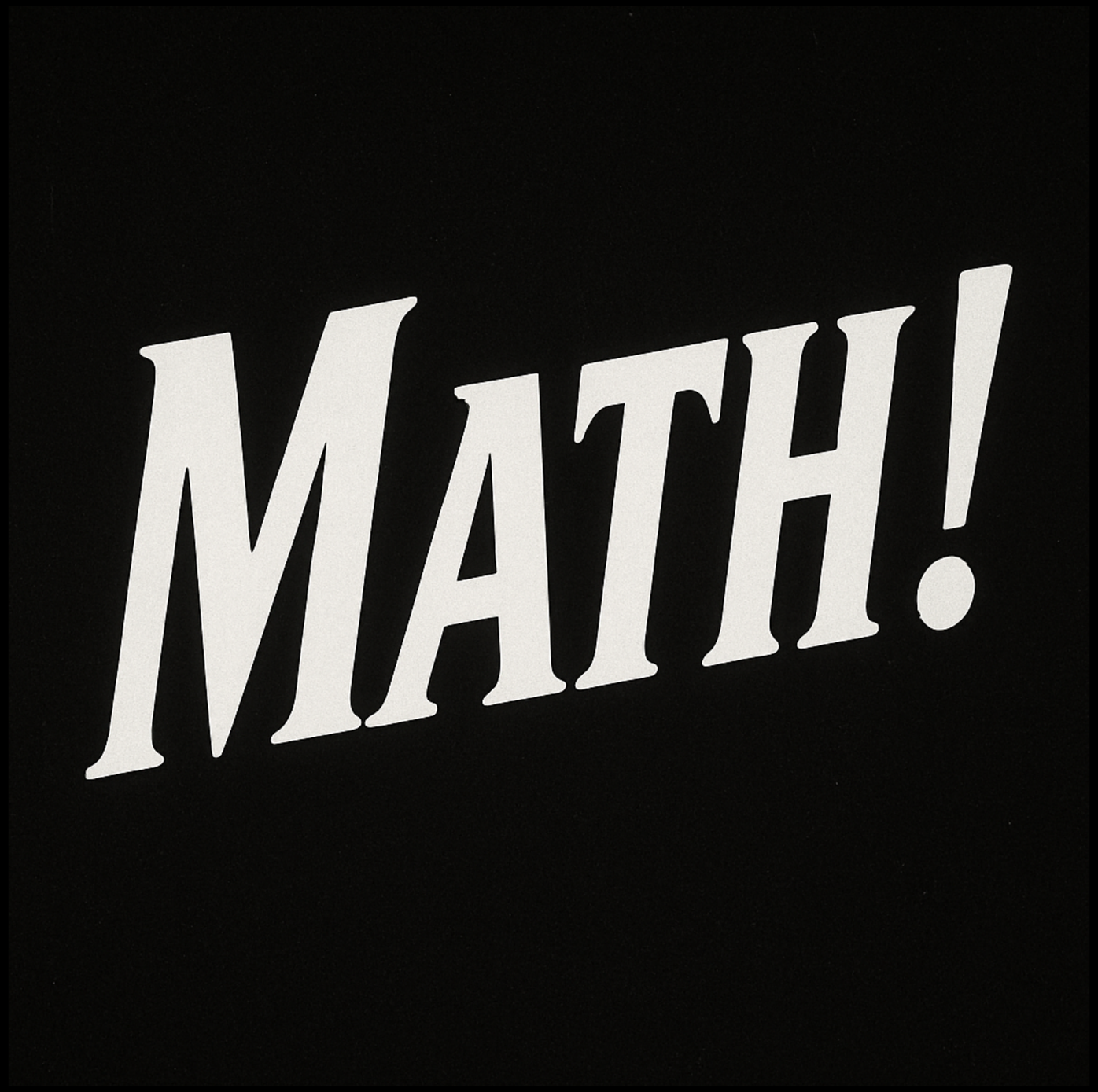
AI from Scratch: Let's Build and Train a Perceptron in Pure Swift

Johannes Fahrenkrug - @jfahrenkrug - springenwerk.com - #PragmaConf 2025


HISTORY!


MATH!


CODE!


INTRIGUE!

INTEGER!

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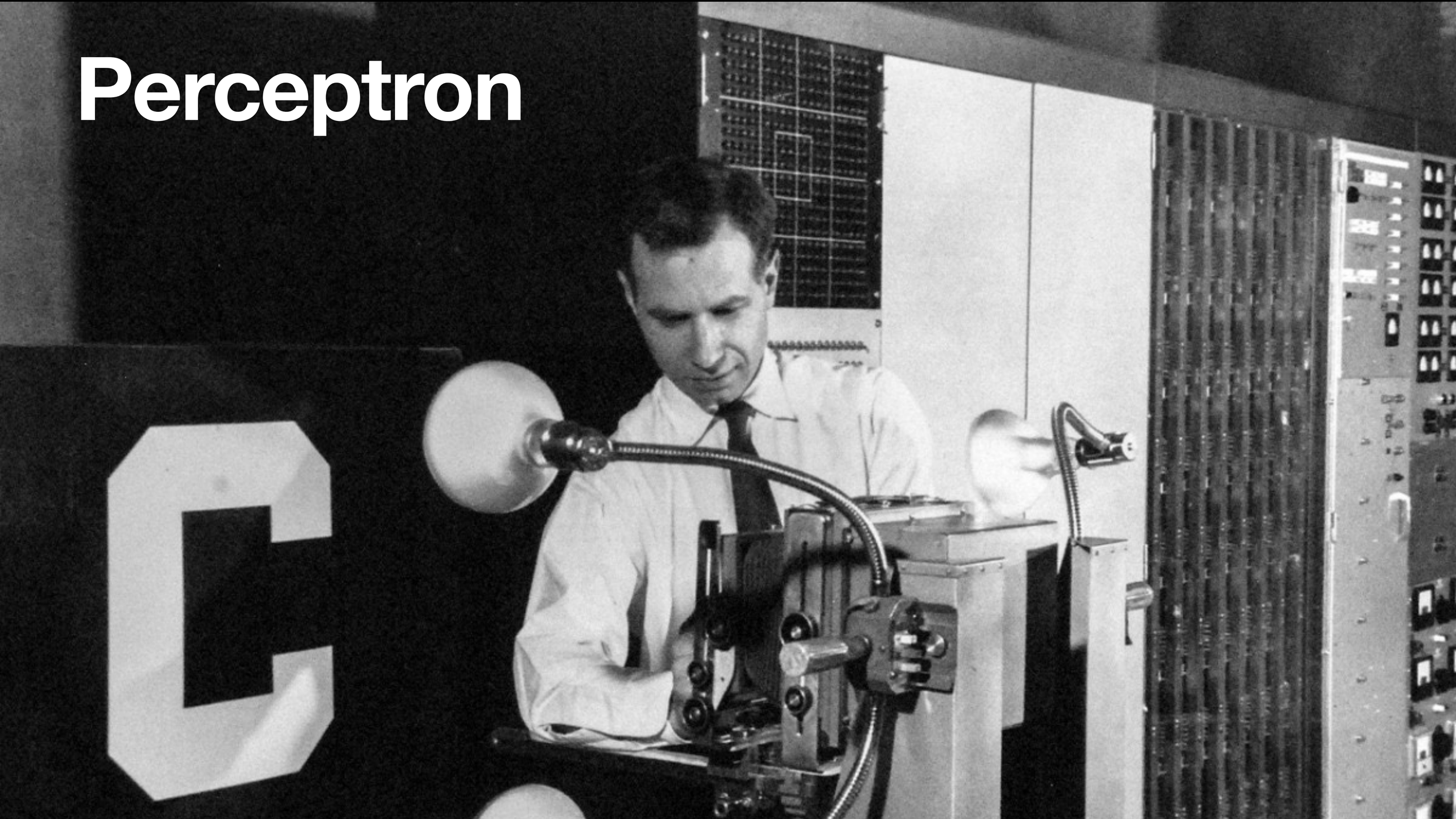
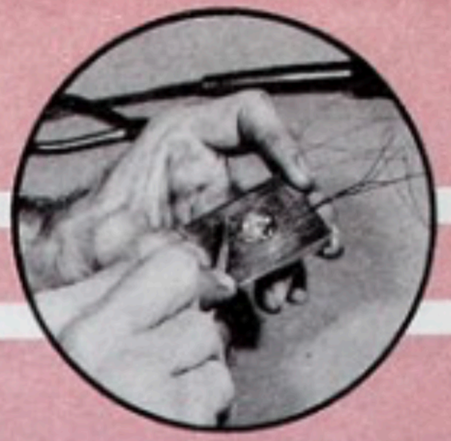
Perceptron



