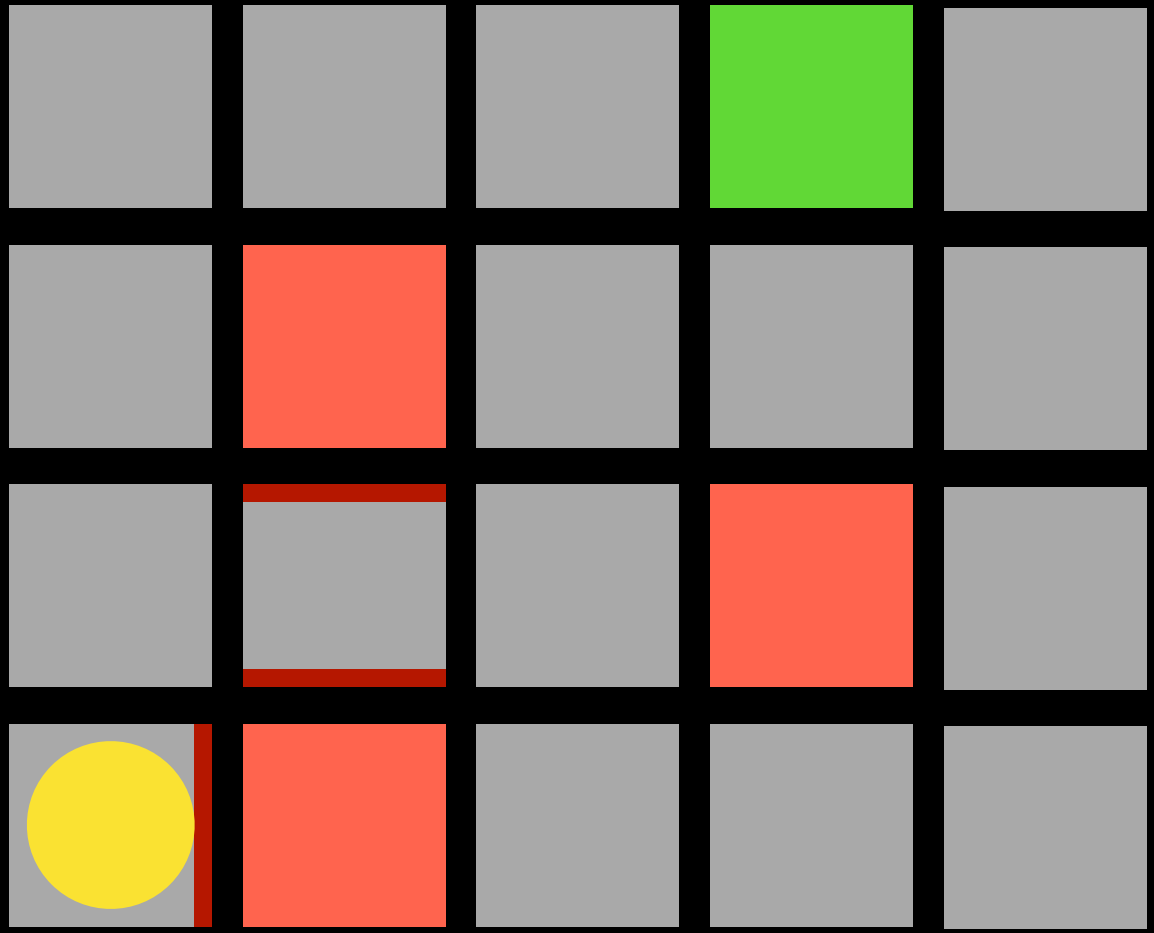
# Reinforcement Learning

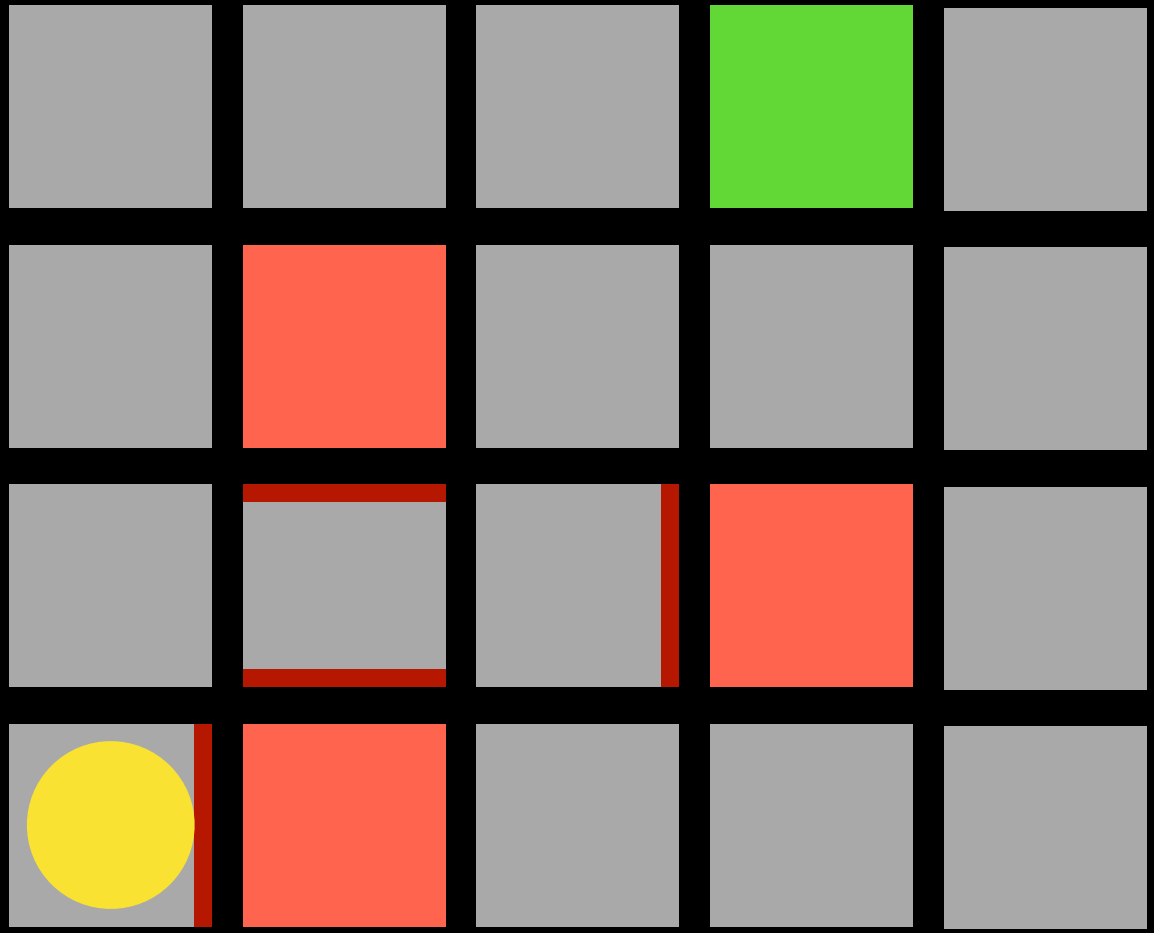


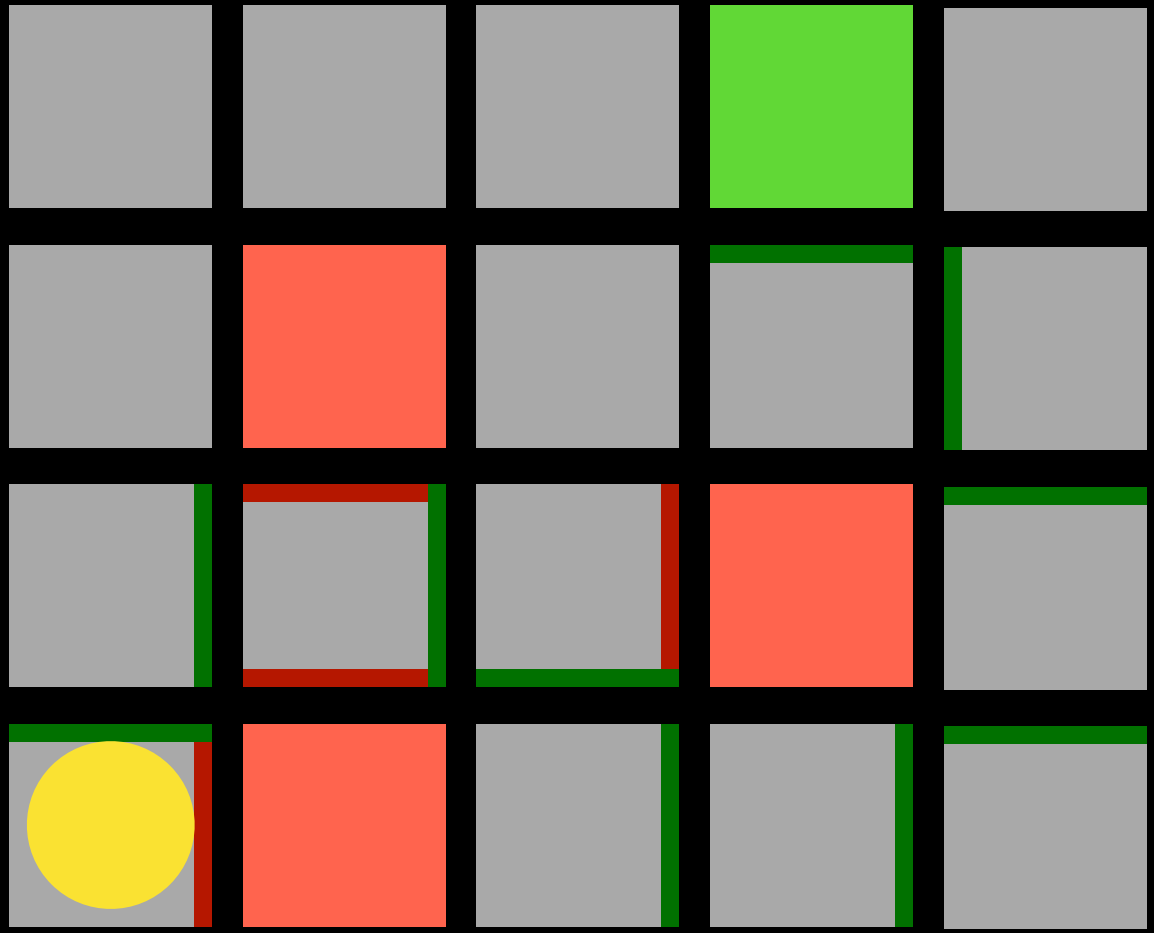


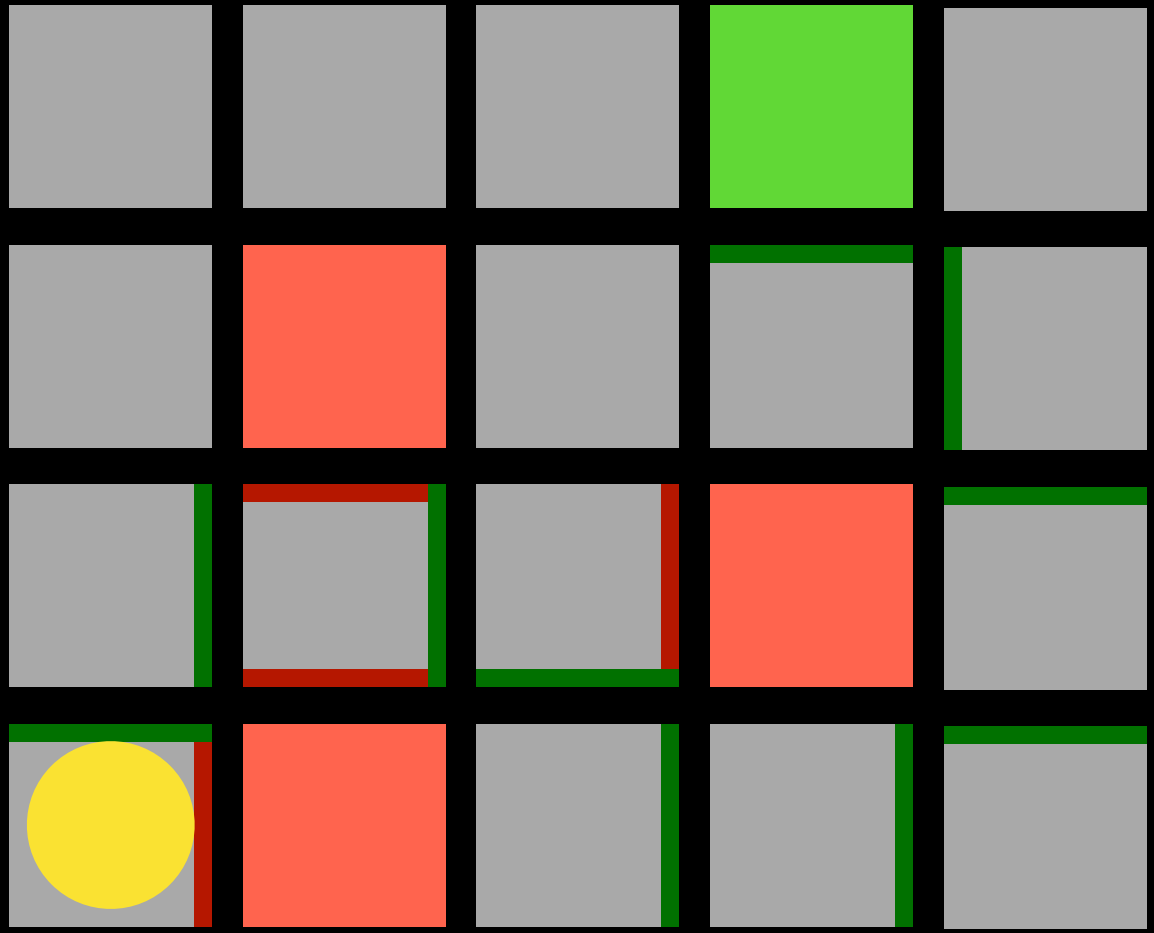










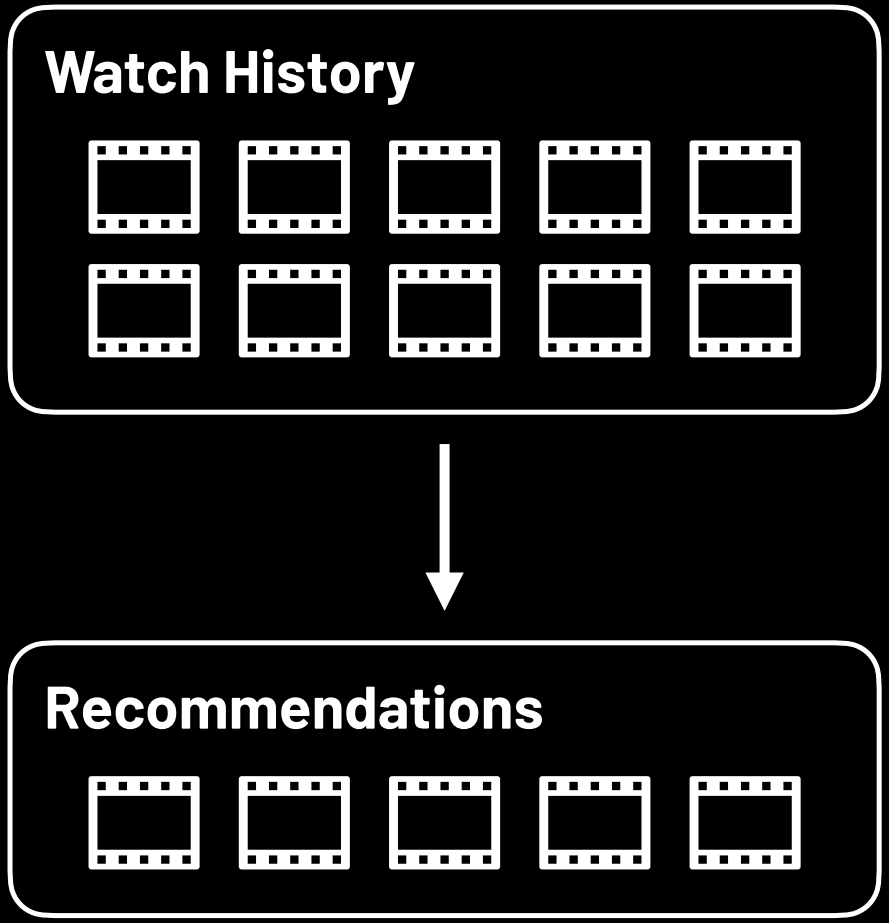


# Explore vs. Exploit

# Explore vs. Exploit Strategy

```
epsilon = 0.10

if random() < epsilon:
    make a random move
else:
    make the move with the highest value
```

