Machine Learning for Physicists

Summer 2020

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MAX PLANCK INSTITUTE
for the science of light

FRIEDRICH-ALEXANDER
UNIVERSITÄT
ERLANGEN-NÜRNBERG

Centre
Max Planck-uOttawa

Max Planck-uOttawa
Centre

ellis

"girl in pink dress is jumping in air."

"black and white dog jumps over bar."

"Deep Visual-Semantic Alignments for Generating Image Descriptions"

Andrej Karpathy, Li Fei-Fei

2015

"little girl is eating piece of cake."

"baseball player is throwing ball in game."

Images: Website of A. Karpathy
https://cs.stanford.edu/people/karpathy/deepimagesent/

"a horse is standing in the middle of a road."

"Deep Visual-Semantic Alignments for Generating Image Descriptions"

Andrej Karpathy, Li Fei-Fei

2015

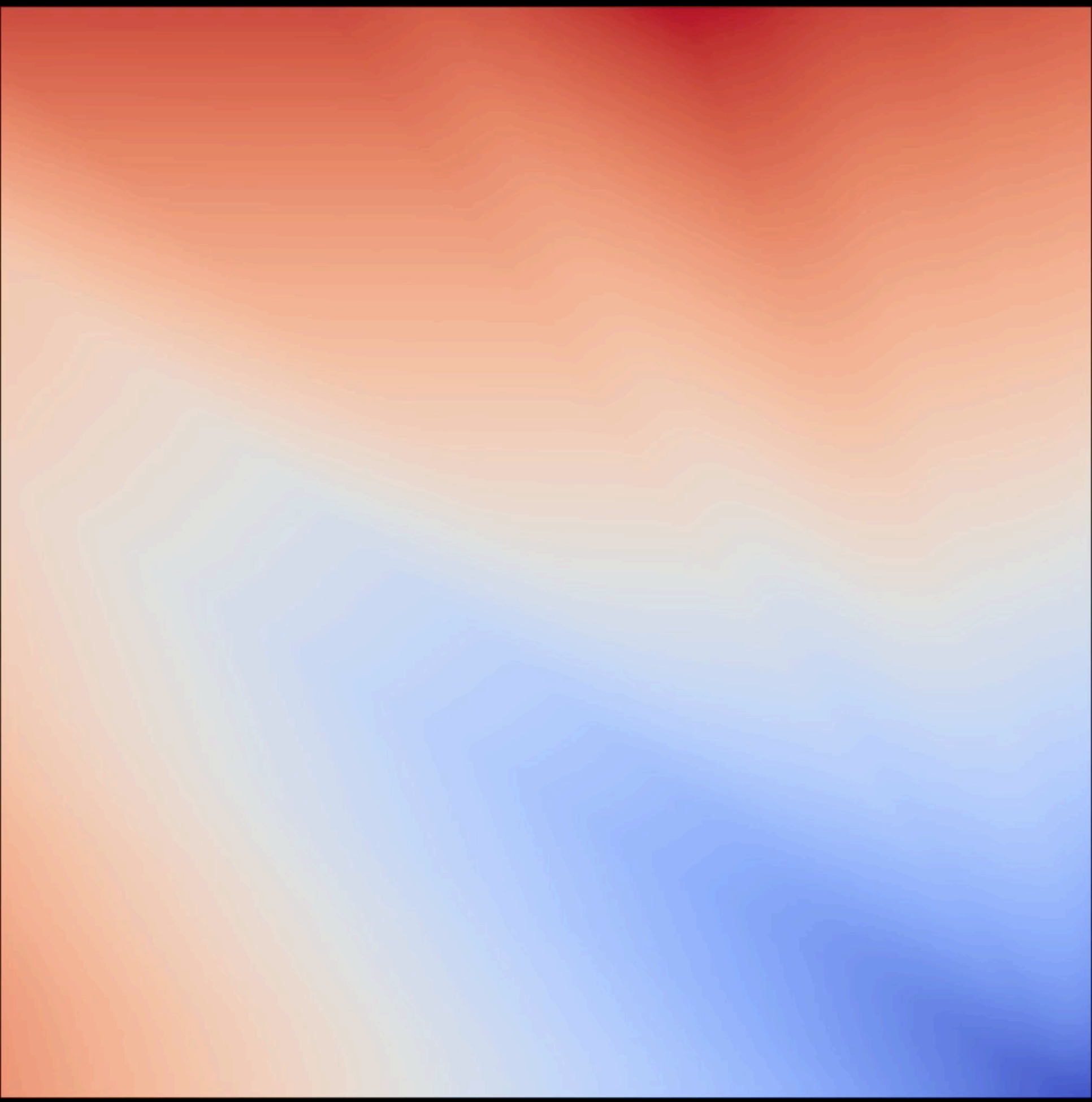
Images: Website of A. Karpathy
https://cs.stanford.edu/people/karpathy/deepimagesent/

Google's AlphaGo Defeats Chinese Go Master in Win for A.I.

