

Machine Learning for Designers

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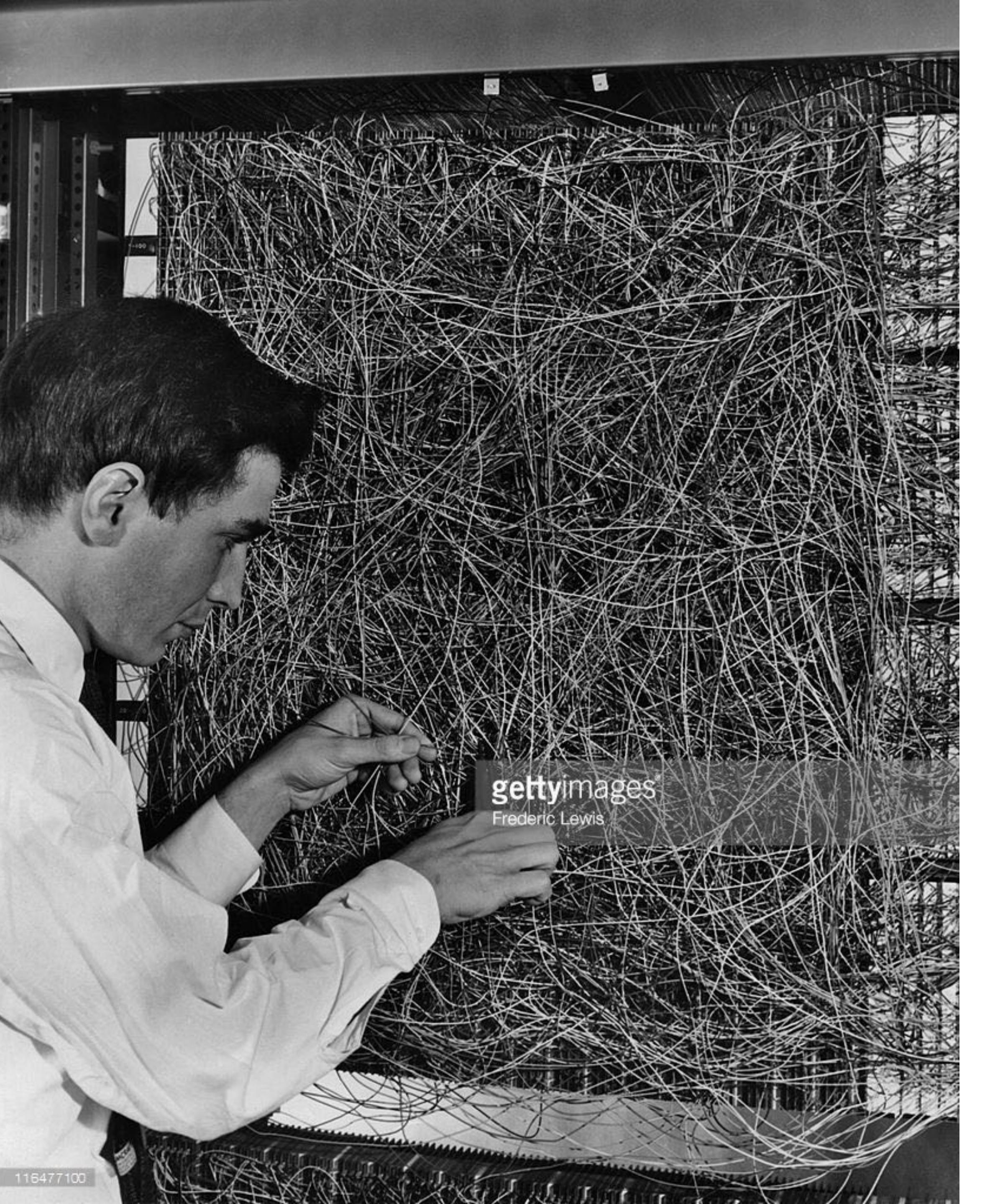




gettyimages
Frederic Lewis

NEW NAVY DEVICE LEARNS BY DOING

**Psychologist Shows Embryo
of Computer Designed to
Read and Grow Wiser**



Read and Grow Wiser

WASHINGTON, July 7 (UPI)
—The Navy revealed the embryo of an electronic computer today that it expects will be able to walk, talk, see, write, reproduce itself and be conscious of its existence.

The embryo—the Weather Bureau's \$2,000,000 "704" computer—learned to differentiate between right and left after fifty attempts in the Navy's

WHAT IS MACHINE LEARNING?

WHAT IS MACHINE LEARNING?

“improving performance in some task with experience”

-Tom Mitchell, author of *Machine Learning*

WHAT IS MACHINE LEARNING?

“it is a method of teaching computers to make and improve predictions or behaviors based on some data.”

-Daniel G, guy on Stack Overflow

Gen 34 species 14 genome 14 (37%)

Fitness: 2

Max Fitness: 4322

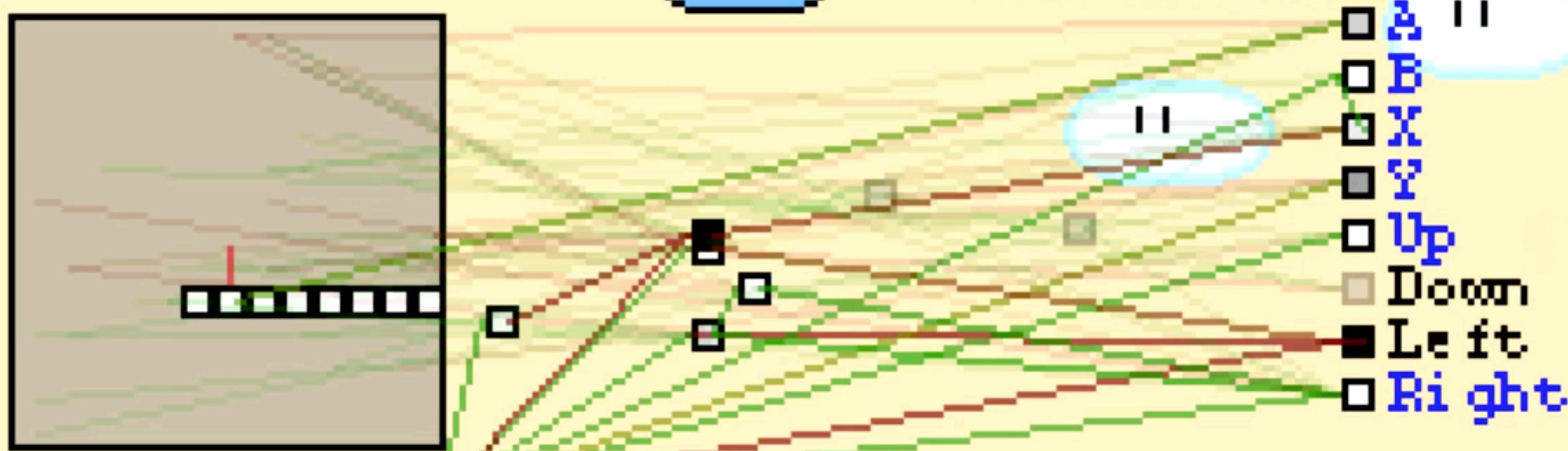
♂

♀

♂

♀

♂



Gen 0 species 23 genome 1 (7%)

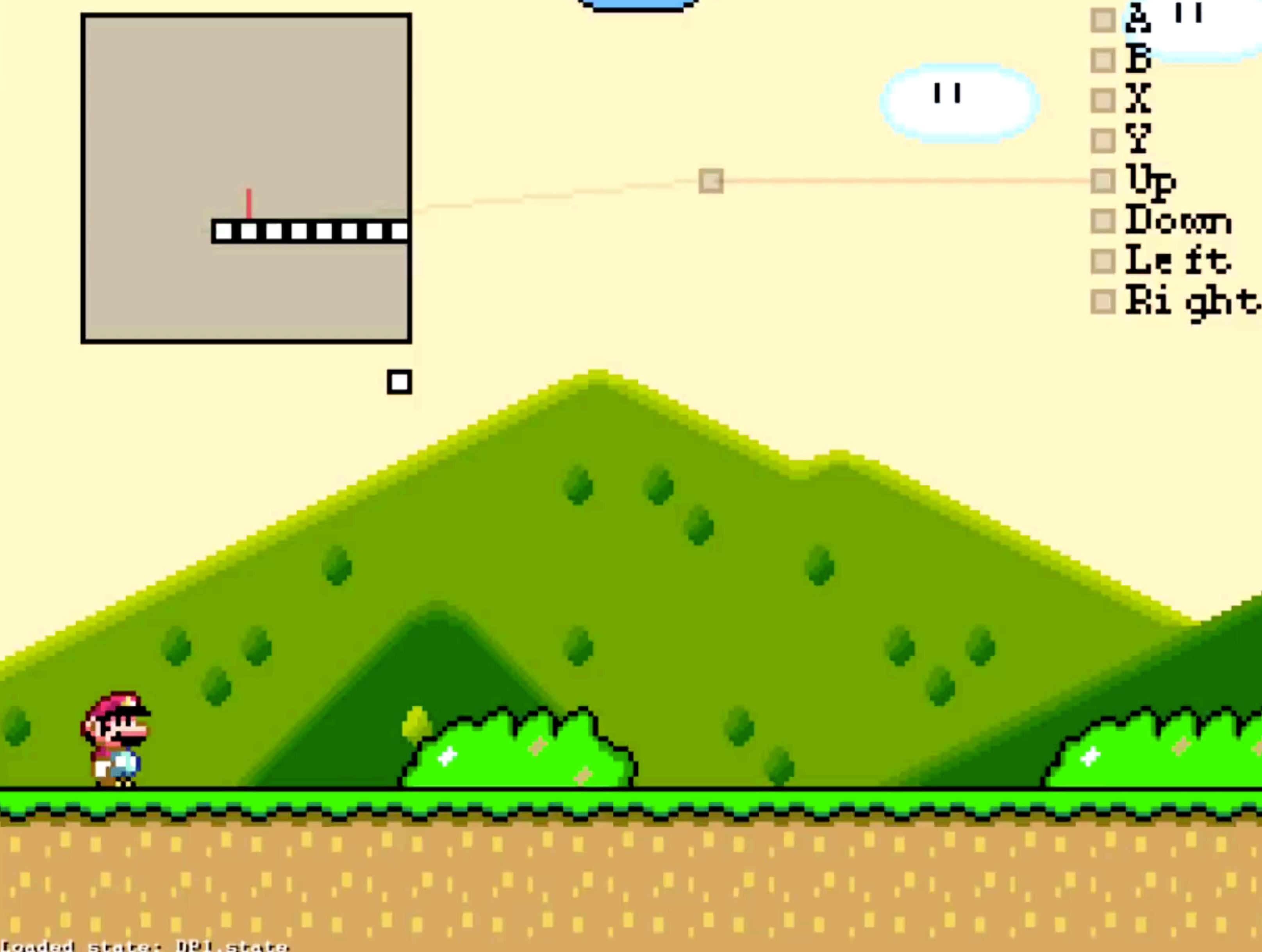
Fitness: 2

Max Fitness: 528

X S A X

Y S A Y

G 1 S G



WHAT IS MACHINE LEARNING?

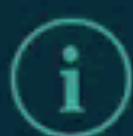
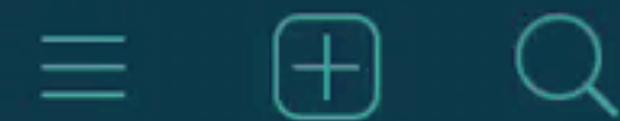
What's different?

WHAT IS MACHINE LEARNING?

What's different?

traditional code:

Explicit



```
1 import random
2
3 randomNumber = random.randint(1,100)
4
5 correct = False
6
7 while correct == False:
8     guess = int(input("Your guess: "))
9
10    if guess == randomNumber:
11        print("You got it!")
12        correct = True
13    elif guess > randomNumber:
14        print("LOWER")
15    elif guess < randomNumber:
16        print("HIGHER") |
```

WHAT IS MACHINE LEARNING?

What's different?

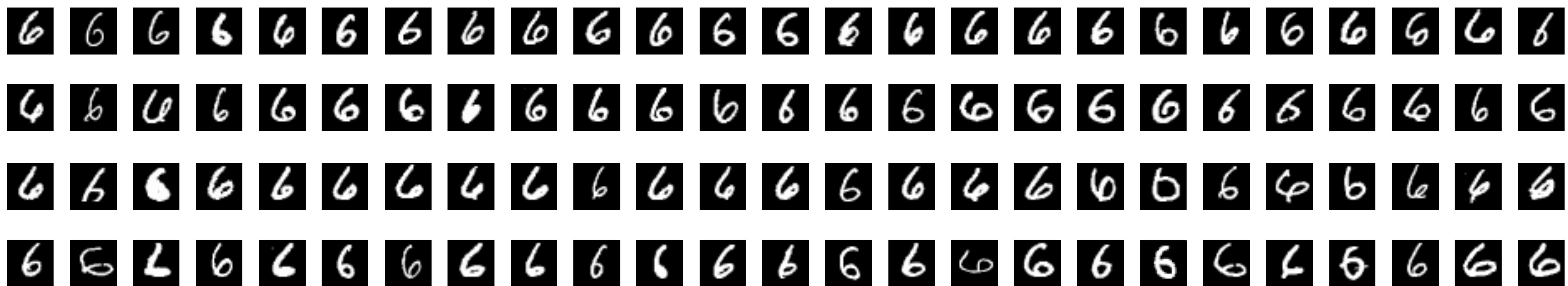
traditional code:

Explicit

machine learning:

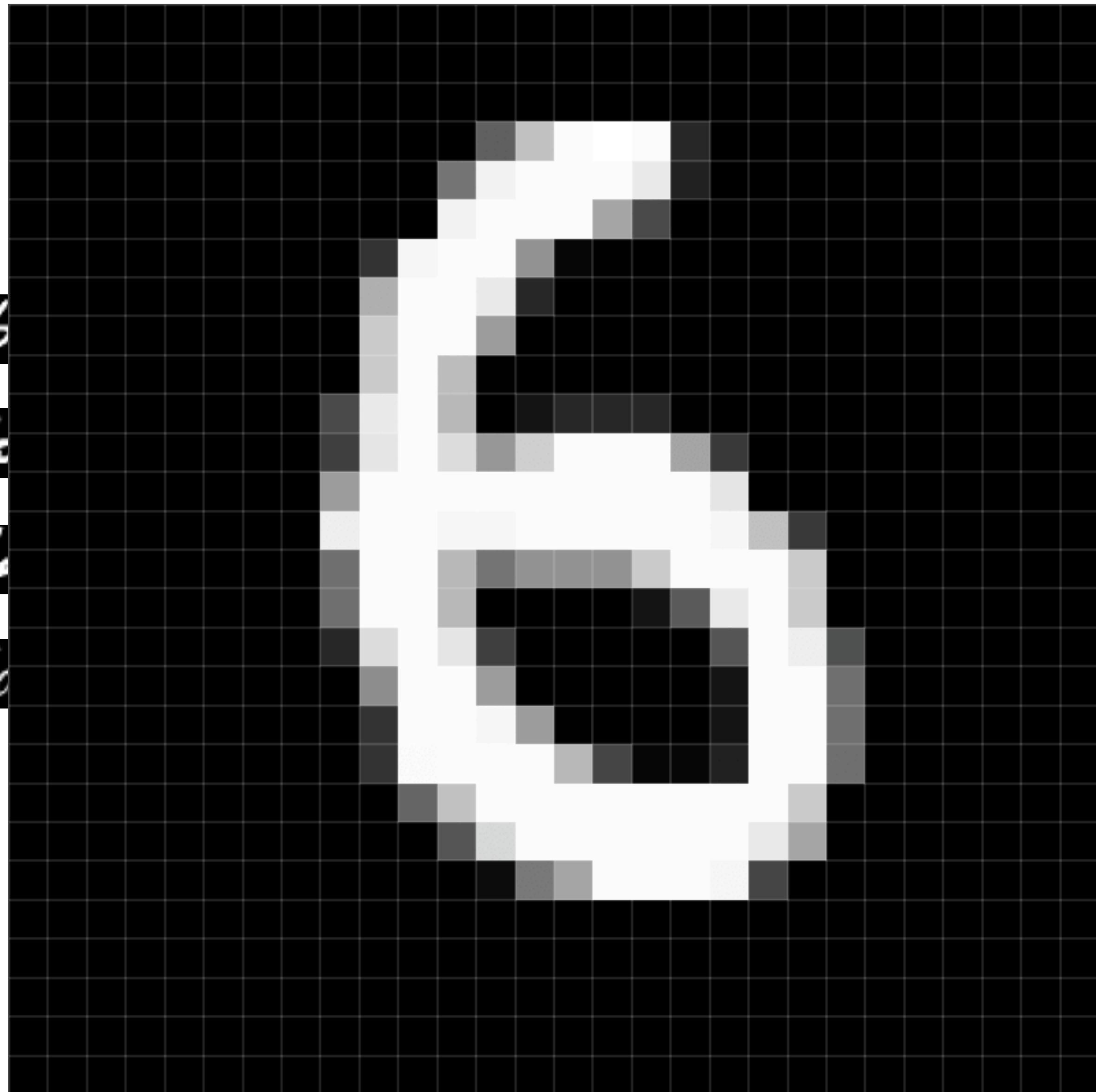
Implicit

WHAT IS MACHINE LEARNING?



WHAT IS MACHINE LEARNING?

6 6 6 6 6 6 6
6 6 6 6 6 6 6
6 6 6 6 6 6 6
6 6 L 6 6 6 6



6 6 6 6 6 6 6
6 6 6 6 6 6 6
6 6 6 6 6 6 6
6 6 6 6 6 6 6

WHAT IS MACHINE LEARNING?



Classification

Regression

Clustering

Recommendations

WHAT IS MACHINE LEARNING?

Super important stuff

Jane Smith (foo.com)

Super important stuff

Please see attached

mail.google.com says:

It seems like you forgot to attach a file.

You wrote "see attached" in your message, but there are no files attached.
Send anyway?

Cancel OK

Send A   \$     

MICRO EXERCISE 1: PSEUDOCODING

MICRO EXERCISE 1: PSEUDOCODING

- Describe step-by-step how to brush your teeth on the left side of the page.

5 minutes

PSEUDOCODE

WHAT Brush your teeth

1 Pick up your tooth
brush

2 _____

3 _____

4 _____

5 _____

6 _____

7 _____

8 _____

9 _____

10 _____

WHAT _____

1 _____

2 _____

3 _____

4 _____

5 _____

6 _____

7 _____

8 _____

9 _____

10 _____

MICRO EXERCISE 1: PSEUDOCODING

- Describe step-by-step how to recognize a human face.

5 more minutes

PSEUDOCODE

WHAT Brush your teeth

1 Pick up your tooth
brush

2 _____

3 _____

4 _____

5 _____

6 _____

7 _____

8 _____

9 _____

10 _____

WHAT Recognize a face

1 _____

2 _____

3 _____

4 _____

5 _____

6 _____

7 _____

8 _____

9 _____

10 _____

LANGUAGE & PROCESS

LANGUAGE & PROCESS

“The limits of my language are the limits of my world”

-Ludwig Wittgenstein

LANGUAGE & PROCESS

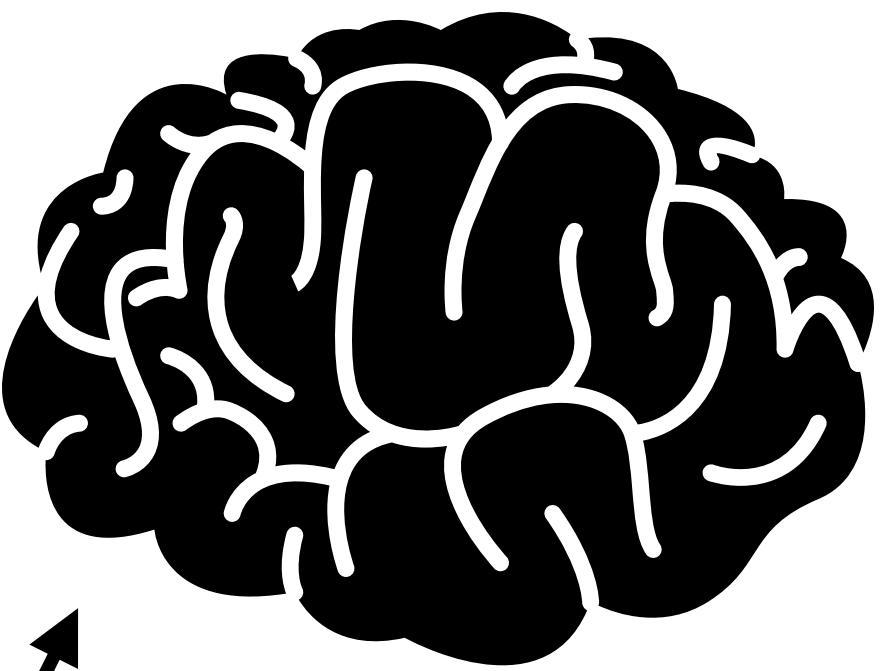


Decide what
data is useful

Training Data

Test Data

LANGUAGE & PROCESS



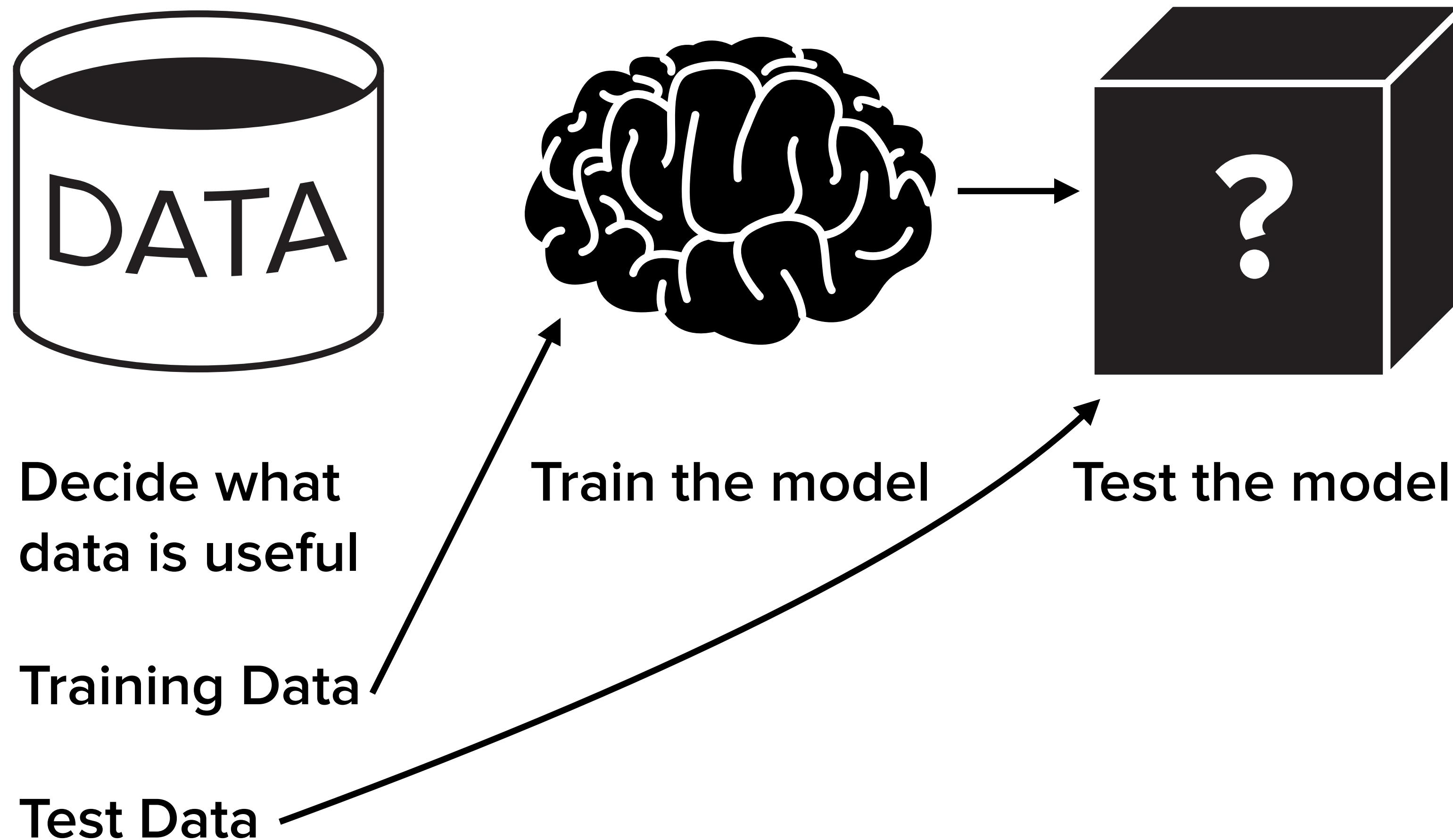
Decide what
data is useful

Training Data

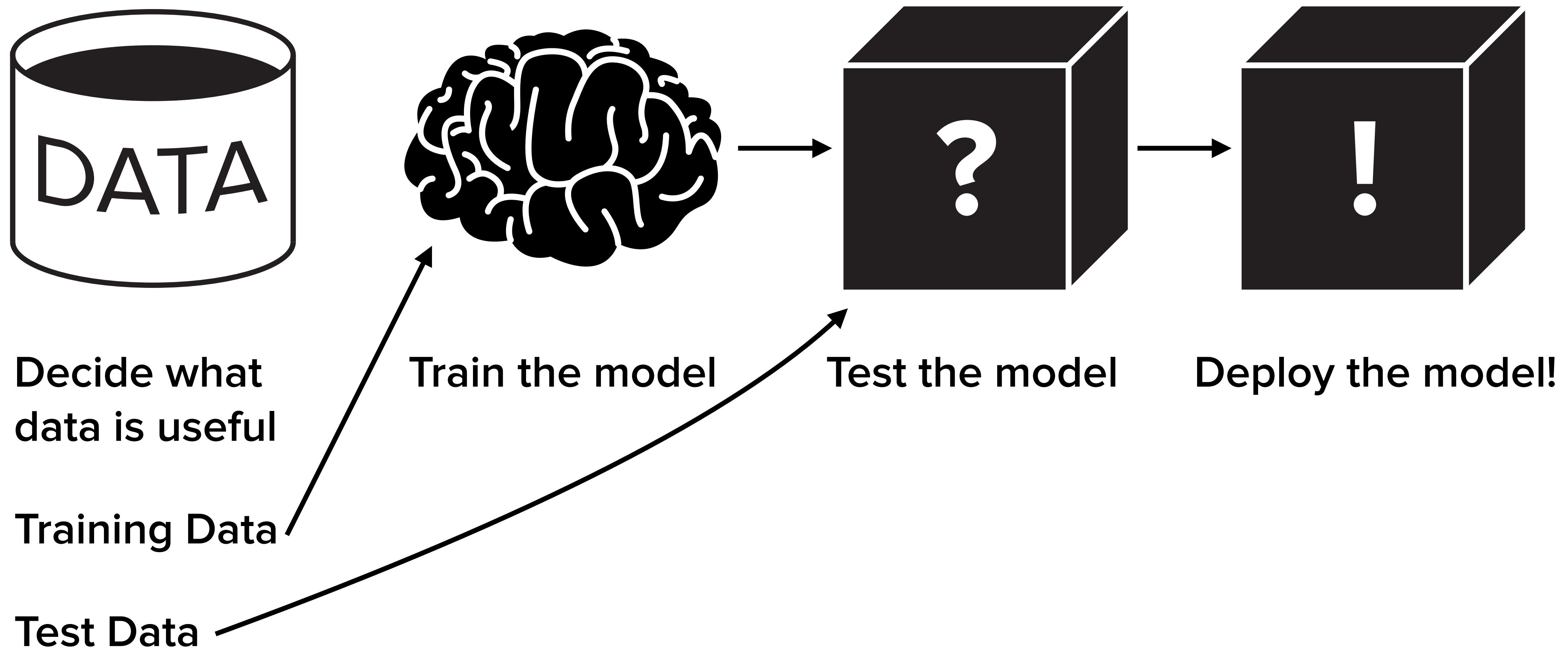
Test Data

Train the model

LANGUAGE & PROCESS

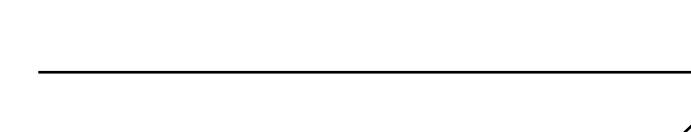


LANGUAGE & PROCESS



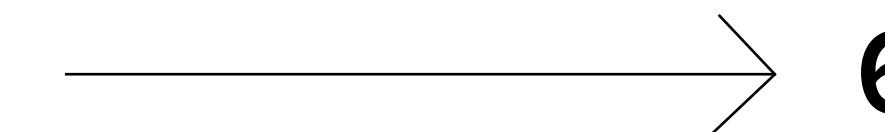
SUPERVISED LEARNING

input variables

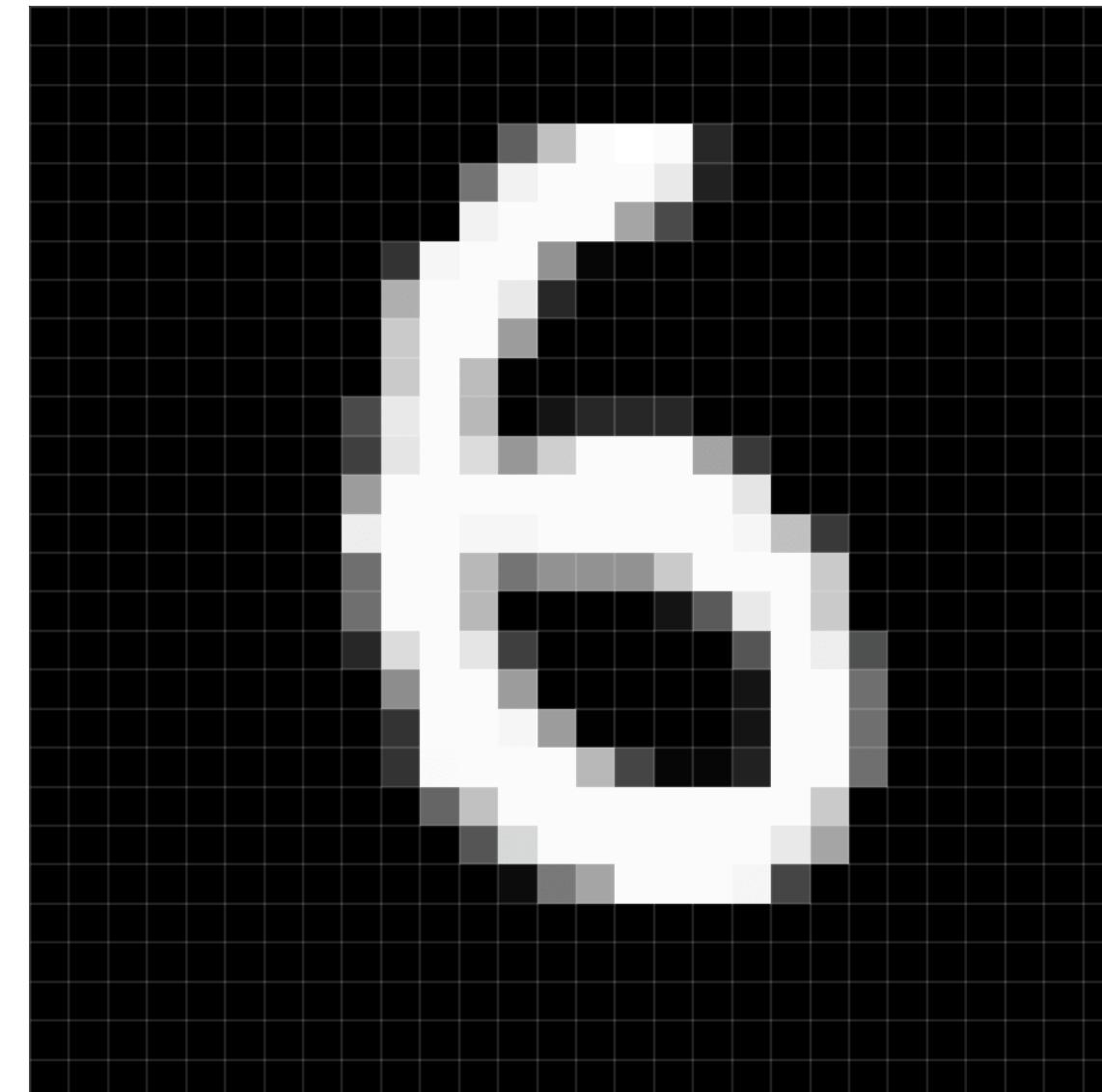


target variable (label)

