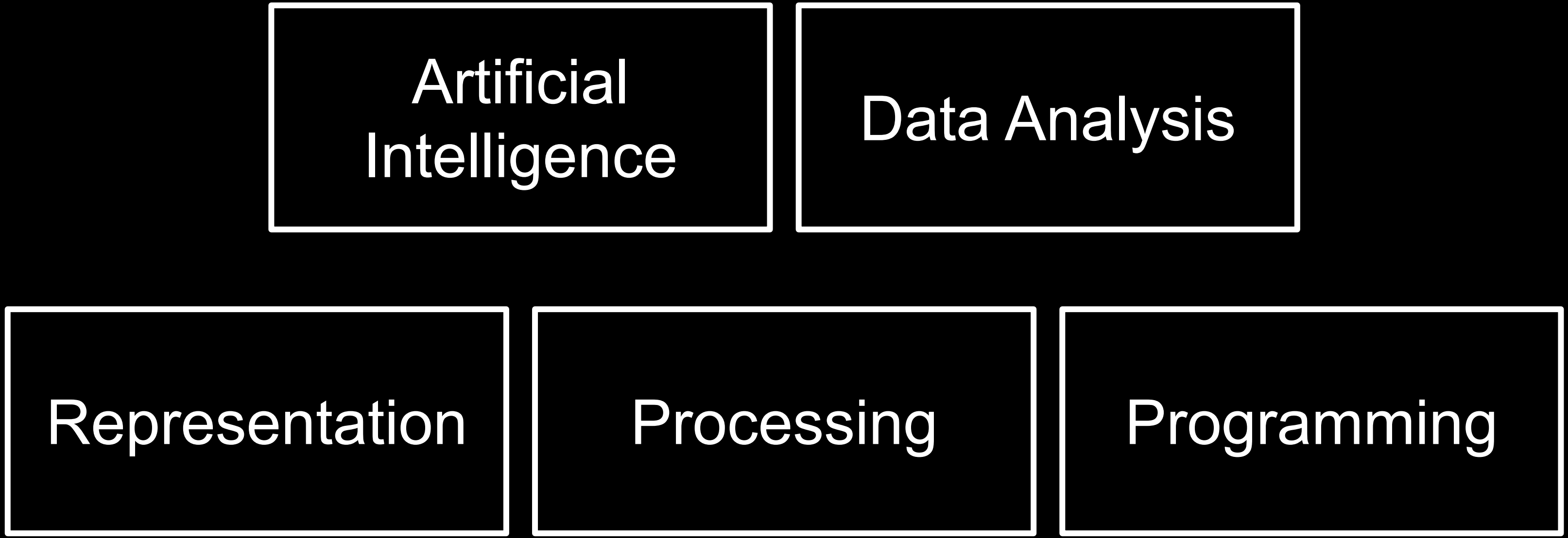
MOTIVATION



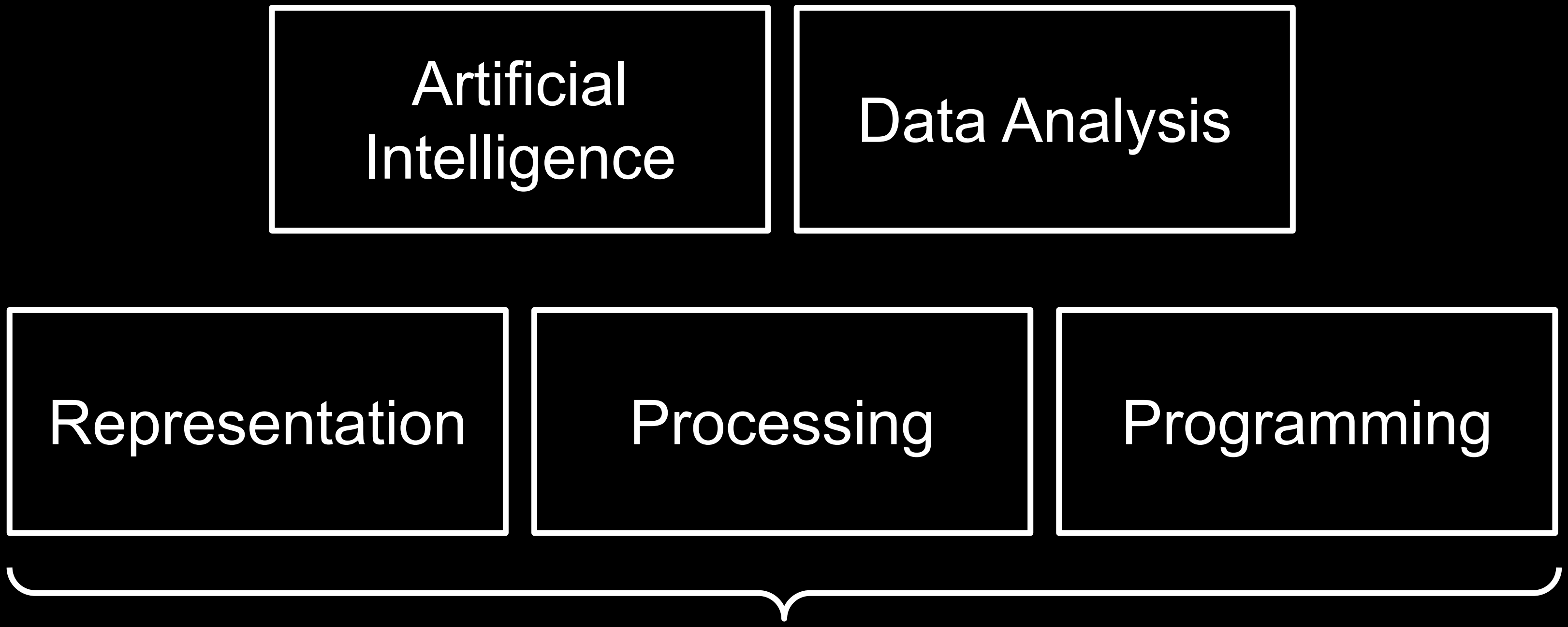
Artificial Intelligence

Data Analysis

Representation

Processing

Programming



Artificial Intelligence

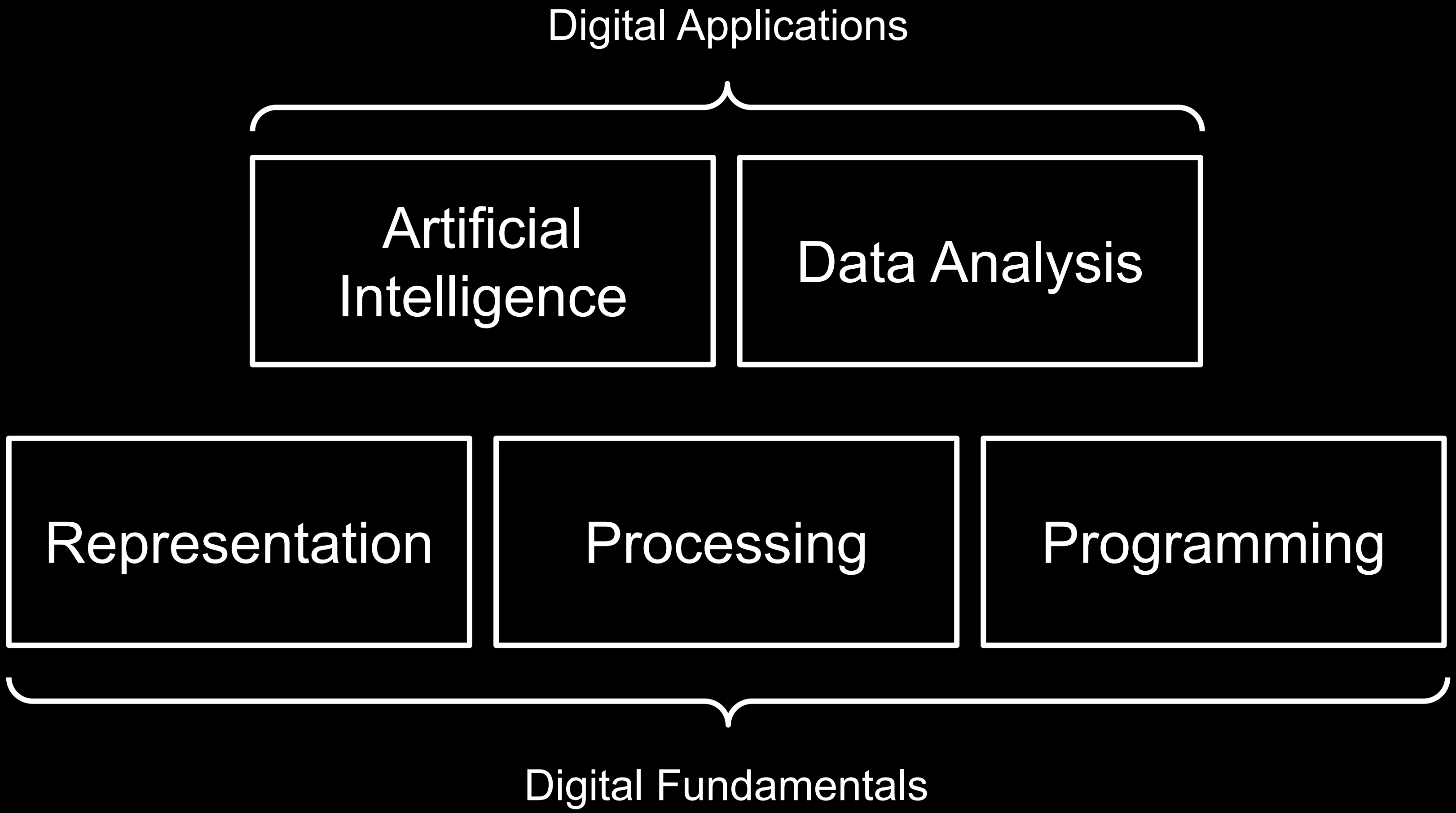
Data Analysis

Representation

Processing

Programming

Digital Fundamentals



Digital Applications

Artificial Intelligence

Data Analysis

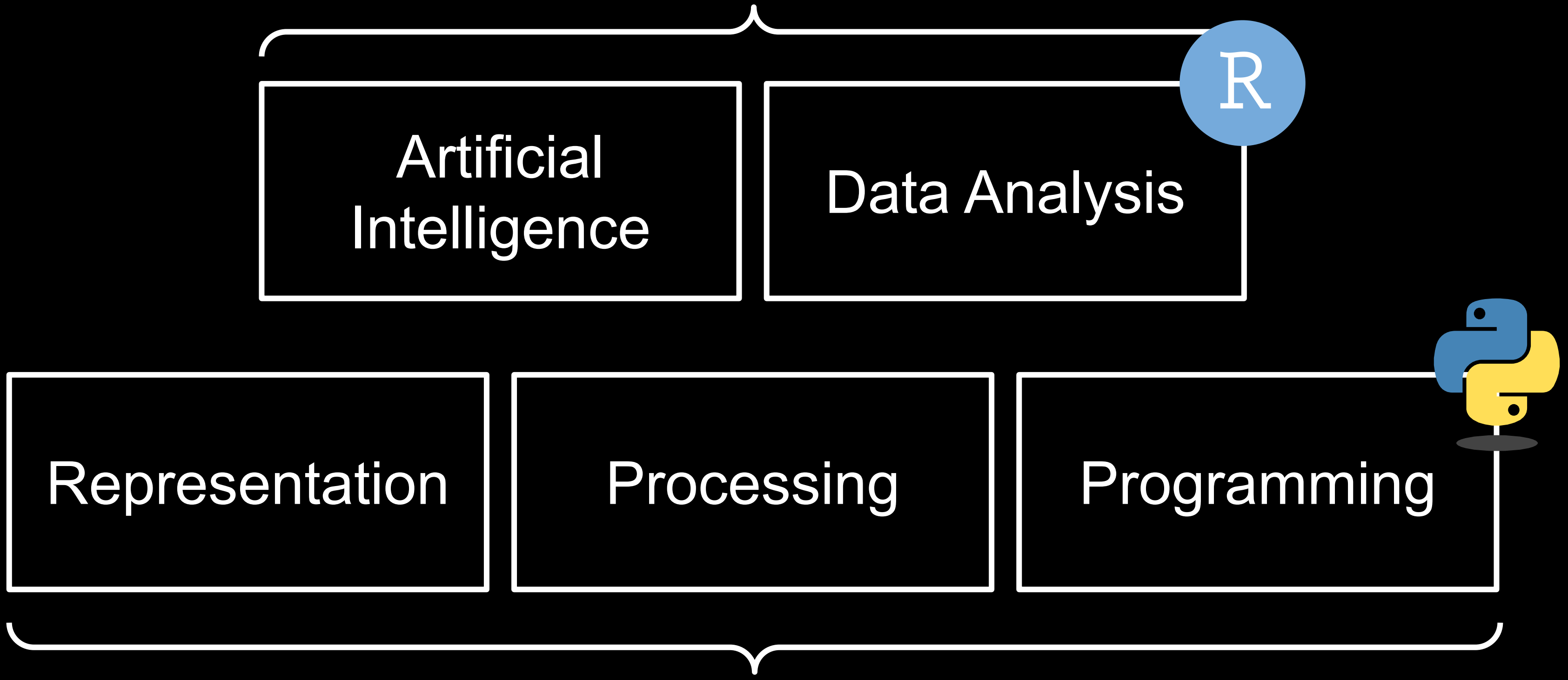
Representation

Processing

Programming

Digital Fundamentals

Digital Applications



Artificial Intelligence

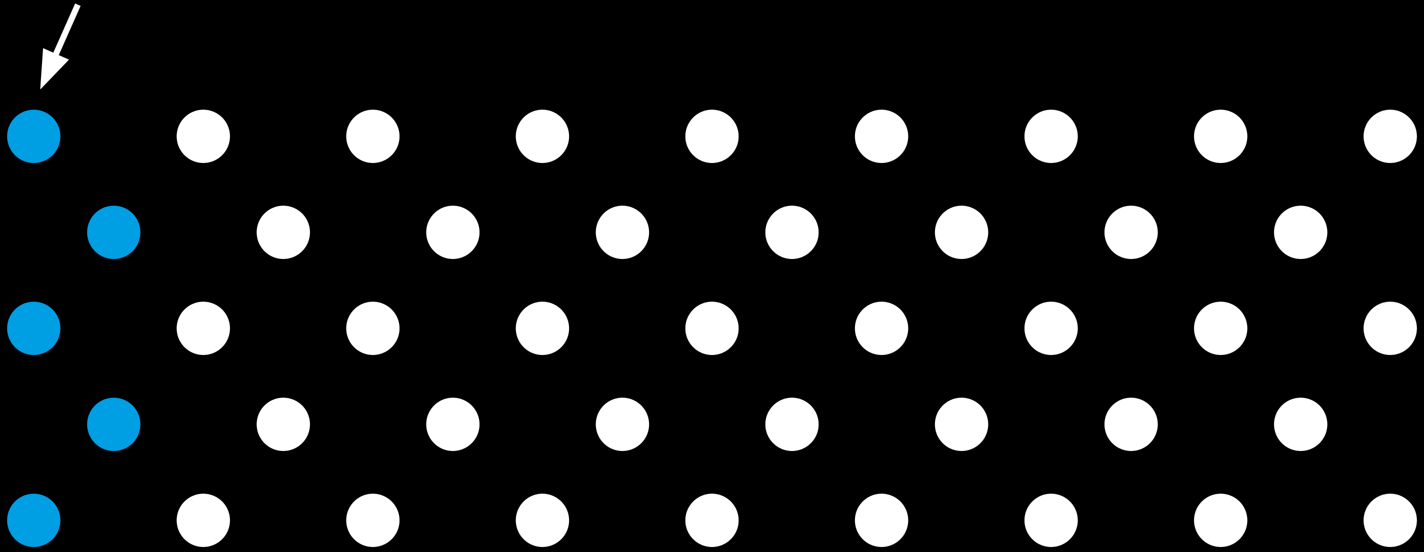
Data Analysis

Representation

Processing

Programming

Digital Fundamentals

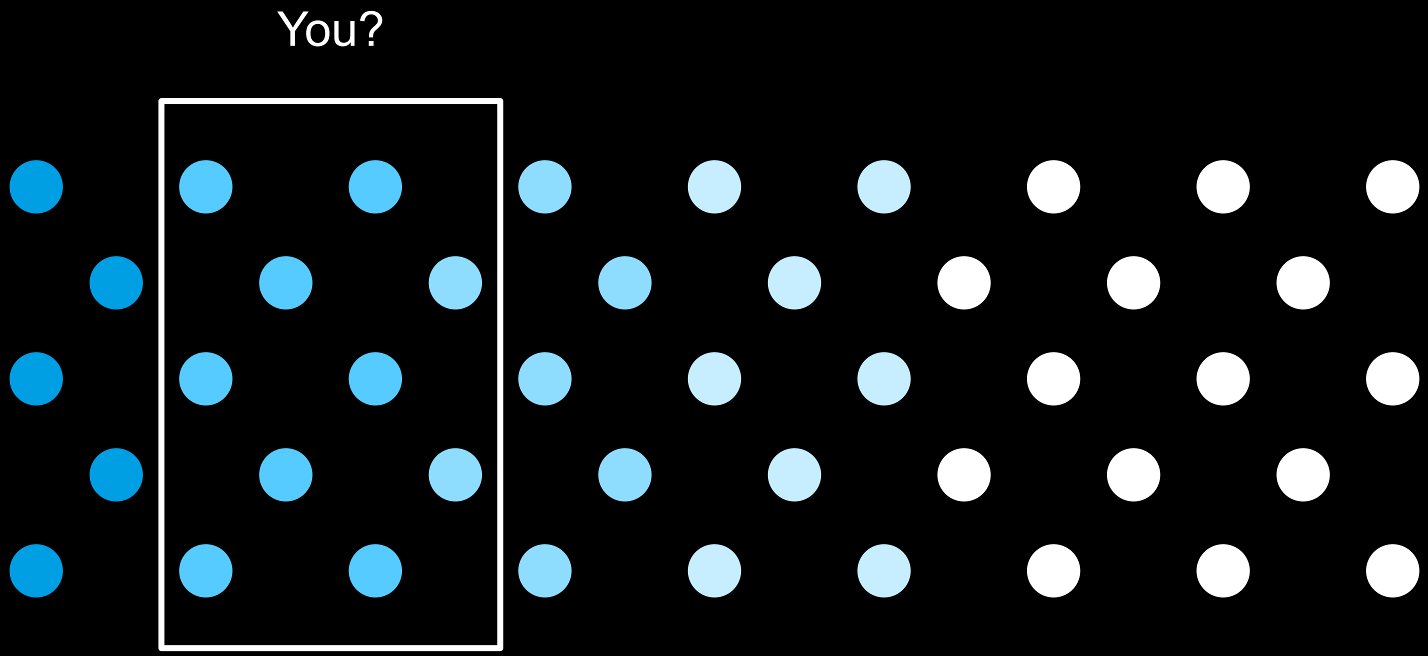


A few experts