Source: *YouTube, Italian Institute of Technology*

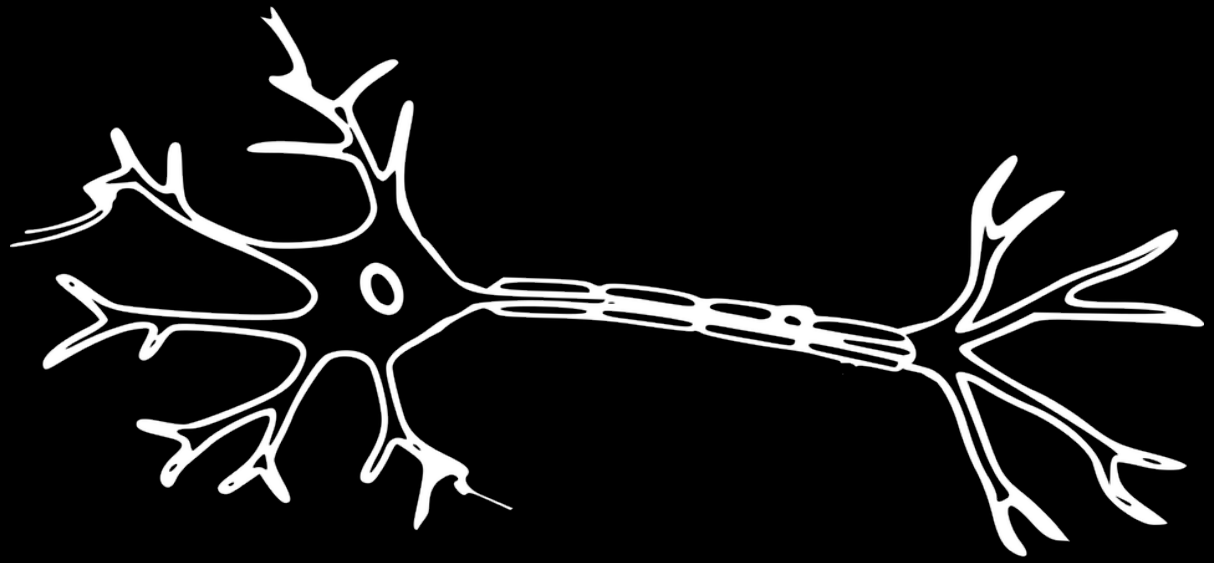



# Recommendation Systems

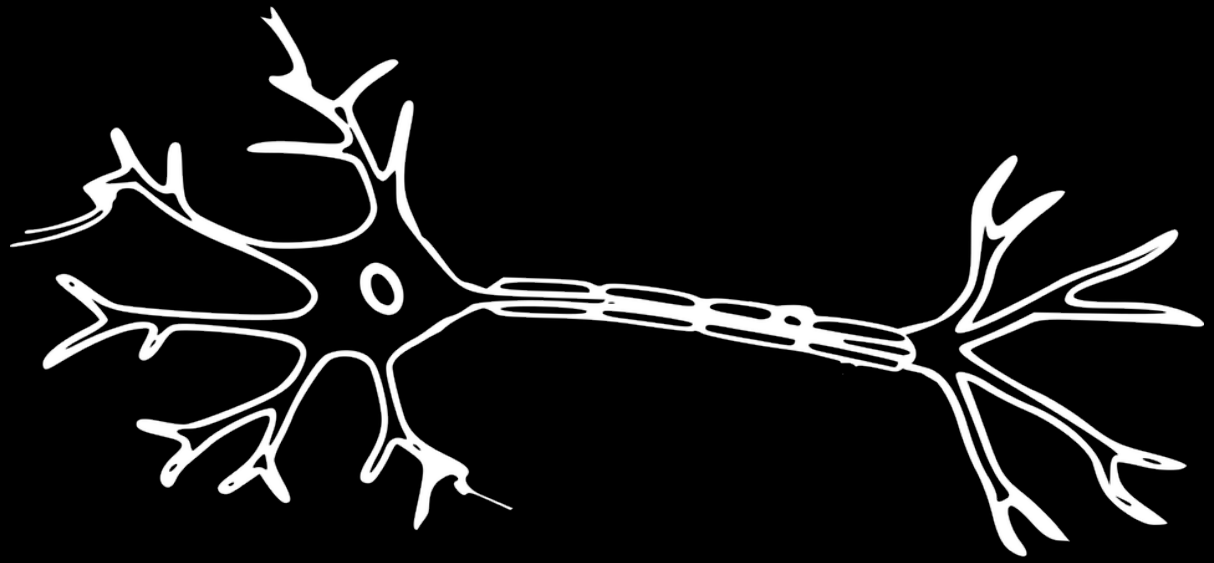
AlphaGo versus Lee Sedol, 2016

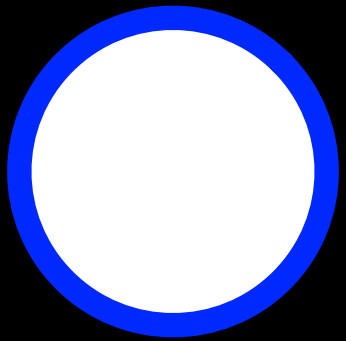
# Go

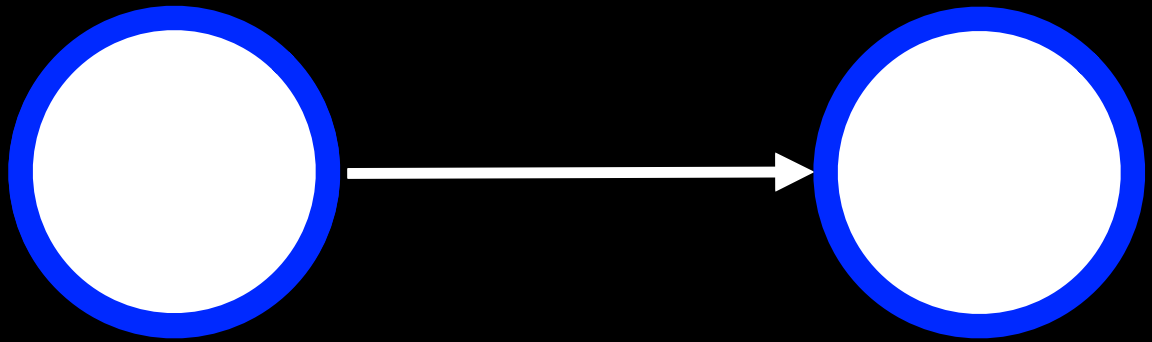
Source: *The Keyword — Google*

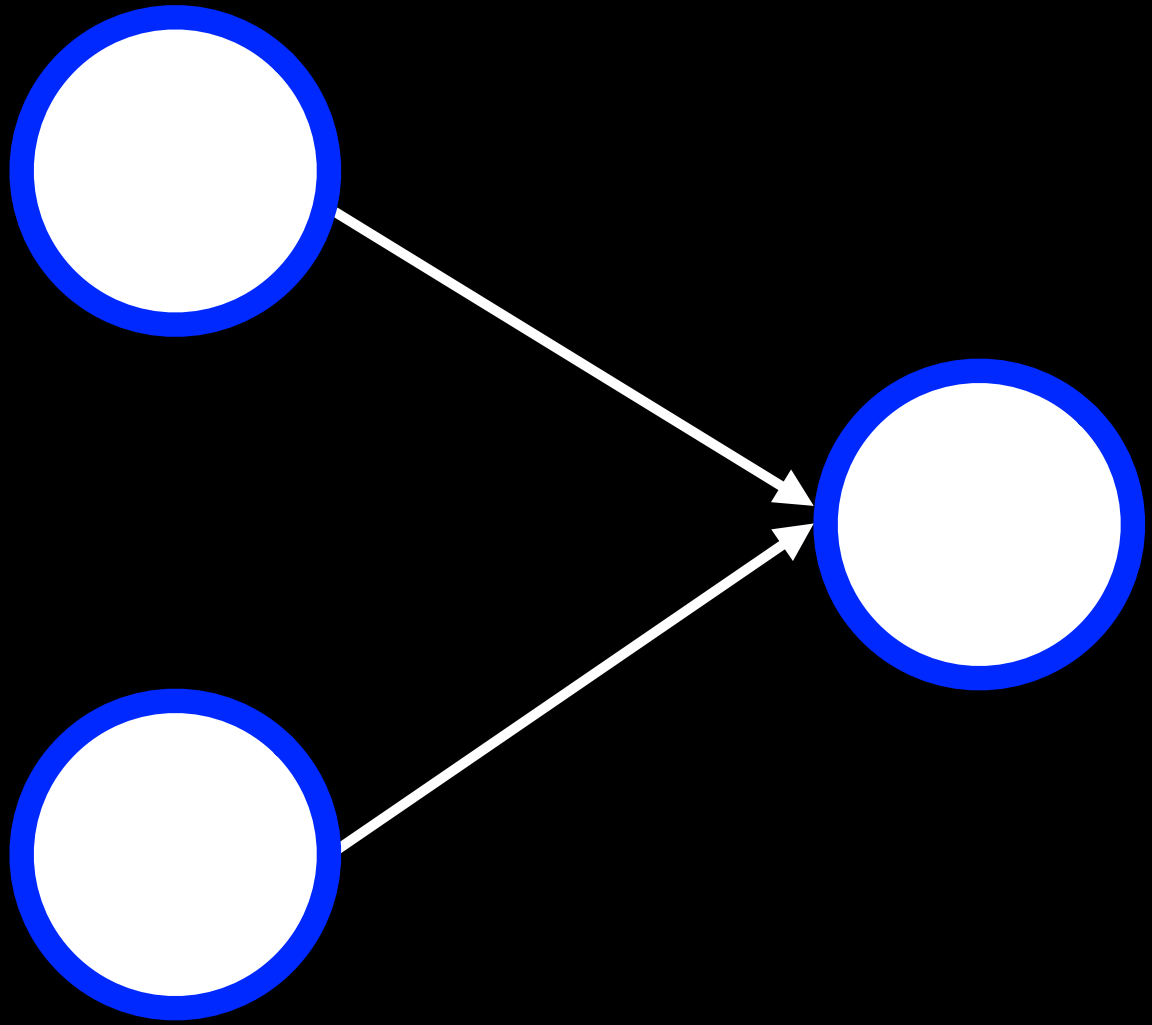


