MEI®
Because maths matters!

Hands On With Machine Learning

Start time

Rob Butler & Ben Sparks

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Hands On With Machine Learning

1015 Start

Rob Butler & Ben Sparks

Take the Top Trumps Cards

Sort them into two categories

No further questions will be taken at this time.

ROB BUTLER

Maths Education Support Specialist

(Maths into AI Team)

BEN SPARKS

Maths Education Support Specialist

(Maths into AI Team)

Classification

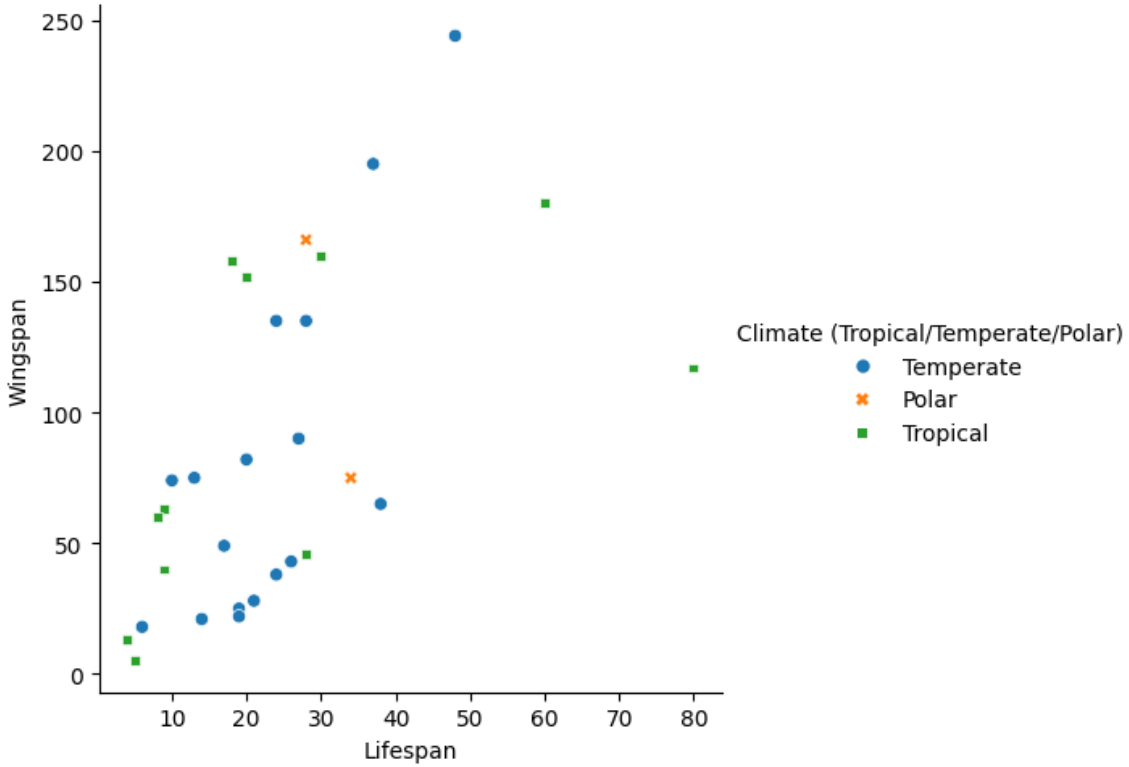
How did you group your cards?

Did you give your groups names?

Which group would a bird with the following information go in?

Wingspan (cm)	Lifespan (years)	Clutch size	Independence
95	15	6	2.0

Classification as a machine learning task



Classification ideas can be applied to many different tasks

Modern AI uses machine learning to recognise patterns in data before creating models to make predictions

Types of Machine Learning

Supervised

Unsupervised

Reinforcement

Supervised Machine Learning

"Tell it the answers"

Spam or Ham?

What rules would you make to detect a spam email?

Decision Tree Classification

A human built model?

"If the sender in the address book then it's not spam"

Otherwise if the subject line mentions borrowing, loans, finance, it's spam

If it mentions 'join now' in the text of the email it's spam

Etc.

Recognising language

- A **vectorizer** converts strings of text into vectors
- Each dimension represents information about the words in the text, e.g. text frequency

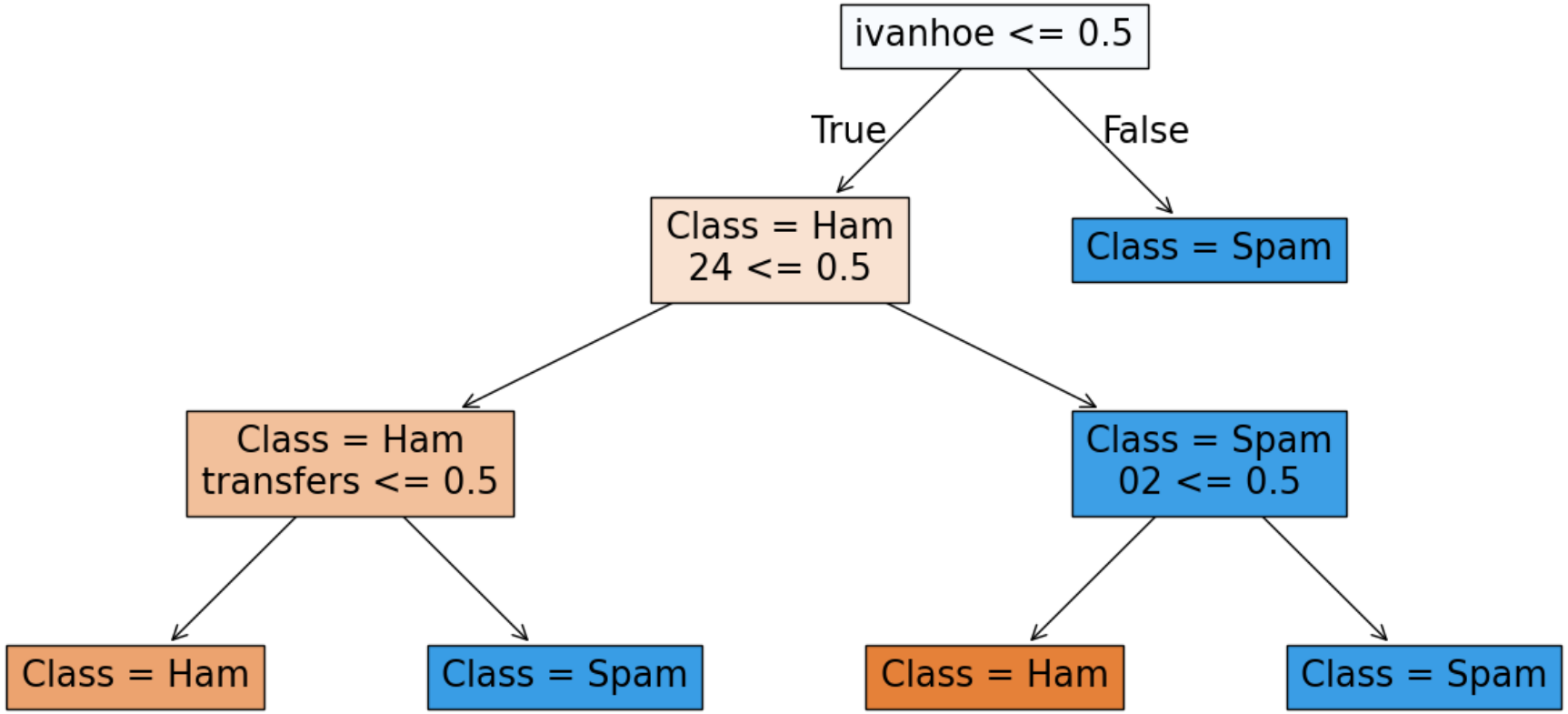
“new files for new project”
“re evergreen deals ”
“re misc questions”

deals	evergreen	files	for	misc	new	project	re	questions
0	0	1	1	0	2	1	0	0
1	1	0	0	0	0	0	1	0
0	0	0	0	1	0	0	1	1

