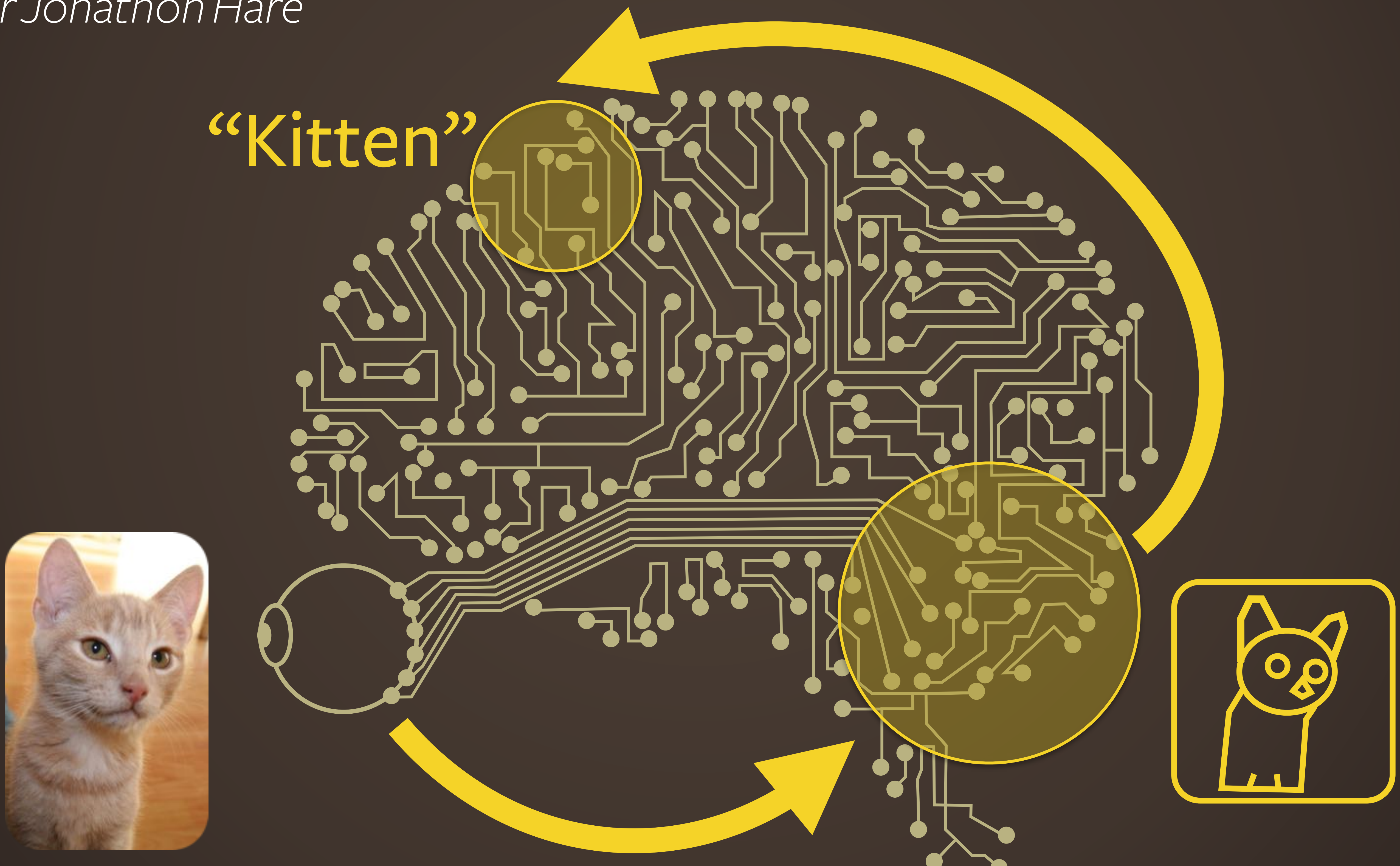
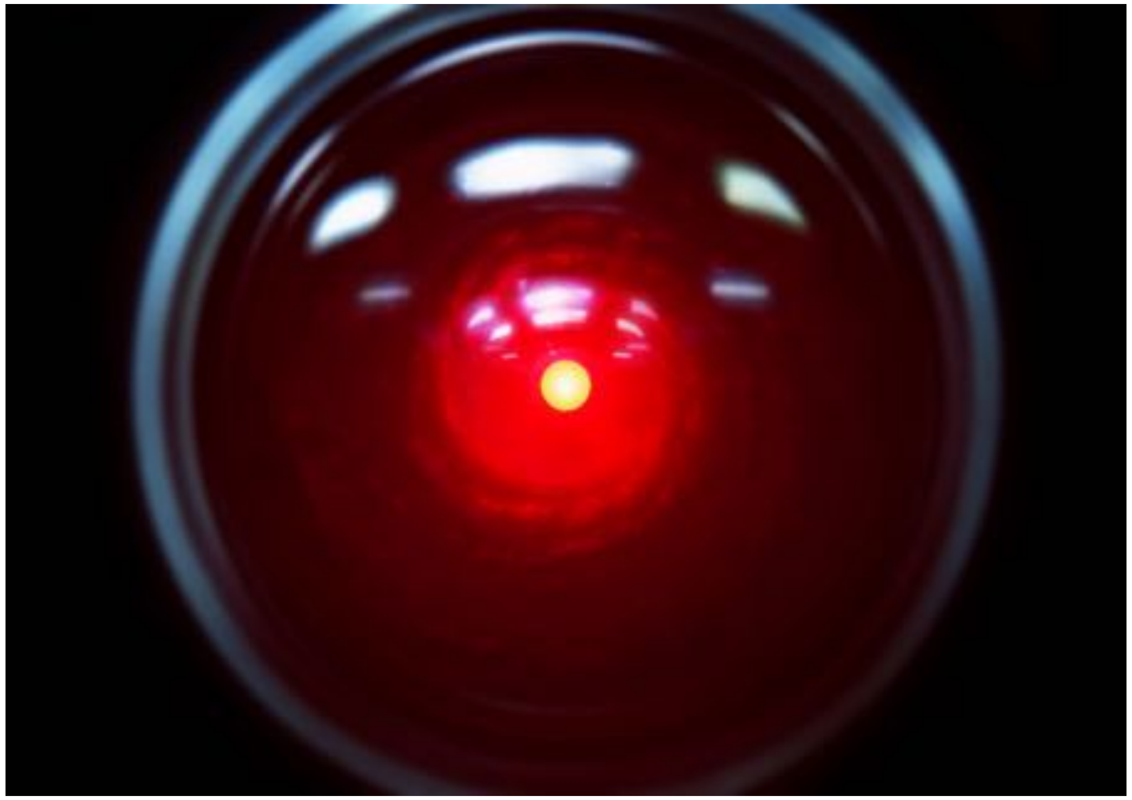
UNIVERSITY OF
Southampton

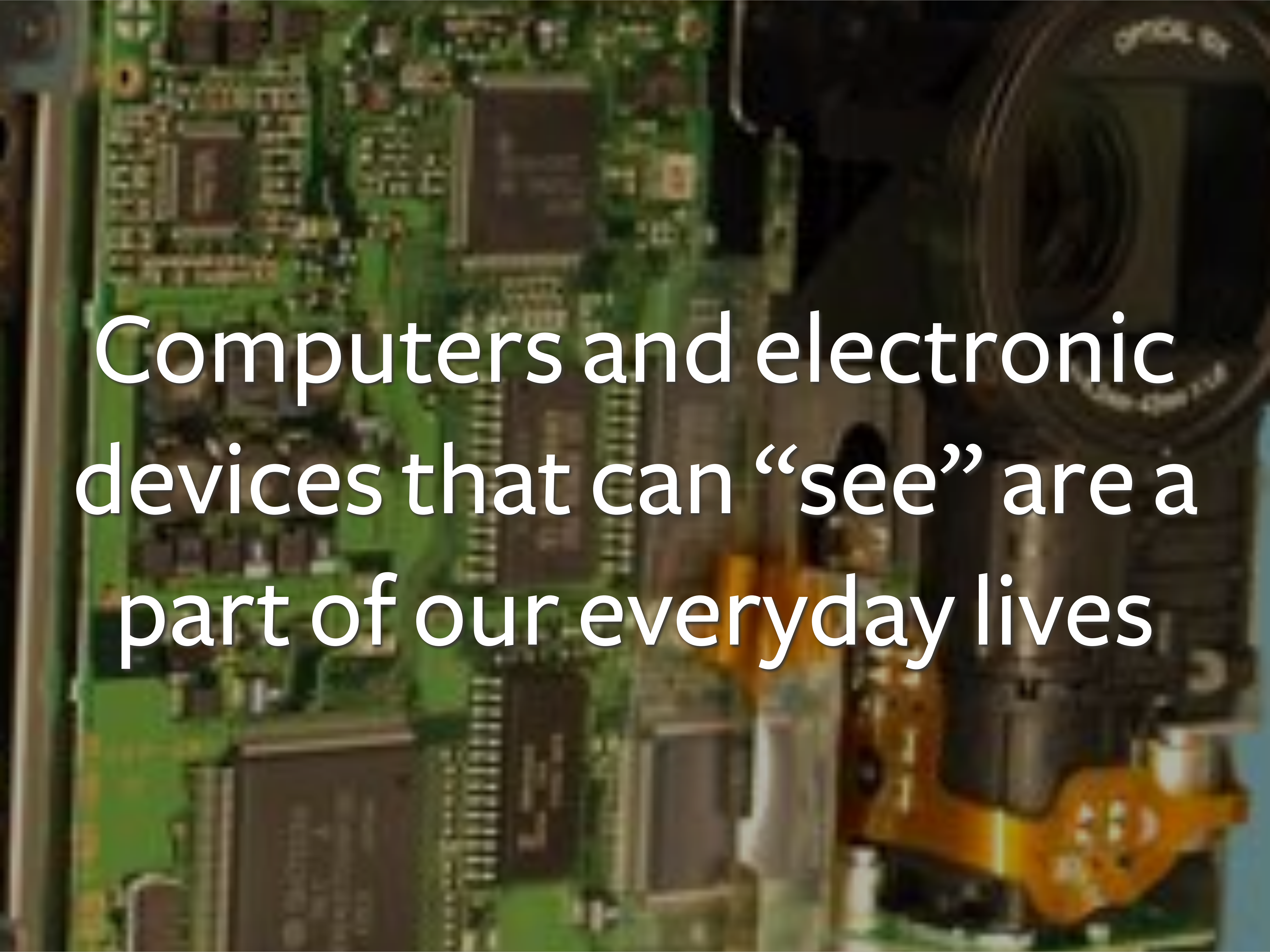
Teaching machines to see

Dr Jonathon Hare

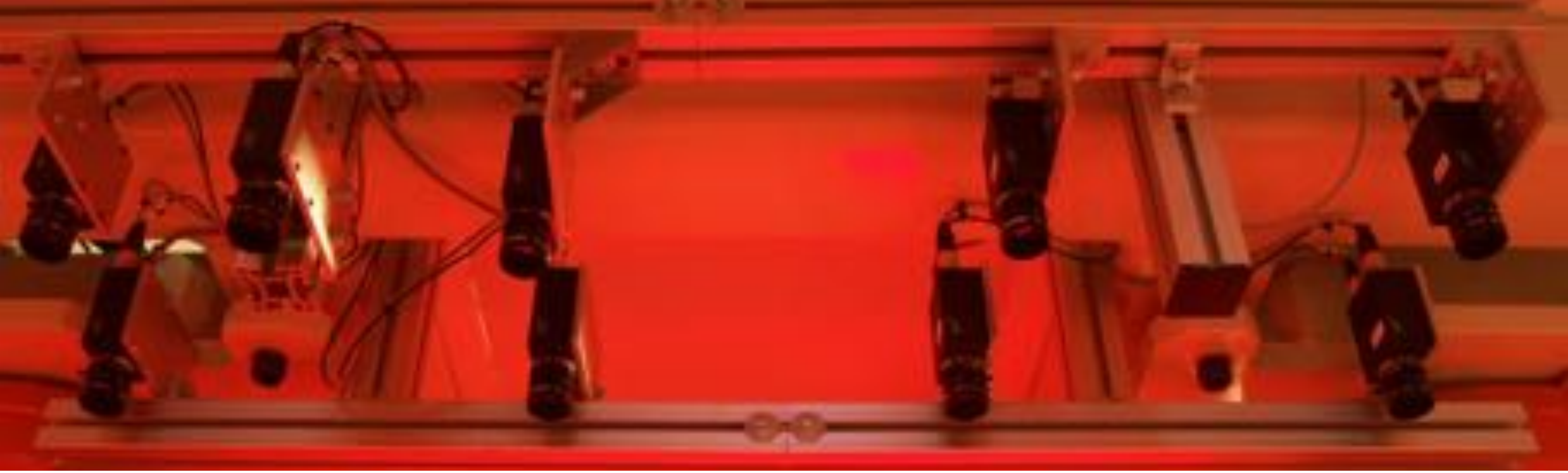



VISUAL:
MODEL 236
YAMAHA
ANALYSIS: MATCH:
389 VEHI 55376
690 SIZE 38022
600 TSPD 23022
287 HPWR 12048
105 CODE 20673
798 RNGE 29687

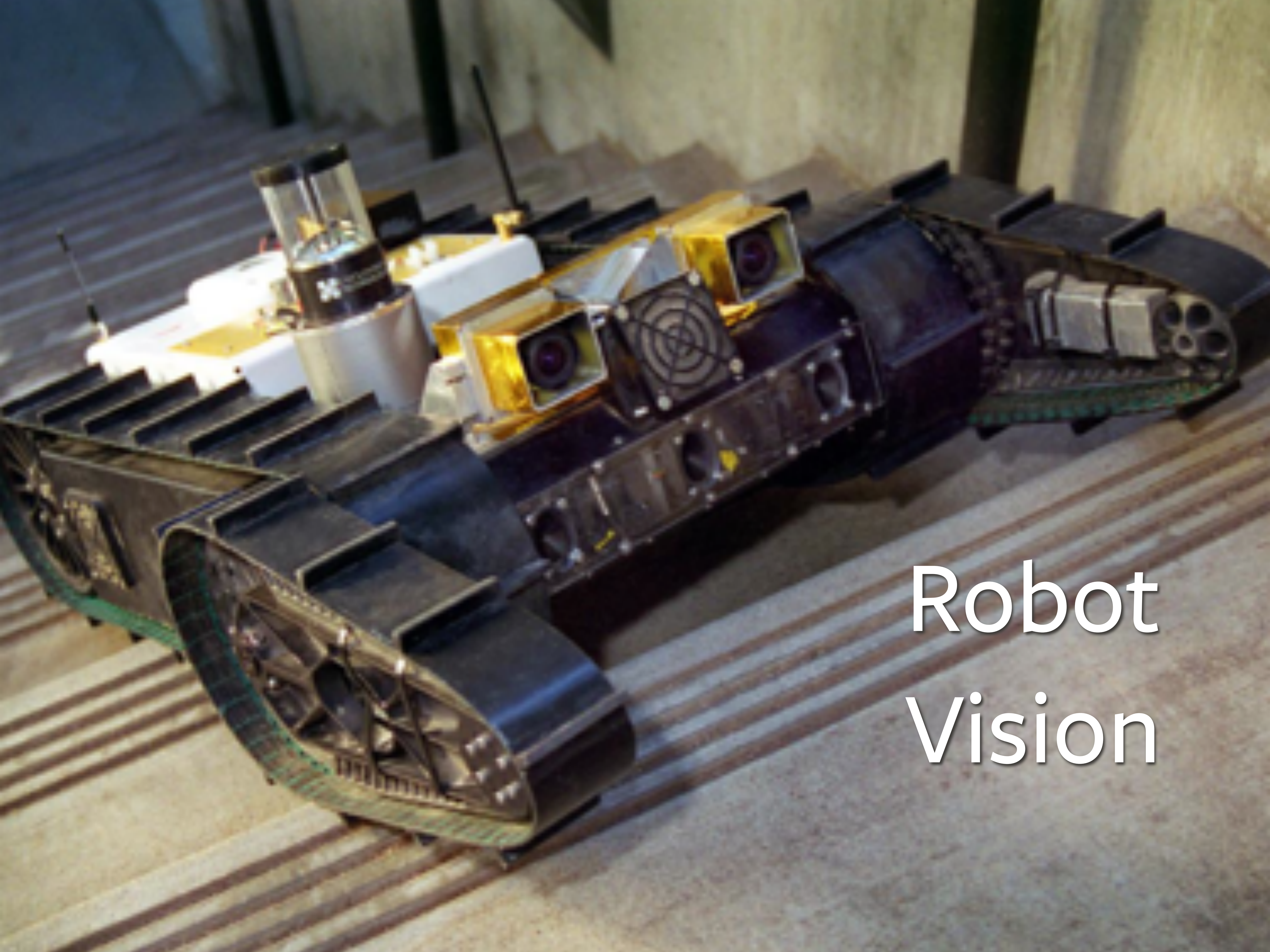




Computers and electronic devices that can “see” are a part of our everyday lives



Industrial Vision


Robot
Vision

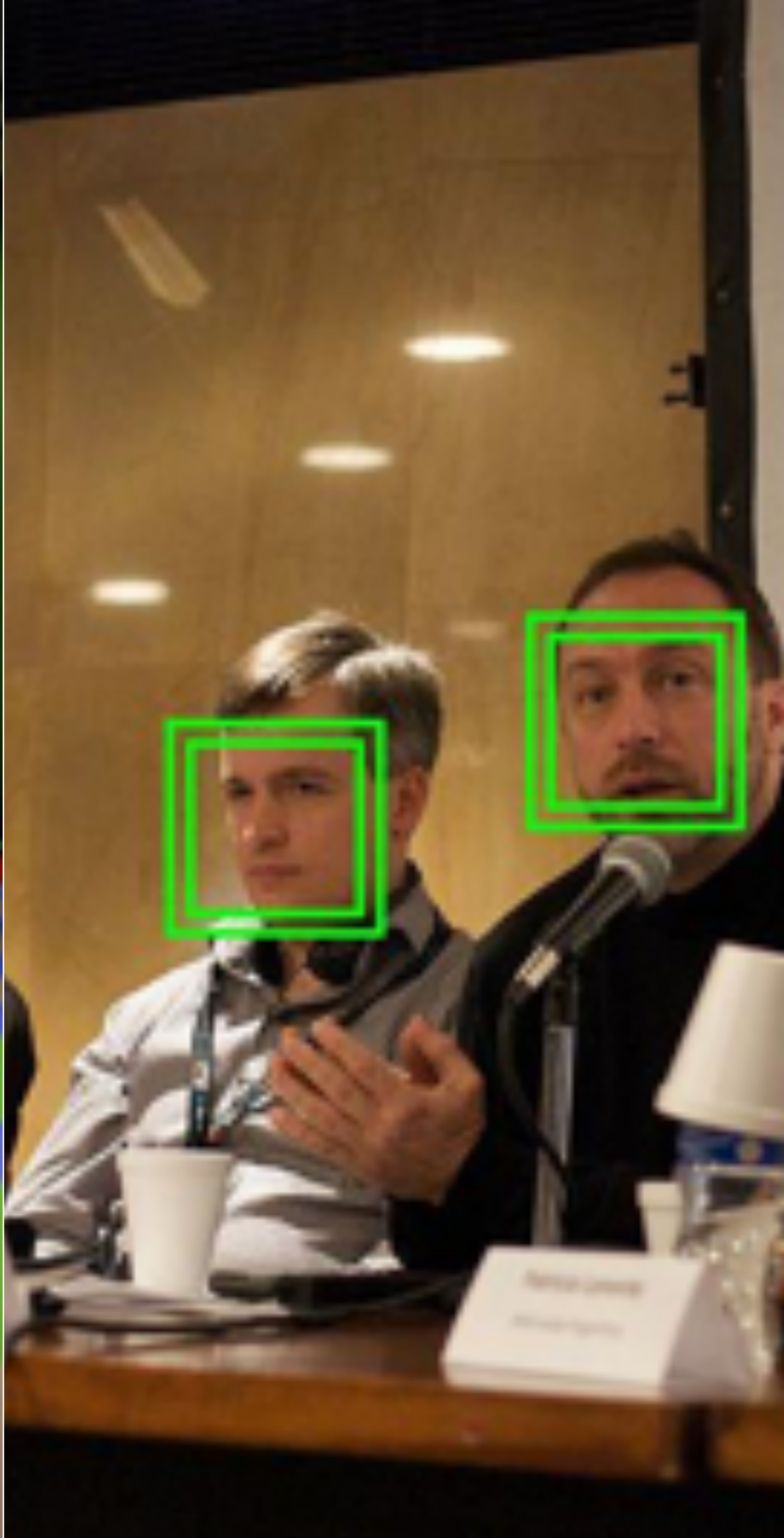

http://vimeo.com/39404736


AI AND THE EYE
Digital Image Processing
Data Structures and C Programs
Introduction to UNIX and Linux
Applied Numerical Methods for Digital Computation
Artificial Intelligence:
ARTIFICIAL INTELLIGENCE
PRACTICAL DIGITAL IMAGE PROCESSING
MACHINE LEARNING
FROM SURFACES TO OBJECTS
COMPUTER VISION & IMAGE PROCESSING

