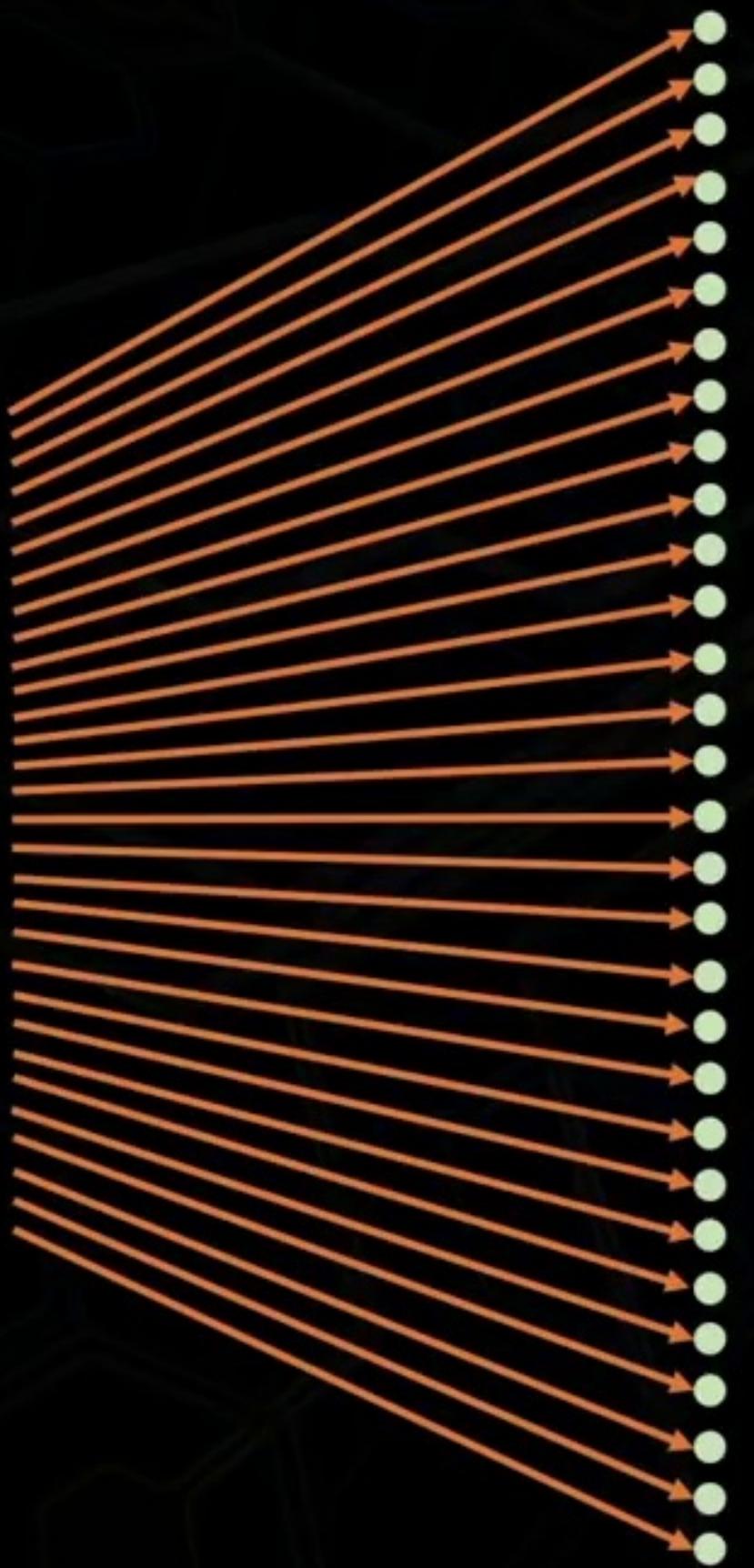


169	171	172	176	182	184	166	91	57	57	62
172	170	176	180	182	183	88	62	55	55	57
172	175	176	181	191	175	66	62	53	57	62
175	172	180	181	188	157	97	75	48	49	62
172	175	180	182	184	110	106	90	55	54	63
172	176	179	188	147	72	96	90	73	62	71