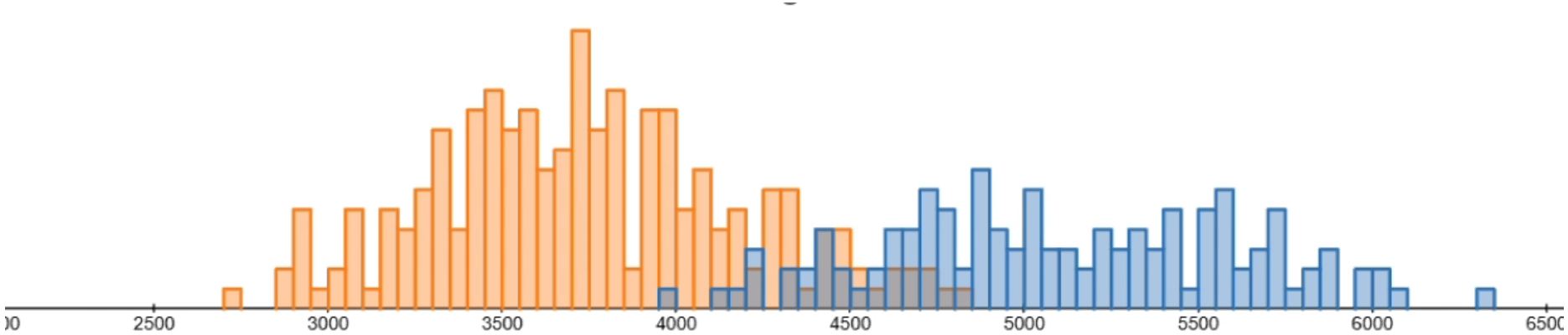
A machine built model

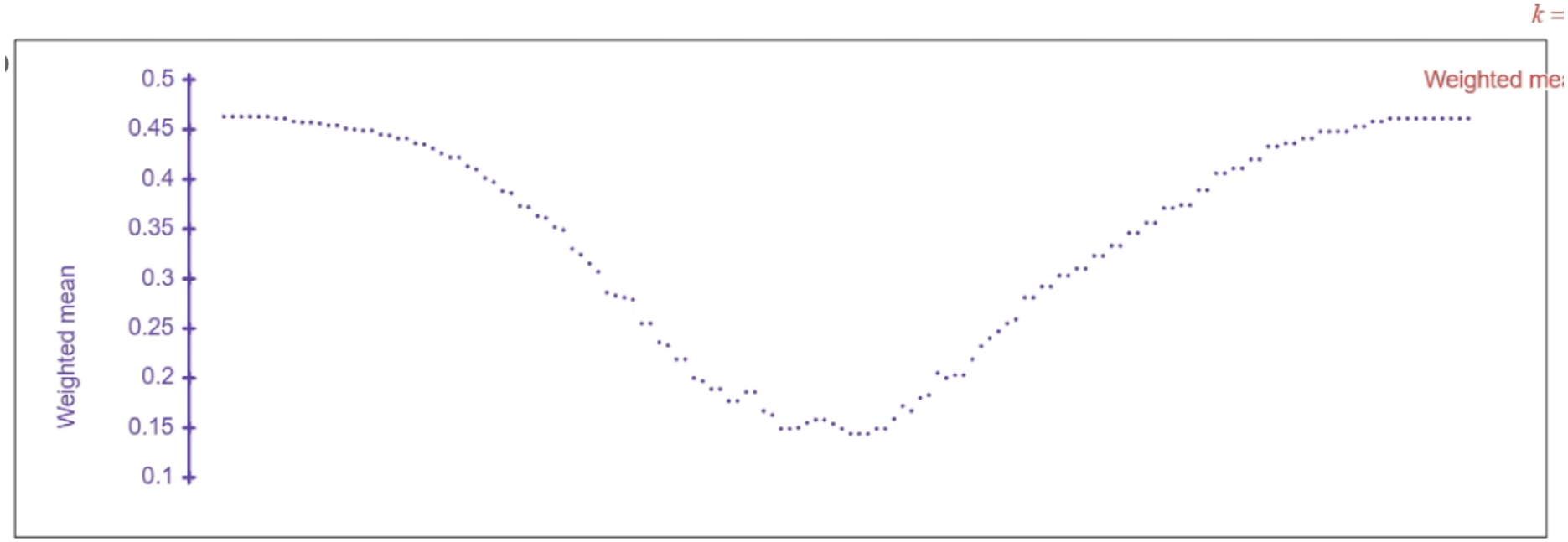
This is very different to how a human would make the decision.

86.4% accurate (on this data set)

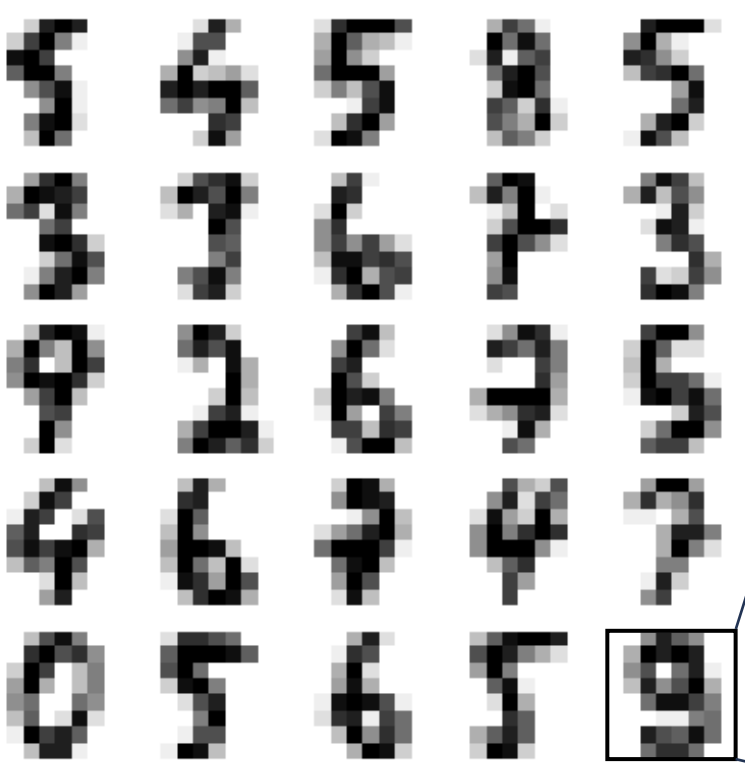


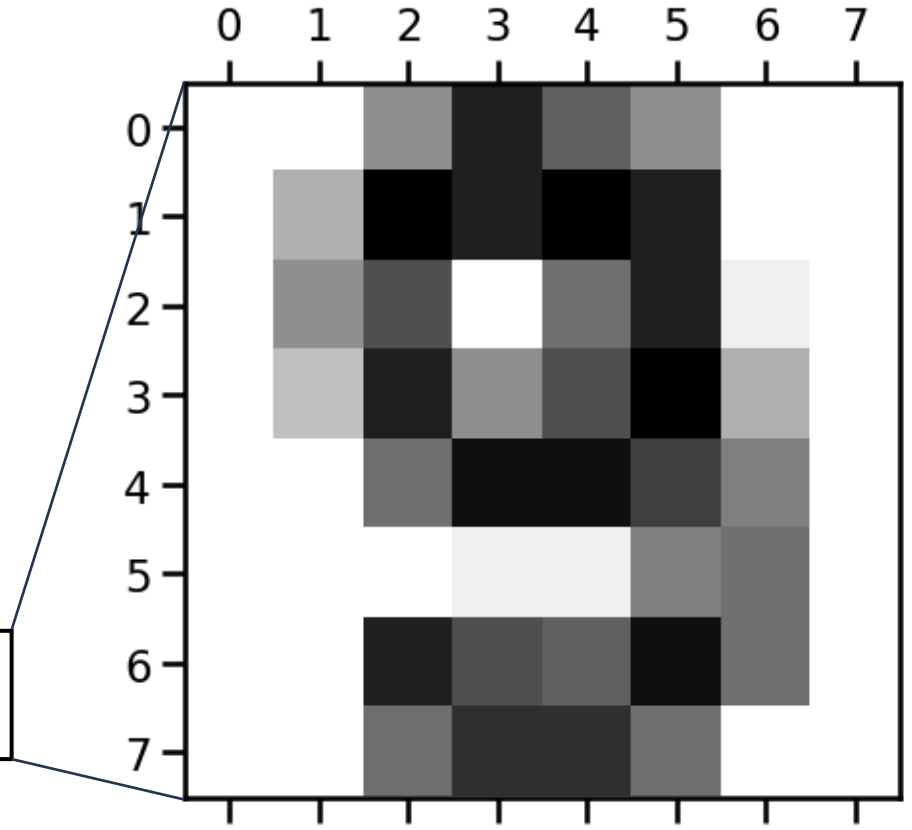
HOW DOES IT WORK?





Recognising handwritten digits





$$\begin{pmatrix} 0 & 0 & 7 & 14 & 10 & 7 & 0 & 0 \\ 0 & 5 & 16 & 14 & 16 & 14 & 0 & 0 \\ 0 & 7 & 11 & 0 & 9 & 14 & 1 & 0 \\ 0 & 4 & 14 & 7 & 11 & 16 & 5 & 0 \\ 0 & 0 & 9 & 15 & 15 & 12 & 8 & 0 \\ 0 & 0 & 0 & 1 & 1 & 8 & 9 & 0 \\ 0 & 0 & 14 & 11 & 10 & 15 & 9 & 0 \\ 0 & 0 & 9 & 13 & 13 & 9 & 0 & 0 \end{pmatrix}$$

Recognising handwritten digits

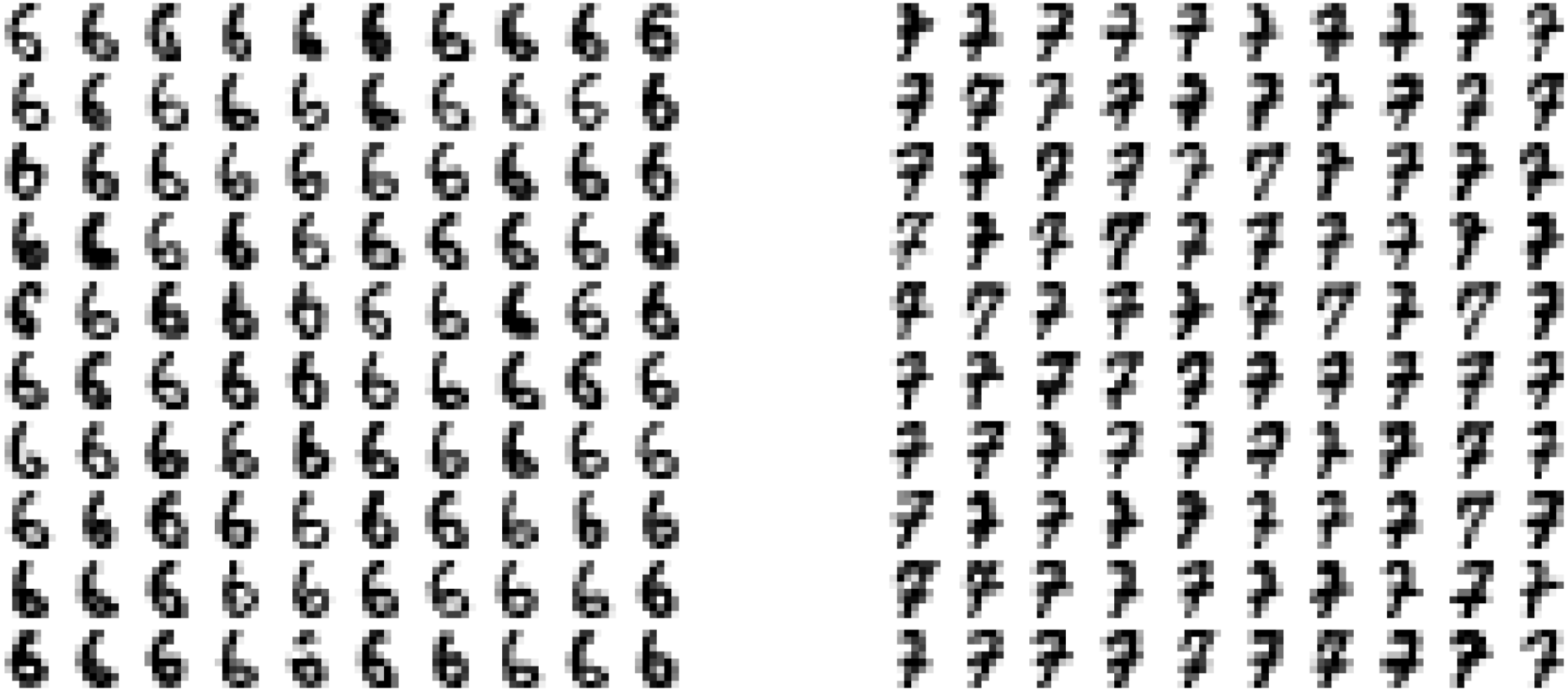
$$\begin{pmatrix} 0 & 0 & 7 & 14 & 10 & 7 & 0 & 0 \\ 0 & 5 & 16 & 14 & 16 & 14 & 0 & 0 \\ 0 & 7 & 11 & 0 & 9 & 14 & 1 & 0 \\ 0 & 4 & 14 & 7 & 11 & 16 & 5 & 0 \\ 0 & 0 & 9 & 15 & 15 & 12 & 8 & 0 \\ 0 & 0 & 0 & 1 & 1 & 8 & 9 & 0 \\ 0 & 0 & 14 & 11 & 10 & 15 & 9 & 0 \\ 0 & 0 & 9 & 13 & 13 & 9 & 0 & 0 \end{pmatrix}$$