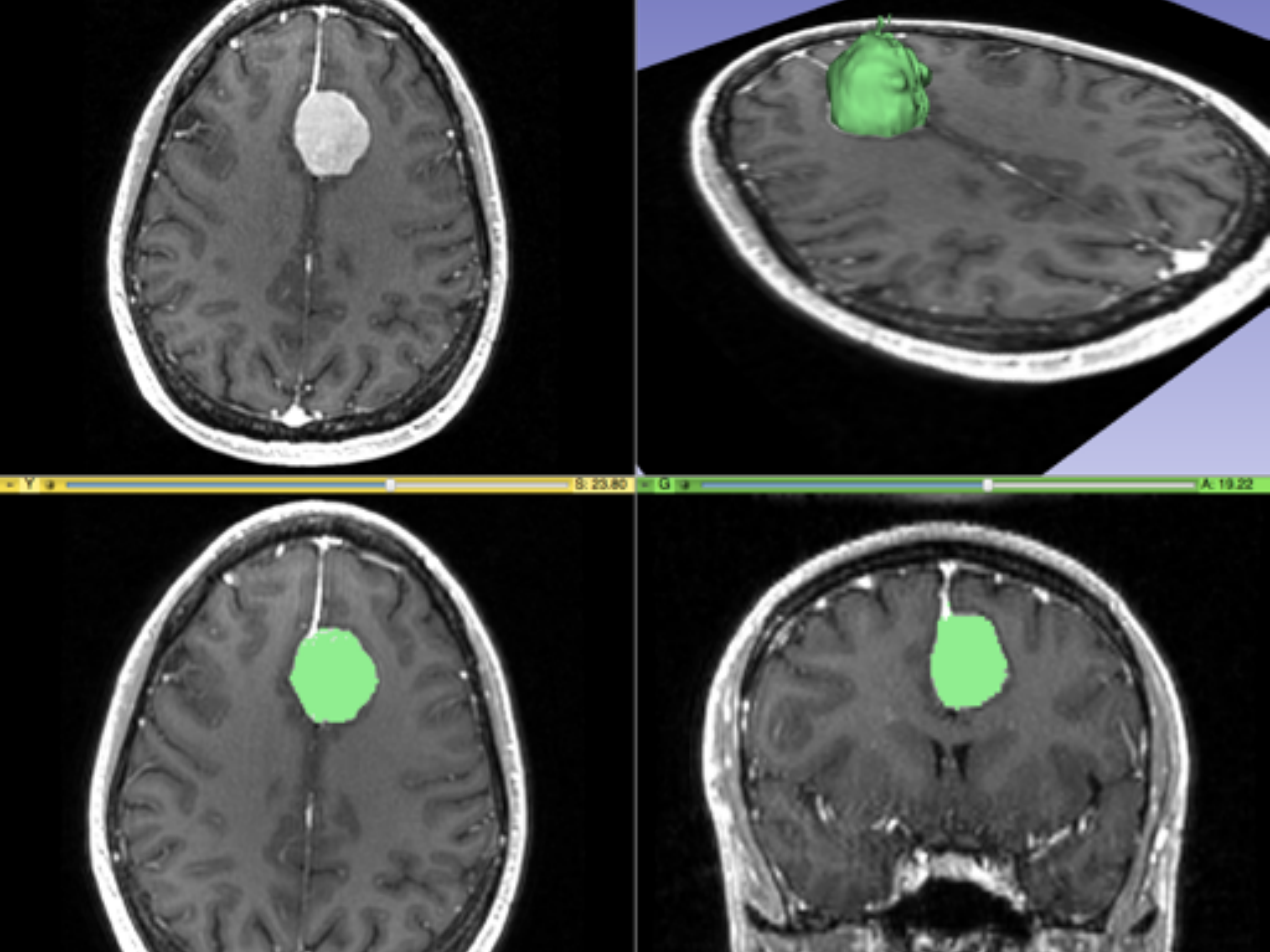
Vision in your pocket


GALLERY

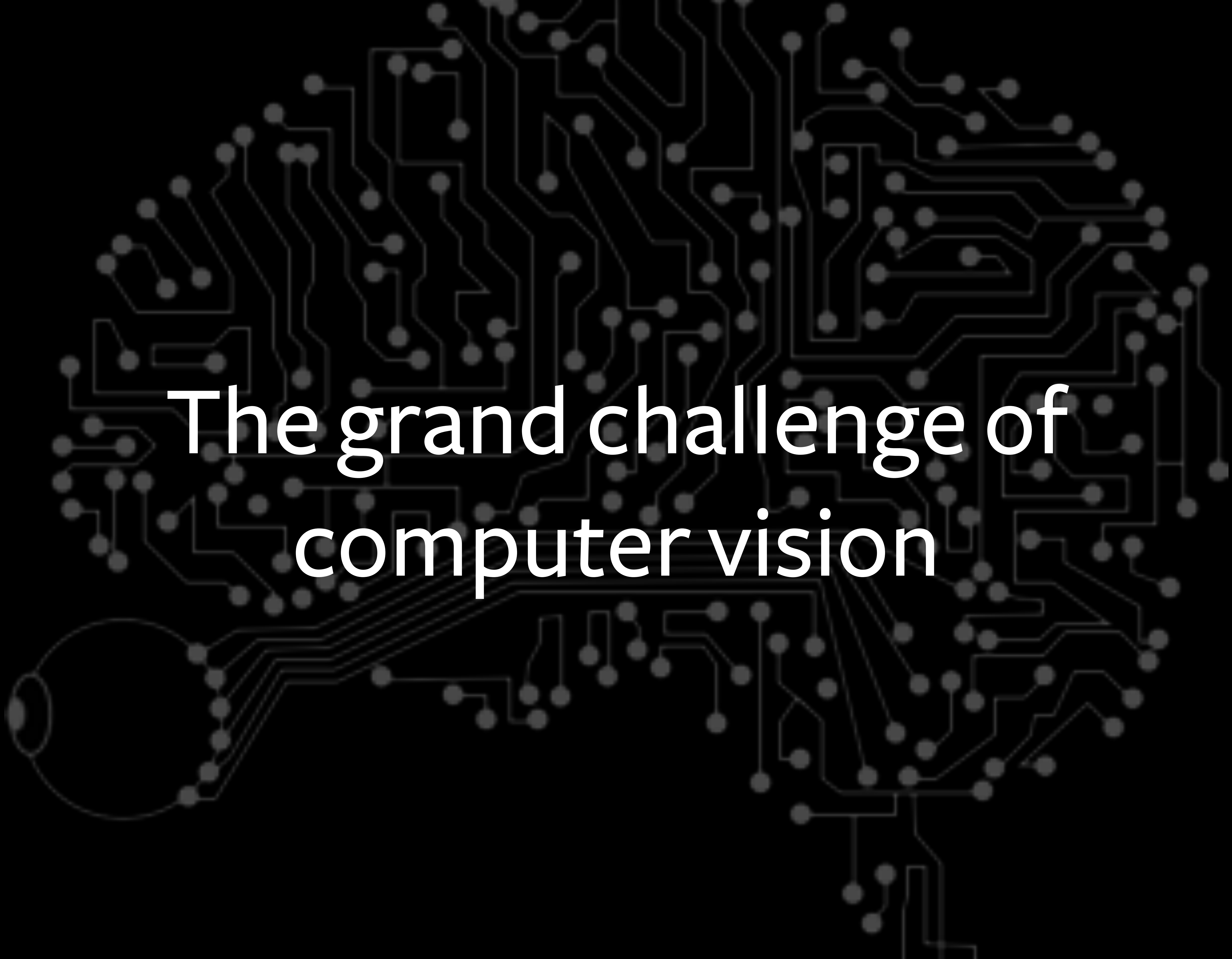

Vision all around




Medical Vision

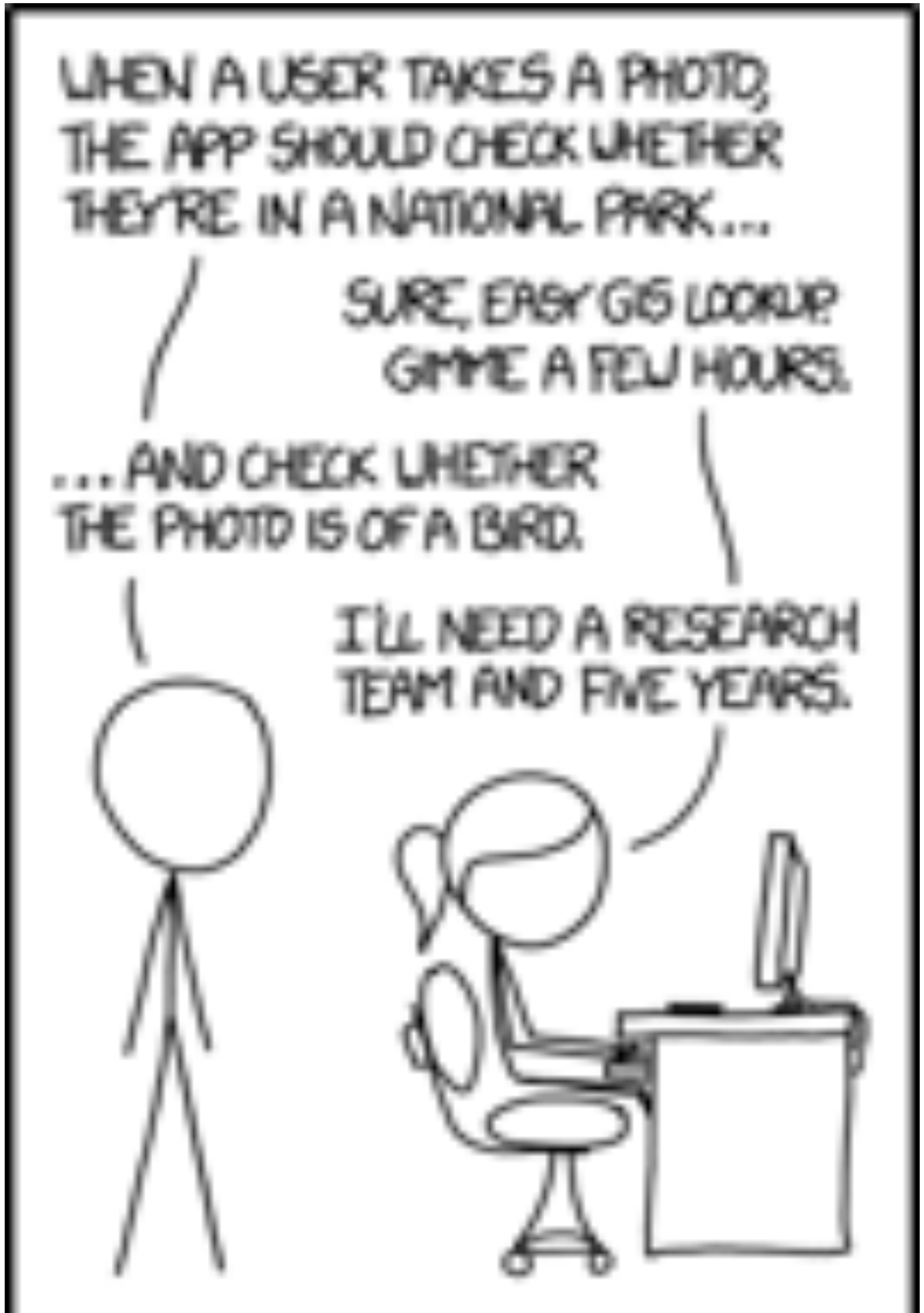


Y
S: 23.80
G
A: 19.22



The grand challenge of computer vision

Computer Vision research has always been inspired by the way humans "see" and perceive the world



IN CS, IT CAN BE HARD TO EXPLAIN THE DIFFERENCE BETWEEN THE EASY AND THE VIRTUALLY IMPOSSIBLE.

A potted history of our understanding of:

- Biological Vision
- Computation
- Machine Learning
- Computer Vision

Circa 300 BC to AD 200

emission/extramission theory
(championed by Euclid & Ptolemy)

versus

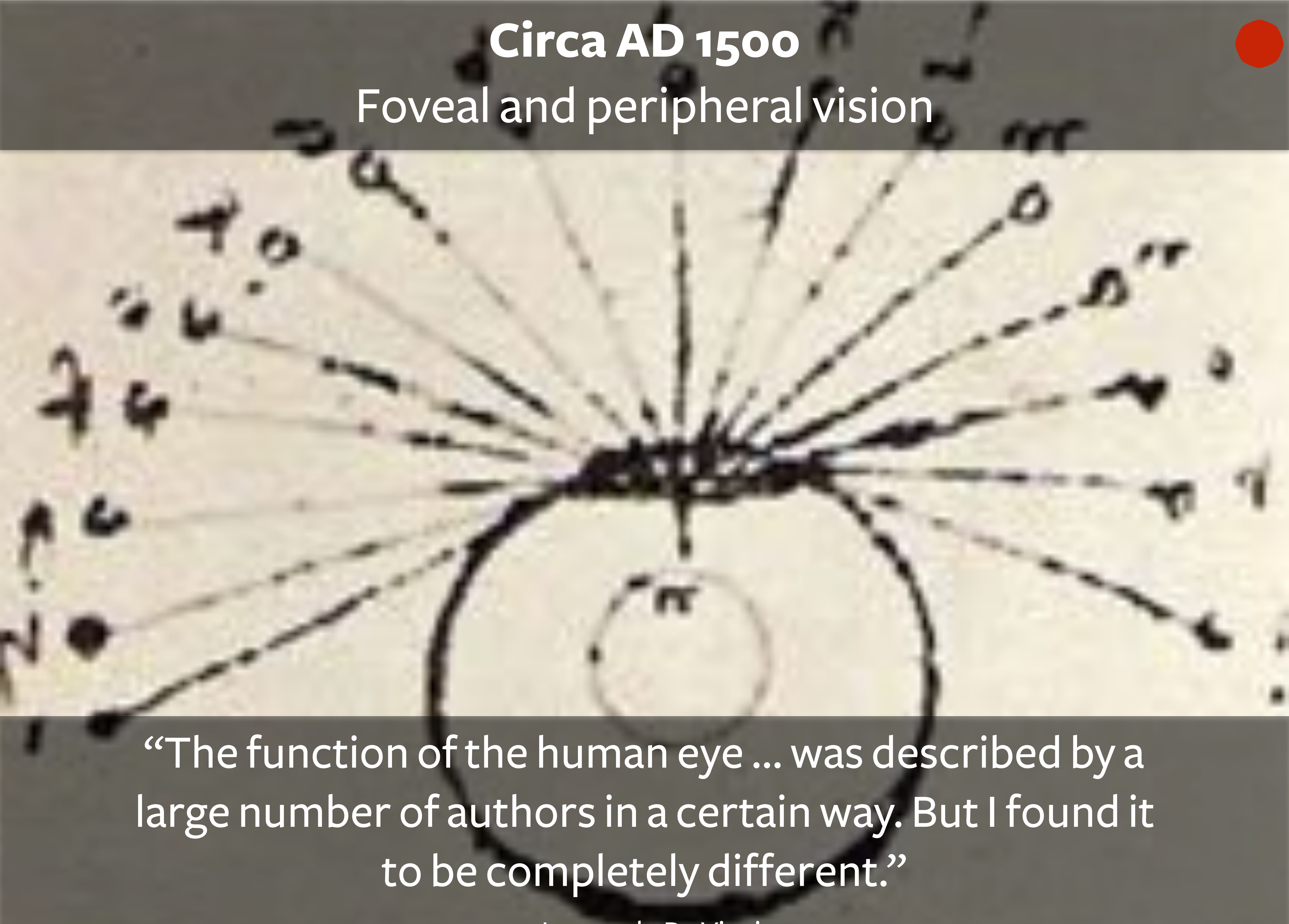
intromission theory
(championed by Aristotle & Galen)

Circa AD 100 - 1000

Understanding of the visual system gross anatomy

Circa AD 1500

Foveal and peripheral vision



"The function of the human eye ... was described by a large number of authors in a certain way. But I found it to be completely different."