874 input variables

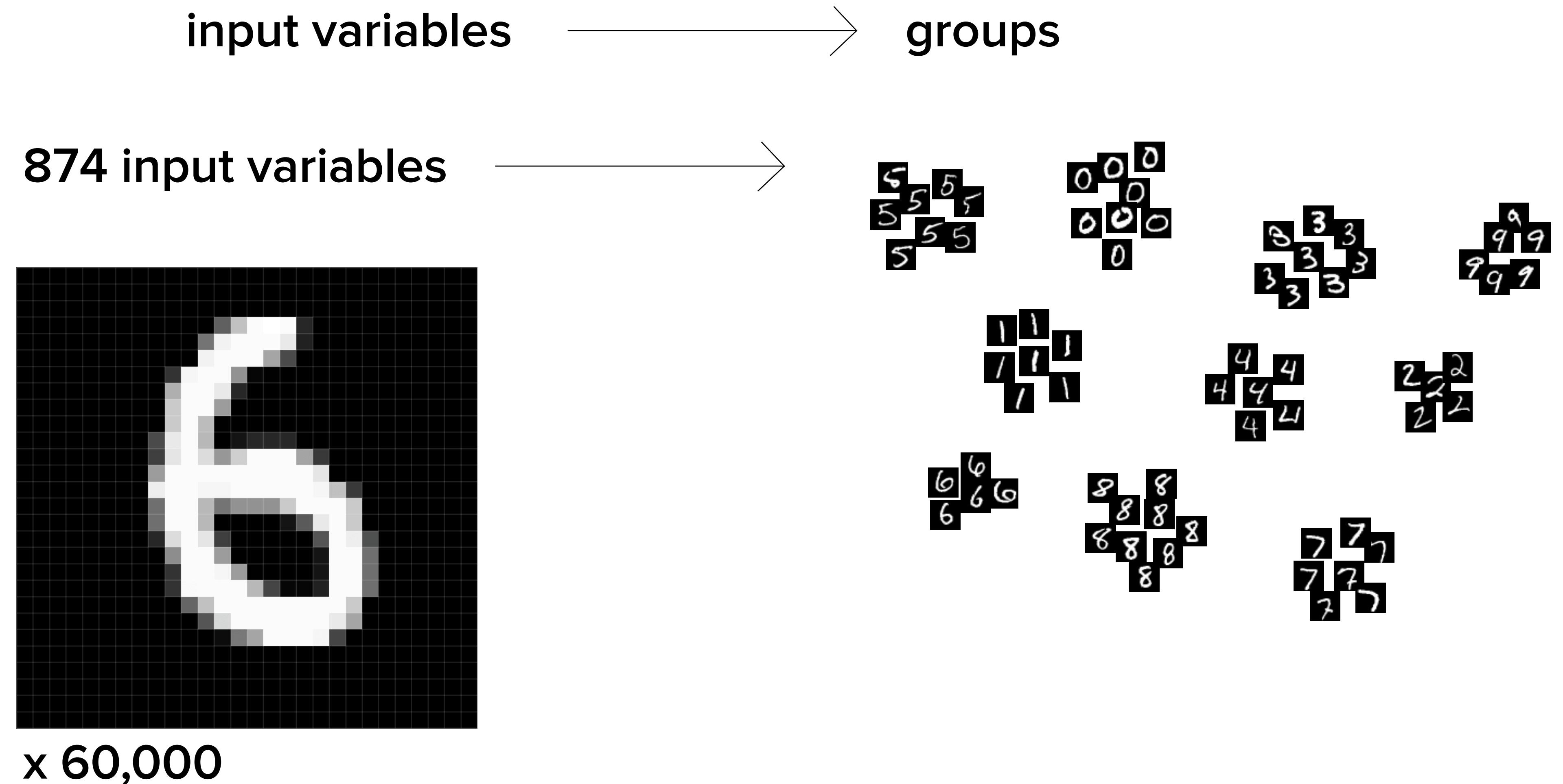


6



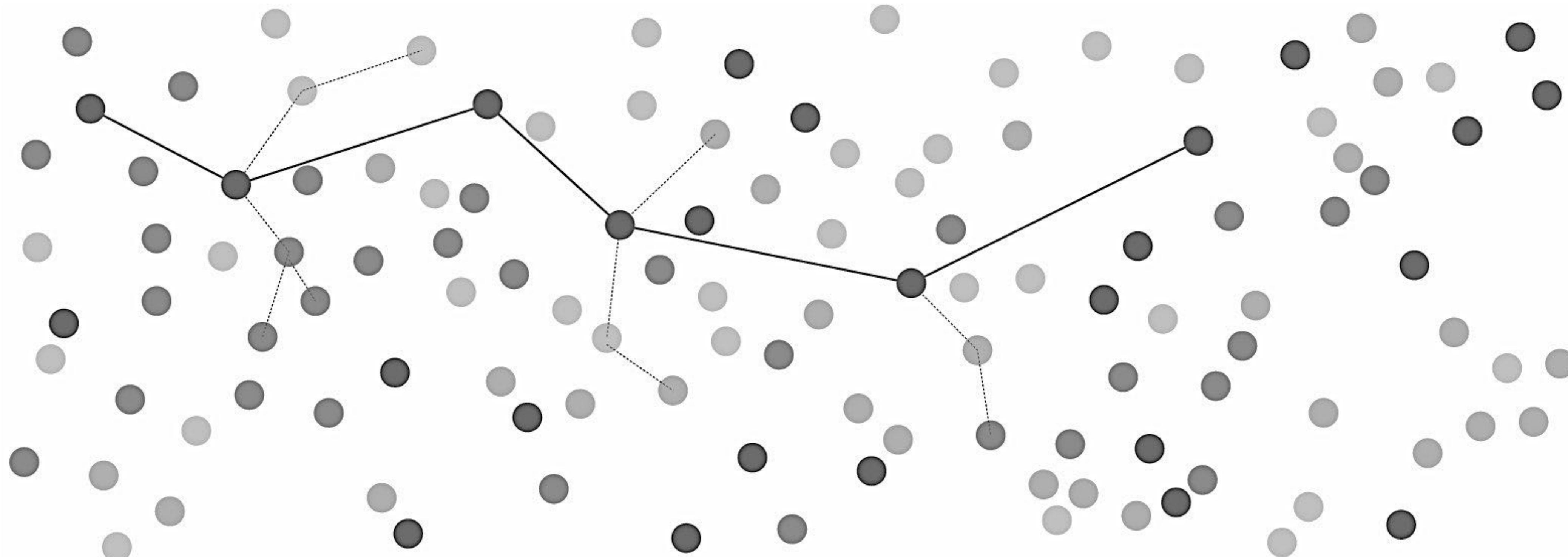
x 60,000

UNSUPERVISED LEARNING



REINFORCEMENT LEARNING

state → action → reward → state



THE MATH PART

WHAT IS MACHINE LEARNING?

“What I cannot create, I do not understand”

-Richard Feynman

DECISION TREE (LINEAR CLASSIFIER)

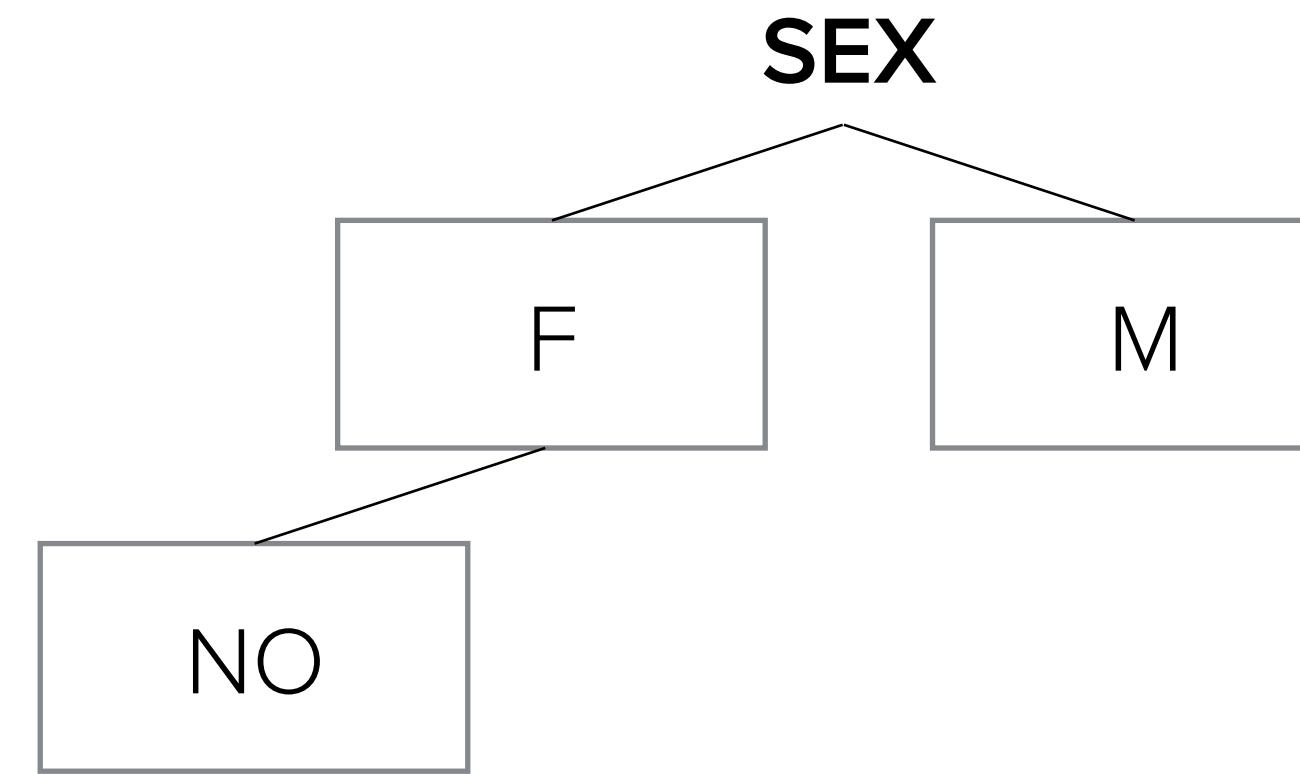
SEX	AGE	ANTLERS?
F	5	NO
M	4	YES
F	1	NO
M	2	NO
M	3	YES
M	1	NO

DECISION TREE (LINEAR CLASSIFIER)

SEX	AGE	ANTLERS?
F	5	NO
M	4	YES
F	1	NO
M	2	NO
M	3	YES
M	1	NO

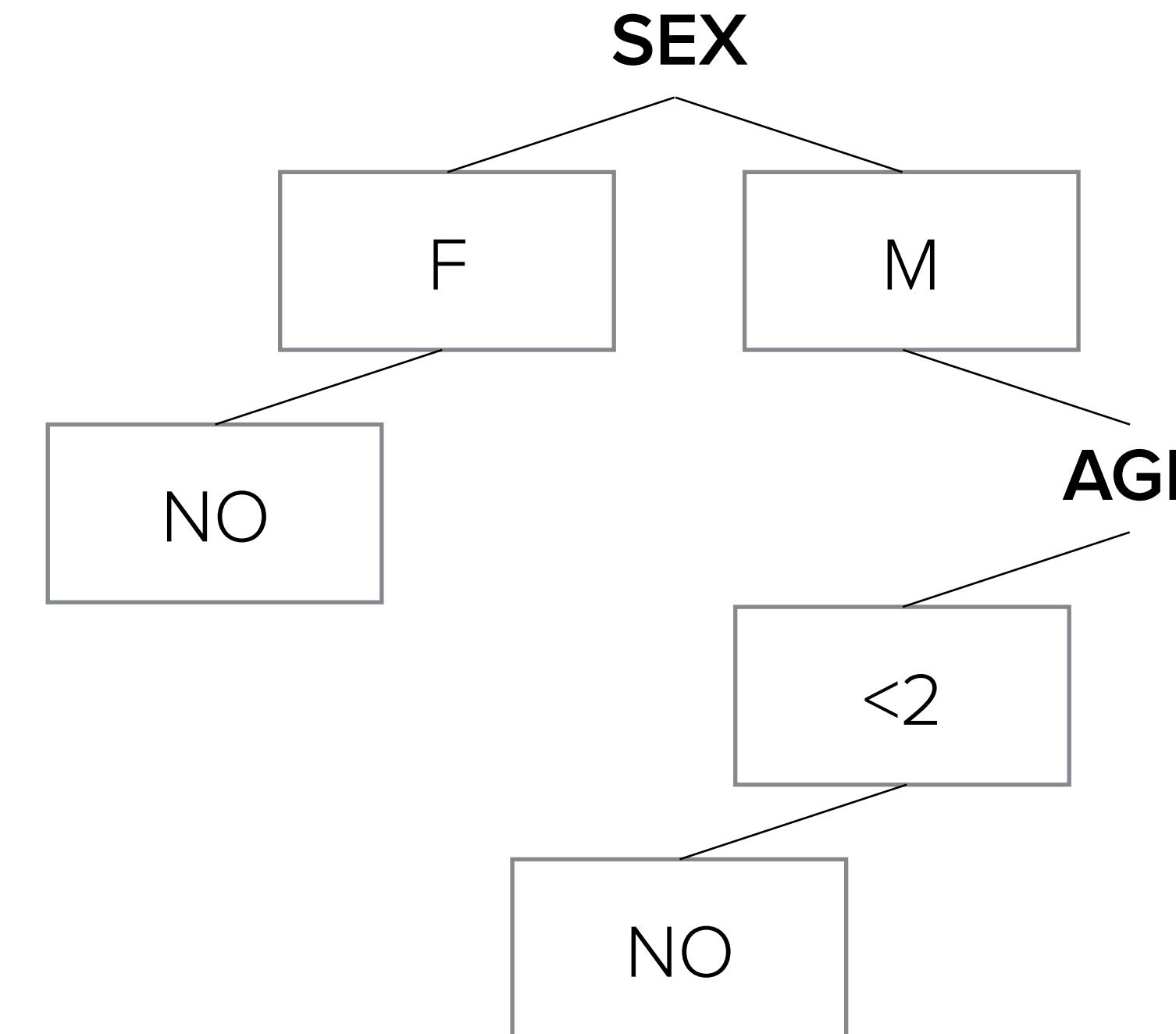
DECISION TREE (LINEAR CLASSIFIER)

SEX	AGE	ANTLERS?
F	5	NO
M	4	YES
F	1	NO
M	2	NO
M	3	YES
M	1	NO



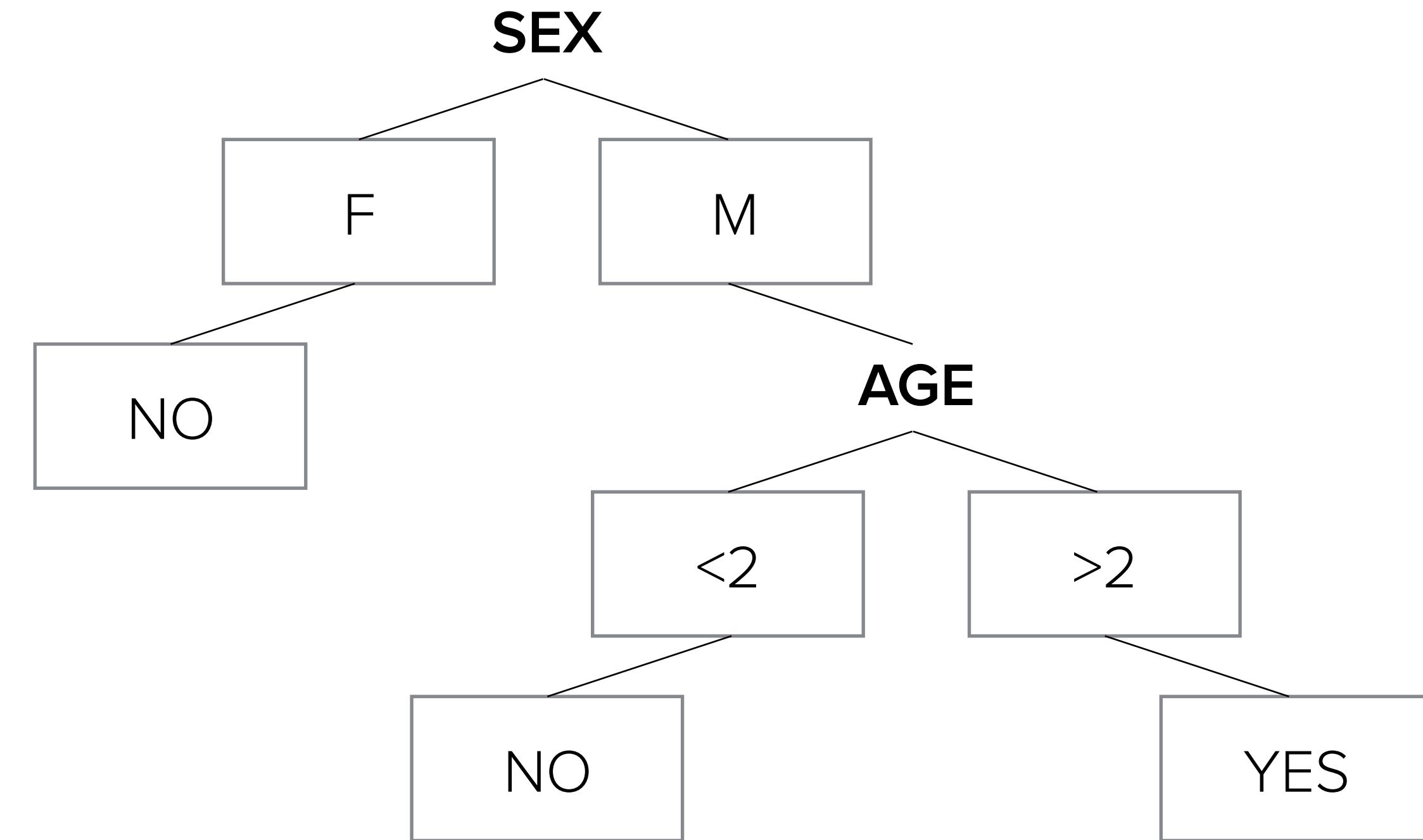
DECISION TREE (LINEAR CLASSIFIER)

SEX	AGE	ANTLERS?
F	5	NO
M	4	YES
F	1	NO
M	2	NO
M	3	YES
M	1	NO



DECISION TREE (LINEAR CLASSIFIER)

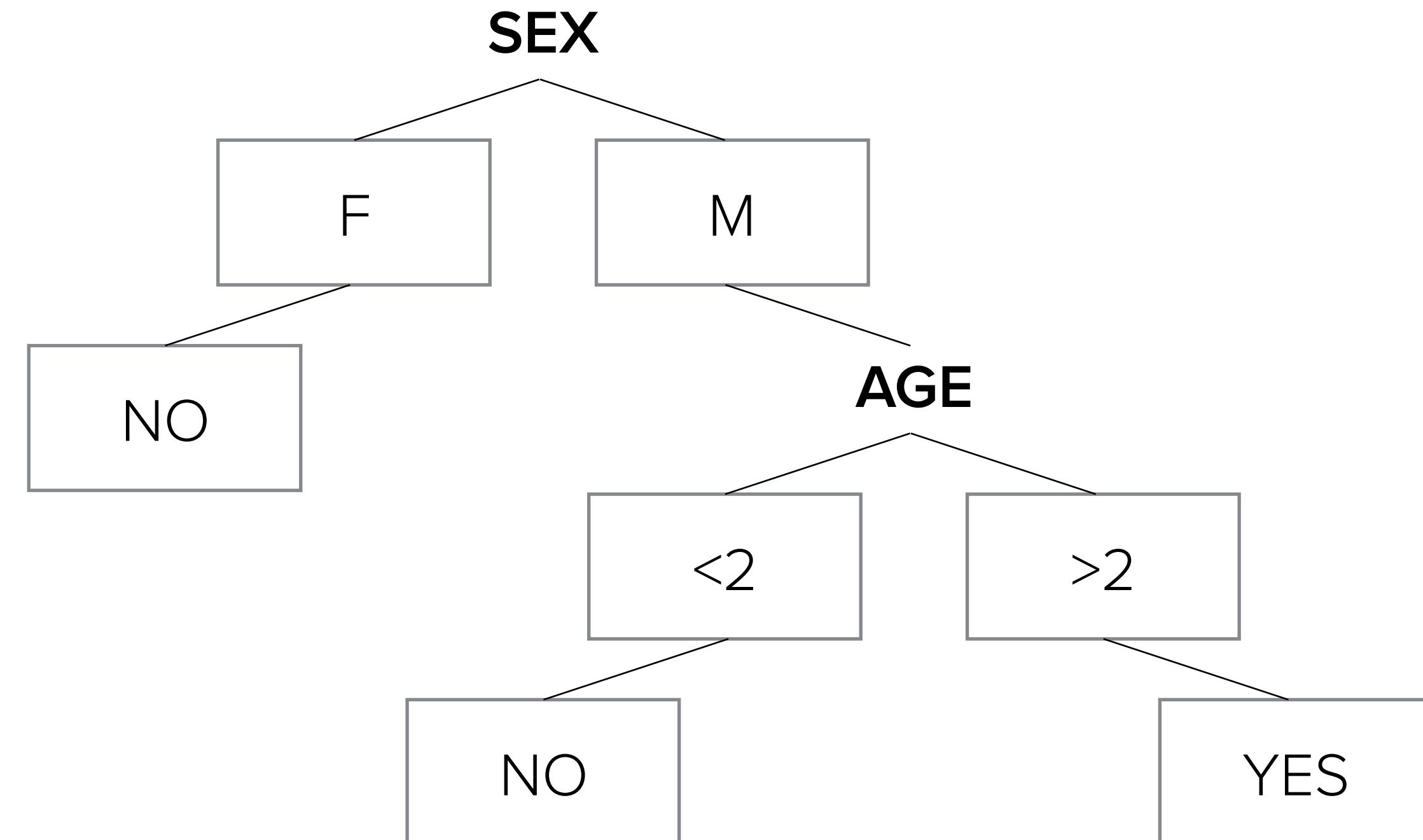
SEX	AGE	ANTLERS?
F	5	NO
M	4	YES
F	1	NO
M	2	NO
M	3	YES
M	1	NO



DECISION TREE (LINEAR CLASSIFIER)

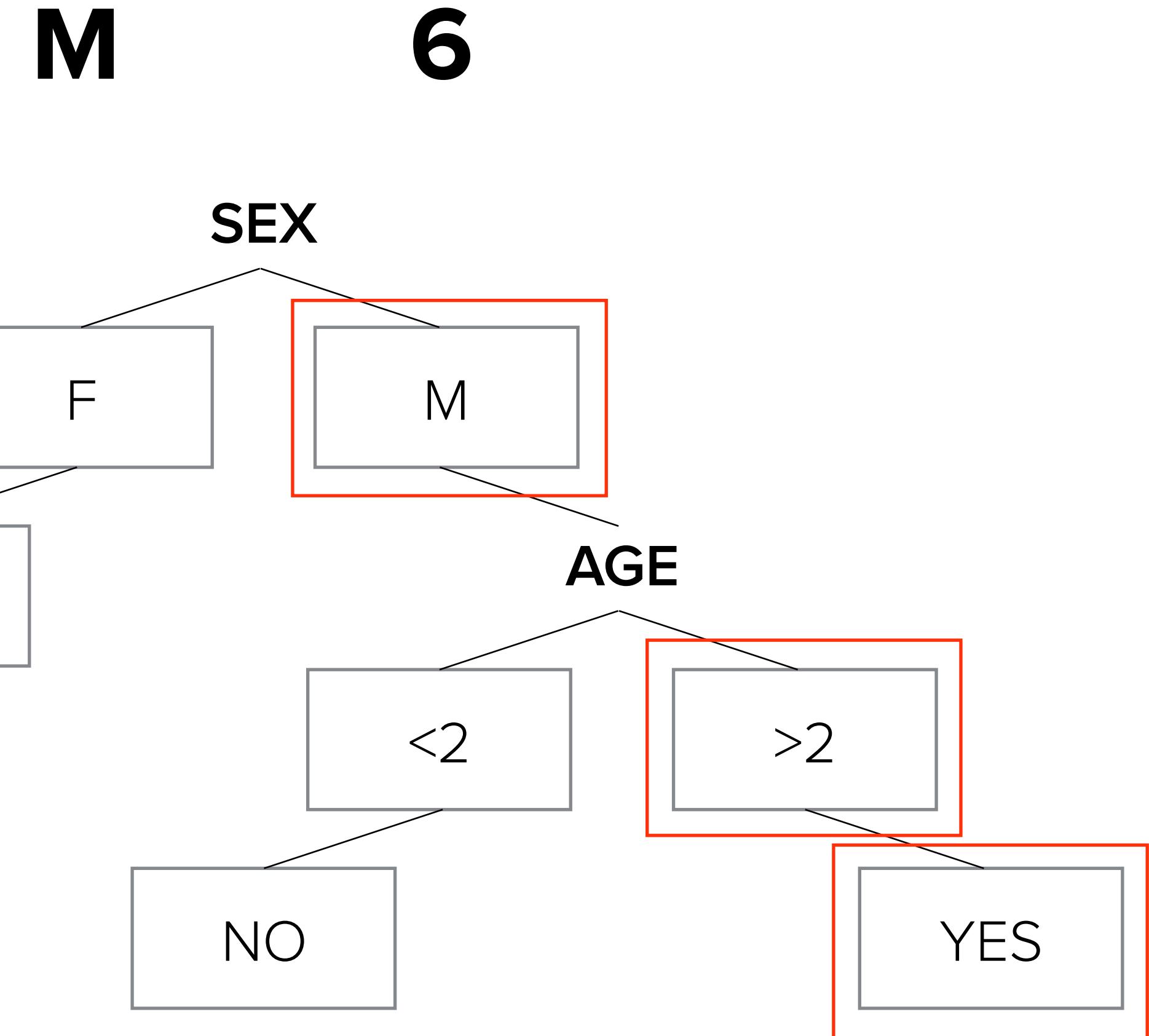
SEX	AGE	ANTLERS?
F	5	NO
M	4	YES
F	1	NO
M	2	NO
M	3	YES
M	1	NO

M **6**

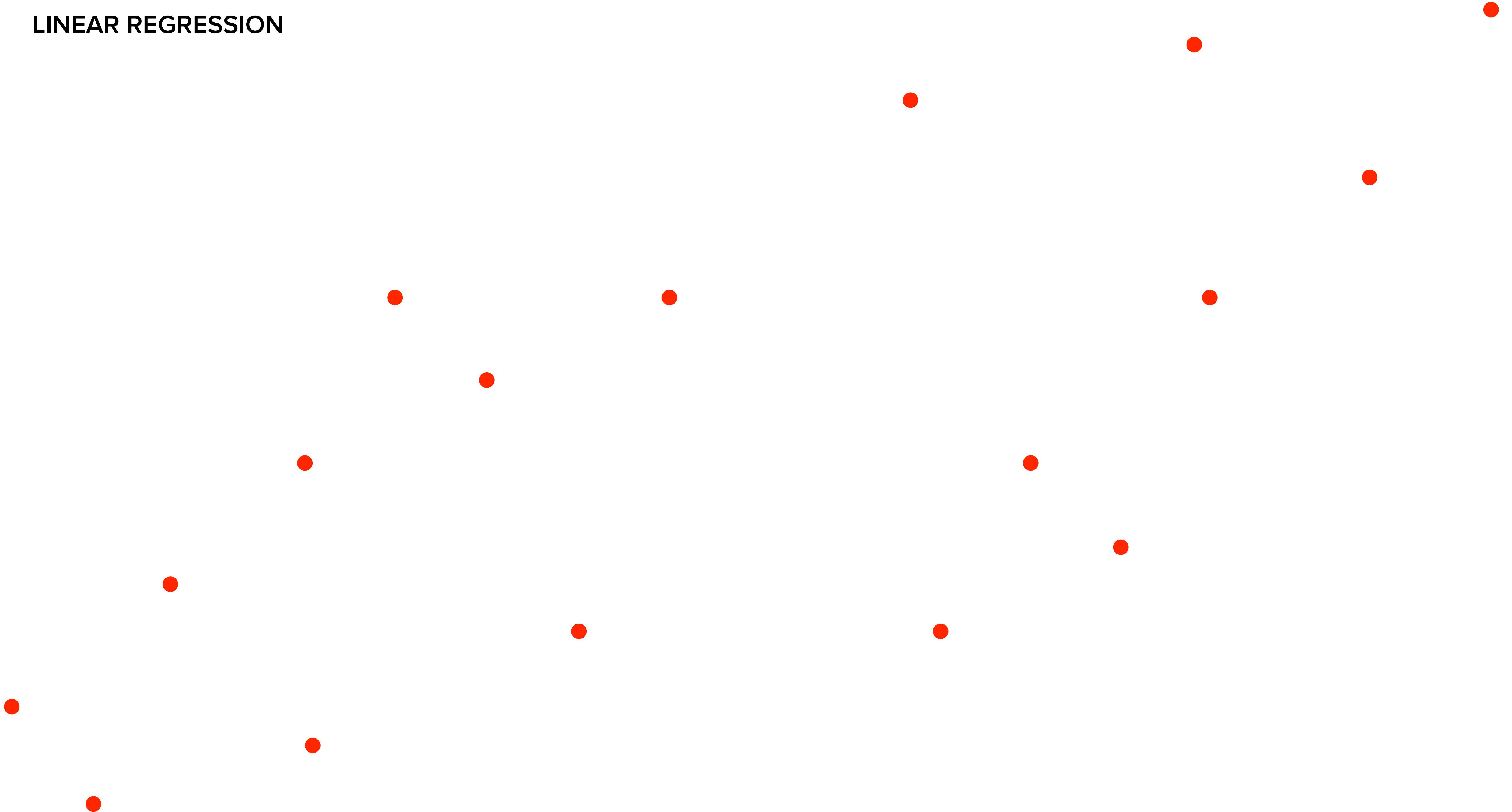


DECISION TREE (LINEAR CLASSIFIER)

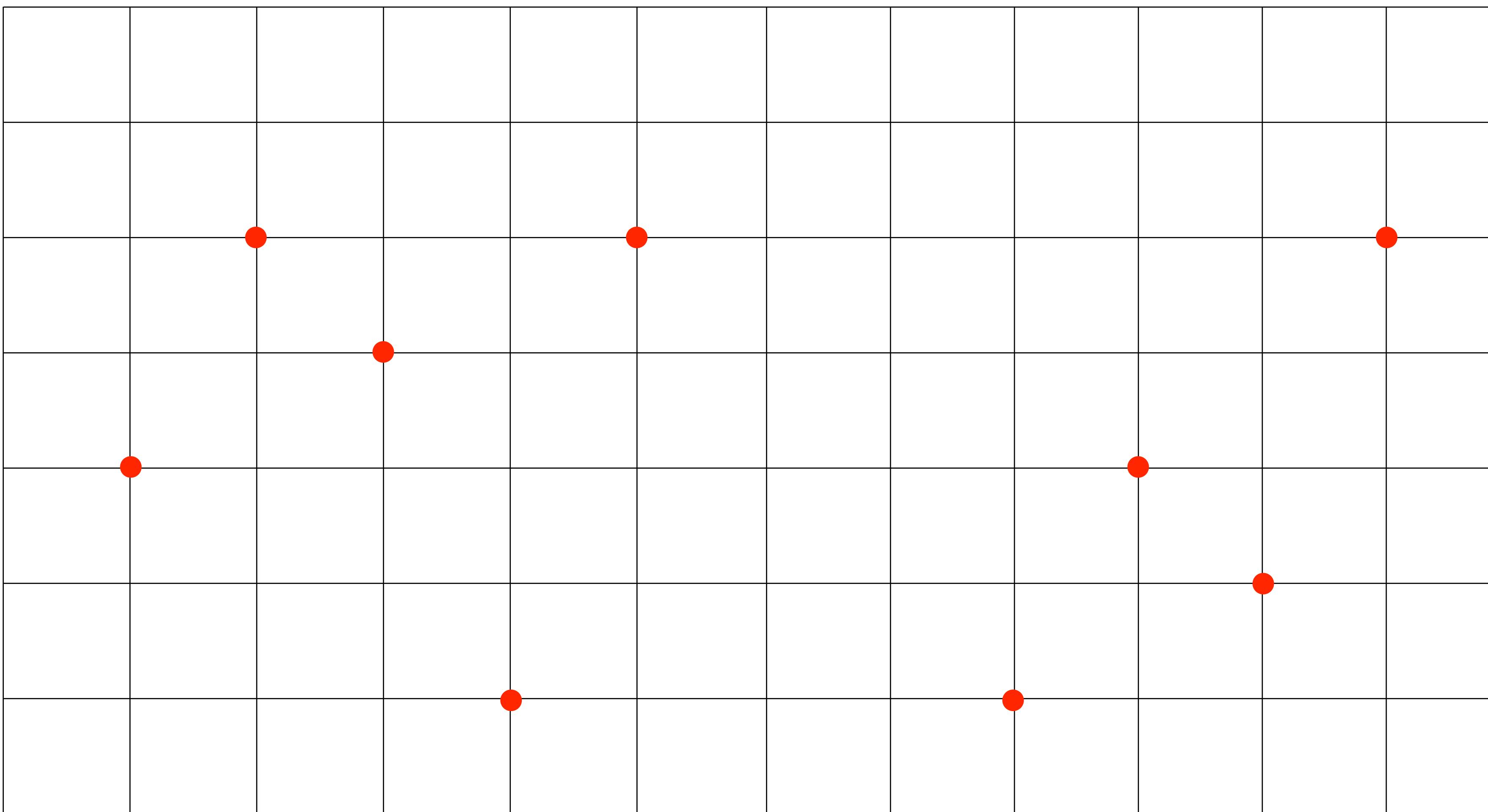
SEX	AGE	ANTLERS?
F	5	NO
M	4	YES
F	1	NO
M	2	NO
M	3	YES
M	1	NO