64 pixels become 64 features

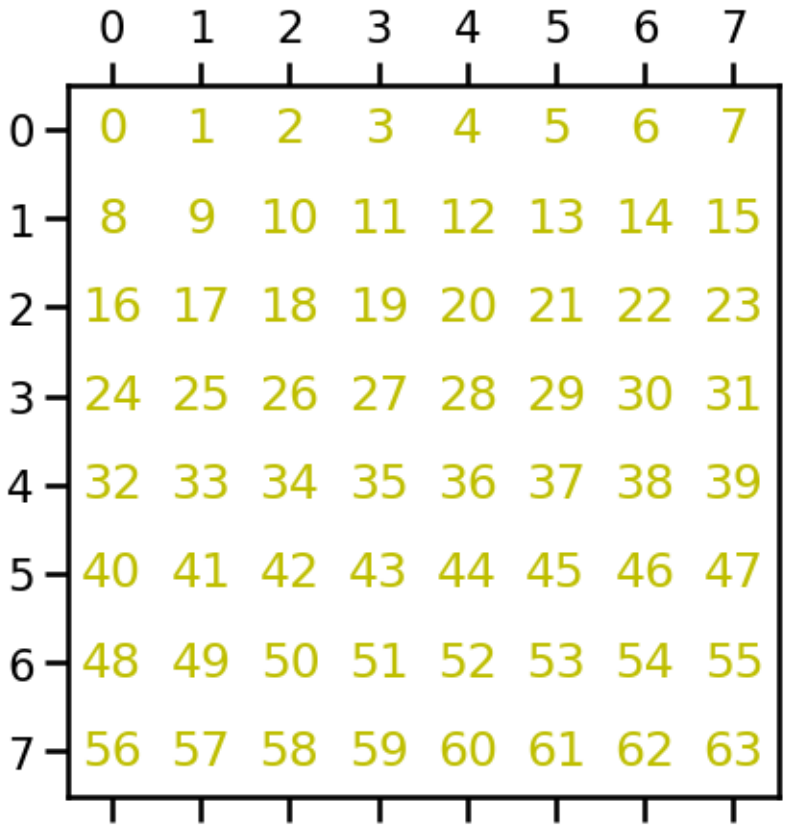
$$\{0,\ 0,\ 7,\ 14,\ 10,\ 7,\ 0,\ 0,\ 0,\ 5,\ 16,\ 14,\ 16,\ 14,\ 0,\ 0,\ 0,\ 7,\ 1$$

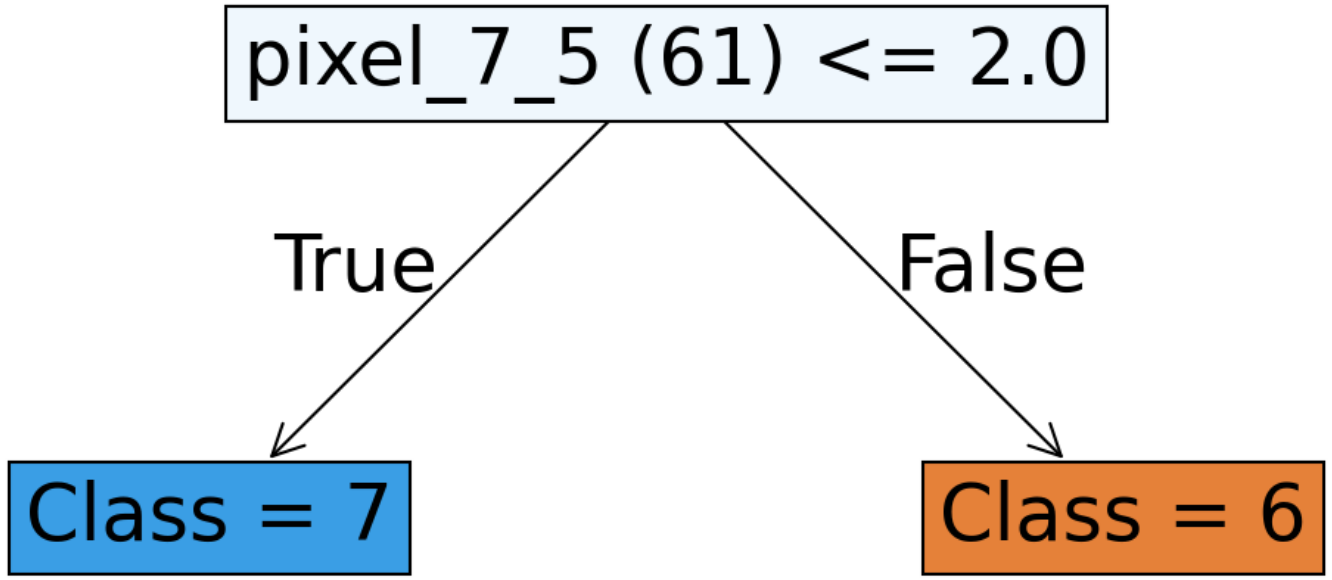
What happens when a decision tree is trained on this data?