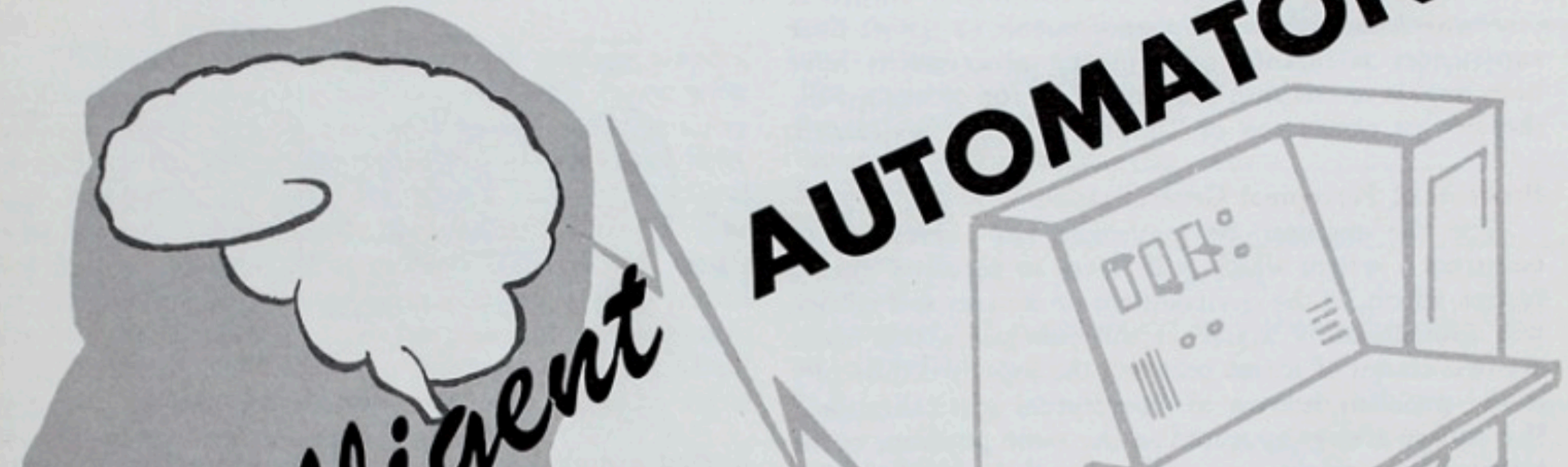
Vol. VI, No. 2, Summer 1958



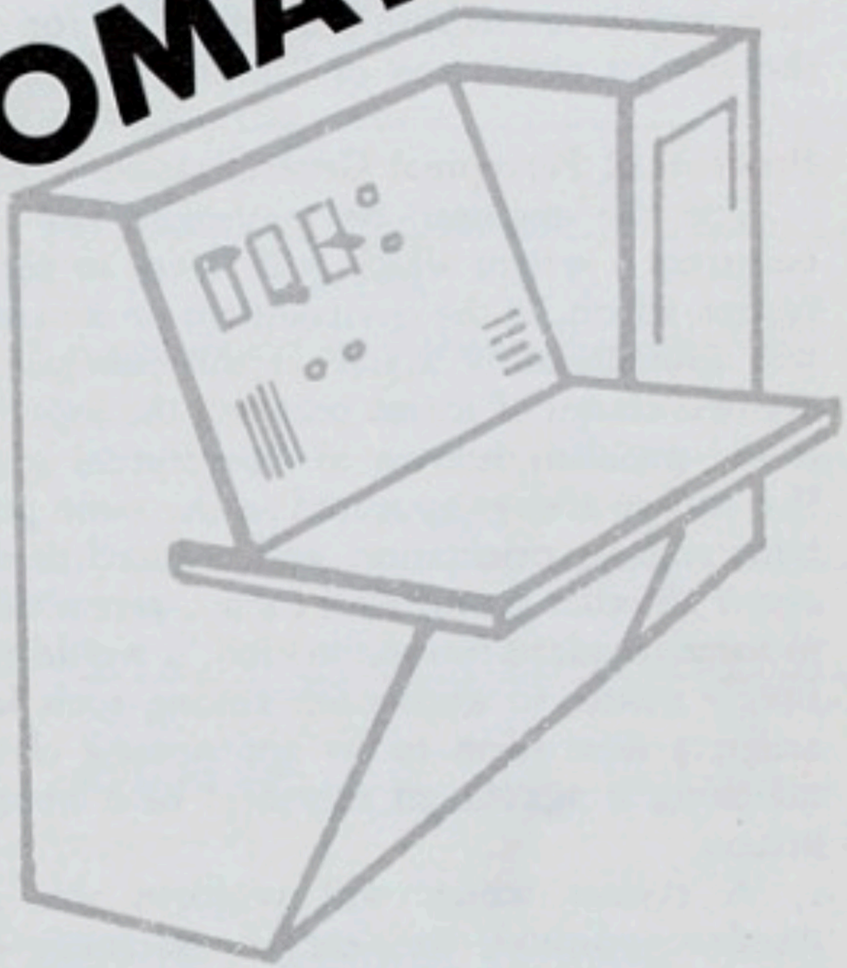
research trends

CORNELL AERONAUTICAL LABORATORY, INC., BUFFALO 21, NEW YORK