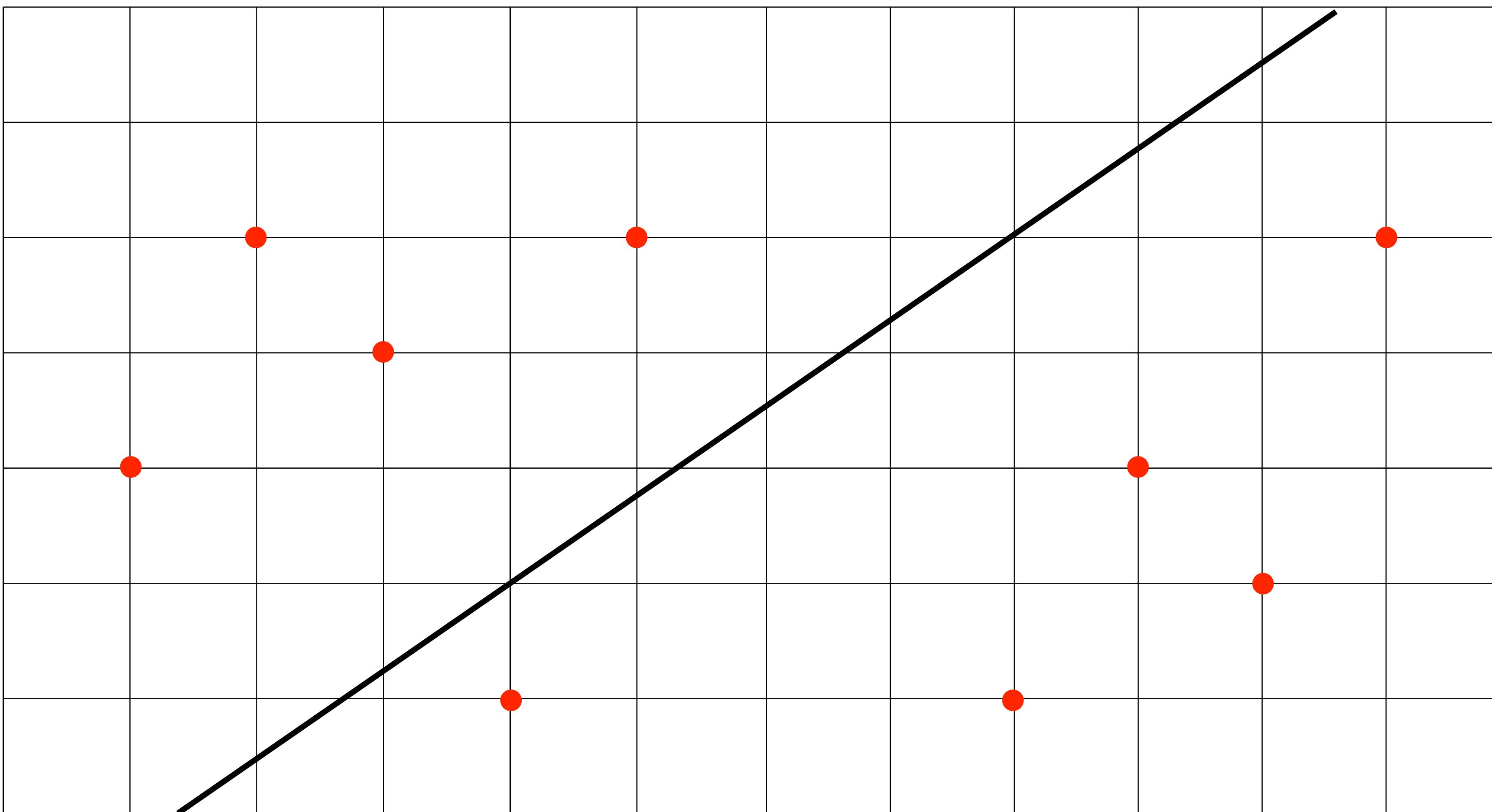
LINEAR REGRESSION



LINEAR REGRESSION

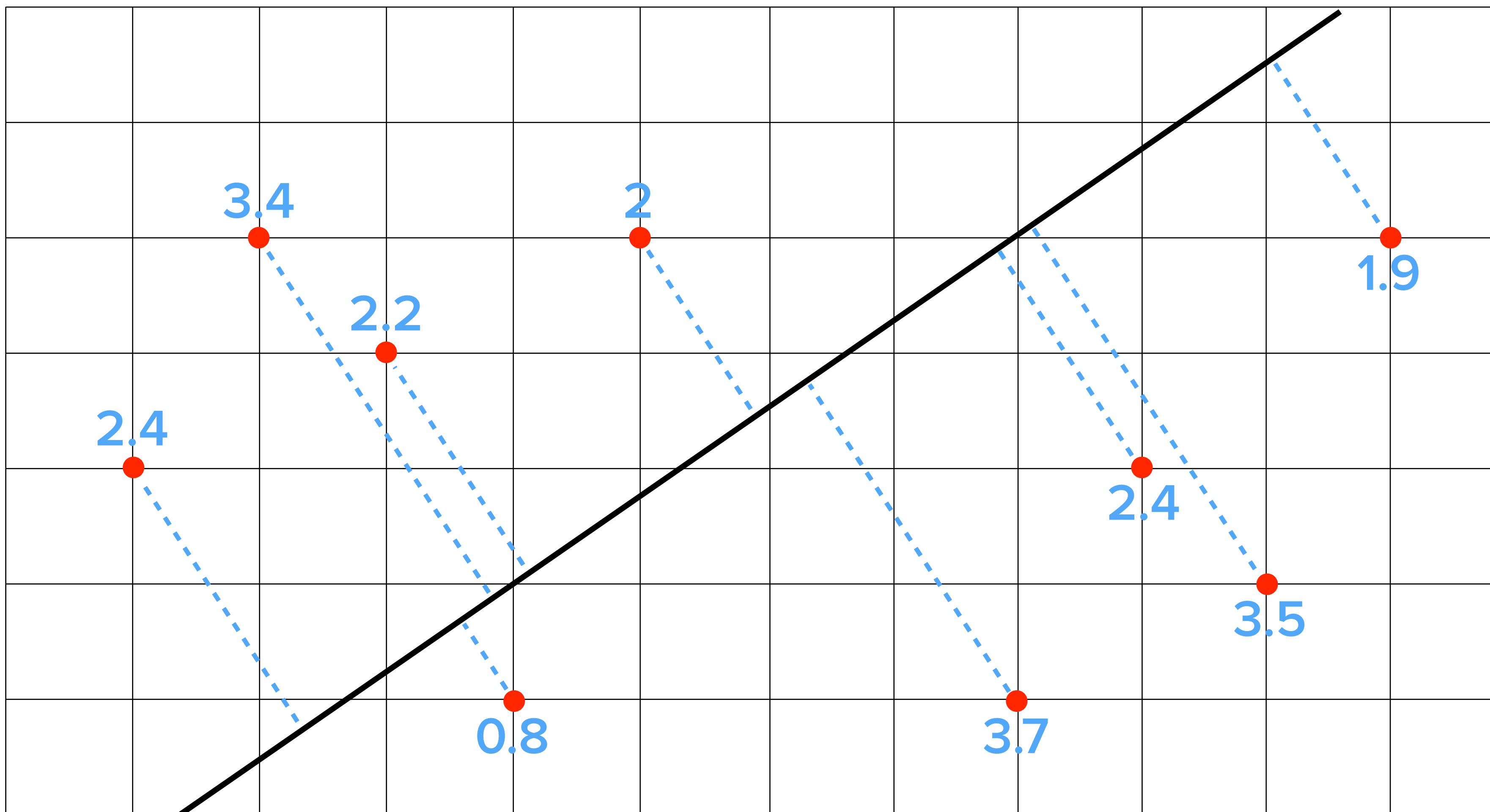


LINEAR REGRESSION



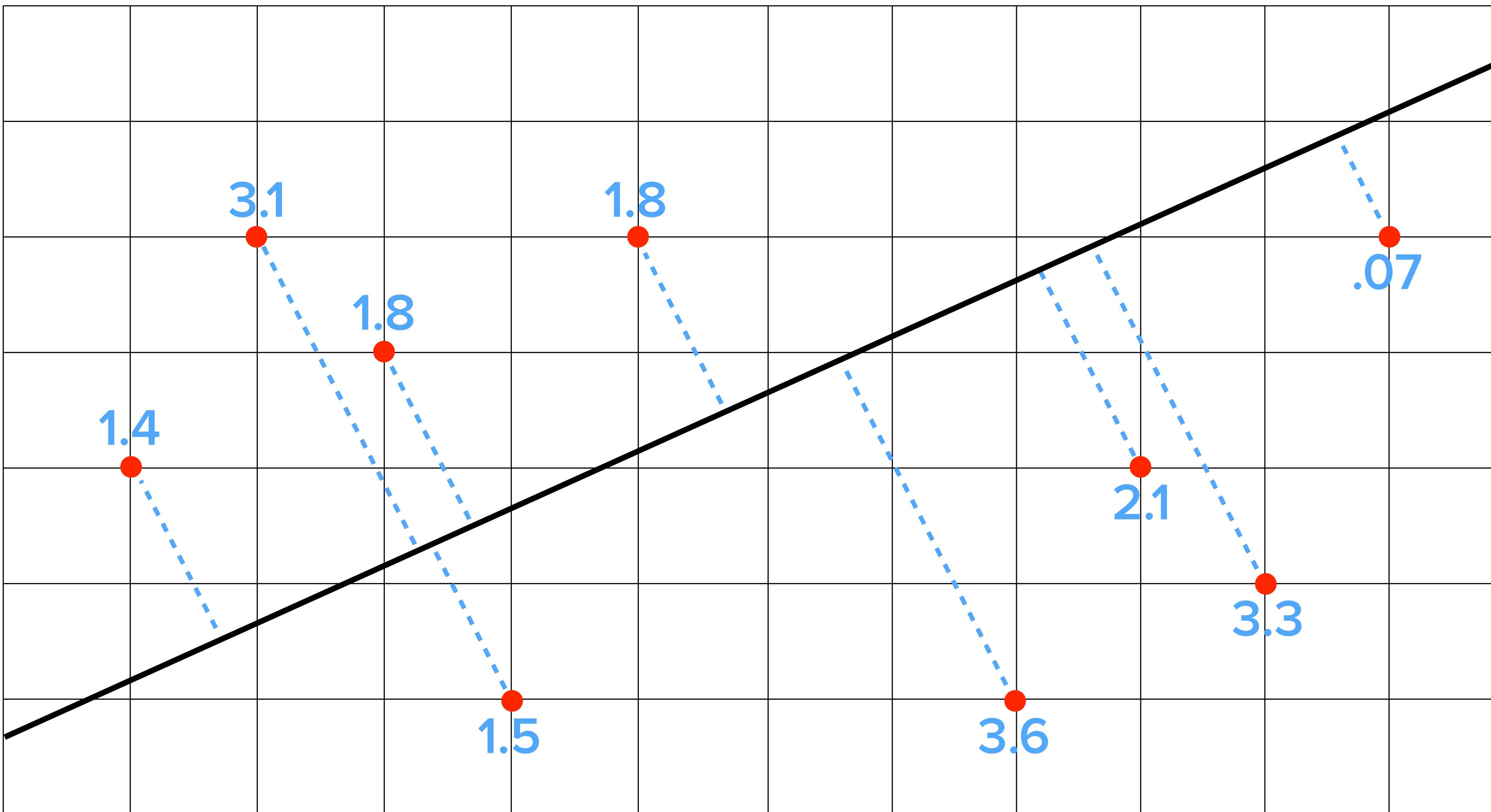
LINEAR REGRESSION

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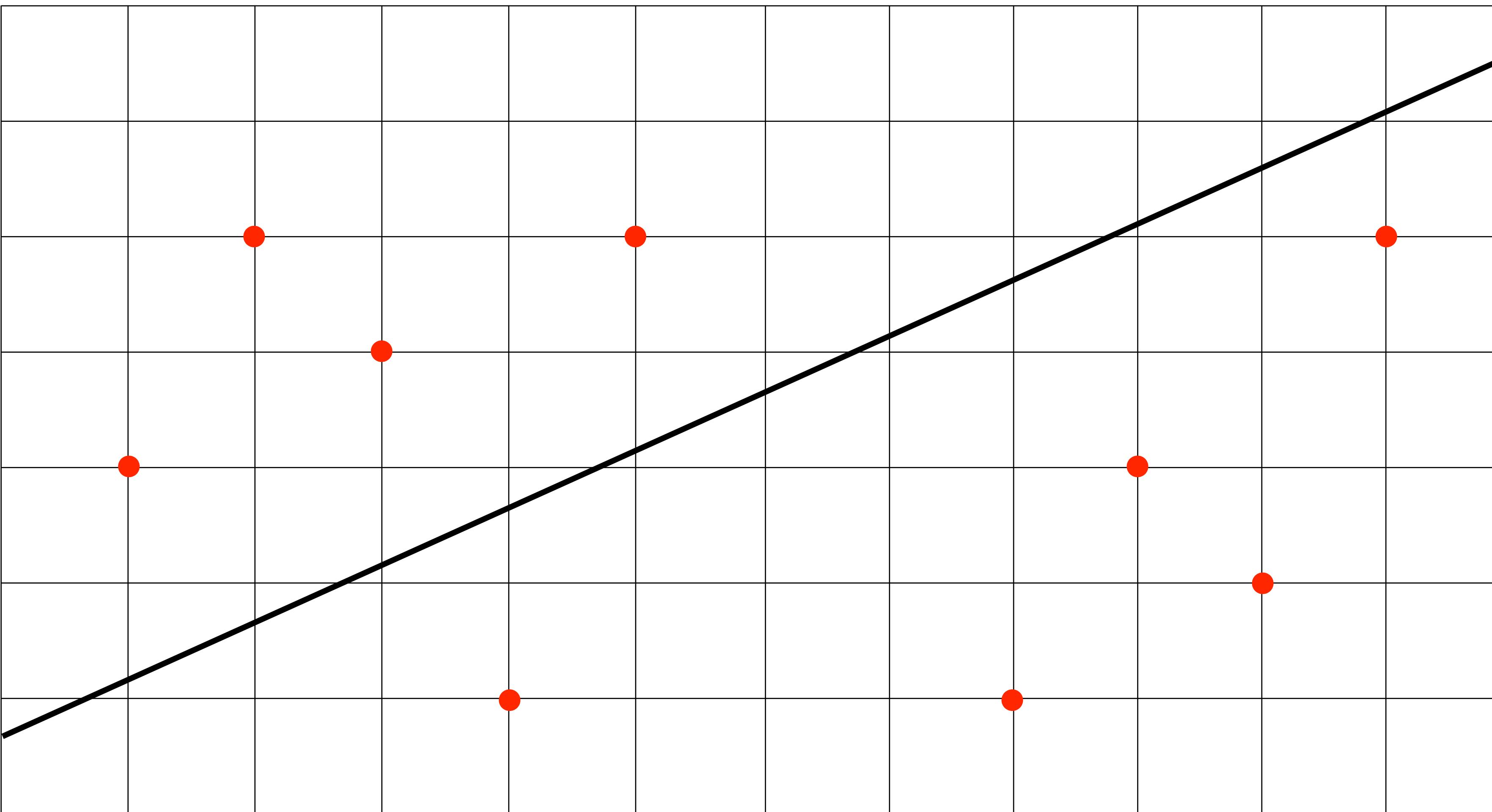


LINEAR REGRESSION

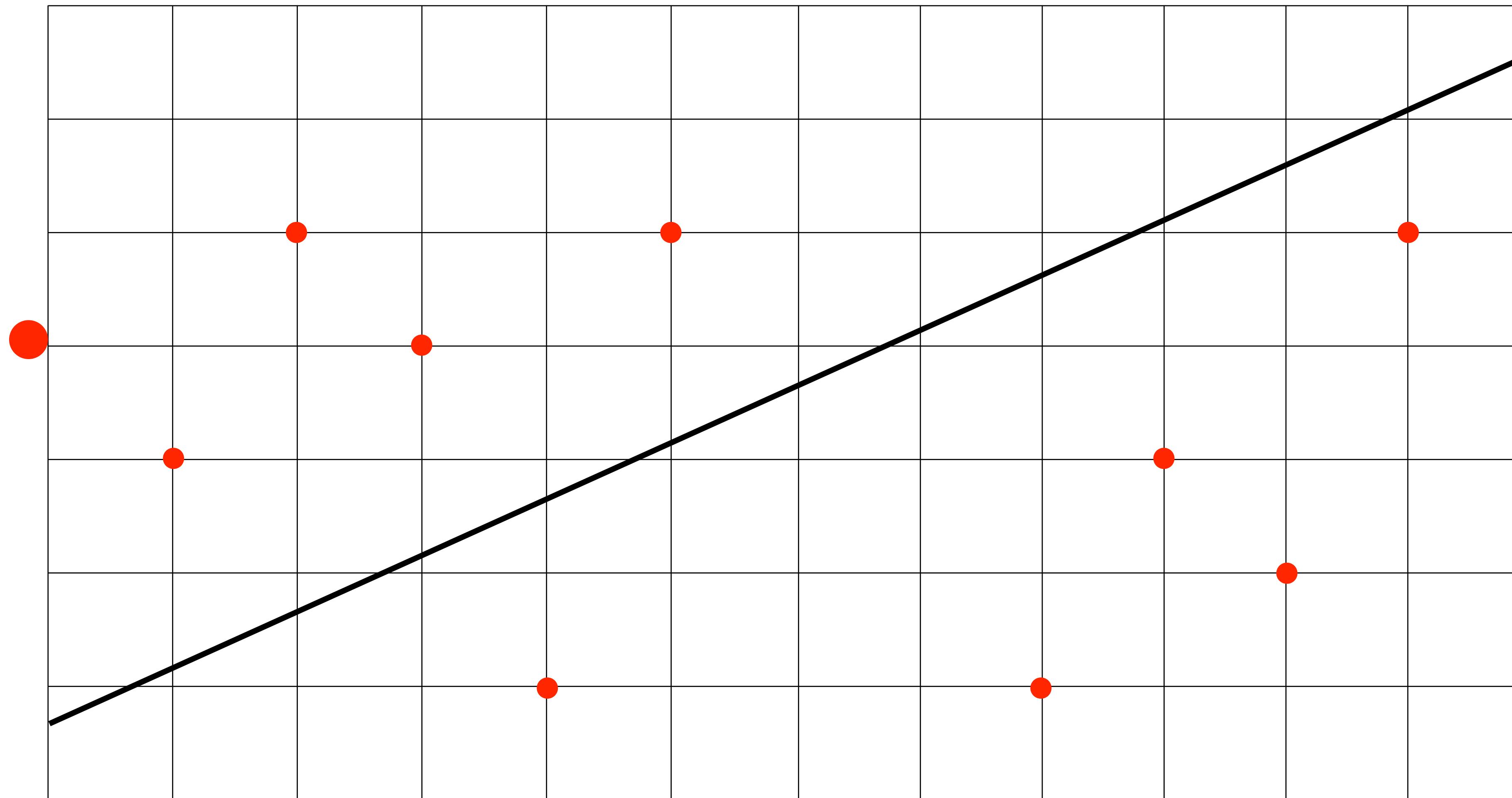
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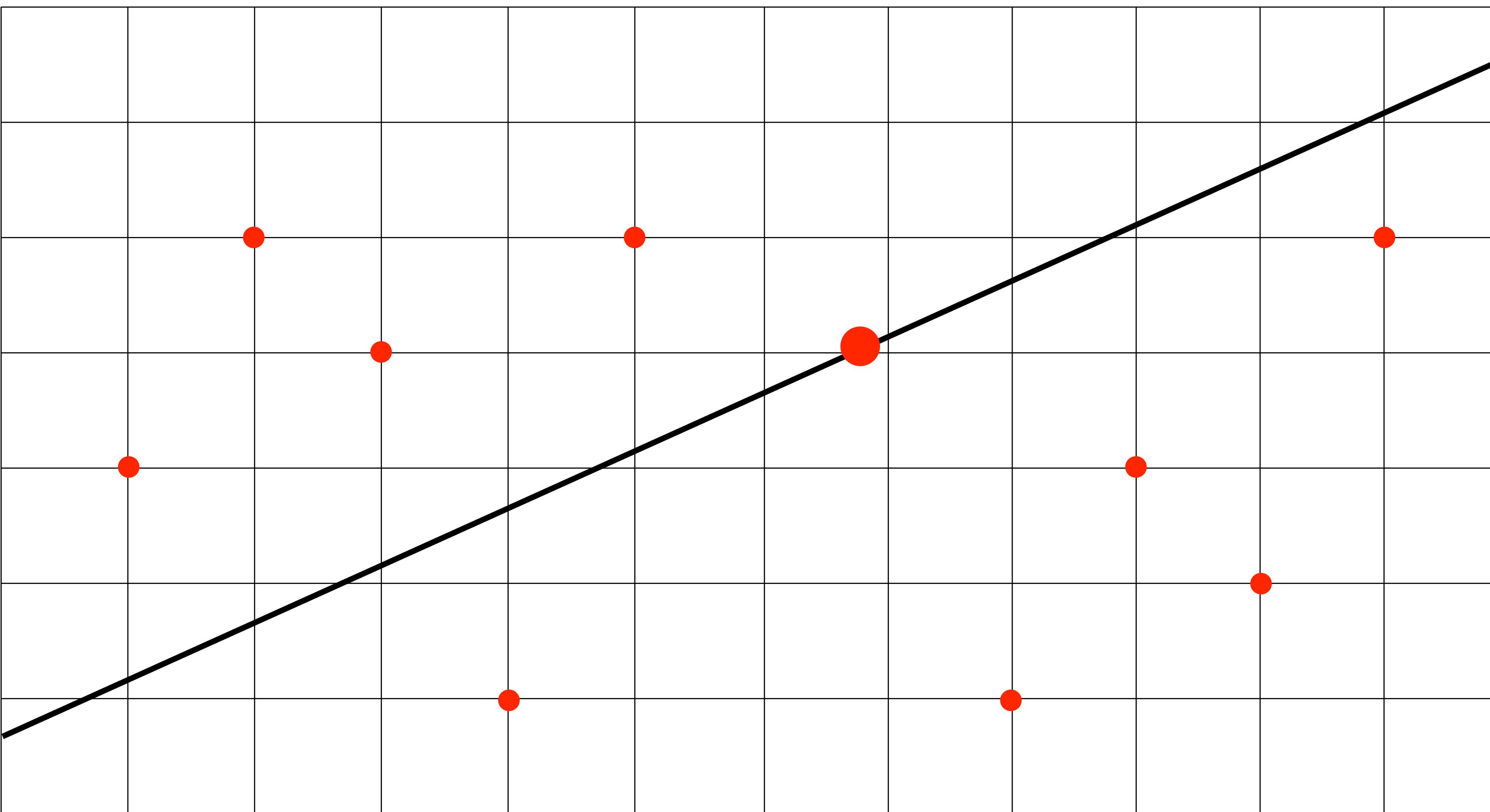
LINEAR REGRESSION