–Leonardo Da Vinci

1642

Pascal’s mechanical adder

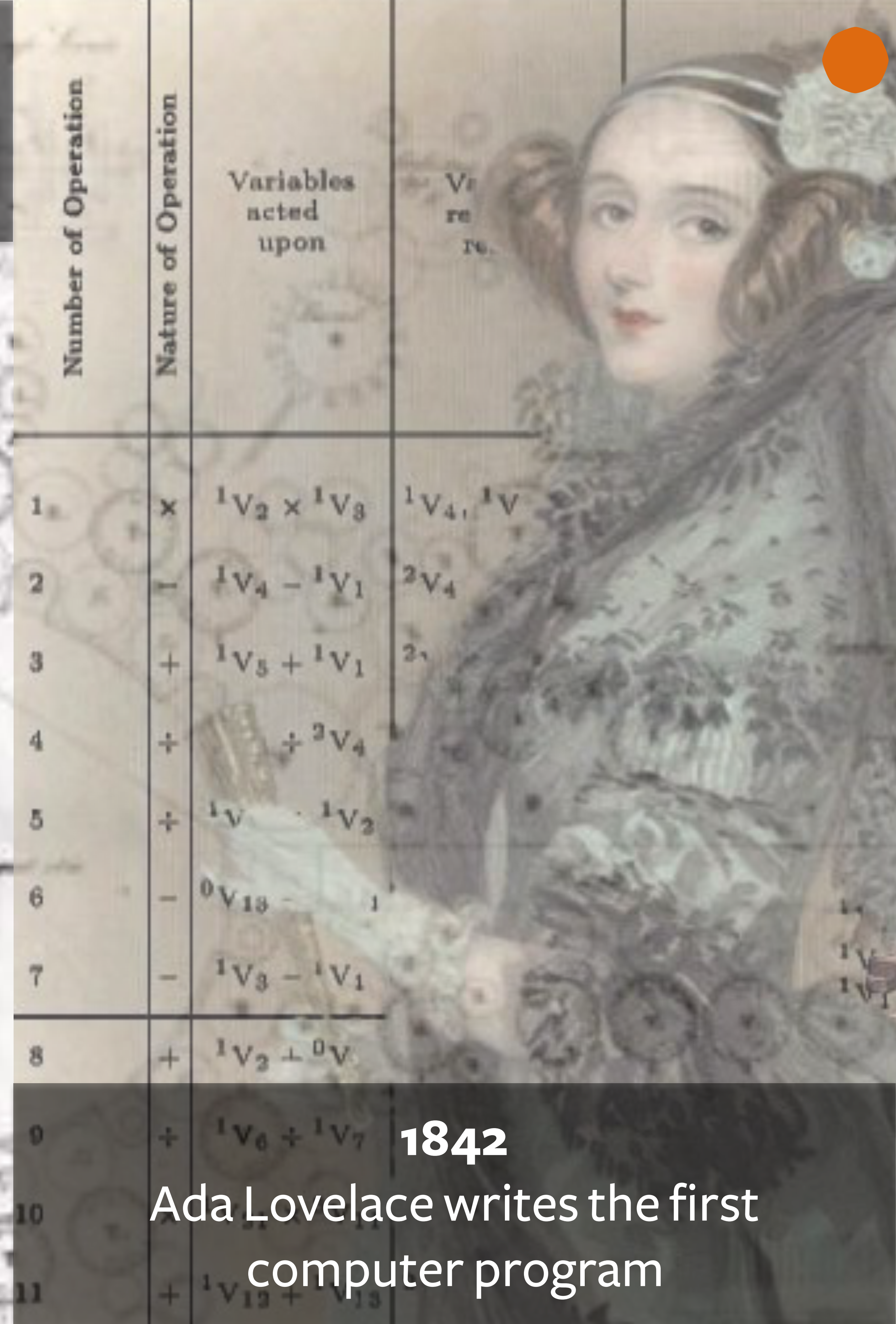
Blaise Pascal

1801

Jacquard Loom - first use of stored instructions

Joseph Marie Jacquard

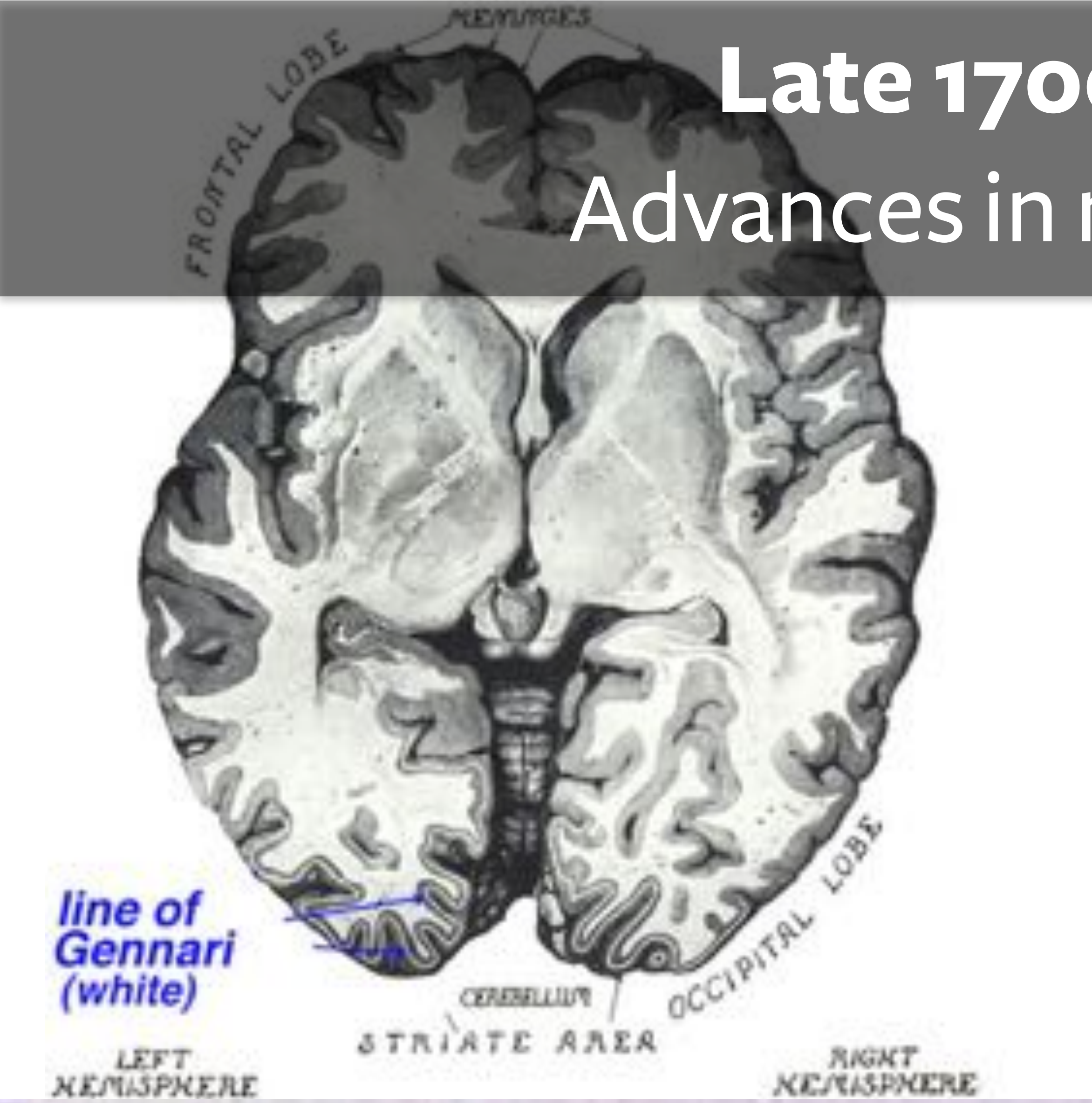
1837
Babbage's Analytical Engine - the first general purpose computer

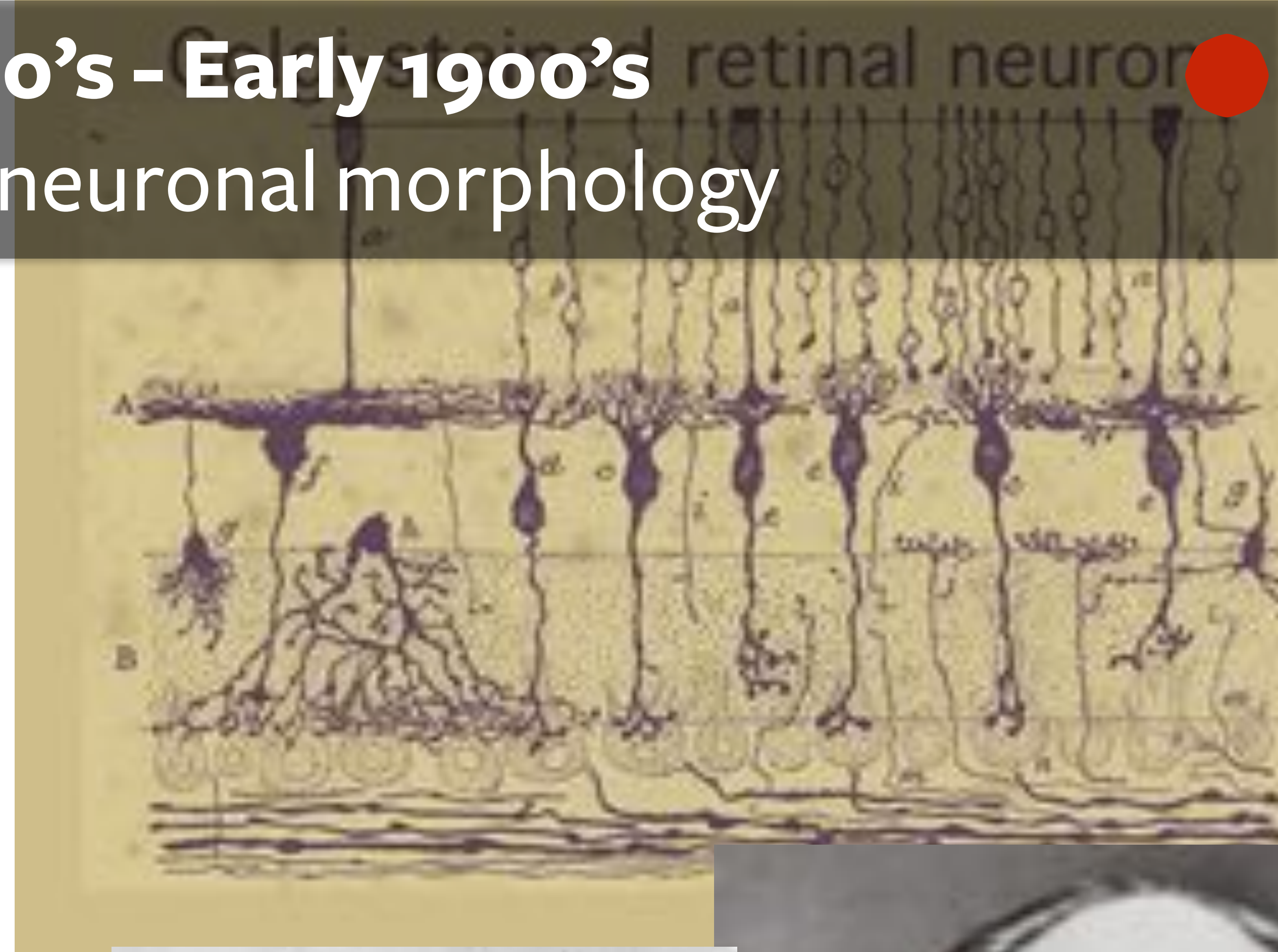


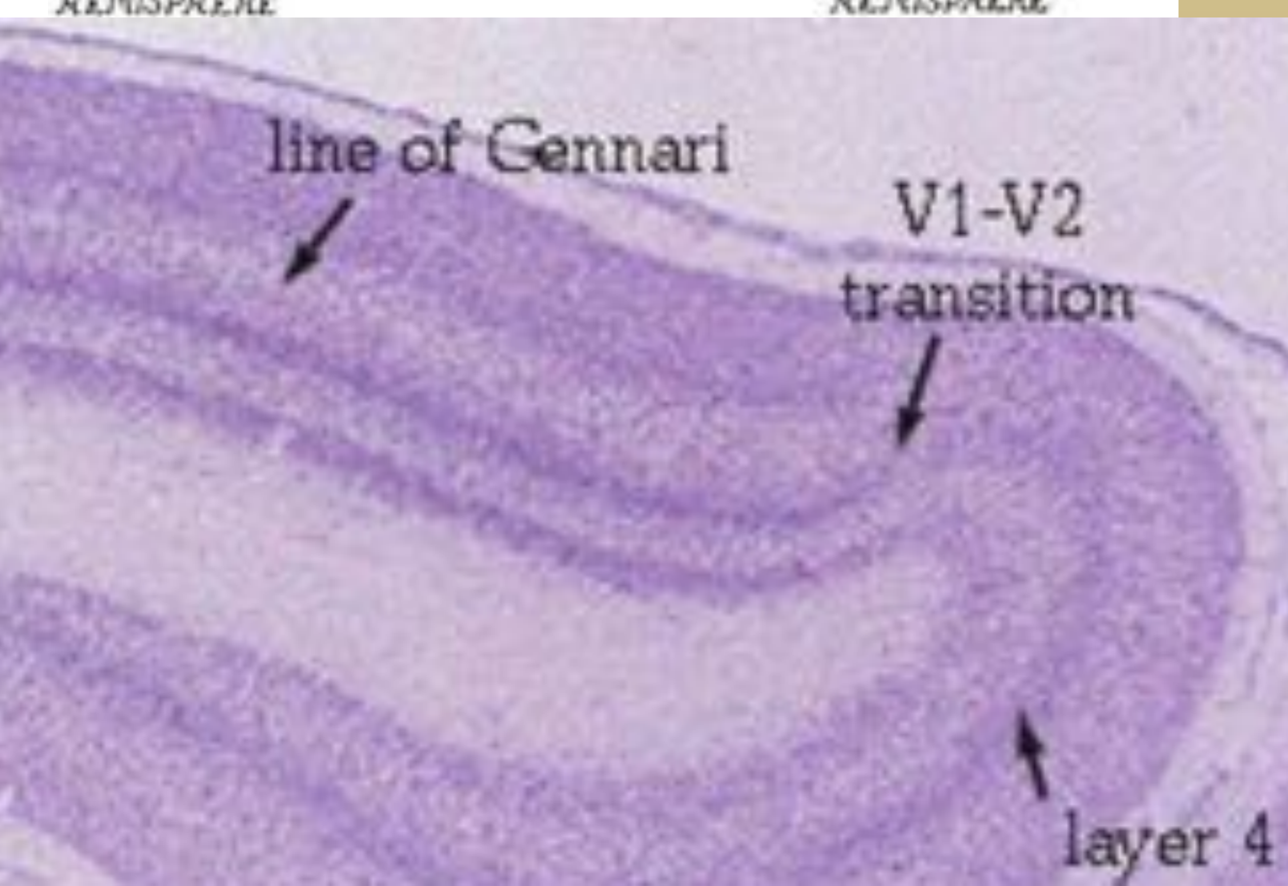
1842
Ada Lovelace writes the first computer program