The Design of an

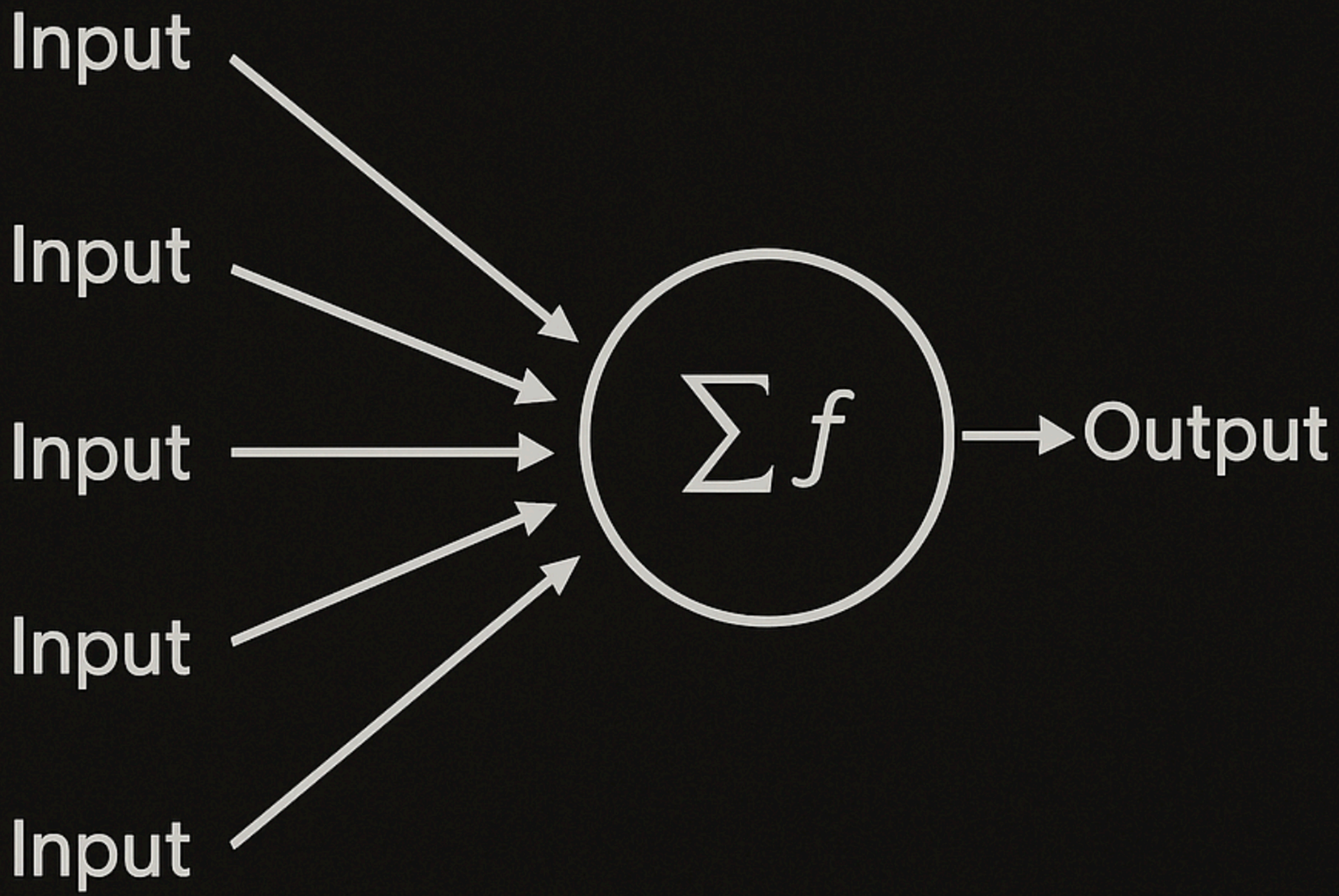


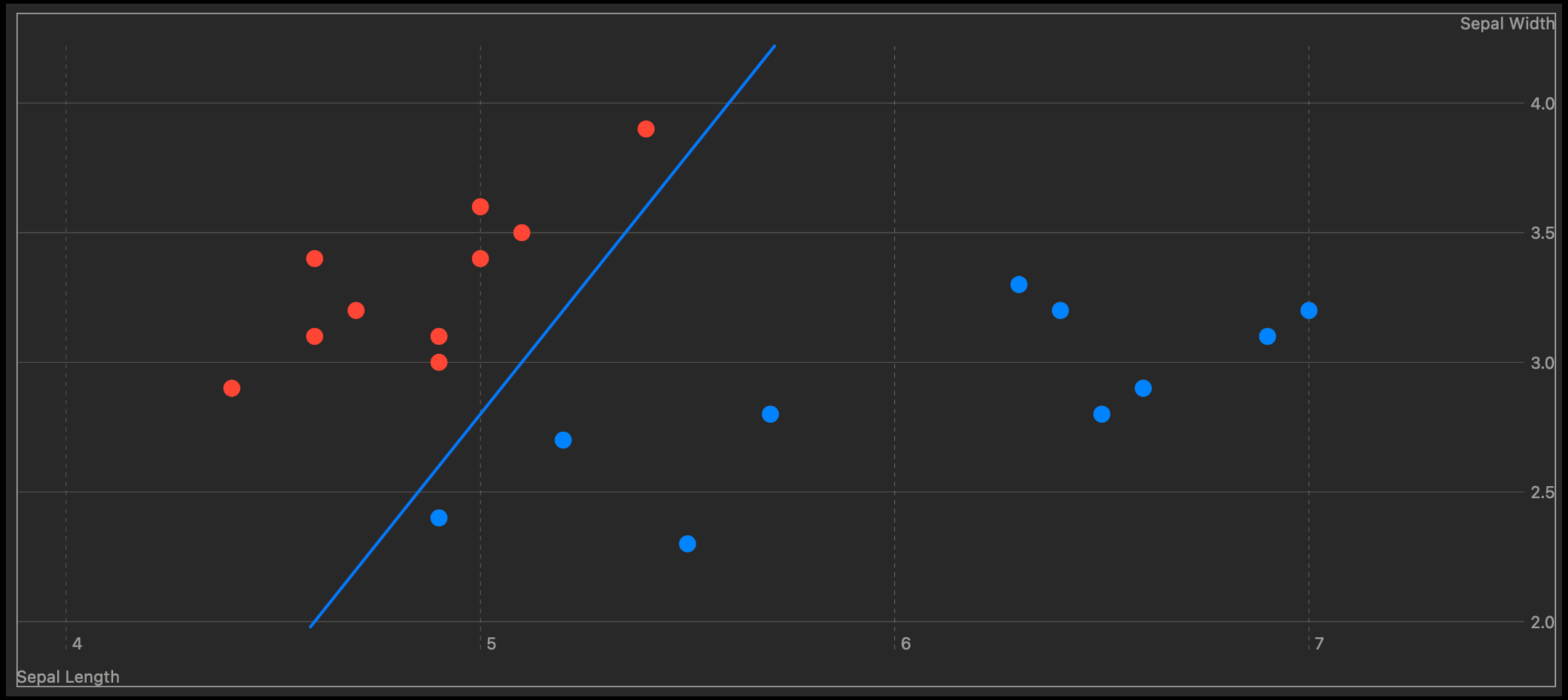
The Design of an *Intelligent* AUTOMATON