Digitally uneducated society

Digitally illiterate society with a few experts

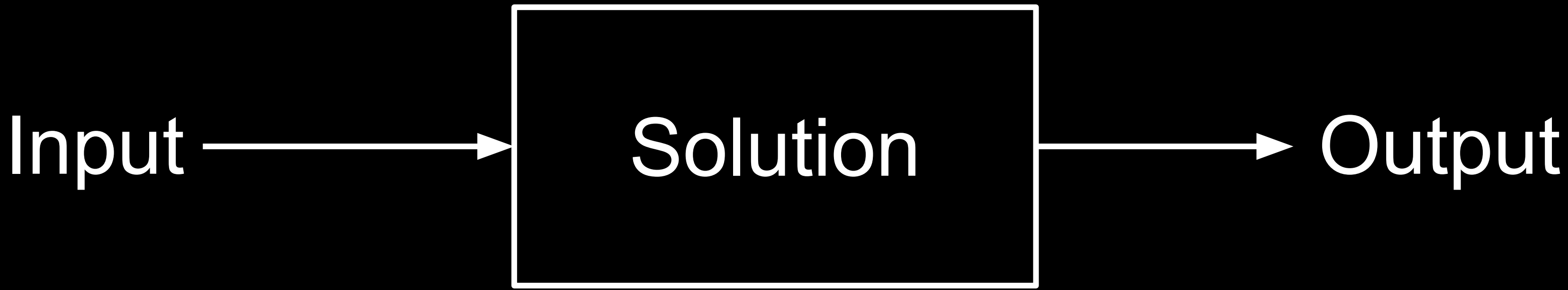
Collective Understanding



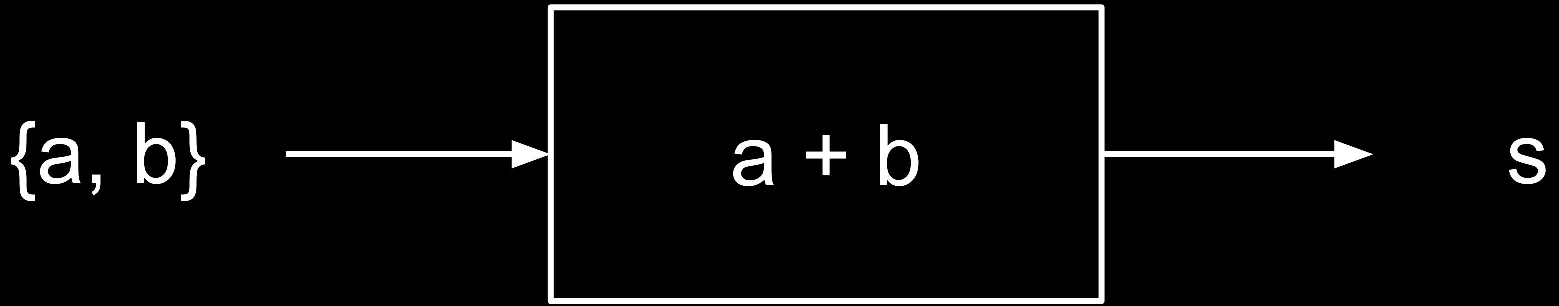
Society with a distributed and high degree of digital education

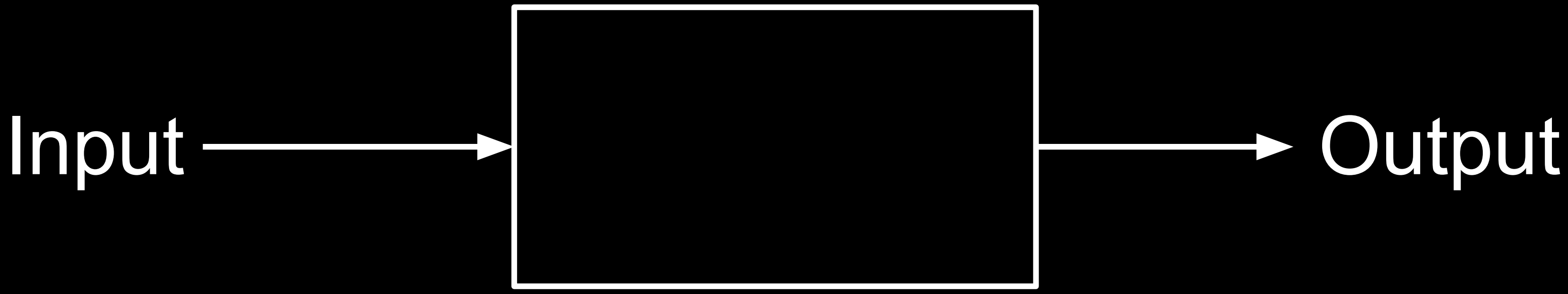
PROBLEM SOLVING

A Model for Solving Problems



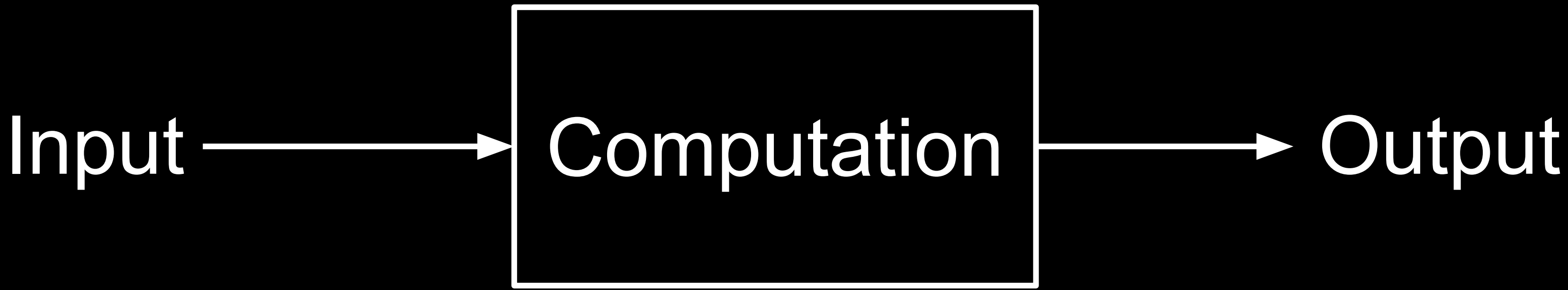
A Model for Solving Problems





Input

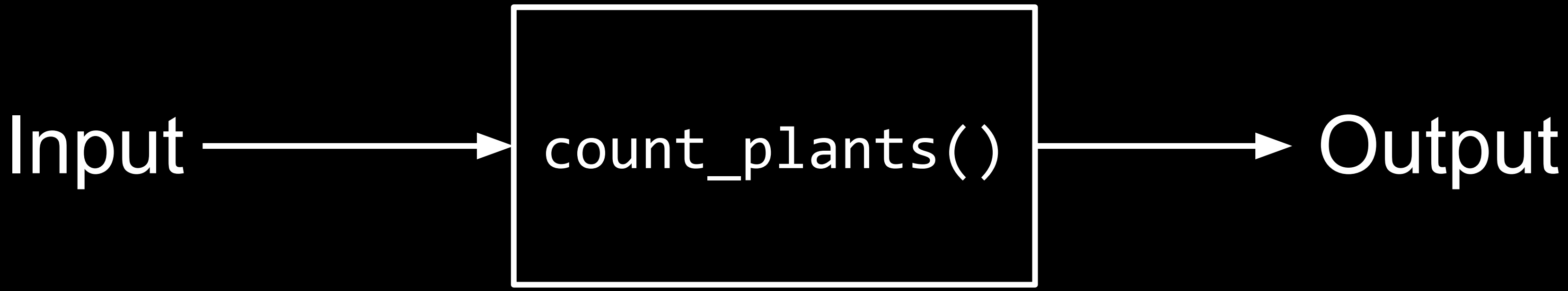
Output



Input

Computation

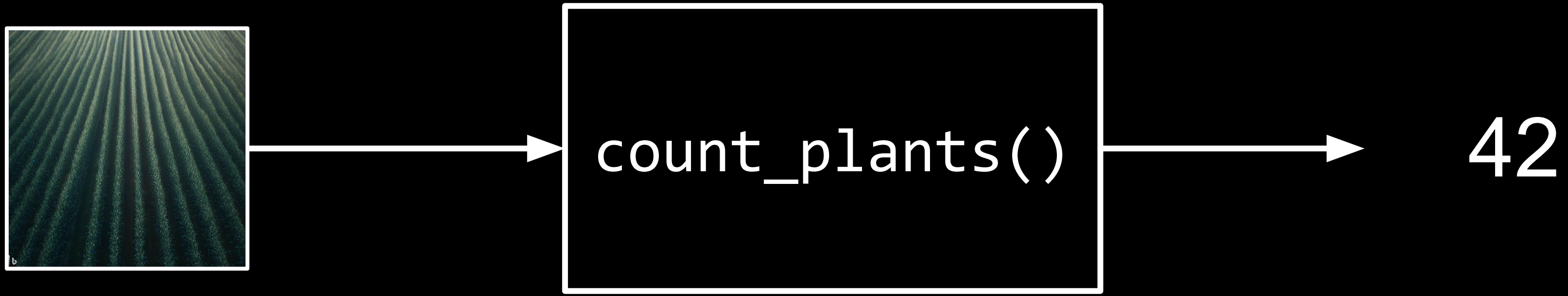
Output



Input

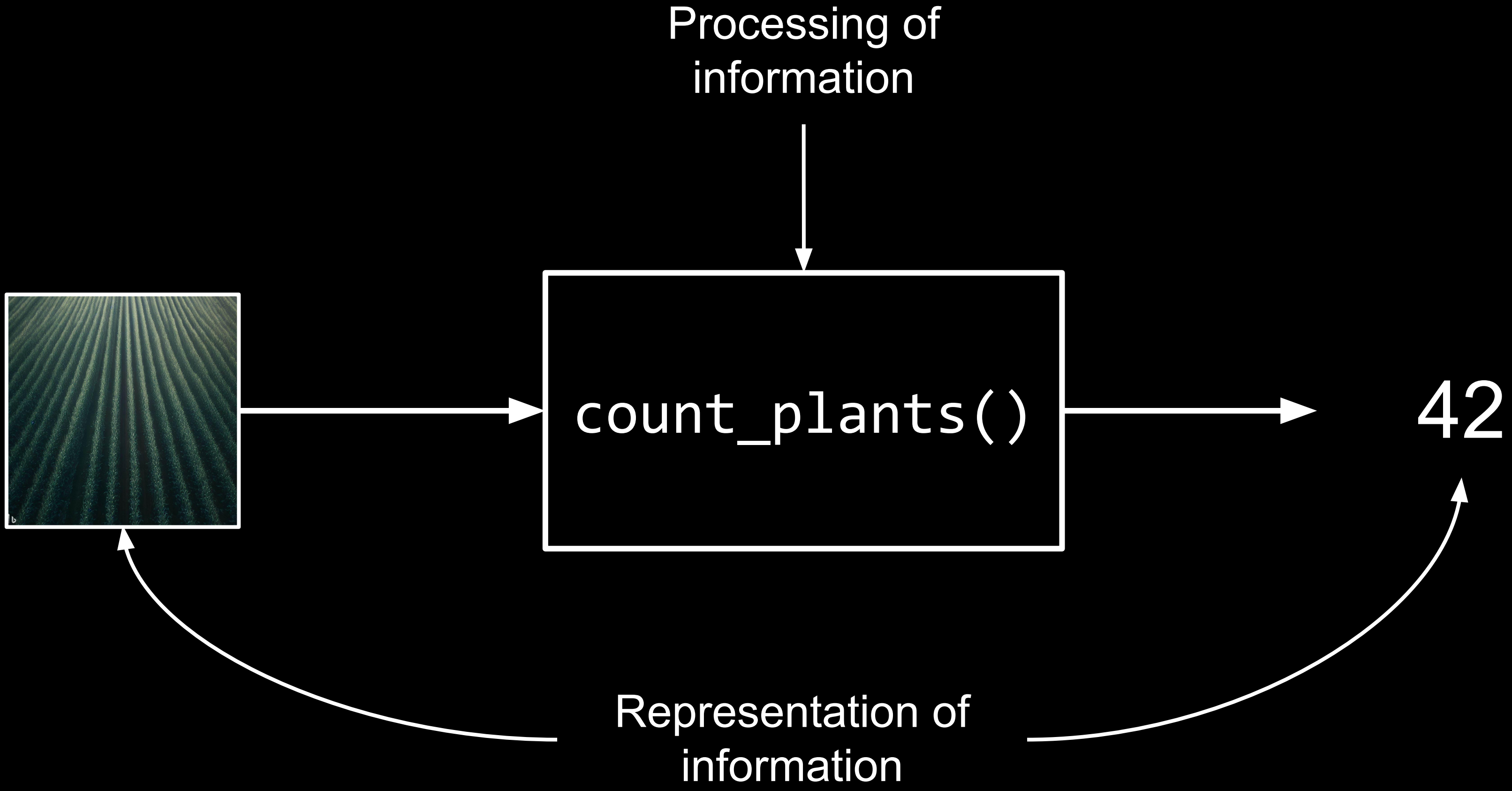
`count_plants()`

Output



count_plants()

42

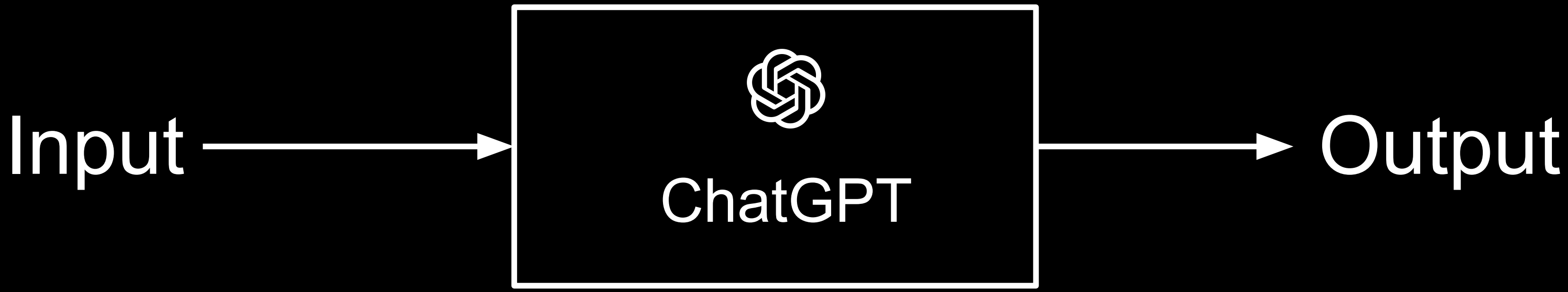


Processing of information

count_plants()