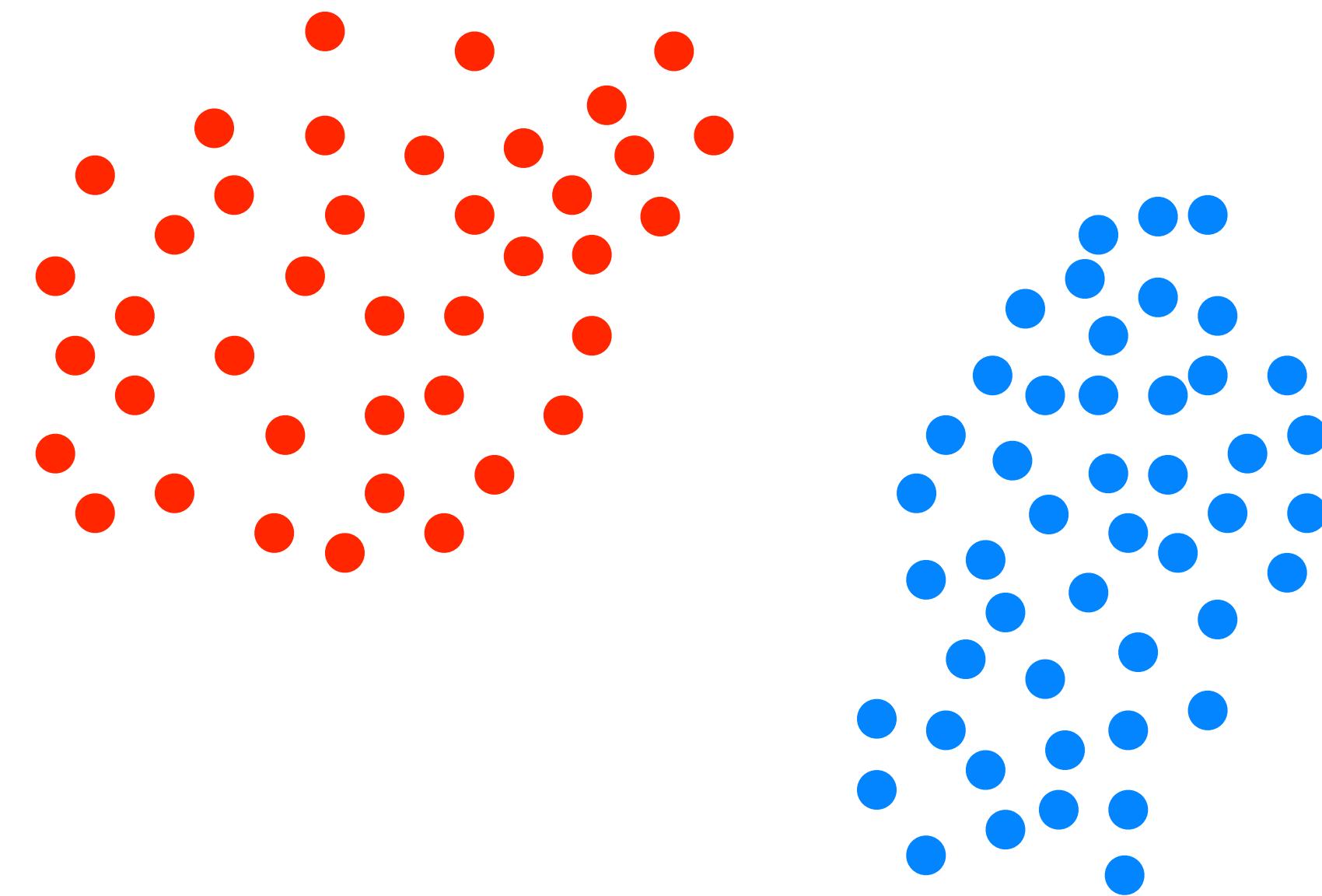
LINEAR REGRESSION



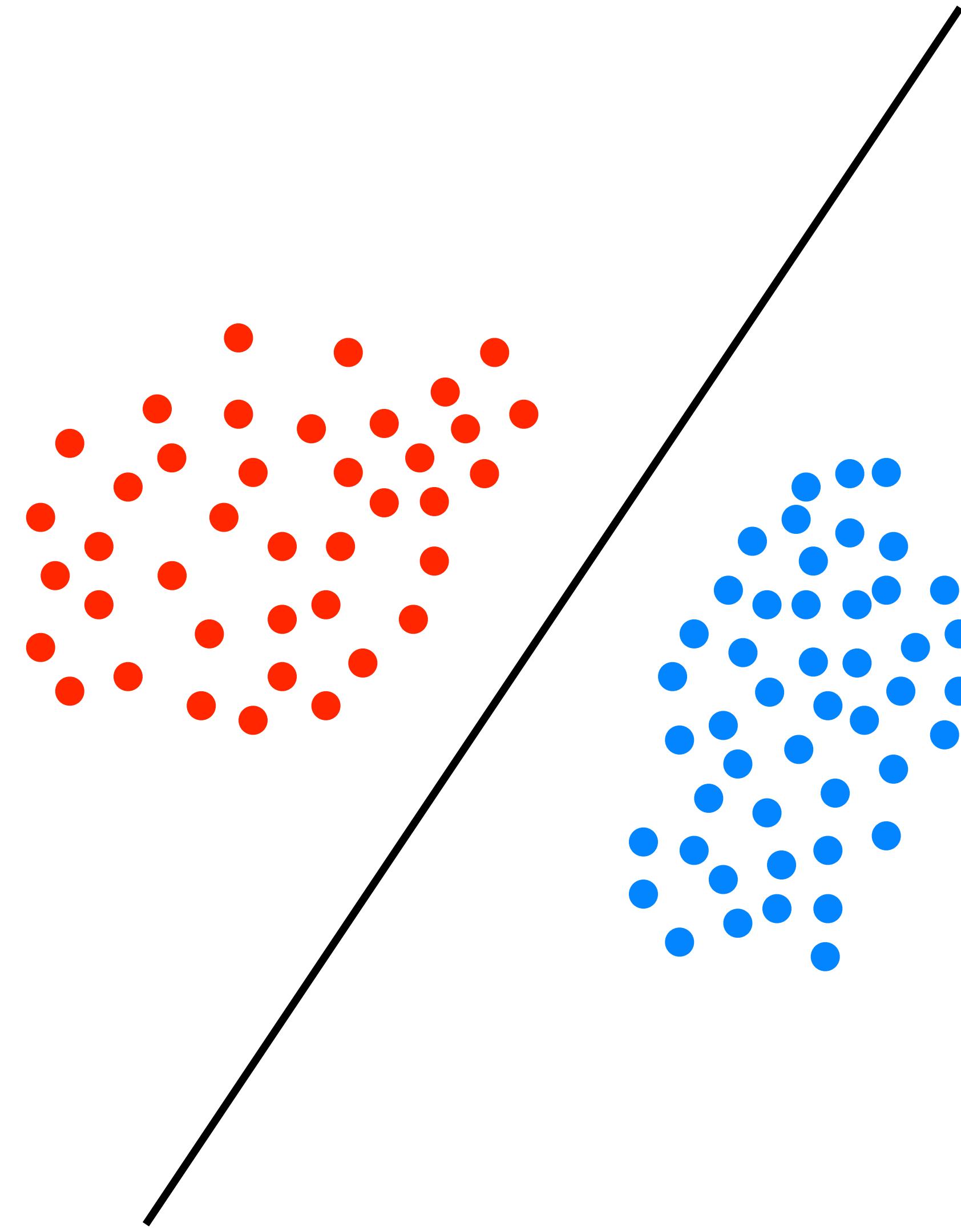
LINEAR REGRESSION



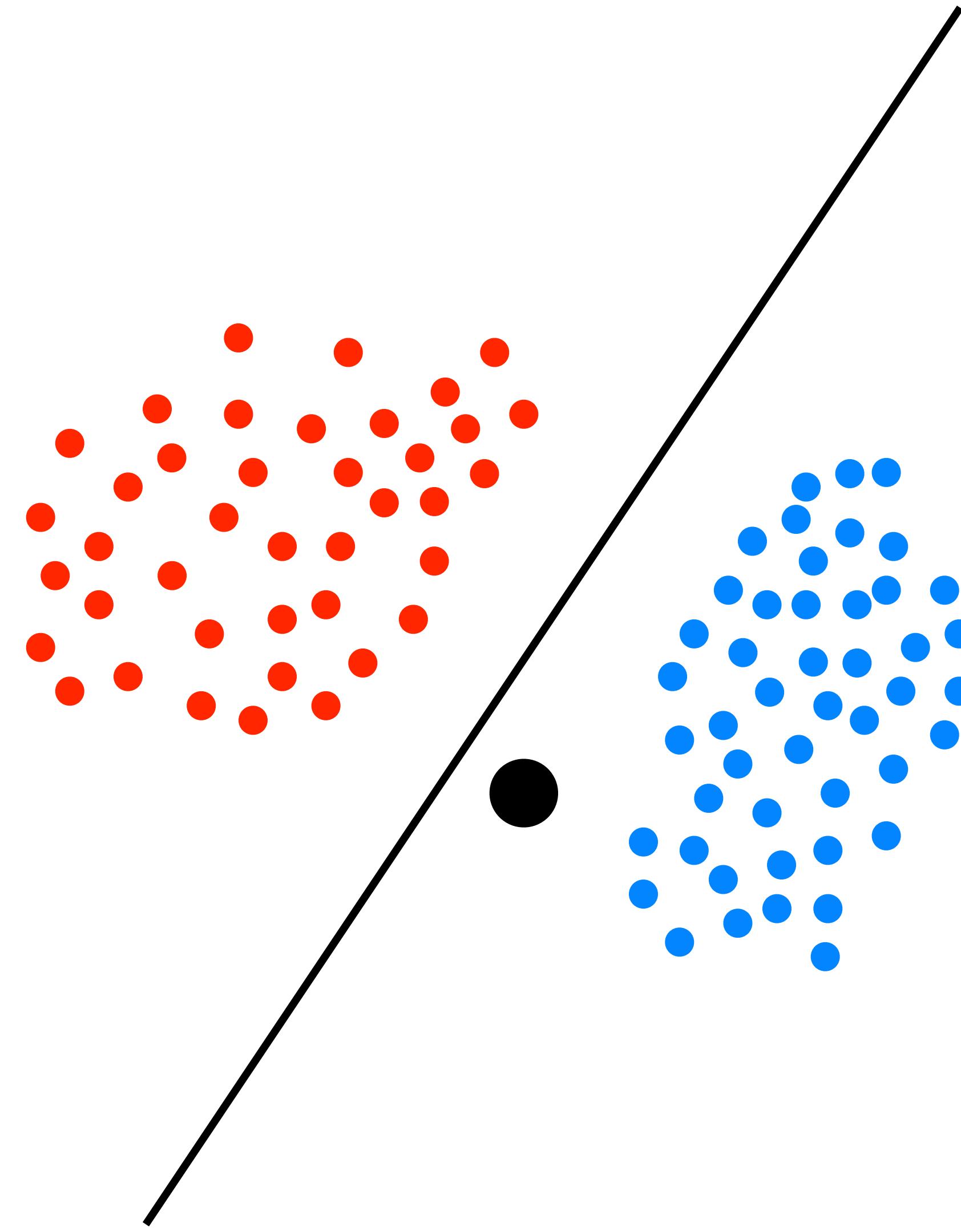
K-MEANS



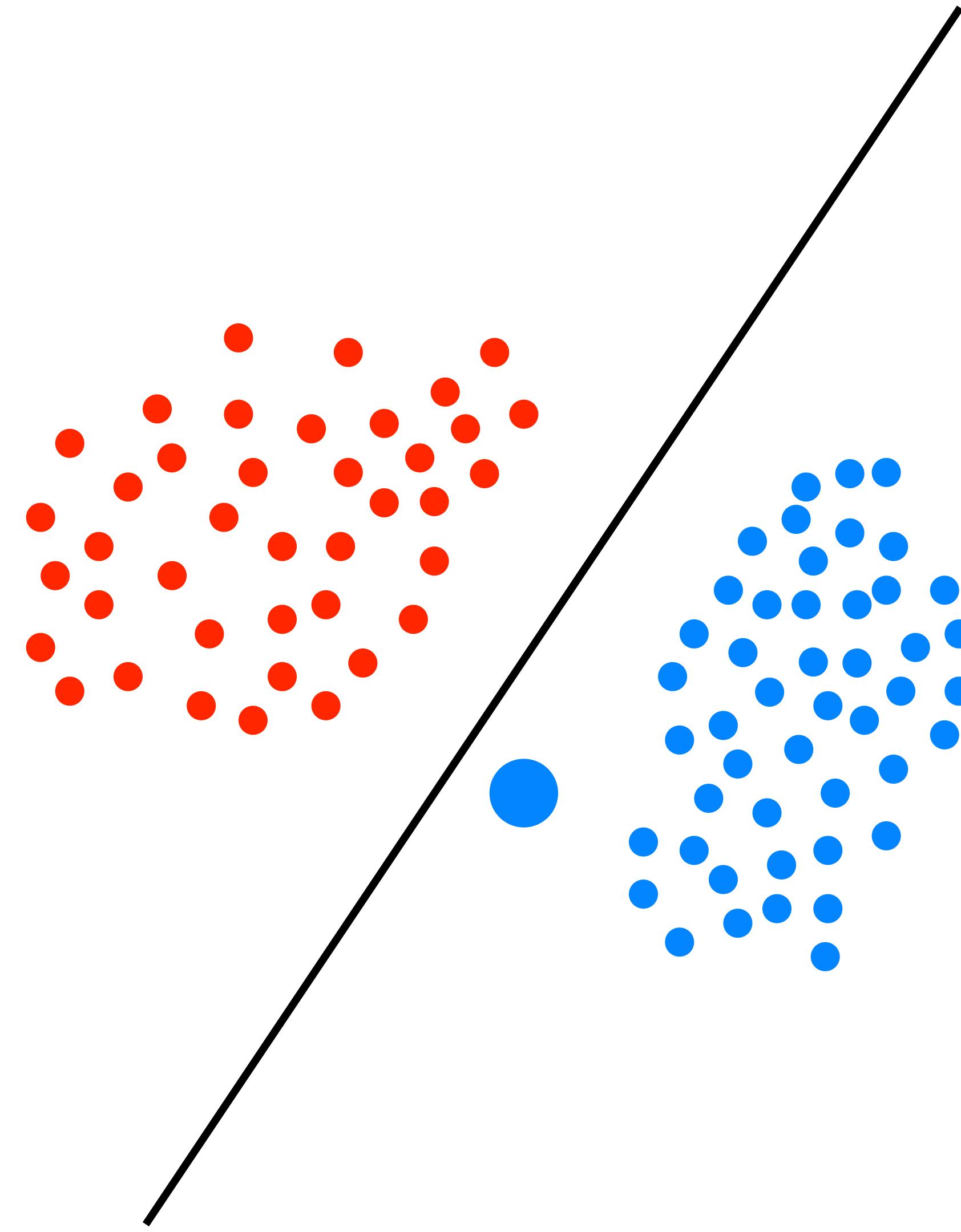
K-MEANS



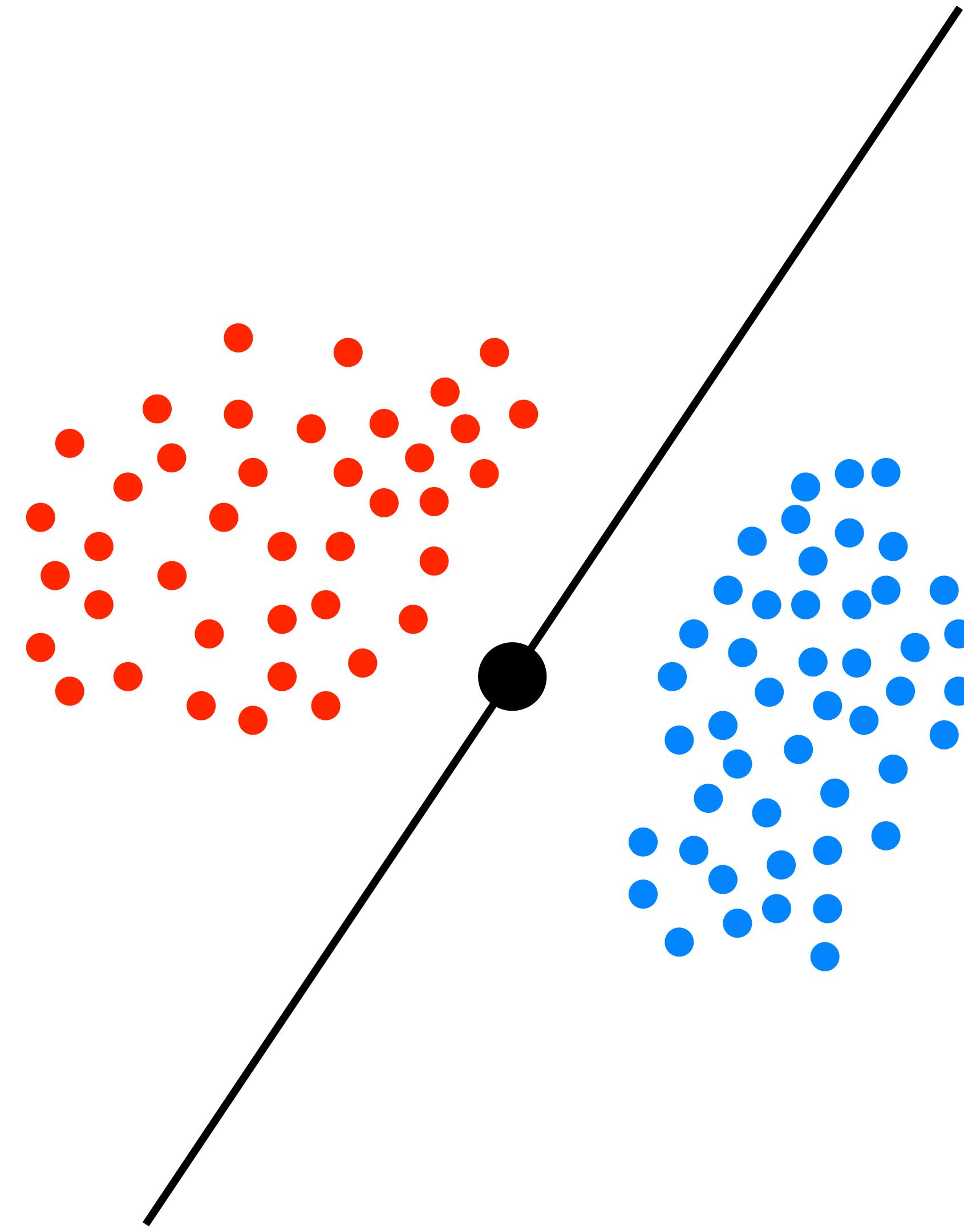
K-MEANS



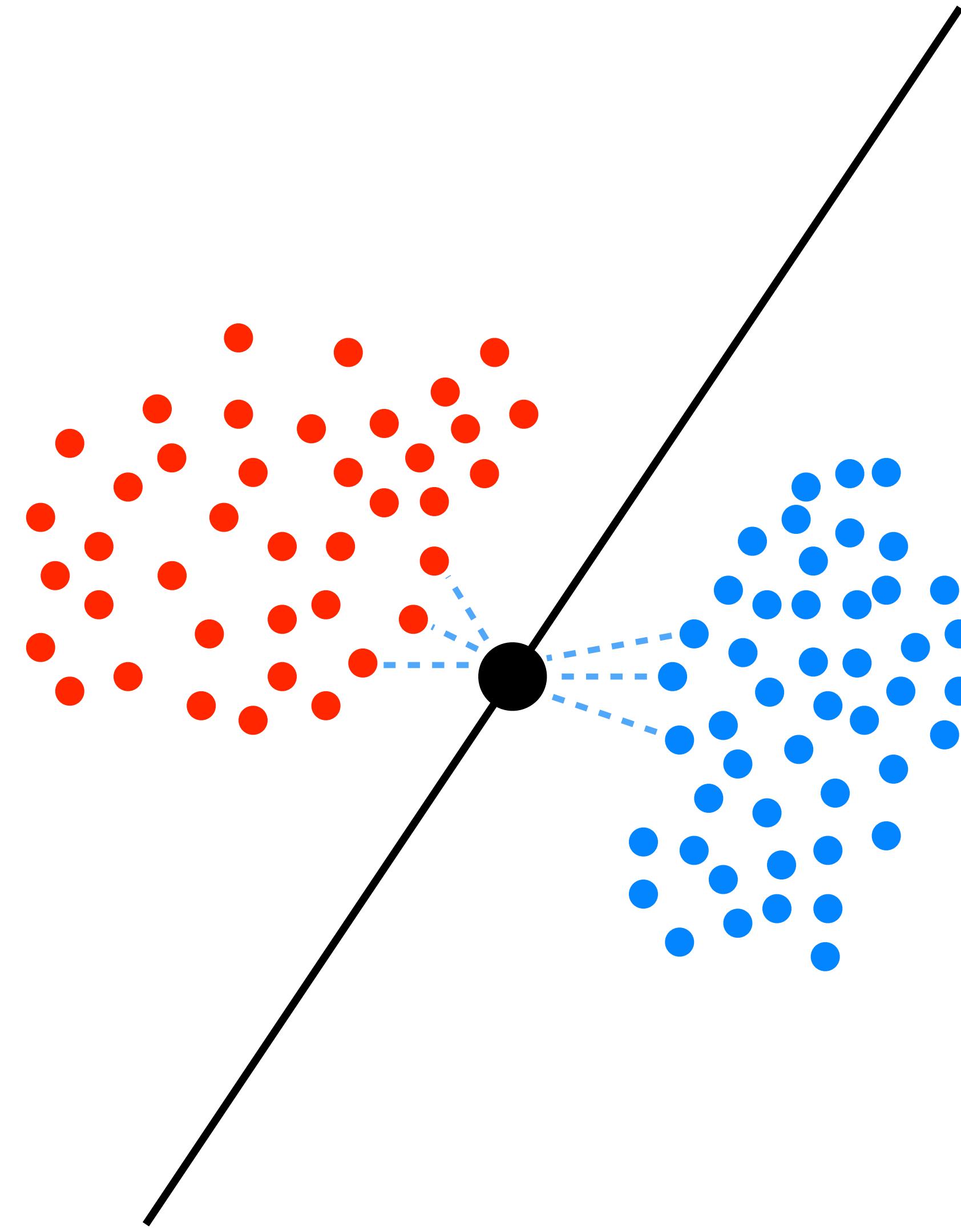
K-MEANS



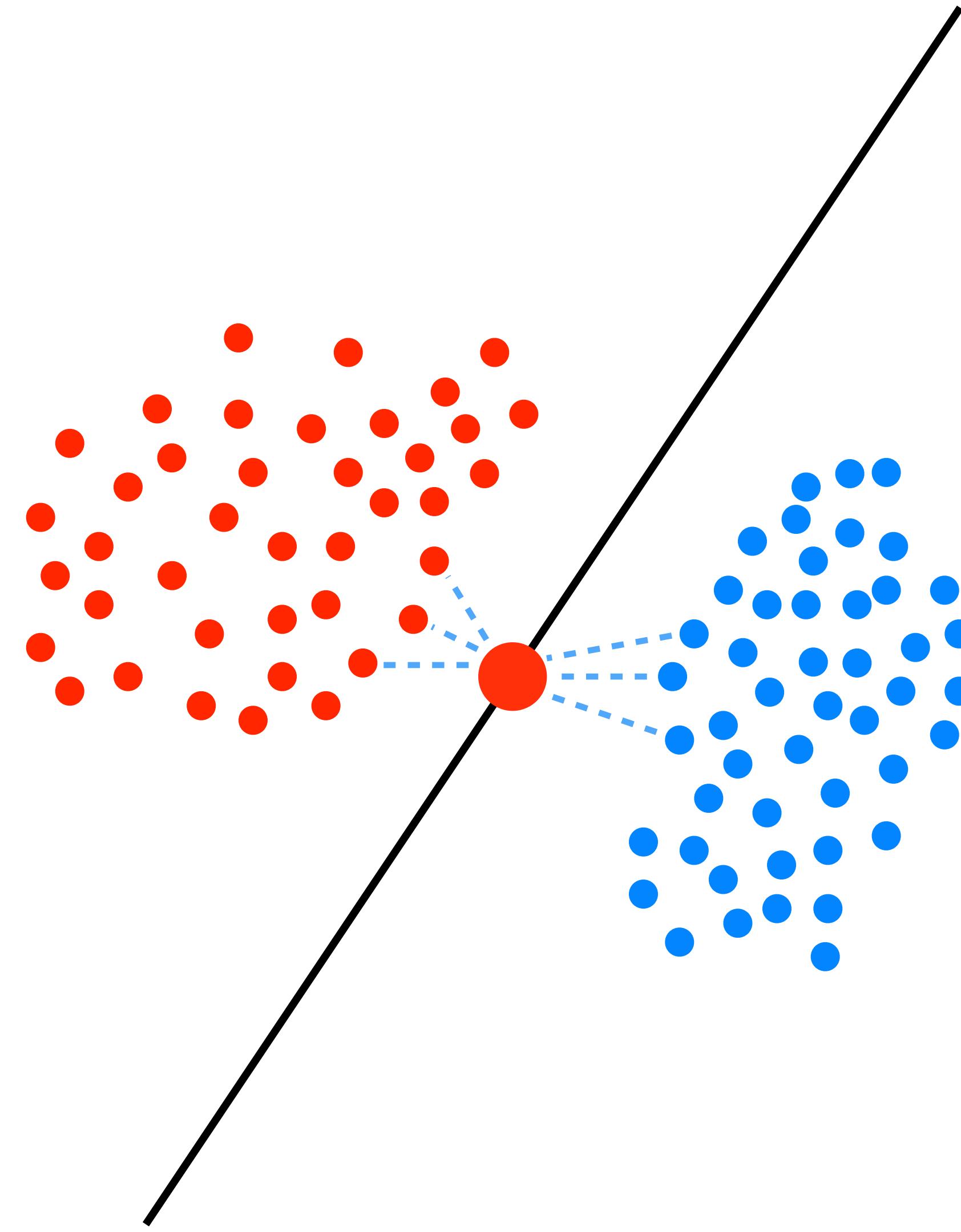
K-MEANS



K-MEANS



K-MEANS



NAIVE BAYES CLASSIFIER

OUTLOOK	TEMP.	HUMIDITY	WINDY	PLAY GOLF?
RAINY	HOT	HIGH	FALSE	NO
RAINY	HOT	HIGH	TRUE	NO
OVERCAST	HOT	HIGH	FALSE	YES
SUNNY	MILD	HIGH	FALSE	YES
SUNNY	COOL	NORMAL	FALSE	YES
SUNNY	COOL	NORMAL	TRUE	NO
OVERCAST	COOL	NORMAL	TRUE	YES
RAINY	MILD	HIGH	FALSE	NO
RAINY	COOL	NORMAL	FALSE	YES
SUNNY	MILD	NORMAL	FALSE	YES
RAINY	MILD	NORMAL	TRUE	YES
OVERCAST	MILD	HIGH	TRUE	YES
OVERCAST	HOT	NORMAL	FALSE	YES
SUNNY	MILD	HIGH	TRUE	NO

NAIVE BAYES CLASSIFIER

OUTLOOK	TEMP.	HUMIDITY	WINDY	PLAY GOLF?
RAINY	HOT	HIGH	FALSE	NO
RAINY	HOT	HIGH	TRUE	NO
OVERCAST	HOT	HIGH	FALSE	YES
SUNNY	MILD	HIGH	FALSE	YES
SUNNY	COOL	NORMAL	FALSE	YES
SUNNY	COOL	NORMAL	TRUE	NO
OVERCAST	COOL	NORMAL	TRUE	YES
RAINY	MILD	HIGH	FALSE	NO
RAINY	COOL	NORMAL	FALSE	YES
SUNNY	MILD	NORMAL	FALSE	YES
RAINY	MILD	NORMAL	TRUE	YES
OVERCAST	MILD	HIGH	TRUE	YES
OVERCAST	HOT	NORMAL	FALSE	YES
SUNNY	MILD	HIGH	TRUE	NO

NAIVE BAYES CLASSIFIER

OUTLOOK	TEMP.	HUMIDITY	WINDY	PLAY GOLF?
RAINY	HOT	HIGH	FALSE	NO
RAINY	HOT	HIGH	TRUE	NO
OVERCAST	HOT	HIGH	FALSE	YES
SUNNY	MILD	HIGH	FALSE	YES
SUNNY	COOL	NORMAL	FALSE	YES
SUNNY	COOL	NORMAL	TRUE	NO
OVERCAST	COOL	NORMAL	TRUE	YES
RAINY	MILD	HIGH	FALSE	NO
RAINY	COOL	NORMAL	FALSE	YES
SUNNY	MILD	NORMAL	FALSE	YES
RAINY	MILD	NORMAL	TRUE	YES
OVERCAST	MILD	HIGH	TRUE	YES
OVERCAST	HOT	NORMAL	FALSE	YES
SUNNY	MILD	HIGH	TRUE	NO

RAINY
NO YES
0/5 0/9

NAIVE BAYES CLASSIFIER

OUTLOOK	TEMP.	HUMIDITY	WINDY	PLAY GOLF?
RAINY	HOT	HIGH	FALSE	NO
RAINY	HOT	HIGH	TRUE	NO
OVERCAST	HOT	HIGH	FALSE	YES
SUNNY	MILD	HIGH	FALSE	YES
SUNNY	COOL	NORMAL	FALSE	YES
SUNNY	COOL	NORMAL	TRUE	NO
OVERCAST	COOL	NORMAL	TRUE	YES
RAINY	MILD	HIGH	FALSE	NO
RAINY	COOL	NORMAL	FALSE	YES
SUNNY	MILD	NORMAL	FALSE	YES
RAINY	MILD	NORMAL	TRUE	YES
OVERCAST	MILD	HIGH	TRUE	YES
OVERCAST	HOT	NORMAL	FALSE	YES
SUNNY	MILD	HIGH	TRUE	NO

RAINY

NO	YES
1/5	0/9

NAIVE BAYES CLASSIFIER

OUTLOOK	TEMP.	HUMIDITY	WINDY	PLAY GOLF?
RAINY	HOT	HIGH	FALSE	NO
RAINY	HOT	HIGH	TRUE	NO
OVERCAST	HOT	HIGH	FALSE	YES
SUNNY	MILD	HIGH	FALSE	YES
SUNNY	COOL	NORMAL	FALSE	YES
SUNNY	COOL	NORMAL	TRUE	NO
OVERCAST	COOL	NORMAL	TRUE	YES
RAINY	MILD	HIGH	FALSE	NO
RAINY	COOL	NORMAL	FALSE	YES
SUNNY	MILD	NORMAL	FALSE	YES
RAINY	MILD	NORMAL	TRUE	YES
OVERCAST	MILD	HIGH	TRUE	YES
OVERCAST	HOT	NORMAL	FALSE	YES
SUNNY	MILD	HIGH	TRUE	NO

RAINY
NO YES
2/5 0/9

NAIVE BAYES CLASSIFIER

OUTLOOK	TEMP.	HUMIDITY	WINDY	PLAY GOLF?
RAINY	HOT	HIGH	FALSE	NO
RAINY	HOT	HIGH	TRUE	NO
OVERCAST	HOT	HIGH	FALSE	YES
SUNNY	MILD	HIGH	FALSE	YES
SUNNY	COOL	NORMAL	FALSE	YES
SUNNY	COOL	NORMAL	TRUE	NO
OVERCAST	COOL	NORMAL	TRUE	YES
RAINY	MILD	HIGH	FALSE	NO
RAINY	COOL	NORMAL	FALSE	YES
SUNNY	MILD	NORMAL	FALSE	YES
RAINY	MILD	NORMAL	TRUE	YES
OVERCAST	MILD	HIGH	TRUE	YES
OVERCAST	HOT	NORMAL	FALSE	YES
SUNNY	MILD	HIGH	TRUE	NO

RAINY
NO YES
3/5 0/9

NAIVE BAYES CLASSIFIER

OUTLOOK	TEMP.	HUMIDITY	WINDY	PLAY GOLF?
RAINY	HOT	HIGH	FALSE	NO
RAINY	HOT	HIGH	TRUE	NO
OVERCAST	HOT	HIGH	FALSE	YES
SUNNY	MILD	HIGH	FALSE	YES
SUNNY	COOL	NORMAL	FALSE	YES
SUNNY	COOL	NORMAL	TRUE	NO
OVERCAST	COOL	NORMAL	TRUE	YES
RAINY	MILD	HIGH	FALSE	NO
RAINY	COOL	NORMAL	FALSE	YES
SUNNY	MILD	NORMAL	FALSE	YES
RAINY	MILD	NORMAL	TRUE	YES
OVERCAST	MILD	HIGH	TRUE	YES
OVERCAST	HOT	NORMAL	FALSE	YES
SUNNY	MILD	HIGH	TRUE	NO

RAINY

NO	YES
3/5	1/9

NAIVE BAYES CLASSIFIER

OUTLOOK	TEMP.	HUMIDITY	WINDY	PLAY GOLF?
RAINY	HOT	HIGH	FALSE	NO
RAINY	HOT	HIGH	TRUE	NO
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SUNNY	MILD	HIGH	FALSE	YES
SUNNY	COOL	NORMAL	FALSE	YES
SUNNY	COOL	NORMAL	TRUE	NO
OVERCAST	COOL	NORMAL	TRUE	YES
RAINY	MILD	HIGH	FALSE	NO
RAINY	COOL	NORMAL	FALSE	YES
SUNNY	MILD	NORMAL	FALSE	YES
RAINY	MILD	NORMAL	TRUE	YES
OVERCAST	MILD	HIGH	TRUE	YES
OVERCAST	HOT	NORMAL	FALSE	YES
SUNNY	MILD	HIGH	TRUE	NO

RAINY
NO YES
3/5 2/9

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SUNNY	MILD	HIGH	FALSE	YES
SUNNY	COOL	NORMAL	FALSE	YES
SUNNY	COOL	NORMAL	TRUE	NO
OVERCAST	COOL	NORMAL	TRUE	YES
RAINY	MILD	HIGH	FALSE	NO
RAINY	COOL	NORMAL	FALSE	YES
SUNNY	MILD	NORMAL	FALSE	YES
RAINY	MILD	NORMAL	TRUE	YES
OVERCAST	MILD	HIGH	TRUE	YES
OVERCAST	HOT	NORMAL	FALSE	YES
SUNNY	MILD	HIGH	TRUE	NO

RAINY
NO YES
3/5 2/9

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RAINY	HOT	HIGH	FALSE	NO
RAINY	HOT	HIGH	TRUE	NO
OVERCAST	HOT	HIGH	FALSE	YES
SUNNY	MILD	HIGH	FALSE	YES
SUNNY	COOL	NORMAL	FALSE	YES
SUNNY	COOL	NORMAL	TRUE	NO
OVERCAST	COOL	NORMAL	TRUE	YES
RAINY	MILD	HIGH	FALSE	NO
RAINY	COOL	NORMAL	FALSE	YES
SUNNY	MILD	NORMAL	FALSE	YES
RAINY	MILD	NORMAL	TRUE	YES
OVERCAST	MILD	HIGH	TRUE	YES
OVERCAST	HOT	NORMAL	FALSE	YES
SUNNY	MILD	HIGH	TRUE	NO

RAINY	NO	YES
NO	YES	
3/5	2/9	
OVERCAST	NO	YES
0/5	0/9	

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OUTLOOK	TEMP.	HUMIDITY	WINDY	PLAY GOLF?
RAINY	HOT	HIGH	FALSE	NO
RAINY	HOT	HIGH	TRUE	NO
OVERCAST	HOT	HIGH	FALSE	YES
SUNNY	MILD	HIGH	FALSE	YES
SUNNY	COOL	NORMAL	FALSE	YES
SUNNY	COOL	NORMAL	TRUE	NO
OVERCAST	COOL	NORMAL	TRUE	YES
RAINY	MILD	HIGH	FALSE	NO
RAINY	COOL	NORMAL	FALSE	YES
SUNNY	MILD	NORMAL	FALSE	YES
RAINY	MILD	NORMAL	TRUE	YES
OVERCAST	MILD	HIGH	TRUE	YES
OVERCAST	HOT	NORMAL	FALSE	YES
SUNNY	MILD	HIGH	TRUE	NO

RAINY	NO	YES
NO	3/5	2/9
OVERCAST	NO	YES
0/5	1/9	

NAIVE BAYES CLASSIFIER

OUTLOOK	TEMP.	HUMIDITY	WINDY	PLAY GOLF?
RAINY	HOT	HIGH	FALSE	NO
RAINY	HOT	HIGH	TRUE	NO
OVERCAST	HOT	HIGH	FALSE	YES
SUNNY	MILD	HIGH	FALSE	YES
SUNNY	COOL	NORMAL	FALSE	YES
SUNNY	COOL	NORMAL	TRUE	NO
OVERCAST	COOL	NORMAL	TRUE	YES
RAINY	MILD	HIGH	FALSE	NO
RAINY	COOL	NORMAL	FALSE	YES
SUNNY	MILD	NORMAL	FALSE	YES
RAINY	MILD	NORMAL	TRUE	YES
OVERCAST	MILD	HIGH	TRUE	YES
OVERCAST	HOT	NORMAL	FALSE	YES
SUNNY	MILD	HIGH	TRUE	NO

RAINY	NO	YES
NO	YES	
3/5	2/9	
OVERCAST	NO	YES
0/5	2/9	

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RAINY	HOT	HIGH	FALSE	NO
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SUNNY	MILD	HIGH	FALSE	YES
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SUNNY	COOL	NORMAL	TRUE	NO
OVERCAST	COOL	NORMAL	TRUE	YES
RAINY	MILD	HIGH	FALSE	NO
RAINY	COOL	NORMAL	FALSE	YES
SUNNY	MILD	NORMAL	FALSE	YES
RAINY	MILD	NORMAL	TRUE	YES
OVERCAST	MILD	HIGH	TRUE	YES
OVERCAST	HOT	NORMAL	FALSE	YES
SUNNY	MILD	HIGH	TRUE	NO

RAINY

NO YES

3/5 2/9

OVERCAST

NO YES

0/5 3/9

NAIVE BAYES CLASSIFIER

OUTLOOK	TEMP.	HUMIDITY	WINDY	PLAY GOLF?
RAINY	HOT	HIGH	FALSE	NO
RAINY	HOT	HIGH	TRUE	NO
OVERCAST	HOT	HIGH	FALSE	YES
SUNNY	MILD	HIGH	FALSE	YES
SUNNY	COOL	NORMAL	FALSE	YES
SUNNY	COOL	NORMAL	TRUE	NO
OVERCAST	COOL	NORMAL	TRUE	YES
RAINY	MILD	HIGH	FALSE	NO
RAINY	COOL	NORMAL	FALSE	YES
SUNNY	MILD	NORMAL	FALSE	YES
RAINY	MILD	NORMAL	TRUE	YES
OVERCAST	MILD	HIGH	TRUE	YES
OVERCAST	HOT	NORMAL	FALSE	YES
SUNNY	MILD	HIGH	TRUE	NO

RAINY

NO YES

3/5 2/9

OVERCAST

NO YES

0/5 4/9

NAIVE BAYES CLASSIFIER

OUTLOOK	TEMP.	HUMIDITY	WINDY	PLAY GOLF?
RAINY	HOT	HIGH	FALSE	NO
RAINY	HOT	HIGH	TRUE	NO
OVERCAST	HOT	HIGH	FALSE	YES
SUNNY	MILD	HIGH	FALSE	YES
SUNNY	COOL	NORMAL	FALSE	YES
SUNNY	COOL	NORMAL	TRUE	NO
OVERCAST	COOL	NORMAL	TRUE	YES
RAINY	MILD	HIGH	FALSE	NO
RAINY	COOL	NORMAL	FALSE	YES
SUNNY	MILD	NORMAL	FALSE	YES
RAINY	MILD	NORMAL	TRUE	YES
OVERCAST	MILD	HIGH	TRUE	YES
OVERCAST	HOT	NORMAL	FALSE	YES
SUNNY	MILD	HIGH	TRUE	NO

RAINY	NO	YES
NO	YES	
3/5	2/9	
OVERCAST	NO	YES
0/5	4/9	

NAIVE BAYES CLASSIFIER

OUTLOOK	TEMP.	HUMIDITY	WINDY	PLAY GOLF?
RAINY	HOT	HIGH	FALSE	NO
RAINY	HOT	HIGH	TRUE	NO
OVERCAST	HOT	HIGH	FALSE	YES
SUNNY	MILD	HIGH	FALSE	YES
SUNNY	COOL	NORMAL	FALSE	YES
SUNNY	COOL	NORMAL	TRUE	NO
OVERCAST	COOL	NORMAL	TRUE	YES
RAINY	MILD	HIGH	FALSE	NO
RAINY	COOL	NORMAL	FALSE	YES
SUNNY	MILD	NORMAL	FALSE	YES
RAINY	MILD	NORMAL	TRUE	YES
OVERCAST	MILD	HIGH	TRUE	YES
OVERCAST	HOT	NORMAL	FALSE	YES
SUNNY	MILD	HIGH	TRUE	NO

RAINY	OVERCAST	SUNNY
NO	NO	NO
YES	2/9	YES
3/5	OVERCAST	OVERCAST
4/9	NO	YES
0/5	0/5	0/5
4/9	4/9	0/9

NAIVE BAYES CLASSIFIER

OUTLOOK	TEMP.	HUMIDITY	WINDY	PLAY GOLF?
RAINY	HOT	HIGH	FALSE	NO
RAINY	HOT	HIGH	TRUE	NO
OVERCAST	HOT	HIGH	FALSE	YES
SUNNY	MILD	HIGH	FALSE	YES
SUNNY	COOL	NORMAL	FALSE	YES
SUNNY	COOL	NORMAL	TRUE	NO
OVERCAST	COOL	NORMAL	TRUE	YES
RAINY	MILD	HIGH	FALSE	NO
RAINY	COOL	NORMAL	FALSE	YES
SUNNY	MILD	NORMAL	FALSE	YES
RAINY	MILD	NORMAL	TRUE	YES
OVERCAST	MILD	HIGH	TRUE	YES
OVERCAST	HOT	NORMAL	FALSE	YES
SUNNY	MILD	HIGH	TRUE	NO

RAINY	OVERCAST	SUNNY
NO	NO	YES
3/5	2/9	
0/5	4/9	
0/5	1/9	

NAIVE BAYES CLASSIFIER

OUTLOOK	TEMP.	HUMIDITY	WINDY	PLAY GOLF?
RAINY	HOT	HIGH	FALSE	NO
RAINY	HOT	HIGH	TRUE	NO
OVERCAST	HOT	HIGH	FALSE	YES
SUNNY	MILD	HIGH	FALSE	YES
SUNNY	COOL	NORMAL	FALSE	YES
SUNNY	COOL	NORMAL	TRUE	NO
OVERCAST	COOL	NORMAL	TRUE	YES
RAINY	MILD	HIGH	FALSE	NO
RAINY	COOL	NORMAL	FALSE	YES
SUNNY	MILD	NORMAL	FALSE	YES
RAINY	MILD	NORMAL	TRUE	YES
OVERCAST	MILD	HIGH	TRUE	YES
OVERCAST	HOT	NORMAL	FALSE	YES
SUNNY	MILD	HIGH	TRUE	NO

RAINY	OVERCAST	SUNNY
NO	NO	YES
3/5	2/9	
0/5	4/9	
0/5	2/9	

NAIVE BAYES CLASSIFIER

OUTLOOK	TEMP.	HUMIDITY	WINDY	PLAY GOLF?
RAINY	HOT	HIGH	FALSE	NO
RAINY	HOT	HIGH	TRUE	NO
OVERCAST	HOT	HIGH	FALSE	YES
SUNNY	MILD	HIGH	FALSE	YES
SUNNY	COOL	NORMAL	FALSE	YES
SUNNY	COOL	NORMAL	TRUE	NO
OVERCAST	COOL	NORMAL	TRUE	YES
RAINY	MILD	HIGH	FALSE	NO
RAINY	COOL	NORMAL	FALSE	YES
SUNNY	MILD	NORMAL	FALSE	YES
RAINY	MILD	NORMAL	TRUE	YES
OVERCAST	MILD	HIGH	TRUE	YES
OVERCAST	HOT	NORMAL	FALSE	YES
SUNNY	MILD	HIGH	TRUE	NO

RAINY	NO	YES
NO	YES	
3/5	2/9	
OVERCAST	NO	YES
0/5	4/9	
SUNNY	NO	YES
1/5	2/9	

NAIVE BAYES CLASSIFIER

OUTLOOK	TEMP.	HUMIDITY	WINDY	PLAY GOLF?
RAINY	HOT	HIGH	FALSE	NO
RAINY	HOT	HIGH	TRUE	NO
OVERCAST	HOT	HIGH	FALSE	YES
SUNNY	MILD	HIGH	FALSE	YES
SUNNY	COOL	NORMAL	FALSE	YES
SUNNY	COOL	NORMAL	TRUE	NO
OVERCAST	COOL	NORMAL	TRUE	YES
RAINY	MILD	HIGH	FALSE	NO
RAINY	COOL	NORMAL	FALSE	YES
SUNNY	MILD	NORMAL	FALSE	YES
RAINY	MILD	NORMAL	TRUE	YES
OVERCAST	MILD	HIGH	TRUE	YES
OVERCAST	HOT	NORMAL	FALSE	YES
SUNNY	MILD	HIGH	TRUE	NO

RAINY	NO	YES
NO	YES	
3/5	2/9	
OVERCAST	NO	YES
0/5	4/9	
SUNNY	NO	YES
1/5	3/9	

NAIVE BAYES CLASSIFIER

OUTLOOK	TEMP.	HUMIDITY	WINDY	PLAY GOLF?
RAINY	HOT	HIGH	FALSE	NO
RAINY	HOT	HIGH	TRUE	NO
OVERCAST	HOT	HIGH	FALSE	YES
SUNNY	MILD	HIGH	FALSE	YES
SUNNY	COOL	NORMAL	FALSE	YES
SUNNY	COOL	NORMAL	TRUE	NO
OVERCAST	COOL	NORMAL	TRUE	YES
RAINY	MILD	HIGH	FALSE	NO
RAINY	COOL	NORMAL	FALSE	YES
SUNNY	MILD	NORMAL	FALSE	YES
RAINY	MILD	NORMAL	TRUE	YES
OVERCAST	MILD	HIGH	TRUE	YES
OVERCAST	HOT	NORMAL	FALSE	YES
SUNNY	MILD	HIGH	TRUE	NO

RAINY	OVERCAST	SUNNY
NO	NO	YES
3/5	2/9	
0/5	4/9	
2/5	3/9	

NAIVE BAYES CLASSIFIER

OUTLOOK	TEMP.	HUMIDITY	WINDY	PLAY GOLF?
RAINY	HOT	HIGH	FALSE	NO
RAINY	HOT	HIGH	TRUE	NO
OVERCAST	HOT	HIGH	FALSE	YES
SUNNY	MILD	HIGH	FALSE	YES
SUNNY	COOL	NORMAL	FALSE	YES
SUNNY	COOL	NORMAL	TRUE	NO
OVERCAST	COOL	NORMAL	TRUE	YES
RAINY	MILD	HIGH	FALSE	NO
RAINY	COOL	NORMAL	FALSE	YES
SUNNY	MILD	NORMAL	FALSE	YES
RAINY	MILD	NORMAL	TRUE	YES
OVERCAST	MILD	HIGH	TRUE	YES
OVERCAST	HOT	NORMAL	FALSE	YES
SUNNY	MILD	HIGH	TRUE	NO

RAINY	NO	YES
OVERCAST	NO	YES
OVERCAST	0/5	4/9
SUNNY	NO	YES
SUNNY	2/5	3/9

NAIVE BAYES CLASSIFIER

OUTLOOK	TEMP.	HUMIDITY	WINDY	PLAY GOLF?
RAINY	HOT	HIGH	FALSE	NO
RAINY	HOT	HIGH	TRUE	NO
OVERCAST	HOT	HIGH	FALSE	YES
SUNNY	MILD	HIGH	FALSE	YES
SUNNY	COOL	NORMAL	FALSE	YES
SUNNY	COOL	NORMAL	TRUE	NO
OVERCAST	COOL	NORMAL	TRUE	YES
RAINY	MILD	HIGH	FALSE	NO
RAINY	COOL	NORMAL	FALSE	YES
SUNNY	MILD	NORMAL	FALSE	YES
RAINY	MILD	NORMAL	TRUE	YES
OVERCAST	MILD	HIGH	TRUE	YES
OVERCAST	HOT	NORMAL	FALSE	YES
SUNNY	MILD	HIGH	TRUE	NO

RAINY	NO	YES
OVERCAST	NO	YES
OVERCAST	0/5	4/9
SUNNY	NO	YES
SUNNY	2/5	3/9

NAIVE BAYES CLASSIFIER

OUTLOOK

RAINY

NO YES

3/5 2/9

OVERCAST

NO YES

0/5 4/9

SUNNY

NO YES

2/5 3/9

NAIVE BAYES CLASSIFIER

OUTLOOK TEMP.