Recognising handwritten digits

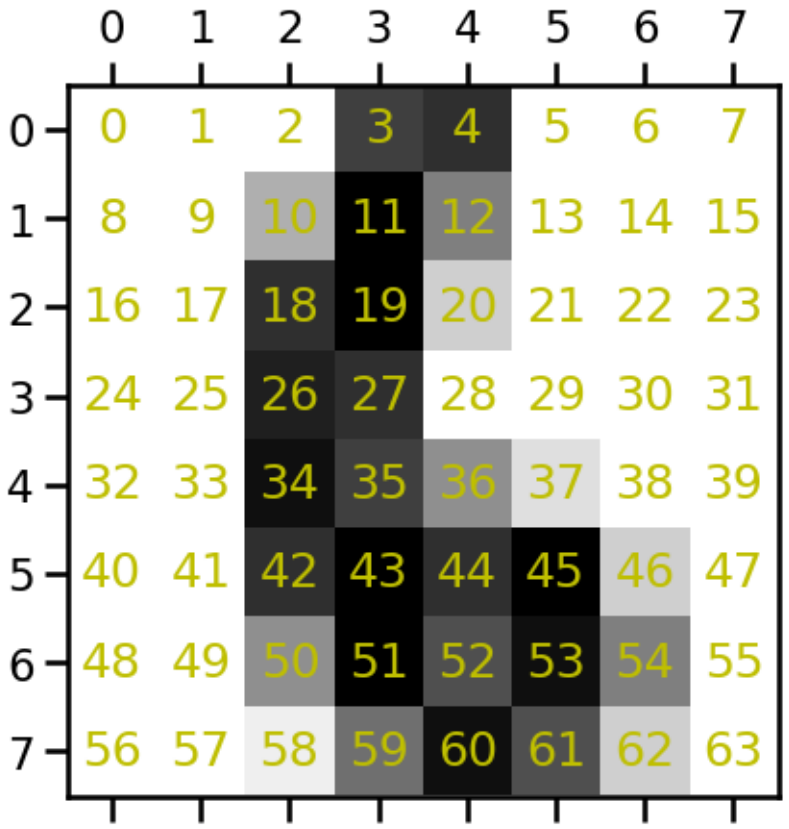


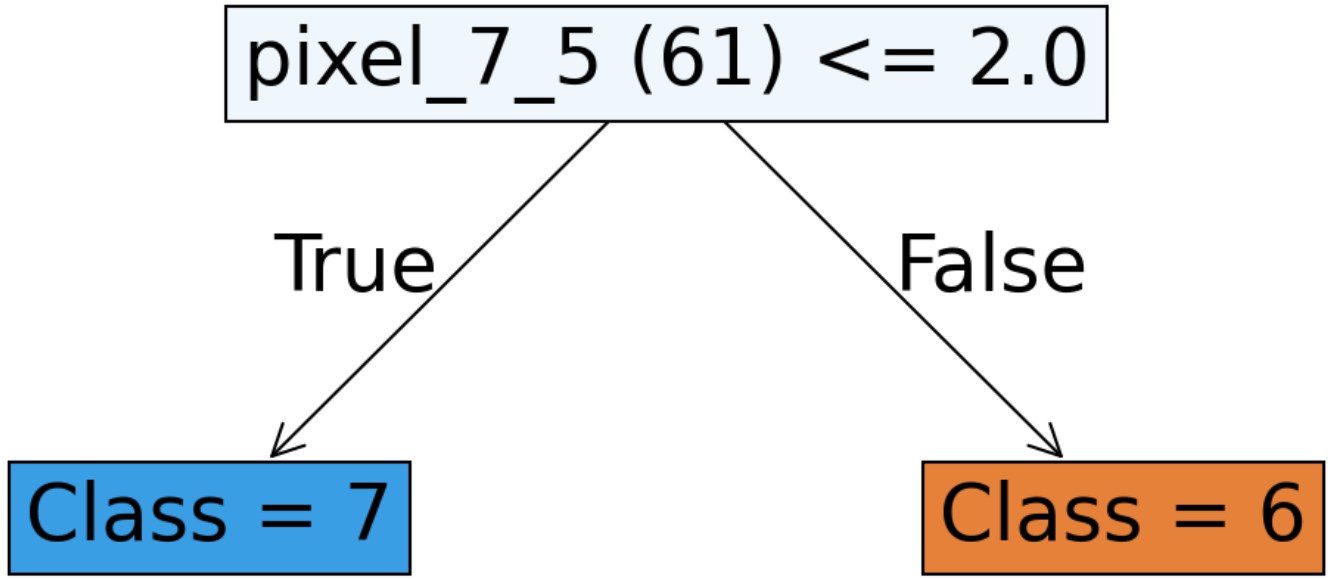
Recognising handwritten digits



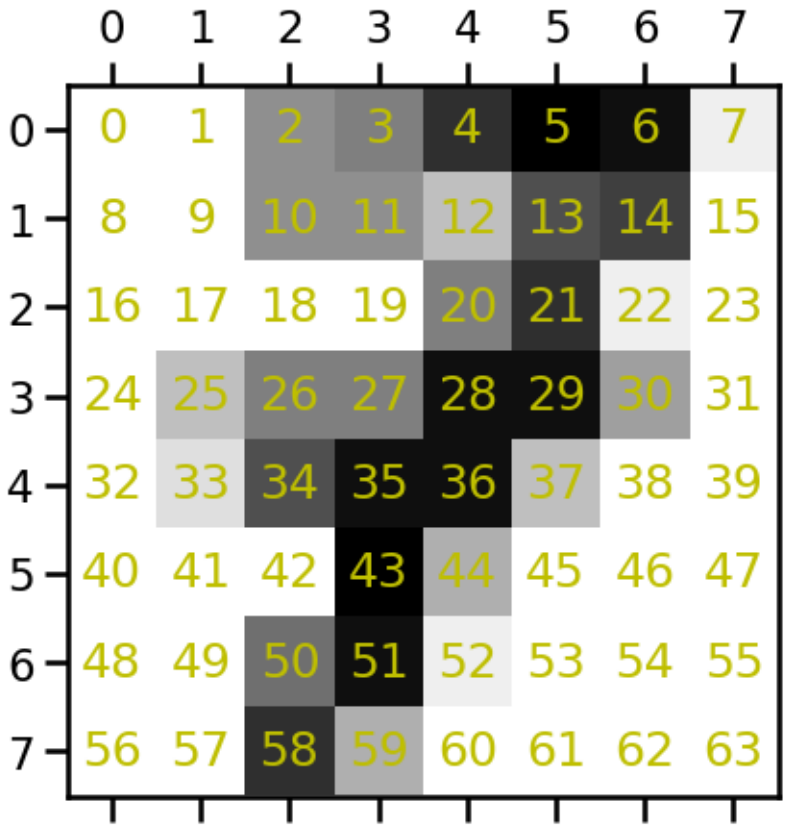


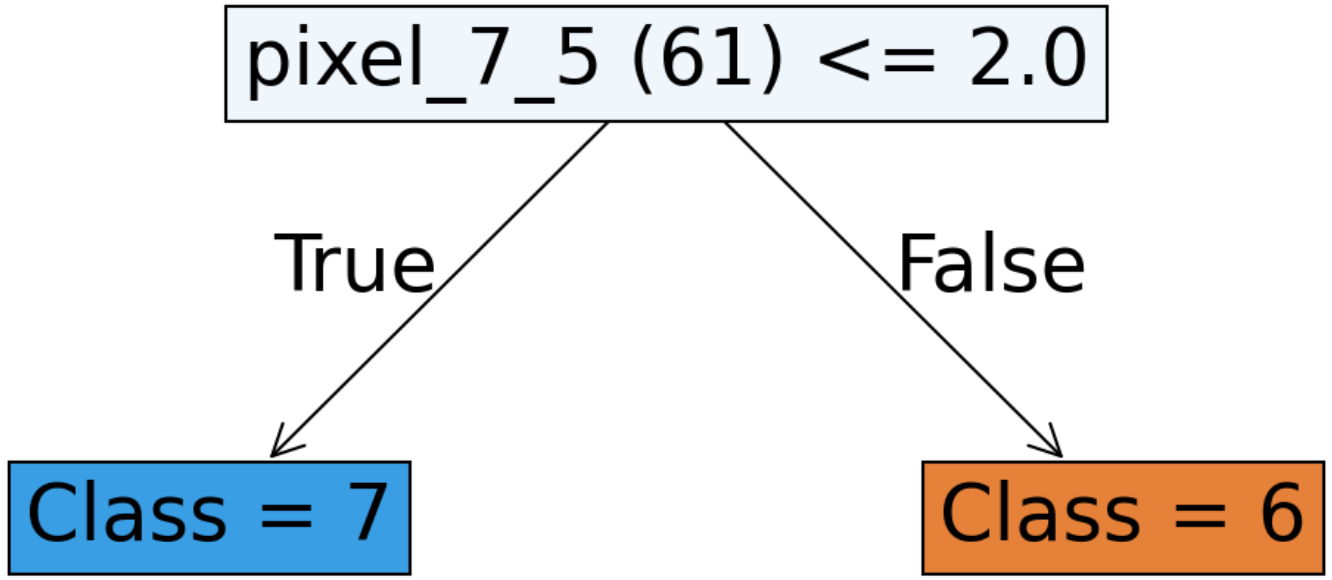
Recognising handwritten digits





Recognising handwritten digits

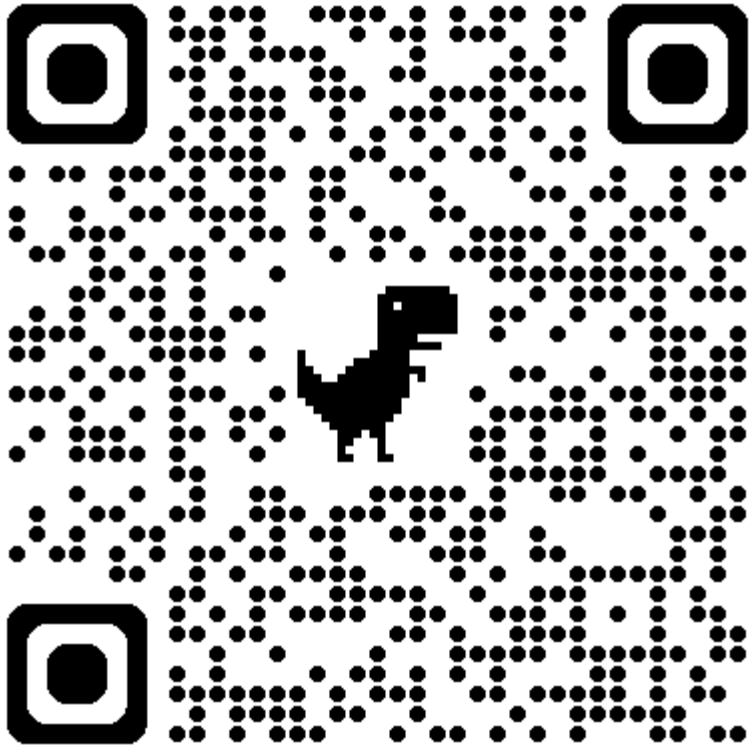




Unsupervised Machine Learning

"Don't tell it the answers"

Controversial Opinions

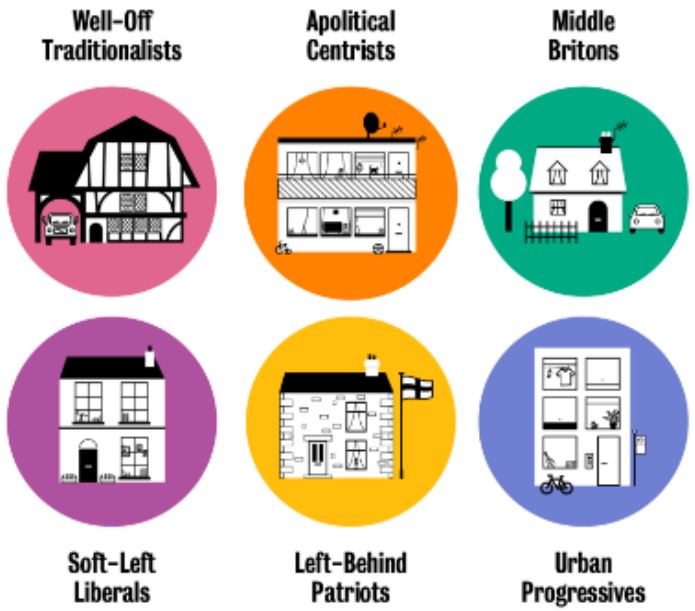


https://forms.gle/C1pyc5uQxA37wHdy9

Clustering

Explore our six voter types for a more nuanced understanding of the dividing lines in British politics.

National Centre for Social Research



Dividing Lines: A Classification of British Voters

https://natcen.ac.uk/dividing-lines

SEVEN SEGMENTS OF BRITAIN

https://www.moreincommon.org.uk/seven-segments/

Callback to Top Trumps

Cluster 1: Large wingspan, long lived, small clutch, independent, ugly birds

BIG UGLY BIRDS

Cluster 2: Quite small wingspan, short lived, small clutch, cute

SMALL CUTE BIRDS

Cluster 3: small wingspan, fairly short-lived, medium clutch size, dependent, not very cute

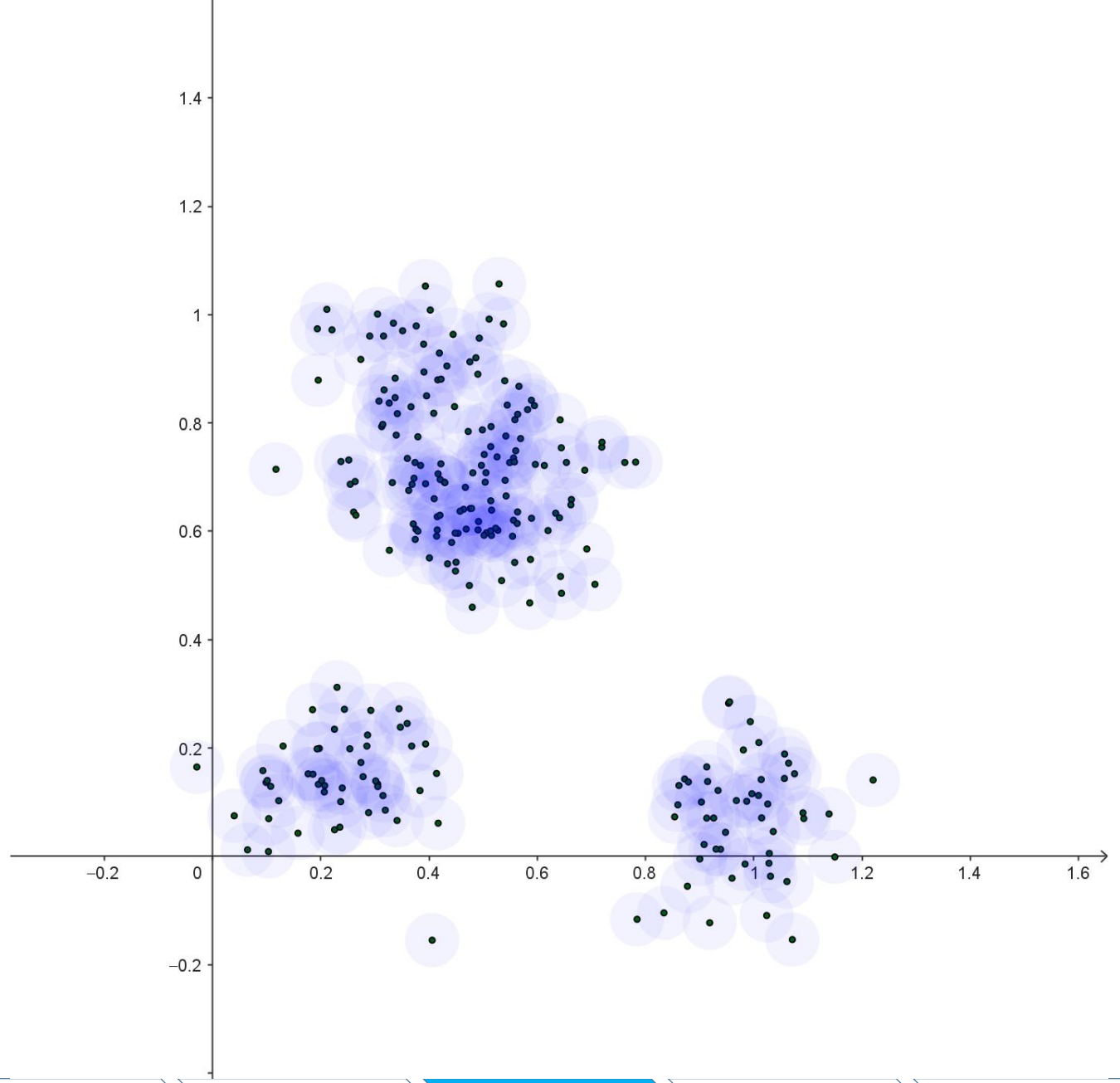
SMALL UGLY BIRDS

Cluster 4: Medium wingspan, medium length life, large clutch size, pretty cute but not very

MEH BIRDS

MEI

Clustering



Controversial Opinions

Your data?