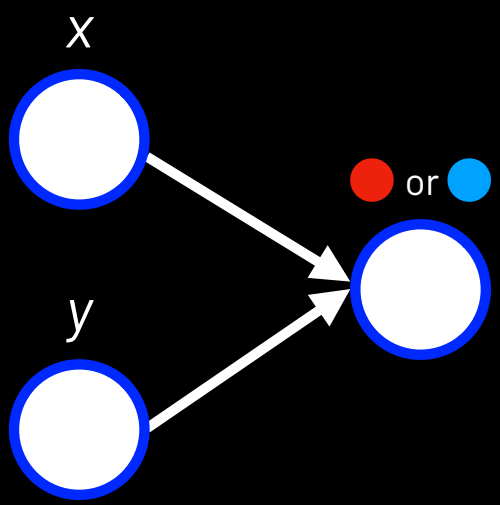
# Neural Networks

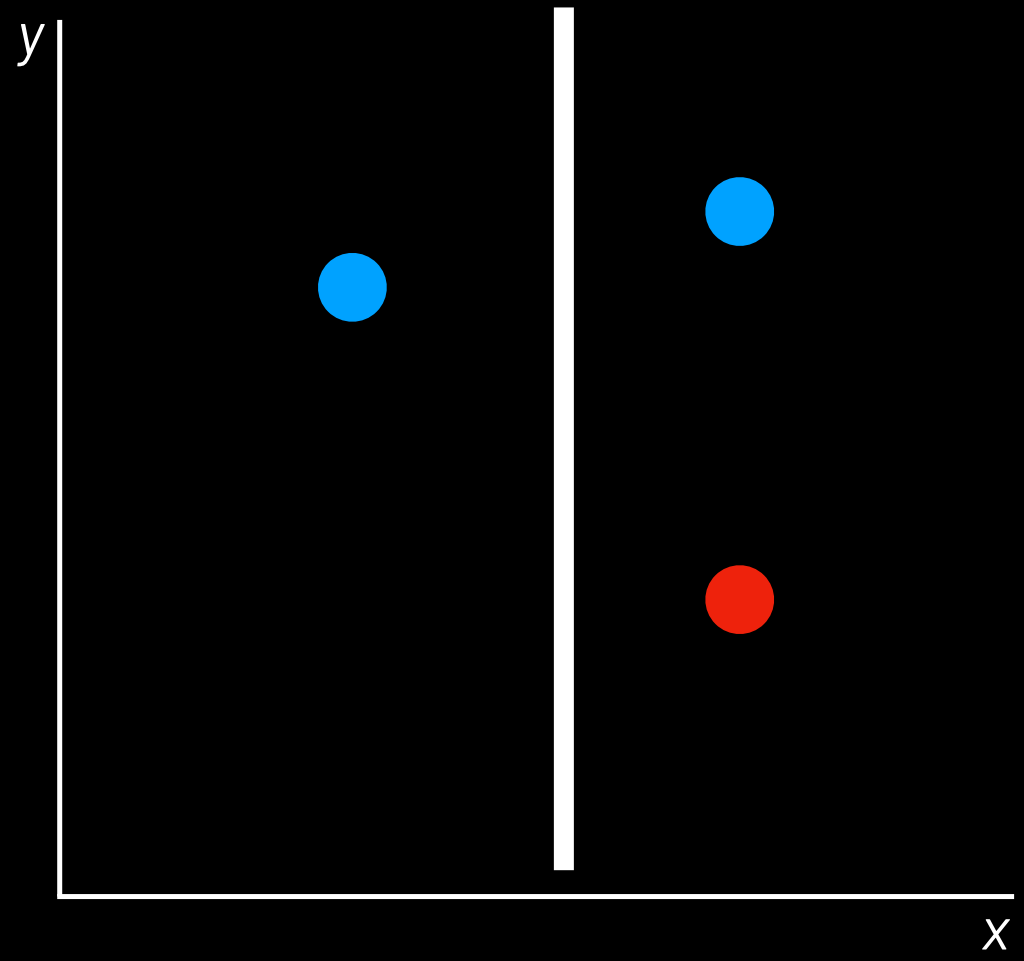


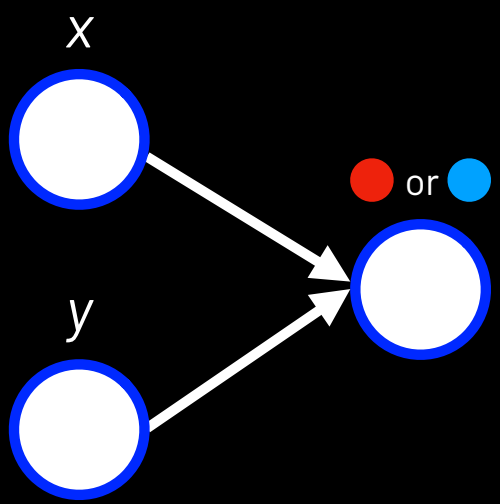







x
y
or


y
x


x
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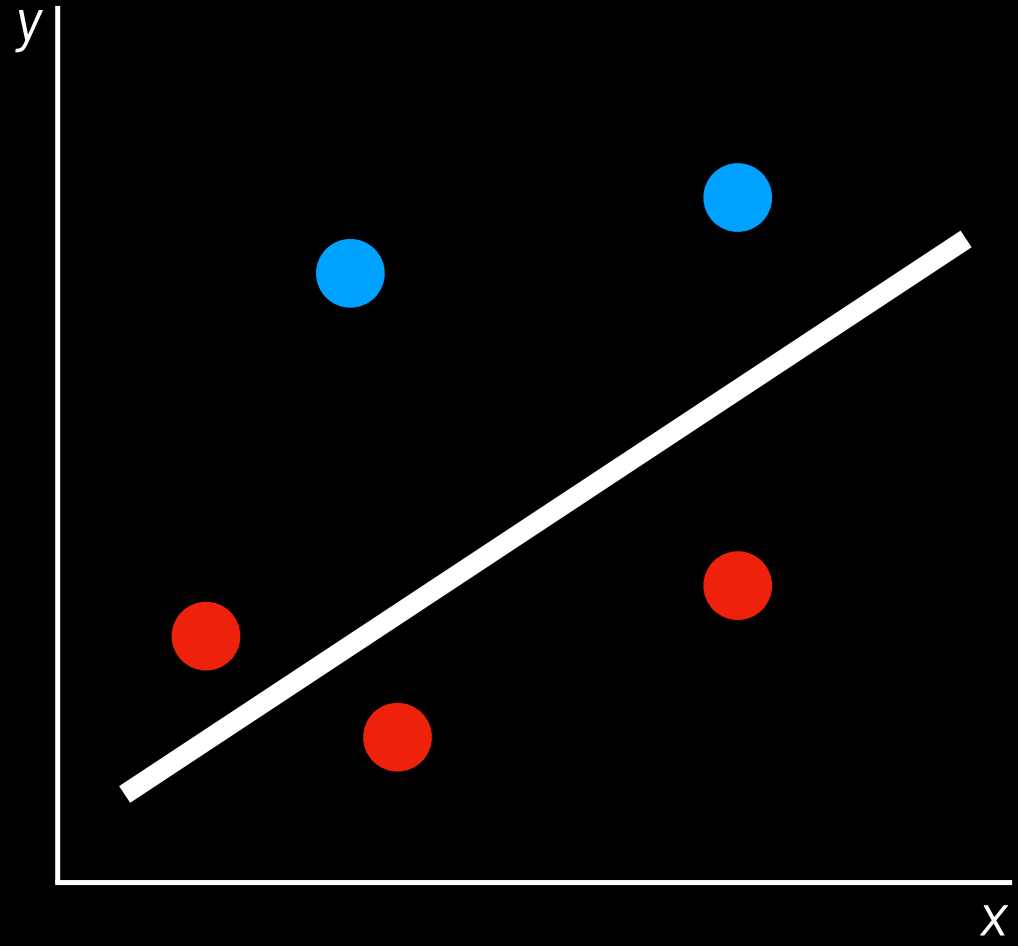
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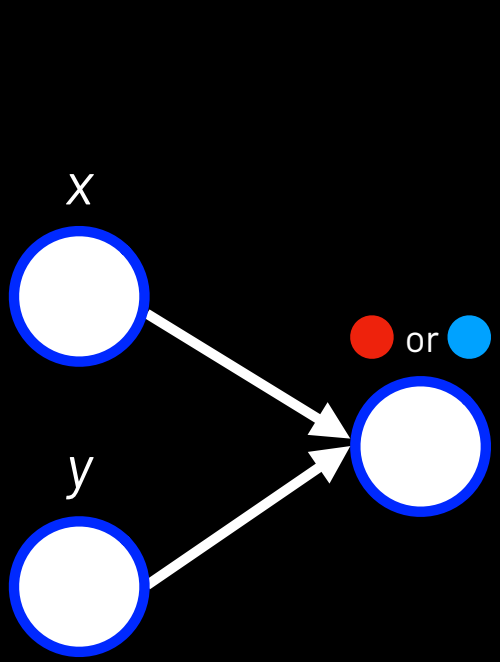