			HOT
RAINY	NO	YES	NO YES
	3/5	2/9	2/5 2/9
<hr/>			
OVERCAST	NO	YES	MILD
	0/5	4/9	2/5 4/9
<hr/>			
SUNNY	NO	YES	COOL
	2/5	3/9	1/5 3/9

NAIVE BAYES CLASSIFIER

OUTLOOK		TEMP.		HUMIDITY	
RAINY		HOT		HIGH	
NO	YES	NO	YES	NO	YES
3/5	2/9	2/5	2/9	4/5	3/9
<hr/>					
OVERCAST		MILD		NORMAL	
NO	YES	NO	YES	NO	YES
0/5	4/9	2/5	4/9	1/5	6/9
<hr/>					
SUNNY		COOL			
NO	YES	NO	YES		
2/5	3/9	1/5	3/9		

NAIVE BAYES CLASSIFIER

OUTLOOK		TEMP.		HUMIDITY		WINDY	
RAINY		HOT		HIGH		TRUE	
NO	YES	NO	YES	NO	YES	NO	YES
3/5	2/9	2/5	2/9	4/5	3/9	1/5	7/9
<hr/>		<hr/>		<hr/>		<hr/>	
OVERCAST		MILD		NORMAL		FALSE	
NO	YES	NO	YES	NO	YES	NO	YES
0/5	4/9	2/5	4/9	1/5	6/9	3/5	3/9
<hr/>		<hr/>		<hr/>		<hr/>	
SUNNY		COOL					
NO	YES	NO	YES				
2/5	3/9	1/5	3/9				

NAIVE BAYES CLASSIFIER

OUTLOOK		TEMP.		HUMIDITY		WINDY	
RAINY		HOT		HIGH		TRUE	
NO	YES	NO	YES	NO	YES	NO	YES
3/5	2/9	2/5	2/9	4/5	3/9	1/5	7/9
<hr/>		<hr/>		<hr/>		<hr/>	
OVERCAST		MILD		NORMAL		FALSE	
NO	YES	NO	YES	NO	YES	NO	YES
0/5	4/9	2/5	4/9	1/5	6/9	3/5	3/9
<hr/>		<hr/>		<hr/>		<hr/>	
SUNNY		COOL					
NO	YES	NO	YES				
2/5	3/9	1/5	3/9				

NAIVE BAYES CLASSIFIER

OUTLOOK	TEMP.		HUMIDITY		WINDY
RAINY	HOT		HIGH		TRUE
NO YES	NO YES		NO YES		NO YES
3/5 2/9	2/5 2/9		4/5 3/9		1/5 7/9
OVERCAST	MILD		NORMAL		FALSE
NO YES	NO YES		NO YES		NO YES
0/5 4/9	2/5 4/9		1/5 6/9		3/5 3/9
SUNNY	COOL				
NO YES	NO YES				
2/5 3/9	1/5 3/9				

NAIVE BAYES CLASSIFIER

OUTLOOK	TEMP.		HUMIDITY	WINDY	
RAINY	HOT		HIGH	TRUE	NO
NO YES	NO YES	NO YES	NO YES	NO YES	
3/5 2/9	2/5 2/9	4/5 3/9	1/5 7/9		
OVERCAST	MILD		NORMAL	FALSE	
NO YES	NO YES	NO YES	NO YES	NO YES	
0/5 4/9	2/5 4/9	1/5 6/9	3/5 3/9		
SUNNY	COOL				
NO YES	NO YES				
2/5 3/9	1/5 3/9				

NAIVE BAYES CLASSIFIER

OUTLOOK	TEMP.		HUMIDITY	WINDY
RAINY	HOT		HIGH	TRUE
NO YES	NO YES	NO YES	NO YES	NO YES
3/5 2/9	2/5 2/9	4/5 3/9	1/5 7/9	
-----	-----	-----	-----	
OVERCAST	MILD		NORMAL	FALSE
NO YES	NO YES	NO YES	NO YES	NO YES
0/5 4/9	2/5 4/9	1/5 6/9	3/5 3/9	
-----	-----	-----	-----	
SUNNY	COOL			
NO YES	NO YES			
2/5 3/9	1/5 3/9			

NO

$$(3/5) \cdot (1/5) \cdot (4/5) \cdot (3/5) \cdot (5/14) = 0.0205714$$

NAIVE BAYES CLASSIFIER

OUTLOOK	TEMP.		HUMIDITY	WINDY	
RAINY	HOT		HIGH	TRUE	
NO YES	NO YES		NO YES	NO YES	
3/5 2/9	2/5 2/9		4/5 3/9	1/5 7/9	
-----	-----	-----	-----	-----	
OVERCAST	MILD		NORMAL	FALSE	
NO YES	NO YES		NO YES	NO YES	
0/5 4/9	2/5 4/9		1/5 6/9	3/5 3/9	
-----	-----	-----	-----	-----	
SUNNY	COOL				
NO YES	NO YES				
2/5 3/9	1/5 3/9				

NO

$$(3/5) \cdot (1/5) \cdot (4/5) \cdot (3/5) \cdot (5/14) = 0.0205714$$

YES

$$(2/9) \cdot (3/9) \cdot (3/9) \cdot (3/9) \cdot (9/14) = 0.0052910$$

NAIVE BAYES CLASSIFIER

OUTLOOK	TEMP.	HUMIDITY	WINDY
RAINY	HOT	HIGH	TRUE
NO YES	NO YES	NO YES	NO YES
3/5 2/9	2/5 2/9	4/5 3/9	1/5 7/9
-----	-----	-----	-----
OVERCAST	MILD	NORMAL	FALSE
NO YES	NO YES	NO YES	NO YES
0/5 4/9	2/5 4/9	1/5 6/9	3/5 3/9
-----	-----	-----	-----
SUNNY	COOL		
NO YES	NO YES		
2/5 3/9	1/5 3/9		

NO

$$(3/5) \cdot (1/5) \cdot (4/5) \cdot (3/5) \cdot (5/14) = 0.0205714$$

80% chance

+

YES

$$(2/9) \cdot (3/9) \cdot (3/9) \cdot (3/9) \cdot (9/14) = 0.0052910$$

20% chance

=

$$0.0258624$$

0.0205714

0.0052910

0.0258624

~80%

~20%

NAIVE BAYES CLASSIFIER

OUTLOOK		TEMP.		HUMIDITY		WINDY		
RAINY		HOT		HIGH		TRUE		
NO	YES	NO	YES	NO	YES	NO	YES	NO
3/5	2/9	2/5	2/9	4/5	3/9	1/5	7/9	(0/5)•(1/5)•(4/5)•(3/5)•(5/14) = 0
<hr/>		<hr/>		<hr/>		<hr/>		0% chance
OVERCAST		MILD		NORMAL		FALSE		
NO	YES	NO	YES	NO	YES	NO	YES	YES
0/5	4/9	2/5	4/9	1/5	6/9	3/5	3/9	(4/9)•(3/9)•(3/9)•(3/9)•(9/14) = 0.010582
<hr/>		<hr/>		<hr/>		<hr/>		100% chance
SUNNY		COOL						
NO	YES	NO	YES					
2/5	3/9	1/5	3/9					

NO
 $(0/5) \cdot (1/5) \cdot (4/5) \cdot (3/5) \cdot (5/14) = 0$
0% chance

YES
 $(4/9) \cdot (3/9) \cdot (3/9) \cdot (3/9) \cdot (9/14) = 0.010582$
100% chance

MICRO EXERCISE 2:

NAIVE BAYES

MICRO EXERCISE 2: NAIVE BAYES

- Lets do math!

ME2: NAIVE BAYES

OUTLOOK	TEMP.	HUMIDITY	WINDY
RAINY	HOT	HIGH	TRUE
NO YES 3/5 2/9	NO YES 2/5 2/9	NO YES 4/5 3/9	NO YES 1/5 7/9
OVERCAST	MILD	NORMAL	FALSE
NO YES 0/5 4/9	NO YES 2/5 4/9	NO YES 1/5 6/9	NO YES 3/5 3/9
SUNNY	COOL		
NO YES 2/5 3/9	NO YES 1/5 3/9		

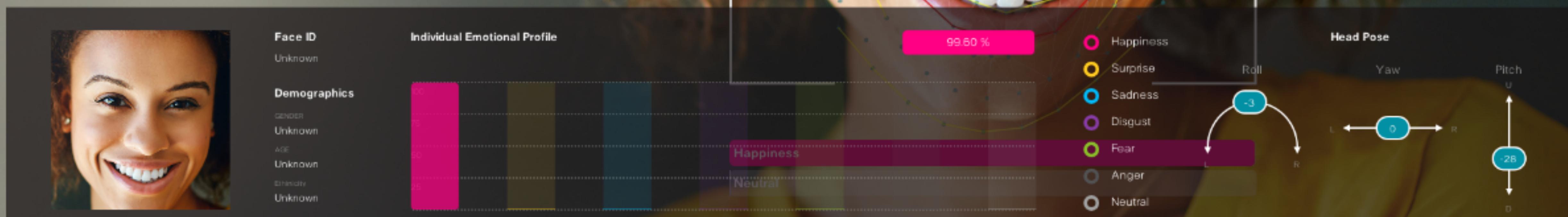
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BREAK

MACHINE LEARNING AS DESIGN MATERIAL

MACHINE LEARNING AS DESIGN MATERIAL



MACHINE LEARNING AS DESIGN MATERIAL

Object and Scene Detection

Rekognition identifies thousands of objects such as vehicles, pets, or furniture, and provides a confidence score.

Rekognition also detects scenes within an image, such as a sunset or beach. This makes it easy for you to add features that search, filter, and curate large image libraries.



MACHINE LEARNING AS DESIGN MATERIAL



Search

CONSOLE



Why Google

Products

Solutions

Launcher

Pricing

Customers

Documentation

Support

Partners

TRY IT FREE

CONTACT SALES

CLOUD SPEECH API

Speech to text conversion powered by machine learning



TRY IT FREE

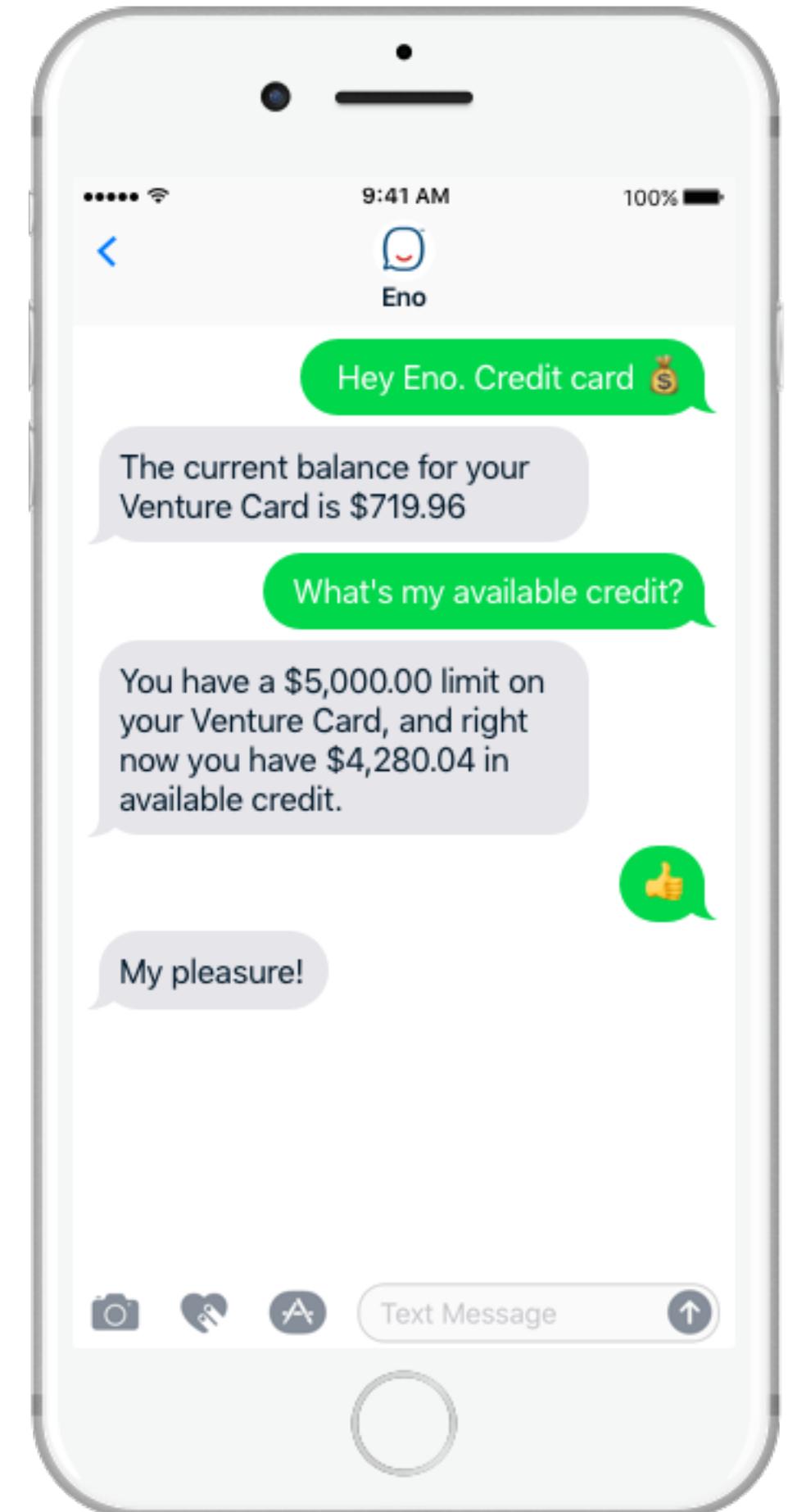
VIEW DOCUMENTATION

Powerful Speech Recognition

Google Cloud Speech API enables developers to **convert audio to text** by applying **powerful neural network models** in an easy to use API. The API **recognizes over 80 languages and variants**, to support your global user base. You can transcribe the text of users dictating to an application's microphone, enable command-and-control through voice, or transcribe audio files, among many other use cases. **Recognize audio uploaded in the request**, and integrate with your audio storage on Google Cloud Storage, by using the same technology Google uses to power its own products.



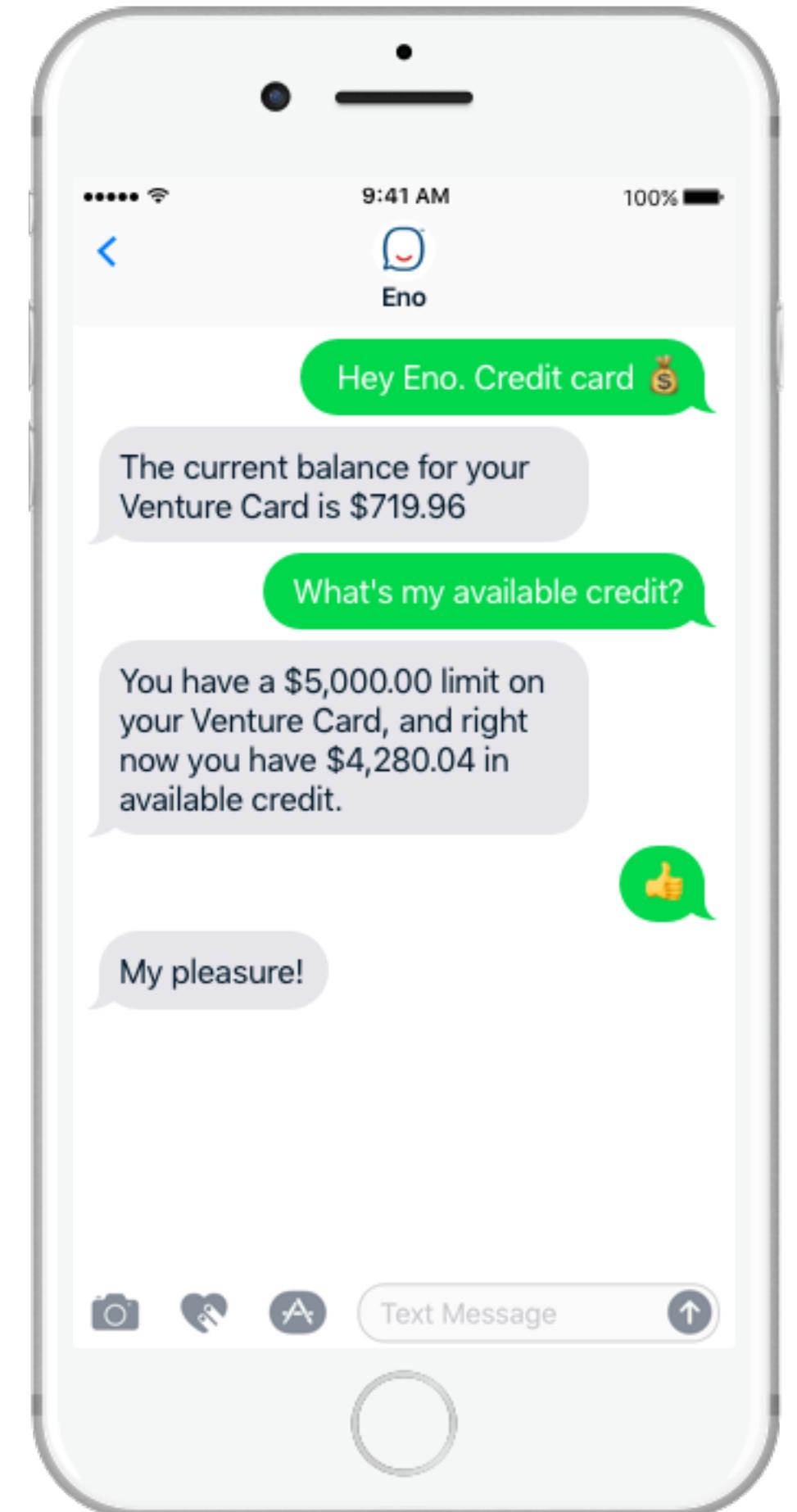
MACHINE LEARNING AS DESIGN MATERIAL



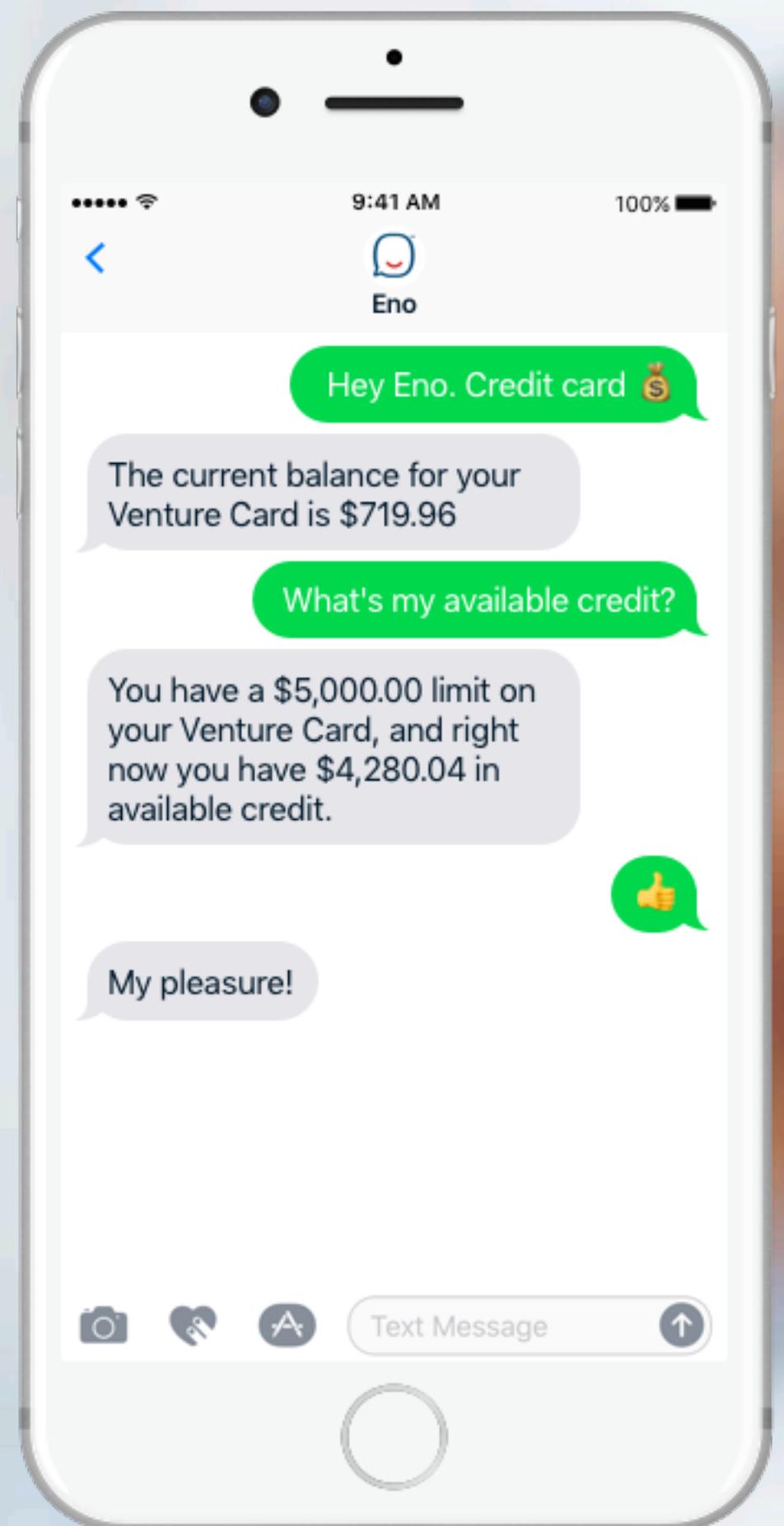
MACHINE LEARNING AS DESIGN MATERIAL



MACHINE LEARNING AS DESIGN MATERIAL



MACHINE LEARNING AS DESIGN MATERIAL



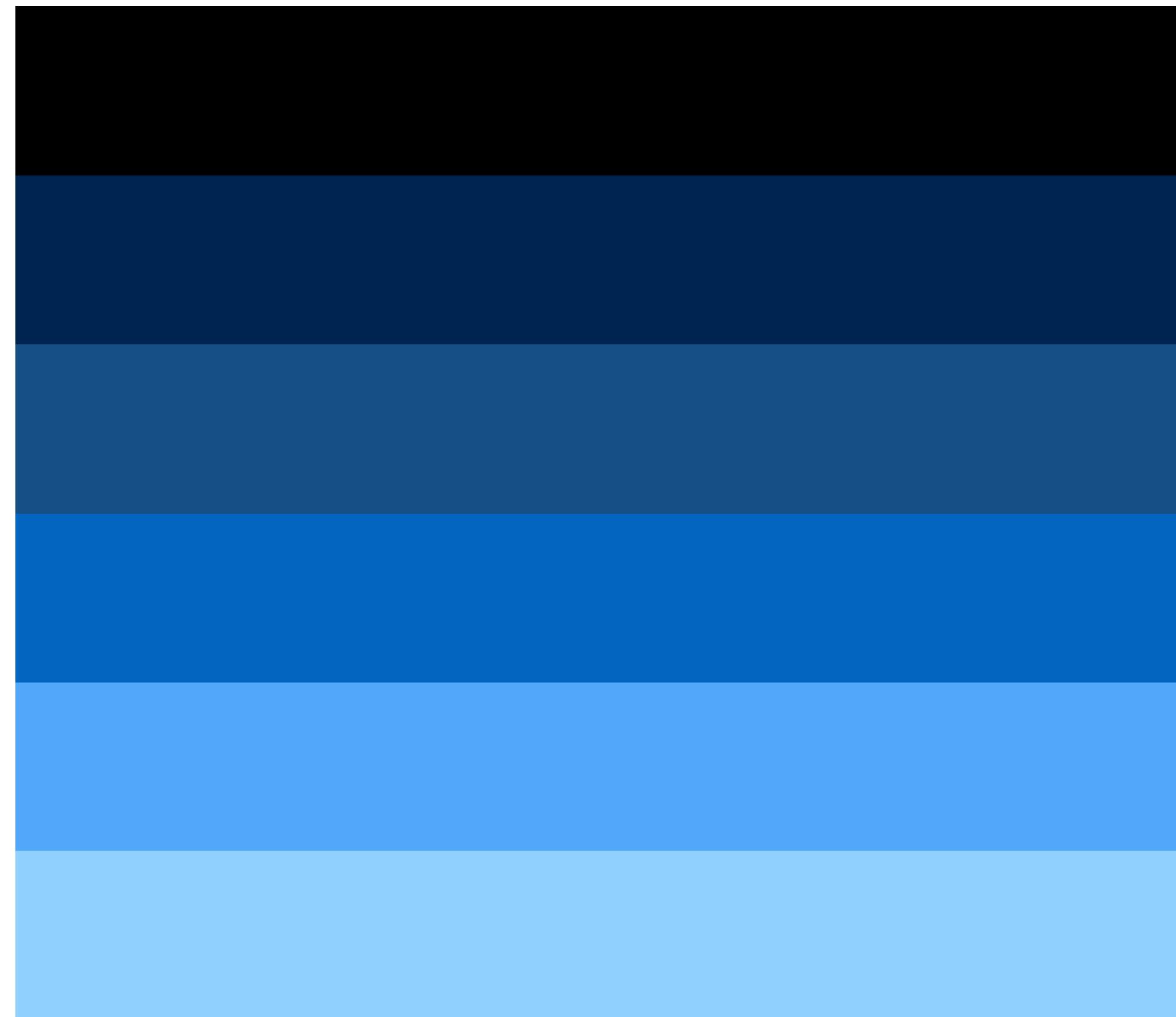
MACHINE LEARNING AS DESIGN ARCHITECTURE

“The fantasies of an intelligent and responsive physical environment are too easily limited by **the gap between the technology of making things and the science of understanding them**, I strongly believe that it is very important to play with these ideas scientifically and explore applications of machine intelligence that totter between being **unimaginably oppressive and unbelievably exciting**.”

- Nicholas Negroponte, 1957

MACHINE LEARNING AS DESIGN ARCHITECTURE

INPUT VARIABLES



TARGET VARIABLE

8 hours of sleep

7.5 hours of sleep

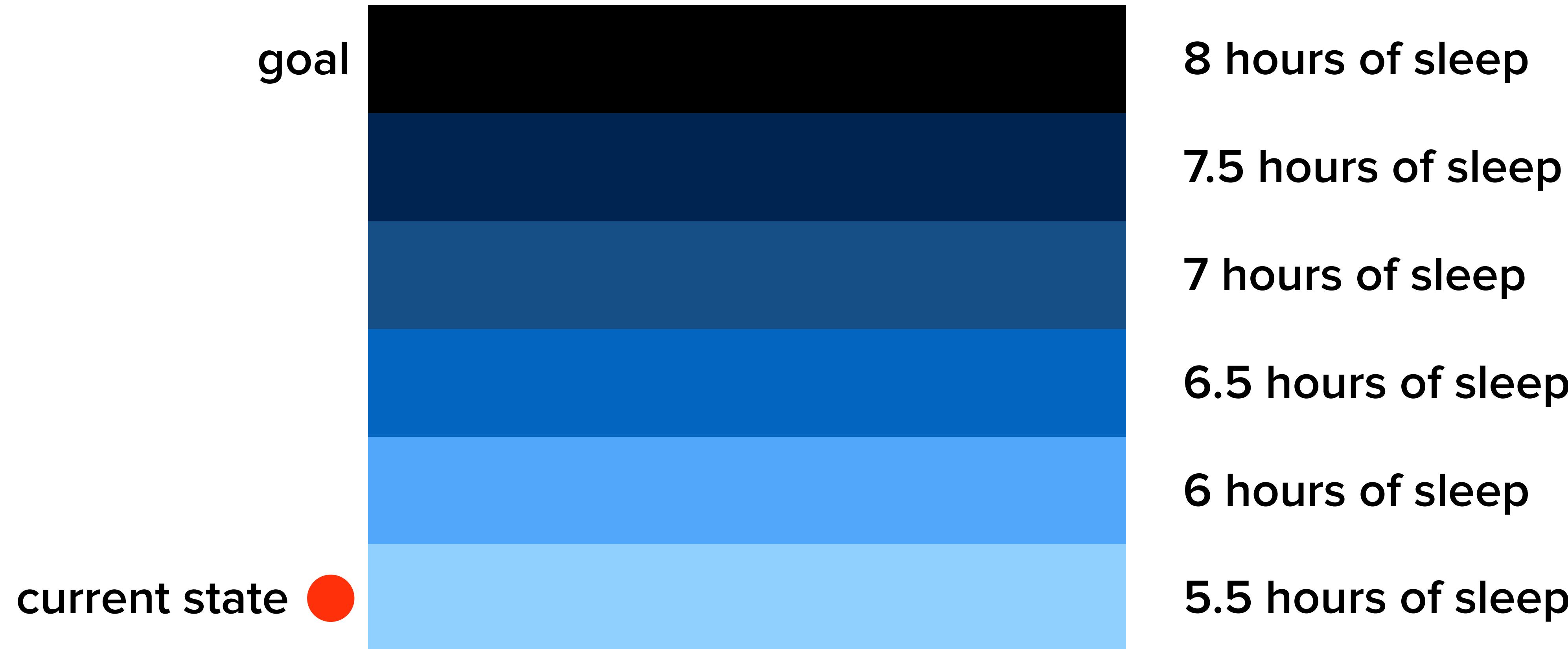
7 hours of sleep

6.5 hours of sleep

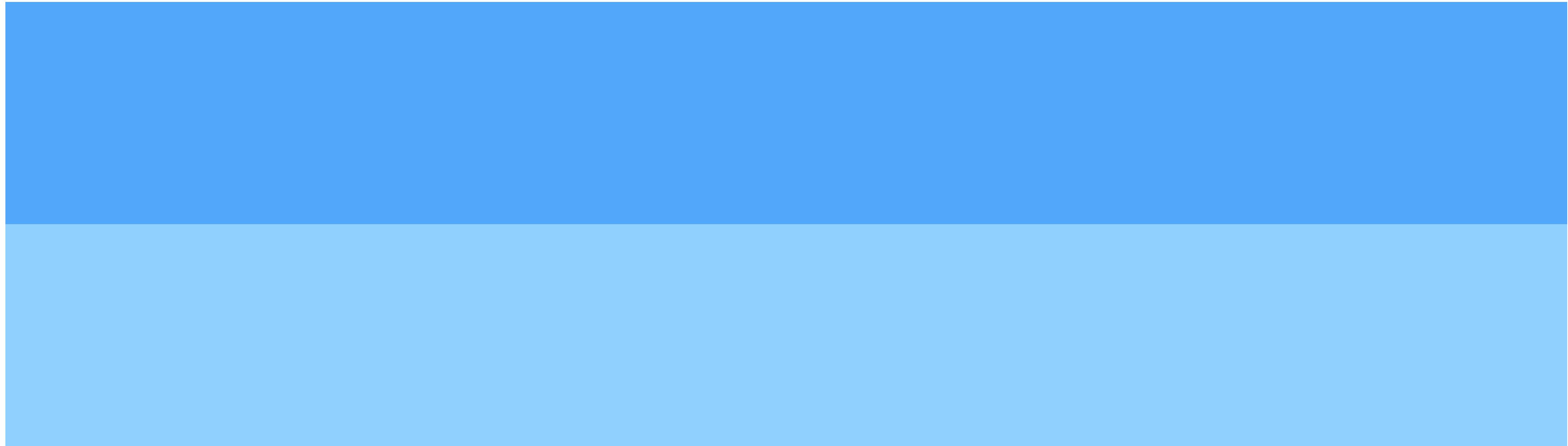
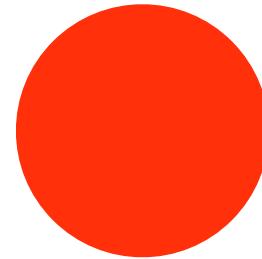
6 hours of sleep