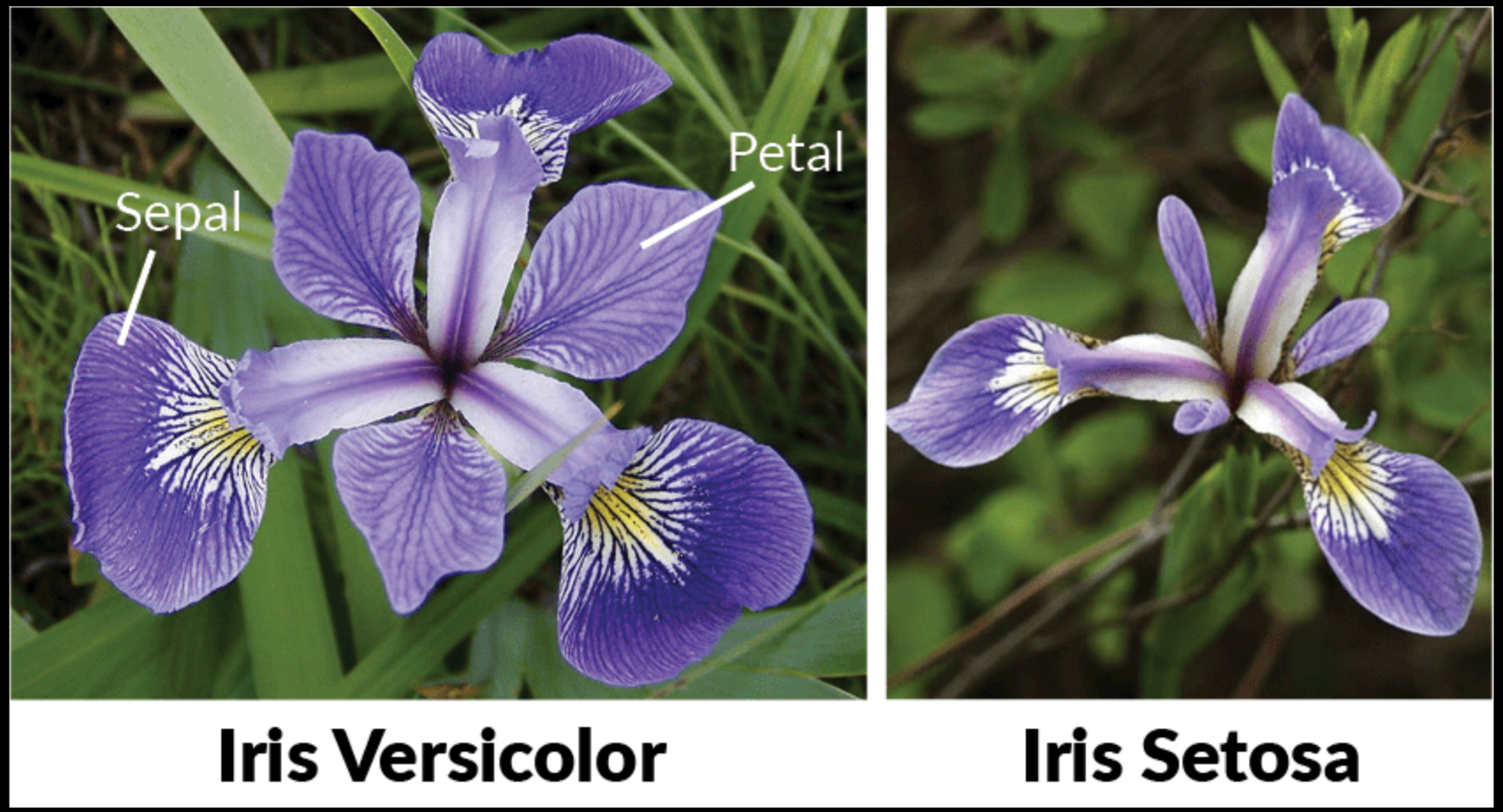


by FRANK ROSENBLATT

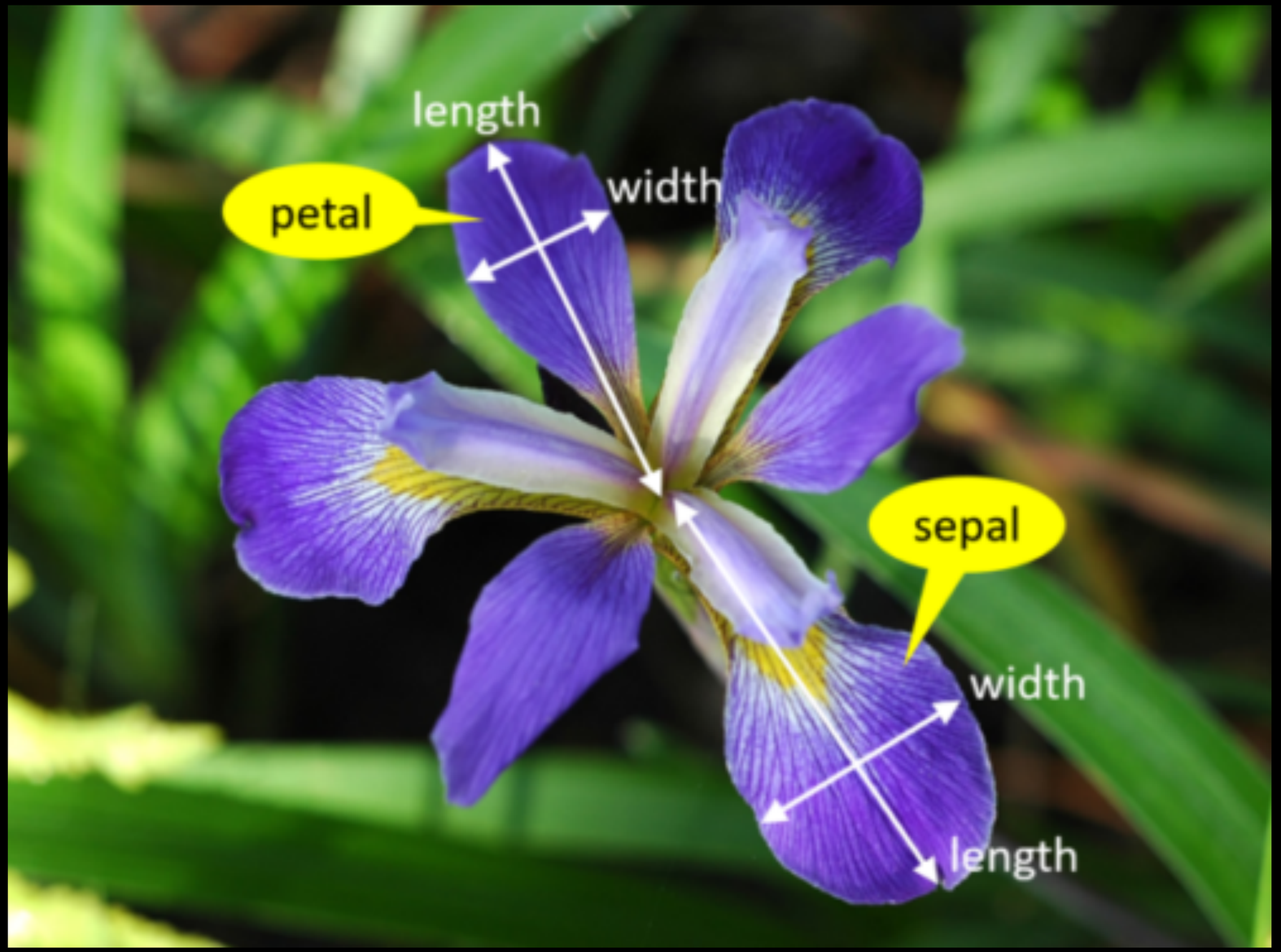
Introducing the perceptron — A machine which senses, recognizes, remembers, and responds like the human mind.