42

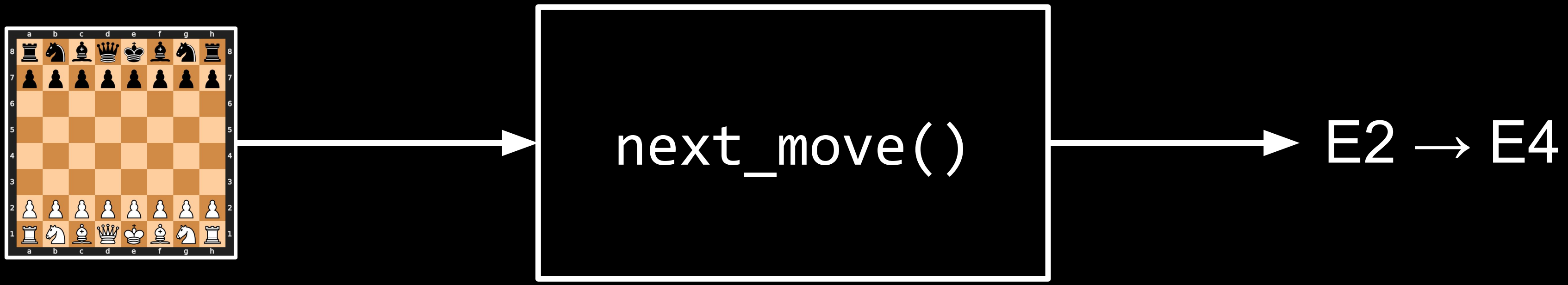
Representation of information



Input

ChatGPT

Output



next_move()

E2 → E4

INFORMATION

Image created with DALLE-3

COUNTING

1 2 3

1	2	3
10^2	10^1	10^0

$$\underline{1 \qquad\qquad 2 \qquad\qquad 3}$$

$$10^2 \qquad\qquad 10^1 \qquad\qquad 10^0$$

$$= 1 \times 10^2 + 2 \times 10^1 + 3 \times 10^0$$

$$= 1 \times 100 + 2 \times 10 + 3 \times 1$$

$$= 123$$

4	1	2	3
?	10^2	10^1	10^0

4	1	2	3
?	10^2	10^1	10^0

$$= 4 \times 10^3 + 1 \times 10^2 + 2 \times 10^1 + 3 \times 10^0$$

4	1	2	3
?	10^2	10^1	10^0

$$= 4 \times 10^3 + 1 \times 10^2 + 2 \times 10^1 + 3 \times 10^0$$

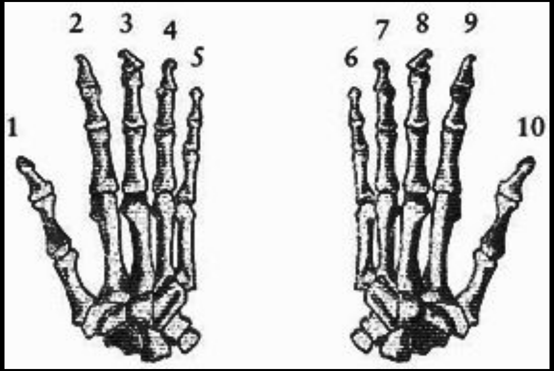
$$= 4 \times 1000 + 1 \times 100 + 2 \times 10 + 3 \times 1$$

4	1	2	3
?	10^2	10^1	10^0

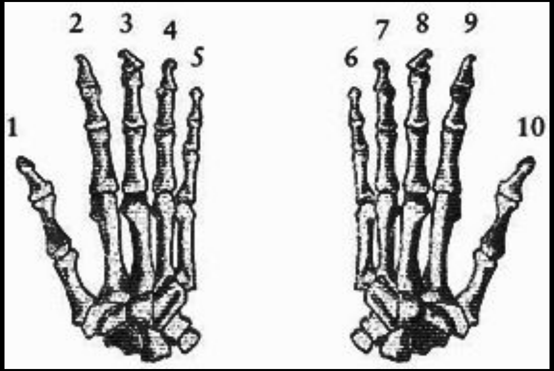
$$= 4 \times 10^3 + 1 \times 10^2 + 2 \times 10^1 + 3 \times 10^0$$

$$= 4 \times 1000 + 1 \times 100 + 2 \times 10 + 3 \times 1$$

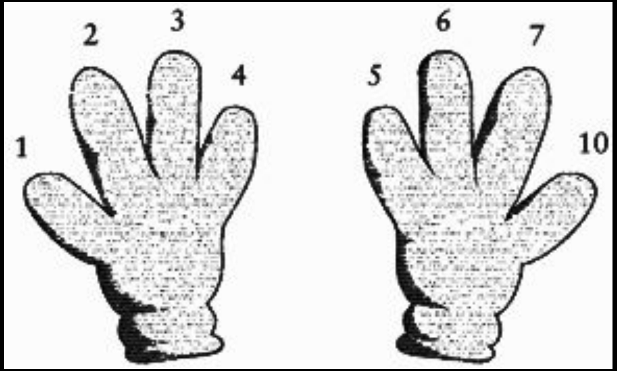
$$= 4123$$



Human Hand



Human Hand



Cartoon Character’s Hand

1 2 3 (octal)

1	2	3	(octal)
8^2	8^1	8^0	

1	2	3	(octal)
8^2	8^1	8^0	

$$= 1 \times 8^2 + 2 \times 8^1 + 3 \times 8^0$$

$$\begin{array}{ccc} 1 & 2 & 3 \\ \hline 8^2 & 8^1 & 8^0 \end{array} \quad \text{(octal)}$$

$$= 1 \times 8^2 + 2 \times 8^1 + 3 \times 8^0$$

$$= 1 \times 64 + 2 \times 8 + 3 \times 1$$

$$\underset{8^2}{1} \quad \underset{8^1}{2} \quad \underset{8^0}{3}$$

(octal)

$$= 1 \times 8^2 + 2 \times 8^1 + 3 \times 8^0$$

$$= 1 \times 64 + 2 \times 8 + 3 \times 1$$

$= 83$ (decimal)

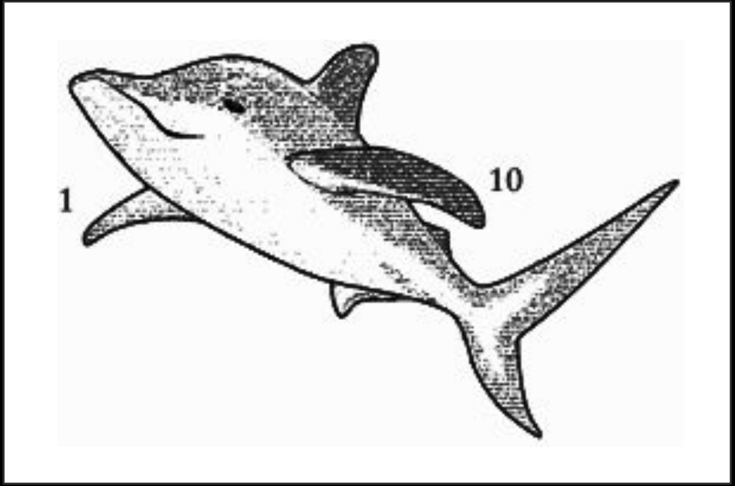
decimal		octal
8	→	?

decimal		octal
?	←	7

decimal octal

16 → ?

decimal		octal
?	←	100



What now?

0, 1, …

0, 1, 10, …

0, 1, 10, 11, …

0, 1, 10, 11, 100, …

0, 1, 10, 11, 100, 101, …

0, 1, 10, 11, 100, 101, 110

1 1 0 (binary)

1	**1**	**0**	(binary)
2^2	2^1	2^0	

$$\begin{array}{ccc} 1 & 1 & 0 \\ \hline 2^2 & 2^1 & 2^0 \end{array}$$

(binary)

$$= 1 \times 2^2 + 1 \times 2^1 + 0 \times 2^0$$

1	1	0	(binary)
2^2	2^1	2^0	

$$= 1 \times 2^2 + 1 \times 2^1 + 0 \times 2^0$$

$$= 1 \times 4 + 1 \times 2 + 0 \times 1$$

1	1	0	(binary)
2^2	2^1	2^0	

$= 1 \times 2^2 + 1 \times 2^1 + 0 \times 2^0$

$= 1 \times 4 + 1 \times 2 + 0 \times 1$

= 6 (decimal)

2 3 4 5 6

0, 1, 10, 11, 100, 101, 110

Place Value Systems

$$N = d_n * R^{n-1} + \ldots + d_1 * R^1 + d_0 * R^0$$

$d \in \{ 0, 1, \ldots R-1 \}$

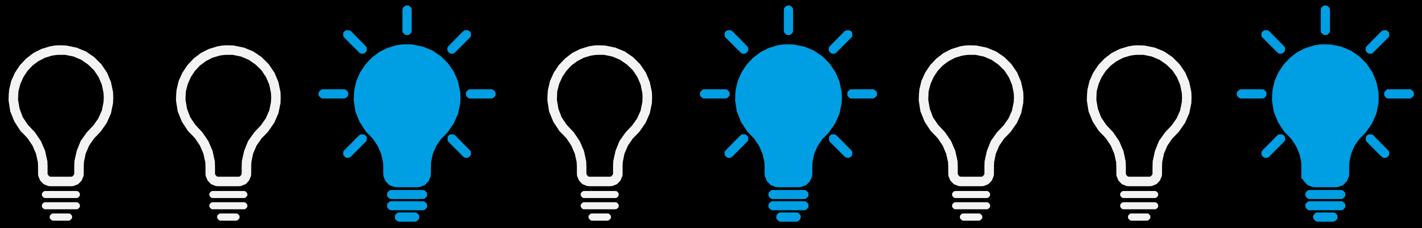
n = Number of digits

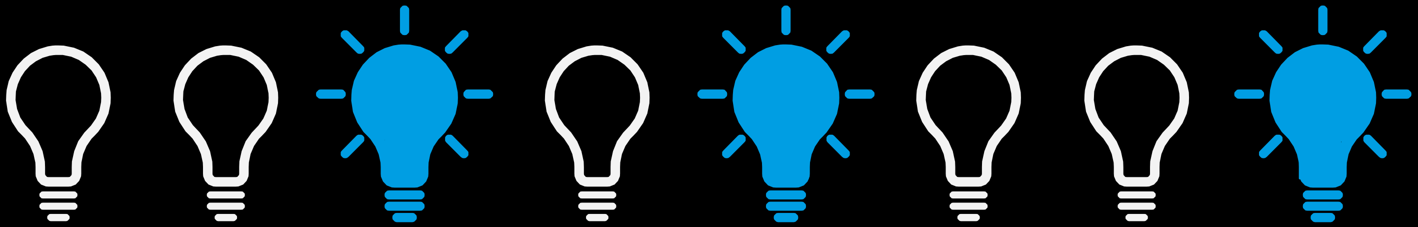
Place Value Systems

$$R \geq 2$$

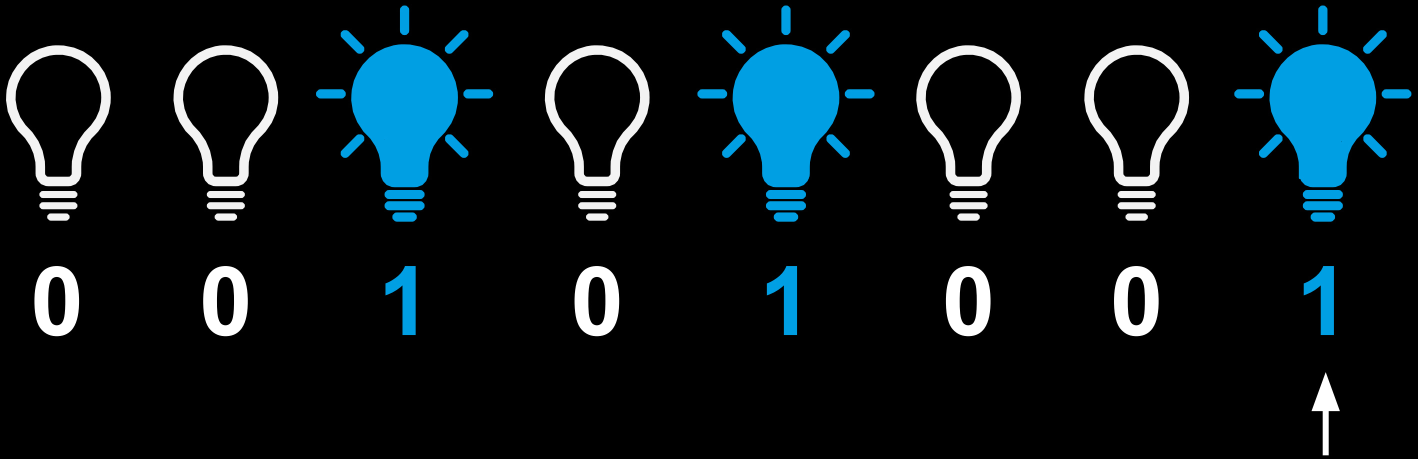
BITS

Why do computers think binary?



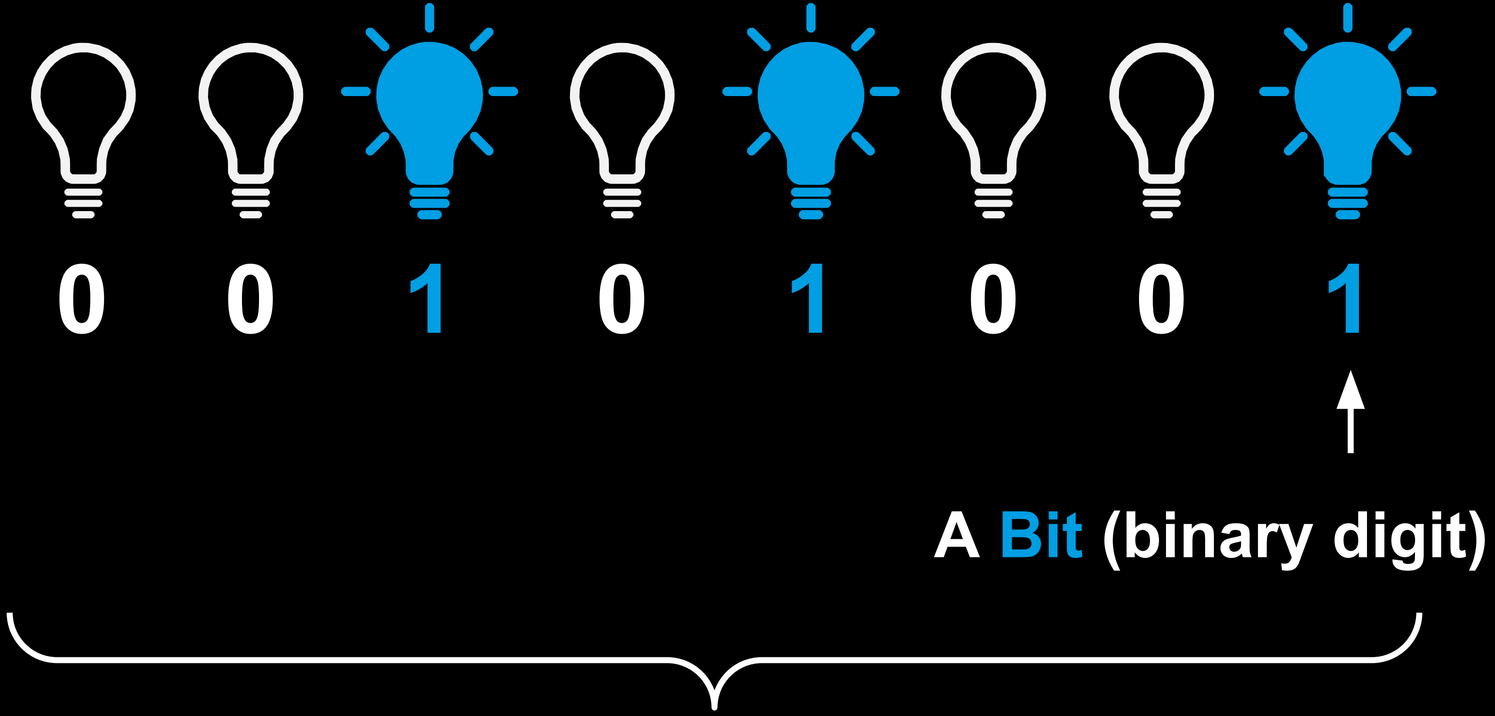


0 0 1 0 1 0 0 1



0 0 1 0 1 0 0 1

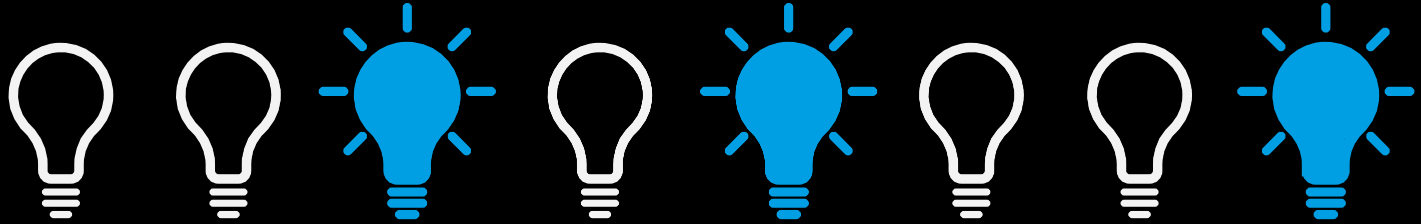
A **Bit** (binary digit)