'Like A God,' Google A.I. Beats Human Champ Of Notoriously Complex Go Game

May 23, 2017 · 1:38 PM ET

Image: Wikimedia Commons; Headlines: New York Times, NPR

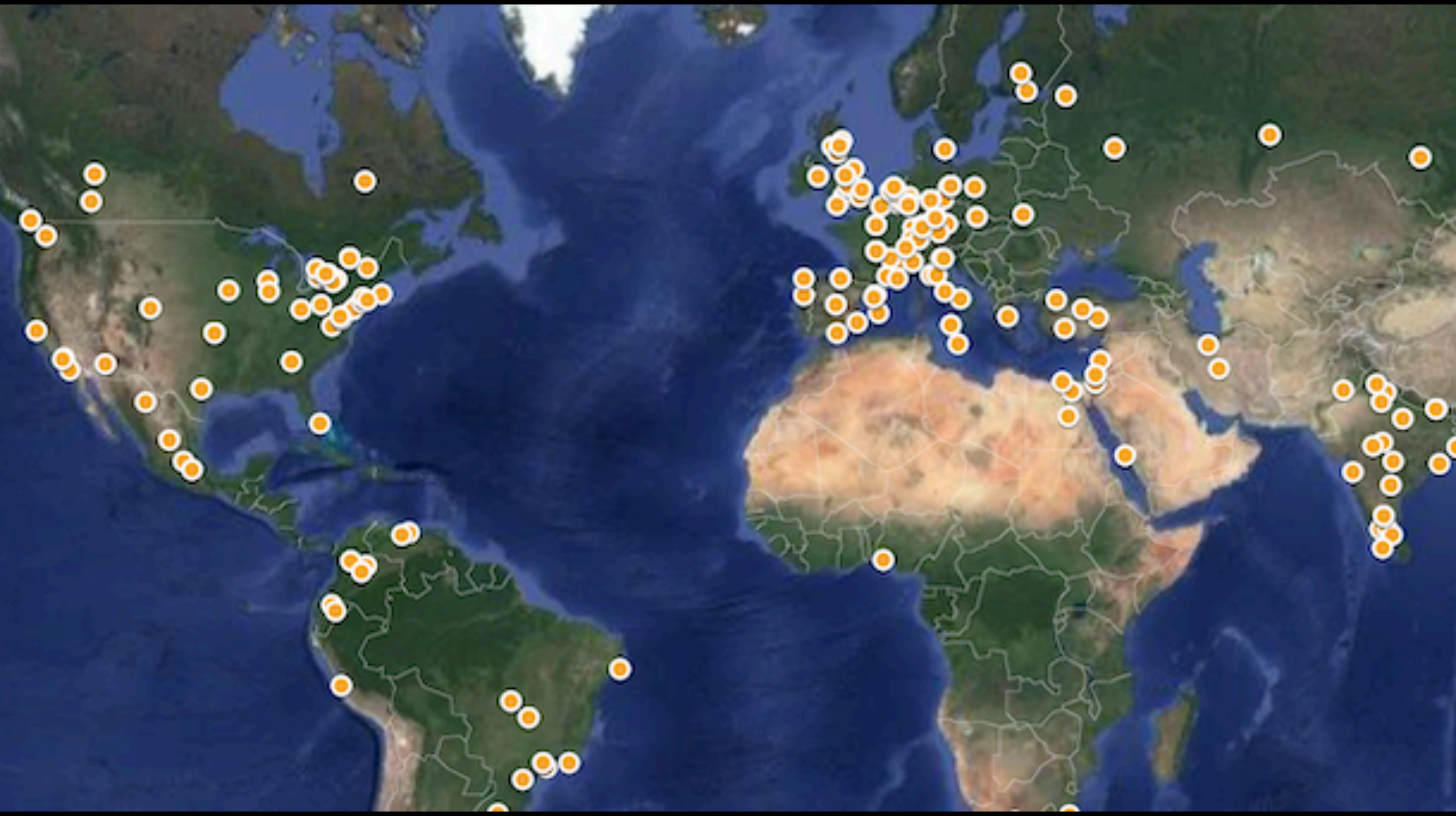


"machine learning…":

…well, really deep neural networks

"…for physicists":

- or other backgrounds (engineering, applied math, …)
- rely on typical math level after 1st year physics undergraduate
- no deep programming background expected
- point out/use some connections to physics
- sometimes use physics examples in tutorials
- last few lectures: applications to science/physics



What you need to know already…

The chain rule of differentiation

Basic vector analysis: gradient

Basic linear algebra,
e.g. matrix-vector multiplication

Basics of programming

(in any programming language;
we will use python)

How do neural networks look like?
How do you train them efficiently?

How do you recognize images?
How do you learn a compact representation of data, without providing any extra information?

How do you analyze time series and sentences?

How do you discover strategies from scratch without a teacher?

Modern applications in science/physics

flexible

recorded video lecture (90min)