Input
Input
Input
Input
Input
$\sum f$
Output

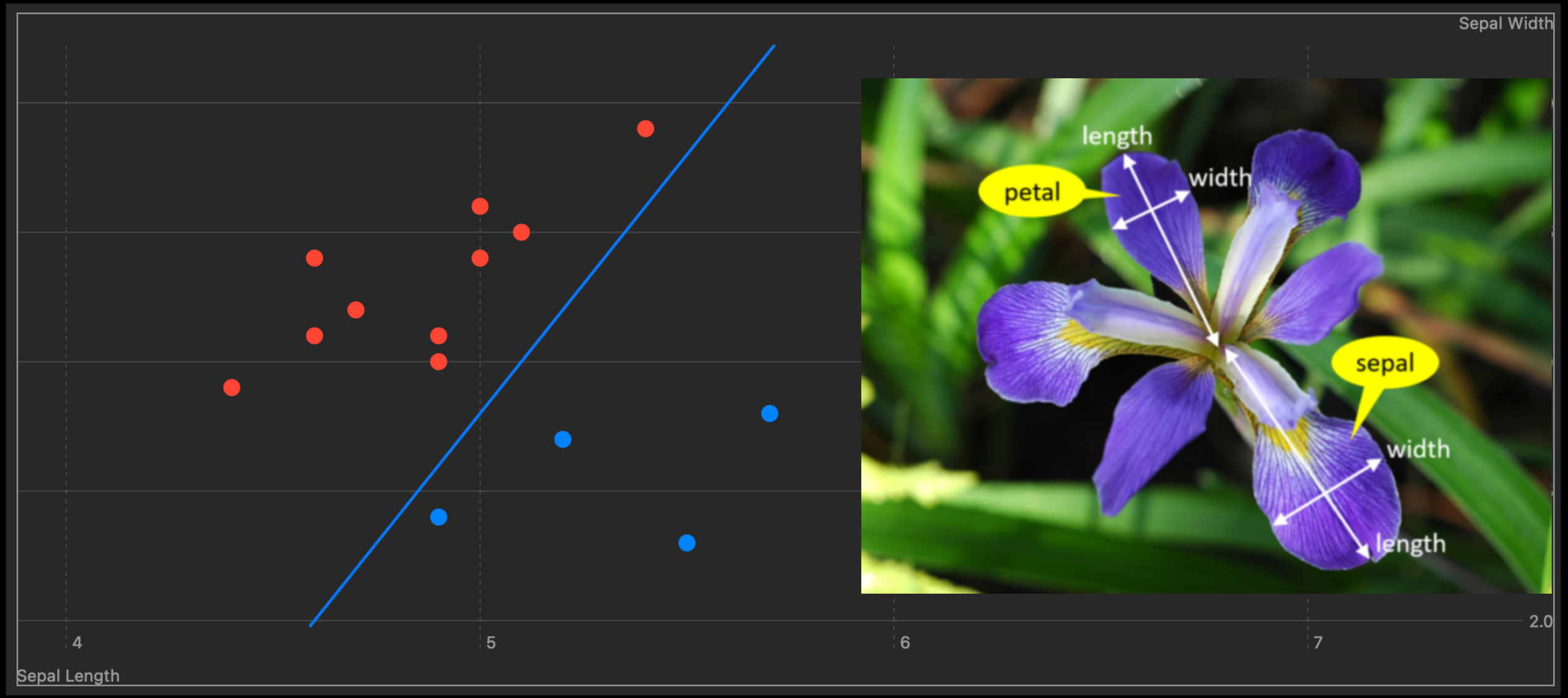

Sepal Width
4.0
3.5
3.0
2.5
2.0
4
5
6
7
Sepal Length



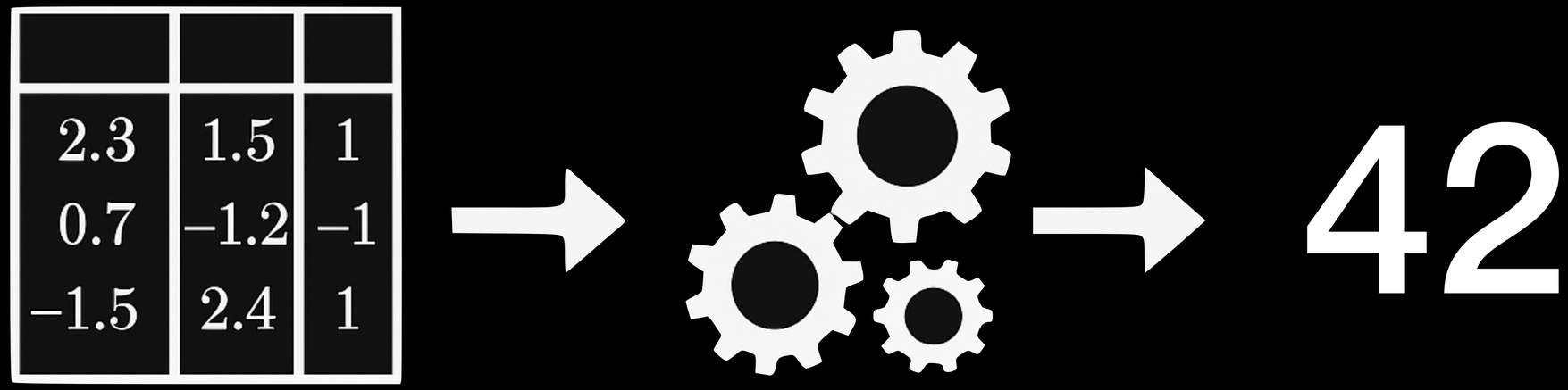
http://www.lac.inpe.br/~rafael.santos/Docs/CAP394/WholeStory-Iris.html