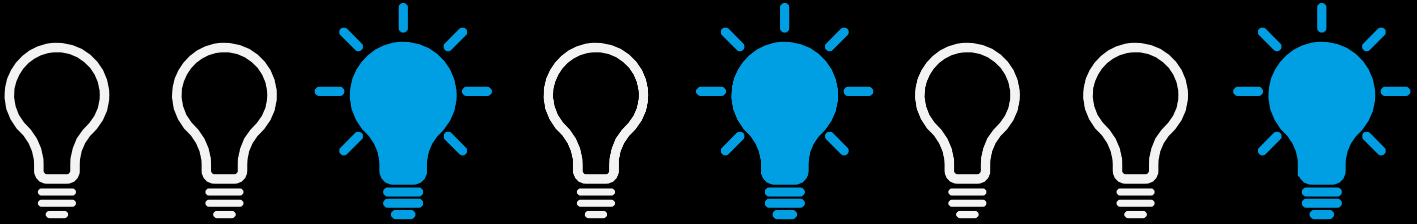
0 0 1 0 1 0 0 1

A **Bit** (binary digit)

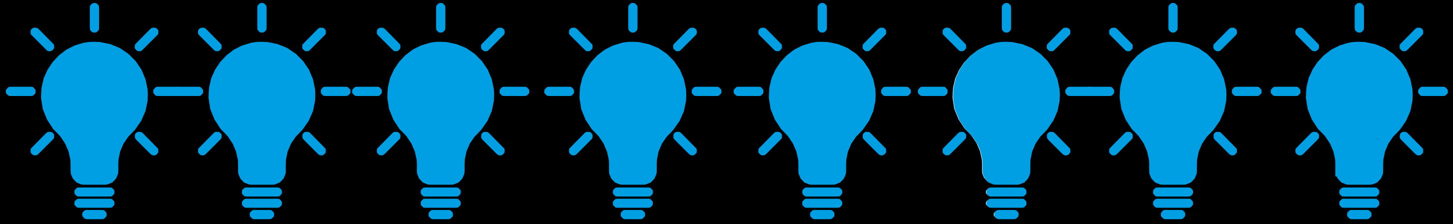
A **byte** (8 bits)



0	0	1	0	1	0	0	1
2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0

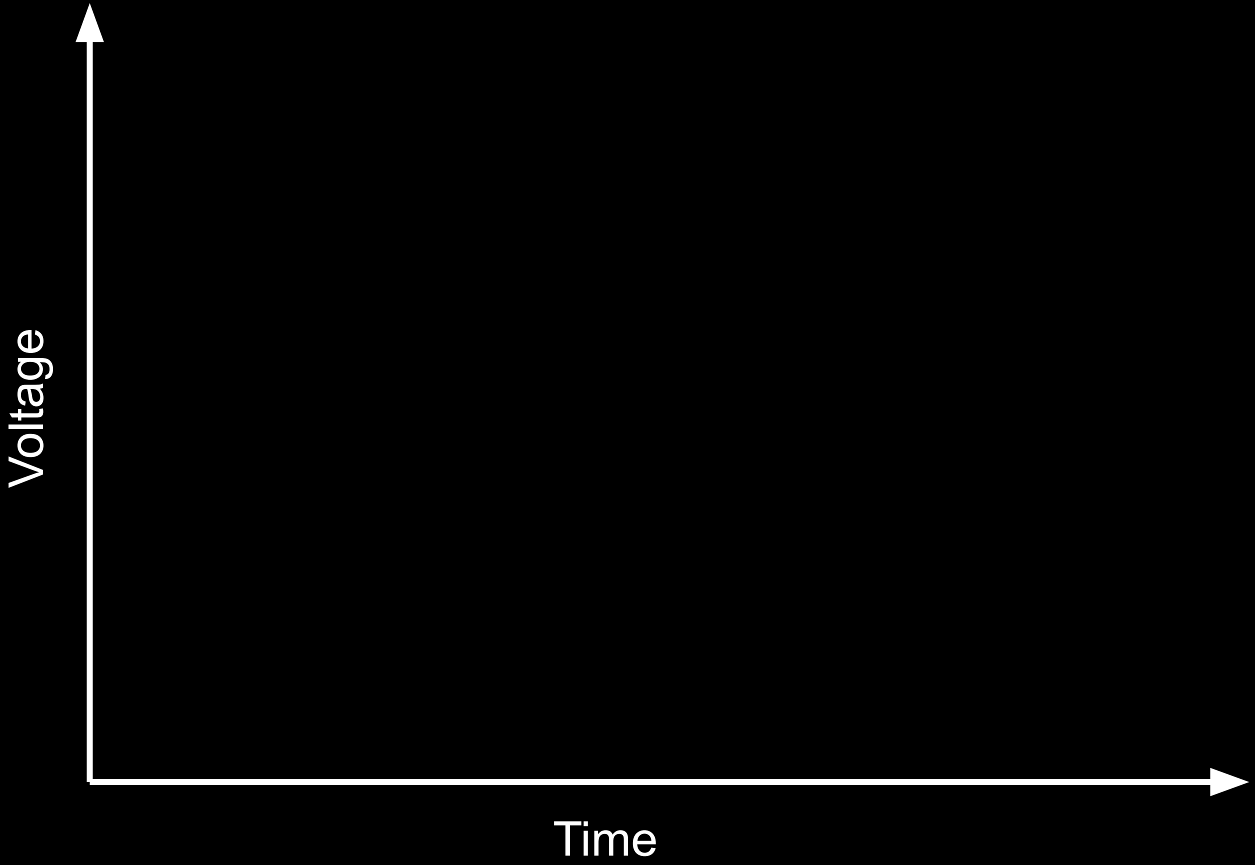


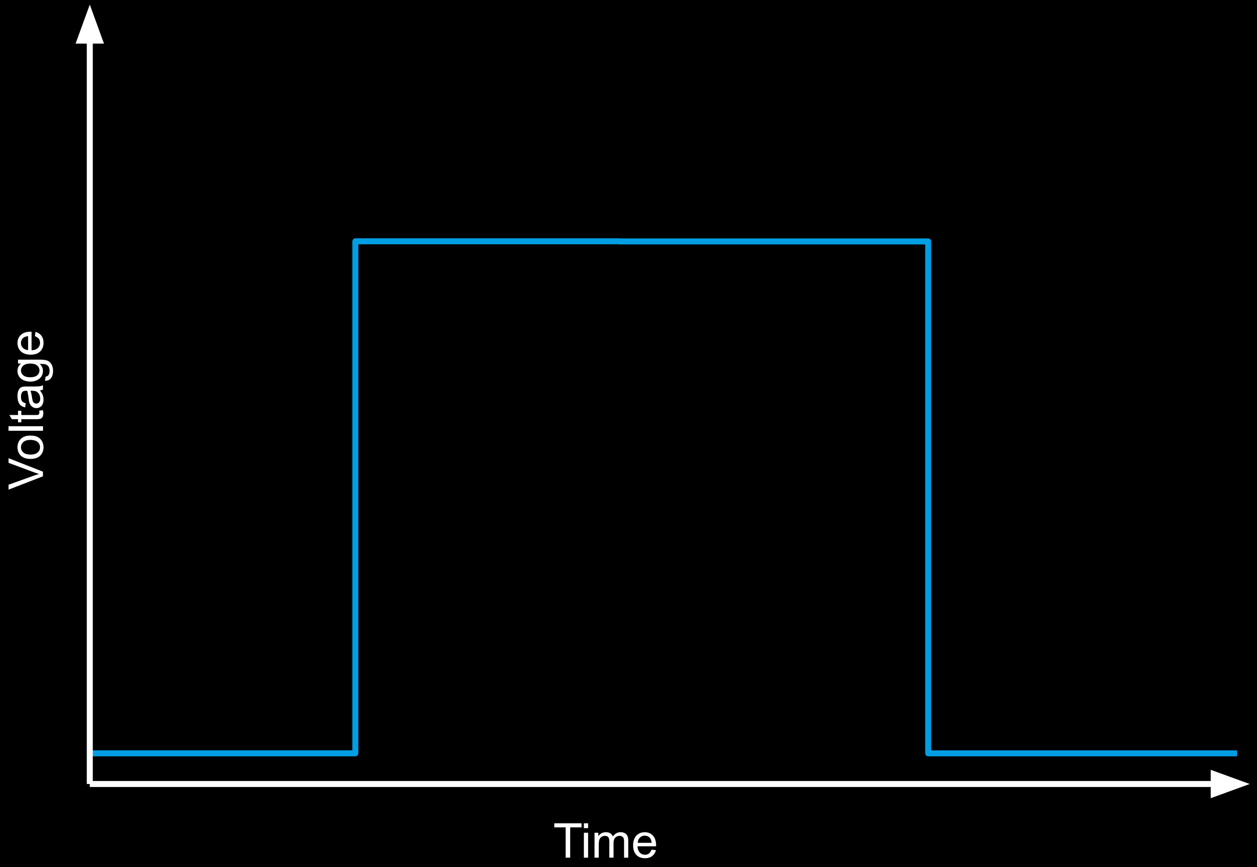
0	0	1	0	1	0	0	1
2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
128	64	32	16	8	4	2	1

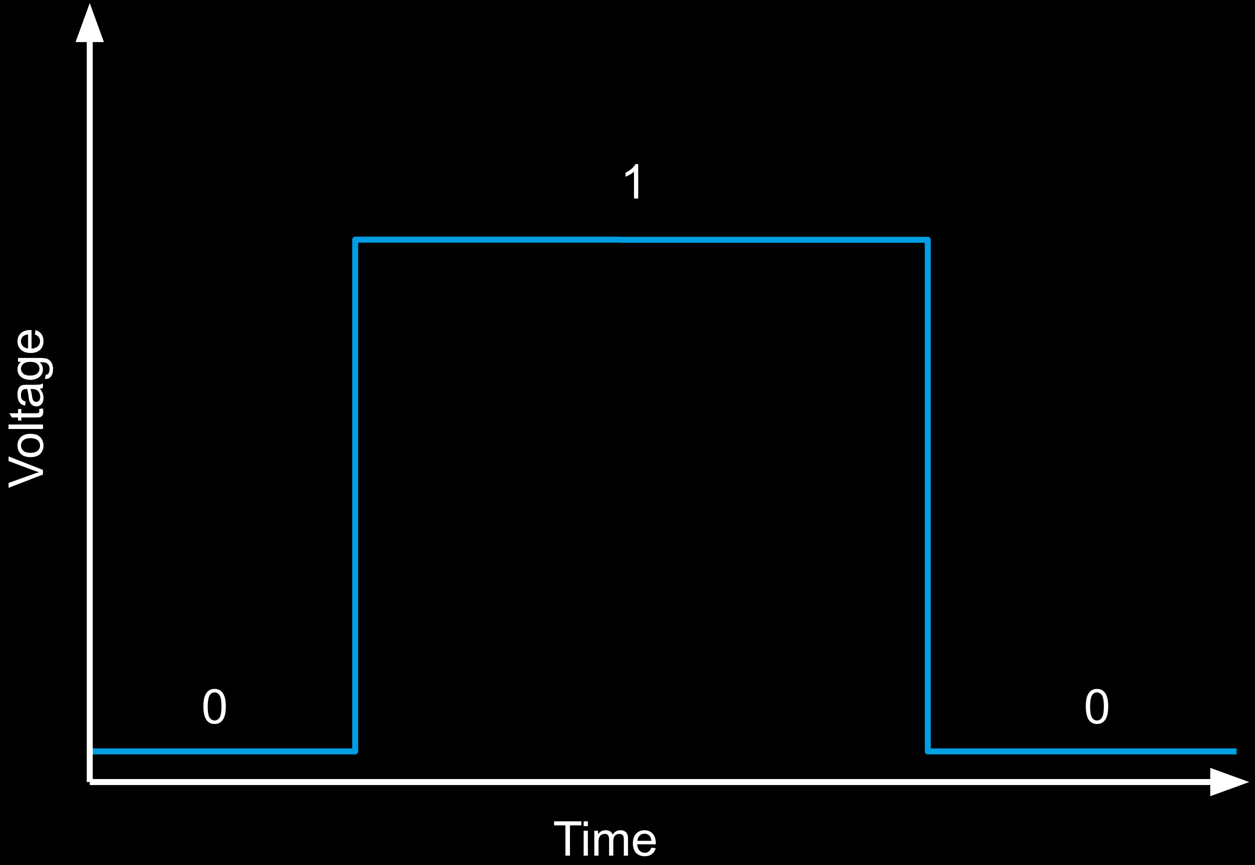


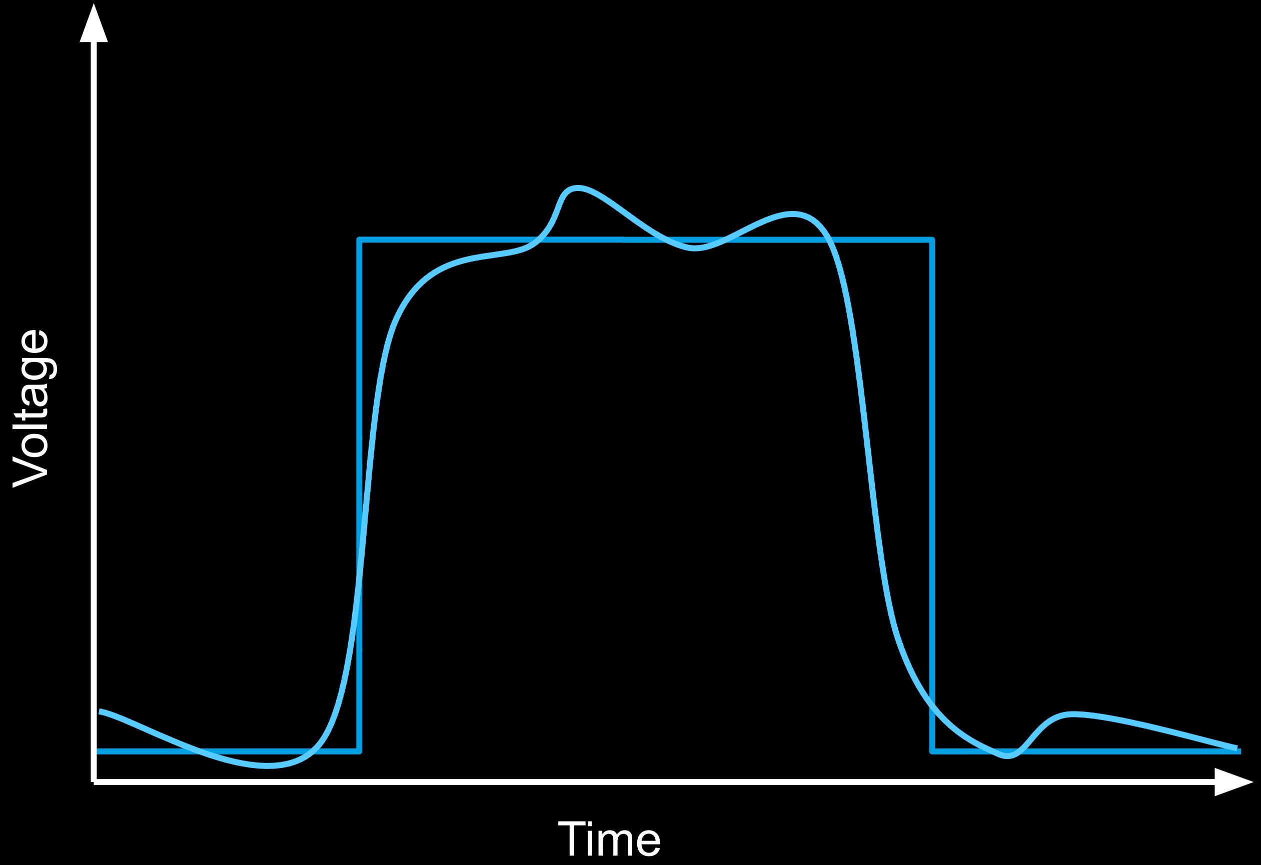
What can we store in one byte?