Capa de entrada



169

171

172

176

182

184

166

91

57

57

62

172

170

176

172

175

176

175

172

180

172

175

180

172

176

179

100

147

72

70

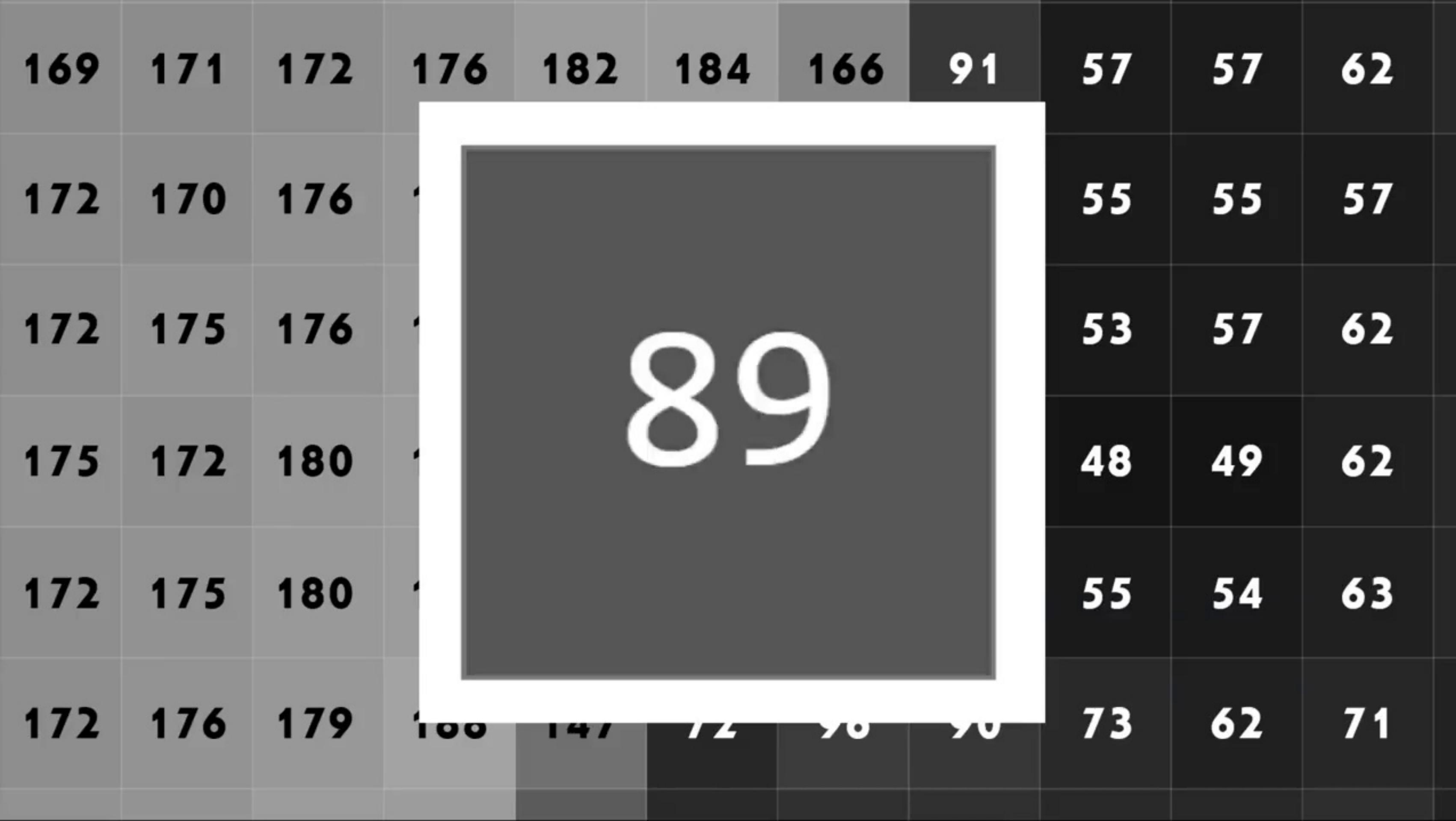
70

73

62

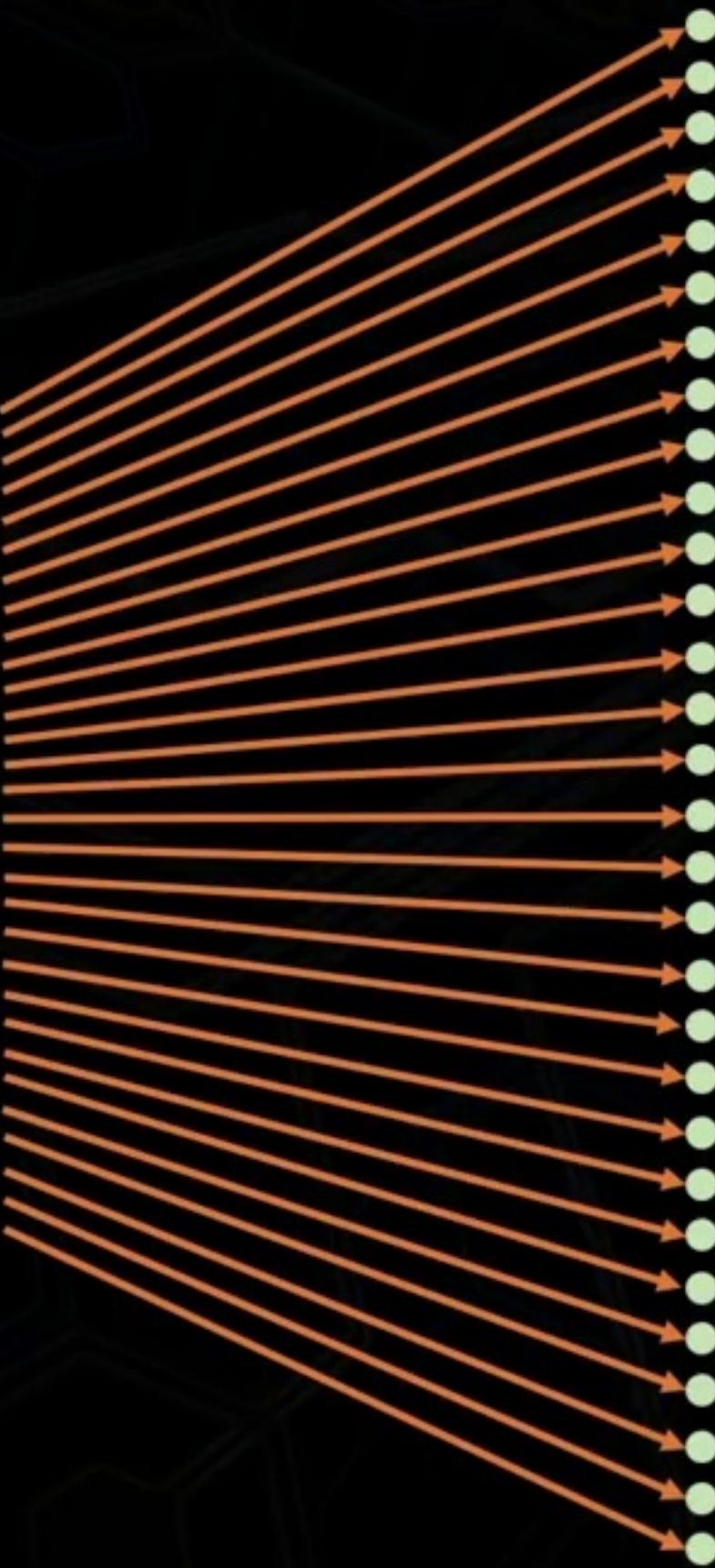
71





169	171	172	176	182	184	166	91	57	57	62
172	170	176	176	176	176	176	176	55	55	57
172	175	176	176	176	176	176	176	53	57	62
175	172	180	180	180	180	180	180	48	49	62
172	175	180	180	180	180	180	180	55	54	63
172	176	179	180	181	182	183	183	73	62	71