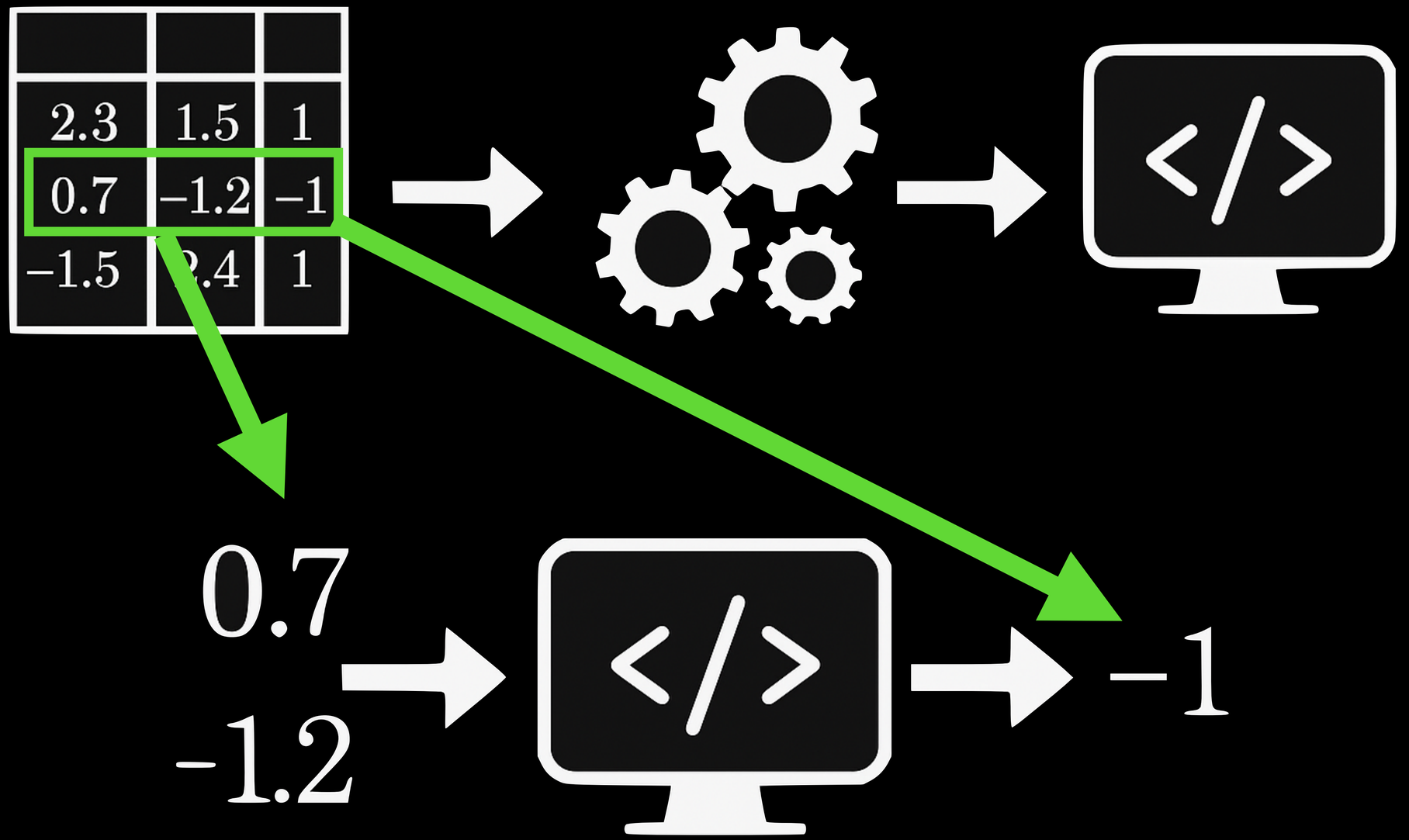


https://www.kaggle.com/code/doreamon11122000/iris-flower-dataset-eda

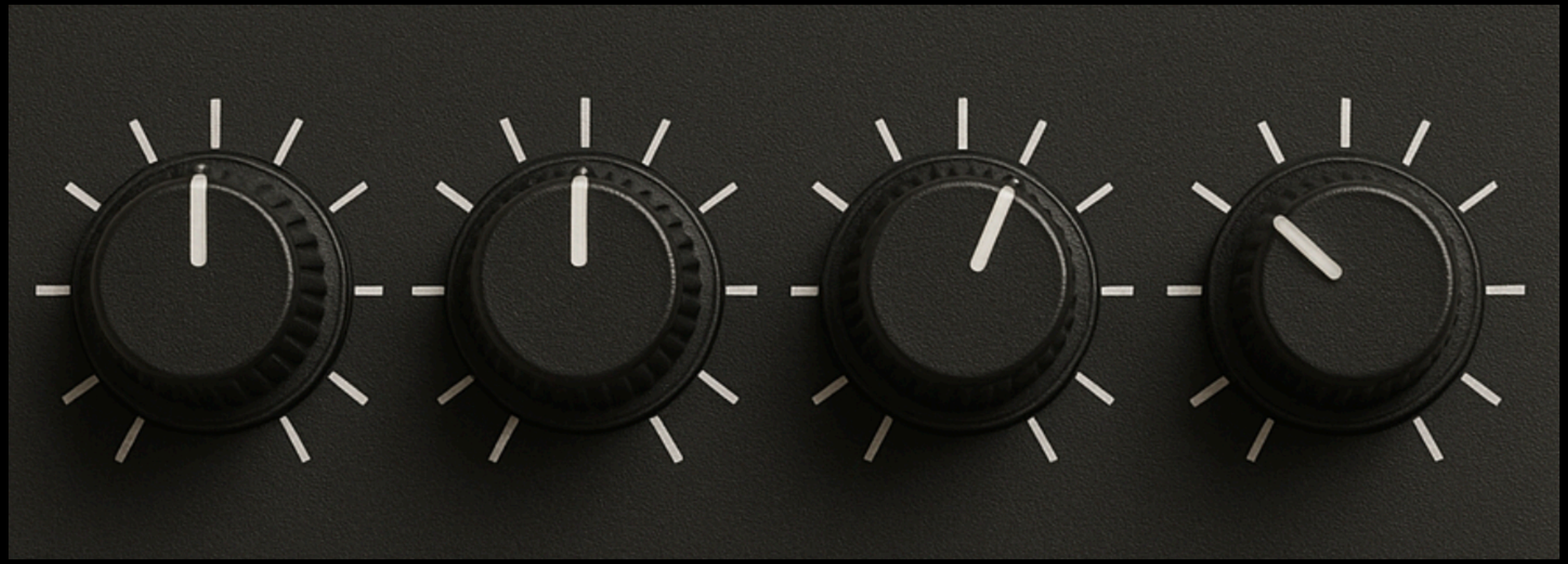

Sepal Width
length
petal
width
sepal
width
length
2.0
4
5
6
7
Sepal Length

Age	M/F	Weight	Length of Stay	Re-admitted?
71	2 (M)	139	10	YES
21	1 (F)	68	1	NO
45	2 (M)	95	15	YES
69	1 (F)	110	8	YES


2.3 1.5 1
0.7 −1.2 −1
−1.5 2.4 1
42


2.3 1.5 1
0.7 −1.2 −1
−1.5 2.4 1
0.7
-1.2
−1

Weights & Bias



1. Dot Product

```
x1 * w1
   +
x2 * w2
```

```
 0.7 * 2.4
     +
-1.2 * 0.5
     =
 1.08
```

2. Bias

```
dot product
     +
   bias
```

```
  1.08
    +
-1.8
    =
-0.72
```

3. Activation

```
result >= 0
  ? 1 : -1
```

```
-0.72 >= 0
  ? 1 : -1
     =
    -1
```

Demo 1

Training

Training

Training Data

#	Input1	Input2	Label
1	0.0	0.0	-1
2	0.0	1.0	-1
3	1.0	0.0	-1
4	1.0	1.0	1

1. Set a “learning rate”, say 0.2
2. Set a max number of “epochs”
3. Set weights to random values
4. Iterate over the training data
5. Make a prediction, say -1
6. Calculate error: expected (1) - predicted (-1) = 2
7. Update all weights (and bias):

```
newW1 = oldW1 + (error * rate * input1)
newW1 = 0.5   + (2     * 0.2  * 1.0)
      = 0.9
```