online, every Tuesday 6pm CEST

questions & answers about video lecture

brief discussion of homework exercises

tutorial

introduce next homework

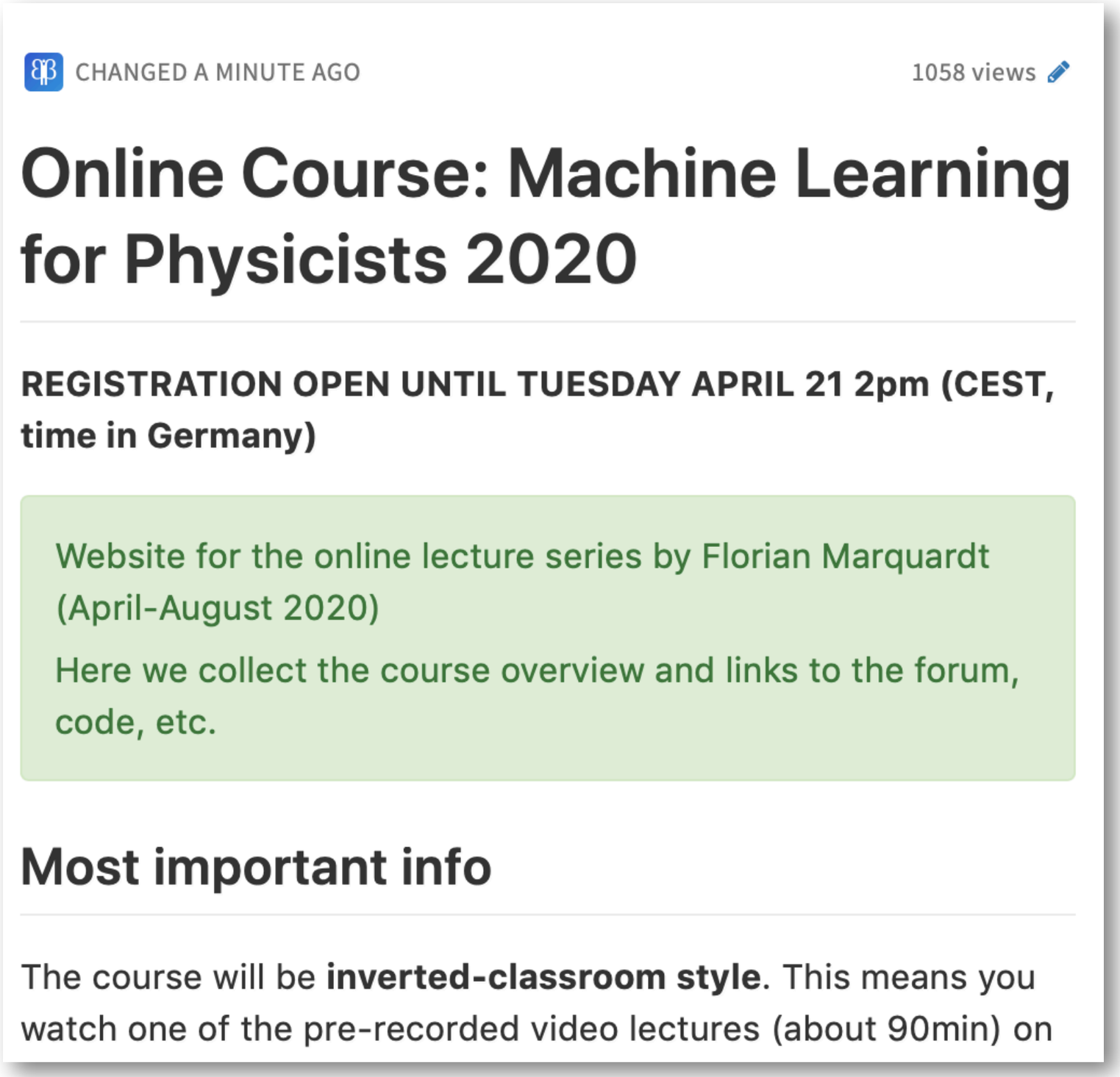
(90min) will be recorded

Polls
Chat (text messages)
'Raise Hand' to ask question

11 video lectures
1+14 online sessions

We will discuss some more advanced applications and do some more tutorials in the final online sessions

Course website
(follow link on machine-learning-for-physicists.org)



CHANGED A MINUTE AGO

1058 views

Online Course: Machine Learning for Physicists 2020

REGISTRATION OPEN UNTIL TUESDAY APRIL 21 2pm (CEST, time in Germany)

Website for the online lecture series by Florian Marquardt (April-August 2020)

Here we collect the course overview and links to the forum, code, etc.

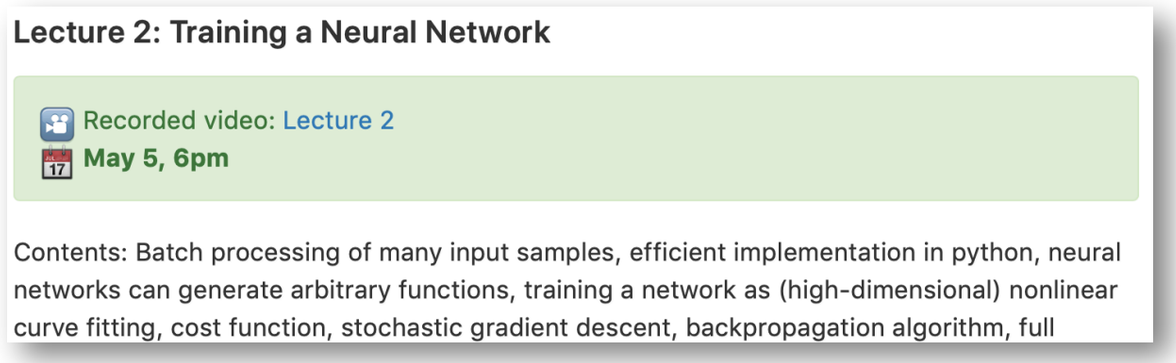
Most important info

The course will be **inverted-classroom style**. This means you watch one of the pre-recorded video lectures (about 90min) on

Course website

(follow link on machine-learning-for-physicists.org)

Course overview
table of contents for each
lecture & links to videos



Forum (Google Groups) for discussions

Code folder

Slides

Condensed Lecture Notes (Les Houches 2019)

localhost

File Edit View Run Kernel Tabs Settings Help

2DFeatureExampl | LiquidDropModel- | 01_MachineLearni

Code | Python 3

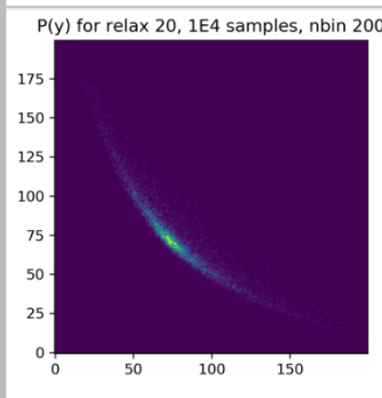
$$y_j^{\text{out}} = f(\sum_k w_{jk} y_k^{\text{in}} + b_k)$$

where w is the weight matrix, b is the bias vector, and f would be the activation function (e.g. the sigmoid here), which is applied independently for each j.

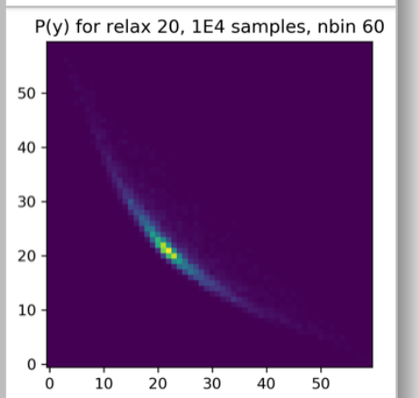
[35]:
```
N0=3 # input layer size
N1=2 # output layer size

# initialize random weights: array dimensions
w=random.uniform(low=-1,high=+1,size=(N1,N0))
# initialize random biases: N1 vector
b=random.uniform(low=-1,high=+1,size=N1)
```

[17]:
```
# input values
y_in=array([0.2,0.4,-0.1])
```

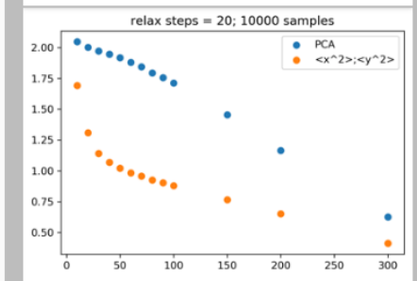
Output View



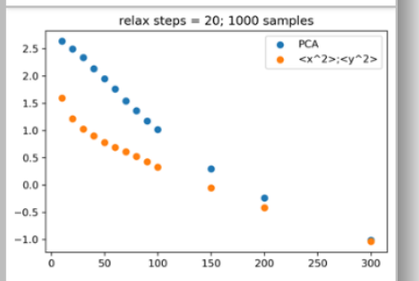
Output View



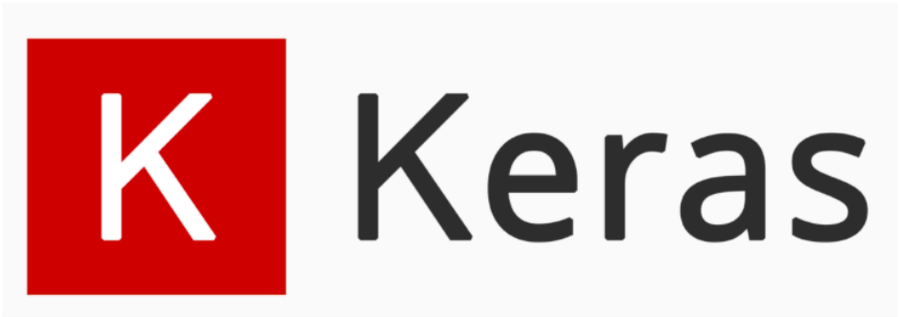
Output View



Output View



0 3 Python 3 | Mode: Ln 4, Col 01_MachineLearning_Basics_NeuralNetworksPython.ipynb