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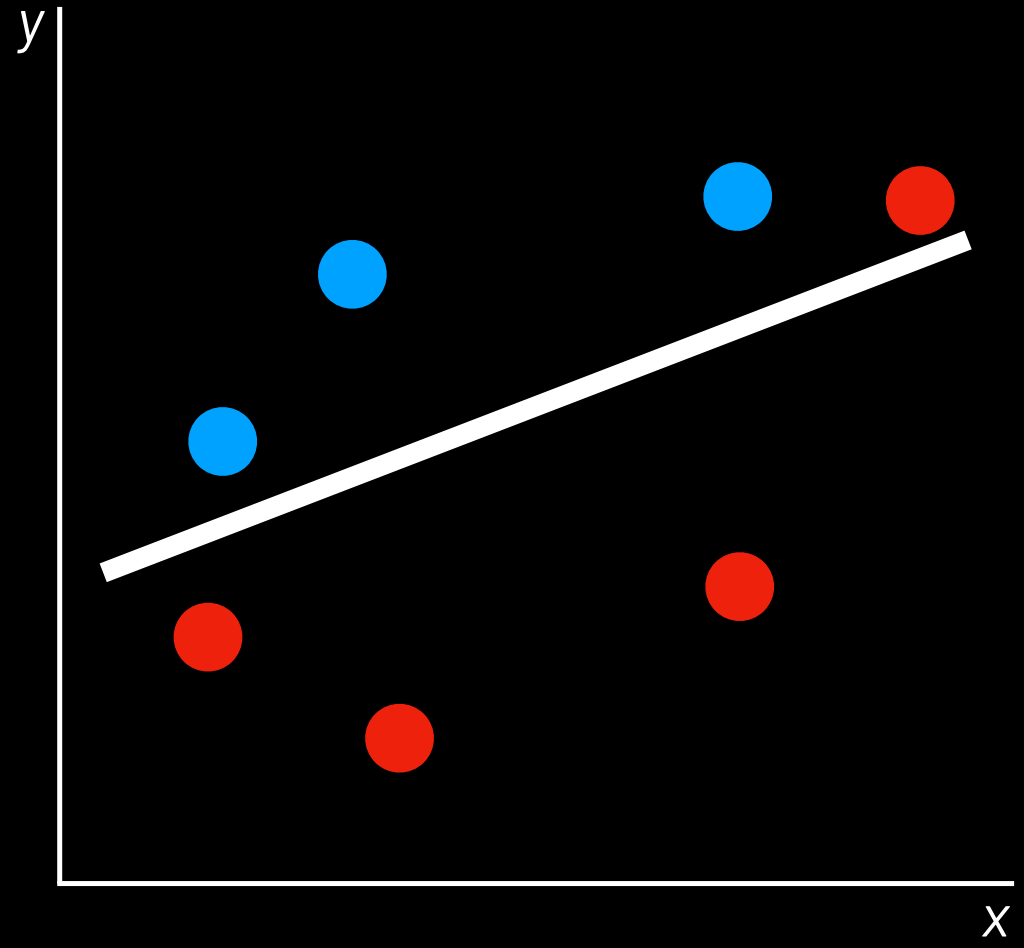
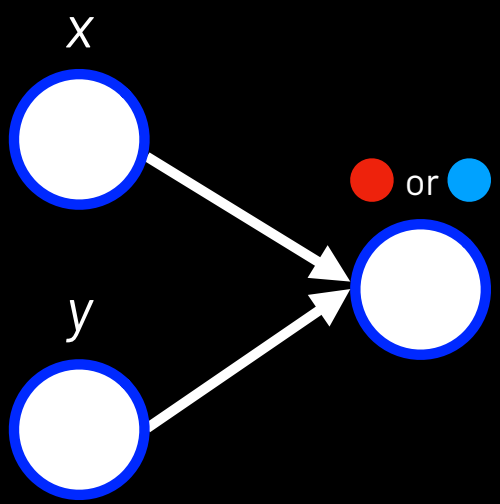
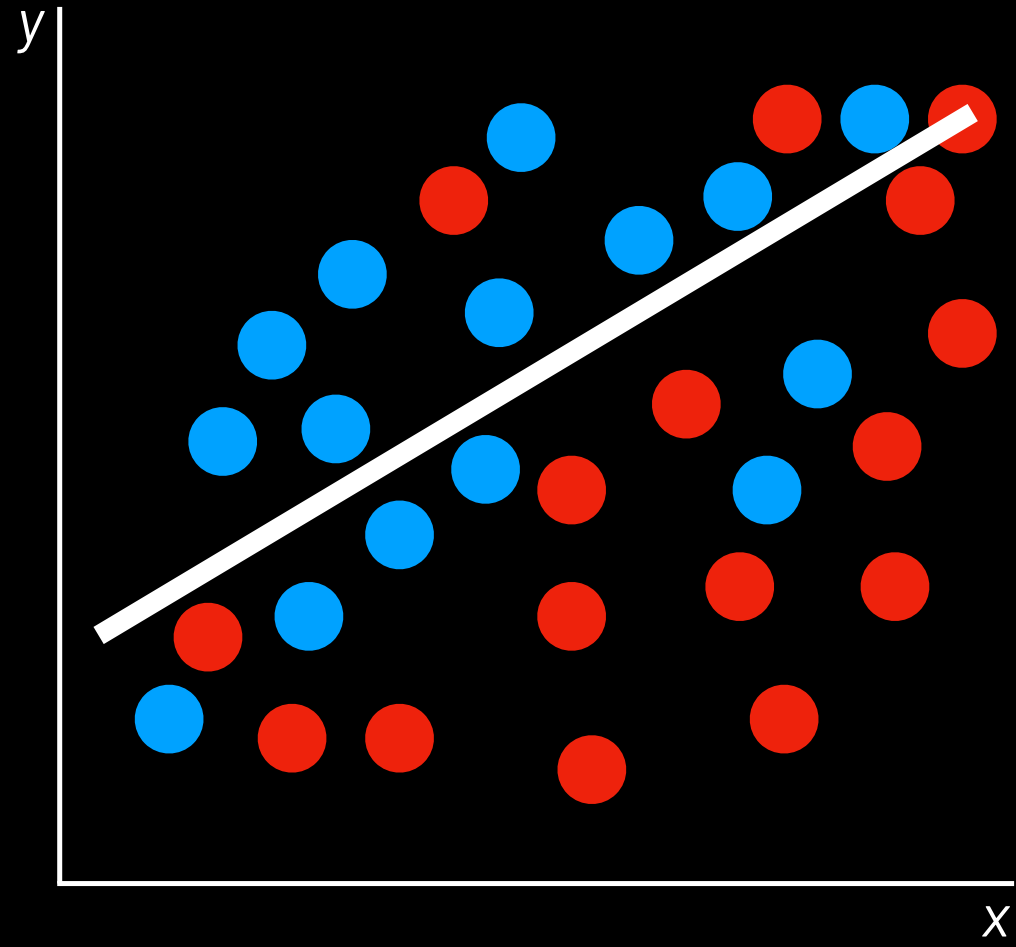
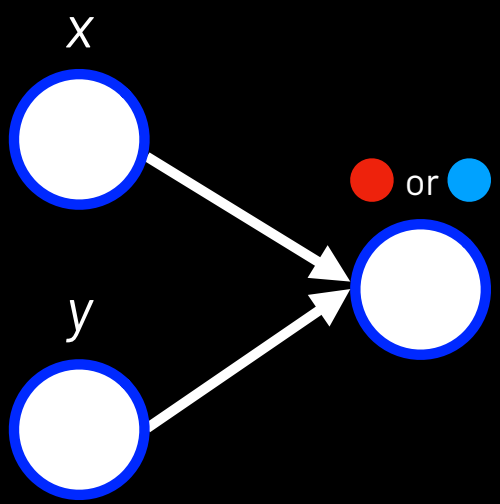
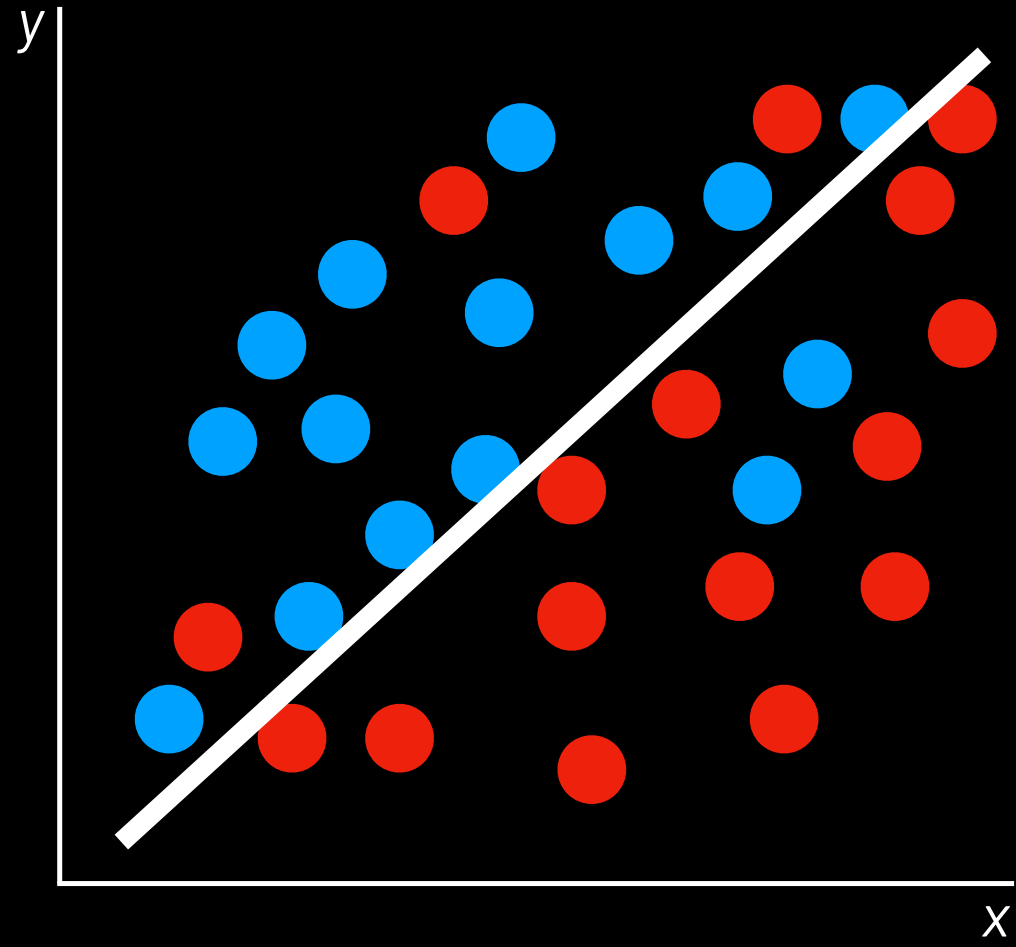
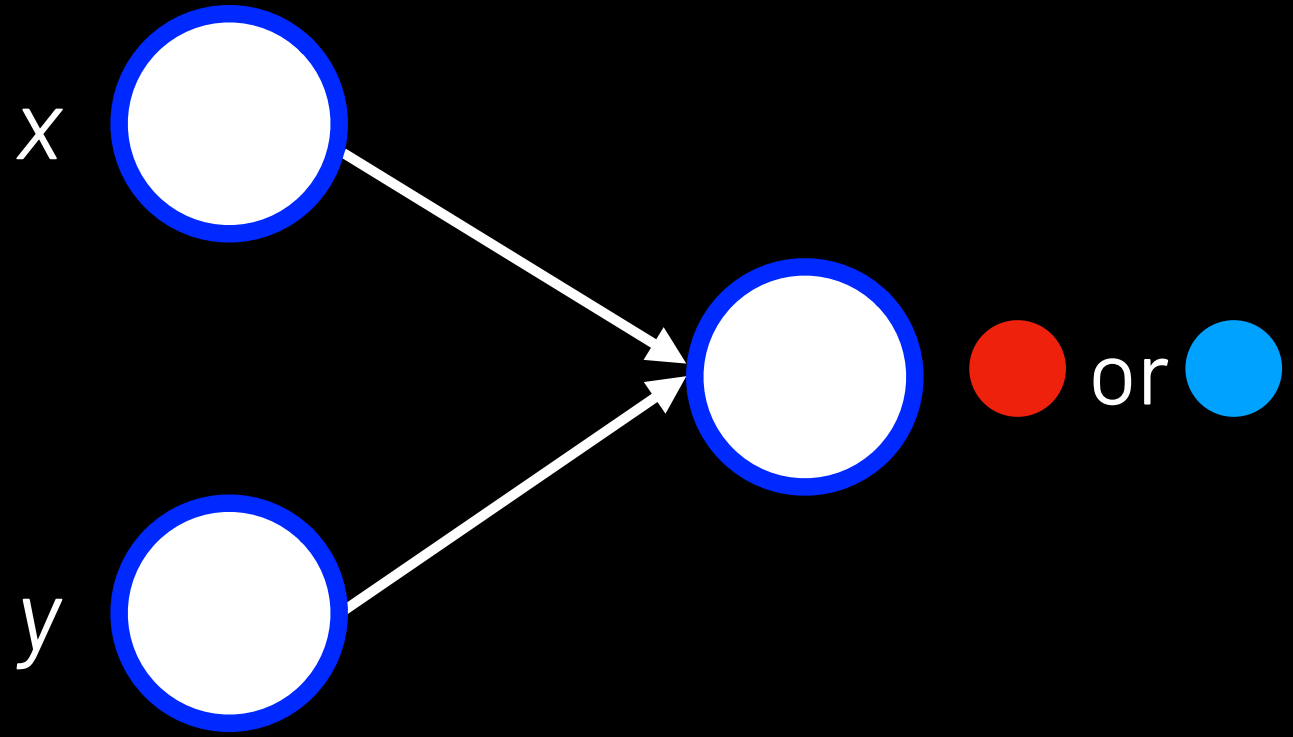