5.5 hours of sleep

MACHINE LEARNING AS DESIGN ARCHITECTURE



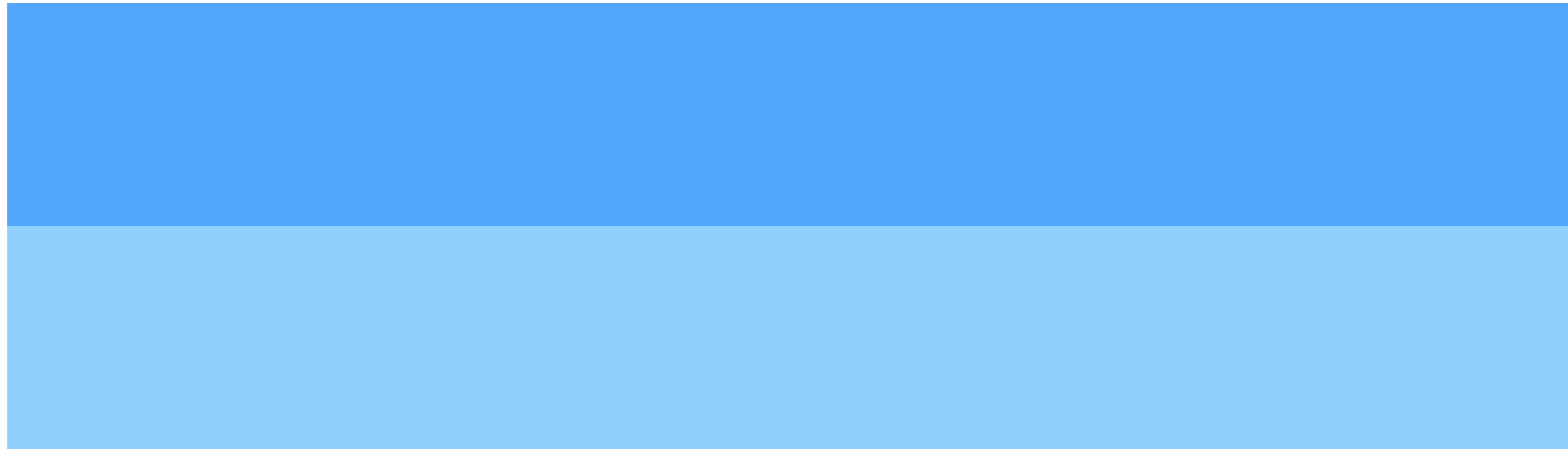
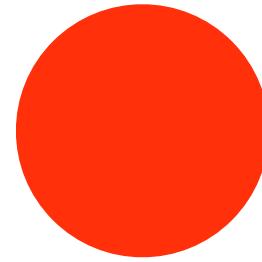
MACHINE LEARNING AS DESIGN ARCHITECTURE



6

5.5

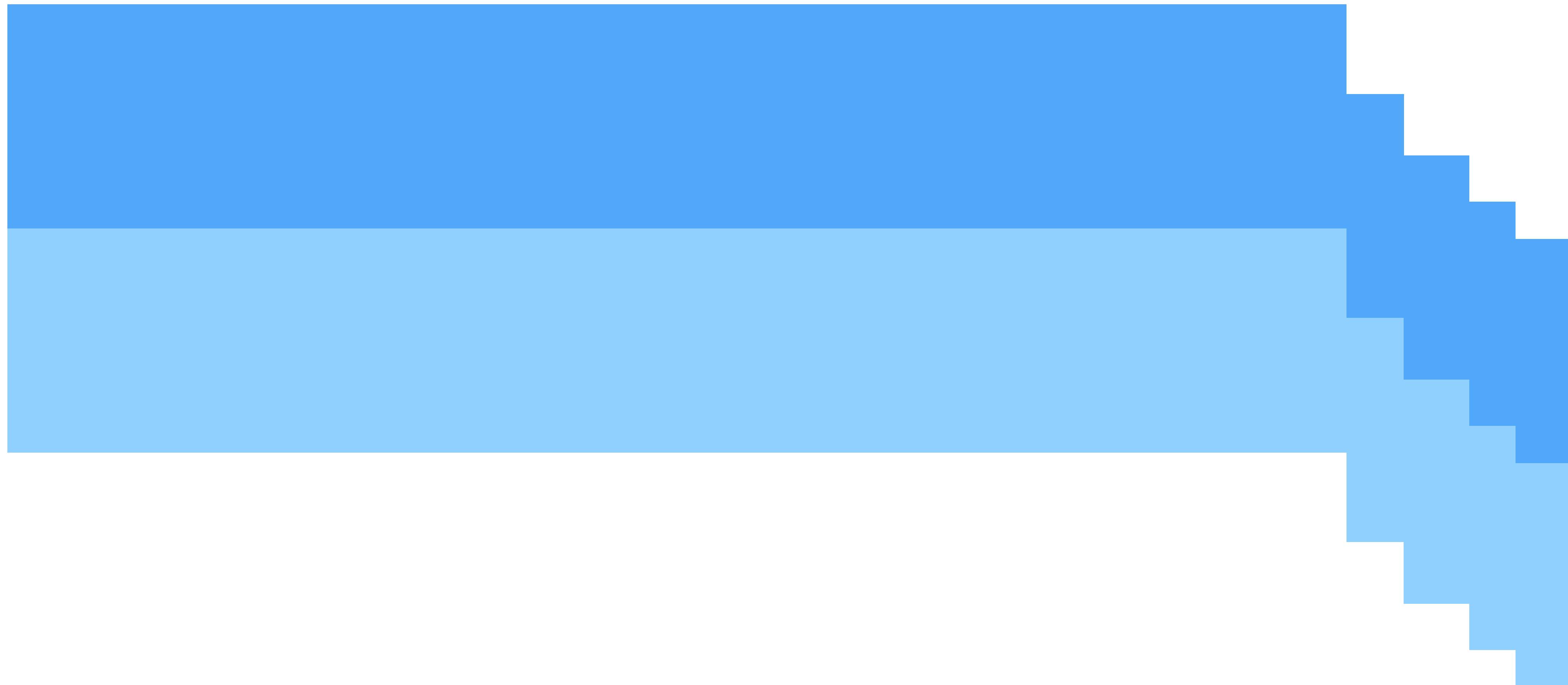
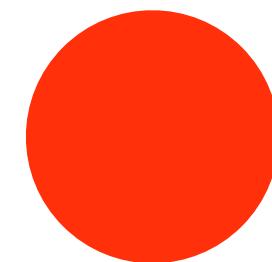
MACHINE LEARNING AS DESIGN ARCHITECTURE



6

5.5

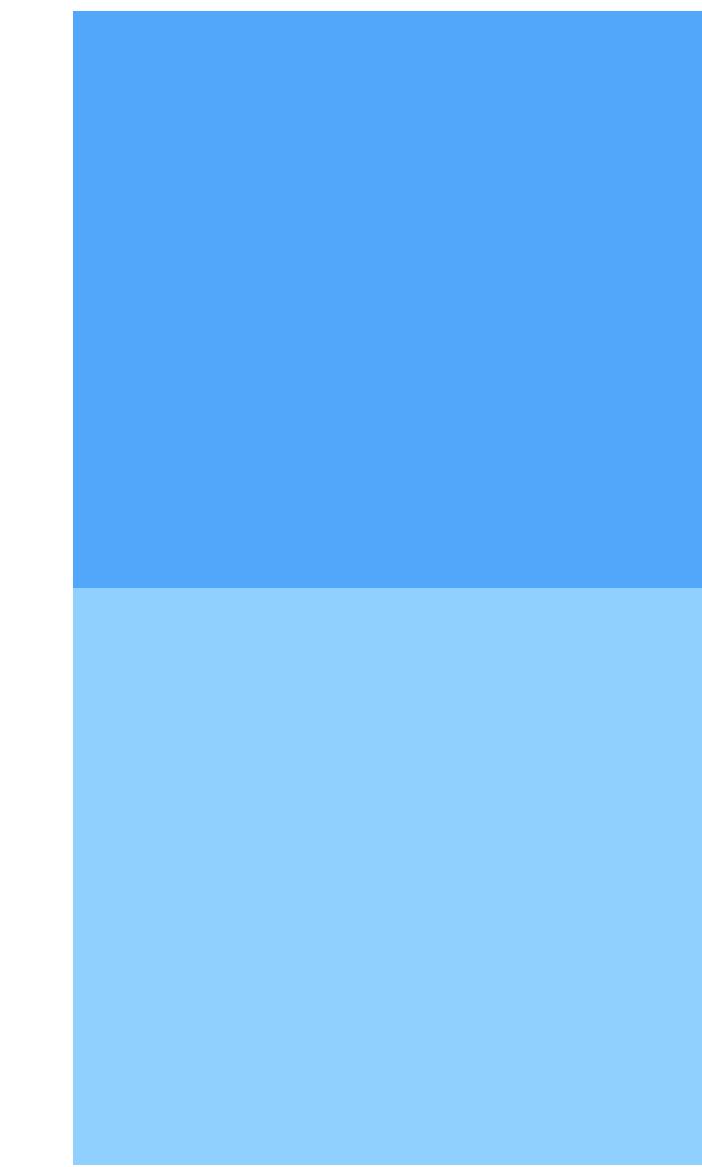
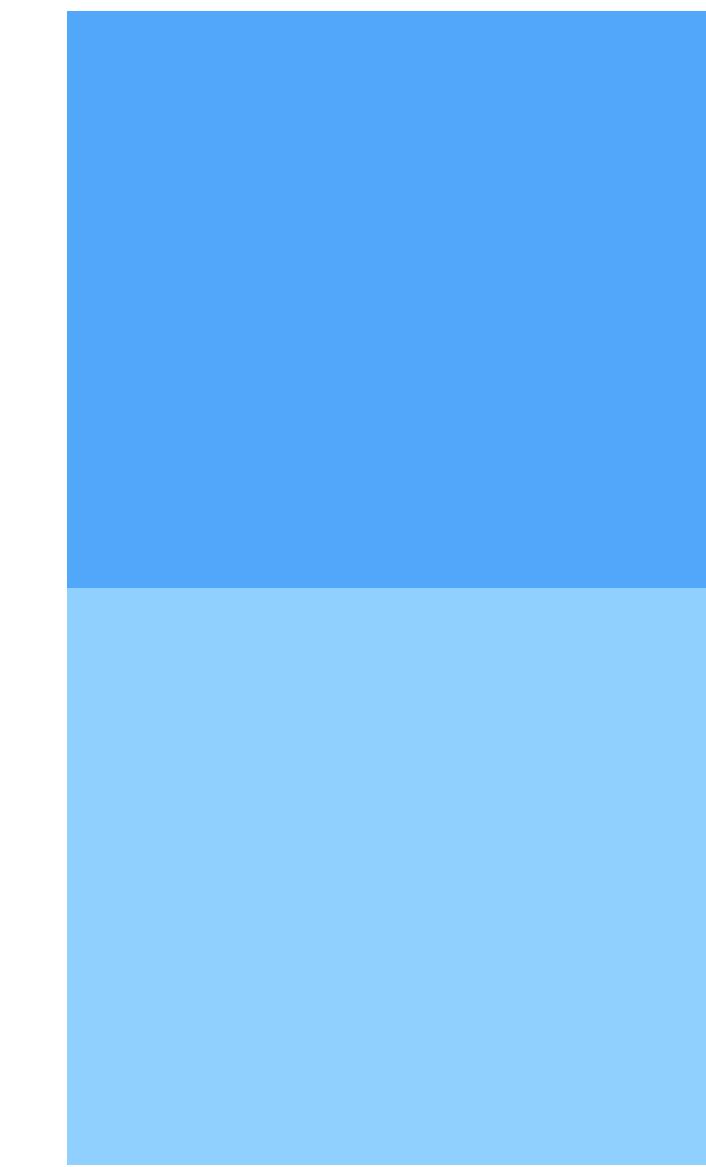
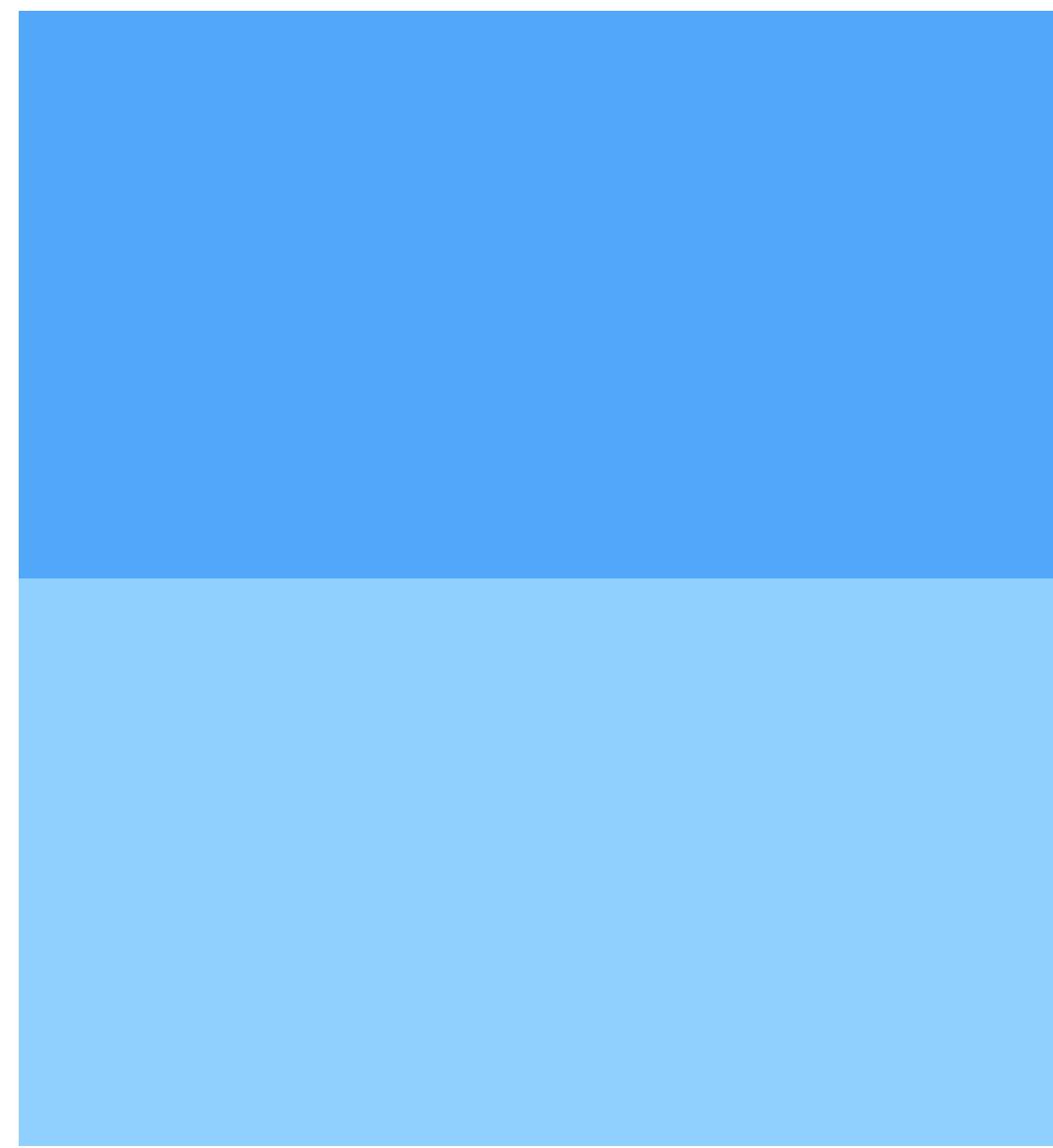
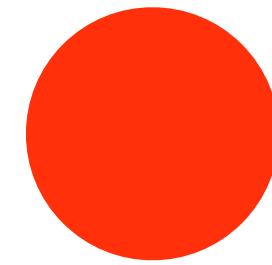
MACHINE LEARNING AS DESIGN ARCHITECTURE



6

5.5

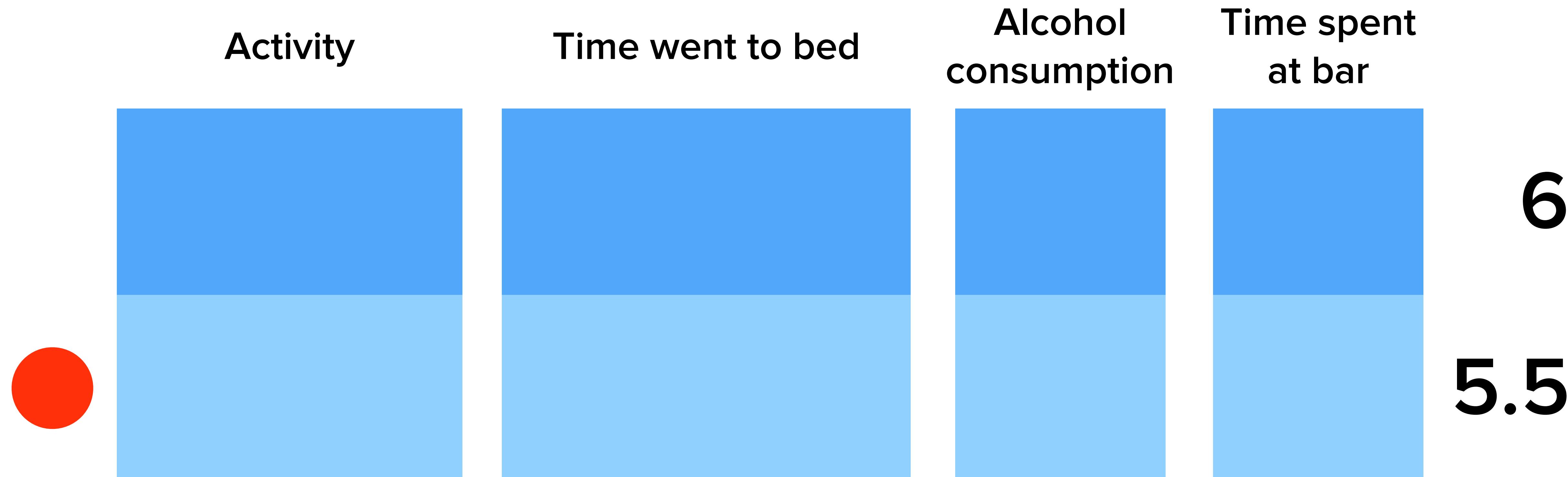
MACHINE LEARNING AS DESIGN ARCHITECTURE



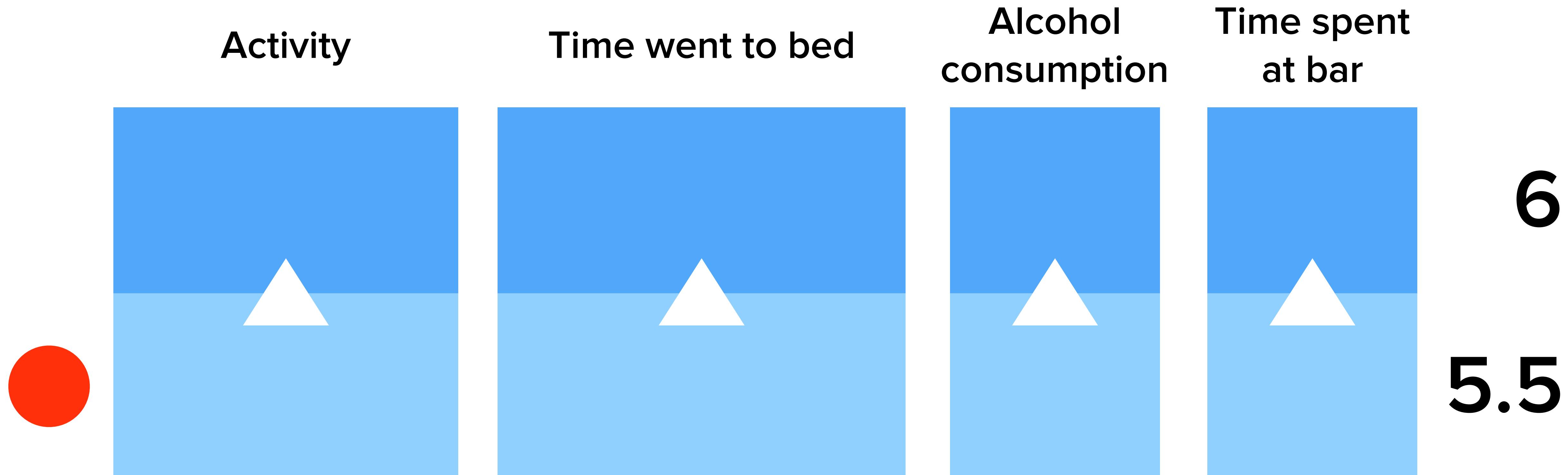
6

5.5

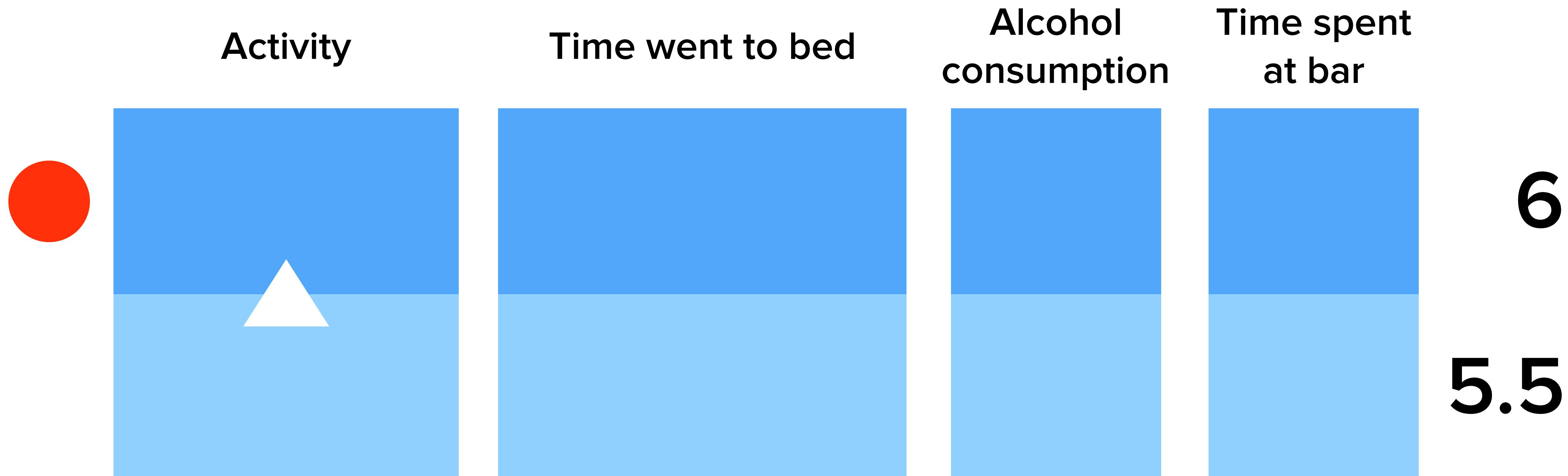
MACHINE LEARNING AS DESIGN ARCHITECTURE



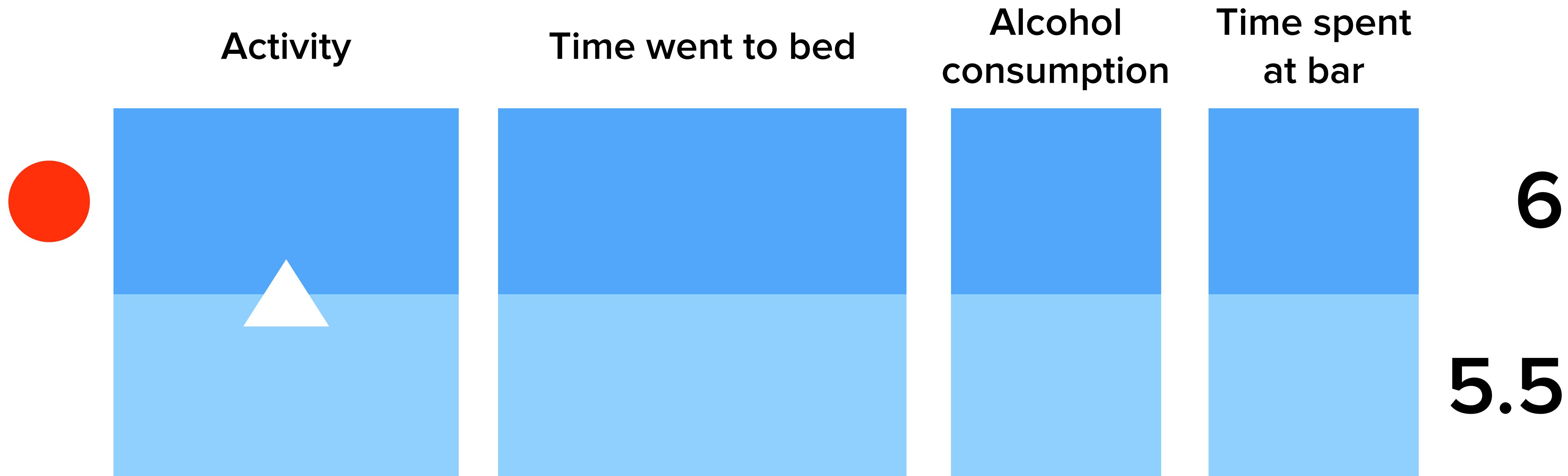
MACHINE LEARNING AS DESIGN ARCHITECTURE



MACHINE LEARNING AS DESIGN ARCHITECTURE



MACHINE LEARNING AS DESIGN ARCHITECTURE



MACHINE LEARNING AS DESIGN ARCHITECTURE

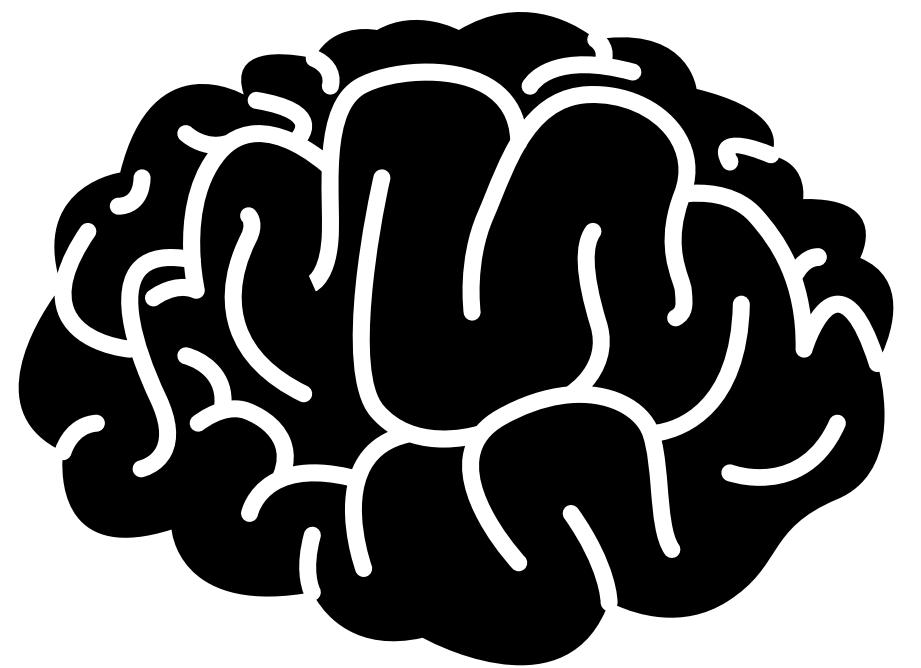
“The shape of the ML-mediated future seems to have been mostly driven by data availability and learner performance rather than a deliberate user-centered vision.”

- Qian Yang CMU HCI Institute

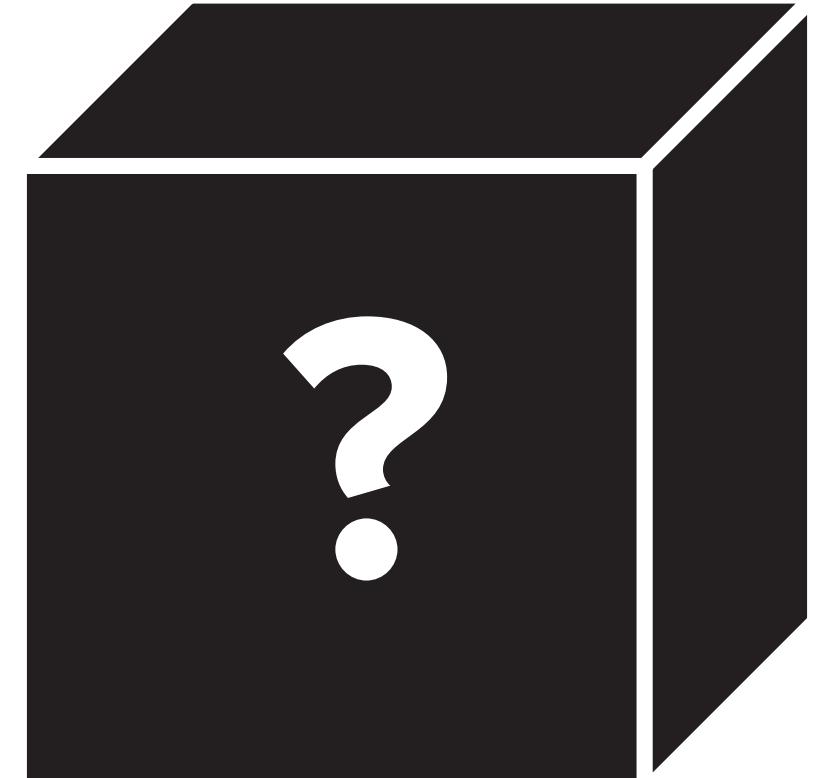
MACHINE LEARNING AS DESIGN ARCHITECTURE



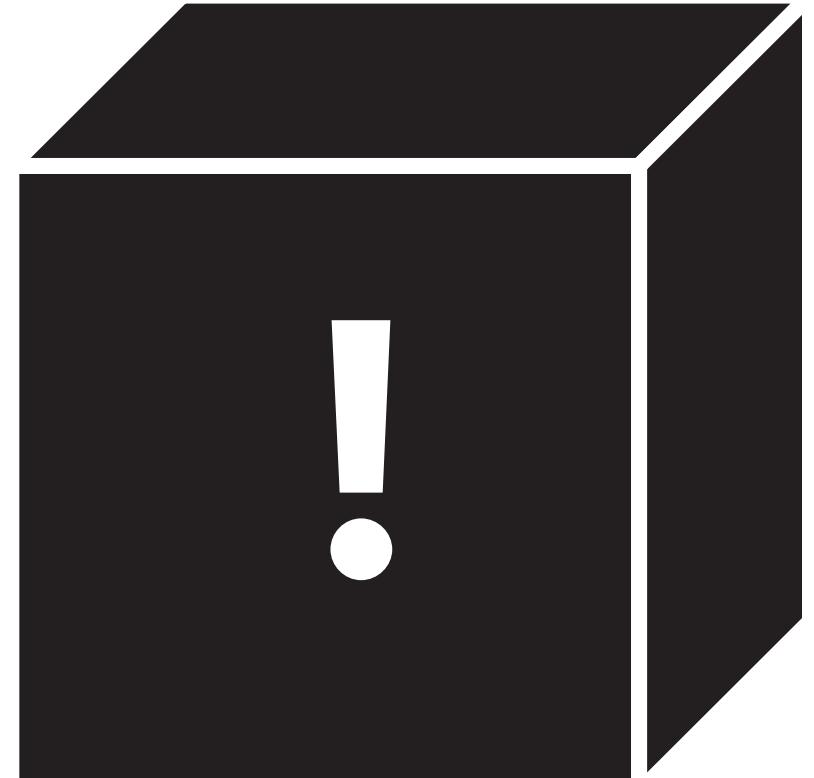
Decide what
data is useful



Train the model



Test the model

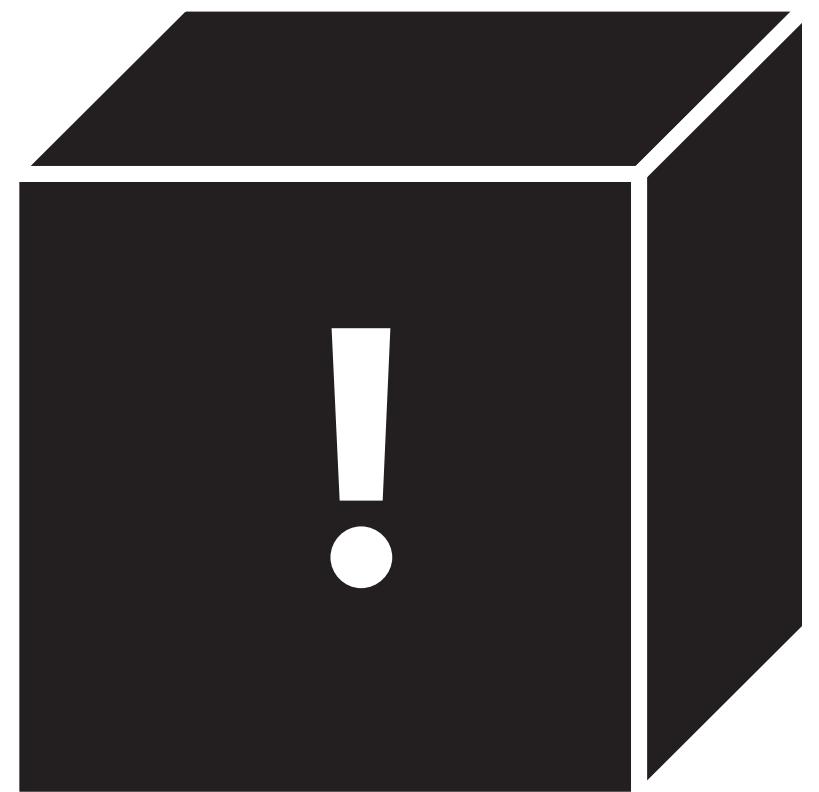


Deploy the model!