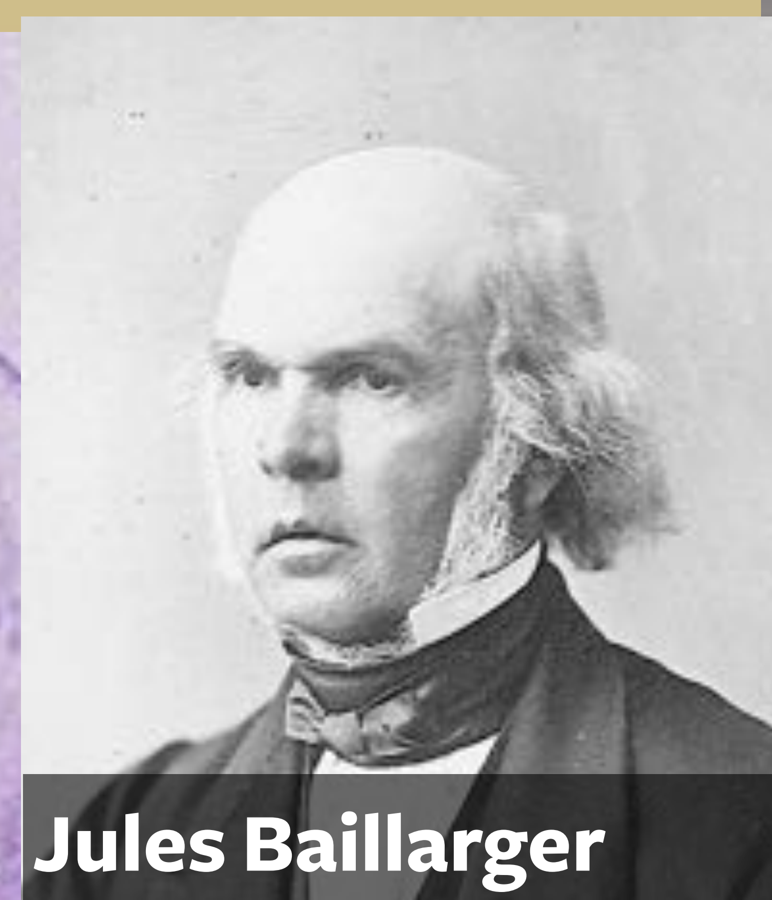
Late 1700's - Early 1900's

Advances in neuronal morphology



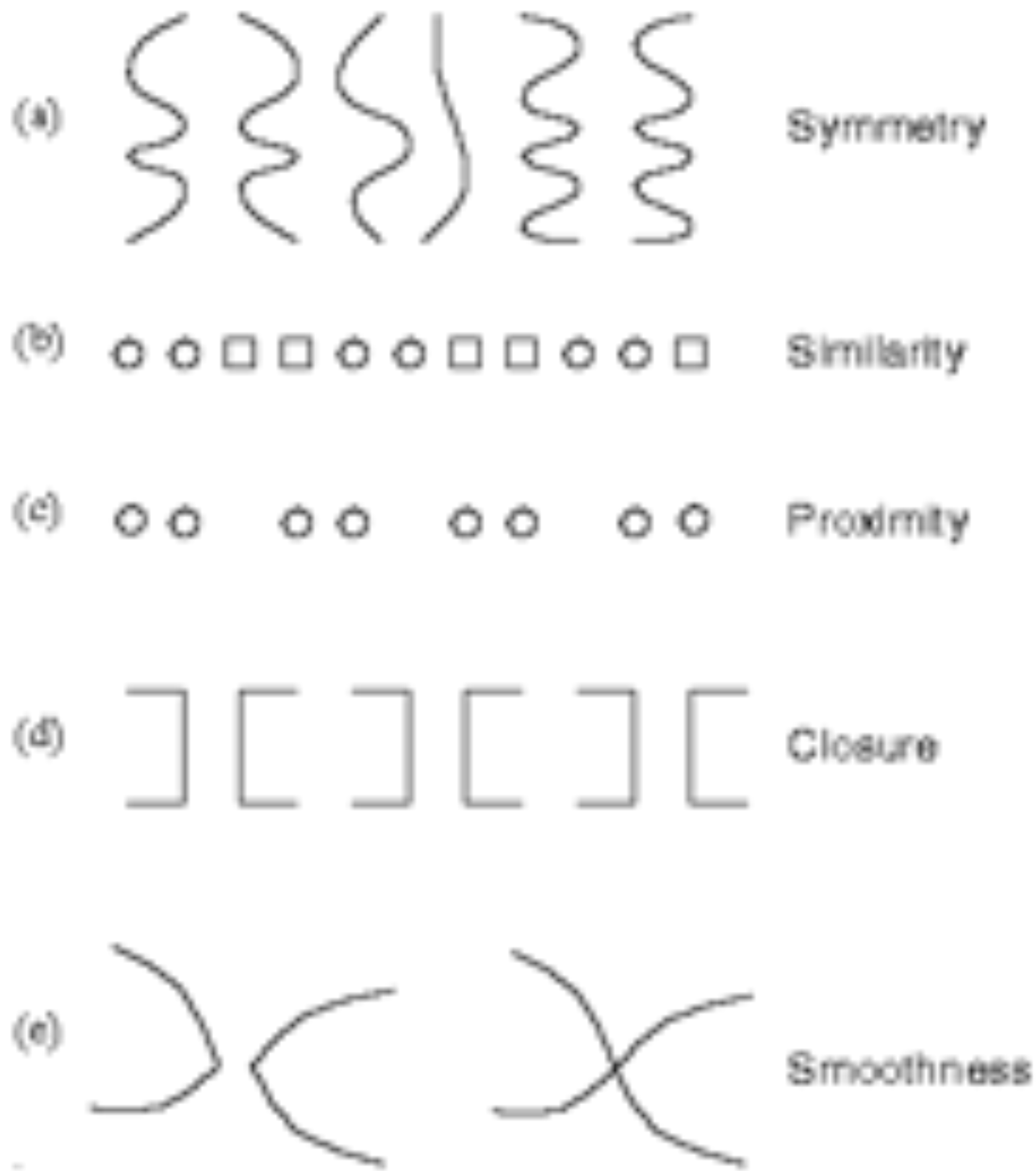




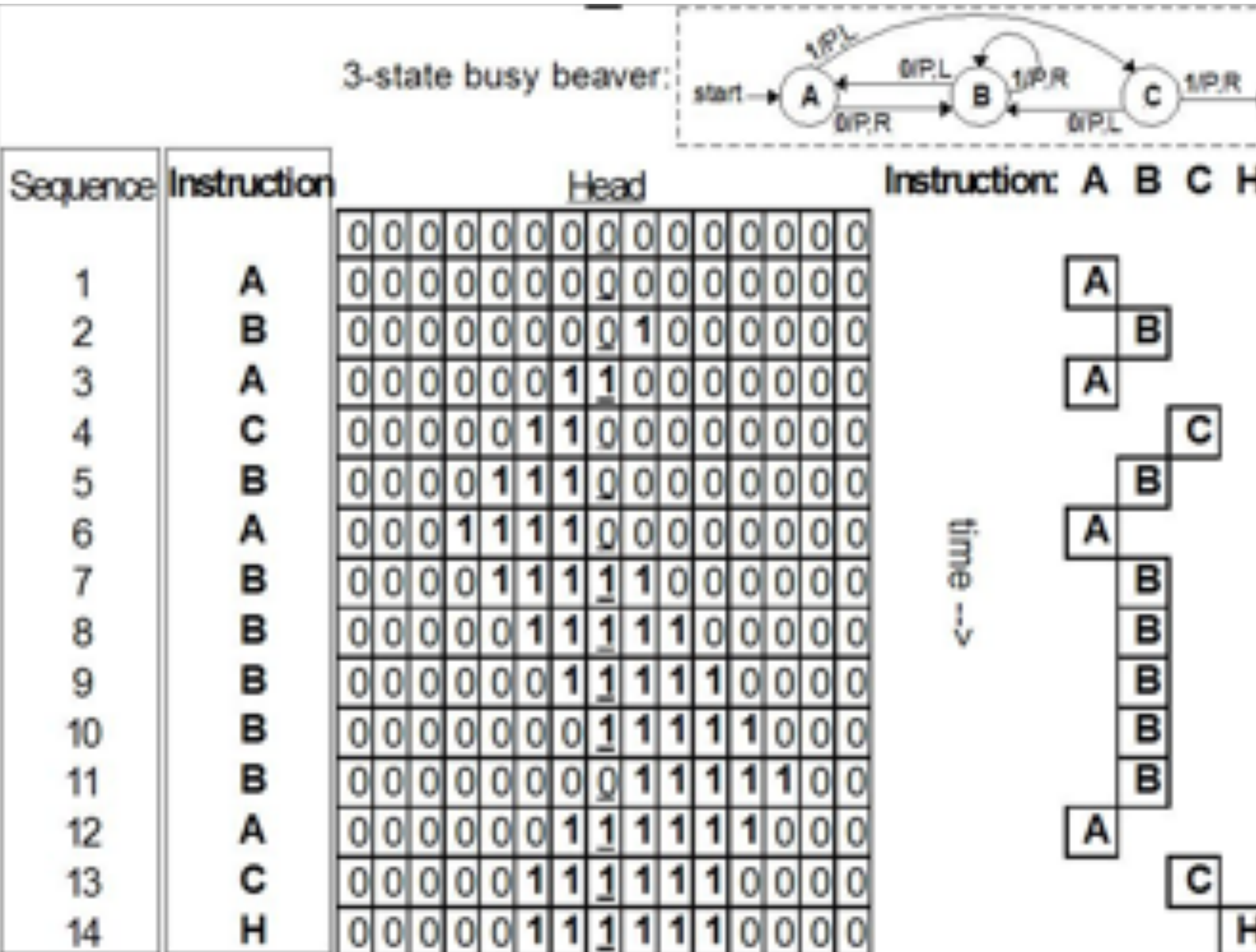

Jules Baillarger

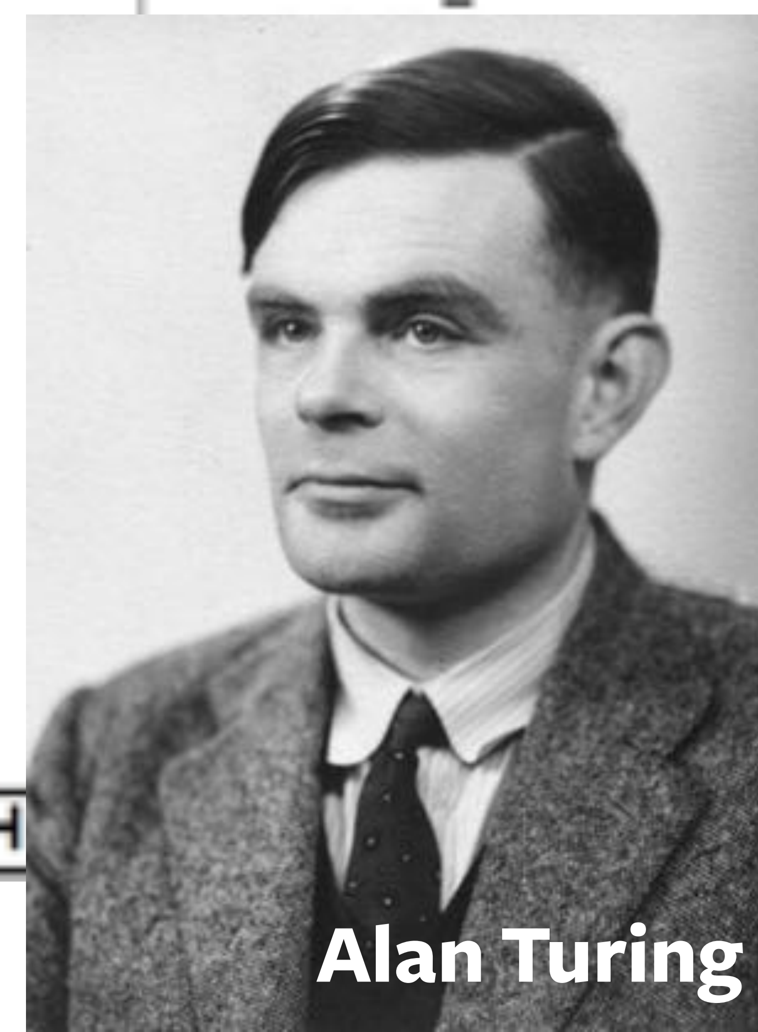

Santiago Ramón y Cajal

1930's
Gestalt Laws of Perceptual Grouping



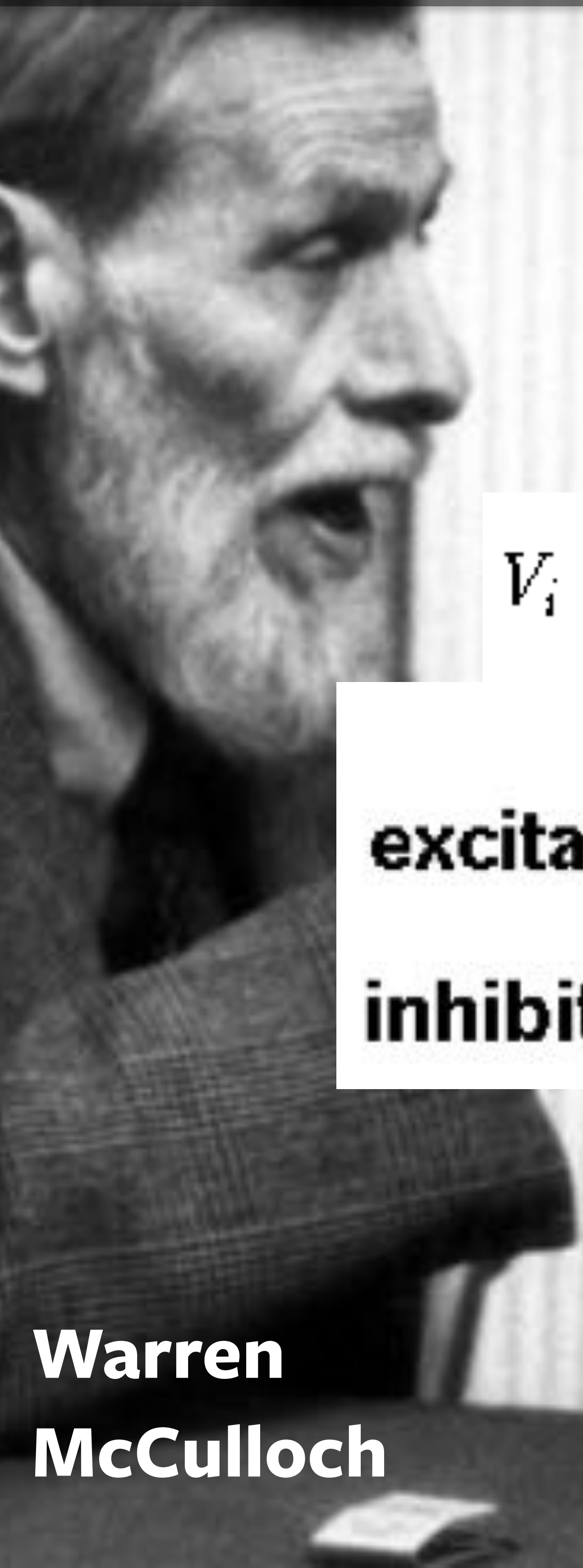
1936
Turing machine



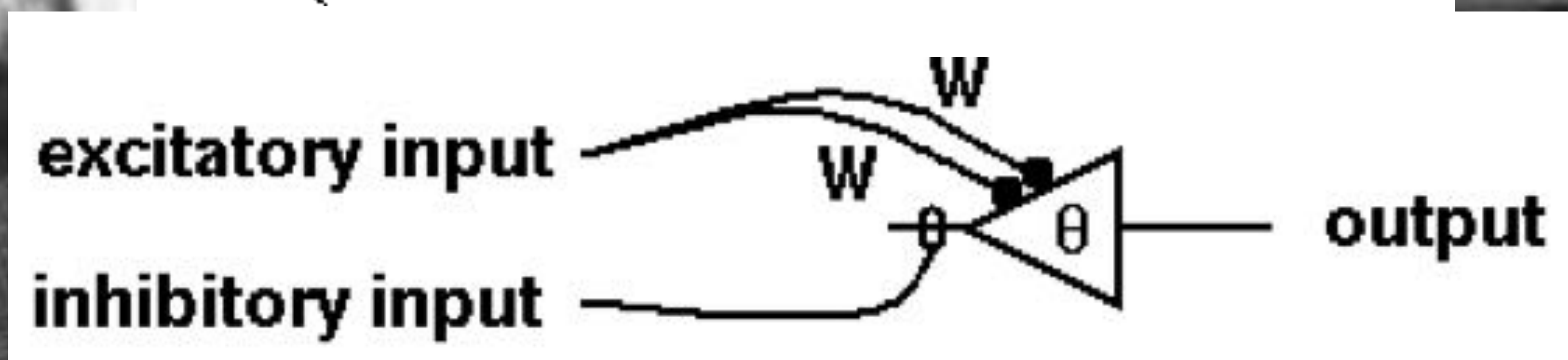


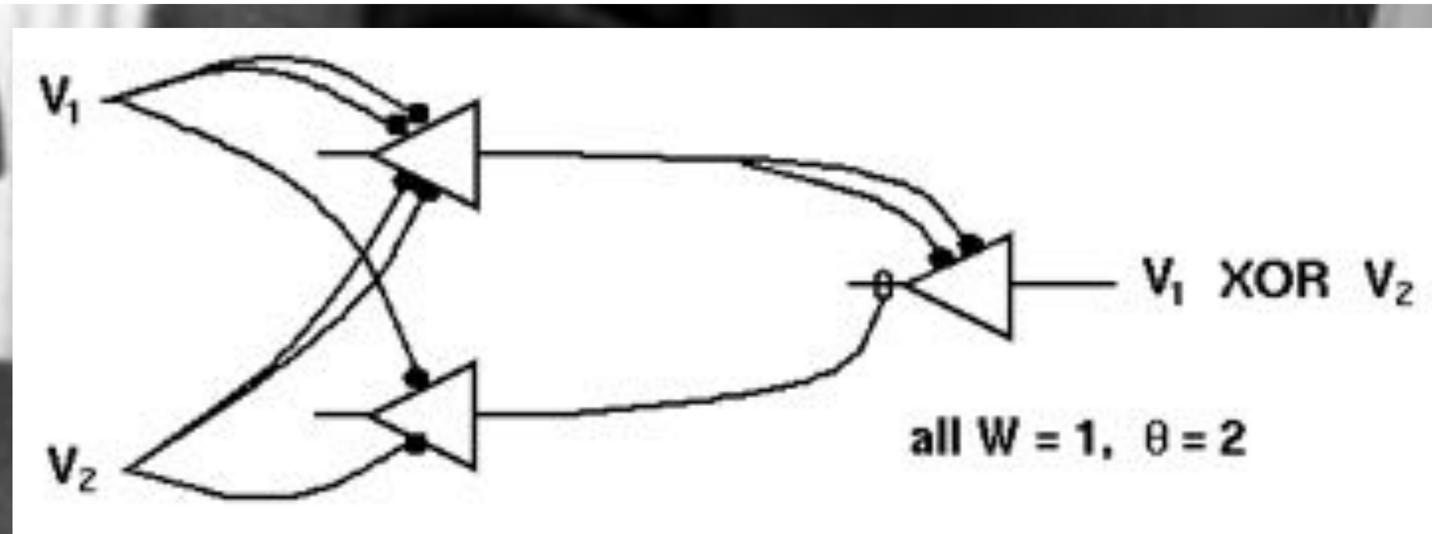
Alan Turing

1943
McCulloch-Pitts Artificial Neuron



$$V_i = \begin{cases} 1 & : \sum_j W V_j \geq \theta \text{ AND no inhibition} \\ 0 & : \text{otherwise} \end{cases}$$