y
x

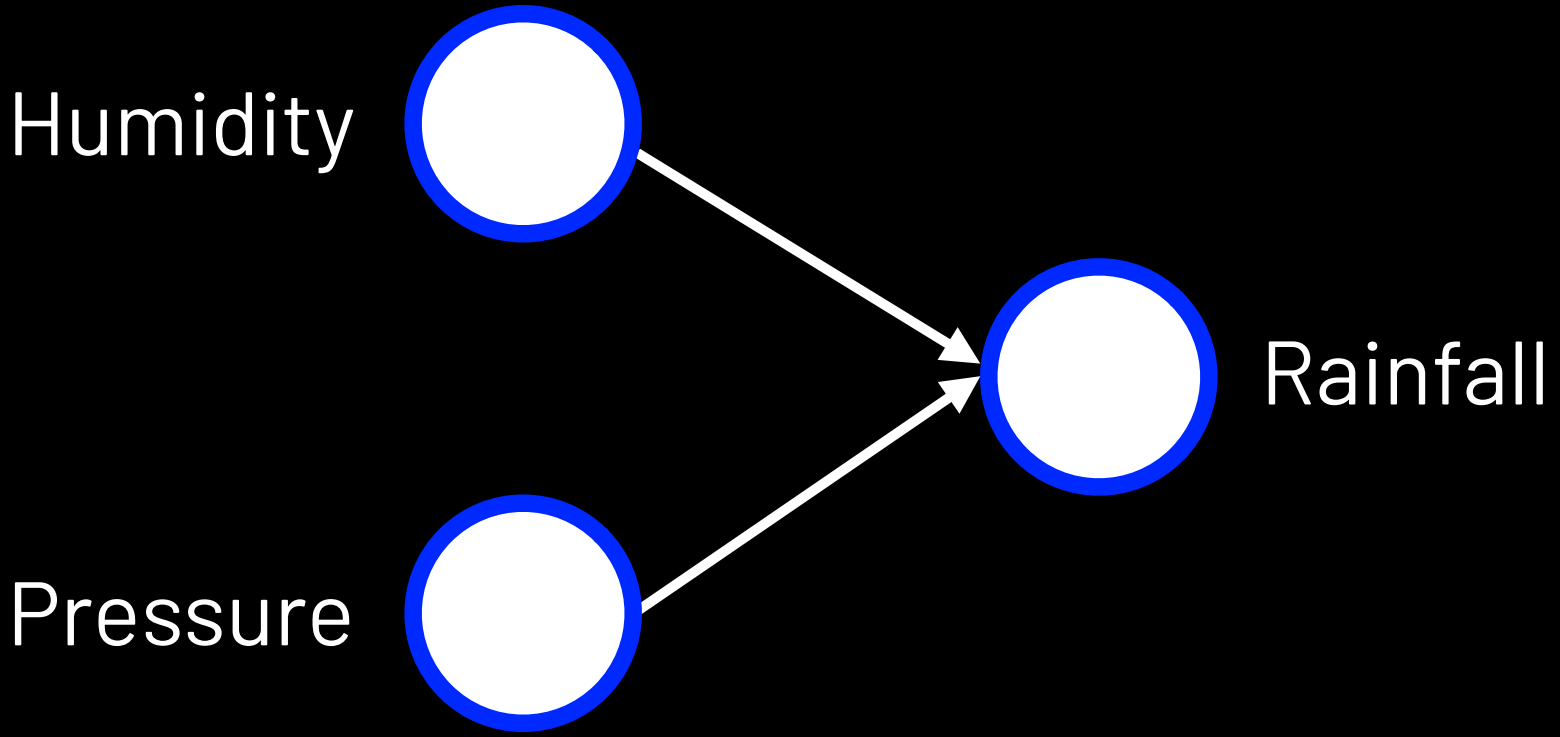

x
y
or

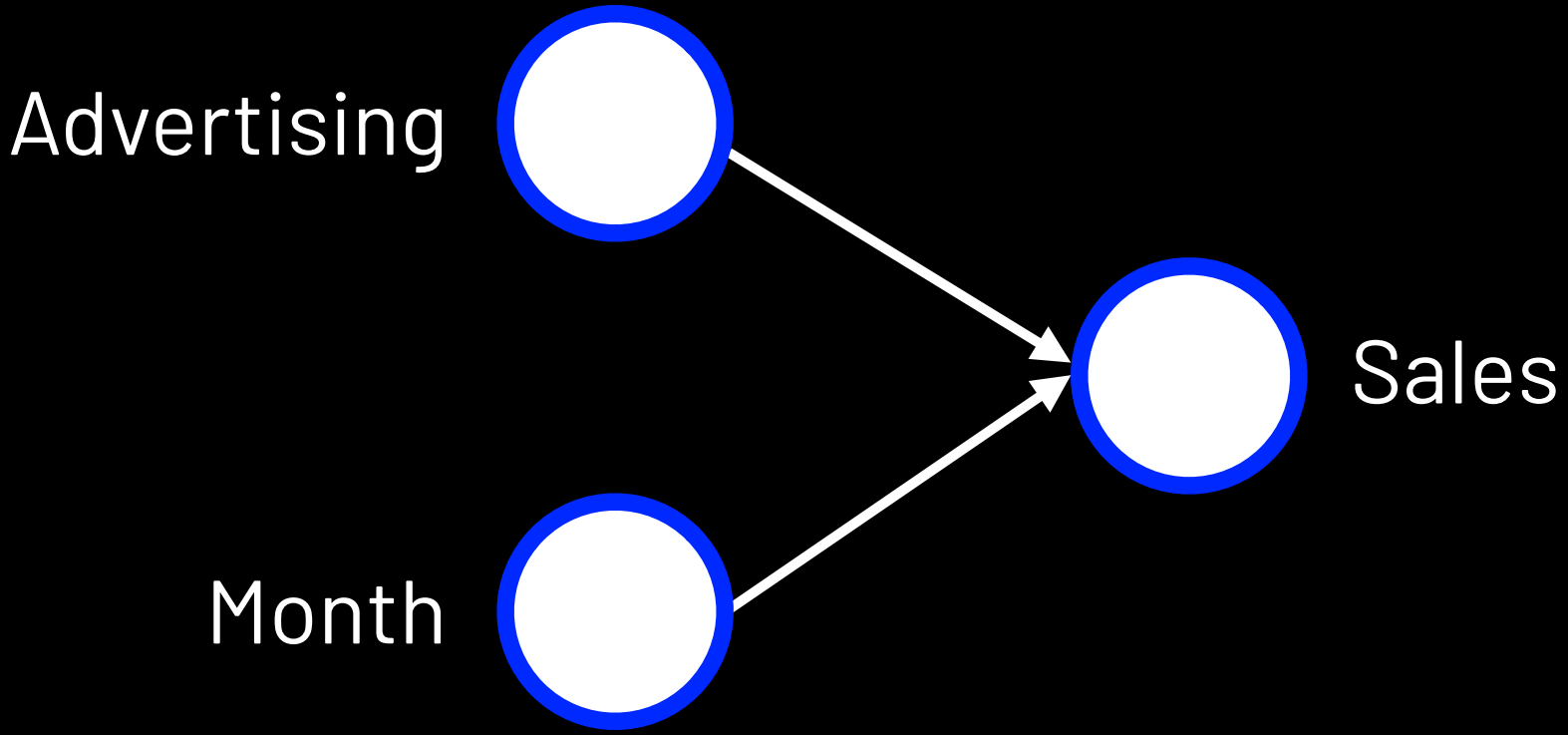

y
x

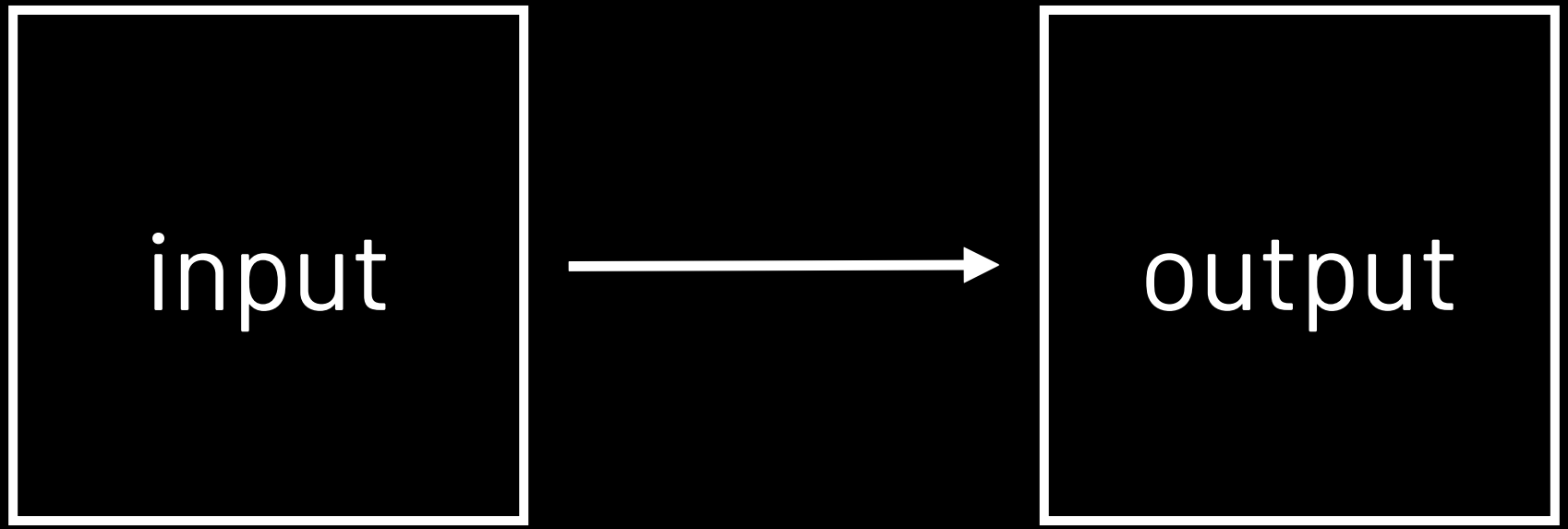

x
y
or

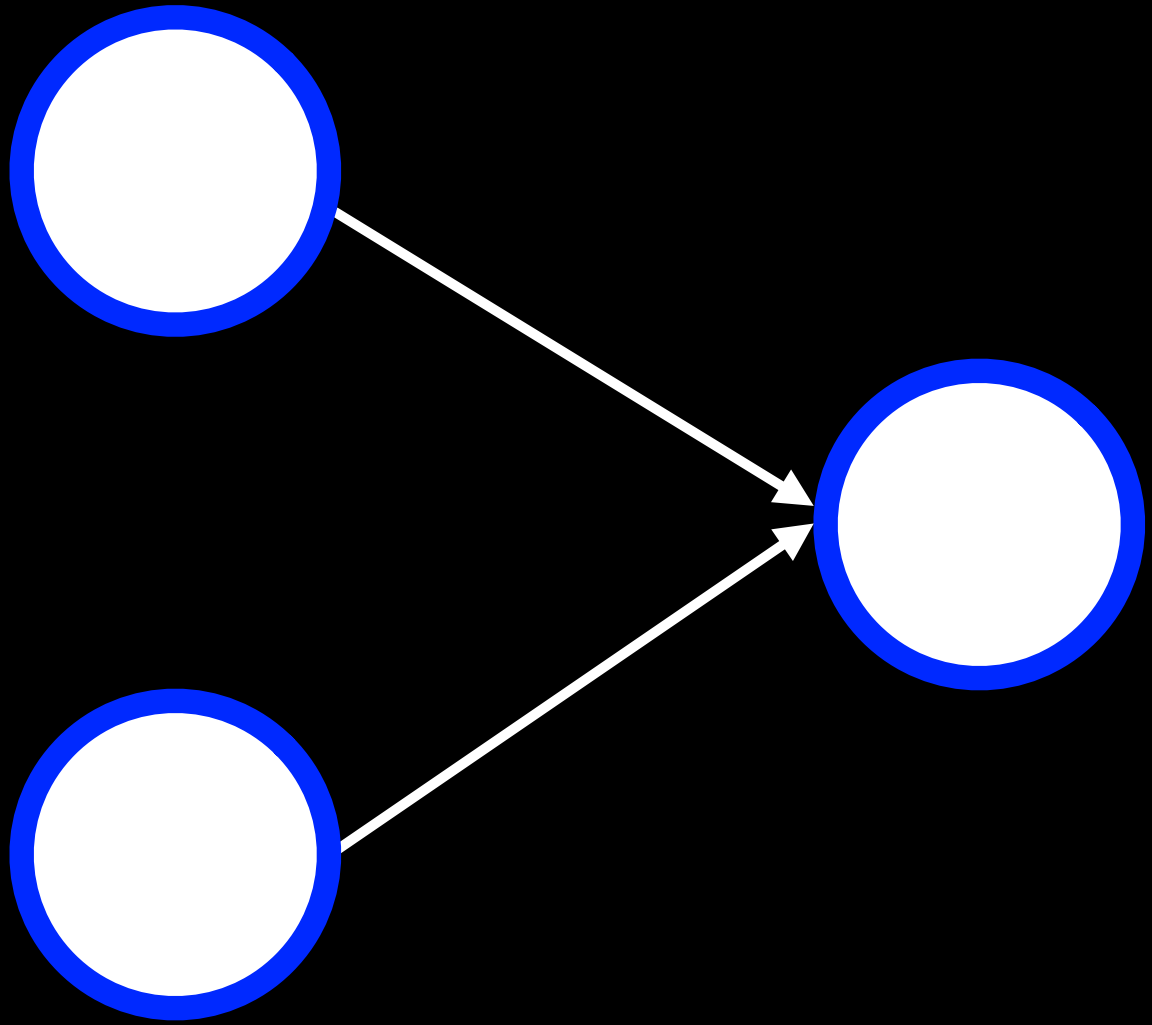

y
x

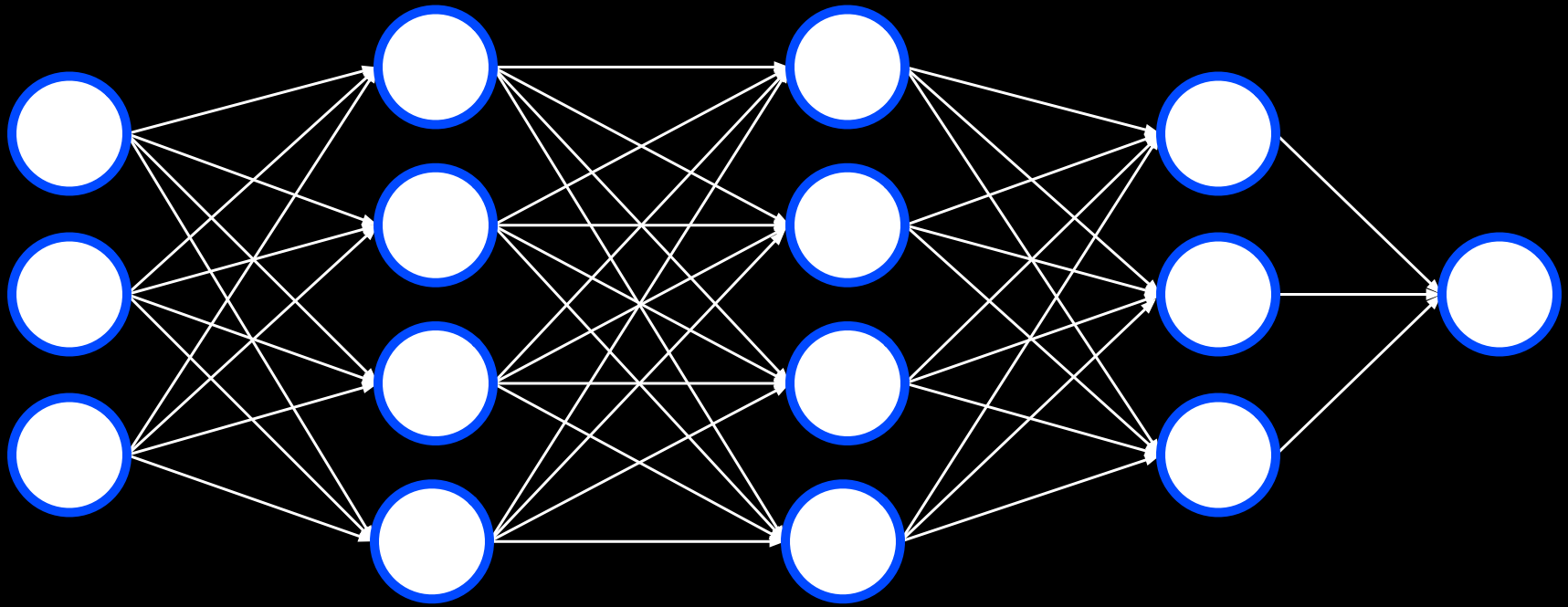

x
y
or

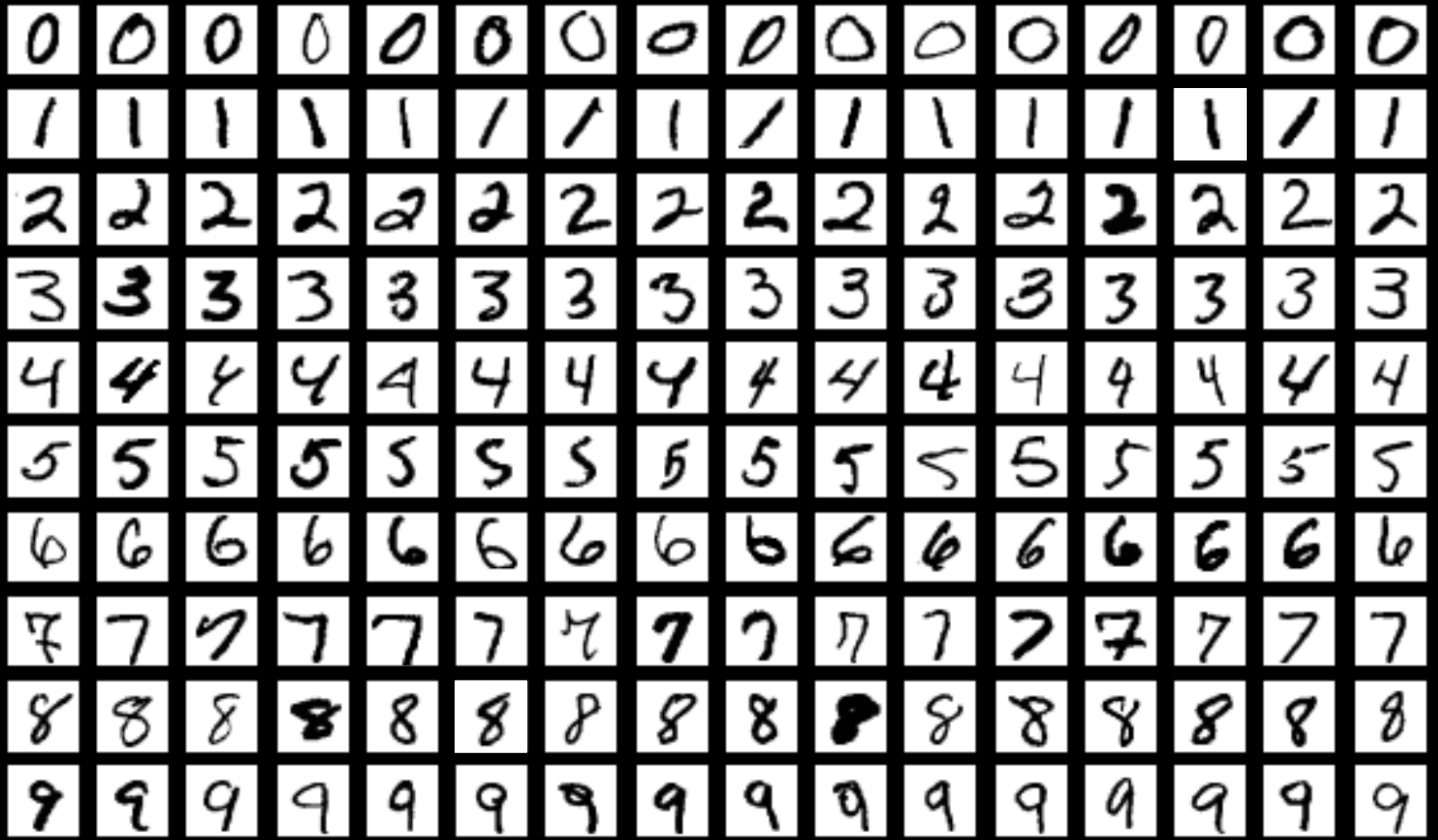

Humidity
Pressure
Rainfall

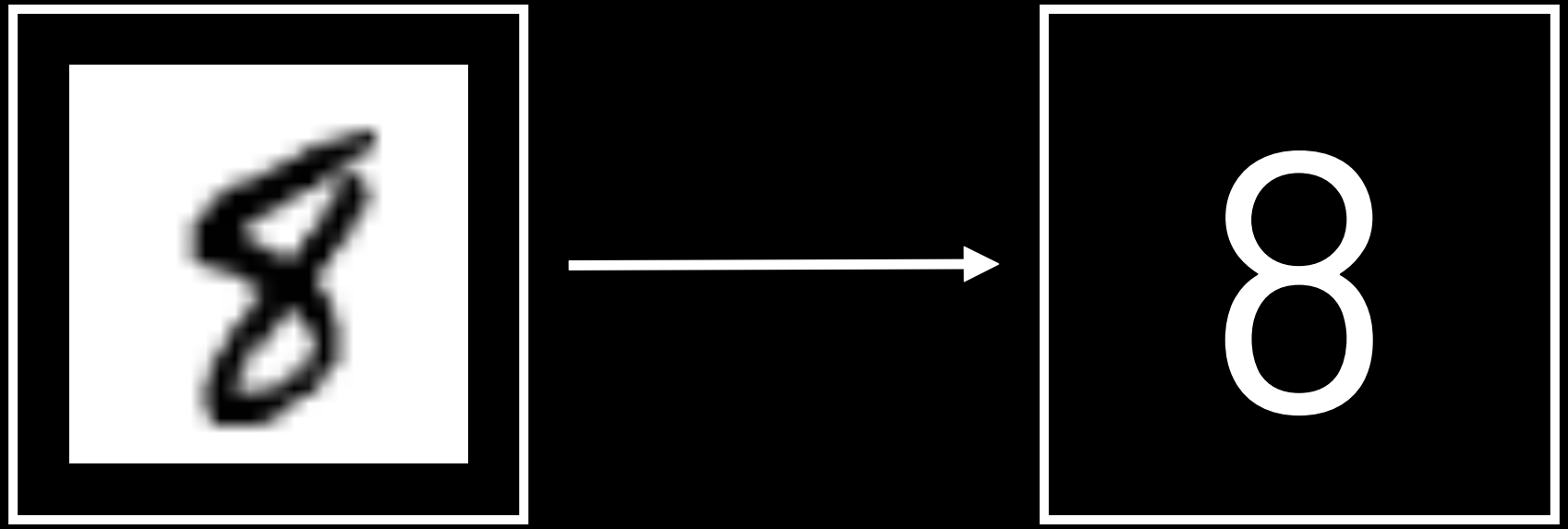

Advertising
Sales
Month