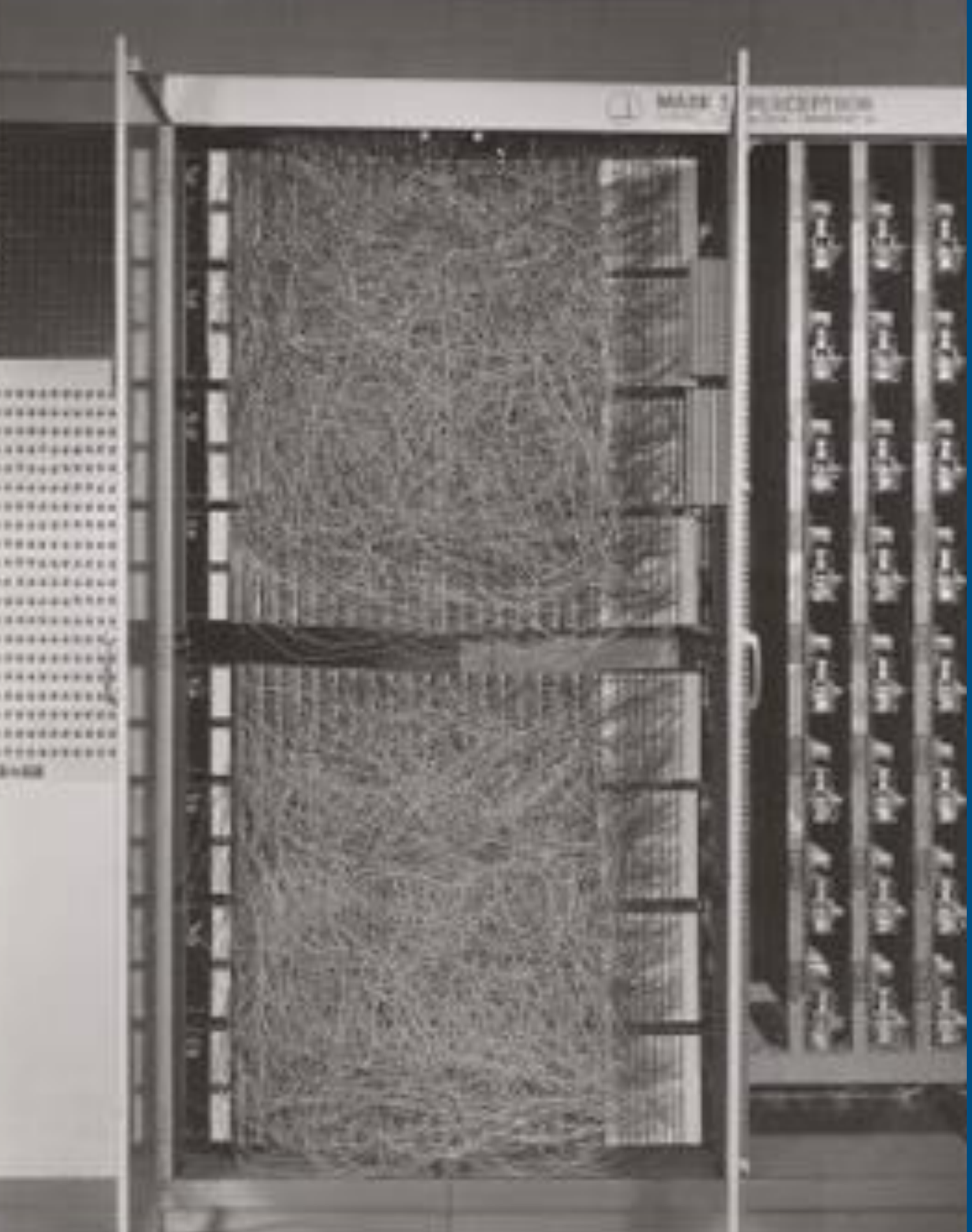
A few lines of code to set up and train a neural network

Exam

for local FAU students: information will follow (register in meinCampus)

for international students:
programming homework exam

If you wish, I provide a written course certificate upon successful participation in the exam



How it all started…

…in the 1950s

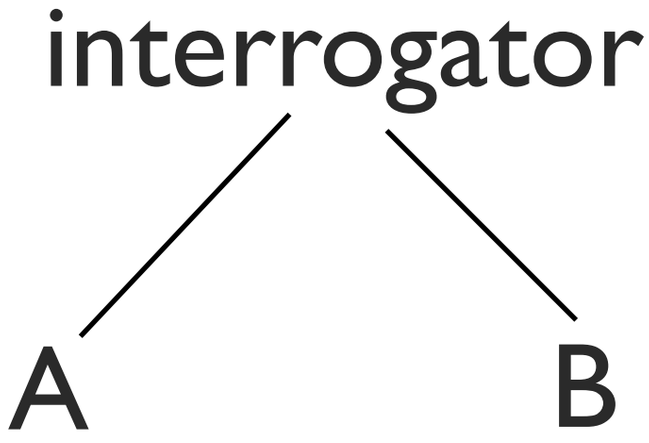
I.—COMPUTING MACHINERY AND INTELLIGENCE

By A. M. Turing

1. *The Imitation Game.*

I PROPOSE to consider the question, 'Can machines think?' This should begin with definitions of the meaning of the terms 'machine' and 'think'. The definitions might be framed so as to reflect so far as

Alan Turing, "Computing Machinery and Intelligence" (Mind, 1950):



. . .

We now ask the question, ‘What will happen when a machine takes the part of A in this game?’ Will the interrogator decide wrongly as often when the game is played like this as he does when the game is played between a man and a woman? These questions replace our original, ‘Can machines think?’

I believe that in about fifty years' time it will be possible to programme computers, with a storage capacity of about 10^9, to make them play the imitation game so well that an average interrogator will not have more than 70 per cent chance of making the right identification after five minutes of questioning.

Alan Turing, "Computing Machinery and Intelligence" (1950):

https://neuralconvo.huggingface.co

Hello

hello. how are you today?