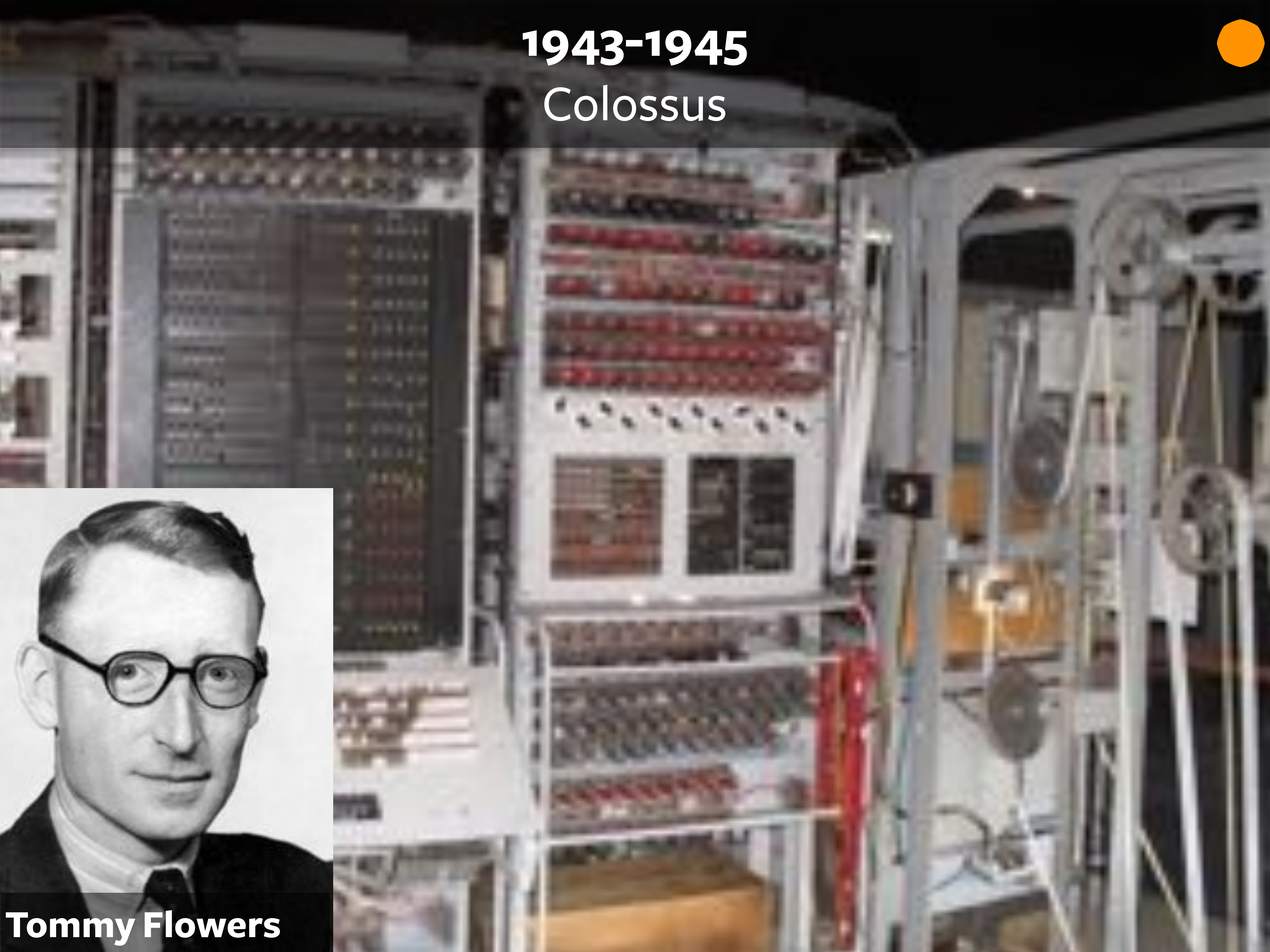


Warren McCulloch

Walter Pitts

1943-1945

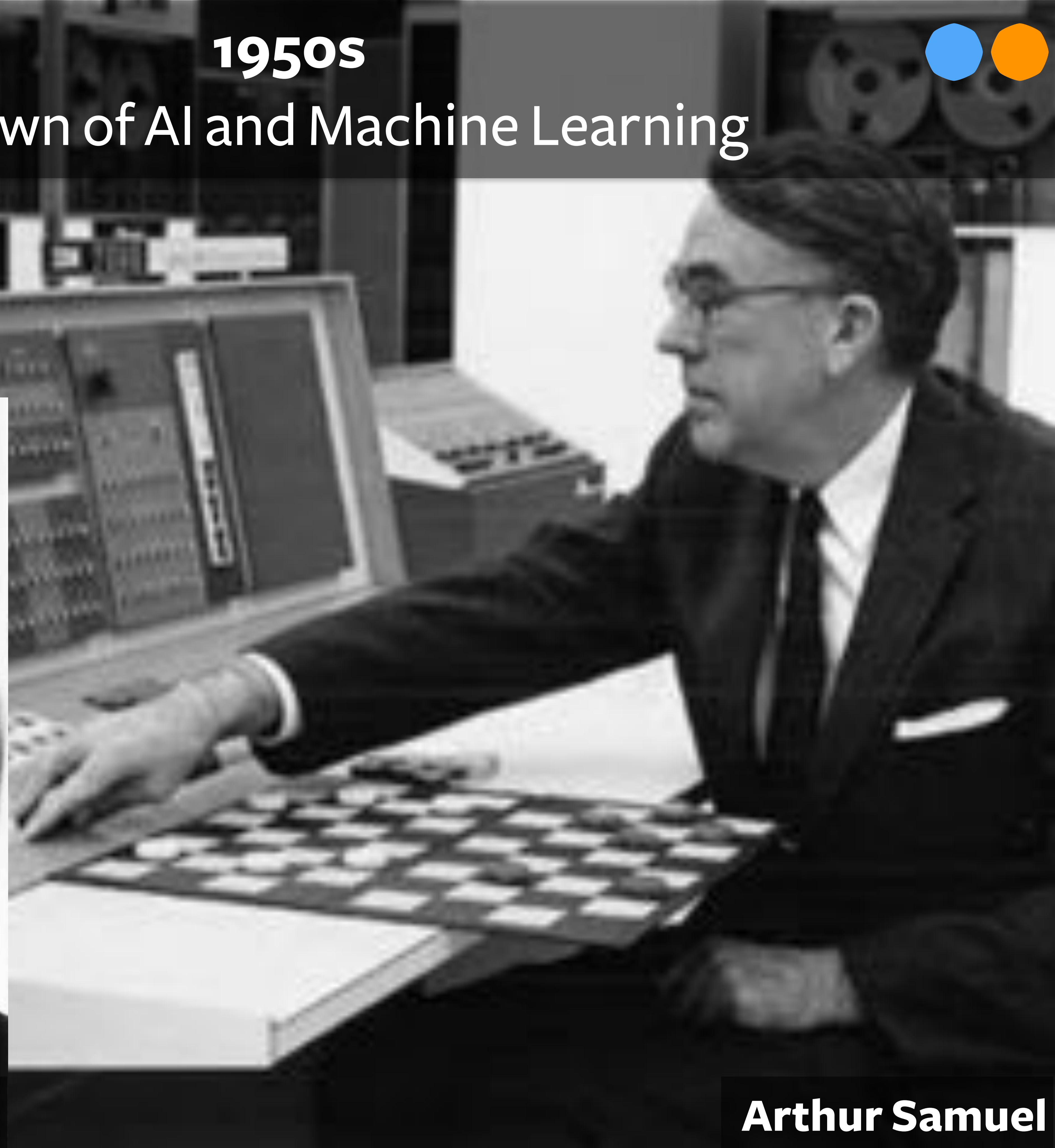
Colossus



1950s

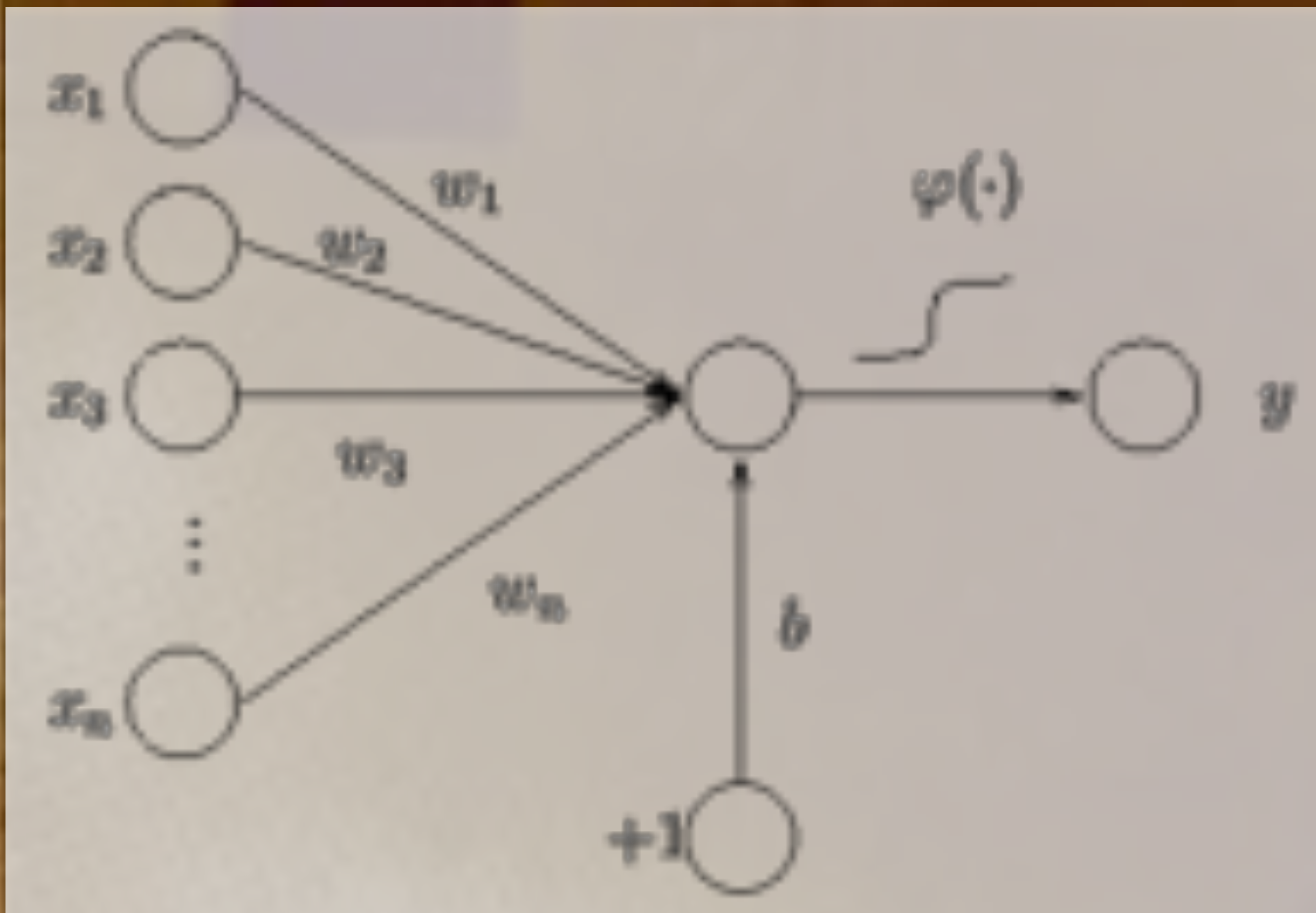
The dawn of AI and Machine Learning

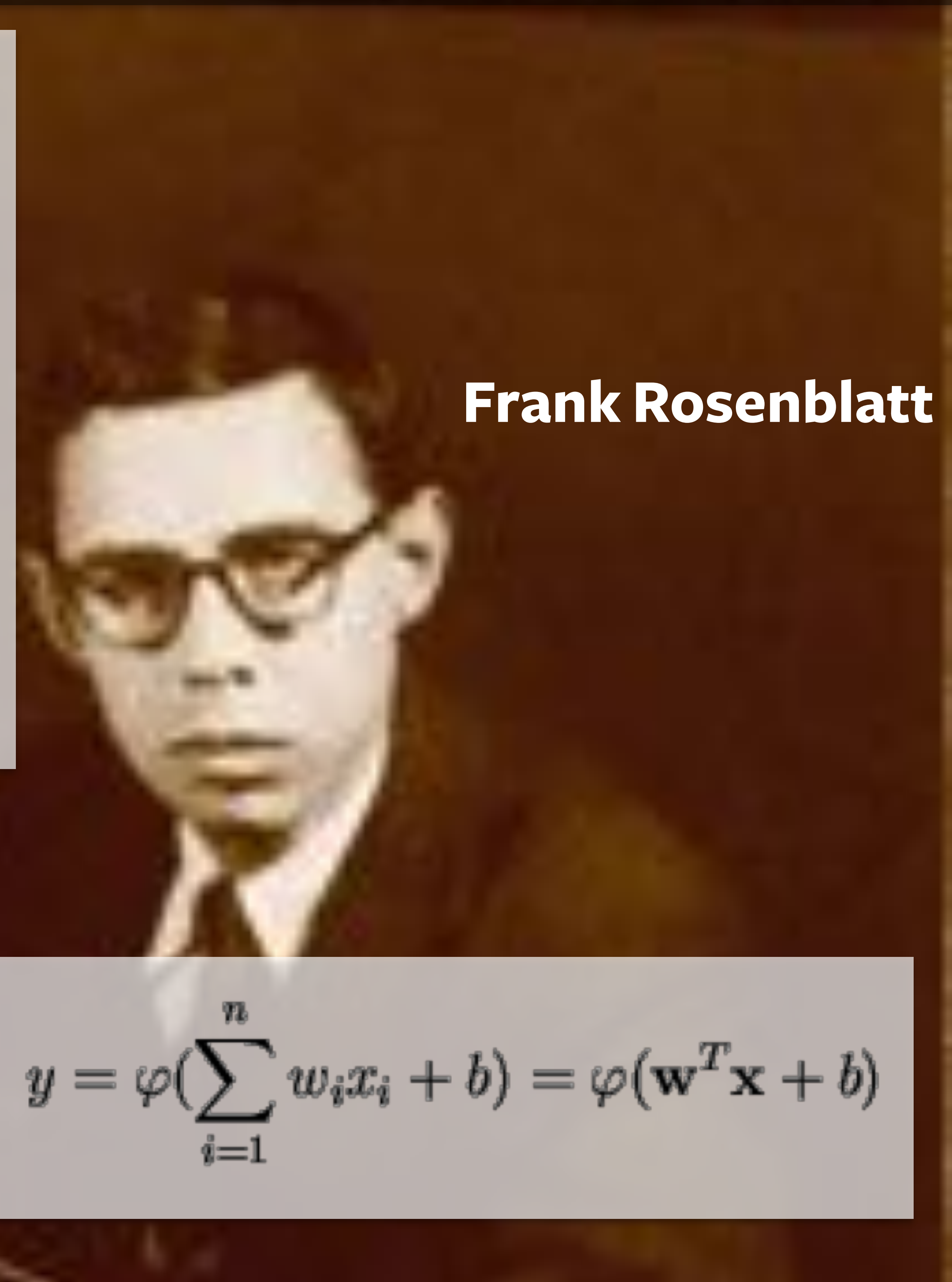
Christopher Strachey



Arthur Samuel

1958
Rosenblatt's Perceptron

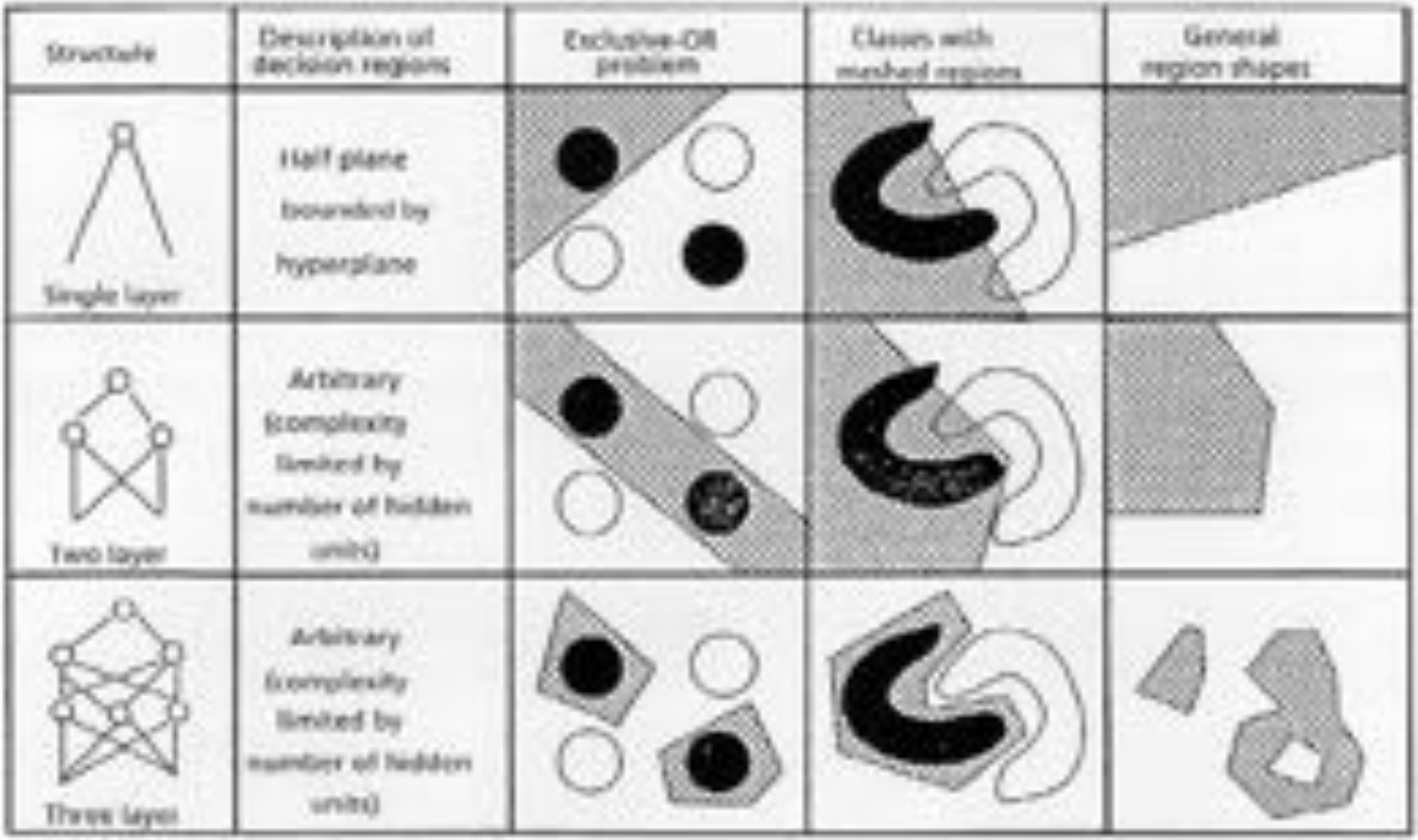




Frank Rosenblatt

$$y = \varphi\left(\sum_{i=1}^{n} w_i x_i + b\right) = \varphi(\mathbf{w}^T \mathbf{x} + b)$$

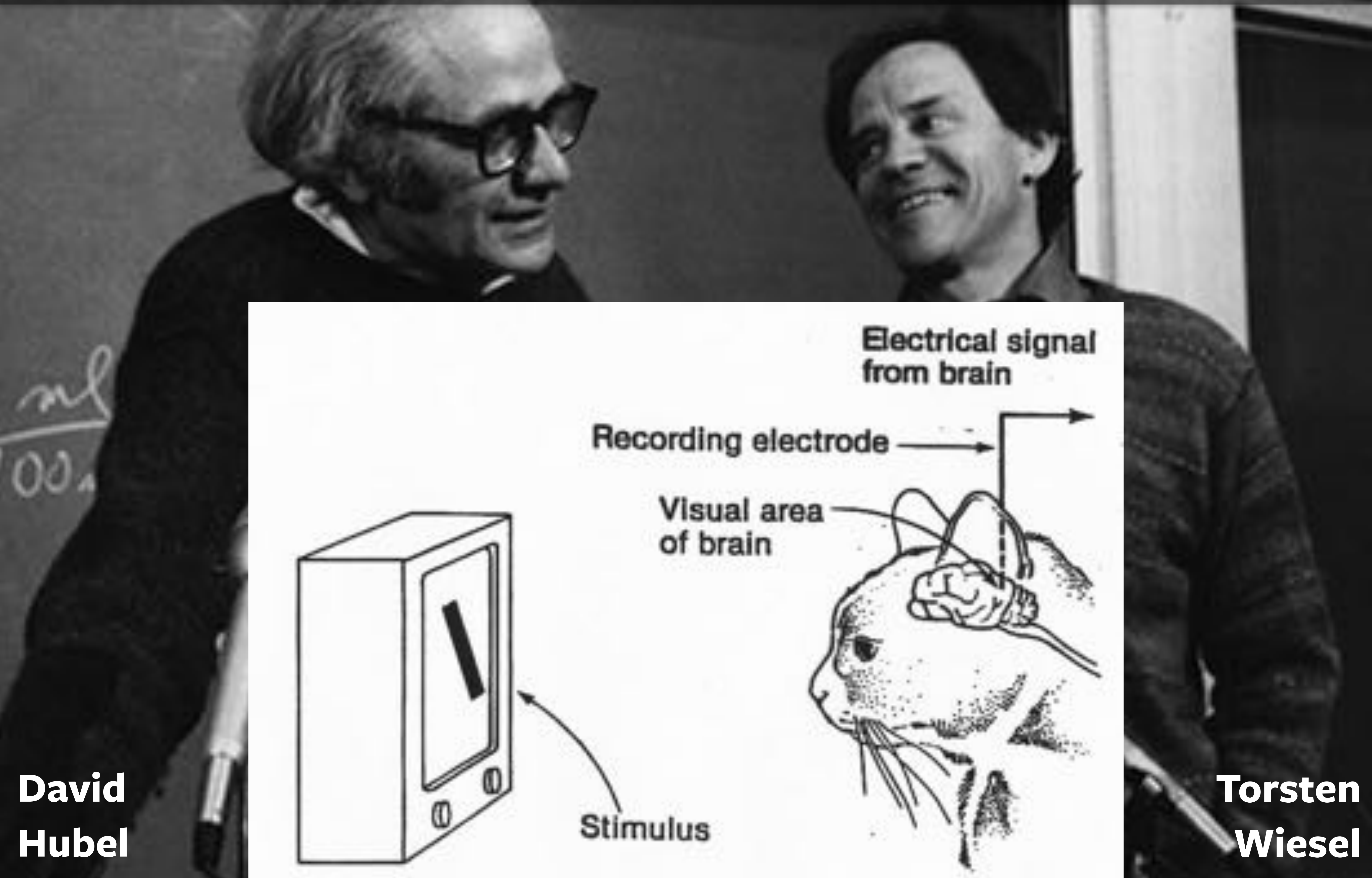

MARK I PERCEPTRON



Structure
Description of decision regions
Exclusive-OR problem
Classes with meshed regions
General region shapes
Single layer
Half plane bounded by hyperplane
Two layer
Arbitrary (complexity limited by number of hidden units)
Three layer
Arbitrary (complexity limited by number of hidden units)

1959

Receptive Fields of Single Neurons in the Cat's Striate Cortex



1966

Computer vision "summer project"

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

PROJECT MAC

Artificial Intelligence Group July 7, 1966

Vision Memo. No. 100.

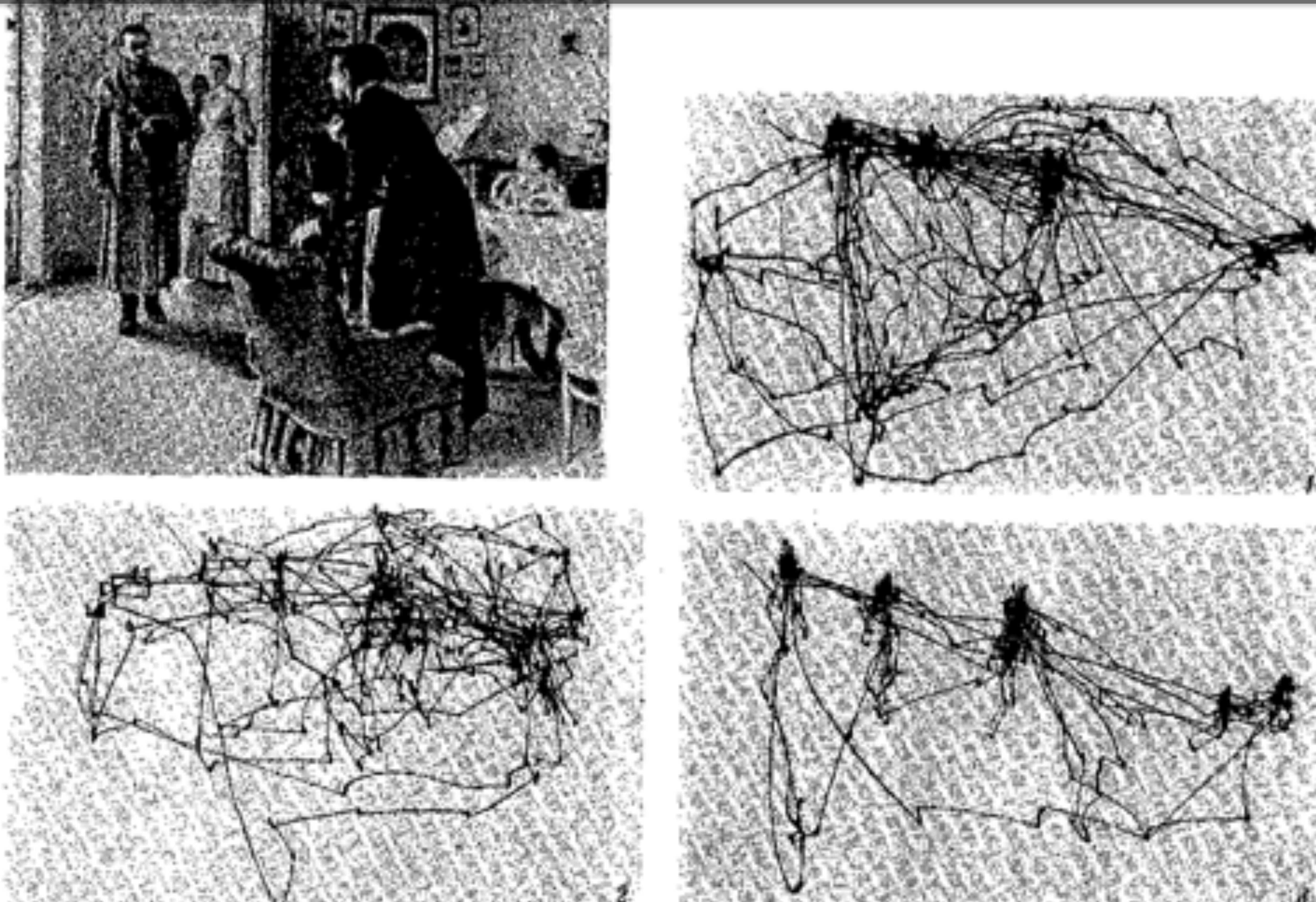
THE SUMMER VISION PROJECT

Seymour Papert

The summer vision project is an attempt to use our summer workers effectively in the construction of a significant part of a visual system. The particular task was chosen partly because it can be segmented into sub-problems which will allow individuals to work independently and yet