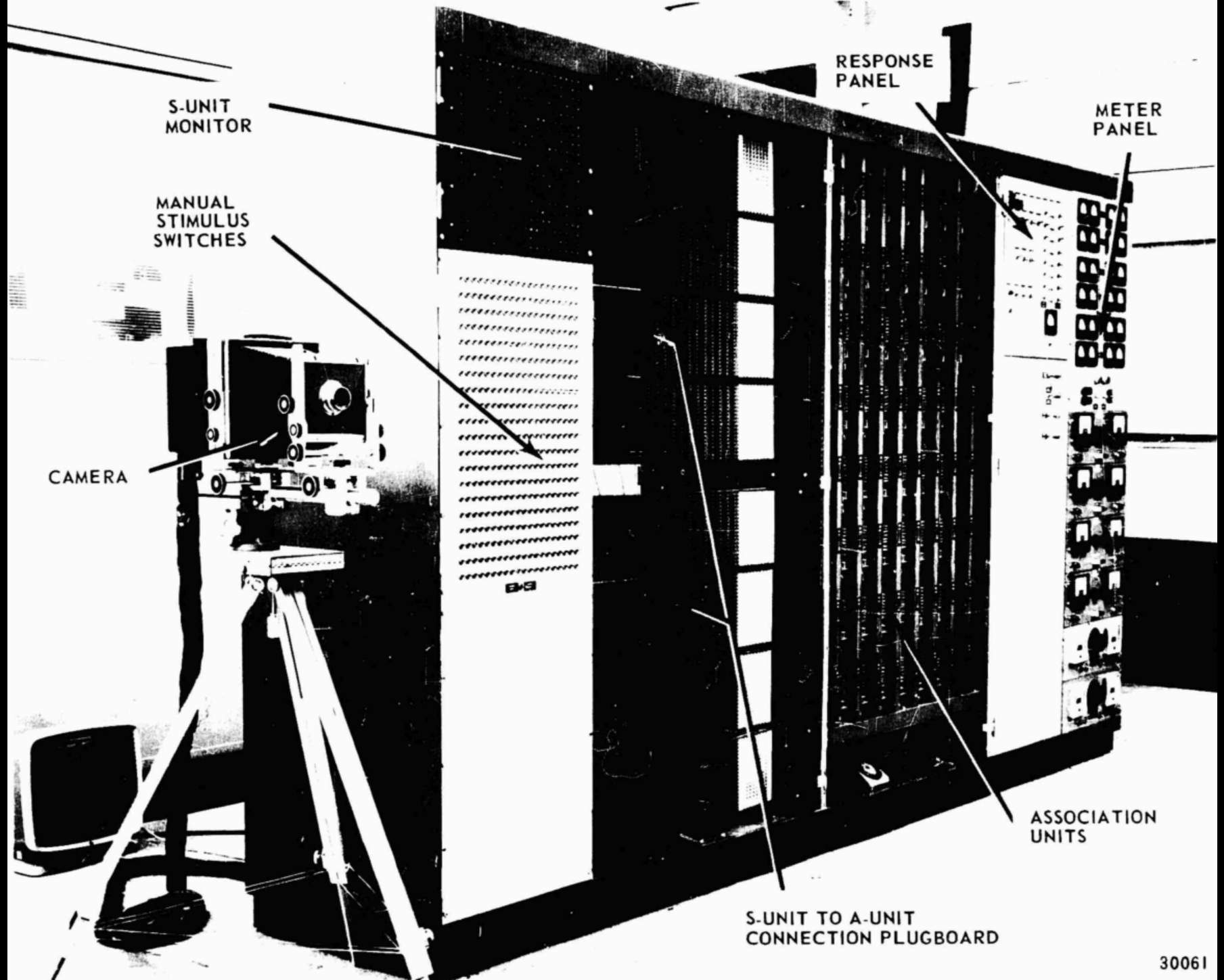
8. Continue

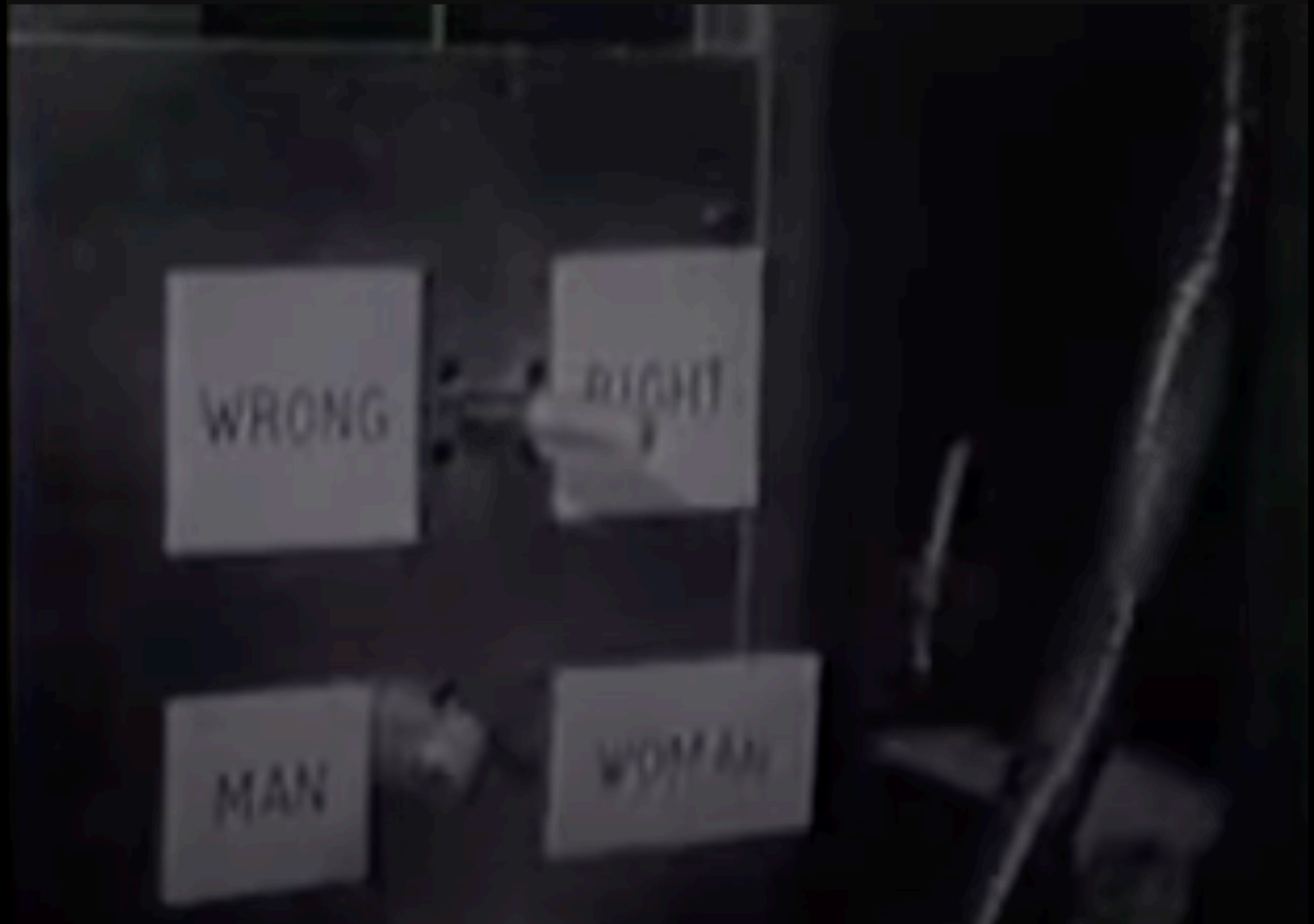
Tiny nudges to reduce the errors

Demo 2


HISTORY!