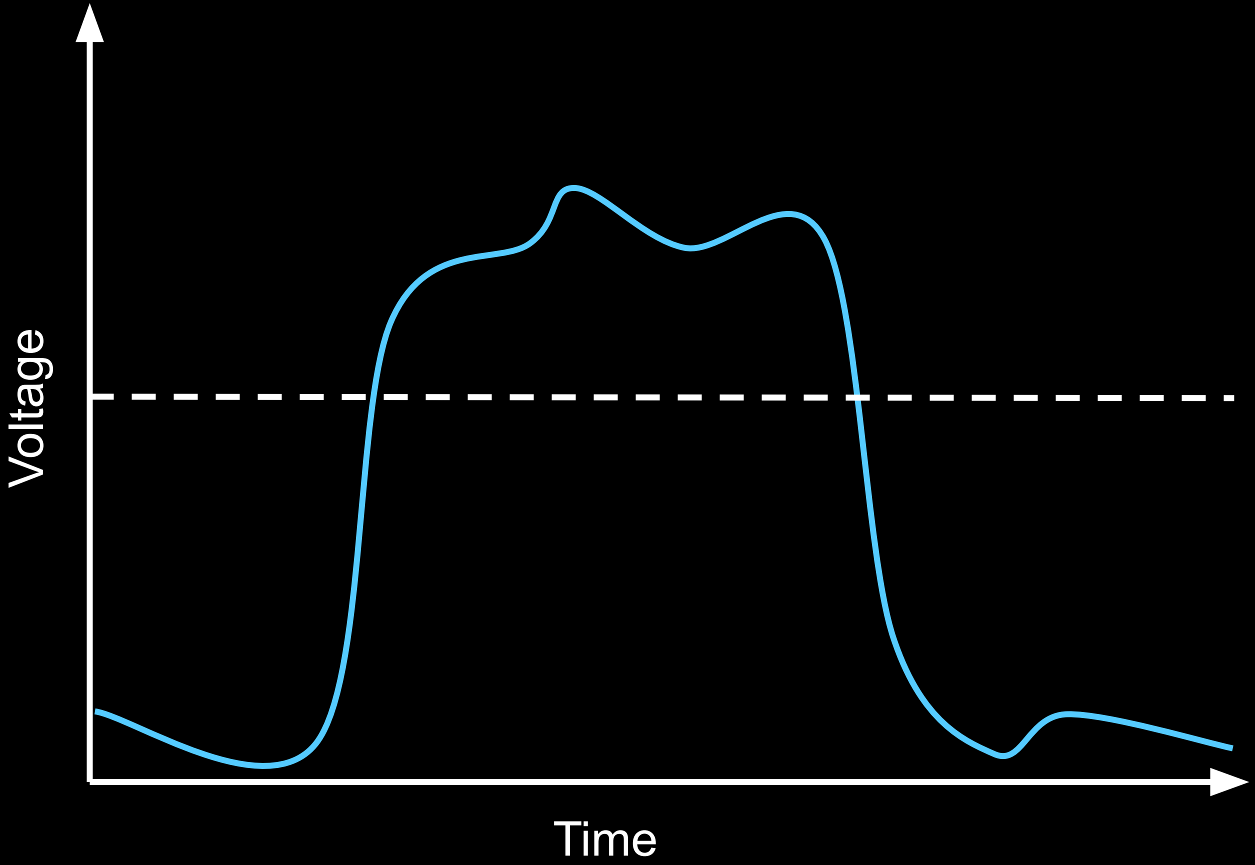
Are we stuck with binary?