input
output





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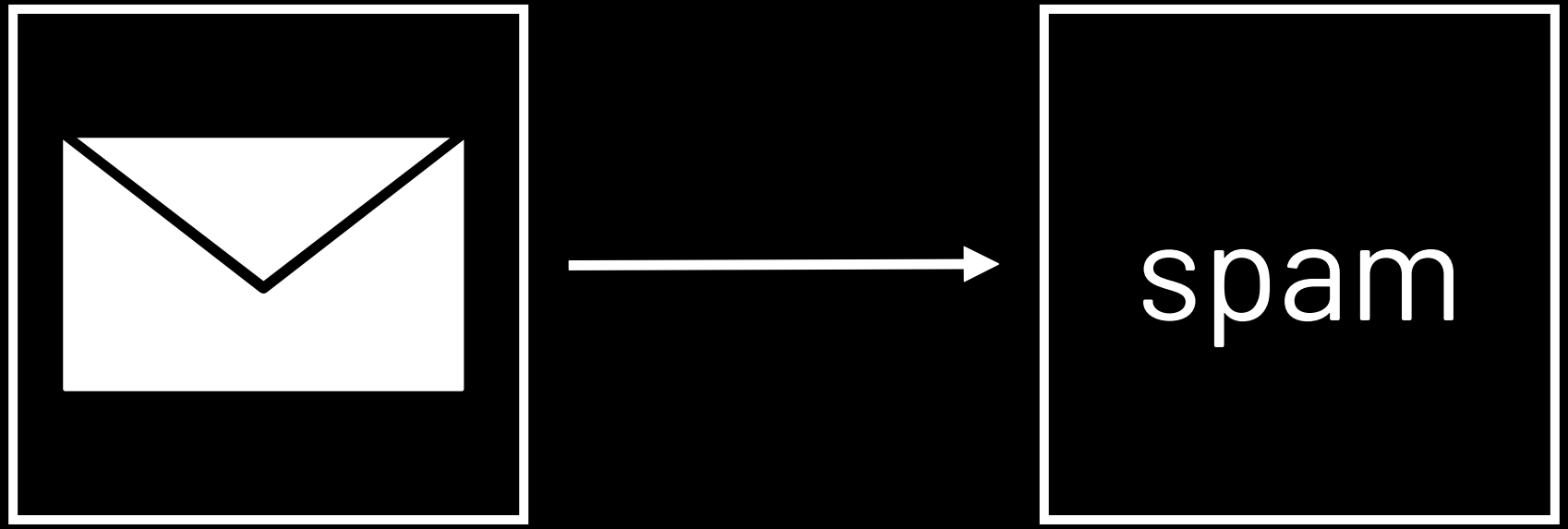
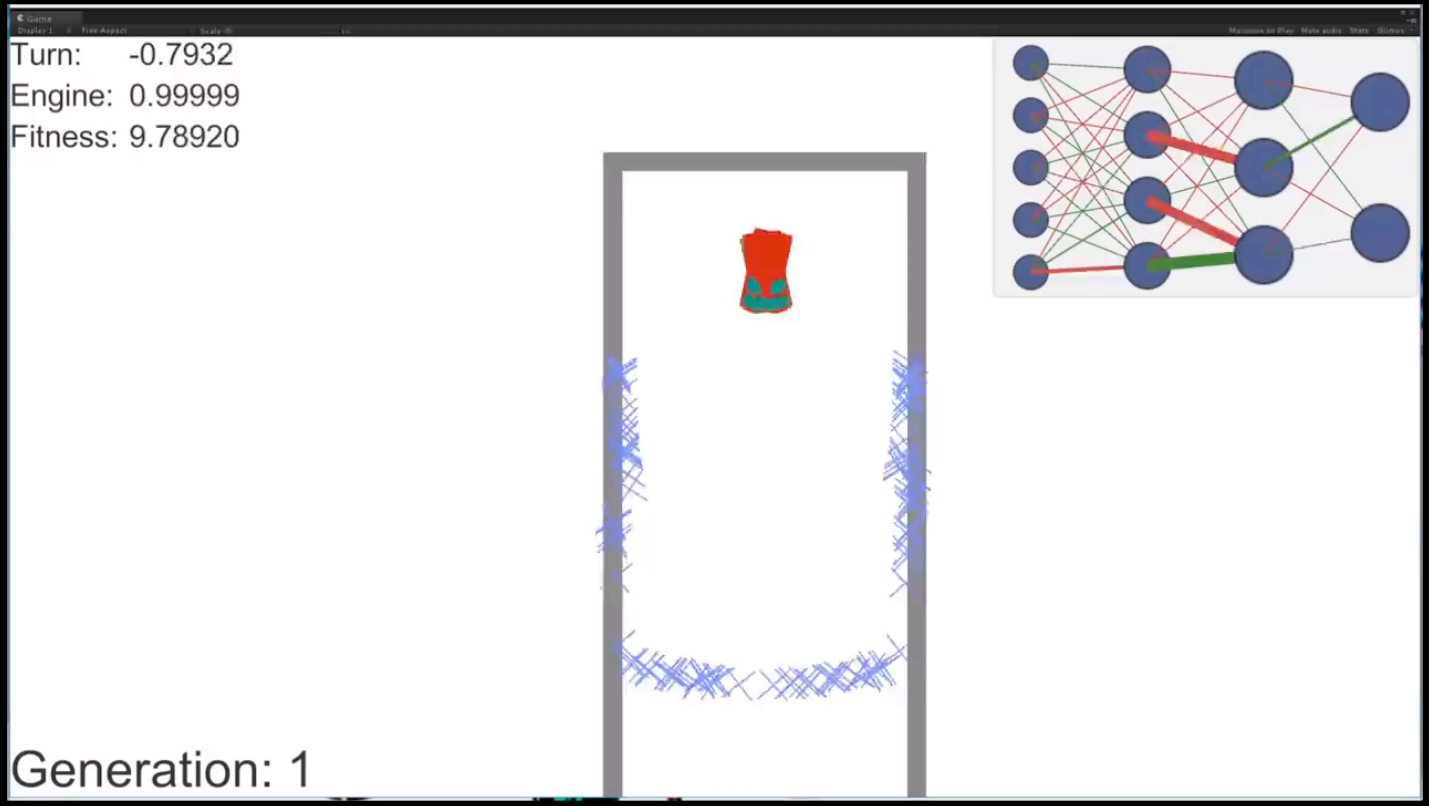
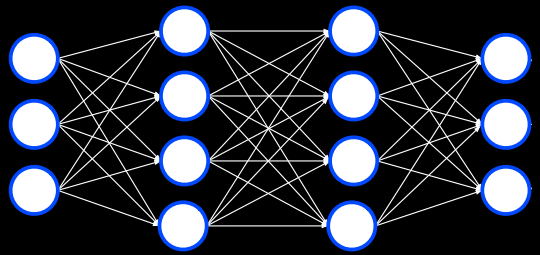

spam

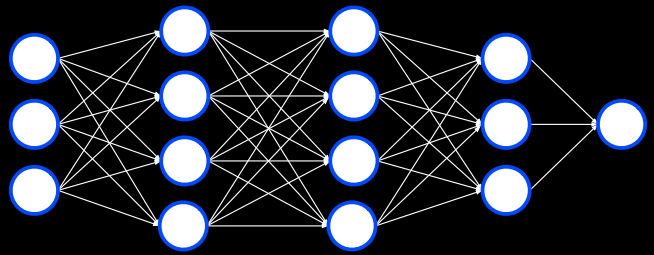



Source: *YouTube, Samuel Arzt*

Dataset of Real Images

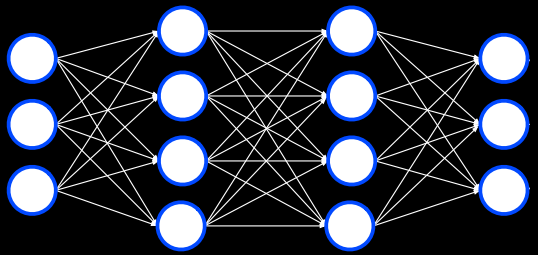
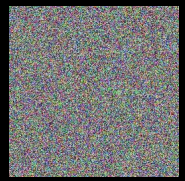