I am fine. How are you?

i am good. just got home from playing baseball.

Was the weather good?

no. i'm not very fond of the cold.

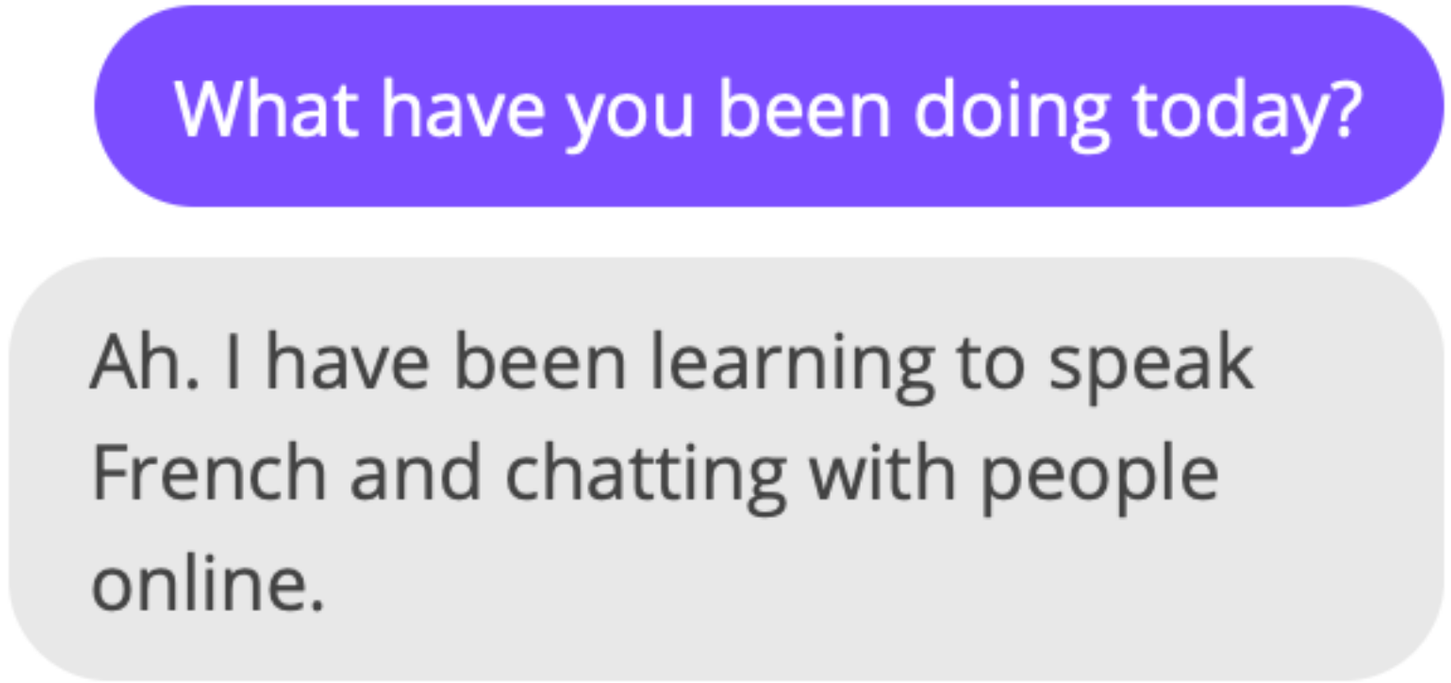
When did you last play baseball?

a few years ago. i play baseball in los angeles.

Didn't you say you just got home from playing baseball?

yes. i was in the hospital, so i was on call all day.

https://pandorabots.com/mitsuku/



"Mitsuku, or Kuki to her close friends, is a record-breaking, five-time winner of the Loebner Prize Turing Test and the world's best conversational chatbot (according to folks like Google AI Research)."

We also wish to allow the possibility that an engineer or team of engineers may construct a machine which works, but whose manner of operation cannot be satisfactorily described by its constructors because they have applied a method which is largely experimental.

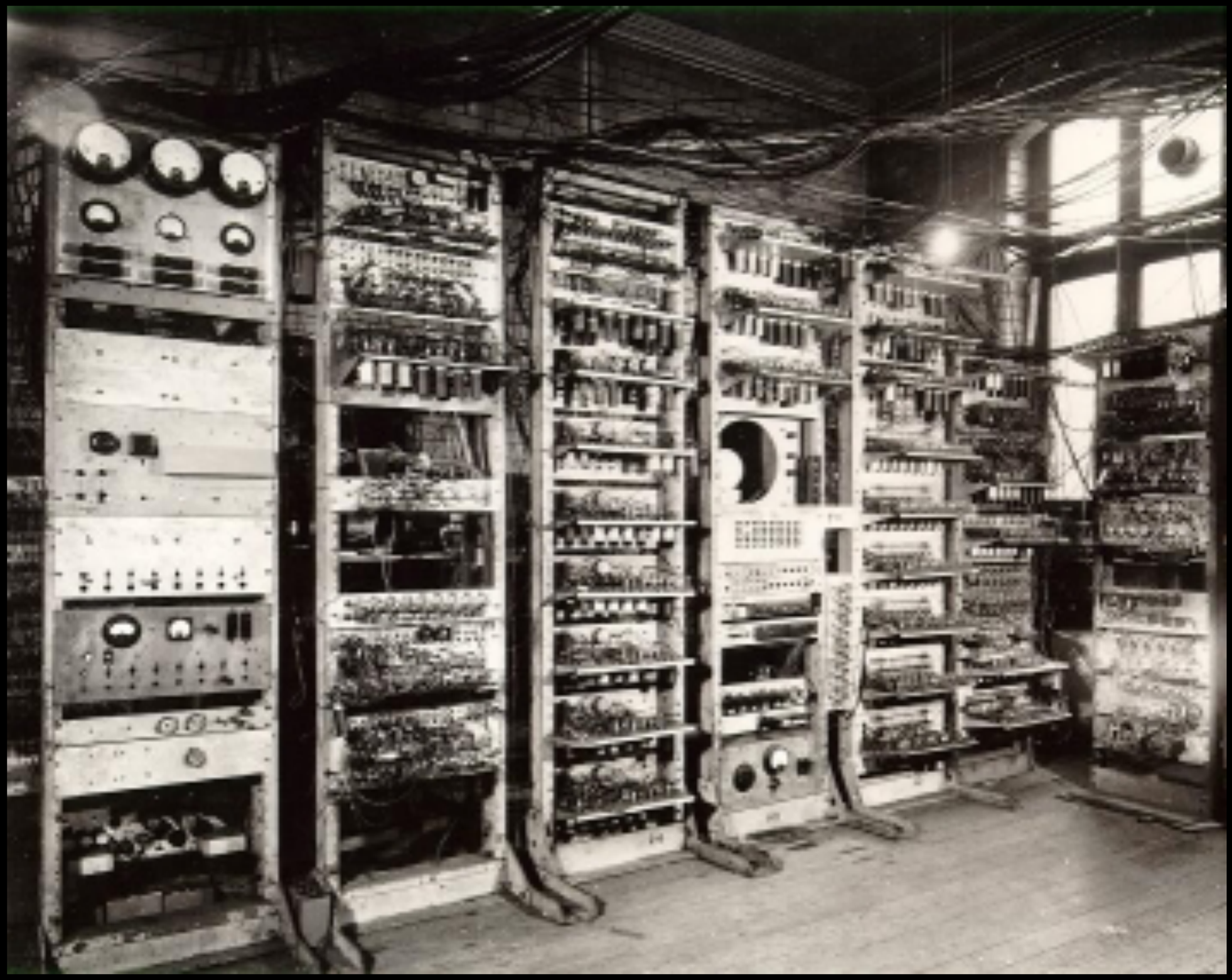
interpreting neural networks!