MACHINE LEARNING AS DESIGN ARCHITECTURE



Decide what
data is useful



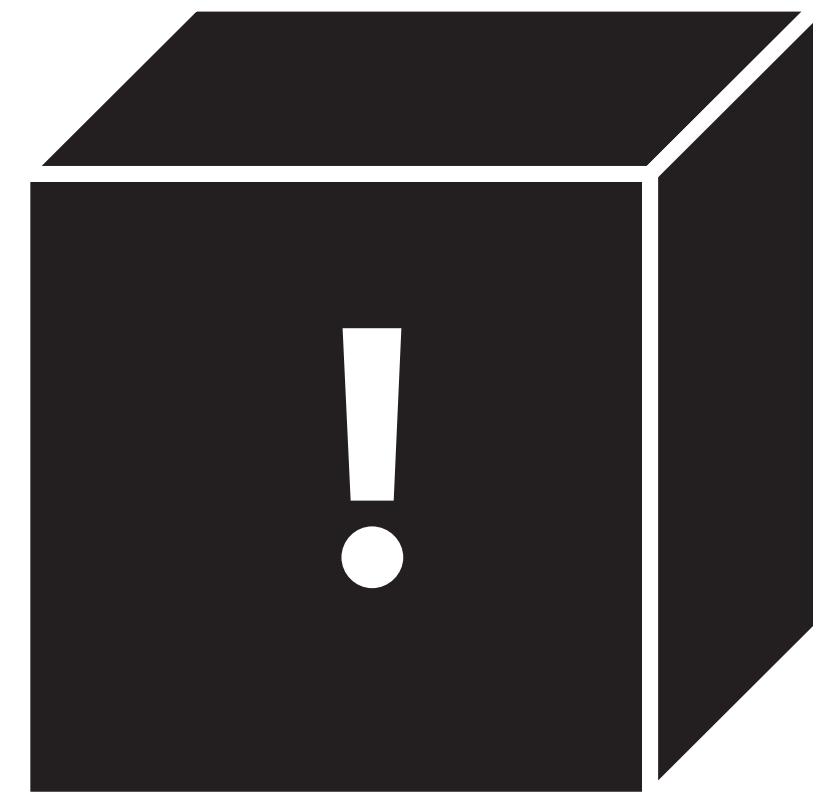
Deploy the model!

MACHINE LEARNING AS DESIGN ARCHITECTURE



Decide what
data is useful

**THIS IS A
HUMAN
PROCESS**



Deploy the model!

MACHINE LEARNING AS DESIGN ARCHITECTURE



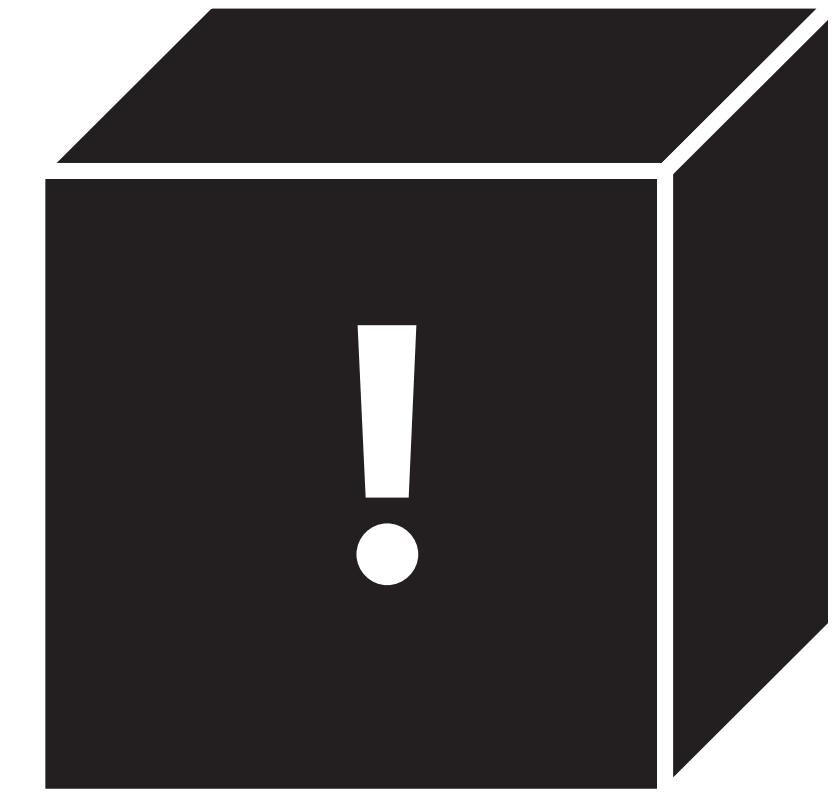
Decide what
data is useful

MACHINE LEARNING AS DESIGN ARCHITECTURE



Decide what
data is useful ... for what

MACHINE LEARNING AS DESIGN ARCHITECTURE

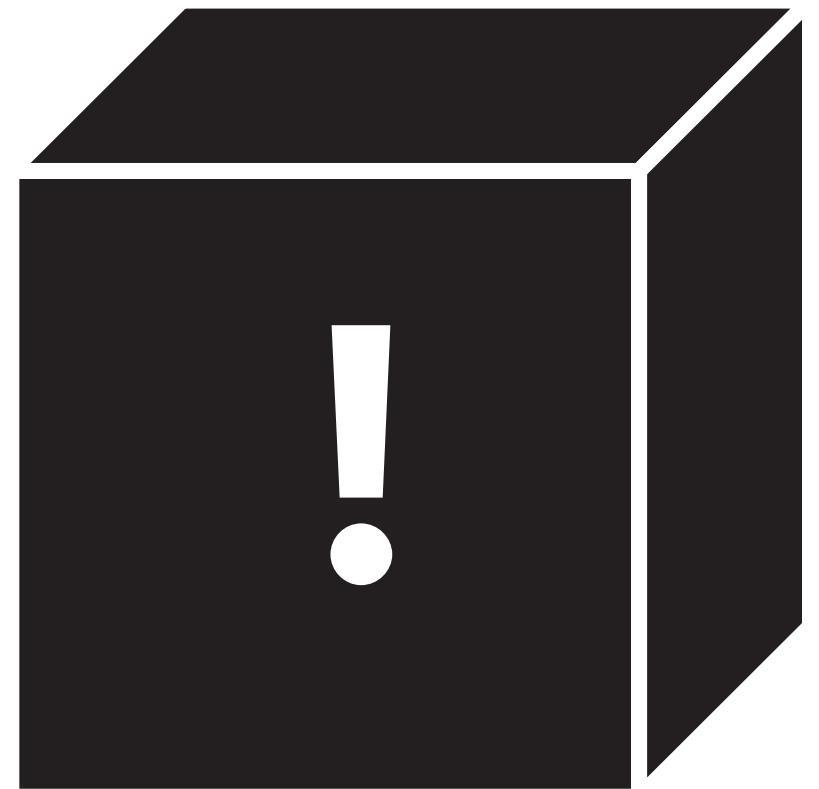


Deploy the model!

MACHINE LEARNING AS DESIGN ARCHITECTURE



Decide what
data is useful ... for what

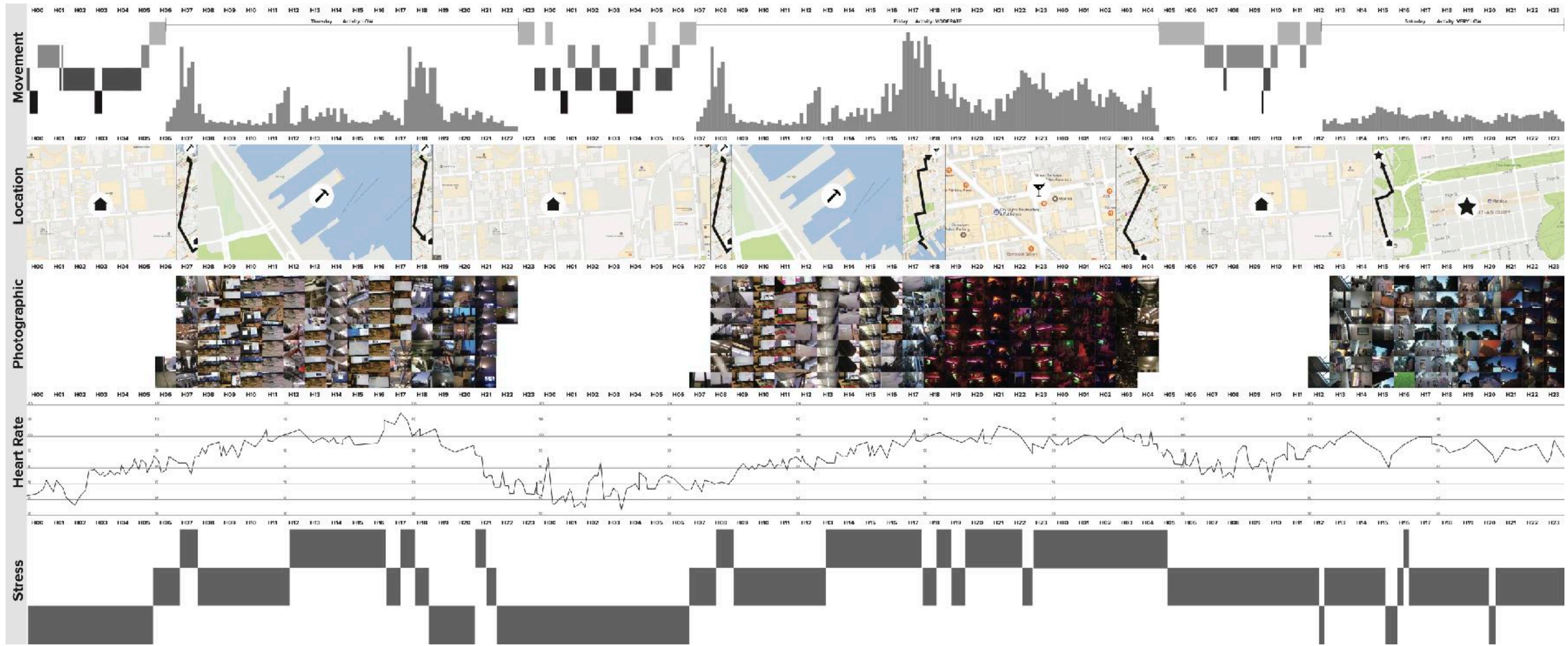


Deploy the model!

EXERCISE 1:

TELLING STORIES FROM DATA

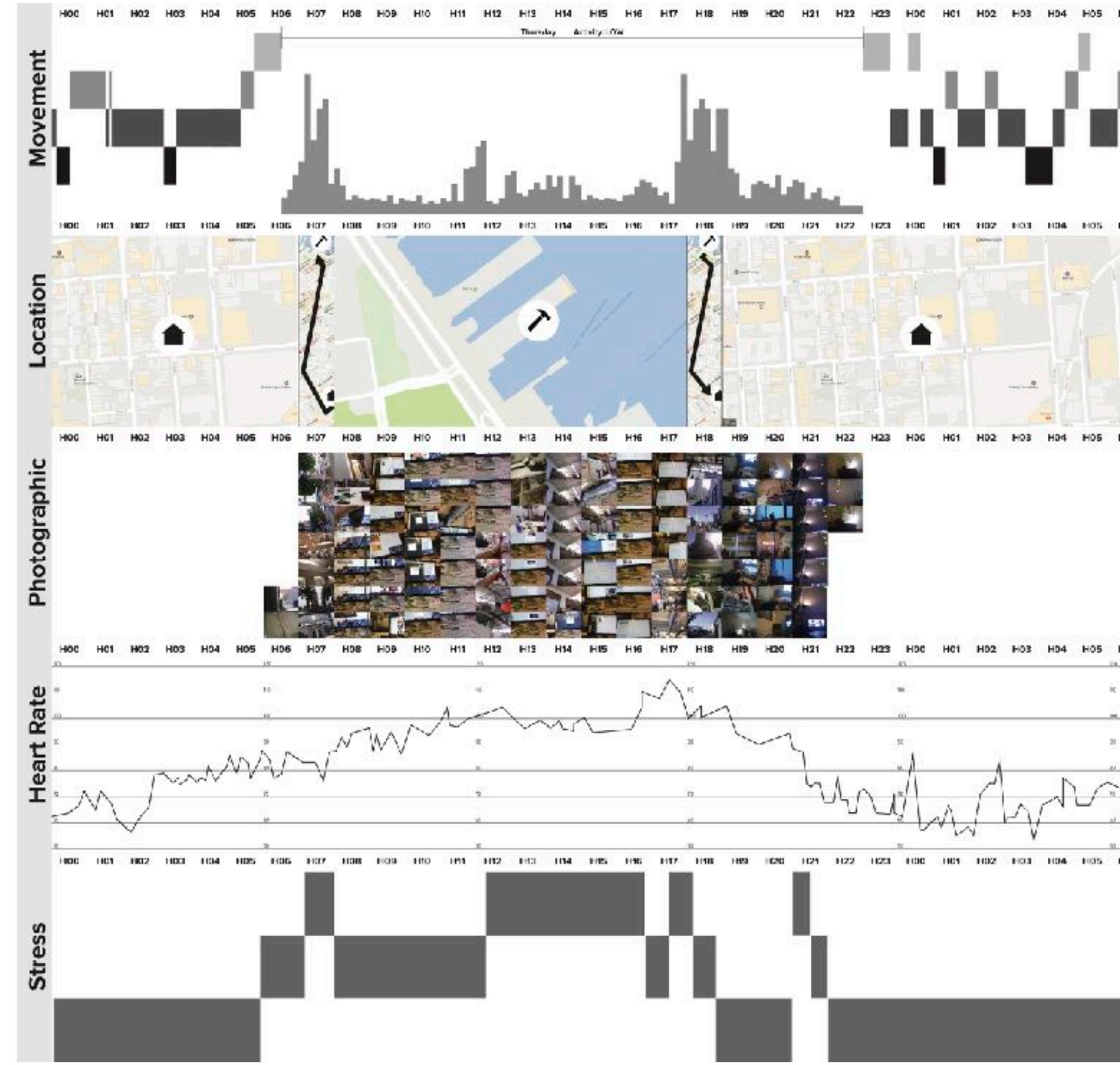
EXERCISE 1: TELLING STORIES FROM DATA



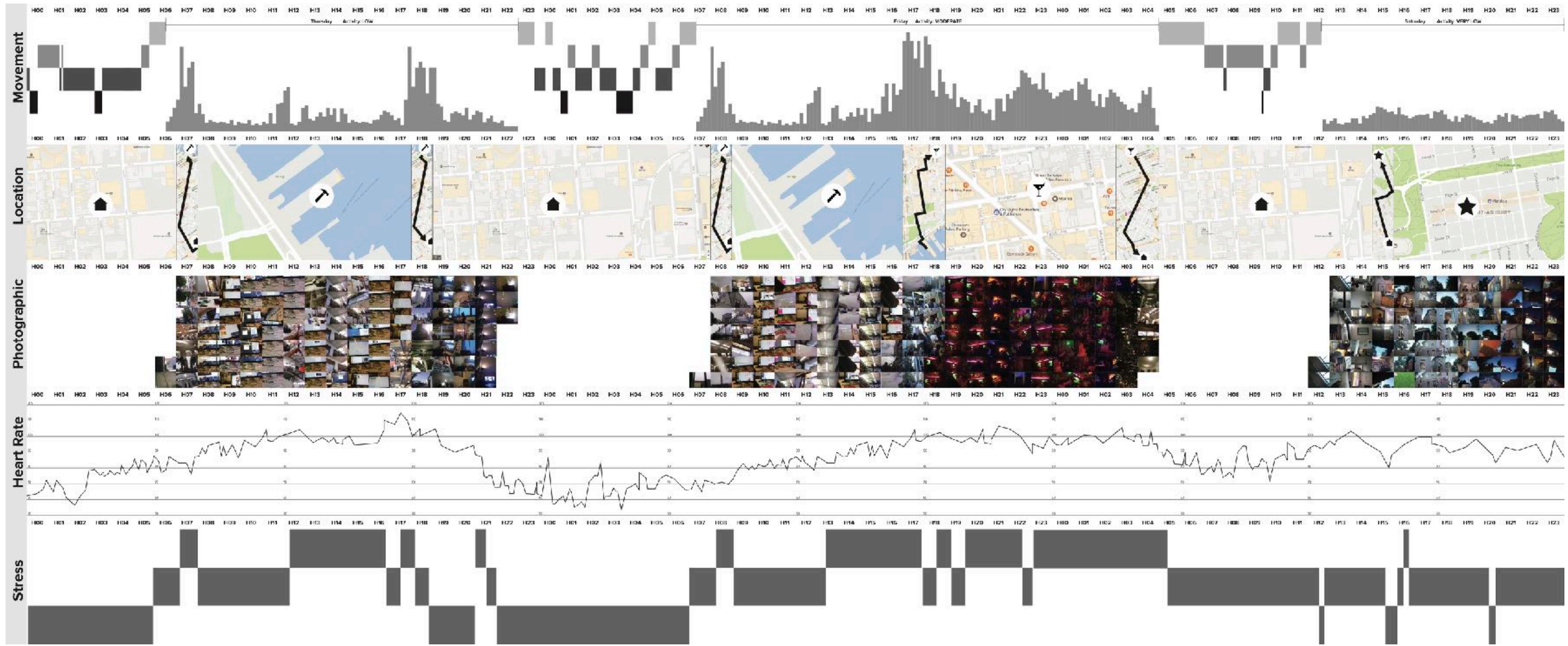
EXERCISE 1: TELLING STORIES FROM DATA

- Take post-it notes and mark what is happening
- A Thursday, Friday, and Saturday
- Assume that this data is repetitive

20 minutes



EXERCISE 1: TELLING STORIES FROM DATA



PROCESS

PROCESS / IDEATION

PROCESS / IDEATION

PROCESS / IDEATION

- What are the goals?
- What are the input variables?
- What is the target variable?

PROCESS / IDEATION

- What are the goals?
- What are the input variables?
- What is the target variable?
- What output are you expecting?

PROCESS / IDEATION

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- What are the input variables?
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- What output are you expecting?

PROCESS / IDEATION

- What are the goals?
- What are the input variables?
- What is the target variable?
- What output are you expecting?

MICRO EXERCISE 3: CONCEPTING

MICRO EXERCISE 3: IDEATION

- What's your goal?
- What's your target variable?
- What are your input variables?
- what are your expected outputs?

ME3: IDEATION

GOAL

TARGET VARIABLE

INPUT VARIABLES

EXPECTED OUTPUTS

PROCESS / DIALOG

PROCESS / DIALOG

“... the center of design becomes the system and it’s outcomes.
Design moves towards building emergent ecologies”

- Philip Van Allen, ArtCenter College of Design

USER INPUT

EXPLICIT FEEDBACK

- Goal setting
- Preferences
- Answering questions
- Manual Adjustments to their model

PROCESS / DIALOG

Action & Platform Games	X	American Football	X	Arts & Entertainment	X
Banking	X	Baseball	X	Basketball	X
Beauty & Fitness	X	Blues	X	Boating	X
Body Art	X	Books & Literature	X	Business & Industrial	X
Business News	X	Celebrities & Entertainment News	X	Classical Music	X
Computer & Video Games	X	Computers & Electronics	X	Condos & Townhomes	X
Cooking & Recipes	X	Country Music	X	Coupons & Discount Offers	X
Cycling	X	Dance & Electronic Music	X	Driving & Racing Games	X
Education	X	Enterprise Technology	X	Fashion & Style	X
Finance	X	Fitness	X	Folk & Traditional Music	X
Food & Drink	X	Foreign Language Study	X	Game Systems & Consoles	X
Games	X	Graphic Design	X	History	X
Home & Garden	X	Home Improvement	X	Jazz	X
Laptops & Notebooks	X	Local News	X	Mac OS	X
Machine Learning & Artificial Intellig...	X	Mathematics	X	Men's Interests	X
Mobile & Wireless	X	Mobile Phones	X	Movies	X
Music & Audio	X	News	X	Online Communities	X

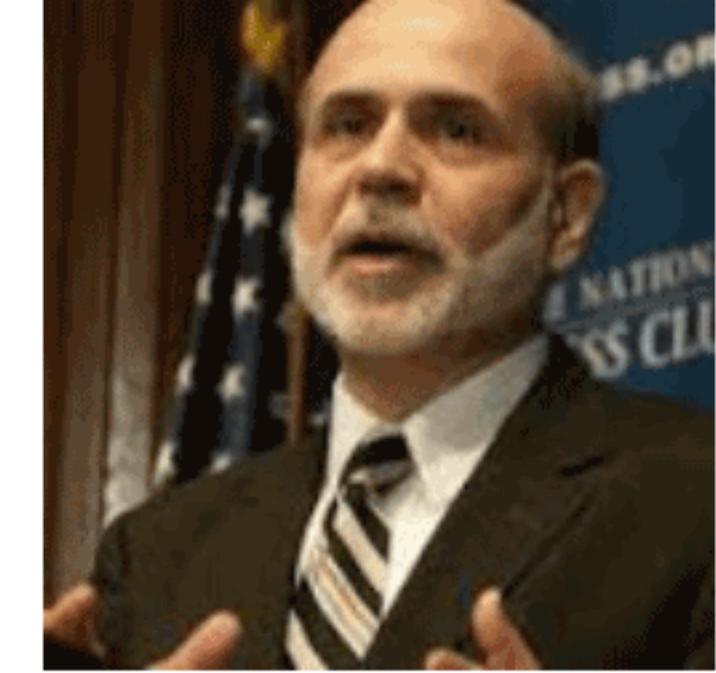


CoinDesk · 13 hours ago

⋮

Ben Bernanke: Bitcoin Has 'Serious Problems'

Former Federal Reserve chairman Ben Bernanke offered both muted praise and criticism when discussing bitcoin in a new...



Is this card useful right now?

NO

YES

USER INPUT

EXPLICIT FEEDBACK

- Goal setting
- Preferences
- Answering questions
- Manual Adjustments to their model

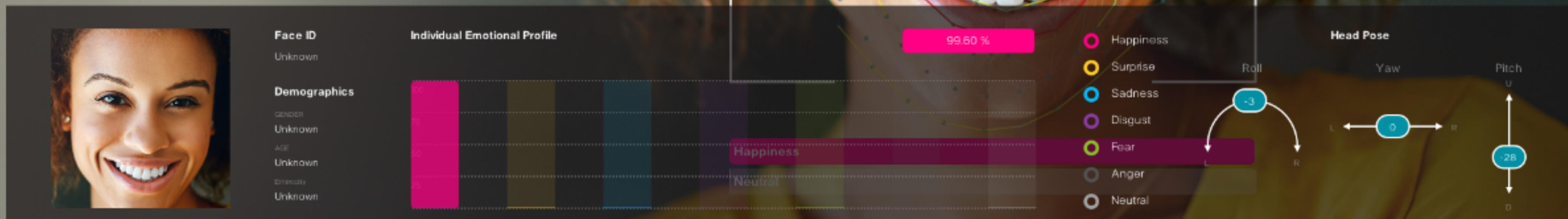
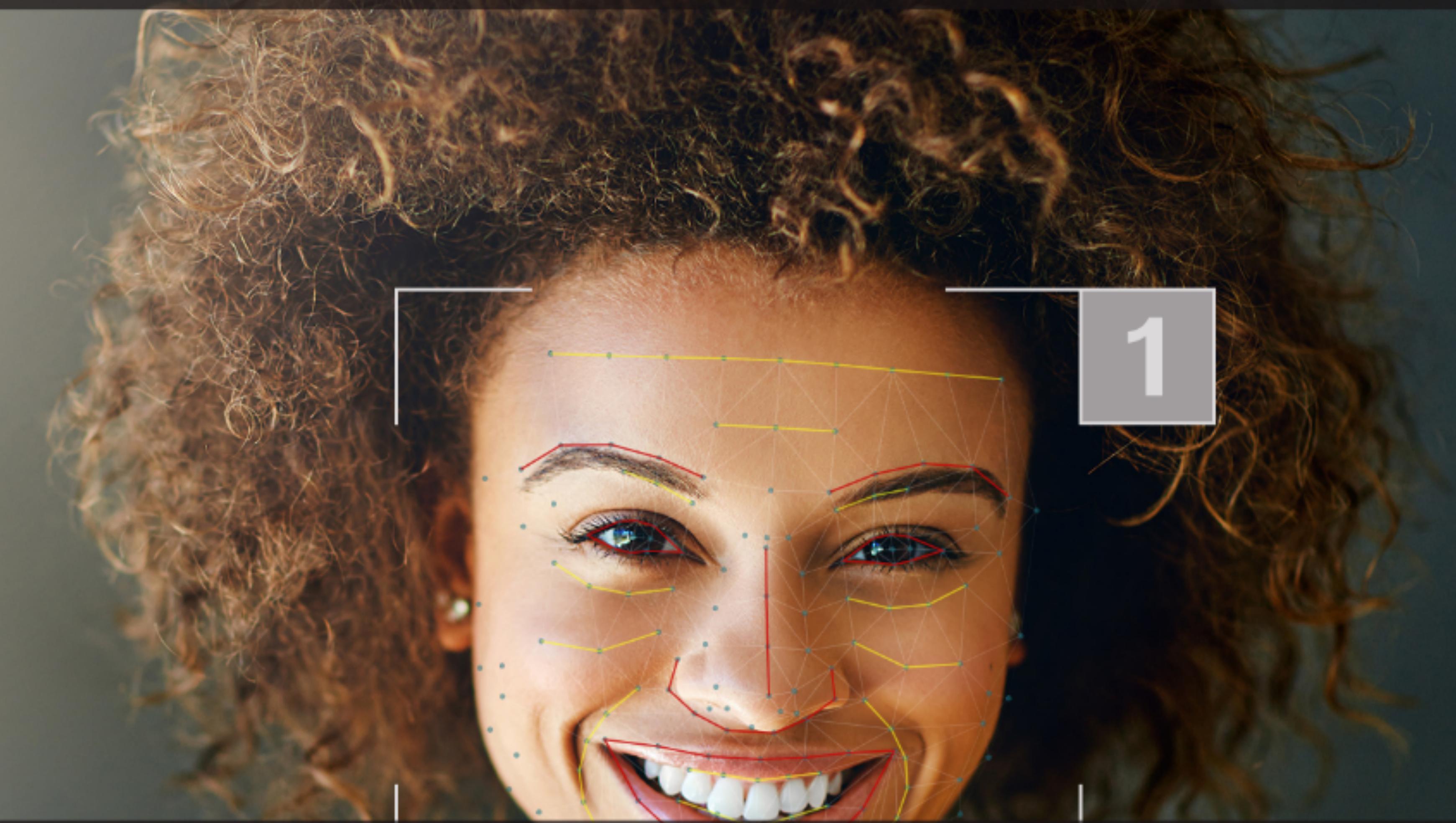
IMPLICIT FEEDBACK

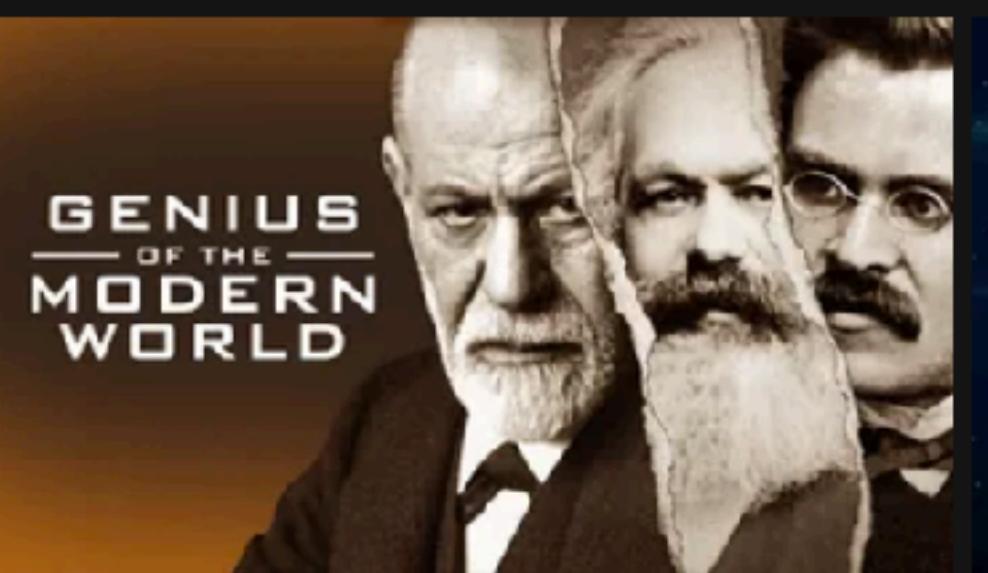
- Adjustments to behavior
- Changes in engagement

TRANSPARENCY

- Demonstrate the decision provenance in the structure of the dialog
- Say where you got the data
- Show a confidence score (classification)
- Show the next couple guesses (classification)
- Don't speak in absolutes

PROCESS / DIALOG





Trending Now



EU'S RIGHT TO EXPLANATION BILL

1. The data subject shall have the right not to be subject to a decision based solely on automated processing, including profiling, which produces legal effects concerning him or her or similarly significantly affects him or her.
2. Paragraph 1 shall not apply if the decision:
 - (a) is necessary for entering into, or performance of, a contract between the data subject and a data controller;
 - (b) is authorised by Union or Member State law to which the controller is subject and which also lays down suitable measures to safeguard the data subject's rights and freedoms and legitimate interests; or
 - (c) is based on the data subject's explicit consent.
3. In the cases referred to in points (a) and (c) of paragraph 2, the data controller shall implement suitable measures to safeguard the data subject's rights and freedoms and legitimate interests, at least the right to obtain human intervention on the part of the controller, to express his or her point of view and to contest the decision.
4. Decisions referred to in paragraph 2 shall not be based on special categories of personal data referred to in Article 9(1), unless point (a) or (g) of Article 9(2) applies and suitable measures to safeguard the data subject's

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DIALOG / PROTOTYPING



Browse ▾

DVD

NEW EPISODES

DIALOG / PROTOTYPING

Action & Adventure



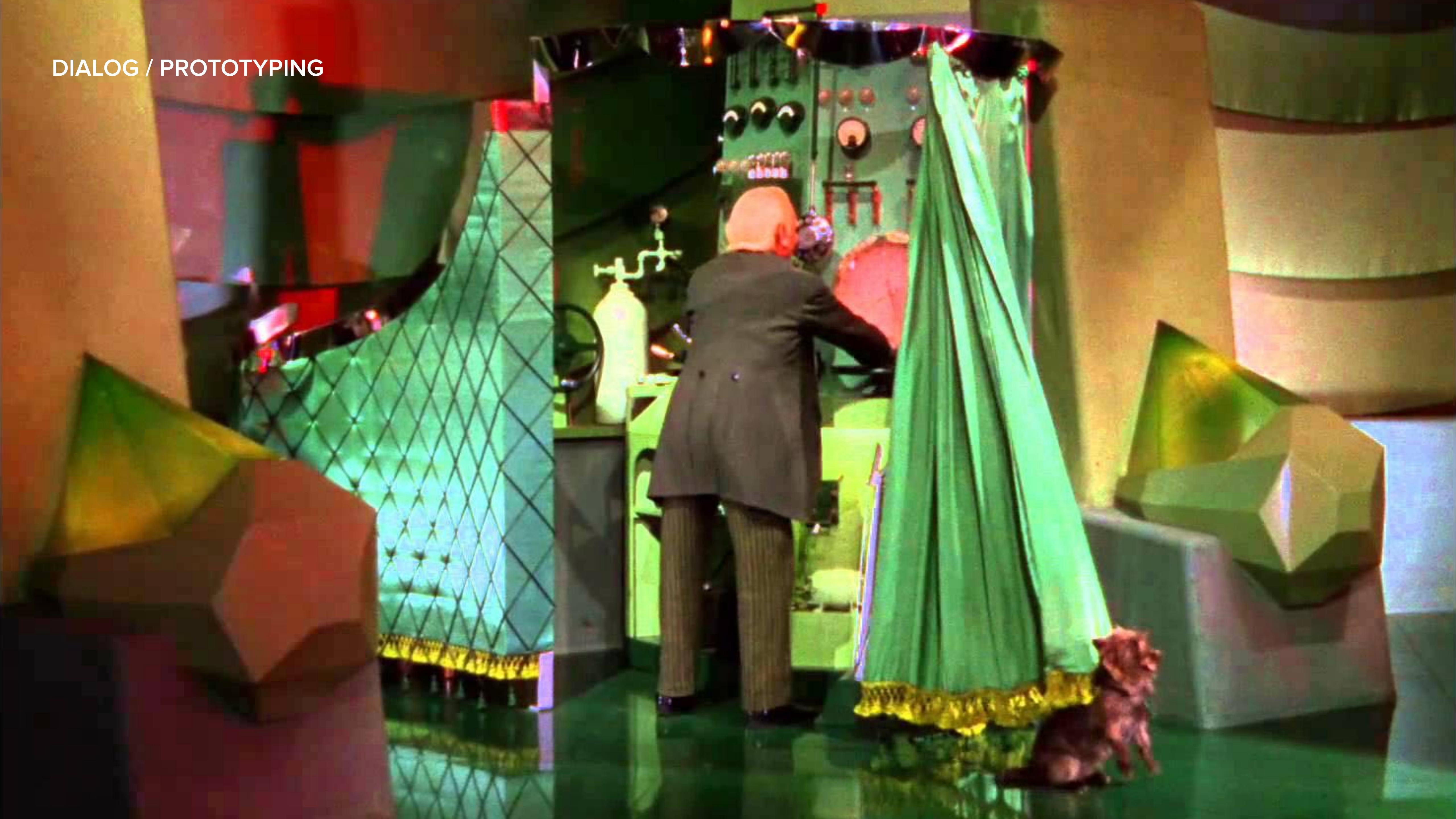
Inspiring Movies



Comedies



DIALOG / PROTOTYPING



DIALOG / ∞

BIAS

BIAS TYPES

- Input bias, in your source data
- Introduced bias, in your algorithm
- Learned bias, learned by your model

AWARENESS

- What is the system learning?
- What is it learning from?
- How is it using this knowledge in its decisions?