Reinforcement Learning

bot bot

"Good ~~dog~~" and "Bad ~~dog~~"

Reinforcement Learning

Reinforcement learning: Training a simple game bot

Higher or Lower, with a single die

Will the next roll will be Higher or Lower?

How might you train a ‘machine’ to play well?

Higher or Lower

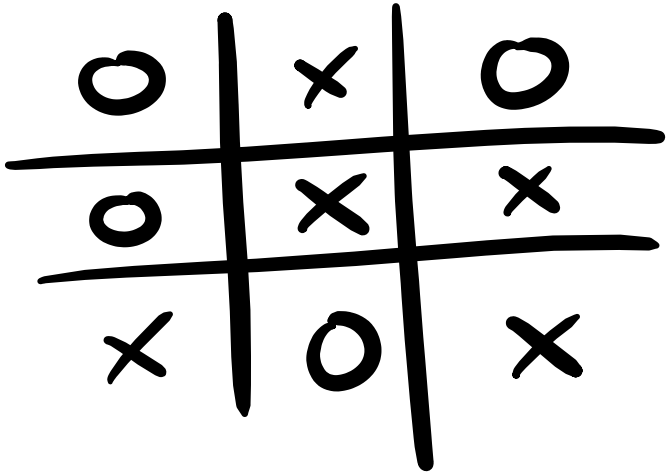
What happens next?

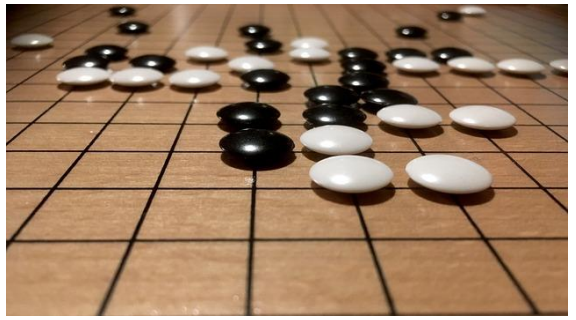
(& what questions do you have?)

What is reinforcement learning?

Reinforcement learning:
Evolving a strategy through reward/punishment

Examples:
Noughts & crosses, chess, Go





HOLDIR: (Higher Or Lower DIce Robot)

This game has 6 states:

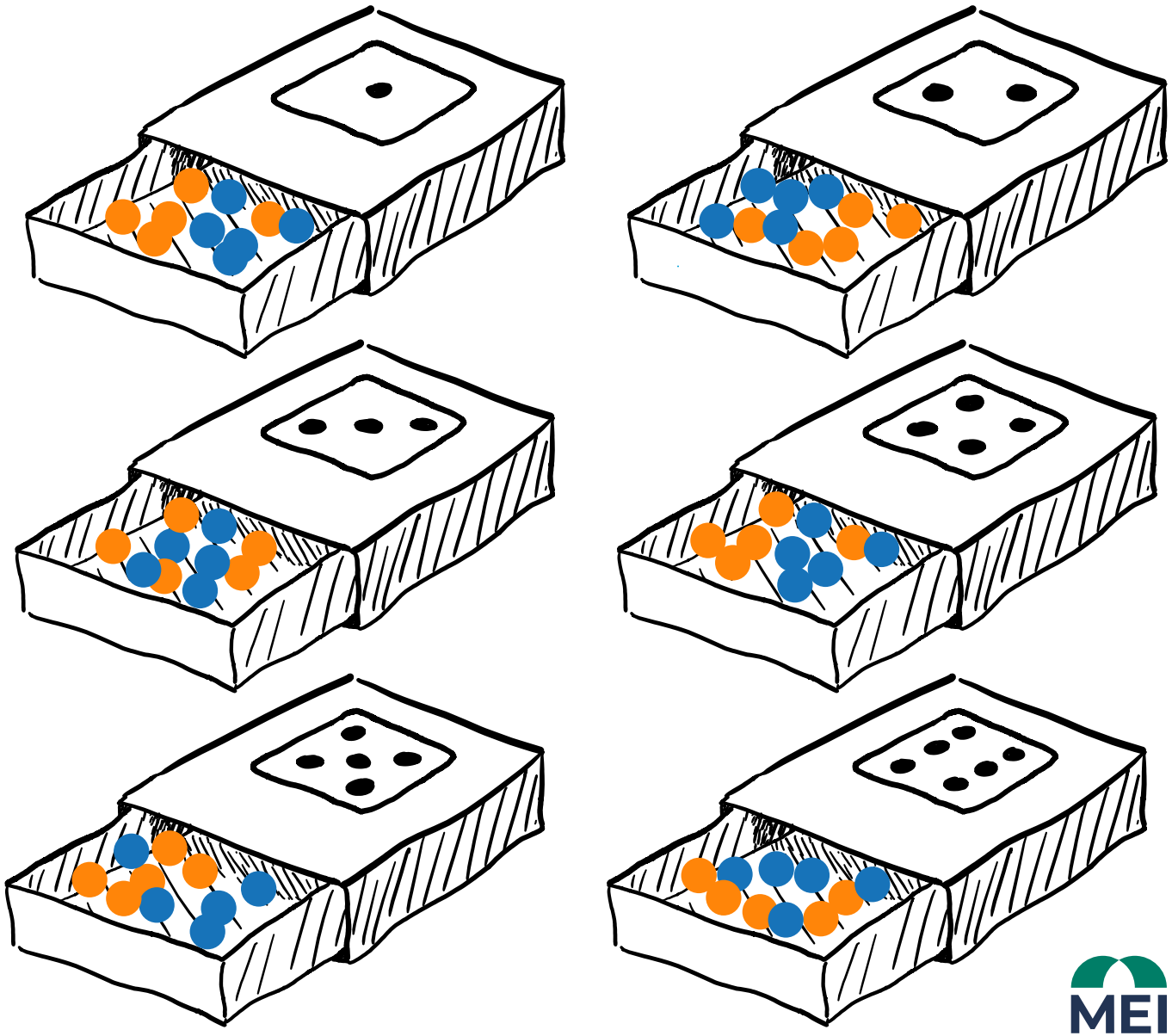
(previous roll was 1, 2, 3, 4, 5, or 6)

Use 6 ‘matchboxes’, labelled appropriately

Start with equal amounts of
blue and orange beads in each box

- Blue = Guess Higher
- Orange = Guess Lower

The ‘machine’ decides how to play by picking a bead at random from the appropriate box.



Reward and/or punish

If the guess is incorrect:
'Punish' by not replacing the chosen bead

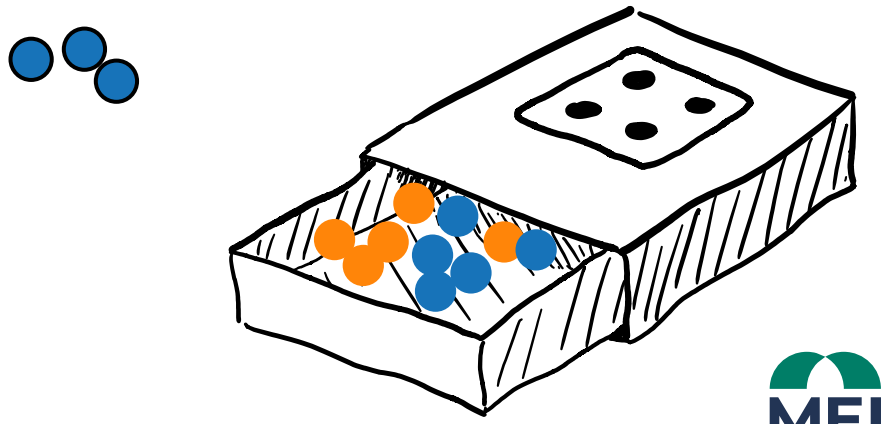
If the guess is correct:
'Reward' by replacing the bead and adding another bead of the same colour

e.g. A '4' is rolled

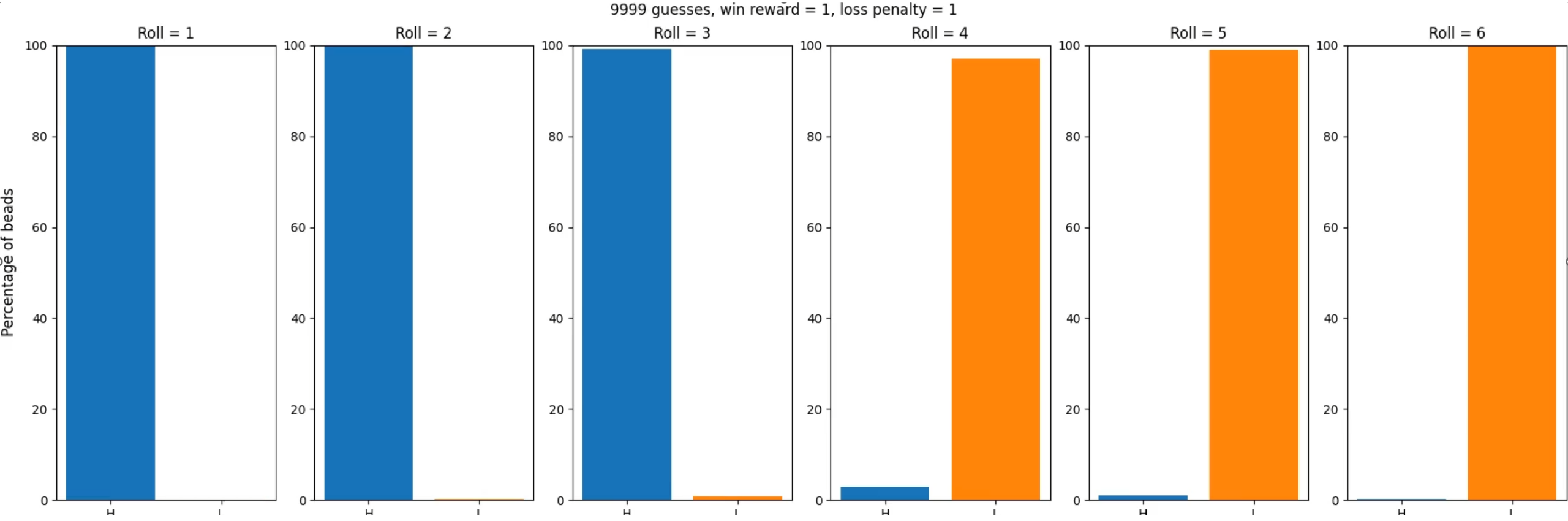
- Randomly pick a bead from the 4 box
- Guess accordingly (Blue = Higher)