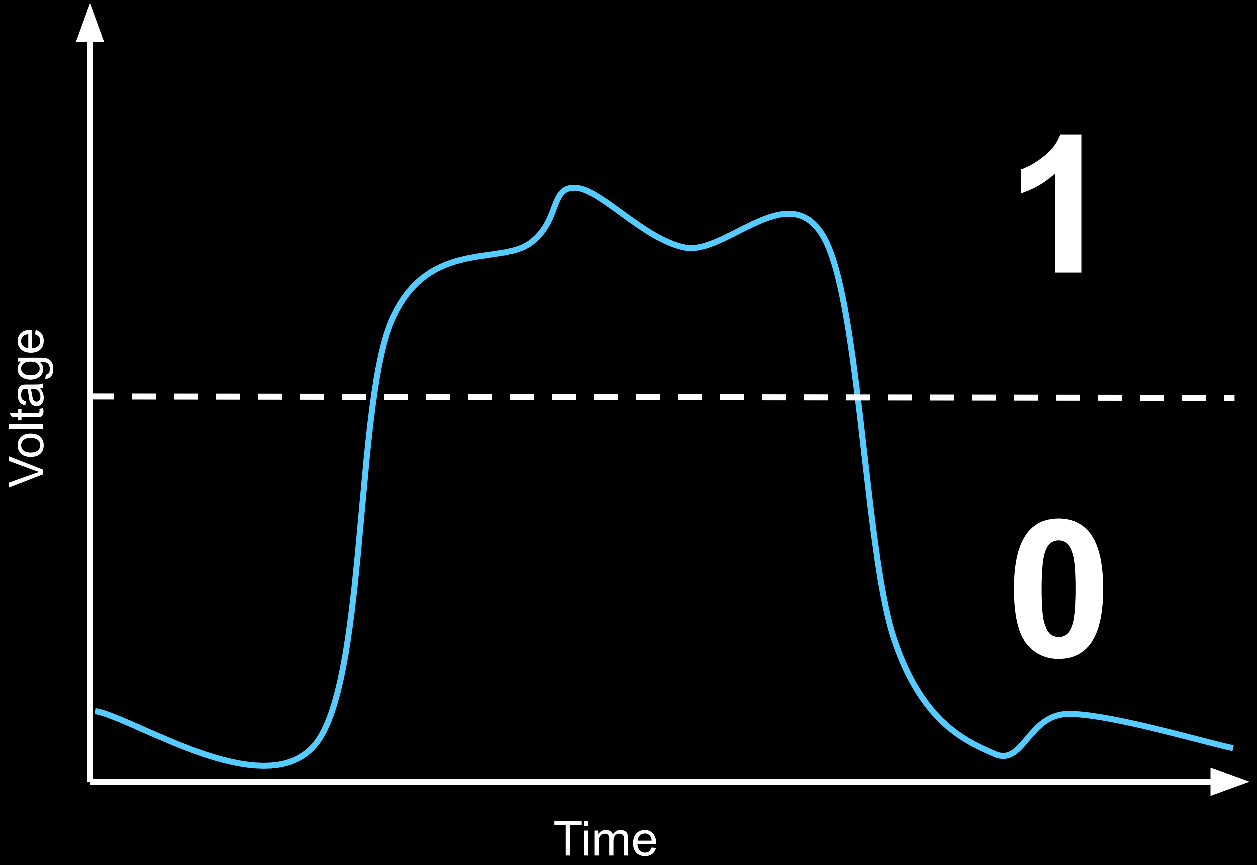

Voltage
Time

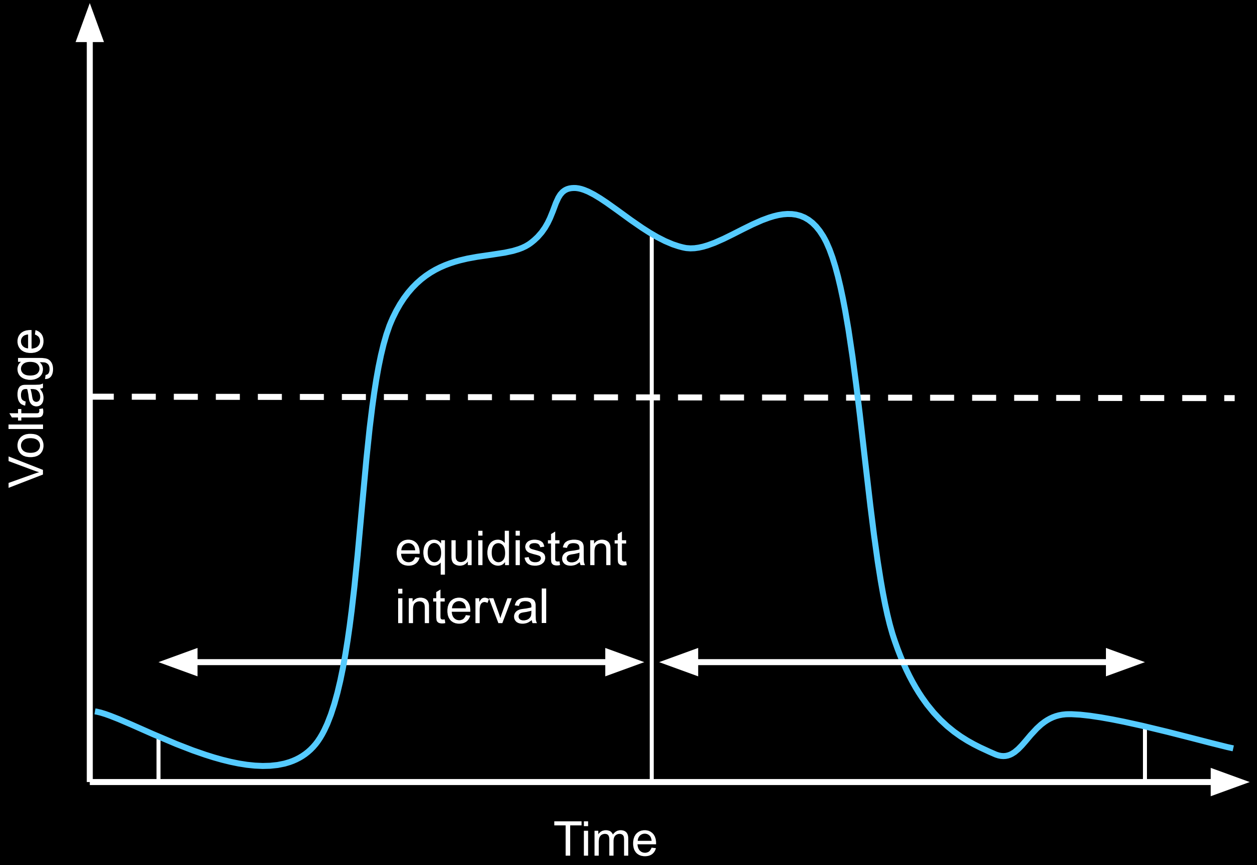

Voltage
Time

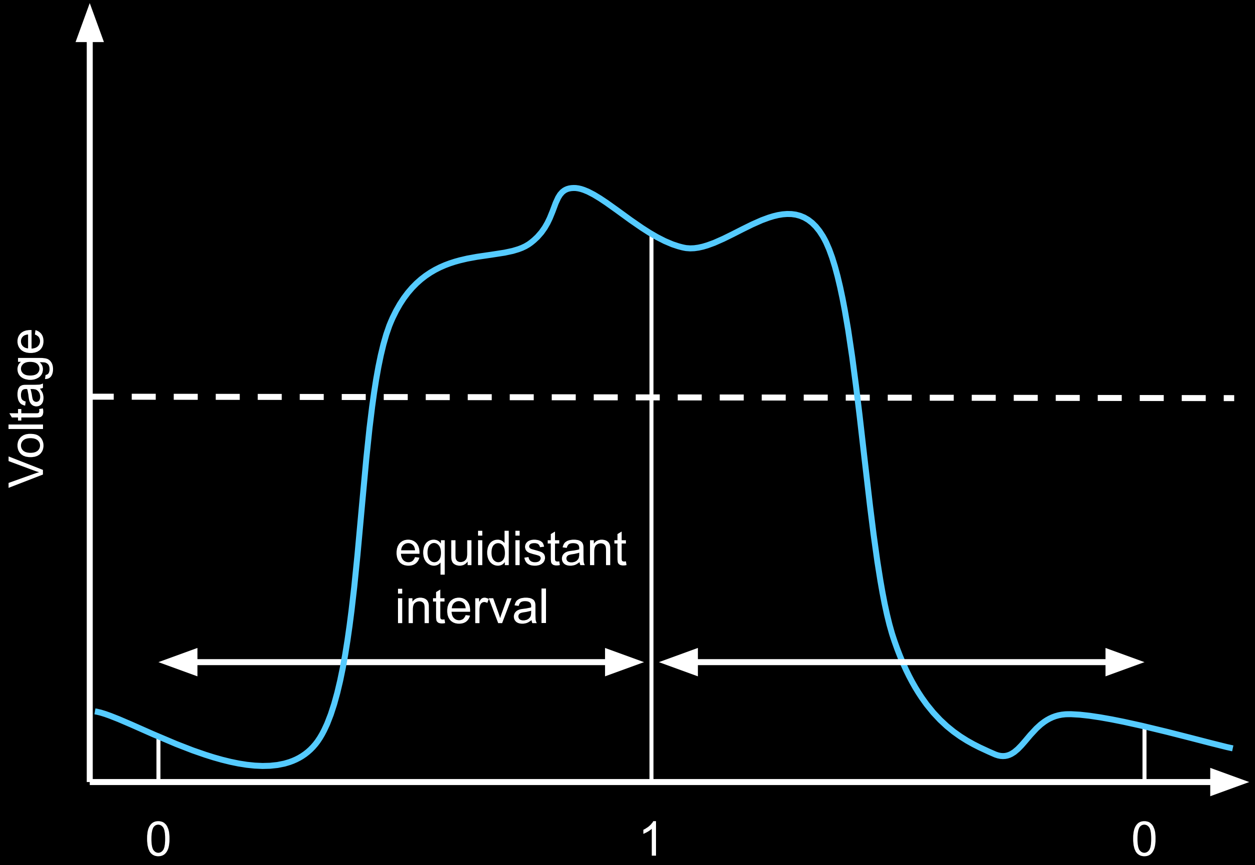

1
Voltage
0
0
Time


Voltage
Time

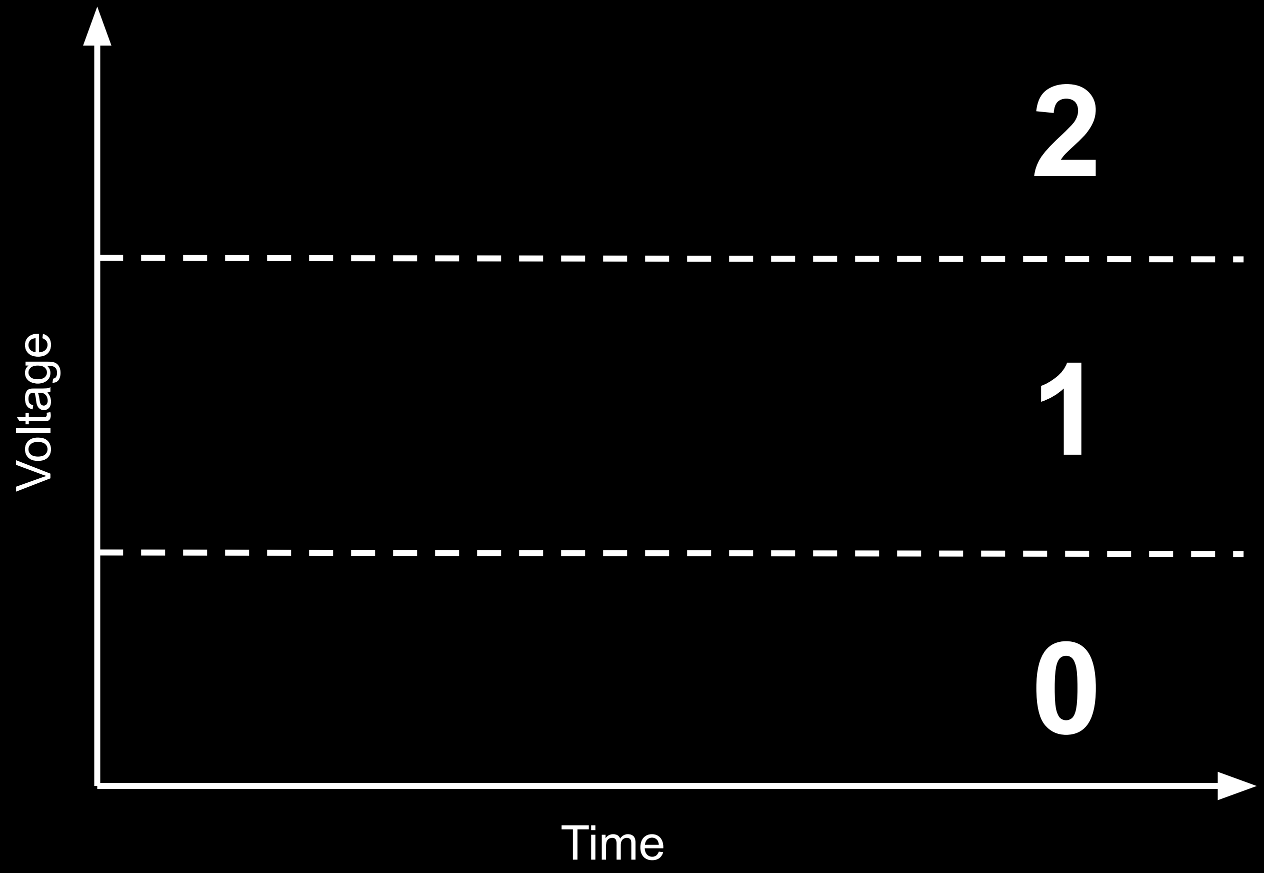

Voltage
Time

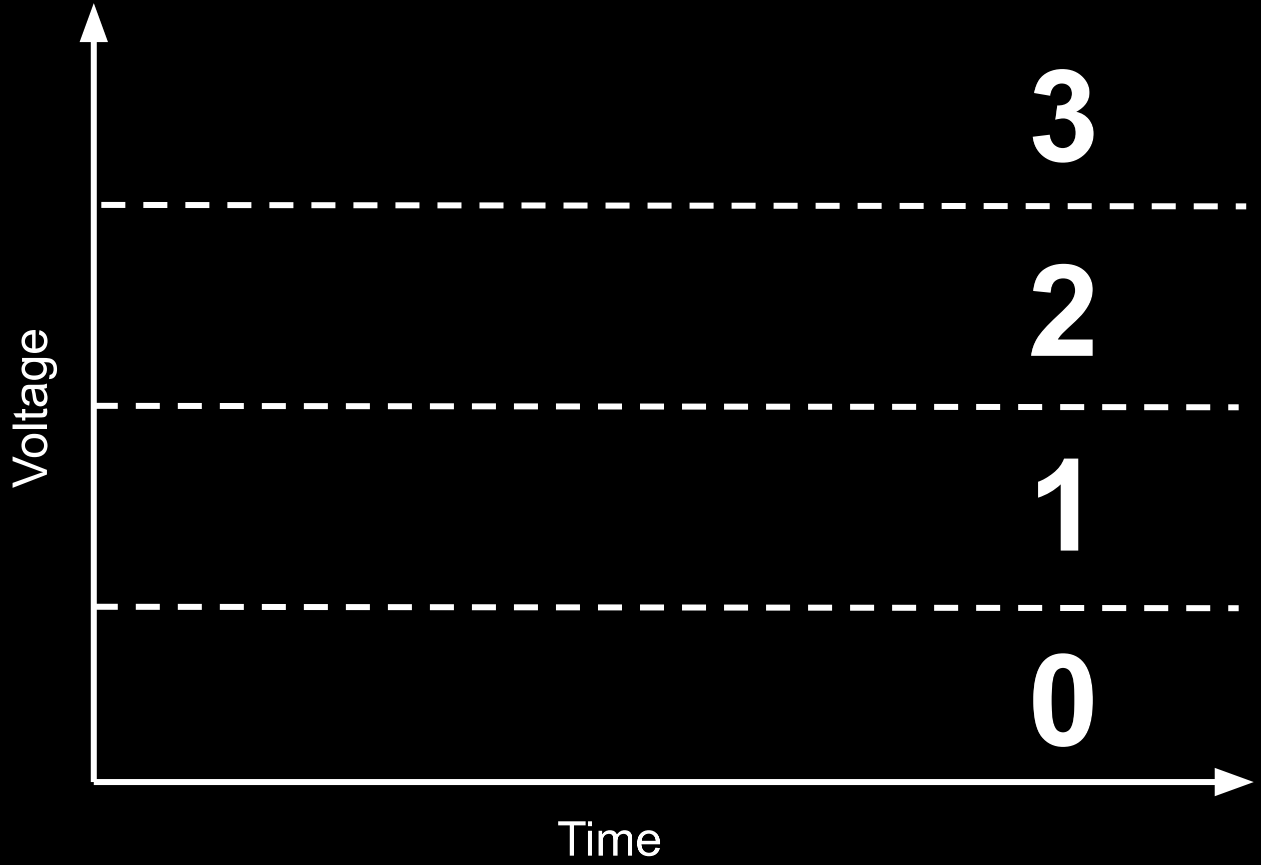

Voltage
1
0
Time

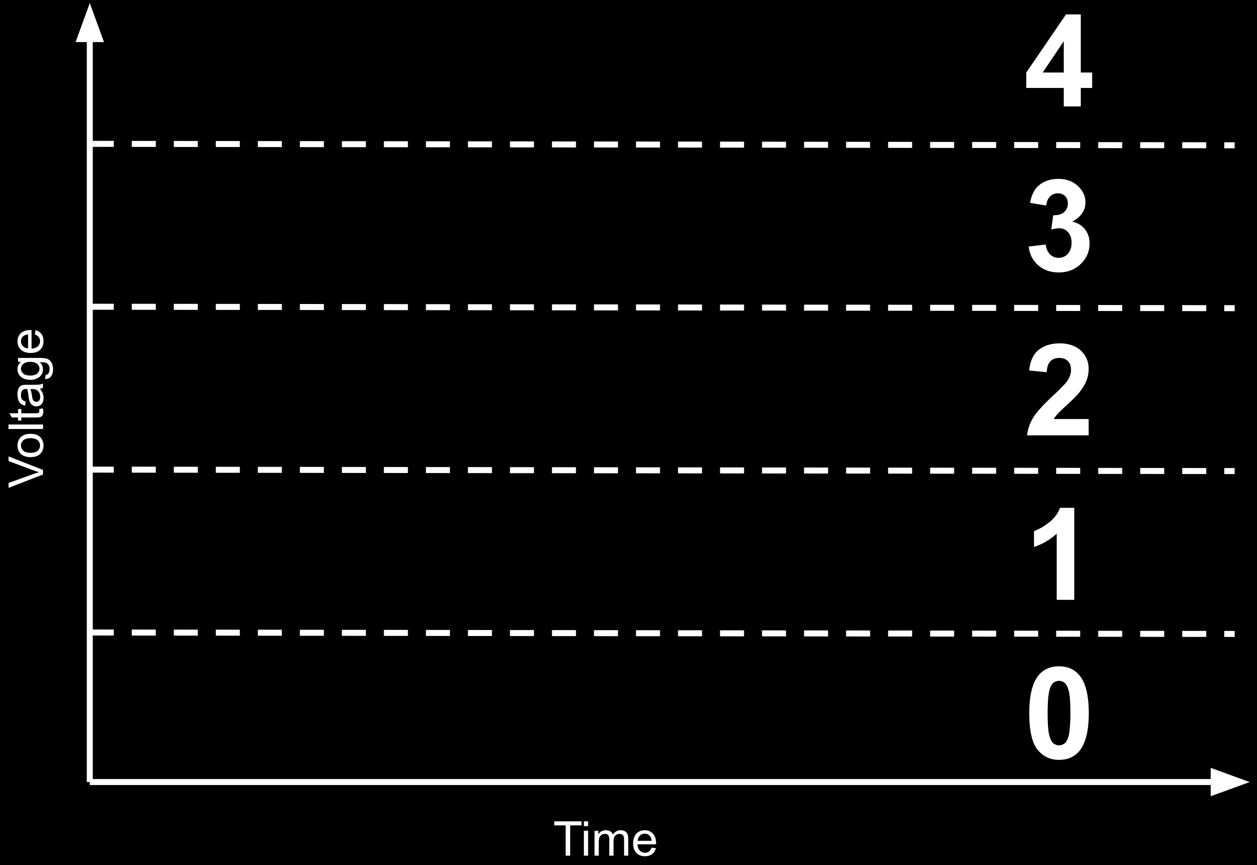

Voltage
equidistant
interval
Time

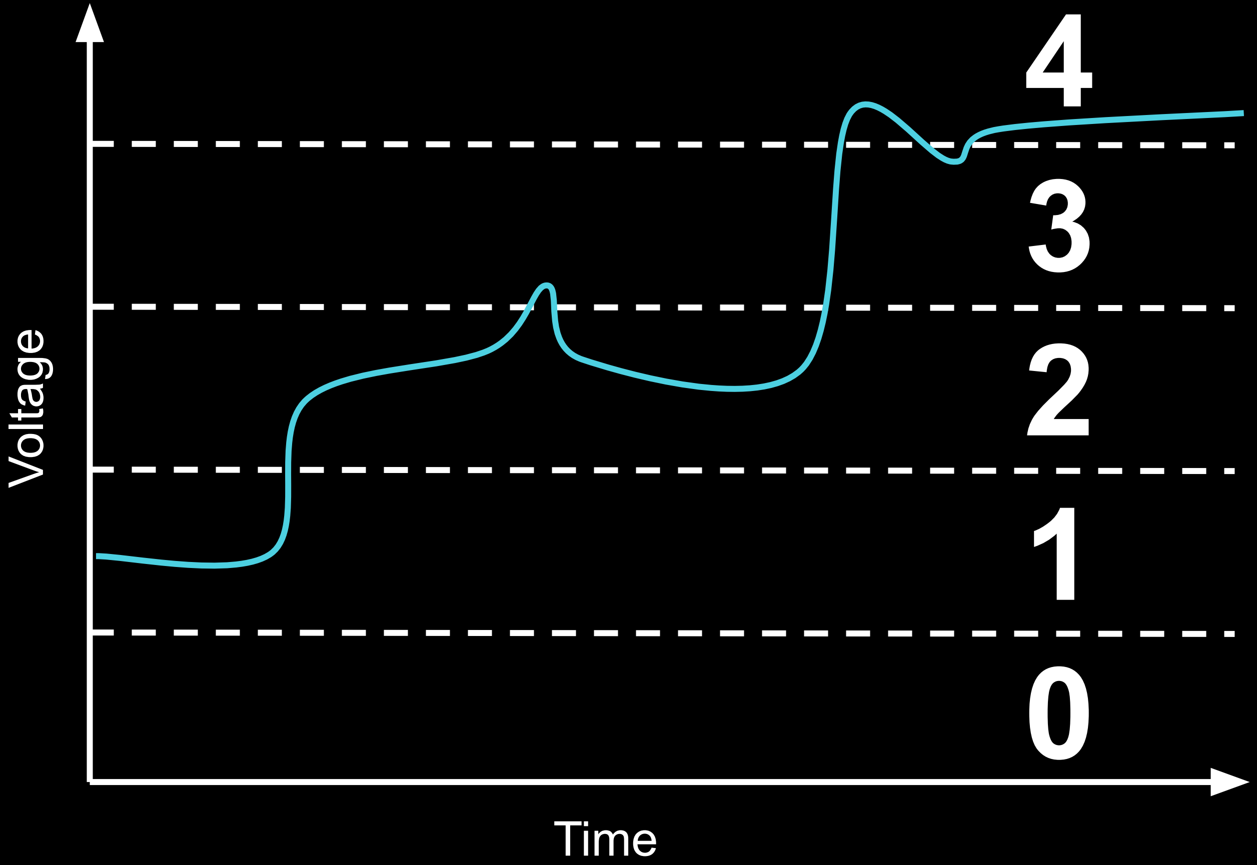

Voltage
equidistant
interval
0
1
0

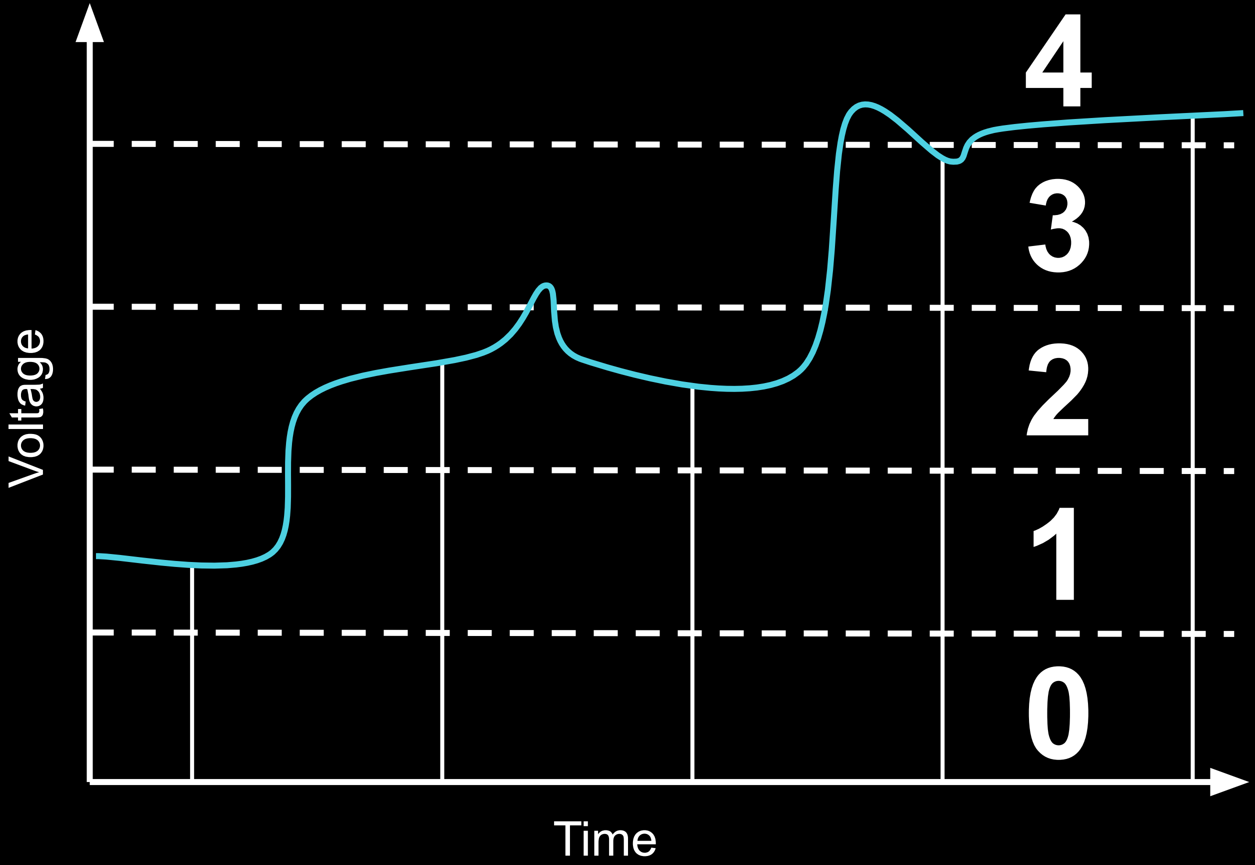
What about ternary?