Generator

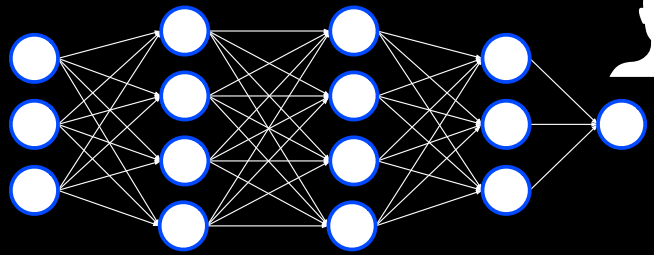


Discriminator

## Dataset of Real Images

Generator

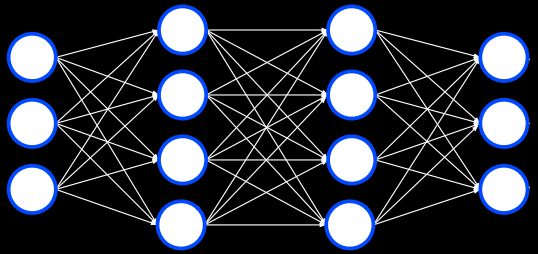


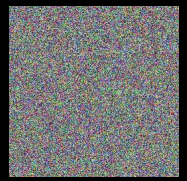
Real

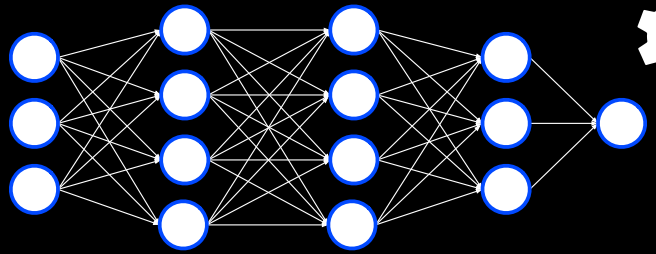
Discriminator

## Dataset of Real Images

Generated



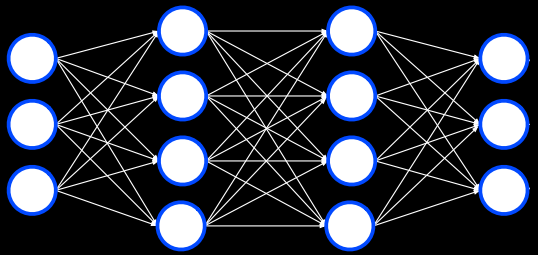


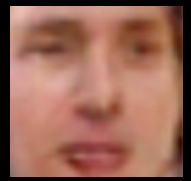


**Generator**

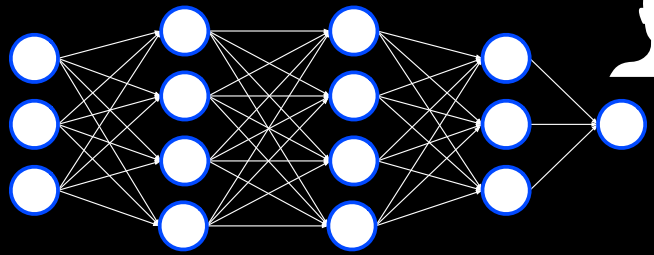
**Discriminator**

Dataset of Real Images





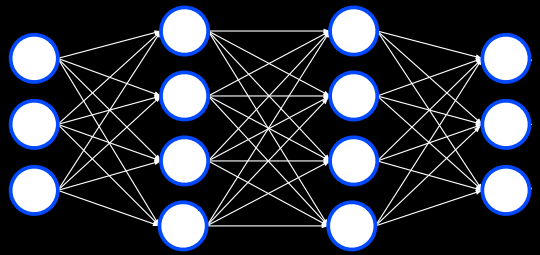
Generator

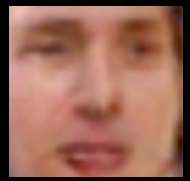


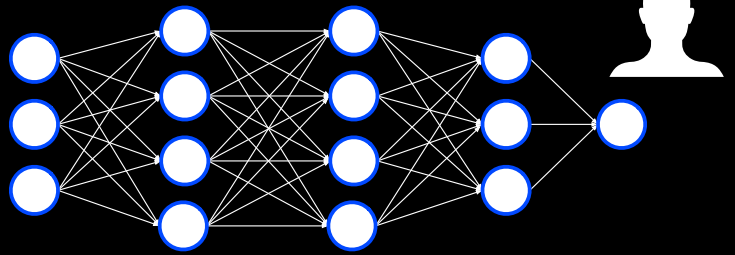
Real

Discriminator

Dataset of Real Images



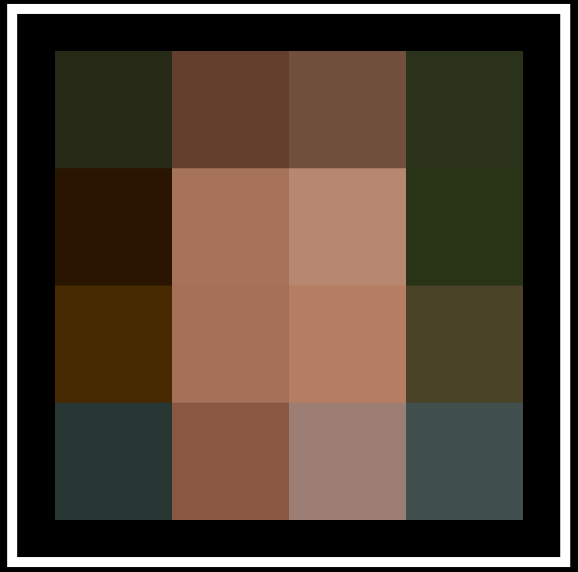




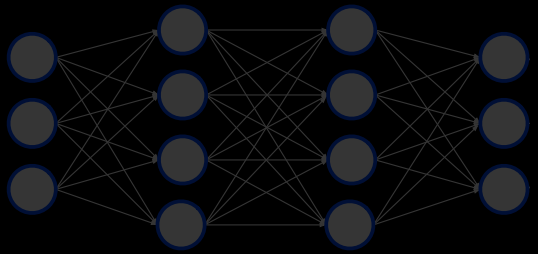
Real

Generator

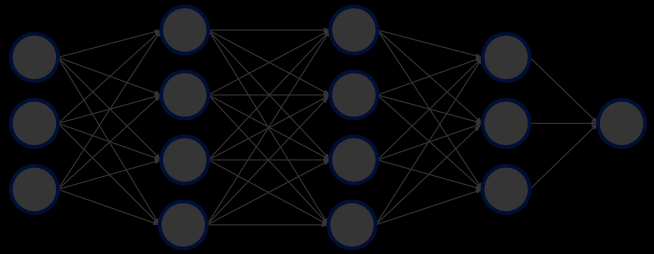
Discriminator



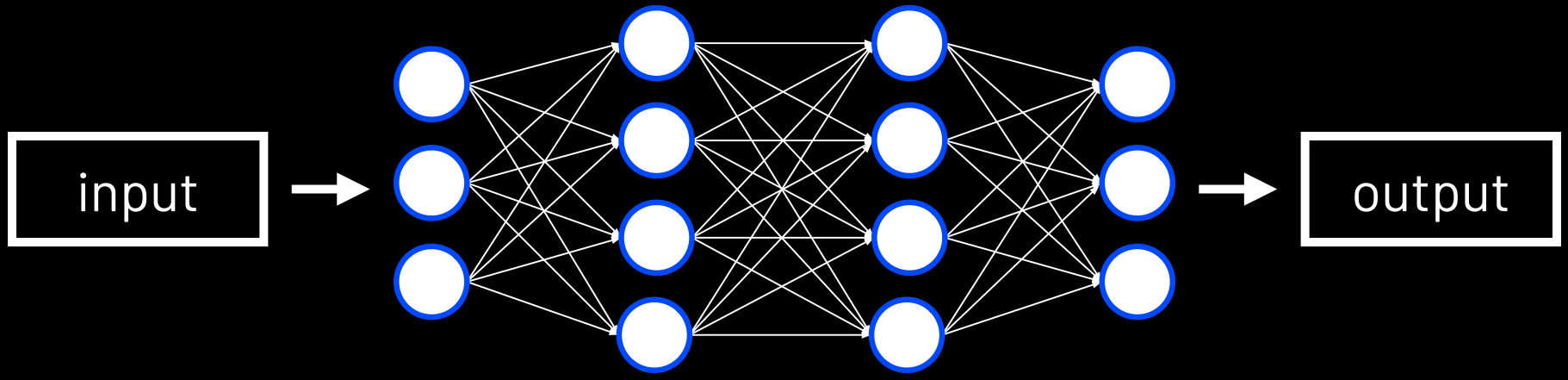
## Dataset of Real Images



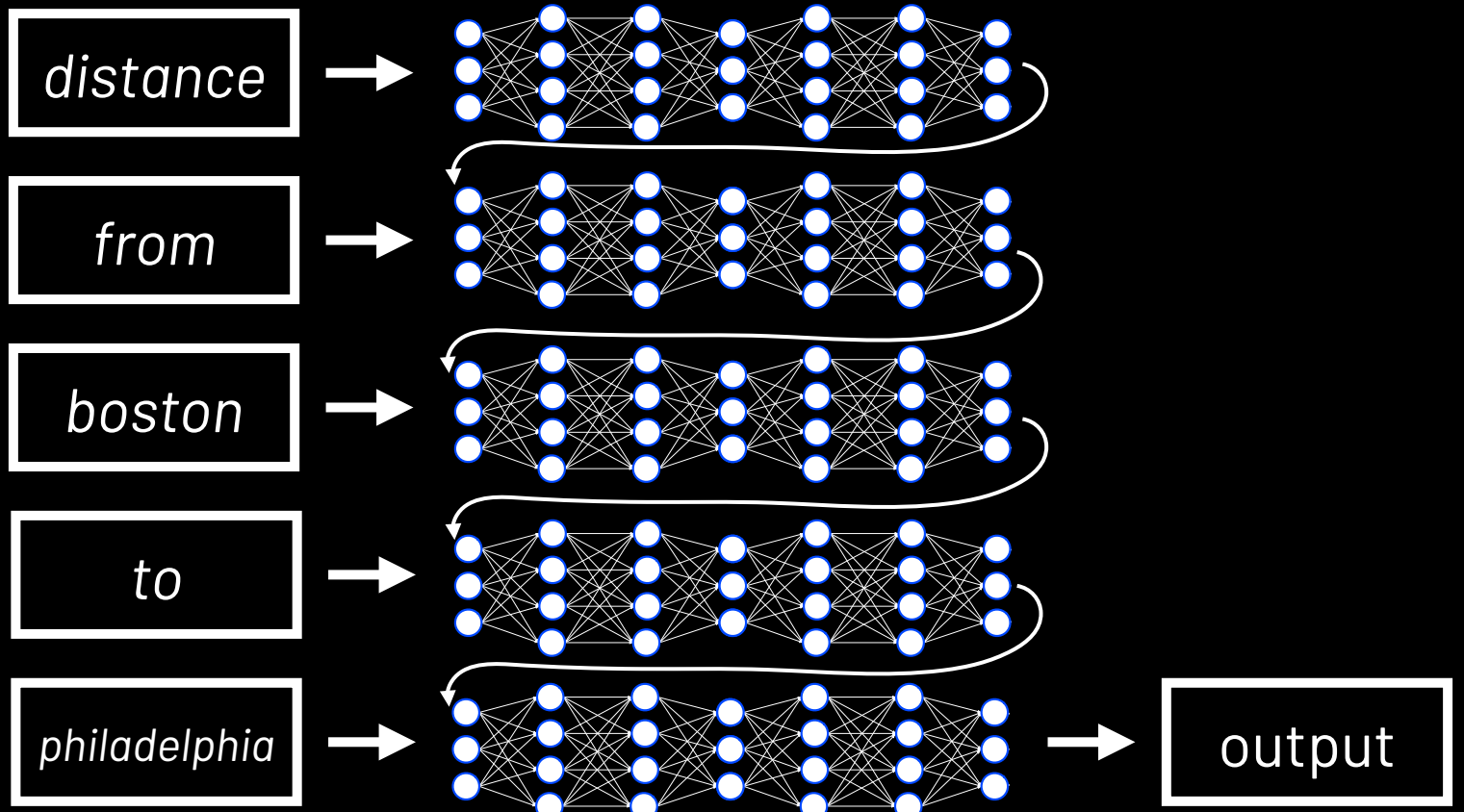
Generator

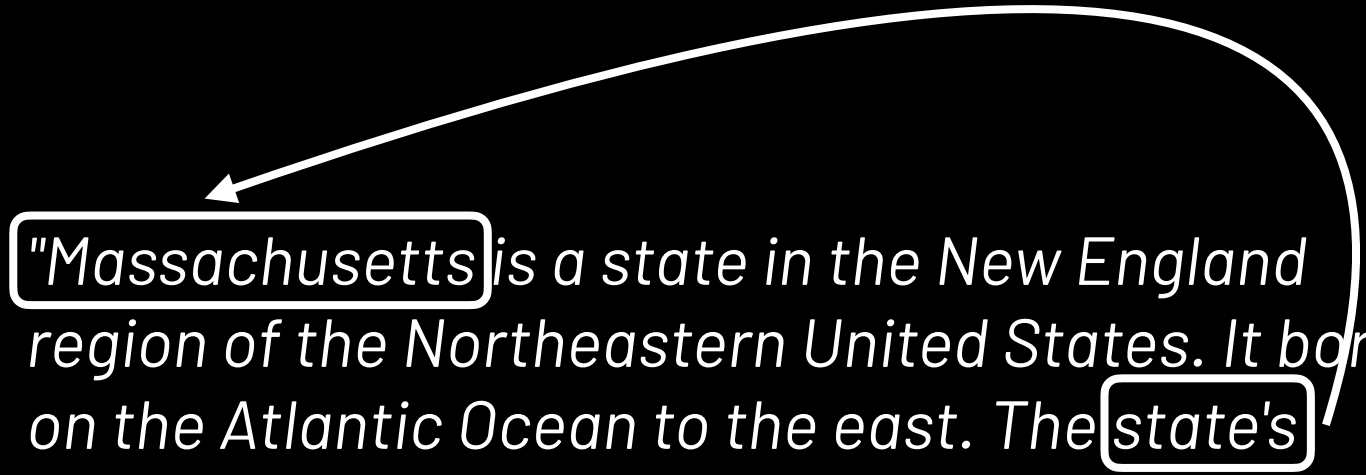


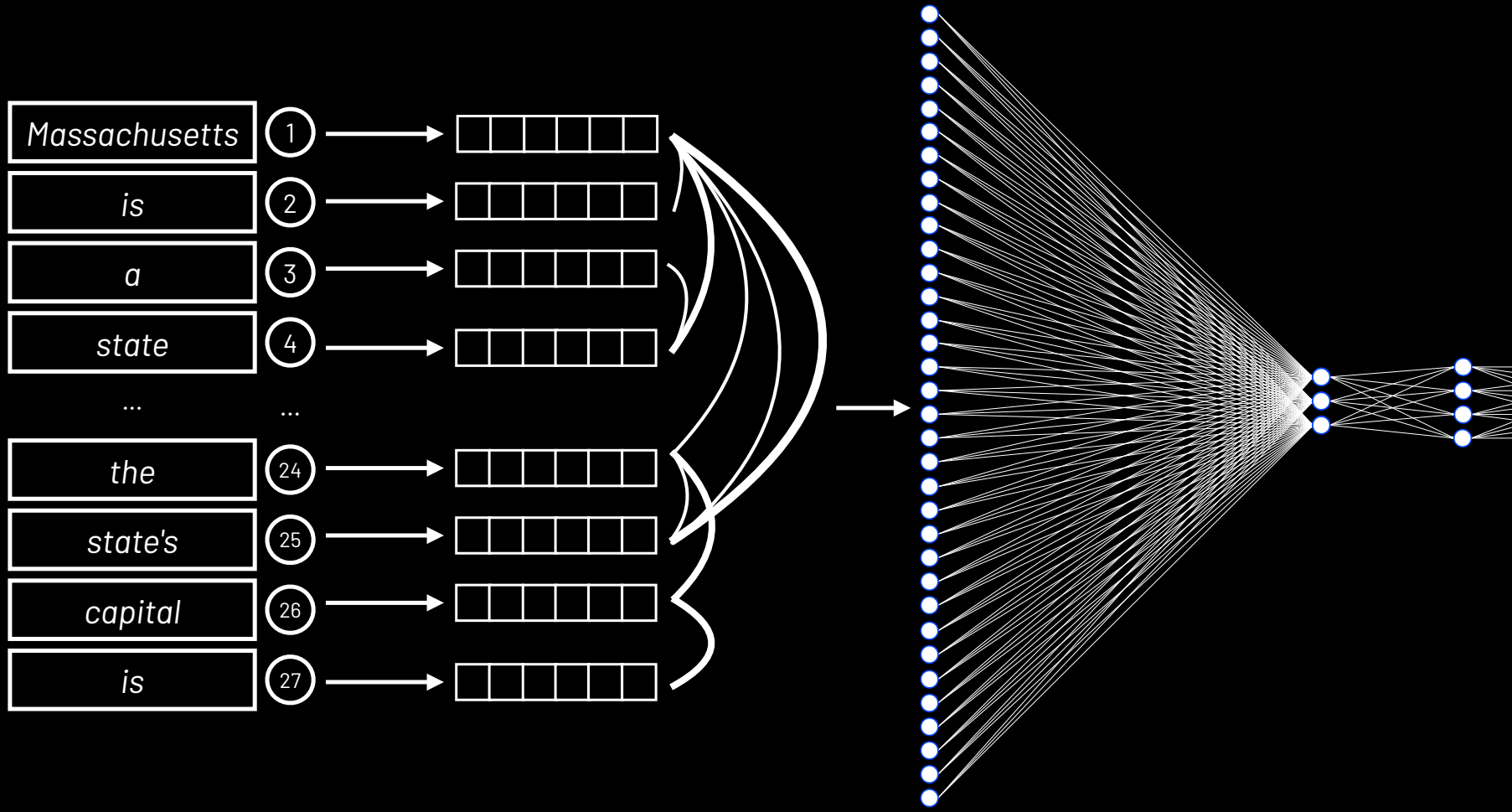
Discriminator




*"Distance from Boston to Philadelphia"*


distance
from
boston
to
philadelphia
output


"Massachusetts is a state in the New England region of the Northeastern United States. It borders on the Atlantic Ocean to the east. The state's capital is..."


Massachusetts
1
is
2
a
3
state
4
...
...
the
24
state's
25
capital
26
is
27

## Attention Is All You Need


**Ashish Vaswani*** Google Brain avaswani@google.com

**Noam Shazeer*** Google Brain noam@google.com

**Niki Parmar*** Google Research nikip@google.com

**Jakob Uszkoreit*** Google Research usz@google.com

**Llion Jones*** Google Research llion@google.com

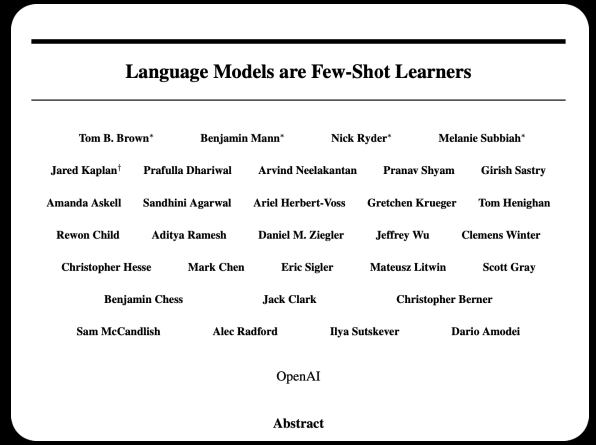
**Aidan N. Gomez*** † University of Toronto aidan@cs.toronto.edu

**Łukasz Kaiser*** Google Brain lukaszkaiser@google.com

**Illia Polosukhin*** ‡ illia.polosukhin@gmail.com


**Abstract**

Transformer Model
2017