  a) If the next roll is higher, reward it

  b) Otherwise, punish it

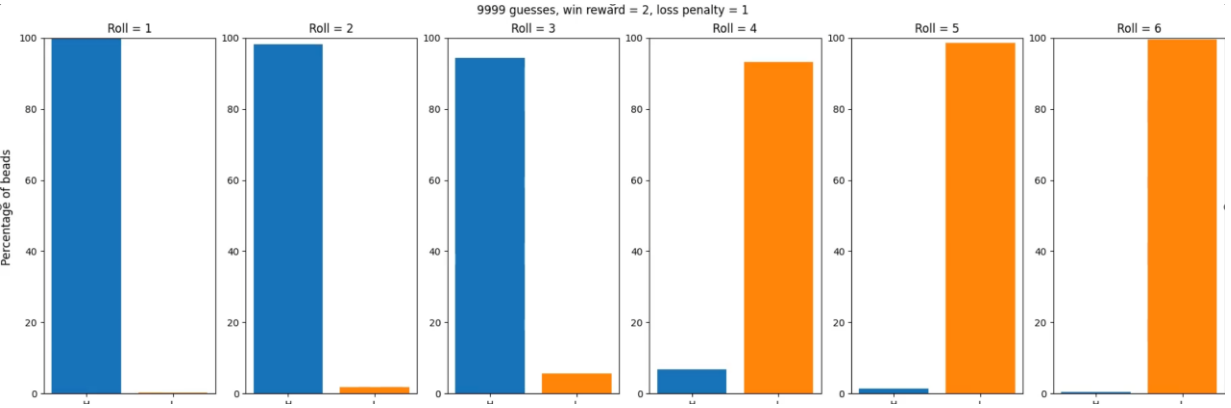


The matchboxes after 10,000 guesses

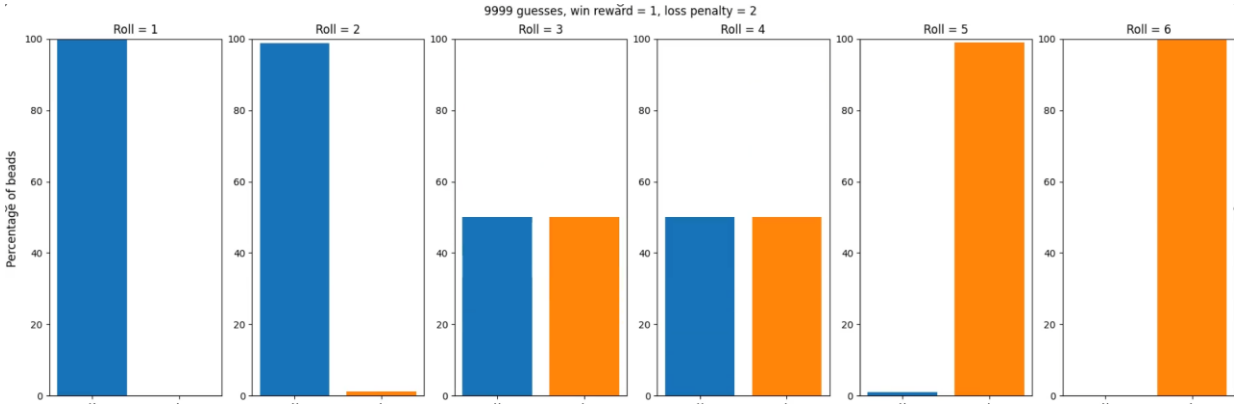


The bars represent the proportions of each colour bead in the box as a percentage