1960's

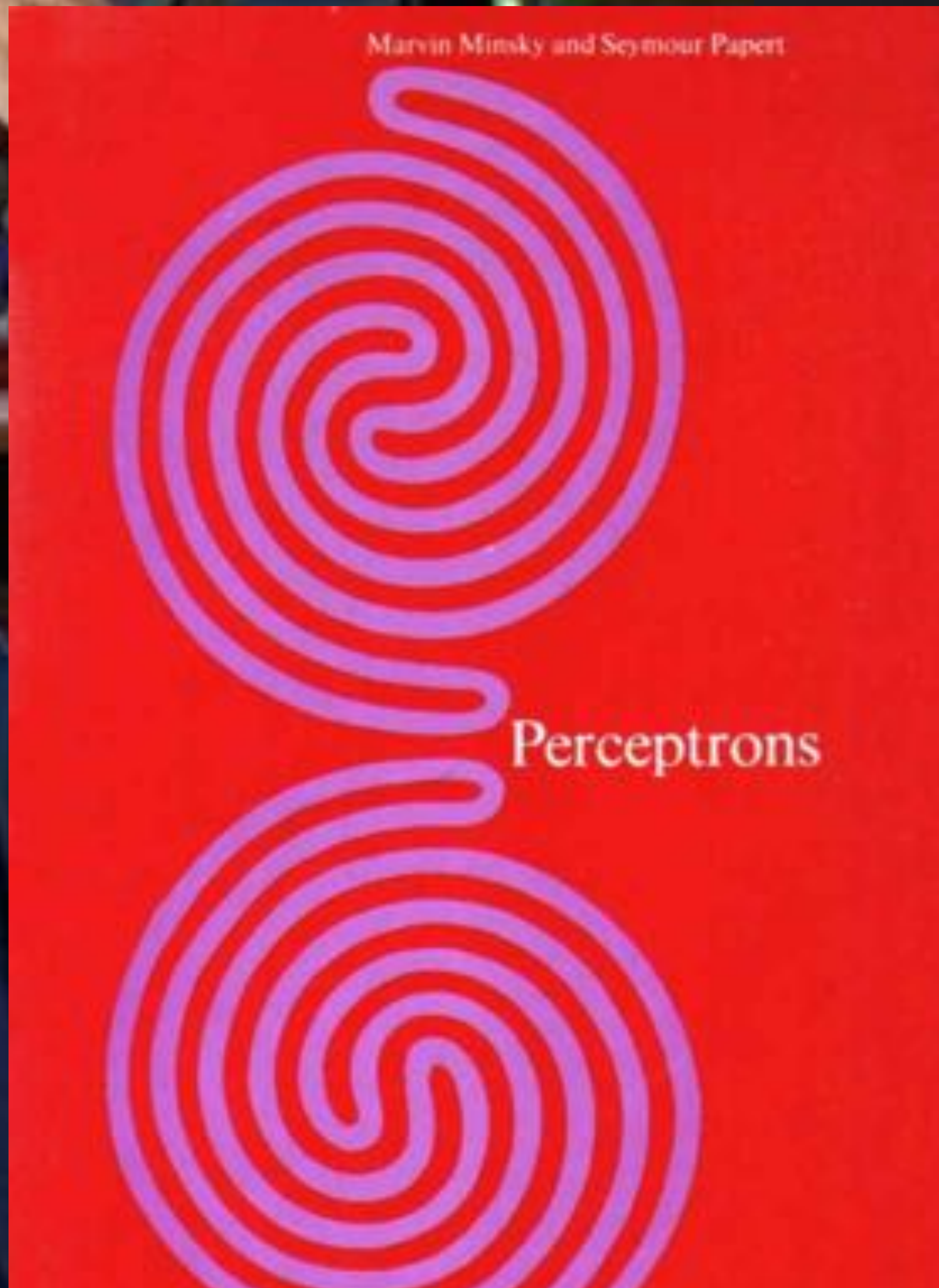
Studies of eye movement



1969

“Perceptrons” and the first AI Winter

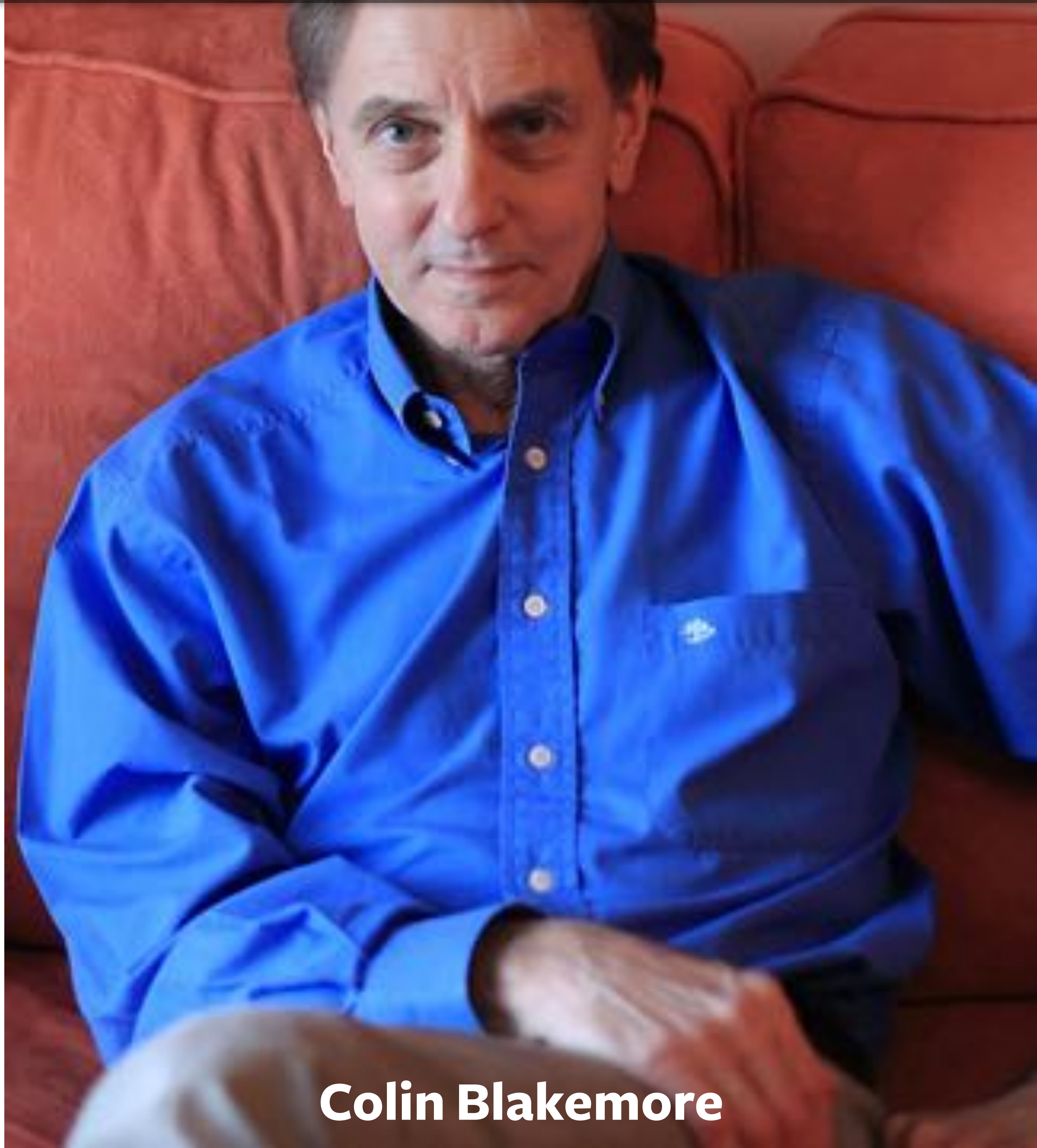
Marvin Minsky



Seymour Papert

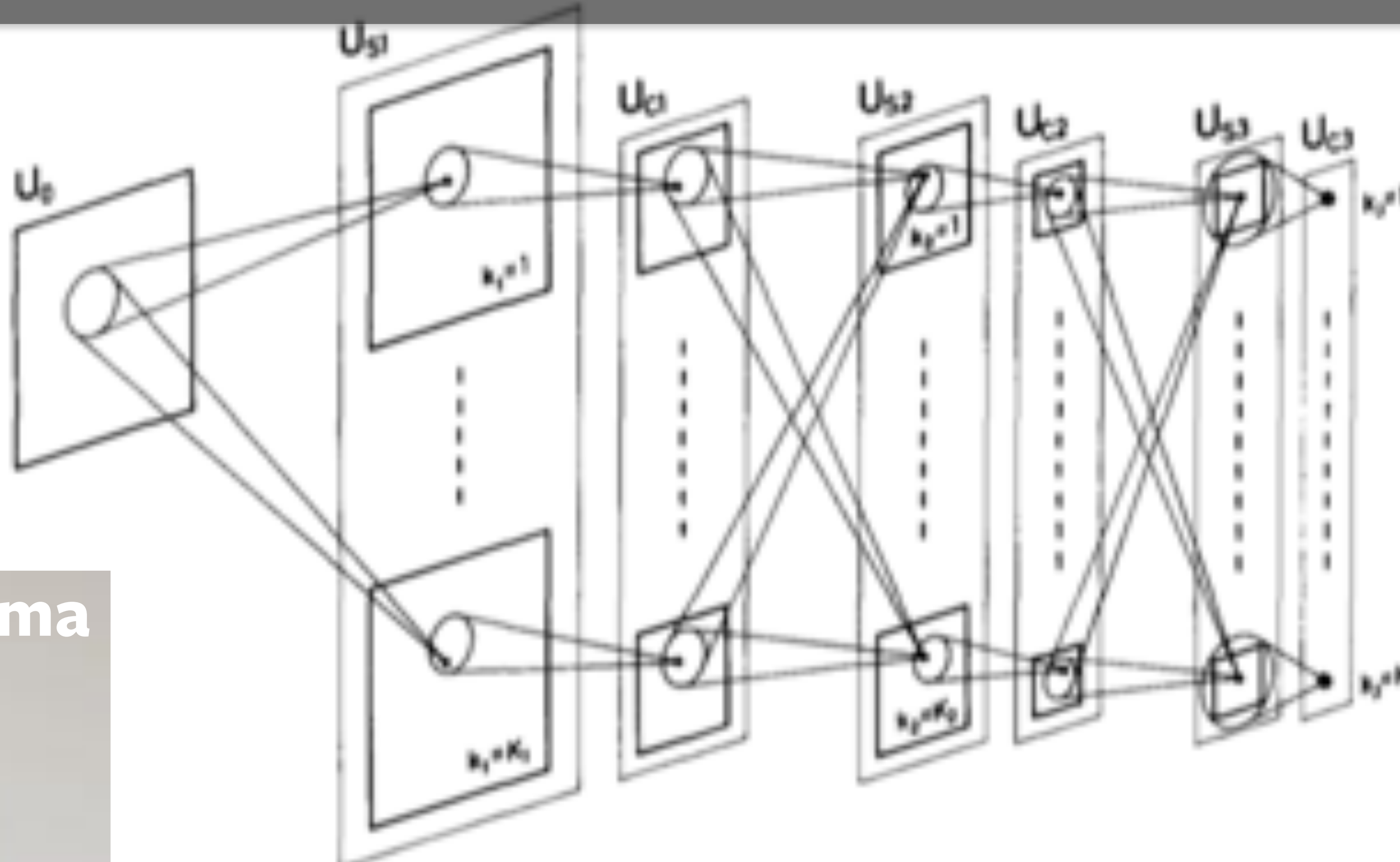
1970

Is vision innate or acquired?

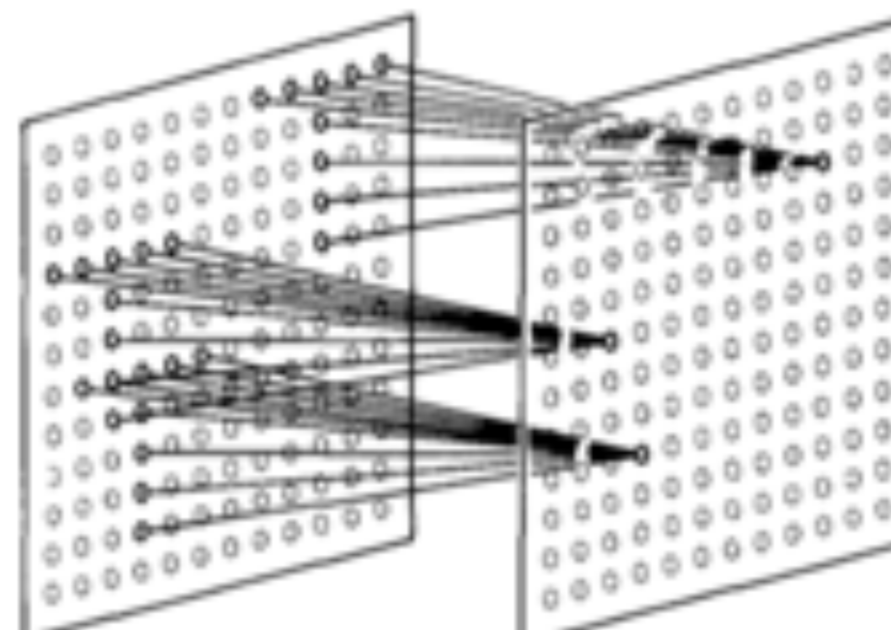


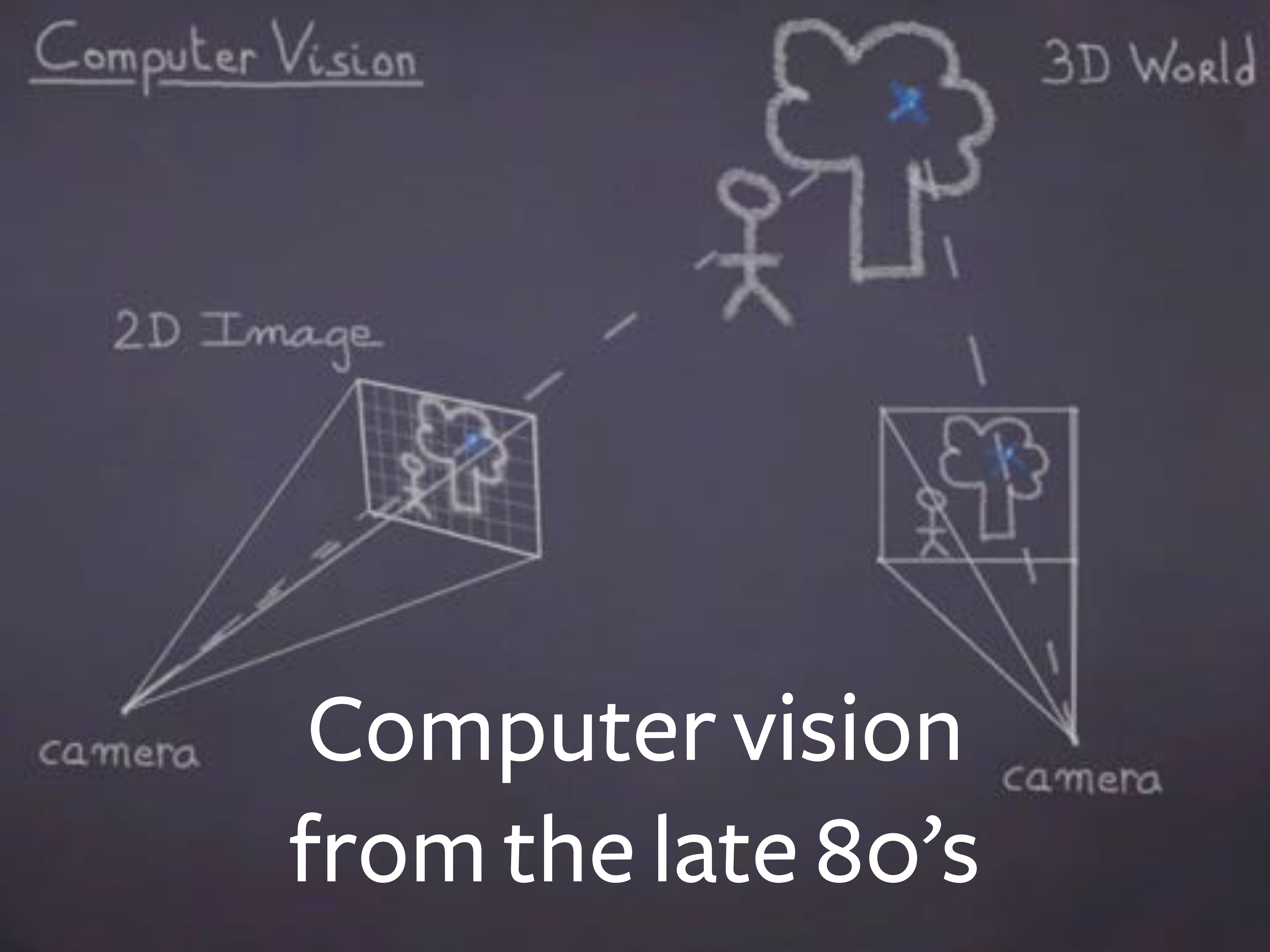
Colin Blakemore

1979
Convolutional Neural Networks & Neocognitron



Kunihiko Fukushima





Computer vision
from the late 80's

Classical approaches to computer vision take the following form:

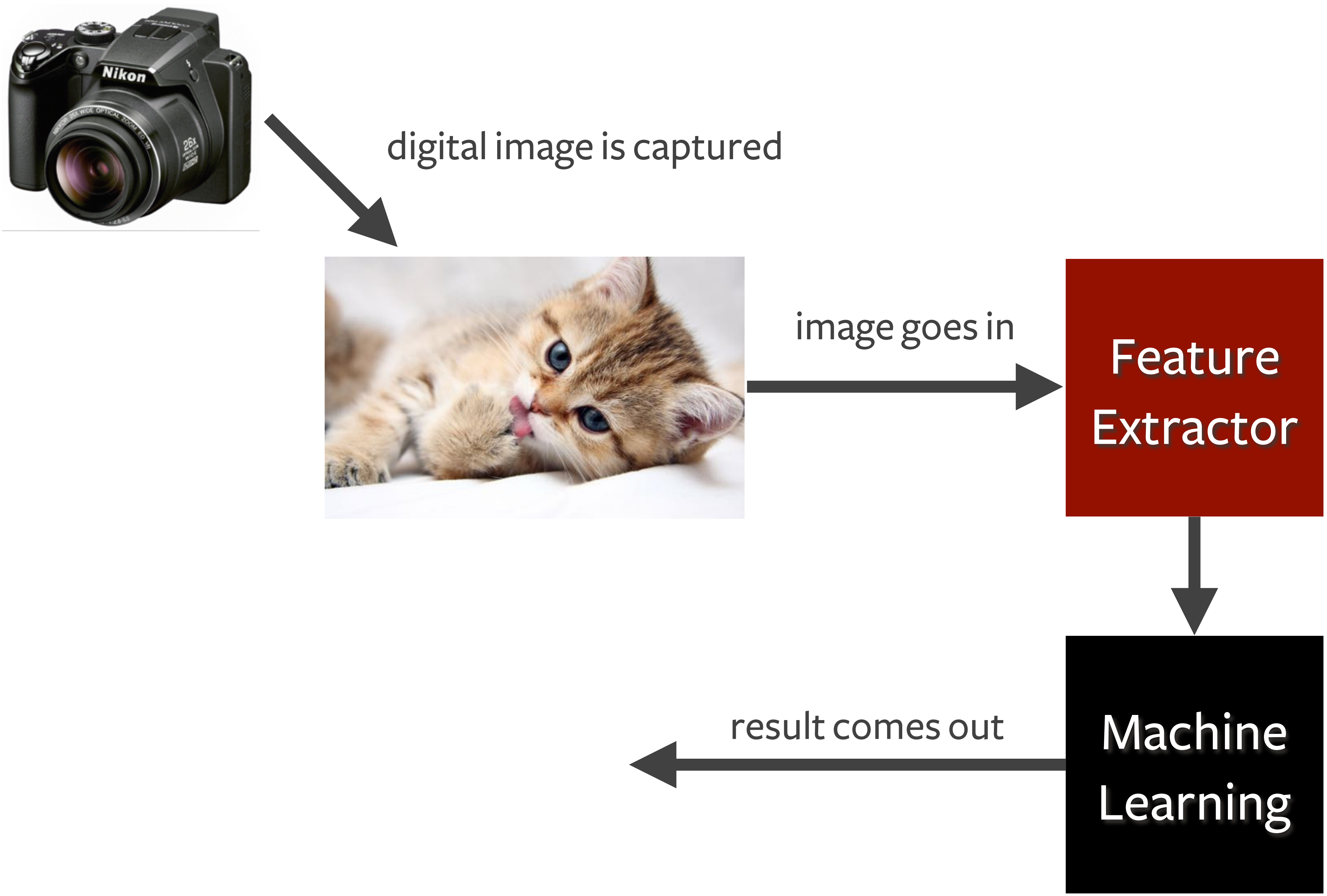
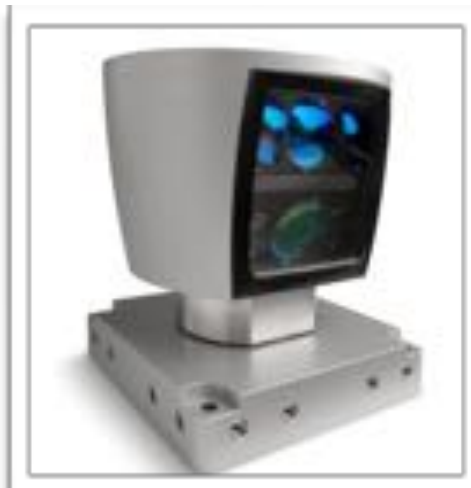
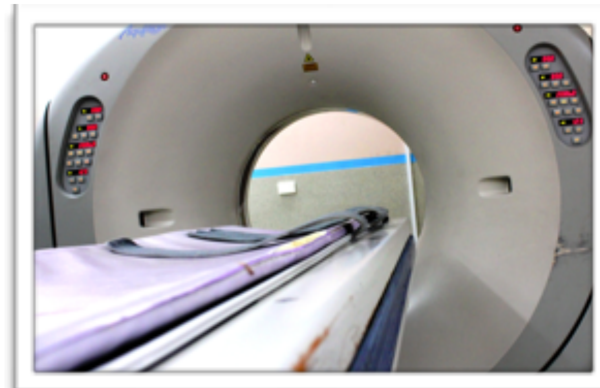
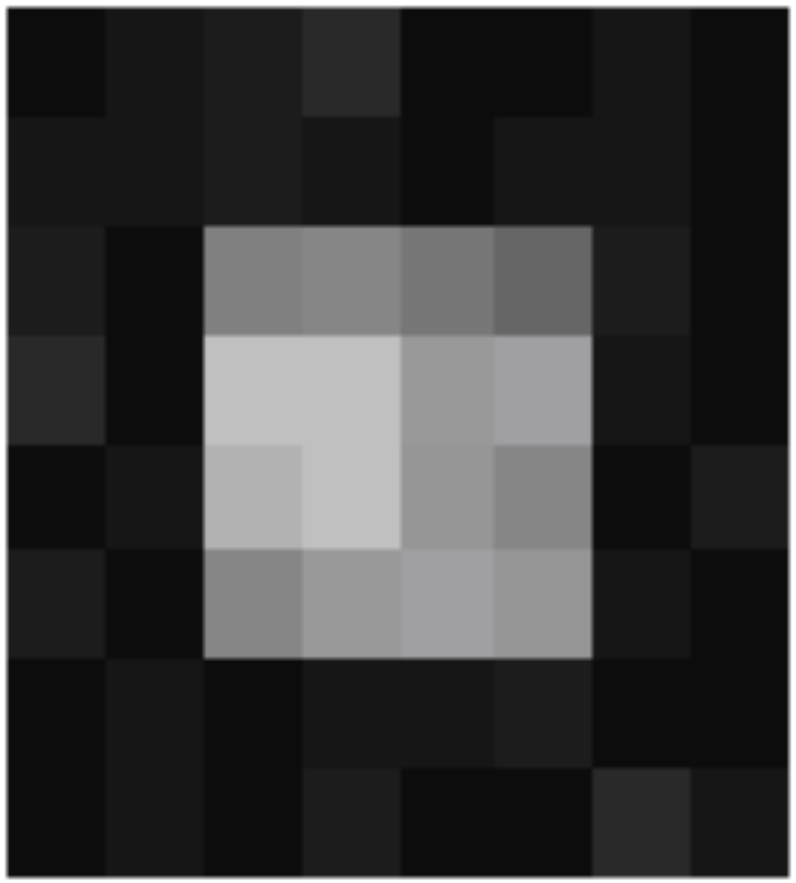