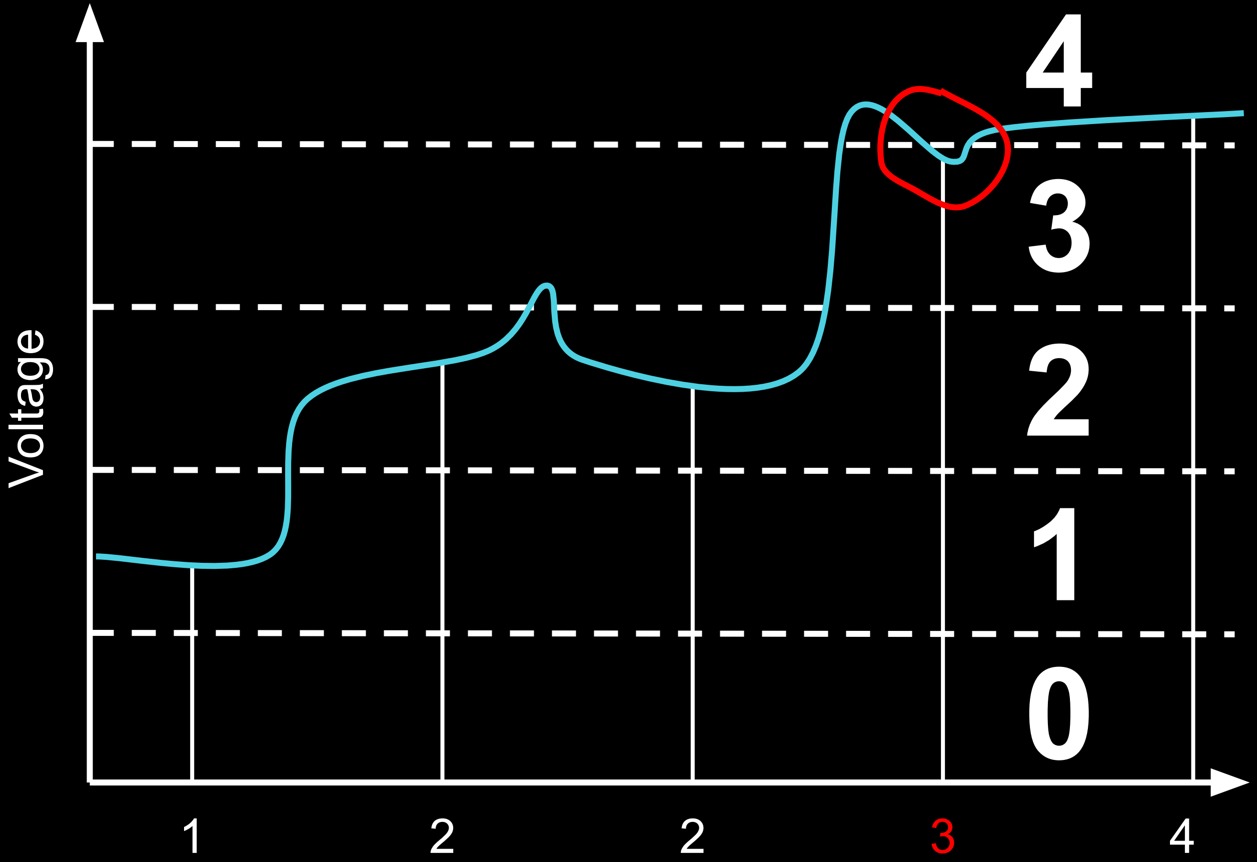

2
1
0
Voltage
Time


3
2
1
0
Voltage
Time


4
3
2
1
0
Voltage
Time

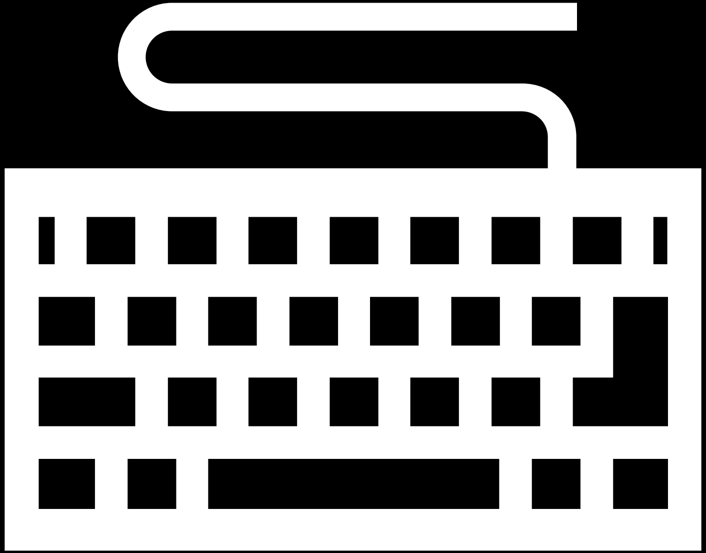

4
3
2
1
0
Voltage
Time


4
3
2
1
0
Voltage
Time


Voltage
4
3
2
1
0
1
2
2
3
4

CODES

● ● ● ▬ ▬ ▬ ● ● ●



A	B	C	D	...	a	b	c	d
65	66	67	68		97	98	99	100

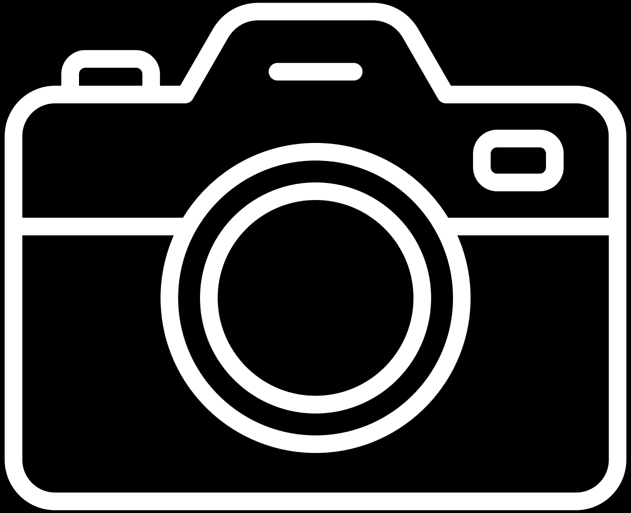
ASCII Code

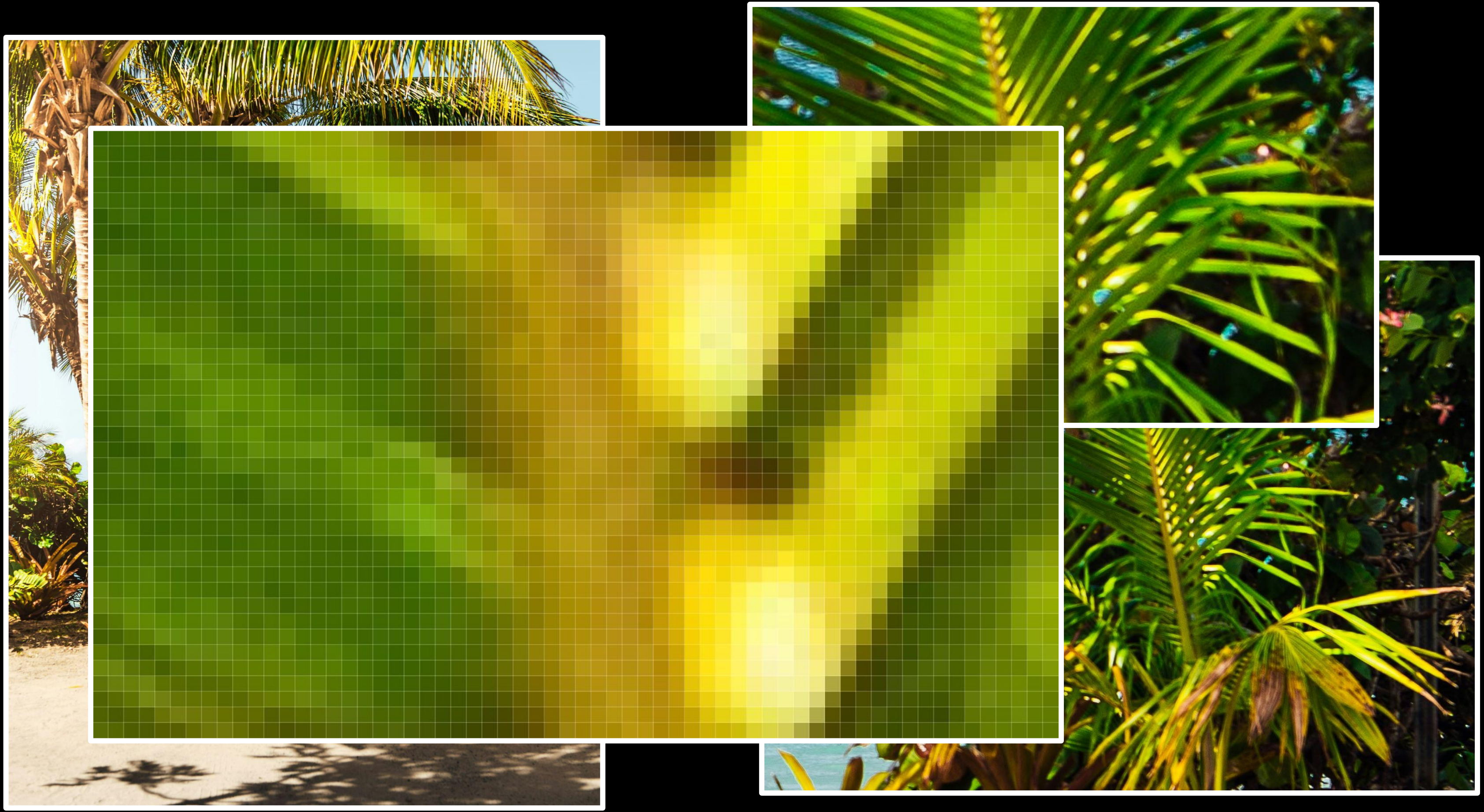
A	B	C	D	...	a	b	c	d
65	66	67	68		97	98	99	100

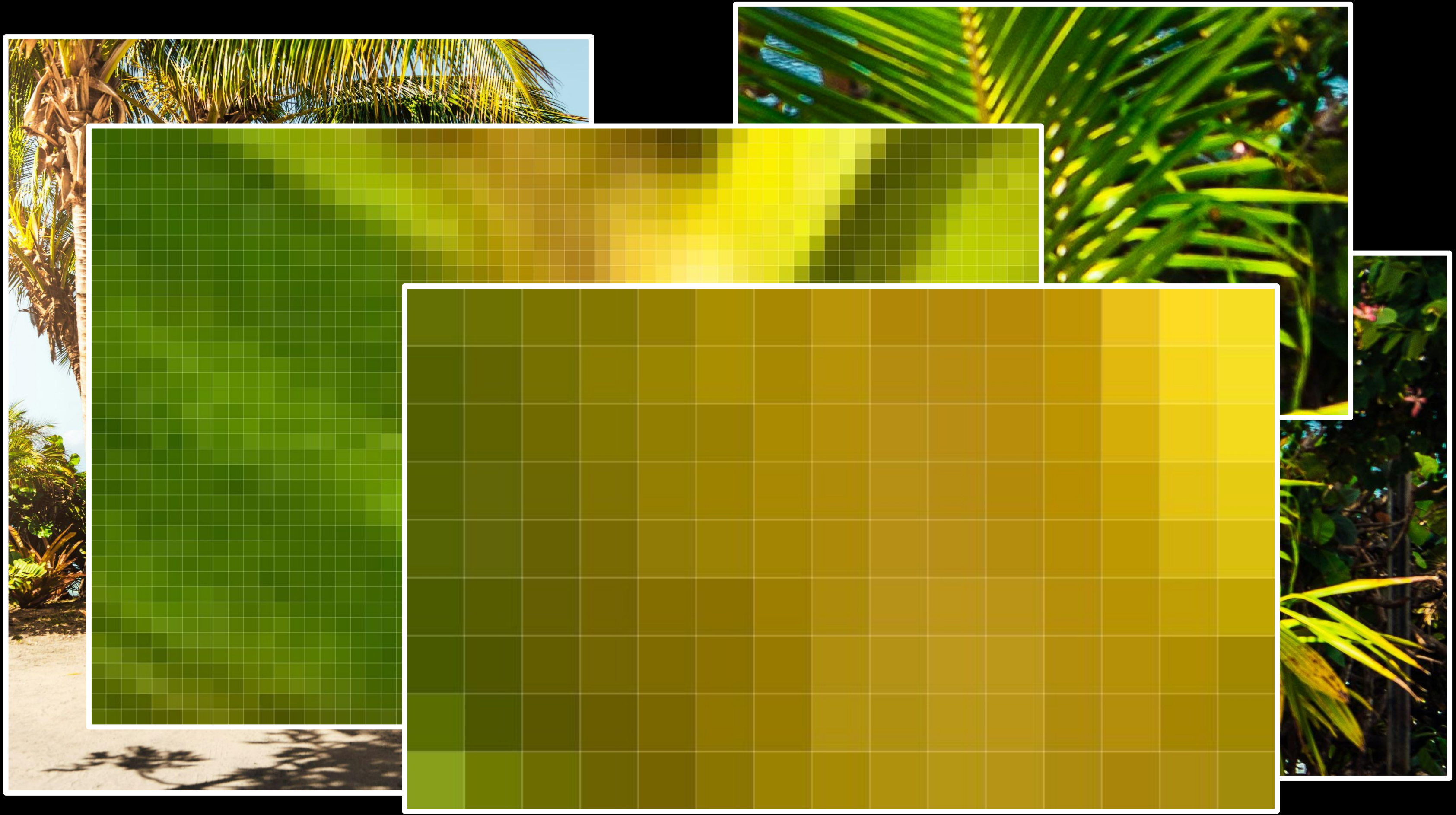
😀	😁	😂	😃	...	🙈	🙉	🙊	🙋
1F600	1F601	1F602	1F603		1F648	1F649	1F64A	1F64B

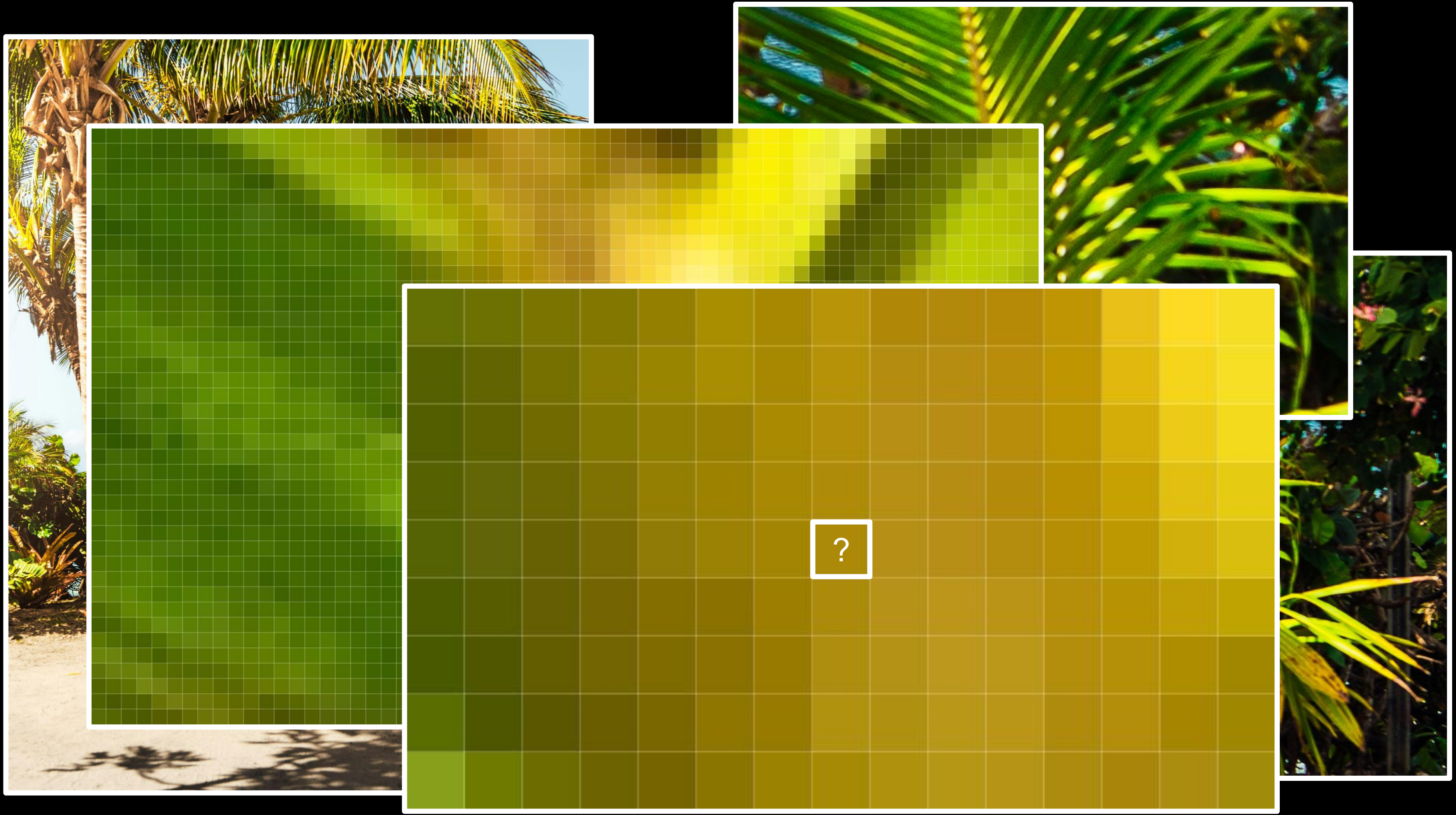
Unicode

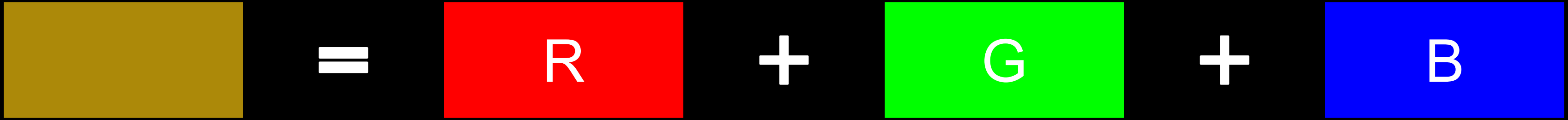
😀	😁	😂	😃	…	🙈	🙉	🙊	🙋
1F600	1F601	1F602	1F603		1F648	1F649	1F64A	1F64B