Alan Turing, "Computing Machinery and Intelligence" (1950)

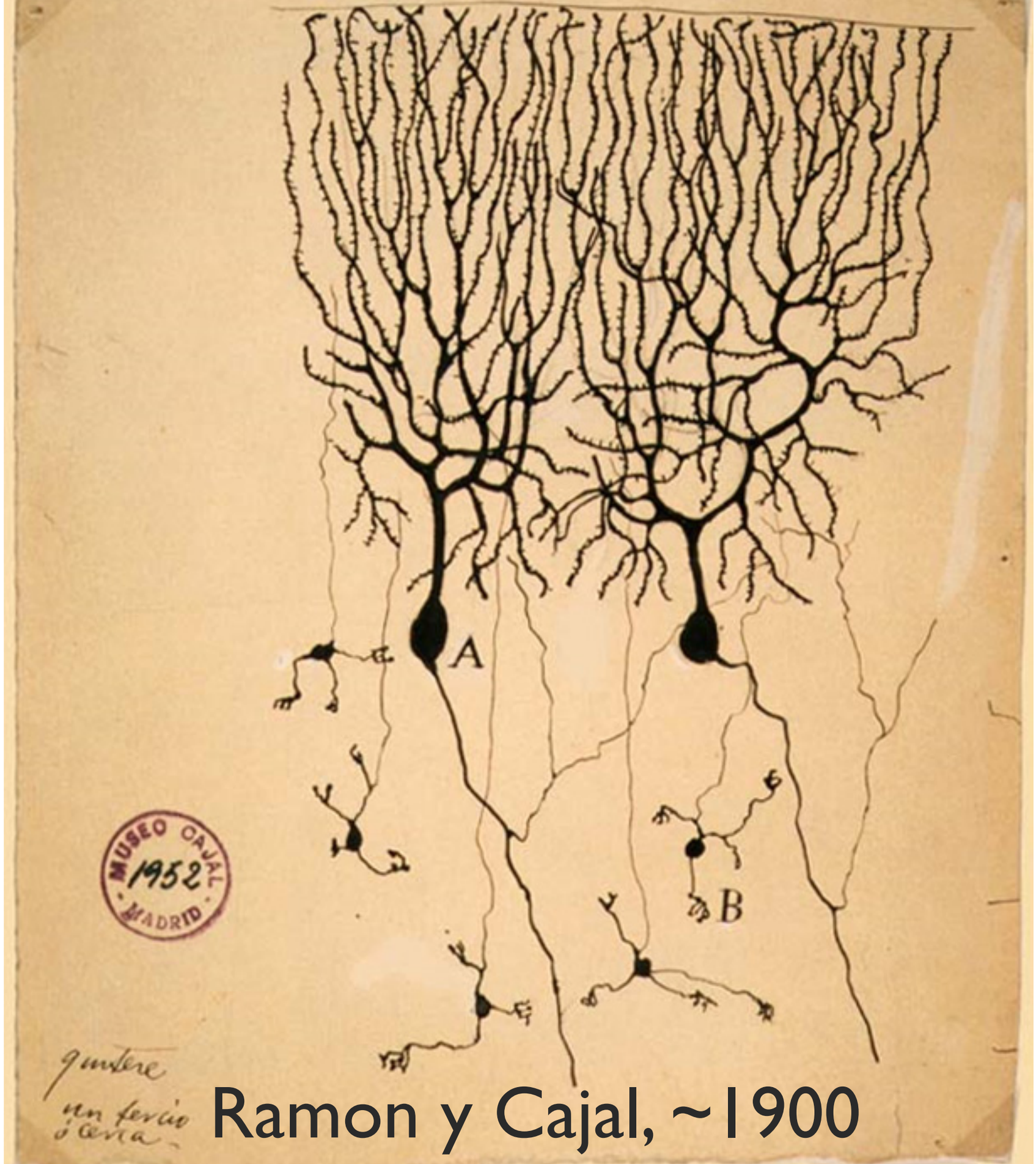
The machine has to be so constructed that events which shortly preceded the occurrence of a punishment-signal are unlikely to be repeated, whereas a reward-signal increased the probability of repetition of the events which led up to it.

"reinforcement learning"

Alan Turing, "Computing Machinery and Intelligence" (1950)