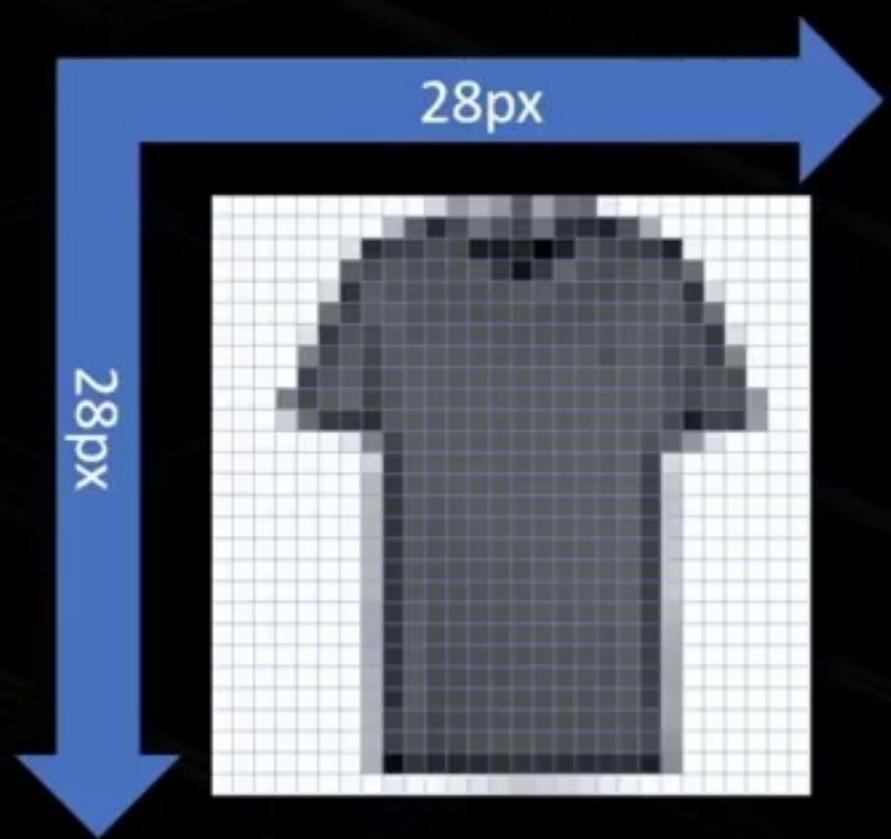
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175	172	180	180	180	180	180	180	48	49	62
172	175	180	180	180	180	180	180	55	54	63
172	176	179	180	181	182	183	183	73	62	71



Capa de entrada

**Un pixel en
cada neurona**





28 x 28

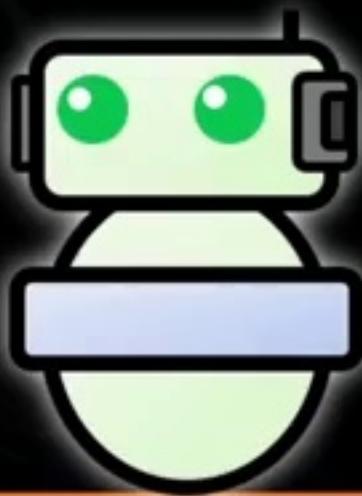
**784
pixels**



169	171	172	176	182	184	166	91	57	57	62
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175	172	180	181	188	157	97	75	48	49	62
172	175	180	182	184	110	106	90	55	54	63
172	176	179	188	147	72	96	90	73	62	71

169	171	172	176	182	184	166	91	57	57	62
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175	172	180	181	188	157	97	75	48	49	62
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172	176	179	188	147	72	96	90	73	62	71

169	171	172	176	182	184	166	91	57	57	62
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9



9



9

9

9

?