BIAS

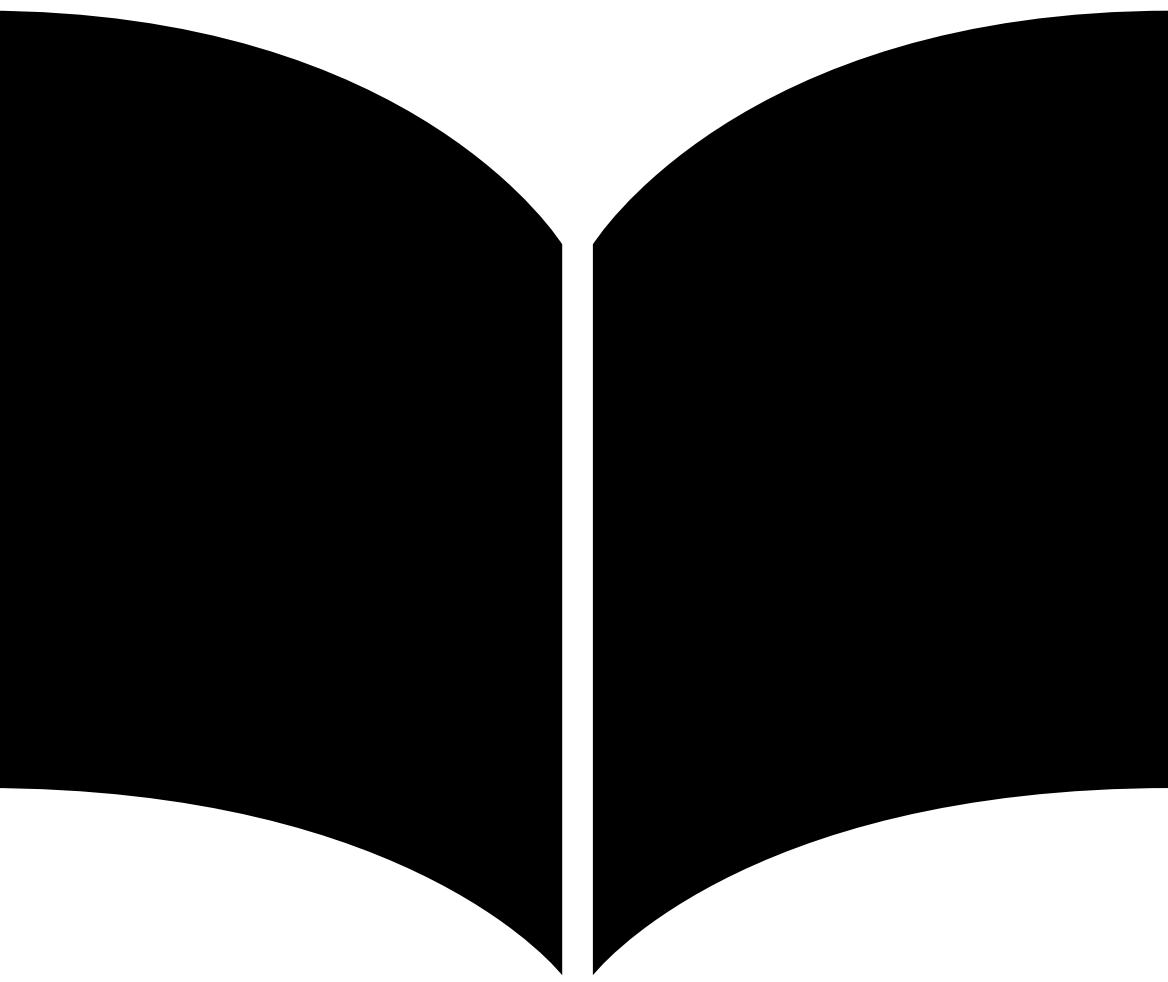
BIAS TYPES

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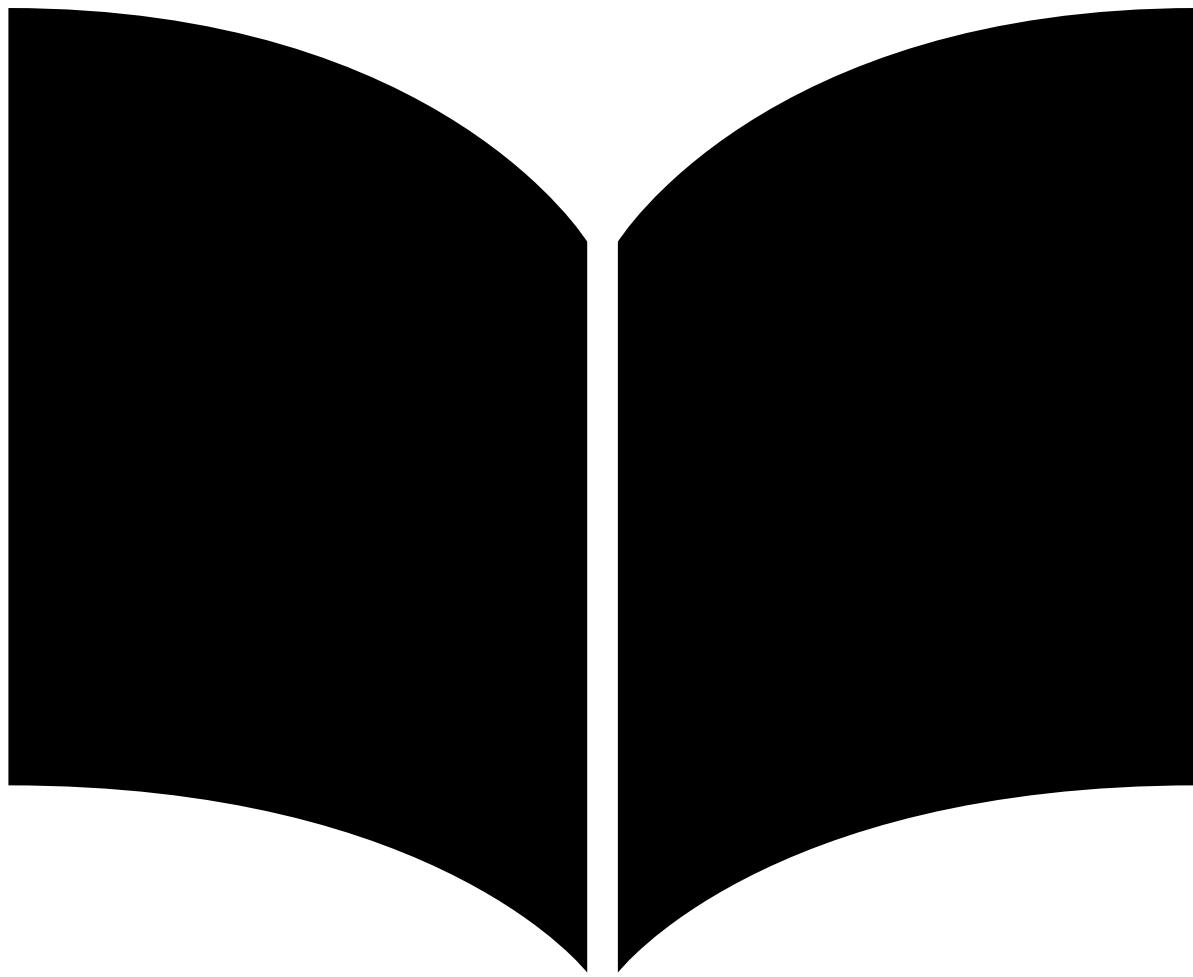
DIALOG / ∞



DIALOG / ∞



x 400



x 900



X 400

**Seniority
Role
Line of business**



X 400

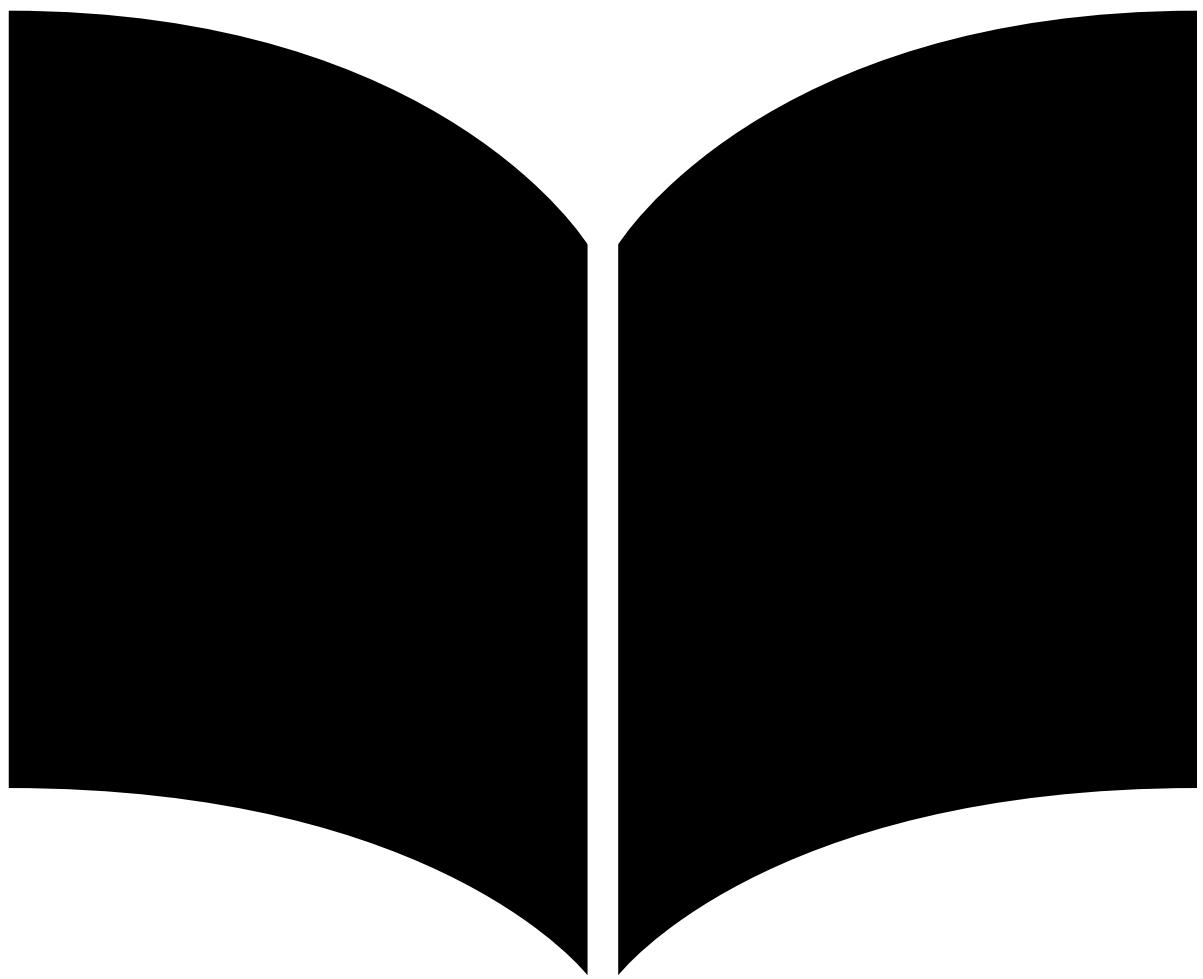
**Junior
Engineer
Manufacturing**

**Junior
Engineer
Manufacturing**

**VP
Sales
Manufacturing**

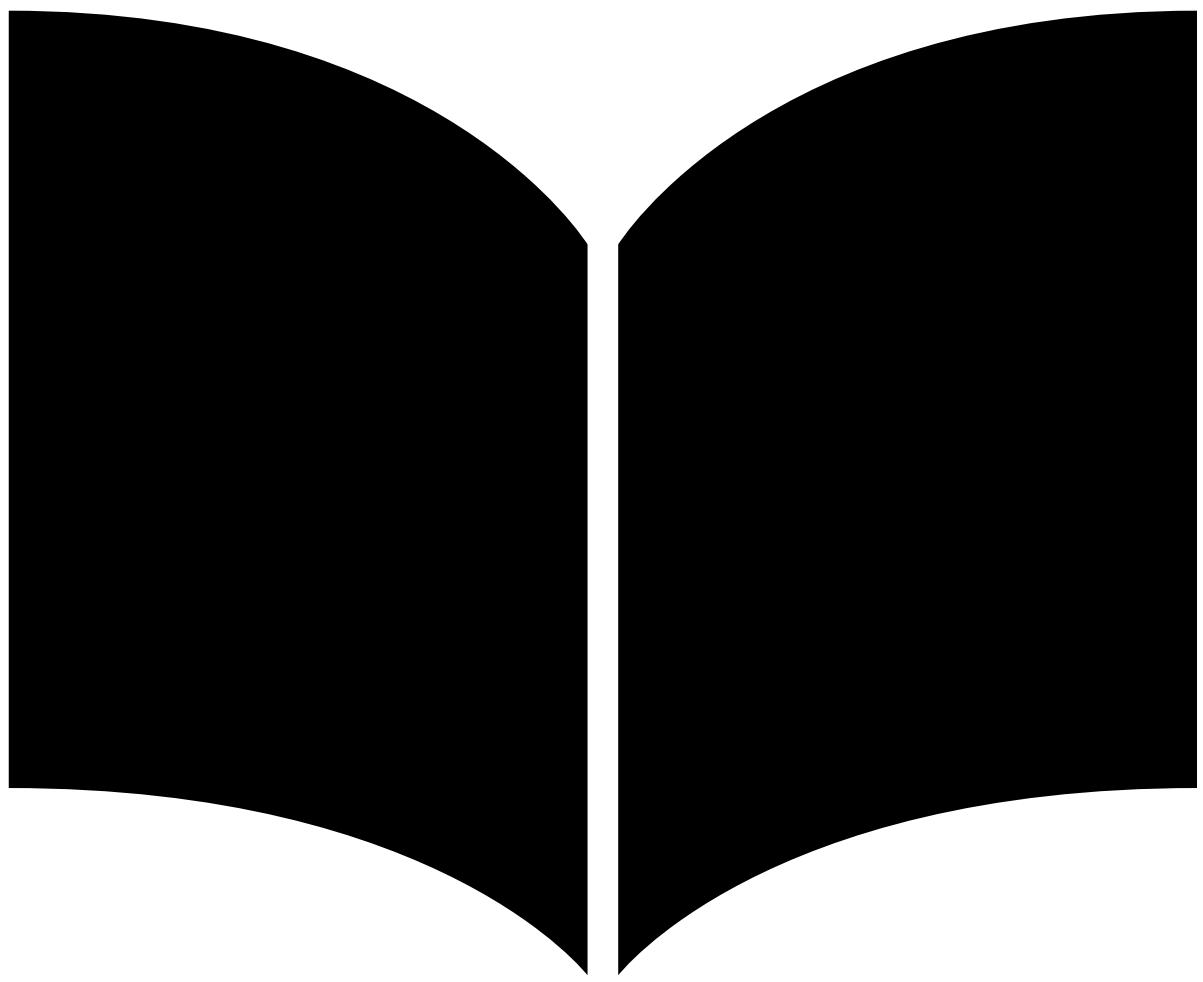
**Junior
Customer Service
Retail**

**Junior
Engineer
R&D**



Content #138

Junior	1
Engineer	1
Manufacturing	1
VP	0
Sales	0
Manufacturing	1
Junior	1
Customer Service	0
Retail	0
Junior	1
Engineer	1
R&D	0



Content #138

**Junior
Engineer
Manufacturing**

1
1
1

3

**VP
Sales
Manufacturing**

0
0
1

1

**Junior
Customer Service
Retail**

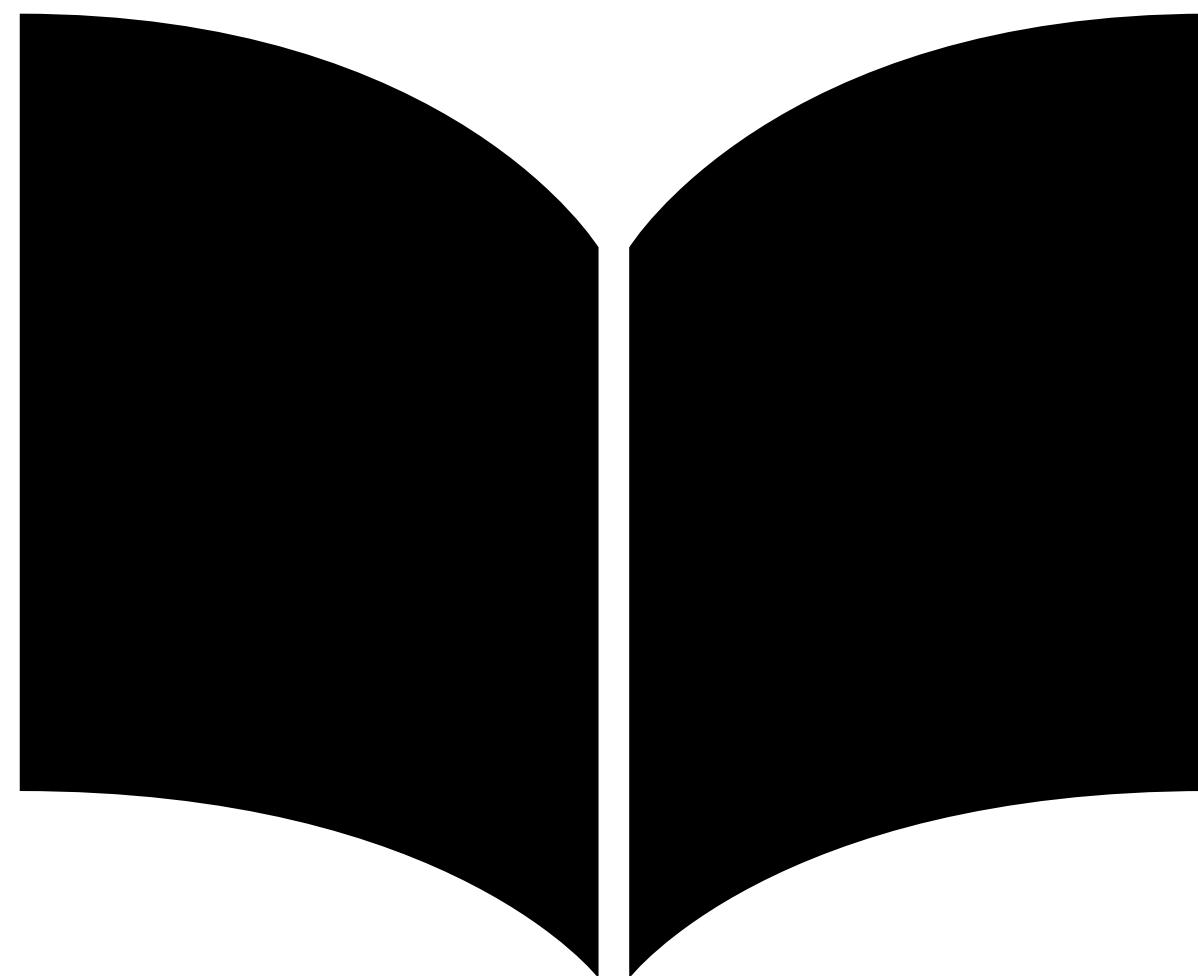
1
0
0

1

**Junior
Engineer
R&D**

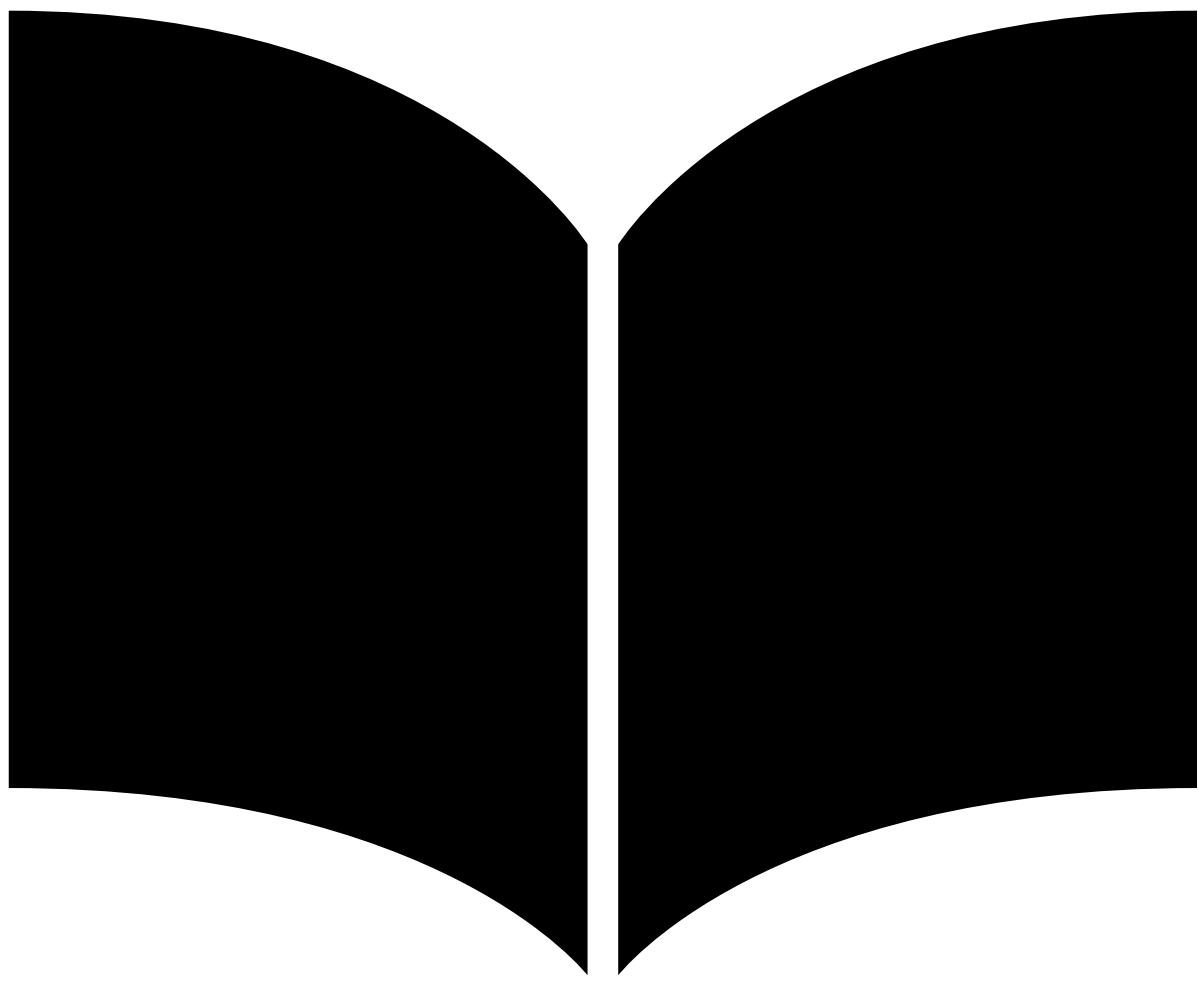
1
1
0

2



Content #138

Junior Engineer Manufacturing	1 1 1	5
VP Sales Manufacturing	0 0 1	1
Junior Customer Service Retail	2 0 0	2
Junior Engineer R&D	2 2 1	5



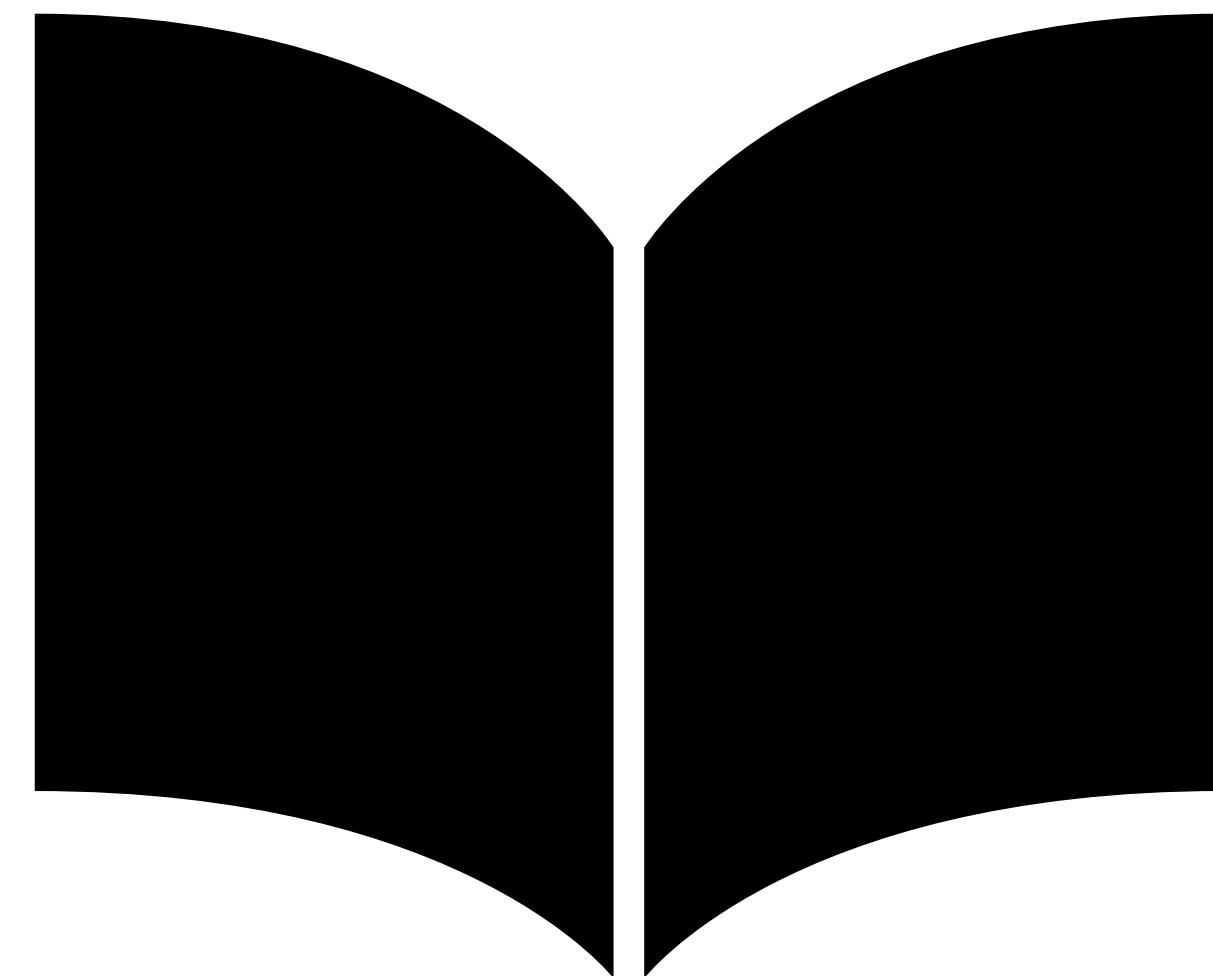
Content #138

Junior	68	
Engineer	91	
Manufacturing	81	
		240

VP	34	
Sales	55	
Manufacturing	81	
		170

Junior	68	
Customer Service	0	
Retail	0	
		68

Junior	68	
Engineer	91	
R&D	18	
		177



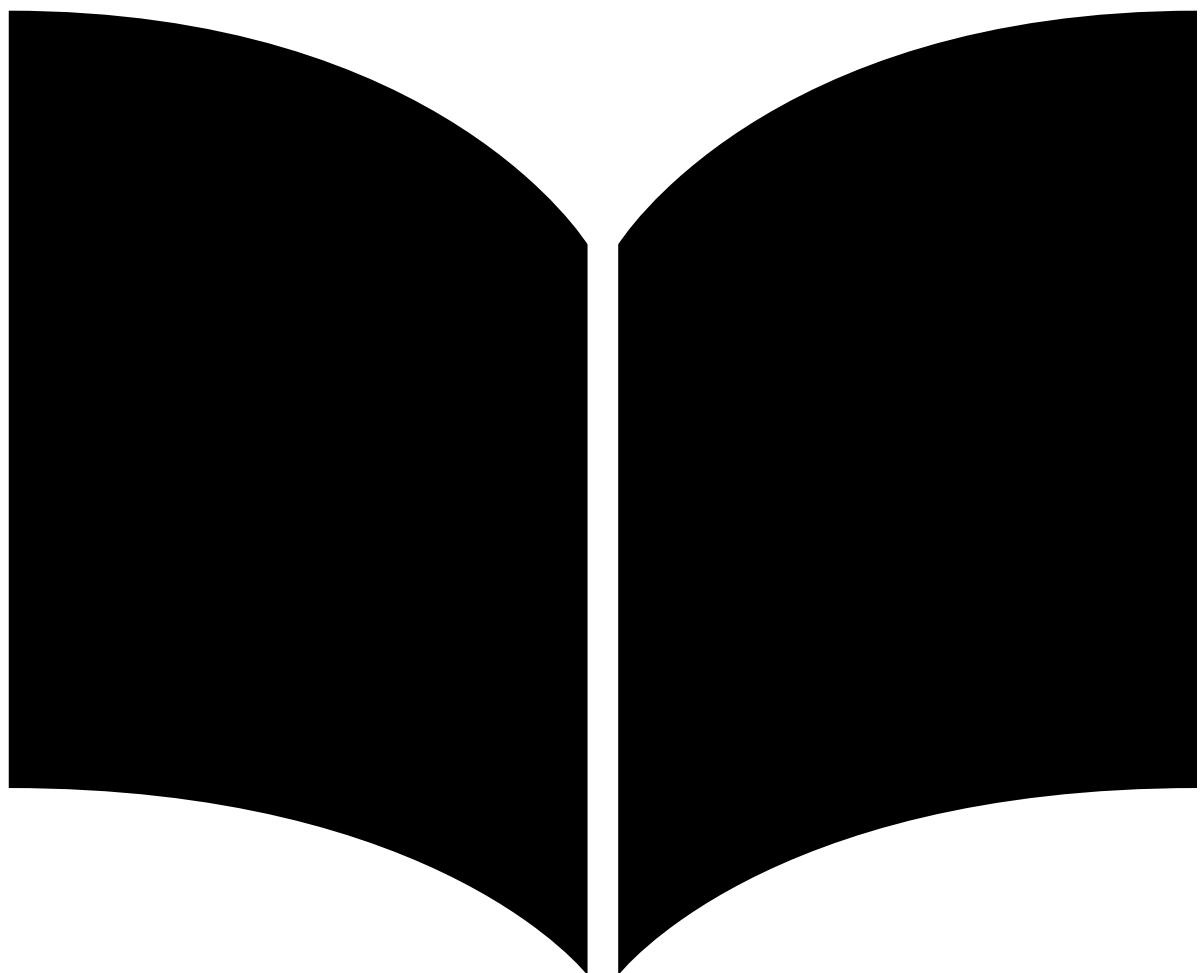
Content #138

Junior	68	
Engineer	91	
Manufacturing	81	240

VP	34	
Sales	55	
Manufacturing	81	170

Junior	68	
Customer Service	0	68
Retail	0	

Junior	68	
Engineer	91	
R&D	18	177



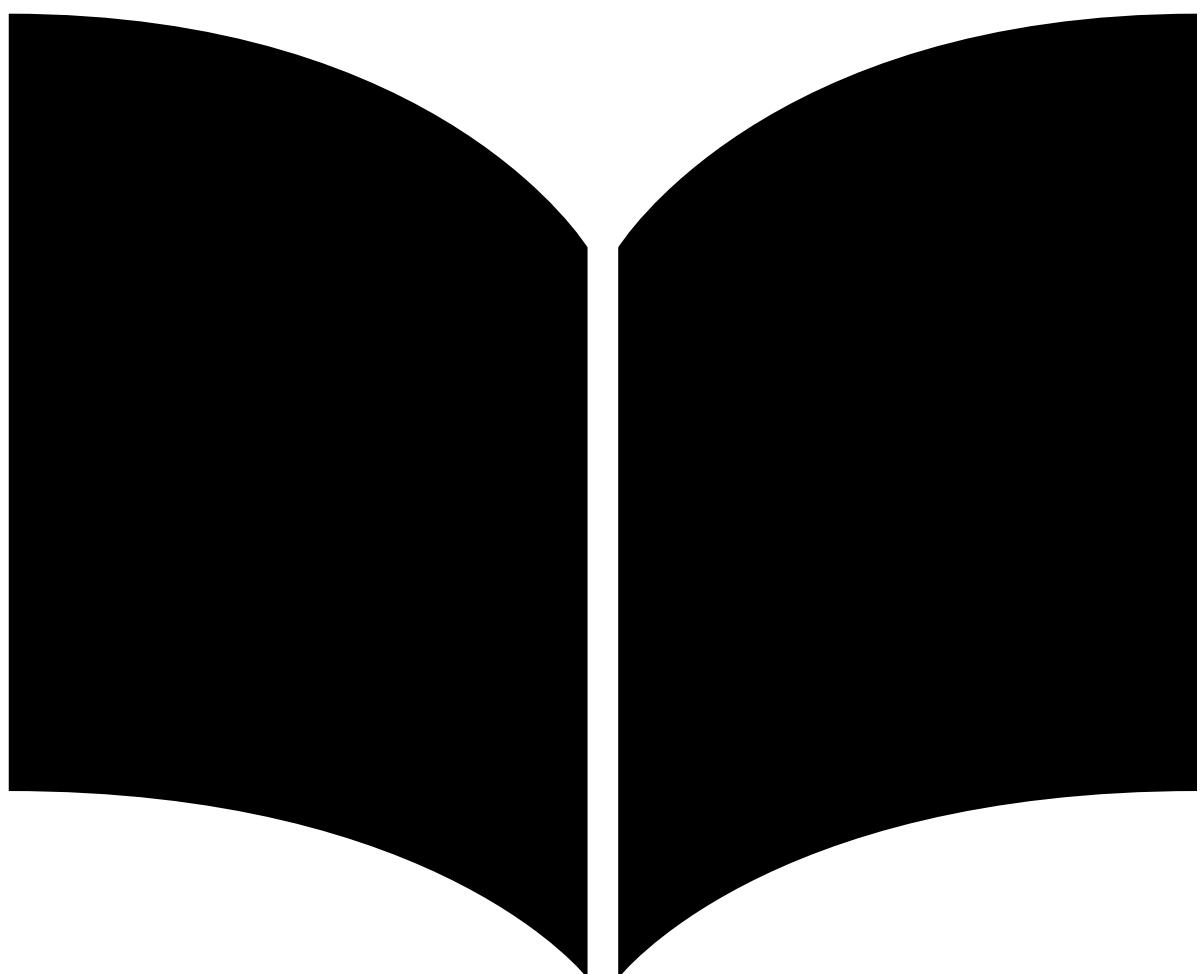
Content #138

Junior	34	
Engineer	91	
Manufacturing	81	
		206

VP	17	
Sales	55	
Manufacturing	81	
		153

Junior	34	
Customer Service	0	
Retail	0	
		34

Junior	34	
Engineer	91	
R&D	18	
		143



Content #138

THANK YOU!

Scott Sullivan
Adaptive Path
@scotsullivan
scottslullivan.io



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