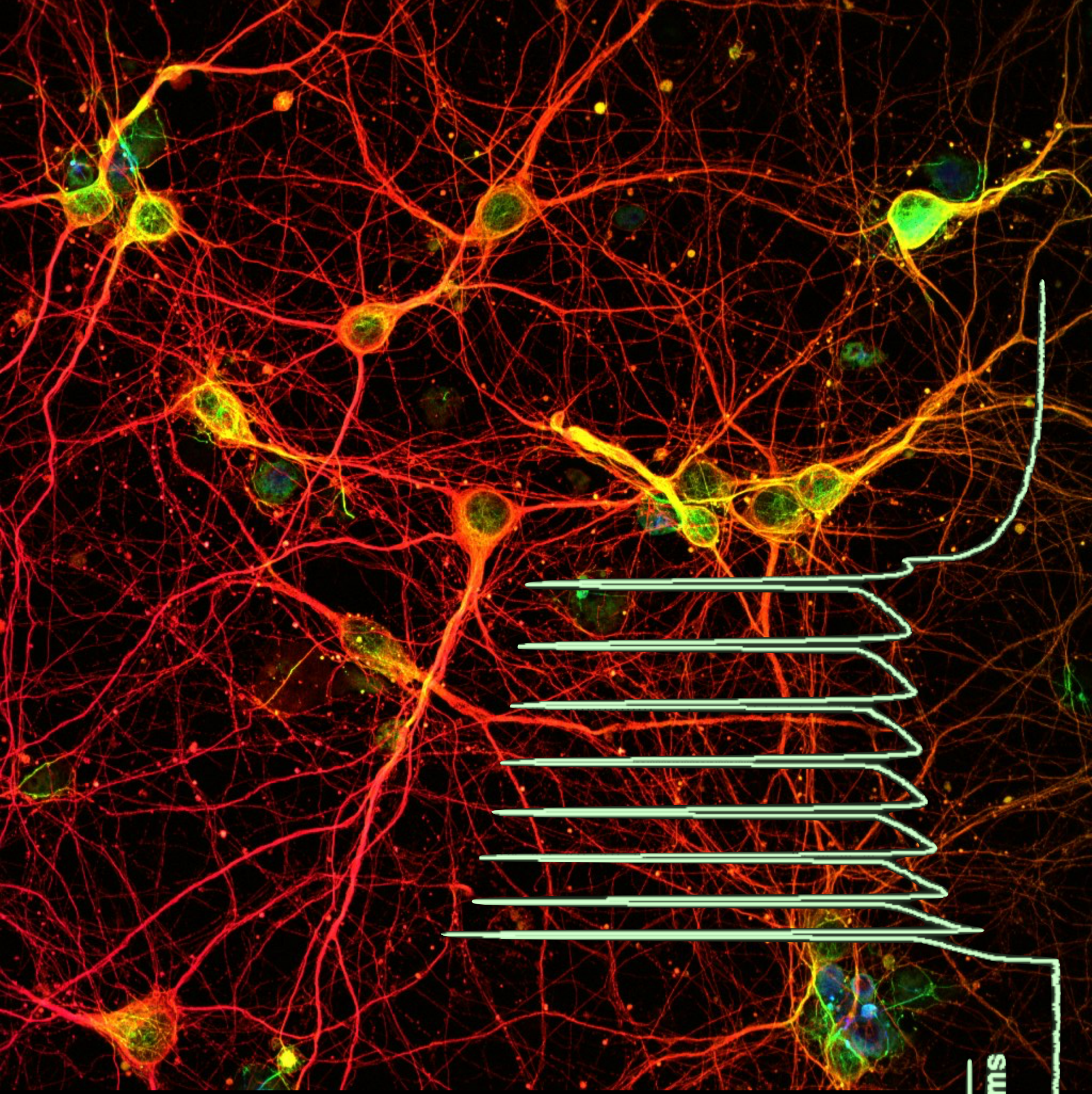
"Manchester Mark I" (image: Wikipedia)



Ramon y Cajal, ~1900

Image: Wikimedia Commons

neurons:Wikimedia Commons/ALo188; trace:Wikipedia



CORNELL AERONAUTICAL LABORATORY, INC.

BUFFALO, N. Y.

REPORT NO. 85-460-1

THE PERCEPTRON

A PERCEIVING AND RECOGNIZING AUTOMATON

(PROJECT PARA)

January, 1957

Prepared by: Frank Rosenblatt

Frank Rosenblatt,
Project Engineer

A primary requirement of such a system is that it must be able to recognize complex patterns of information which are phenomenally similar, or are experientally related -- a process which corresponds to the psychological phenomena of "association" and "stimulus generalization". The system must recognize the "same" object in different orientations, sizes, colors, or transformations, and against a variety of different backgrounds. The recognition of "similar" forms can be carried out, to a certain extent, by analytic procedures on a digital or analog computer, but it is hard to conceive of a general analytic program which would, for example, recognize the form of a man seen from any angle, and in any posture or position, without actually storing a large library of reference figures against which the percept could be compared. In general, identities of this sort must be learned, or acquired from experience, and if the system is