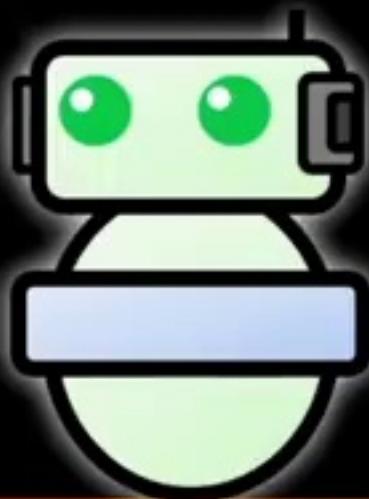


q

q

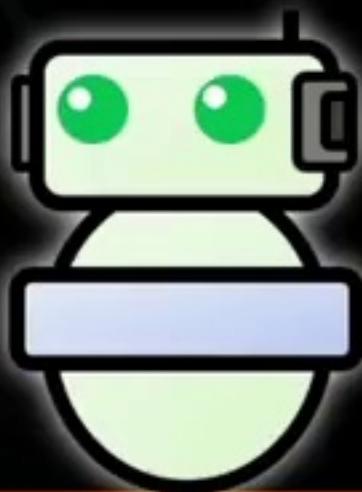
q

q



9

8

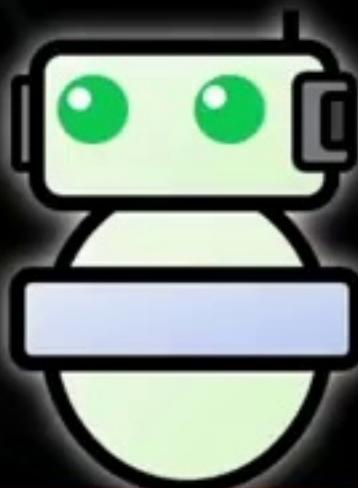


de círculos



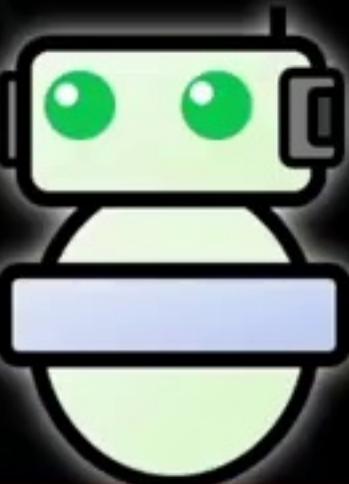
de círculos

2



de círculos

1

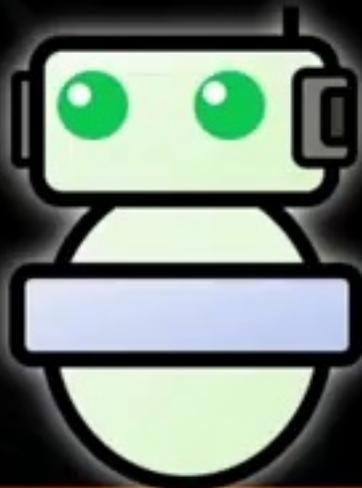


0

9

8

de círculos

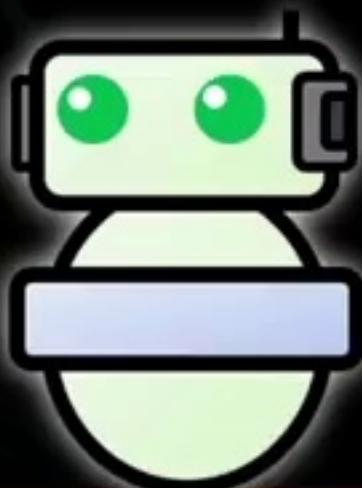