## Language Models are Few-Shot Learners


**Tom B. Brown*** **Benjamin Mann*** **Nick Ryder*** **Melanie Subbiah***

**Jared Kaplan†** **Prafulla Dhariwal** **Arvind Neelakantan** **Pranav Shyam** **Girish Sastry**

**Amanda Askell** **Sandhini Agarwal** **Ariel Herbert-Voss** **Gretchen Krueger** **Tom Henighan**

**Rewon Child** **Aditya Ramesh** **Daniel M. Ziegler** **Jeffrey Wu** **Clemens Winter**

**Christopher Hesse** **Mark Chen** **Eric Sigler** **Mateusz Litwin** **Scott Gray**

**Benjamin Chess** **Jack Clark** **Christopher Berner**

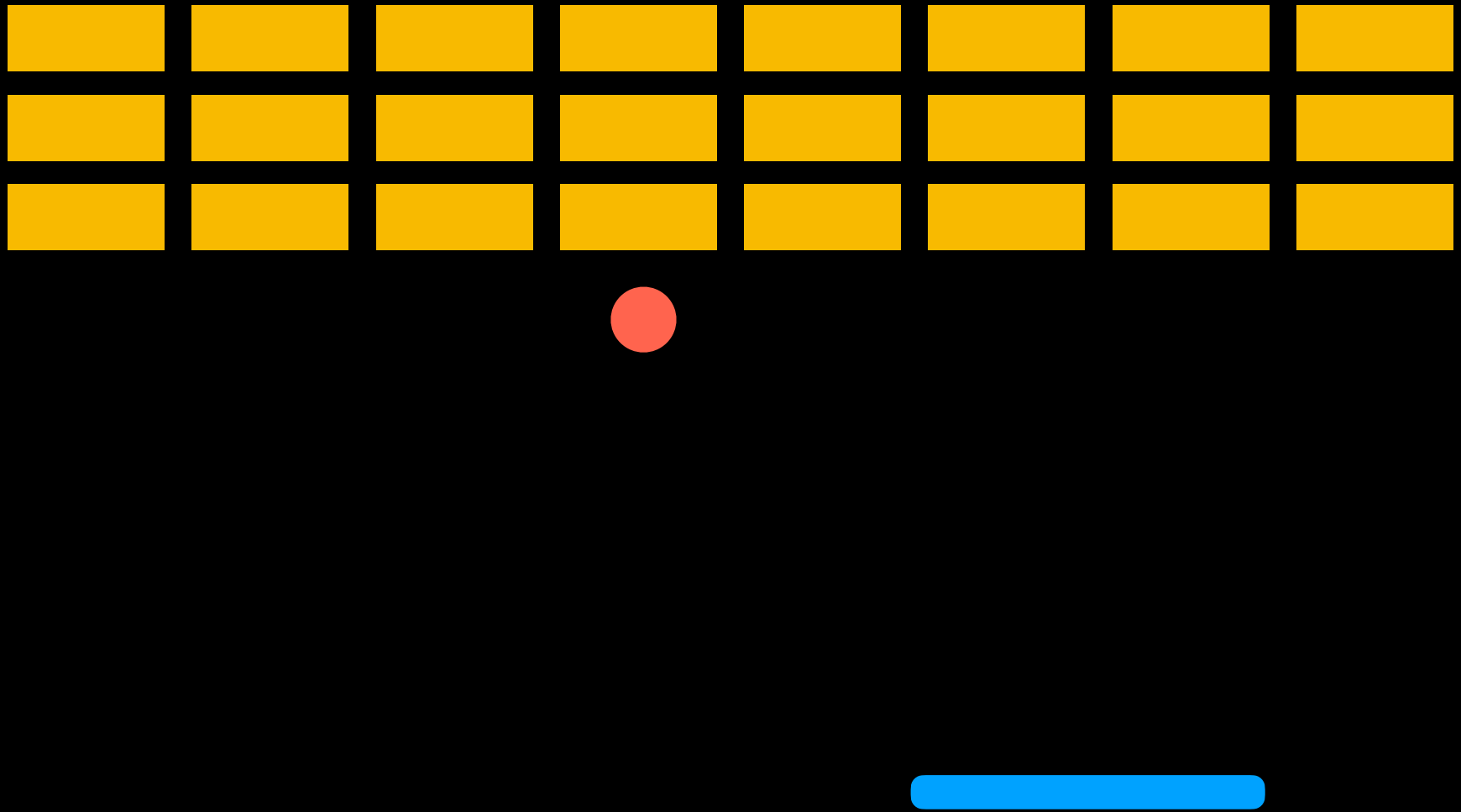
**Sam McCandlish** **Alec Radford** **Ilya Sutskever** **Dario Amodei**

OpenAI


**Abstract**

GPT-3 Language Model
2020

ChatGPT Model
2022



**Google DeepMind**

10 minutes of training

Source: *YouTube, Two Minute Papers*

**Google DeepMind**

2 hours of training

Source: *YouTube, Two Minute Papers*

**Google DeepMind**

4 hours of training

Source: *YouTube, Two Minute Papers*

# Artificial Intelligence

cs50.ly/feedback

helios.law.harvard.edu

cs50.edx.org/ai

thispersondoesnotexist.com

# The Painters Who Passed the Turing Test: History and Impact of AI Art

Thu, Jan 19, 12:00 PM – 2:00 PM EST in WCC Room 1019, with Michael Hu

# past seminars

# Final Assignment

# Thank you!

- Carter, Sophia, Rongxin
- Catherine, Inno, Michael, Patrick, Varsha
- Ian, Andrew, Ramón, Max, Xochi
- Marzieh

"How machine-learning algorithms work, fairness metrics"

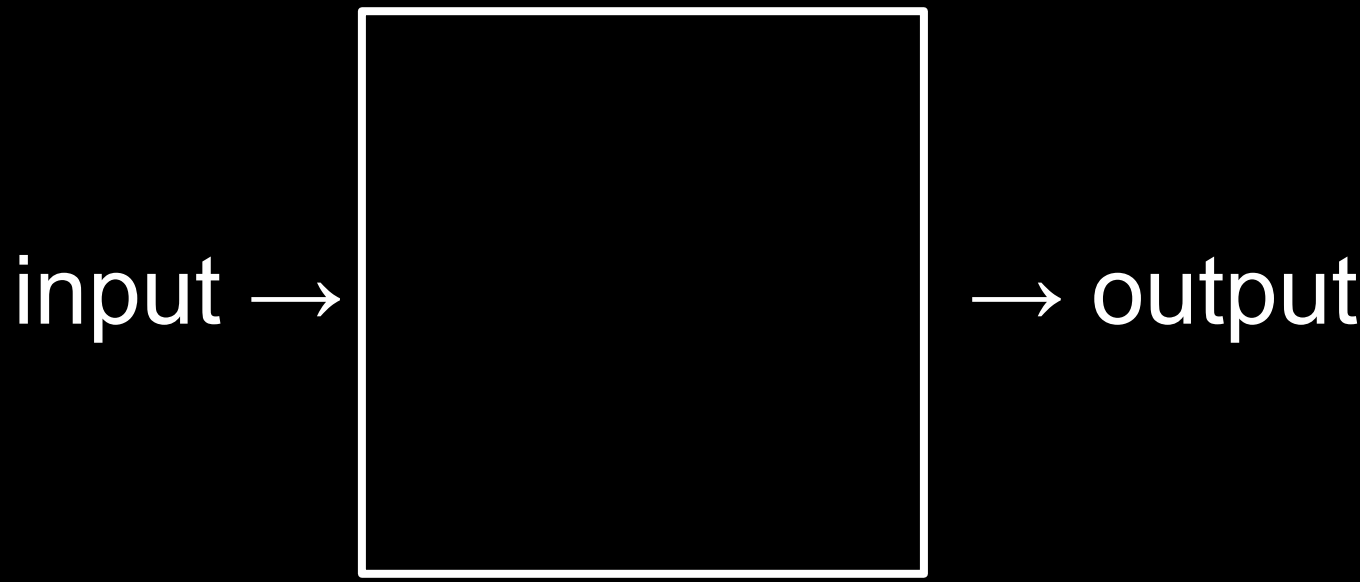
"I want to get familiar with all the knowledge about CS and develop a basic body of knowledge."

"What are common cybersecurity issues lawyers should be aware of…"

"How do the devices we use every day actually work?"

"What is most important to computer scientists when they work with lawyers?"

"I took Java in 2012 and got an 18% on the exam so this will be an adventure to round out my time in academia."


input →
→ output

# Themes

- Abstraction
- Correctness
- Efficiency
- Precision
- Representation
- Security
- Trade-offs
- ...

cs50.harvard.edu/law

# Next Steps

- cs50.harvard.edu/business
- cs50.harvard.edu/technology
- …

# Next Steps

- cs50.harvard.edu/scratch
- cs50.harvard.edu/python
- cs50.harvard.edu/x
- …

I took CS50
I took CS5
I took CS50.
CS50.

pollev.com/cs50

The End