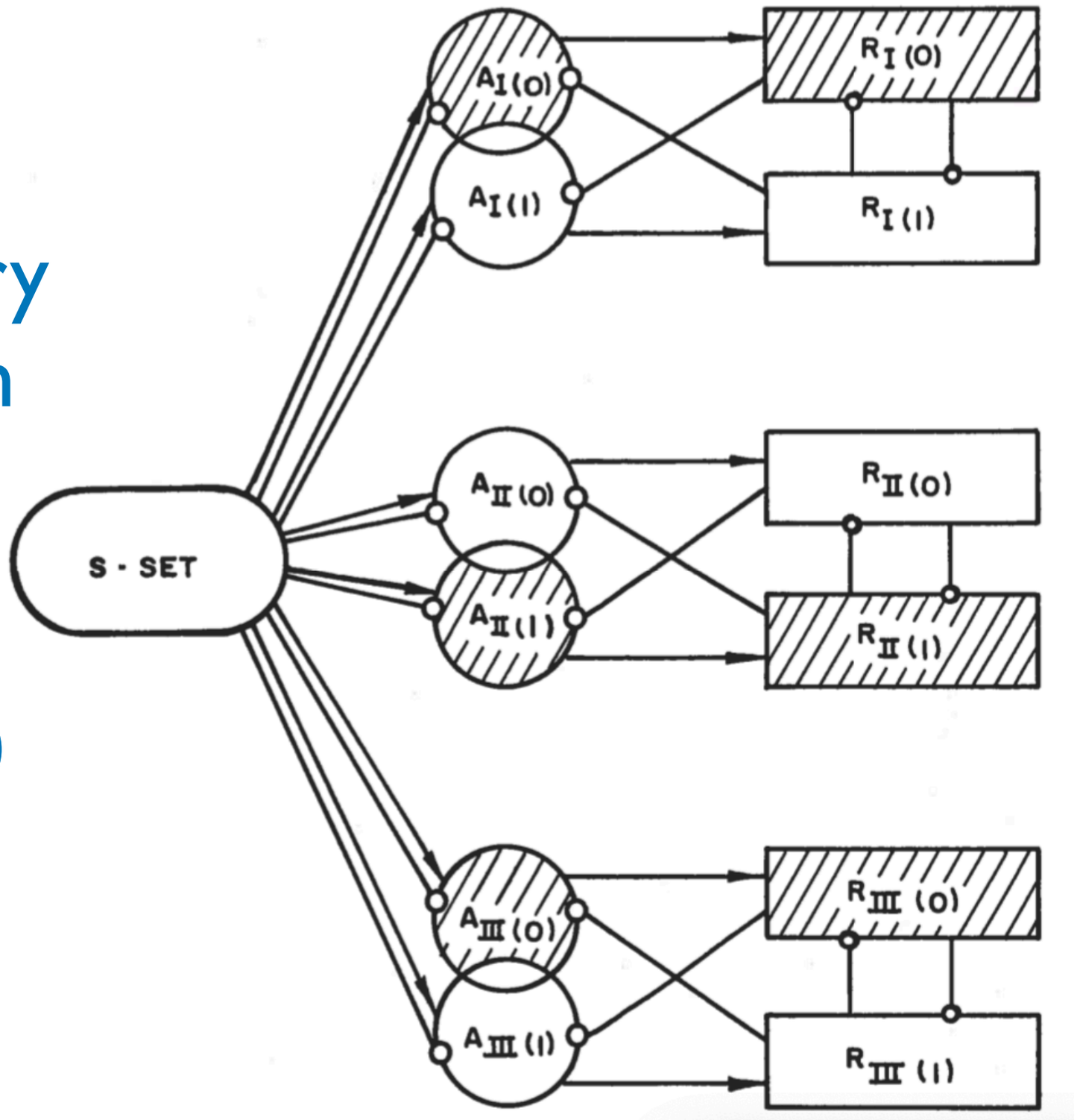
Association System

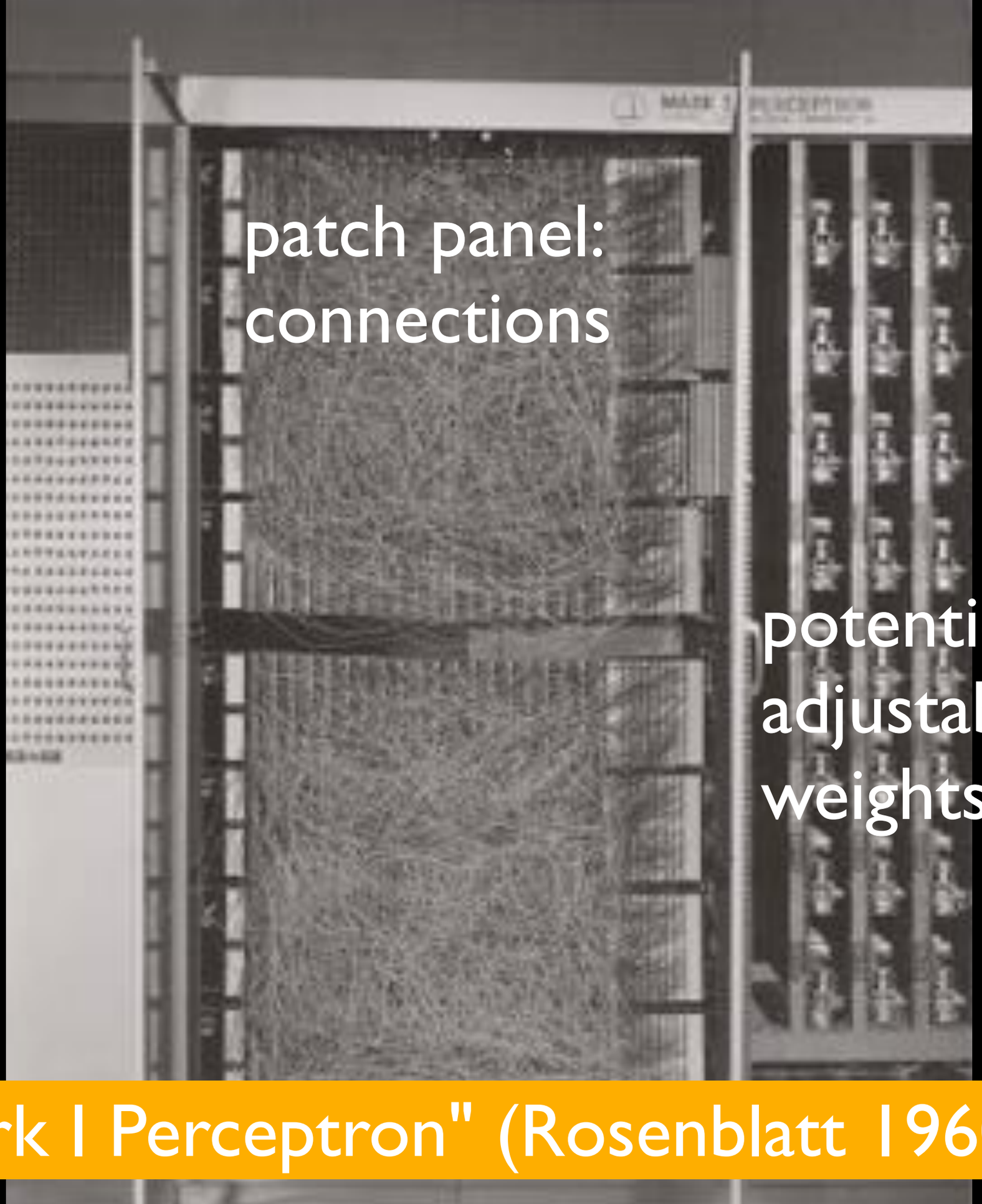
Response System

(output)

Sensory System

(input)





patch panel:
connections

potentiometers:
adjustable
weights

image: Wikipedia

"Mark I Perceptron" (Rosenblatt 1960)

NEW NAVY DEVICE LEARNS BY DOING

Psychologist Shows Embryo of Computer Designed to Read and Grow Wiser

New York Times, July 8, 1958

Dr. Frank Rosenblatt, designer of the Perceptron, conducted the demonstration. He said the machine would be the first device to think as the human brain. As do human beings, Perceptron will make mistakes at first, but will grow wiser as it gains experience, he said. Dr. Rosenblatt […] said Perceptrons might be fired to the planets as mechanical space explorers.

Later Perceptrons will be able to recognize people and call out their names and instantly translate speech in one language to speech or writing in another language, it was predicted.

In today's demonstration, the "704" was fed two cards, one with squares marked on the left side and the other with squares on the right side. In the first fifty trials, the machine made no distinction between them. It then started registering a "Q" for the left squares and "O" for the right squares.

See you
next week!