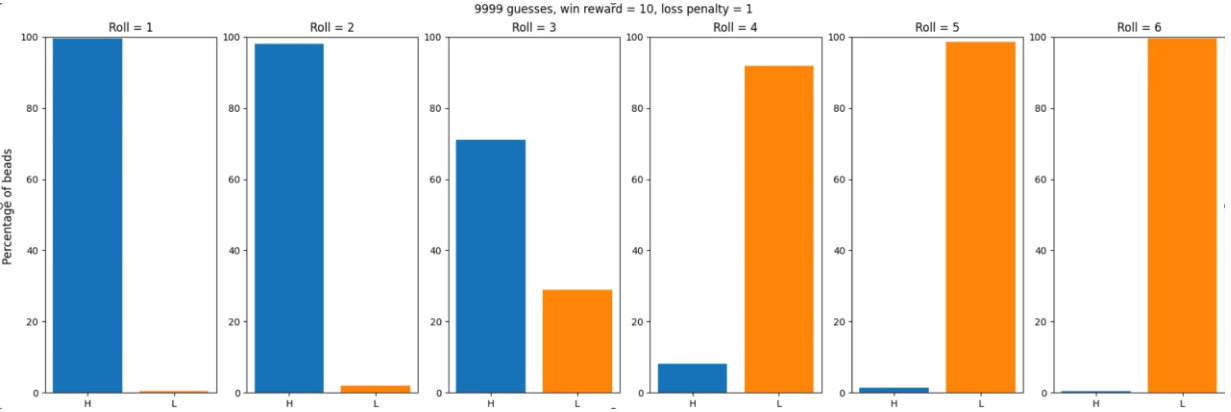
Reward/Punish parameters



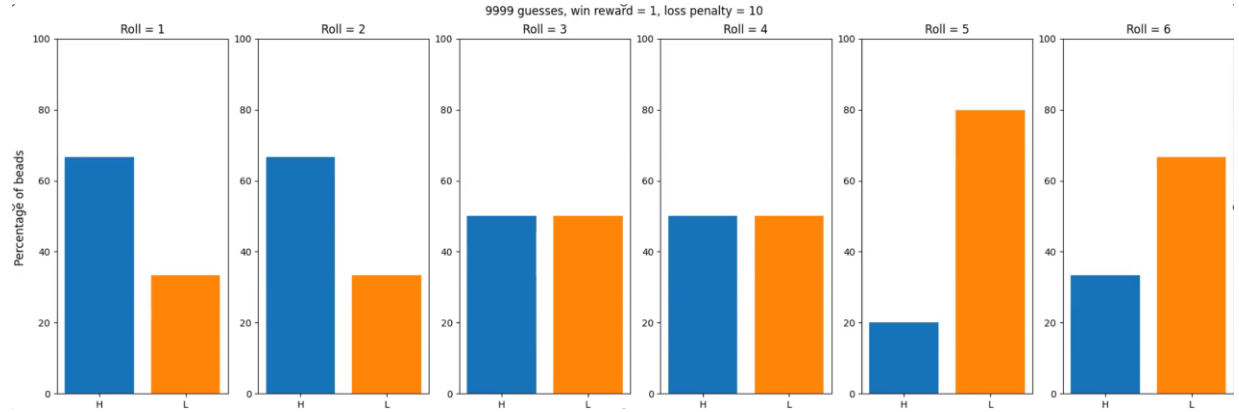
Win reward = 2, Loss penalty = 1



Win reward = 1, Loss penalty = 2



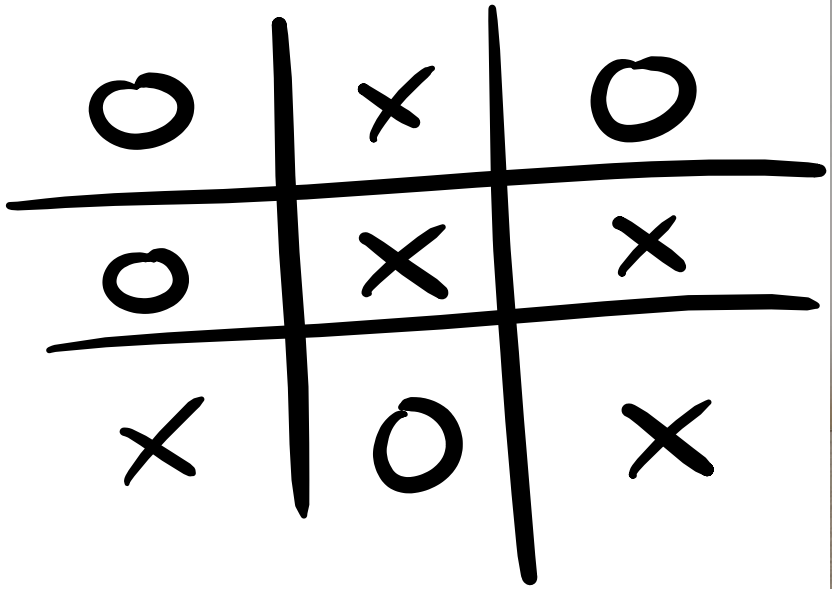
Win reward = 10, Loss penalty = 1

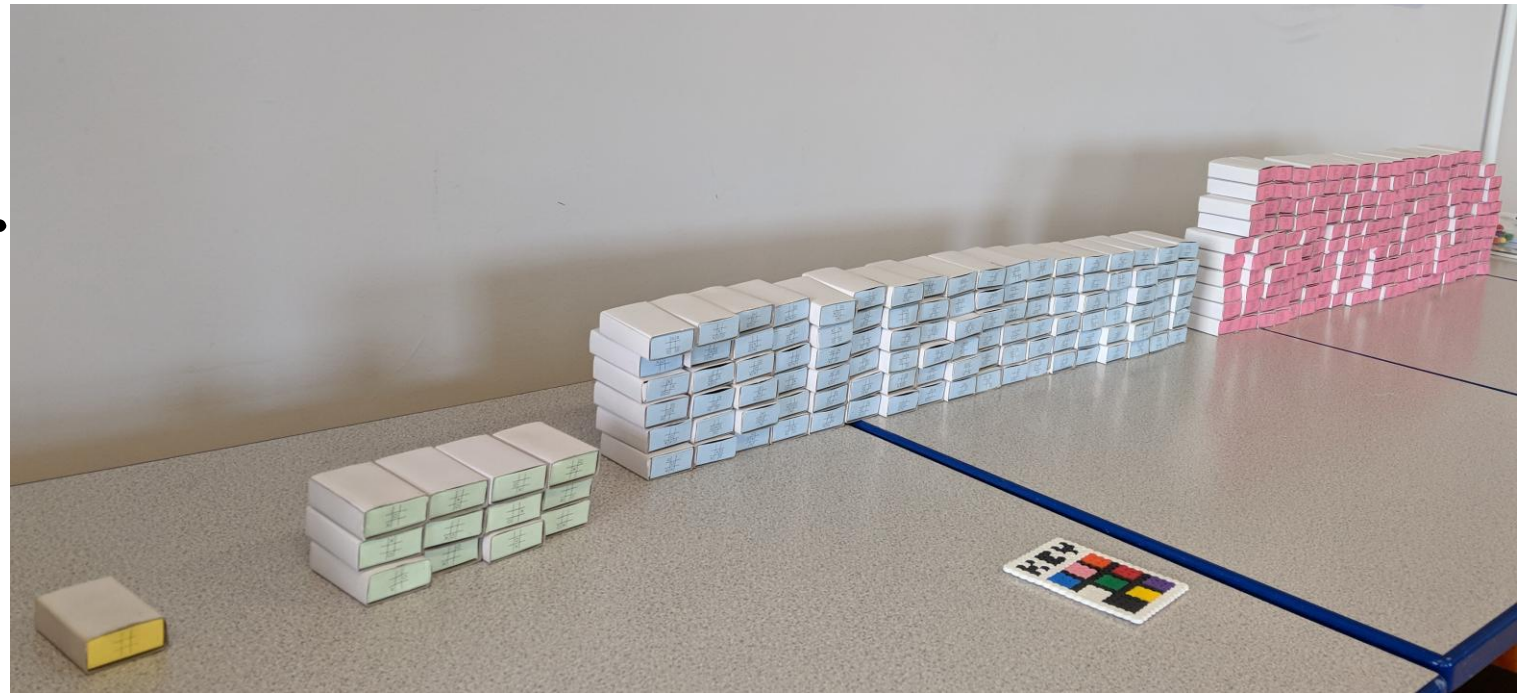


Win reward = 1, Loss penalty = 10

M.E.N.A.C.E.

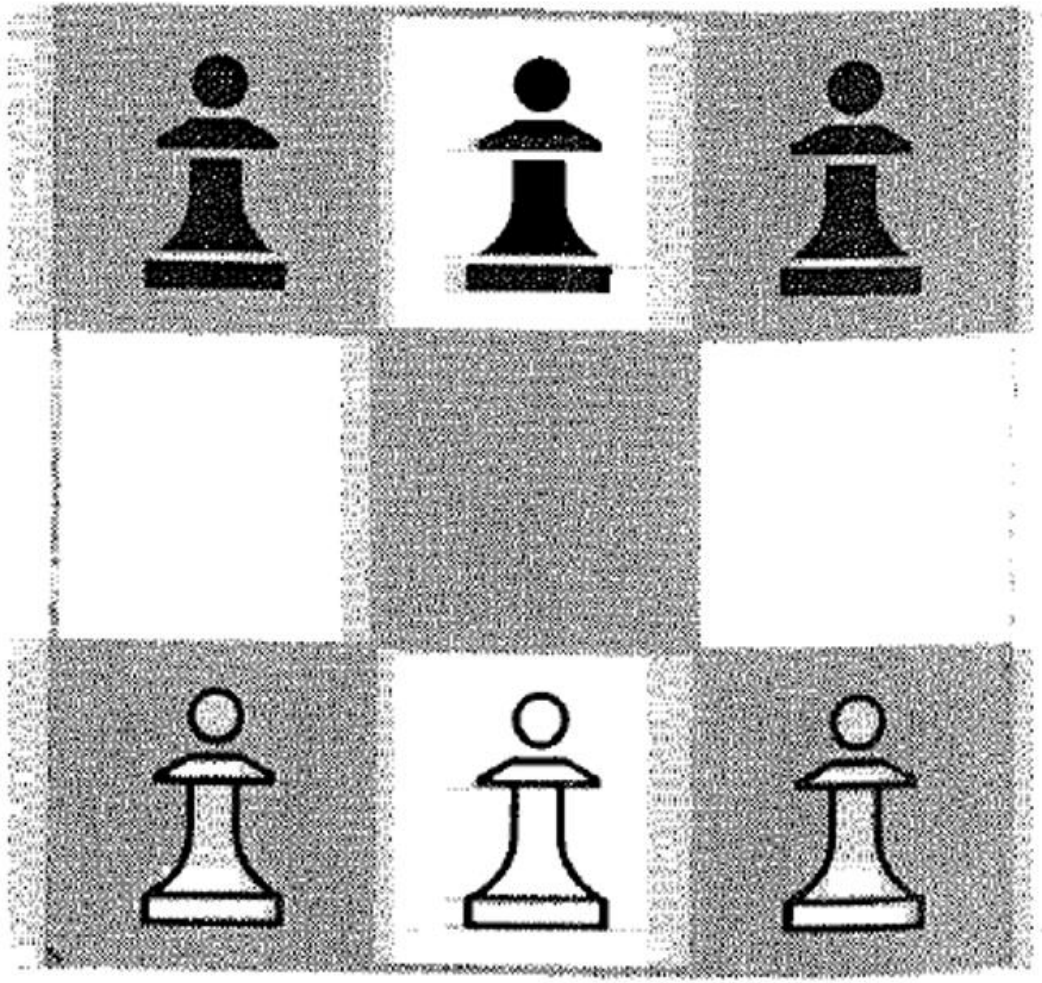
Machine (or Matchbox) Educable Noughts And Crosses Engine





https://www.mscroggs.co.uk/menace/

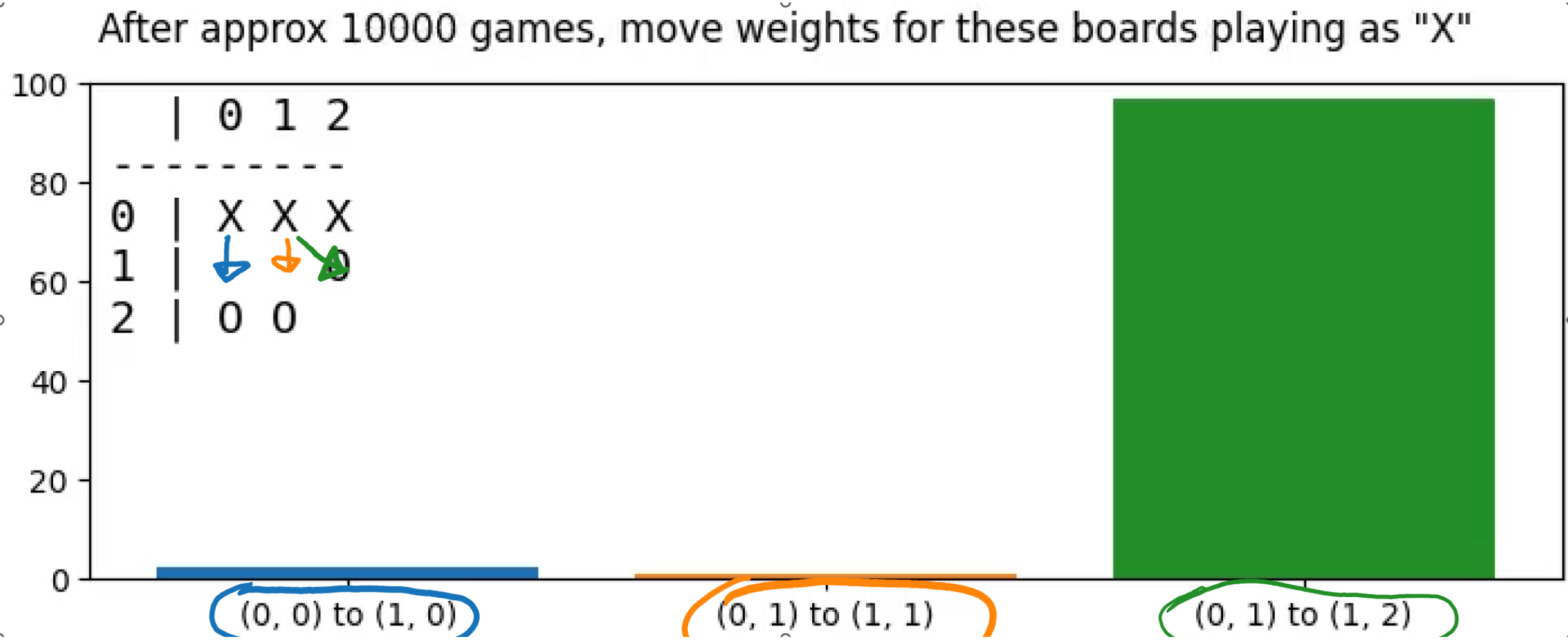
Martin Gardner – Hexapawn – 1962 Scientific American