Mark 1 Perceptron


RESPONSE PANEL
METER PANEL
S-UNIT MONITOR
MANUAL STIMULUS SWITCHES
CAMERA
ASSOCIATION UNITS
S-UNIT TO A-UNIT CONNECTION PLUGBOARD
30061


WRONG
RIGHT
MAN
WOMAN


woman

m a n

20 x 20

400 inputs

400 weights

Our perceptron can do that!

0.3277703642942629 3,
0.2539230394033037 4,
0.0783811936990818 08,
0.1170340615050308 7,
0.3732183595993516 8,
0.2510135637983764 7,
0.0449033814645143 78,
0.834355750041130 94,
0.3775555094245192 1,
0.2324118455177498 2,
0.594010486173363 16,
0.0471062926224836 63,
0.288397352452497 42,
0.016745347335530694,
0.254402110894146 6,
0.216821480935073 06,
0.386030146738678 91,
0.363510606321533 87,
0.038119056445925628,
0.121199609891314 95,
0.11293594403029 9,
0.267110068025771 31,
0.139714030233189 15,
0.182997423380241 91,

0.3578764774166962 6,
0.625340153431277 58,
0.07436985726269515 5,
0.20754403520080994,
0.542115584378893 4,
0.24763652015655535,
0.46026525999152 09,
0.05137845039648 2027,
0.56910838557126653,
0.95486432151799661,
0.57497417695802133,
0.46888967536678122,
0.22032336457796511,
0.04808764586213 4966,
0.09253946893260 9628,
0.10713123790158115,
0.14858167765775868,
0.51737786086628912,
0.31379609563381544,
0.03329440146556 8176,
0.00972892950787 57804,
0.61139823668324167,
0.25893043797871801,
0.37422438403079256,
0.01554048633867 5146,

Training Data

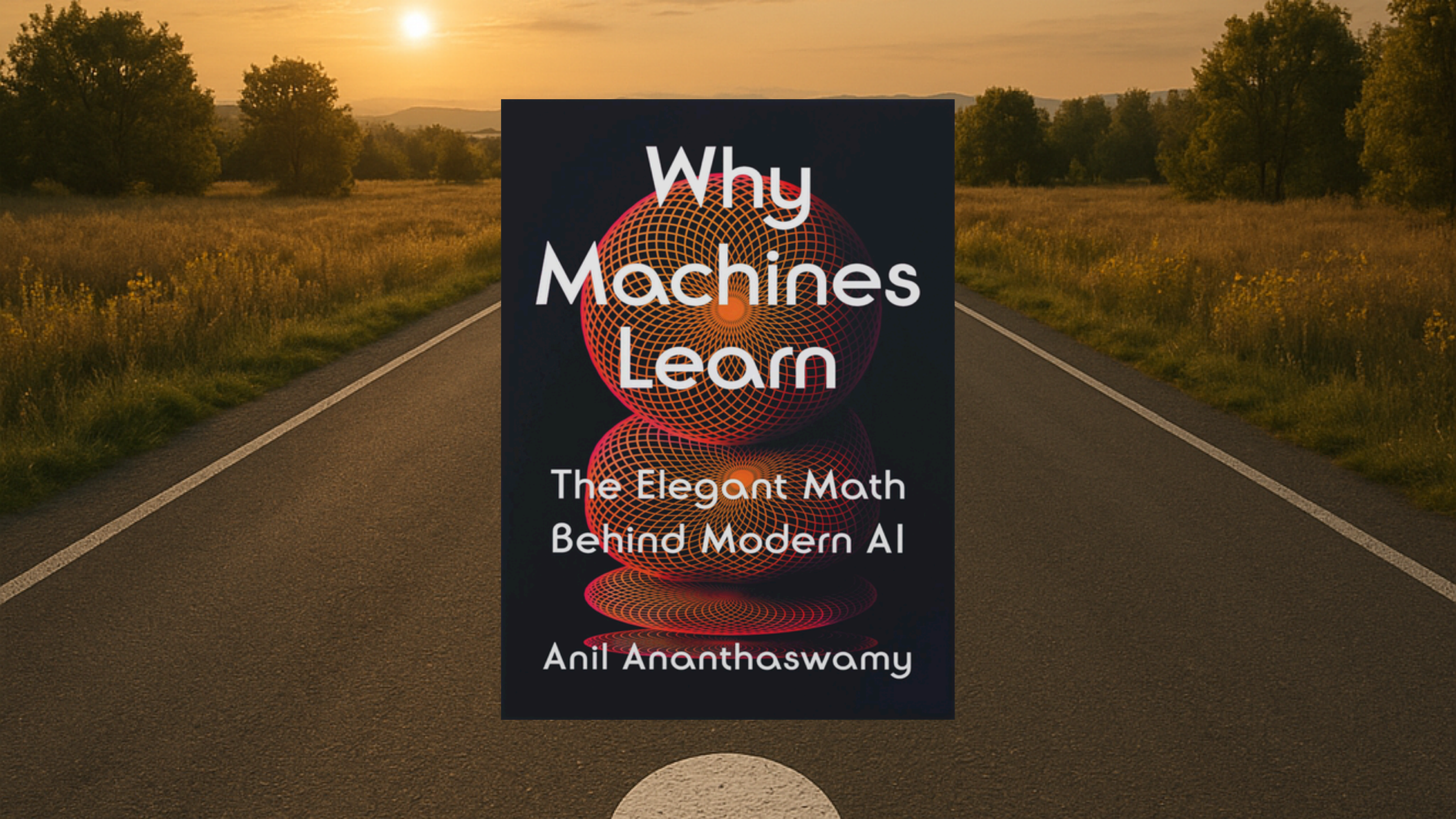
#	Input1	Input2	Label
1	0.0	0.0	-1
2	0.0	1.0	-1
3	1.0	0.0	-1
4	1.0	1.0	1

Pixel1	Pixel2	Pixel3	Pixel400	M/F
0.43423423	0.74342342	0.5568449	0.25548439	**1 (F)**
0.94324324	0.43423423	0.8887677	0.74342342	**-1 (M)**
0.74342342	0.25548439	0.02783833	0.43423423	**-1 (M)**
0.35454545	0.8887677	0.43423423	0.5568449	**1 (F)**

Demo 3

Recap

- Perceptron: Binary linear classifier
- Weights: How important each input is
- Bias: The “threshold” a value has to cross
- Training: Tiny adjustments to reduce errors
- Model: The way neurons are connected, the “blueprint”
- Model: The weights and biases after training
- Parameters: Amount of learnable weights and biases


Why Machines Learn
The Elegant Math Behind Modern AI
Anil Ananthaswamy


FROM SCRATCH
BUILD A
Large Language Model
Sebastian Raschka
MANNING

Keep learning

Thank you!