Image Acquisition





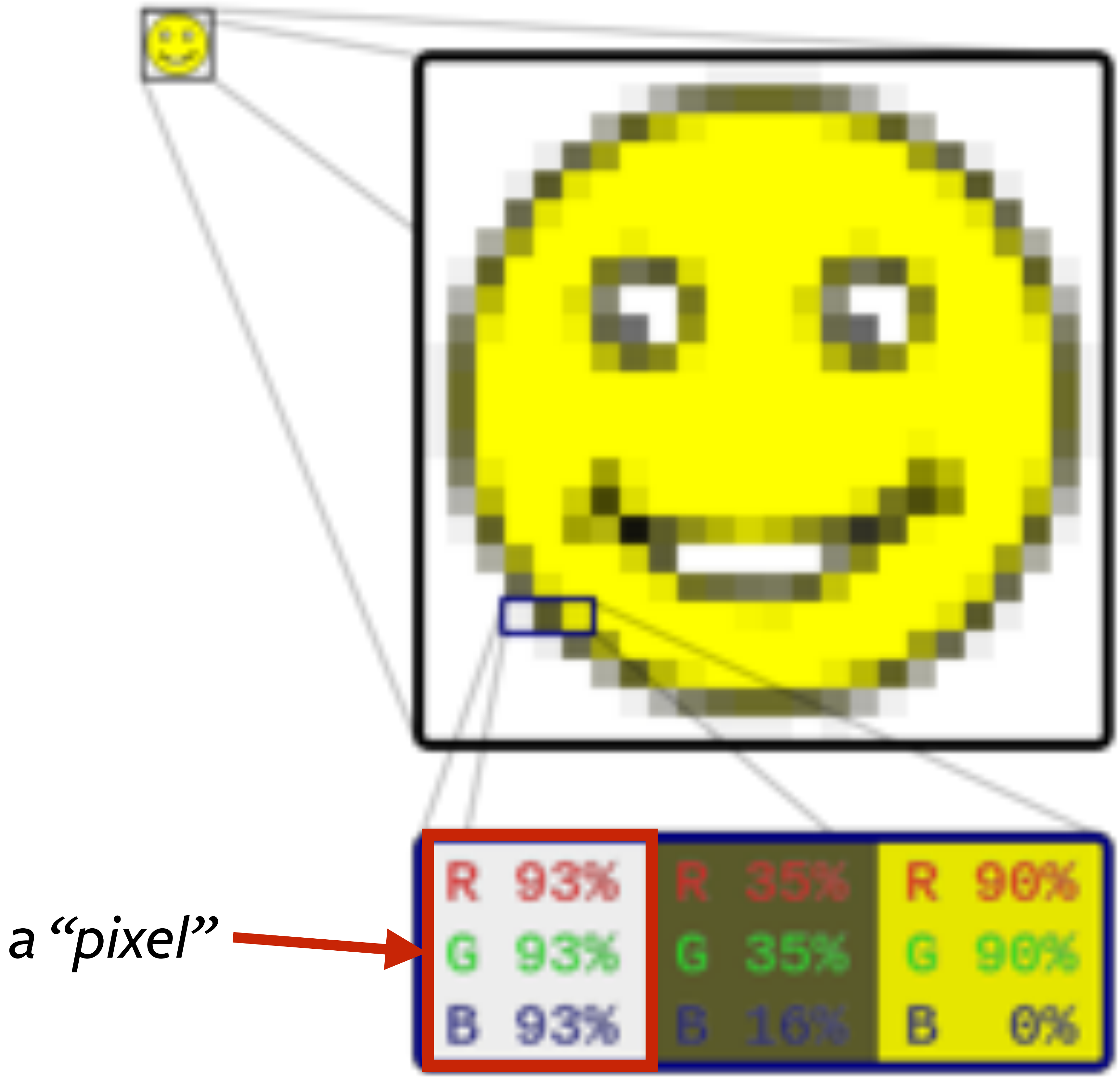



Grey-scale image

a “pixel”

$$
\begin{bmatrix}
1 & 2 & 3 & 4 & 1 & 1 & 2 & 1 \\
2 & 2 & 3 & 2 & 1 & 2 & 2 & 1 \\
3 & 1 & 38 & 39 & 37 & 36 & 3 & 1 \\
4 & 1 & 45 & 44 & 41 & 42 & 2 & 1 \\
1 & 2 & 43 & 44 & 40 & 39 & 1 & 3 \\
2 & 1 & 39 & 41 & 42 & 40 & 2 & 1 \\
1 & 2 & 1 & 2 & 2 & 3 & 1 & 1 \\
1 & 2 & 1 & 3 & 1 & 1 & 4 & 2
\end{bmatrix}
$$

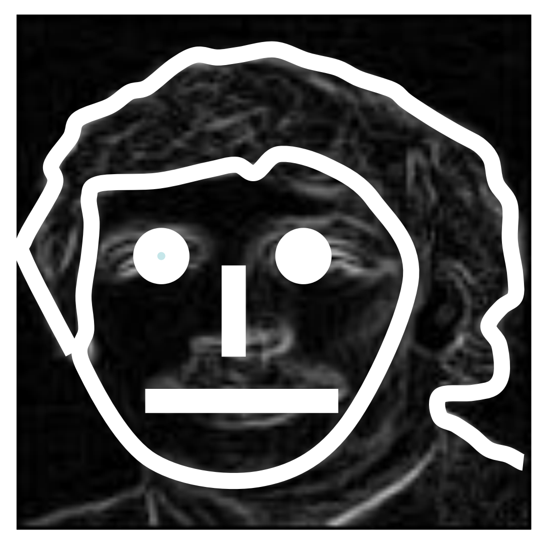
Matrix representation


R 93%
G 93%
B 93%
R 35%
G 35%
B 16%
R 90%
G 90%
B 0%
a "pixel"

Engineered features

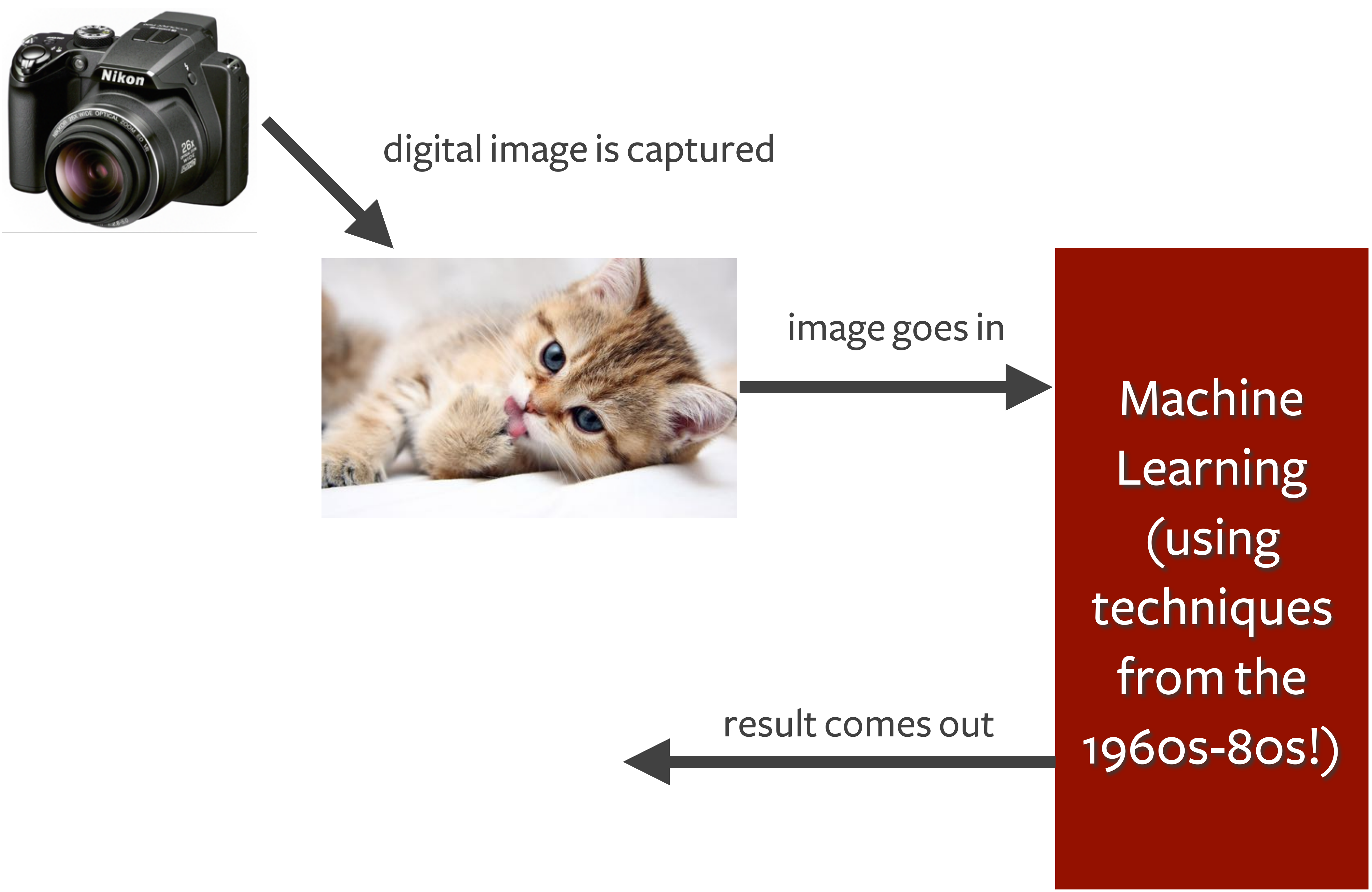
Low-level features:
"Global features"; edges; corners

High-level features:
"Model-based features"; objects; feature combinations

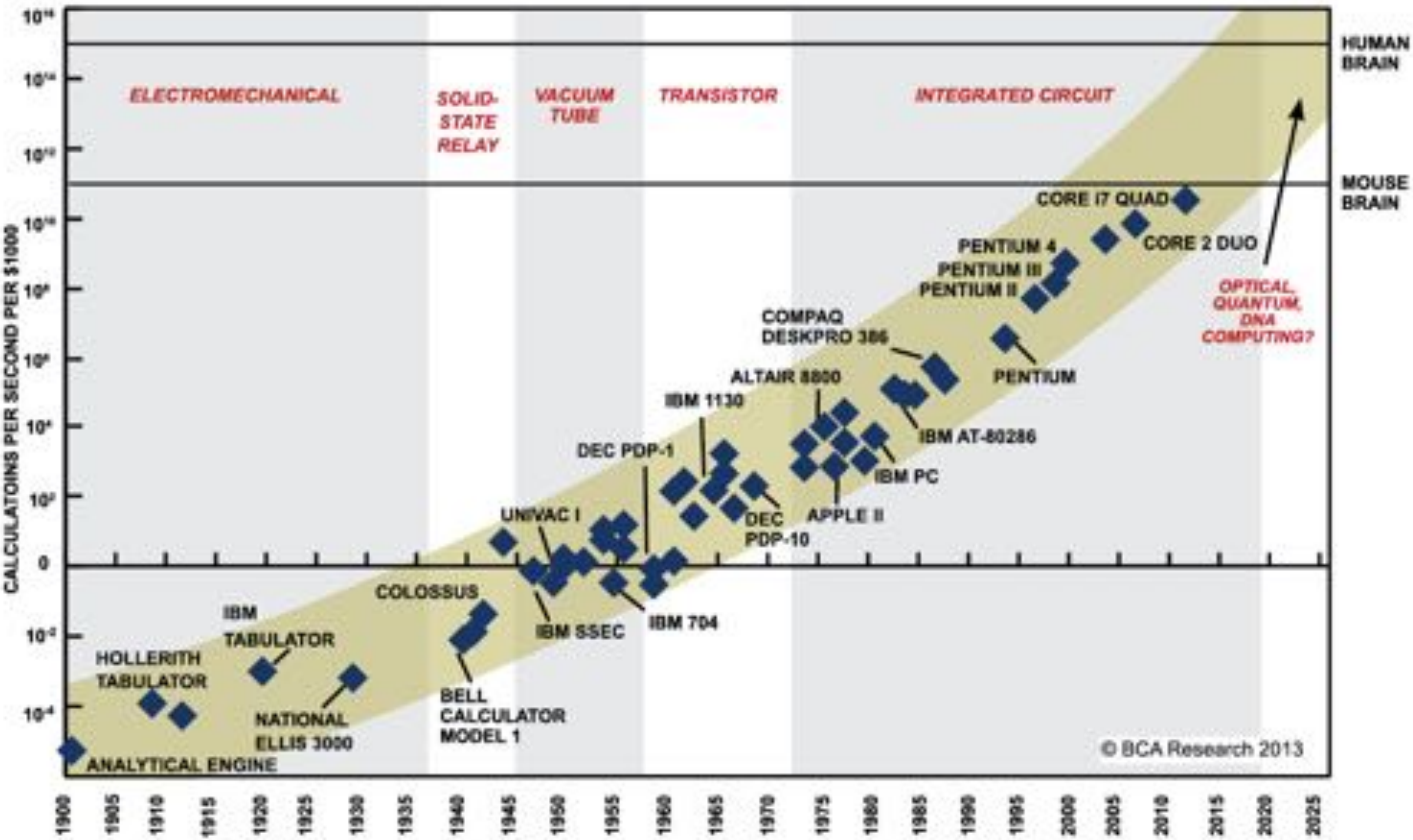


Vision in the last 10 years: *Feature Learning*

Recent approaches to computer vision take the following form:



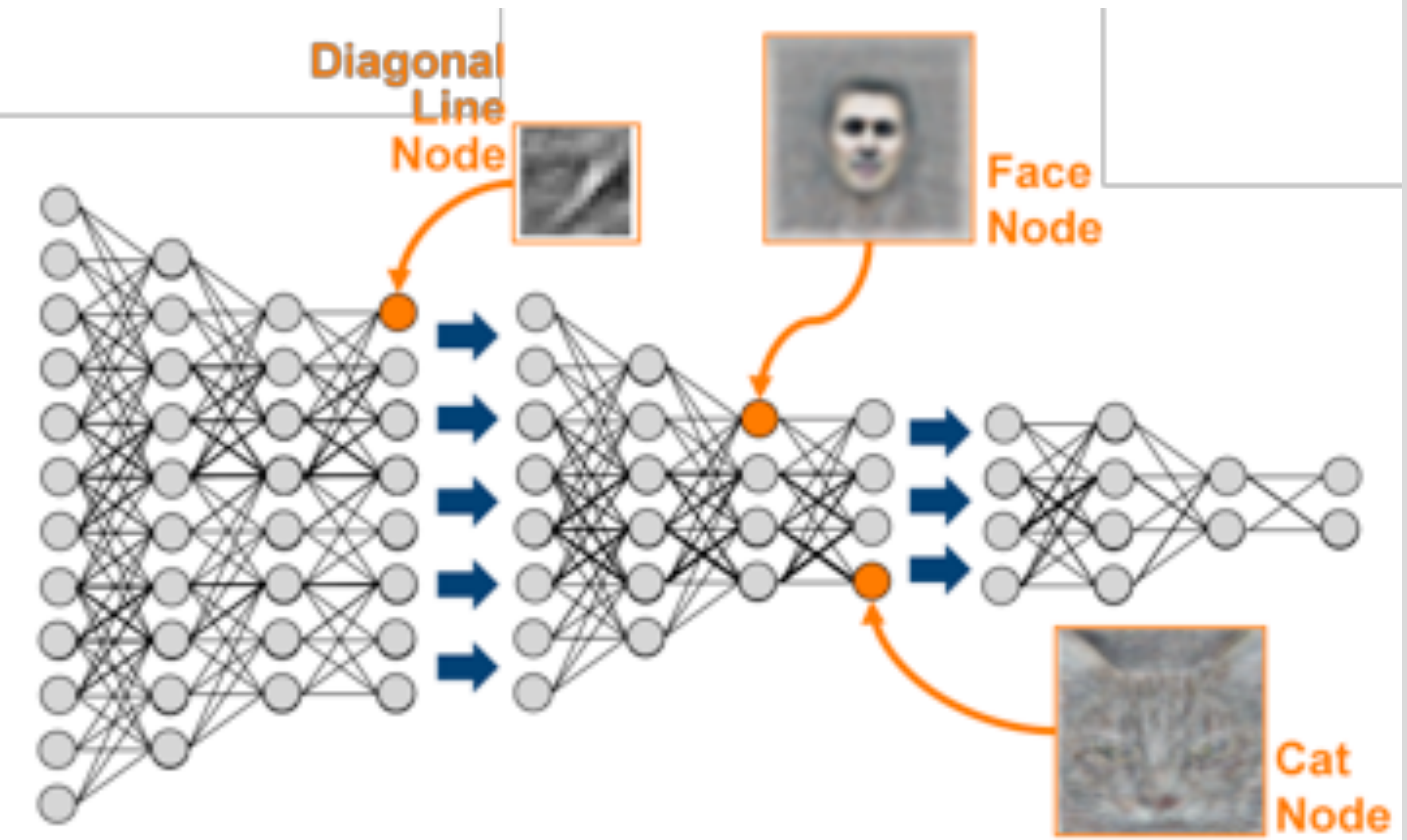
Moore's Law

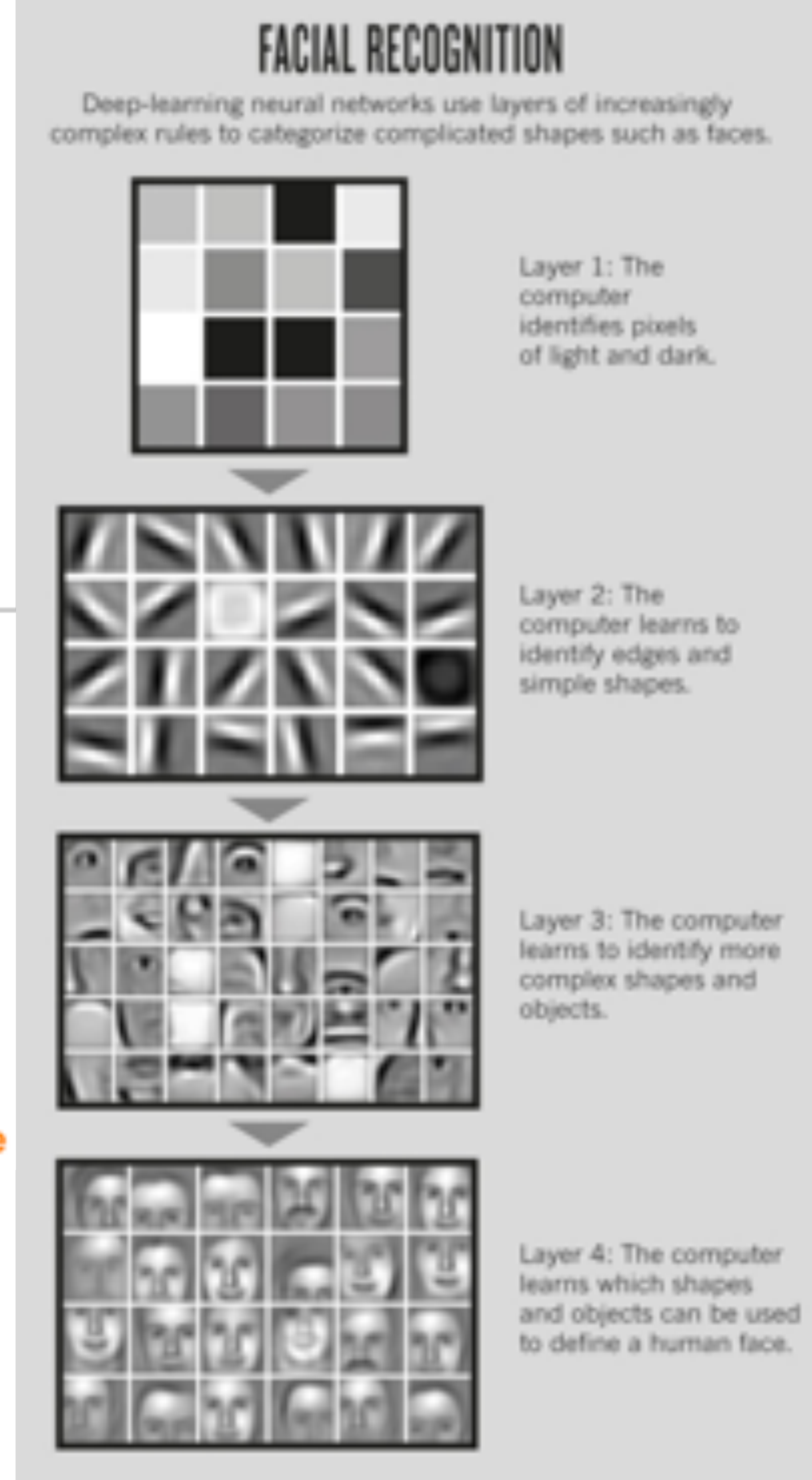


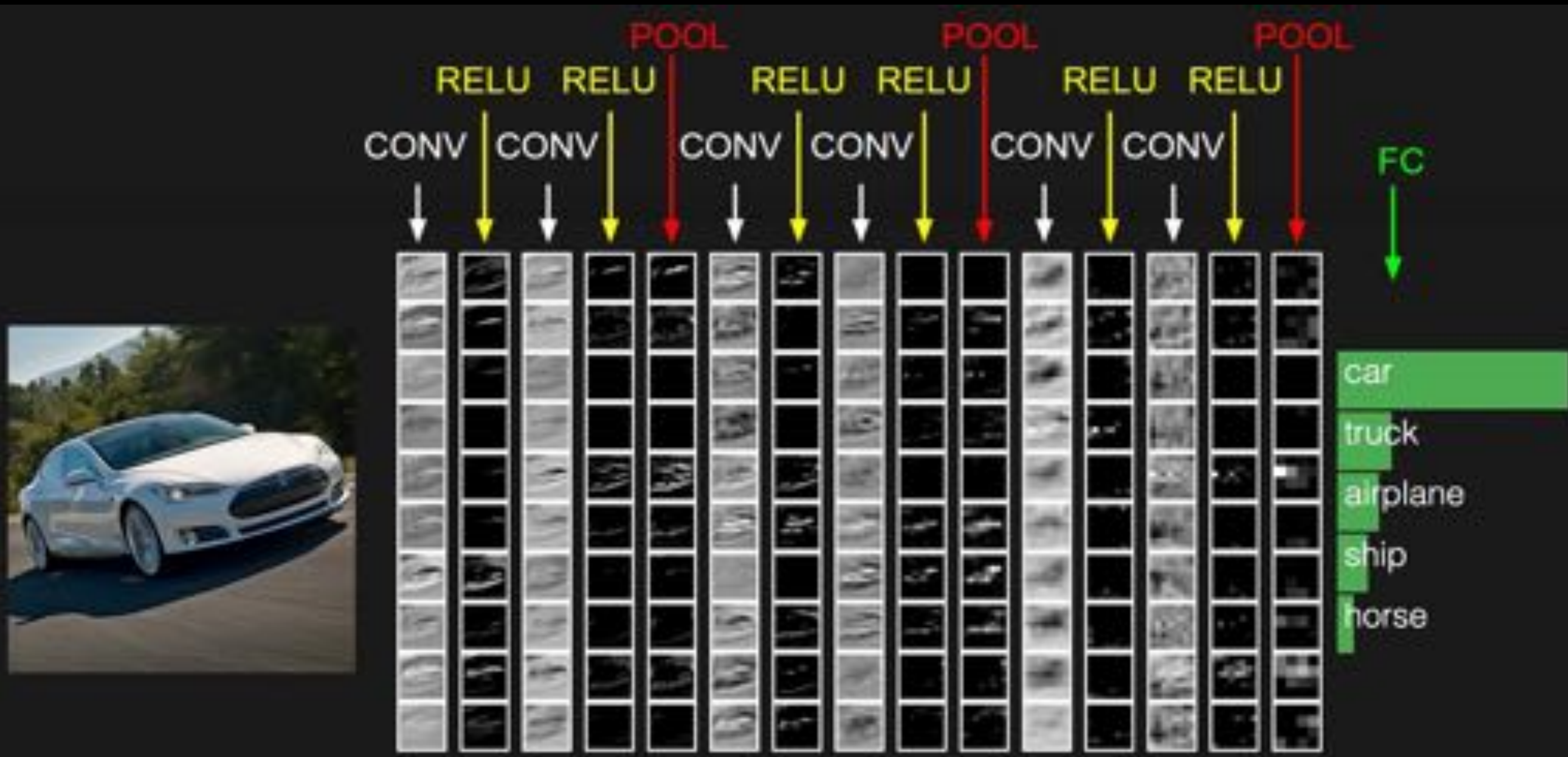
SOURCE: RAY KURZWEIL, "THE SINGULARITY IS NEAR: WHEN HUMANS TRANSCEND BIOLOGY", P.67, THE VIKING PRESS, 2006. DATAPOINTS BETWEEN 2000 AND 2012 REPRESENT BCA ESTIMATES.

The new Moore's Law: Computer's no longer get faster, just wider

Deep learning: learning layers of features



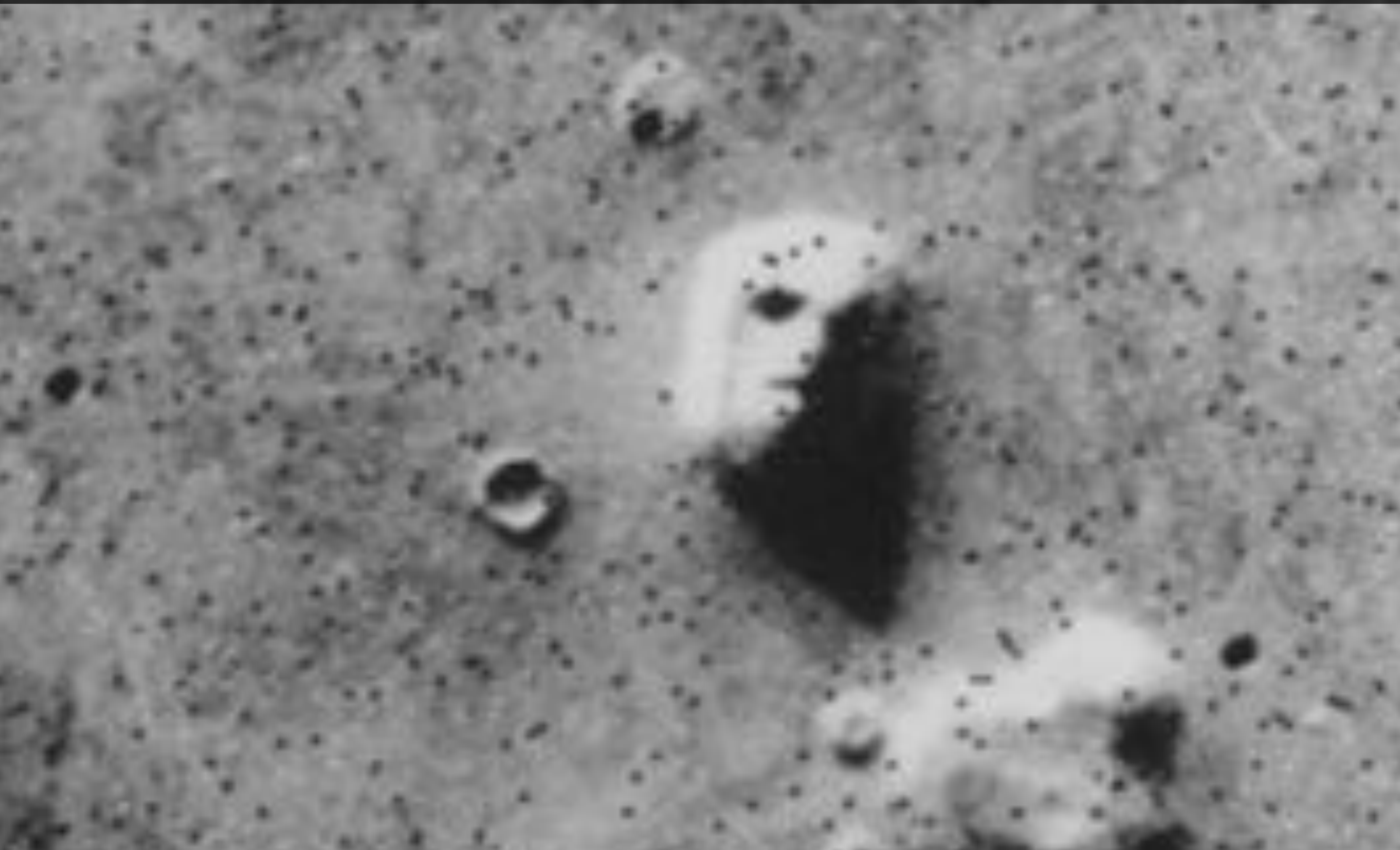




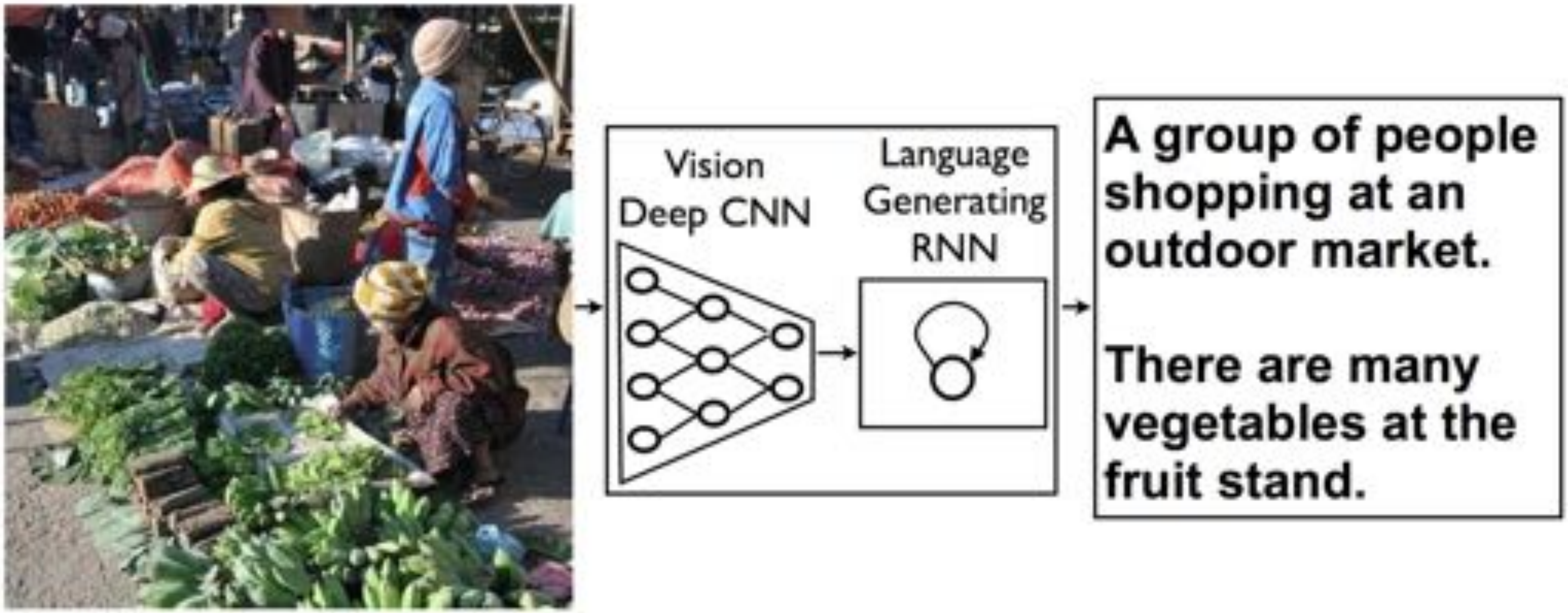
POOL
POOL
POOL
RELU
RELU
RELU
RELU
RELU
RELU
CONV
CONV
CONV
CONV
CONV
CONV
FC
car
truck
airplane
ship
horse

Do computers dream of electric sheep?

Inceptionism and Algorithmic Pareidolia



State-of-the-art computer vision: Recurrent networks for image captioning



“a man is climbing up a rock face”

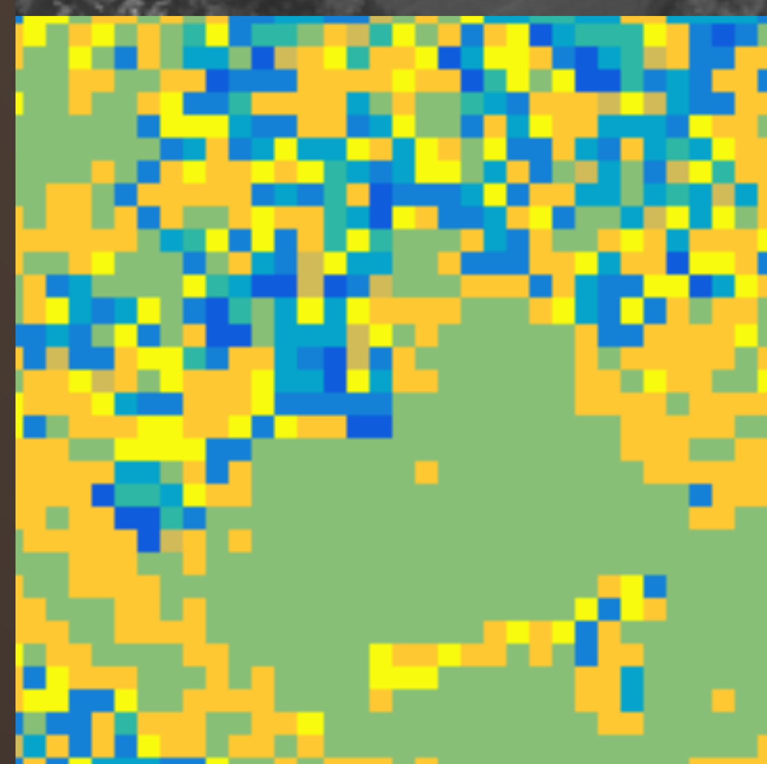
“a motorcycle racer is driving a turn on a racetrack”

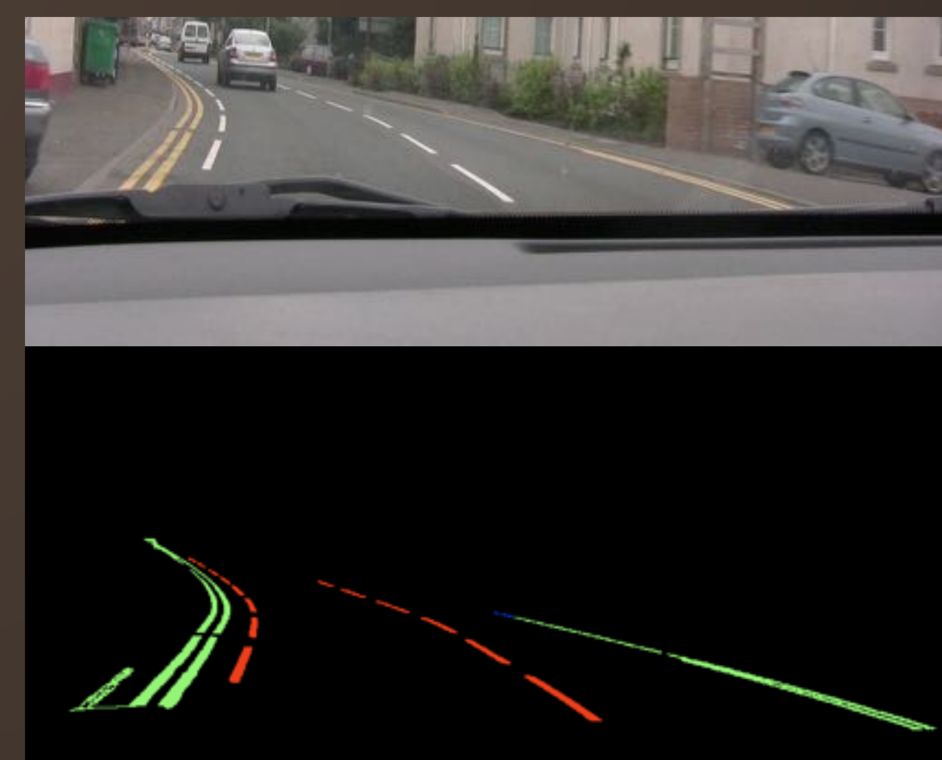
“a basketball player in a red uniform is trying to score a player in the air”

“a man in a red shirt is riding a bike on a snowy hill”

“a surfer is jumping off a snowy hill”

Current Research Areas





Open questions and future directions

Technological issues

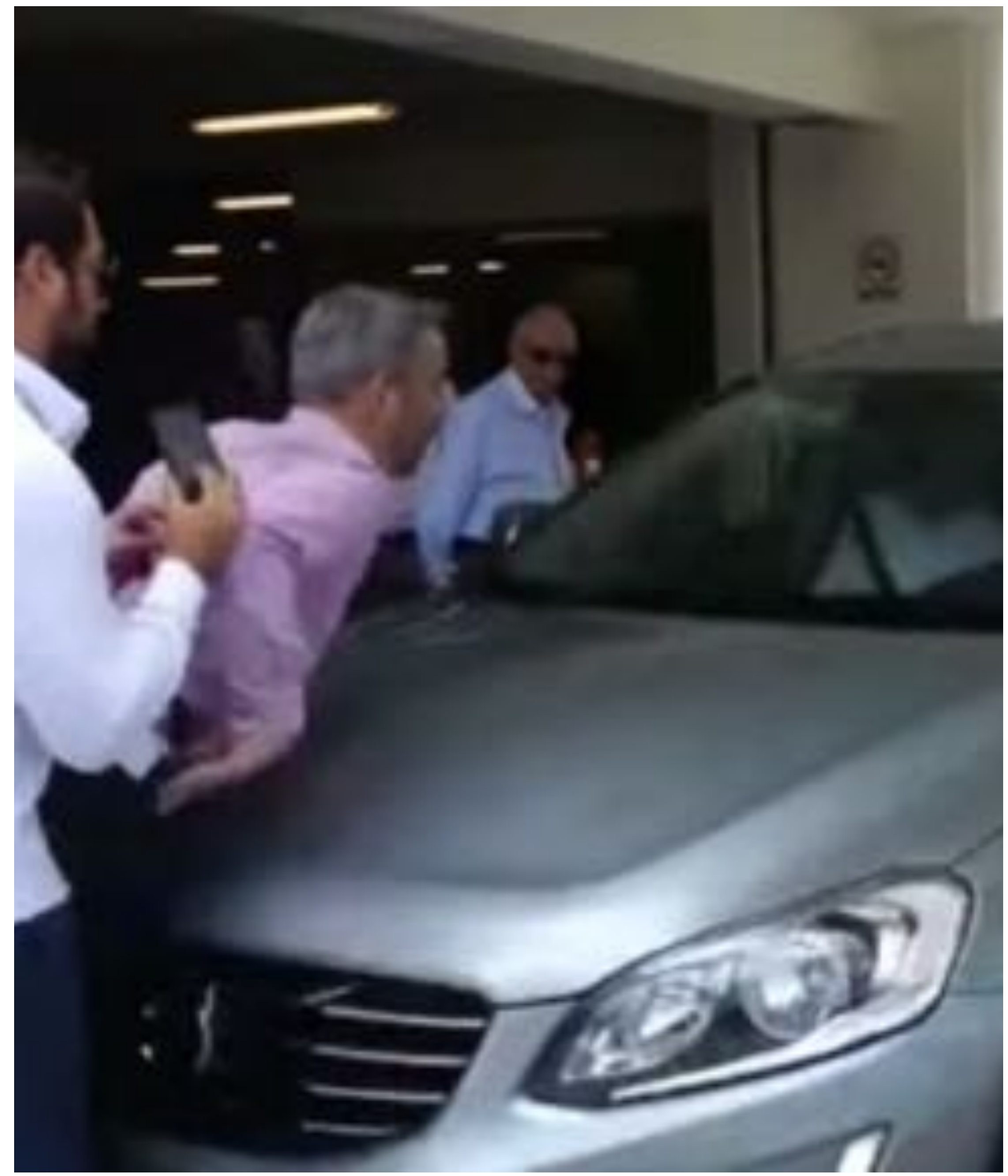
- Modern super-computers only come within a fraction of the computing power of the human brain.
- We still don't understand how the brain works, or what intelligence is.
- Humans don't need to see thousands of examples in order to learn to identify different types of object

Legal and ethical issues

- We still don’t understand the brain; to do so inevitably means more animal experiments.

- With more and more pervasive use of vision technologies we’re going to have to make difficult decisions.

  - Should the self-driving car optimise to preserve the life of it’s occupants or others?



Discussion & Questions