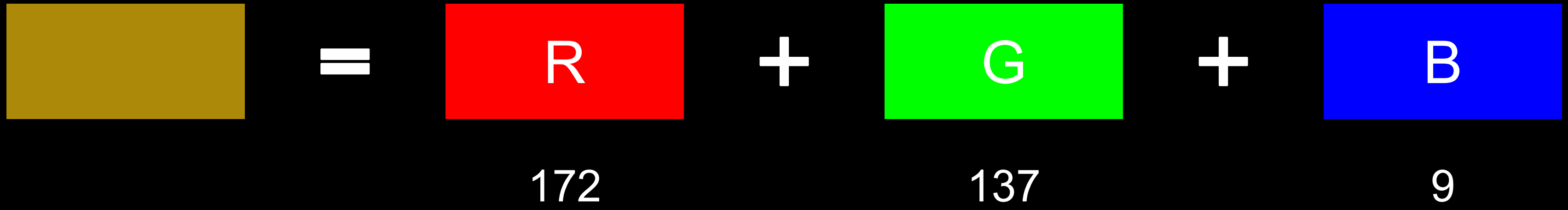






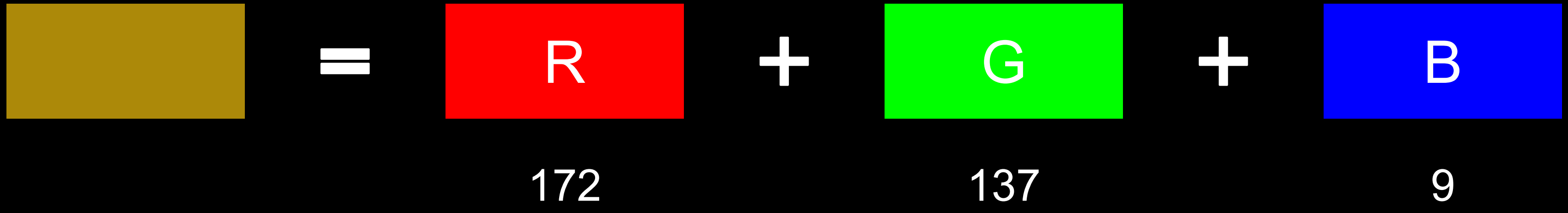


= R + G + B



= R + G + B

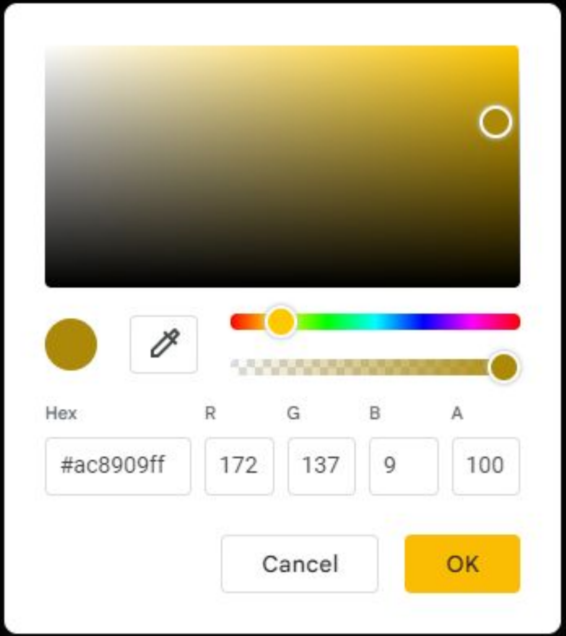
172 137 9



= R + G + B

172 137 9

#AC8909



Hex	R	G	B	A
#ac8909ff	172	137	9	100

🟫	=	🟥 R	+	🟩 G	+	🟦 B
		172		137		9
#AC8909		AC		89		09

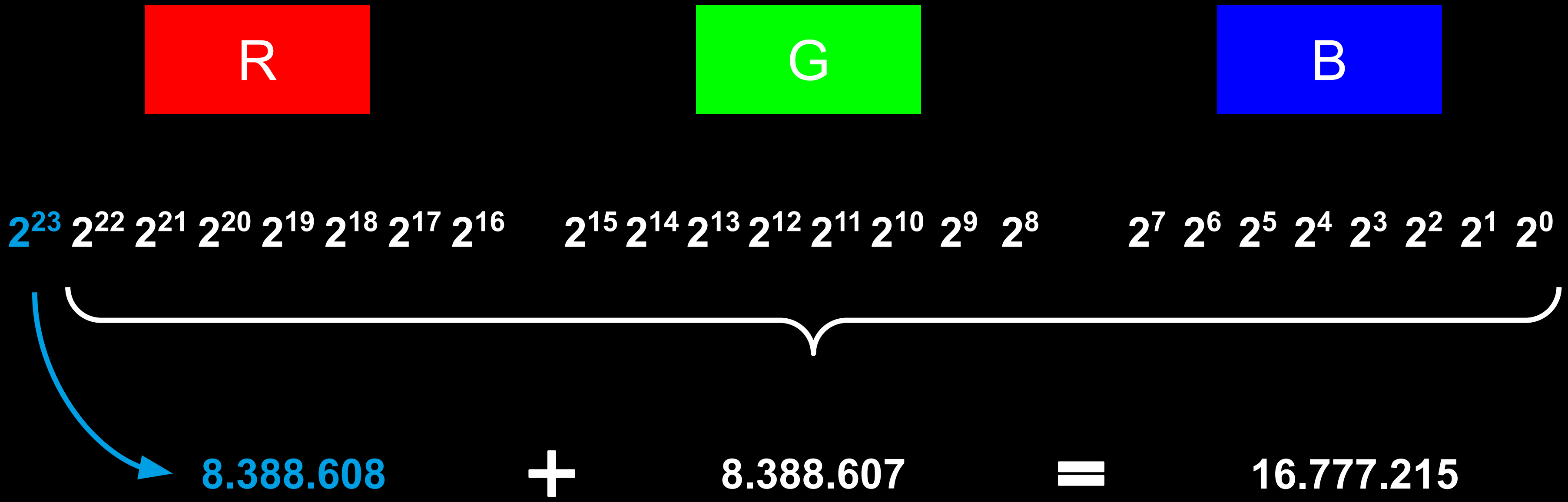
🟨	=	R	+	G	+	B
		172		137		9
#AC8909		AC		89		09
		10101100		01011001		00001001

# possible colors?

R

2^7 2^6 2^5 2^4 2^3 2^2 2^1 2^0

R	G	B
2^{23} 2^{22} 2^{21} 2^{20} 2^{19} 2^{18} 2^{17} 2^{16}	2^{15} 2^{14} 2^{13} 2^{12} 2^{11} 2^{10} 2^{9} 2^{8}	2^{7} 2^{6} 2^{5} 2^{4} 2^{3} 2^{2} 2^{1} 2^{0}



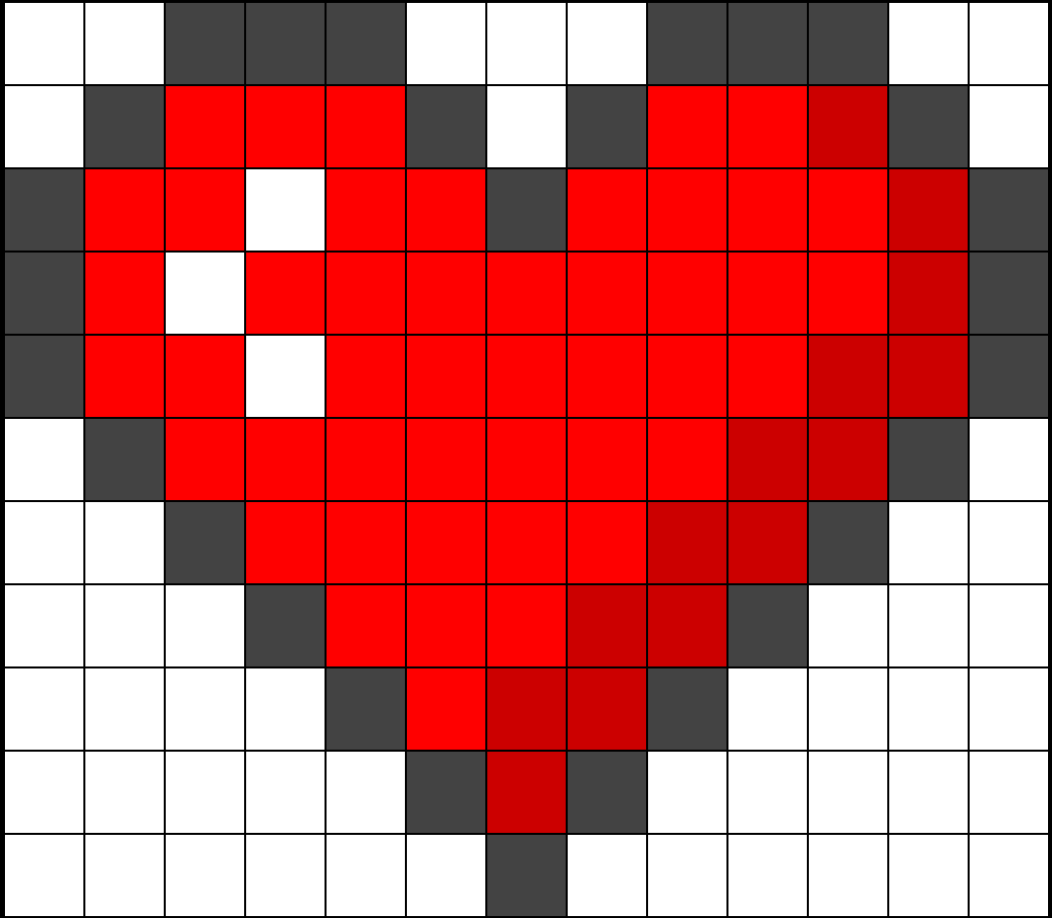
R G B

2^{23} 2^{22} 2^{21} 2^{20} 2^{19} 2^{18} 2^{17} 2^{16} 2^{15} 2^{14} 2^{13} 2^{12} 2^{11} 2^{10} 2^{9} 2^{8} 2^{7} 2^{6} 2^{5} 2^{4} 2^{3} 2^{2} 2^{1} 2^{0}

8.388.608 + 8.388.607 = 16.777.215

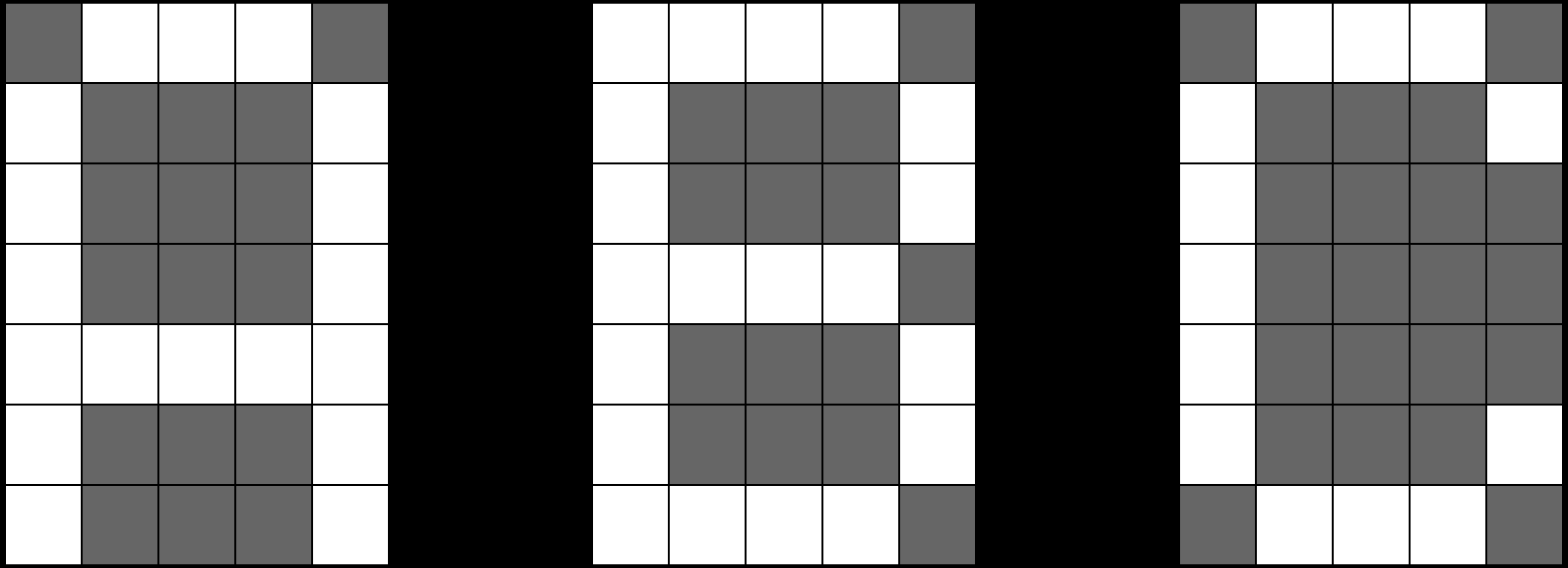
R G B

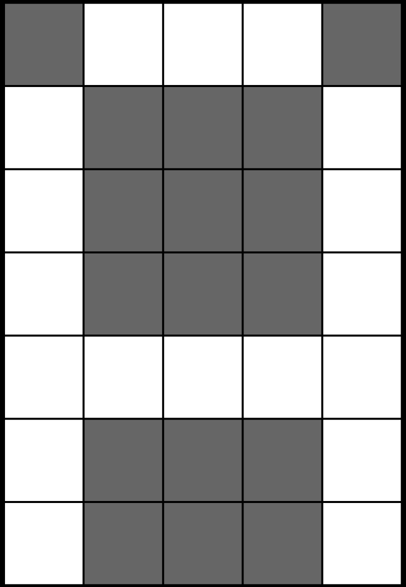
$$\underbrace{2^{23}\ 2^{22}\ 2^{21}\ 2^{20}\ 2^{19}\ 2^{18}\ 2^{17}\ 2^{16}}_{256} \times \underbrace{2^{15}\ 2^{14}\ 2^{13}\ 2^{12}\ 2^{11}\ 2^{10}\ 2^{9}\ 2^{8}}_{256} \times \underbrace{2^{7}\ 2^{6}\ 2^{5}\ 2^{4}\ 2^{3}\ 2^{2}\ 2^{1}\ 2^{0}}_{256}$$



CS50 Pixel Art

compression





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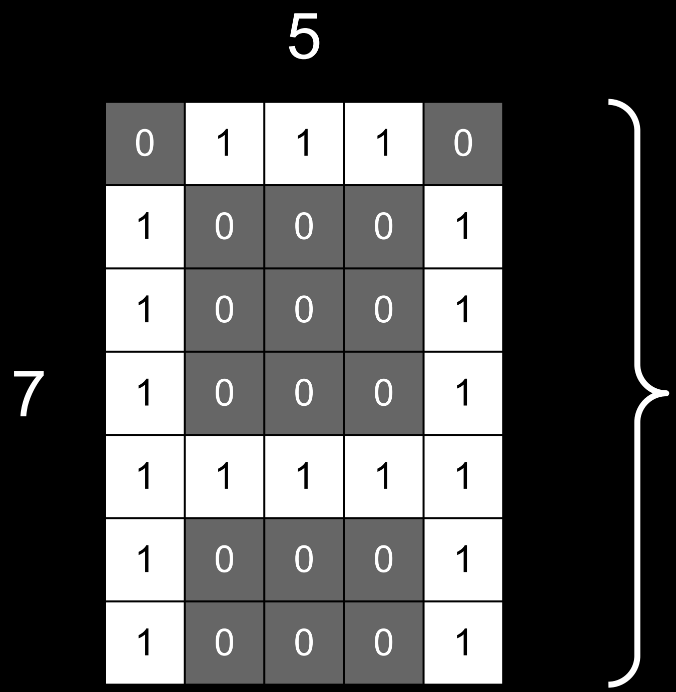

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