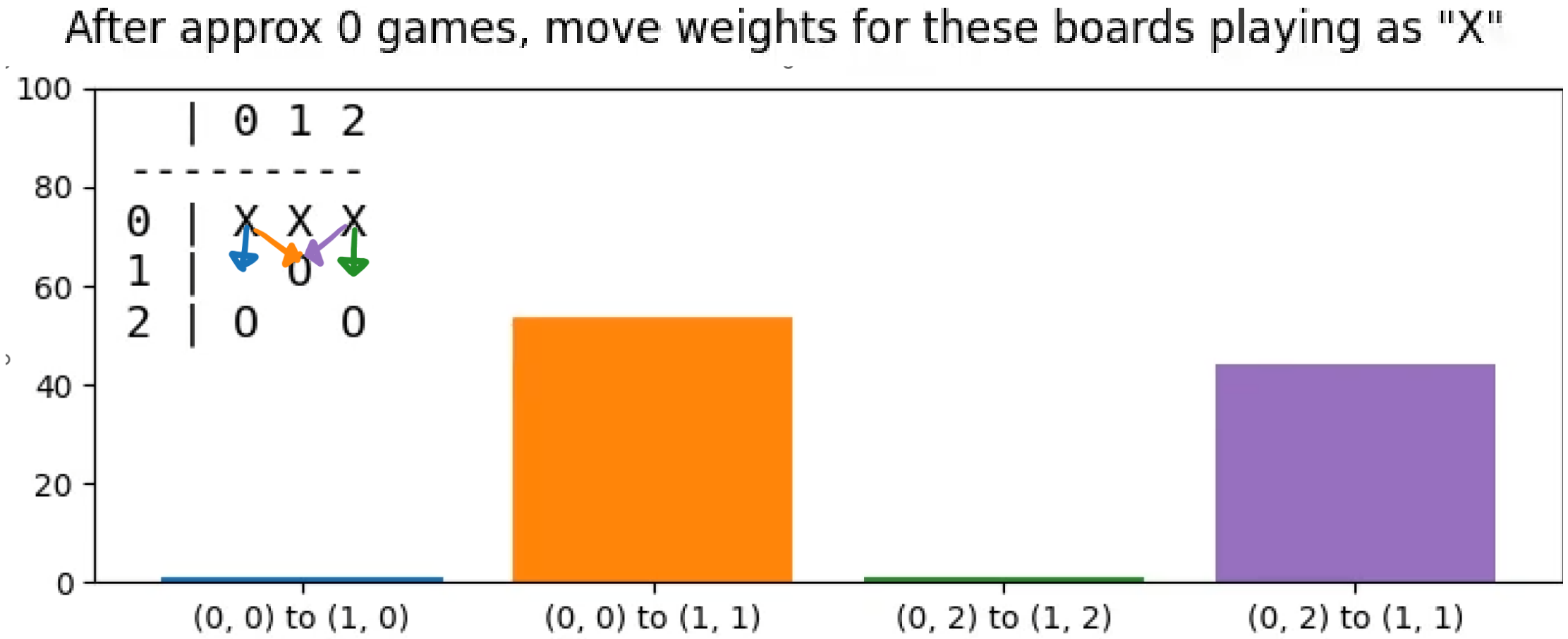
The game of hexapawn

MEI

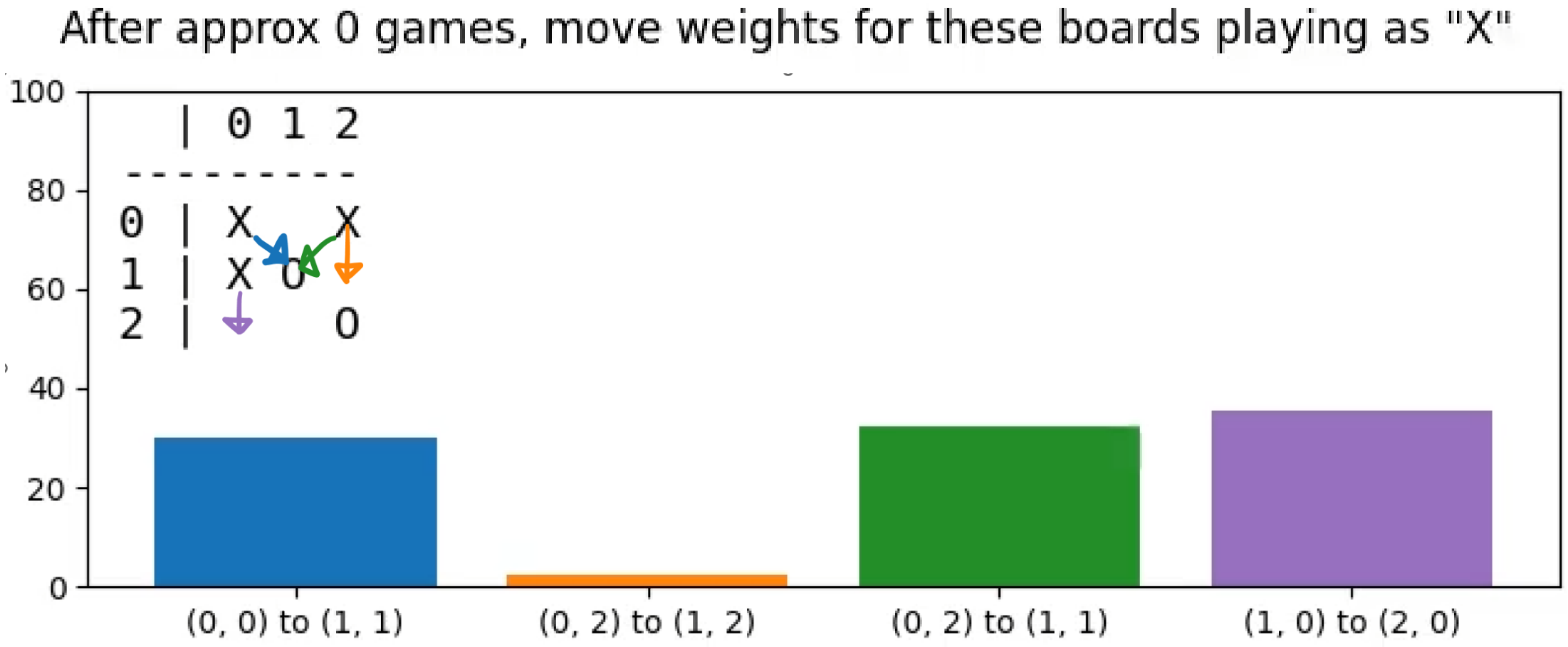
Hexapawn ‘Matchbox’ Animation



More Hexapawn Matchboxes



More Hexapawn Matchboxes



Other games

Chess

Go

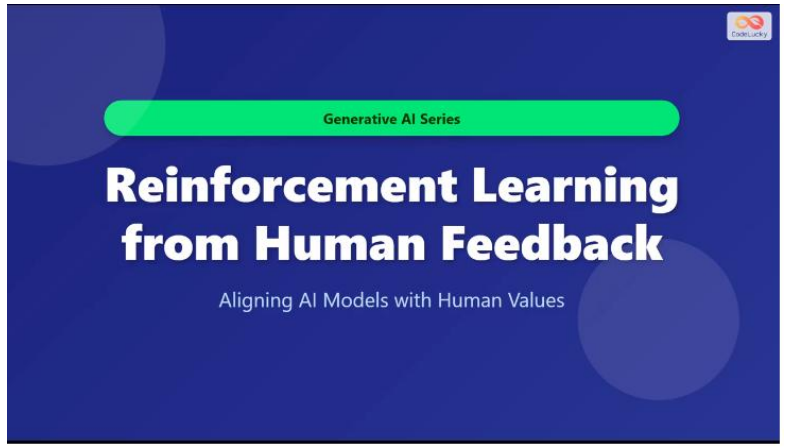
Reinforcement learning: Applications

AlphaGo

youtu.be/WXuK6gekU1Y

Self-driving cars

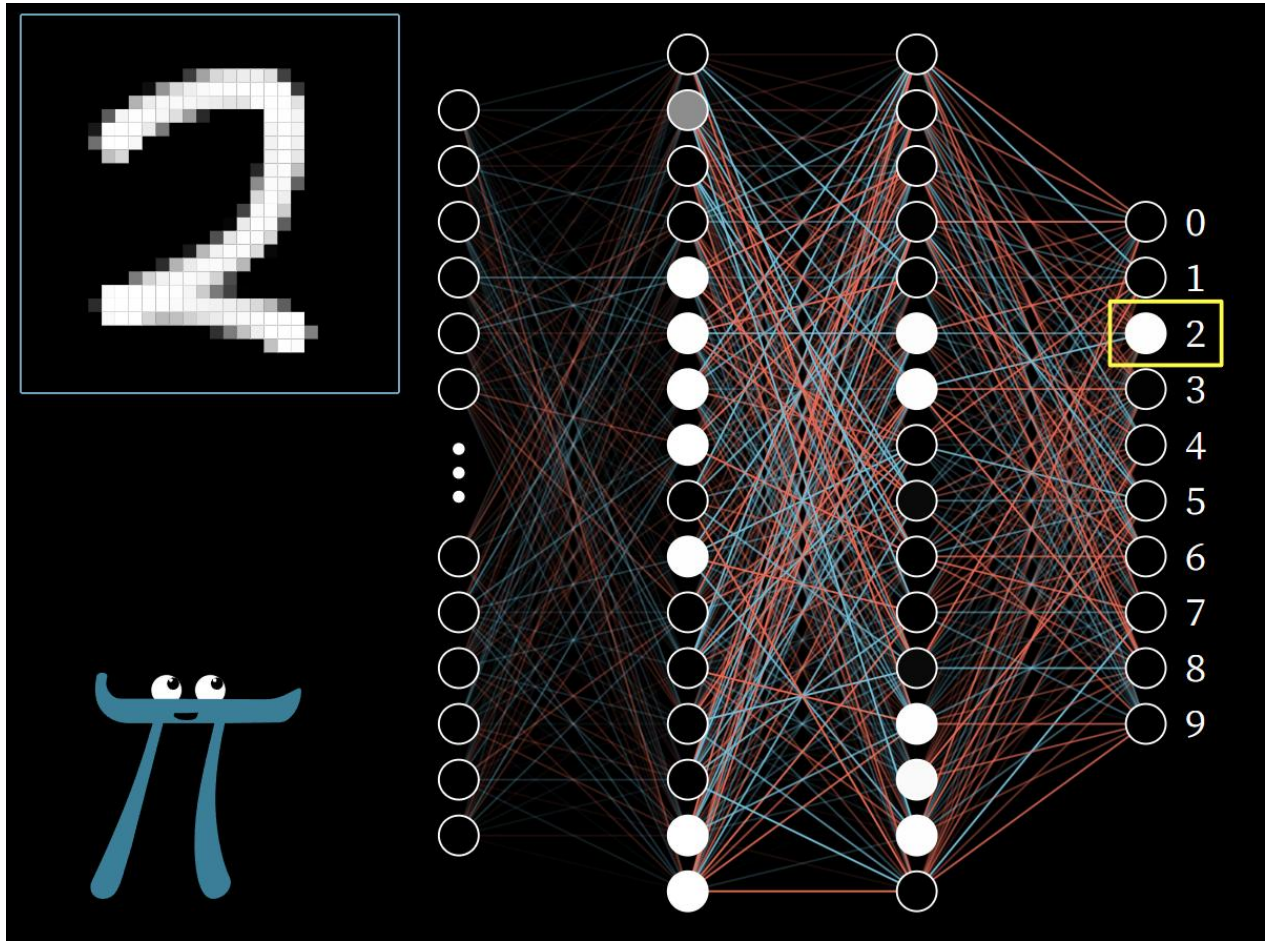
youtu.be/ixIoDYVfKA0



Large language models

youtu.be/-dvIK9zt8qM

Handwritten digits and Neural Networks



https://www.3blue1brown.com/lessons/neural-networks

AMSP Maths into AI courses

Maths into AI Student Programme

Maths into Data Science and AI aims to develop students' knowledge of how maths and statistics underpin machine learning and AI. It supports students' future study and careers by developing practical skills in modelling with real data.

EXPLORE THE STUDENT COURSES »

Maths into AI Teacher Programme

Our professional development aims to develop teachers' understanding of how maths and statistics underpin machine learning and AI, as well as demonstrating how these link to the existing curriculum. We offer an introductory webinar as well as online and blended sustained courses.

EXPLORE THE TEACHER COURSES »

amsp.org.uk/teachers/maths-into-ai-programme/