de círculos

2

de líneas

x

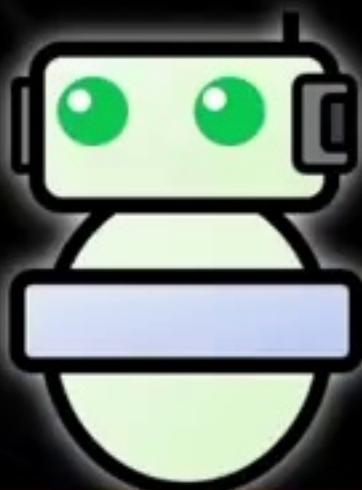


de círculos

1

de líneas

0



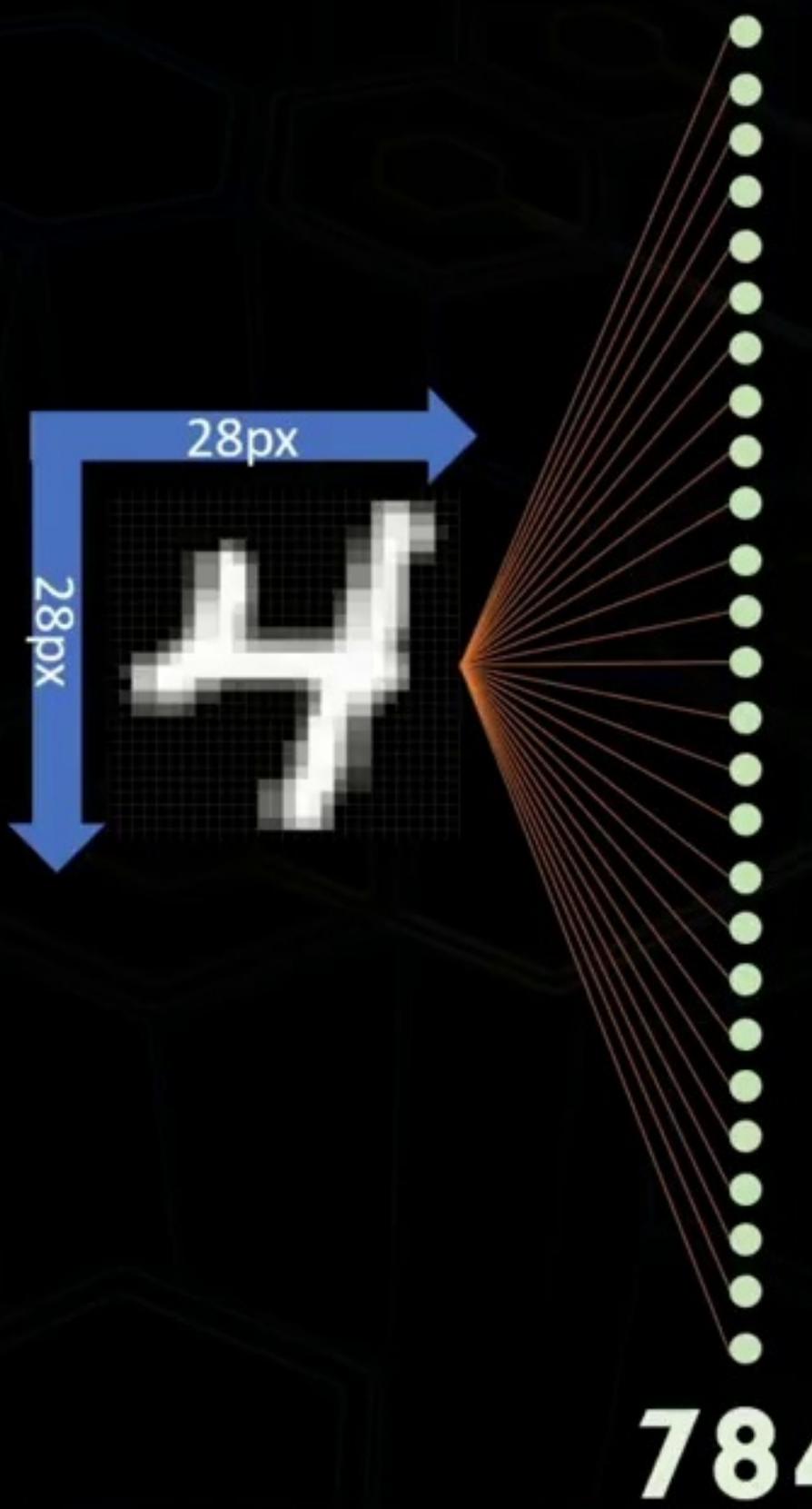
UN CÍRCULO



LINEA VERTICAL A LA
DERECHA DEL CÍRCULO



Capa de entrada



Oculta



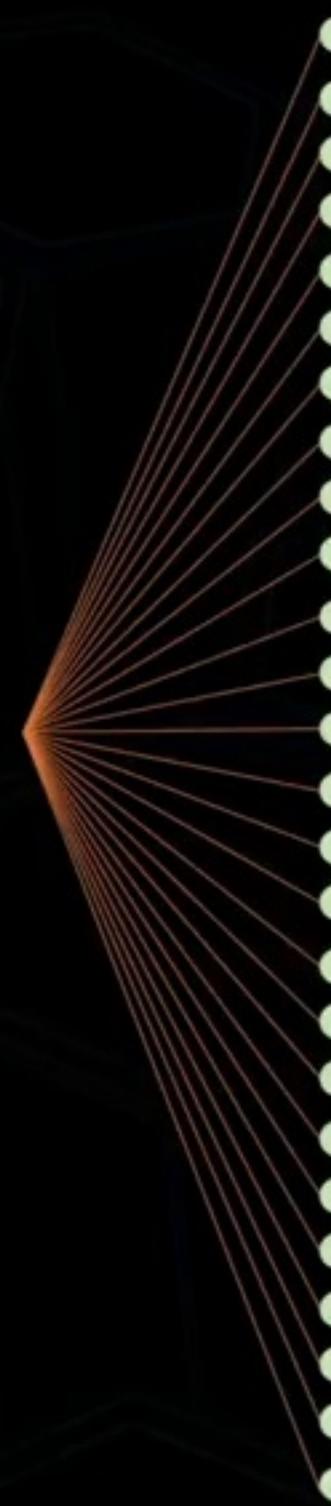
Oculta



Capa de salida

-  0
-  1
-  2
-  3
-  4
-  5
-  6
-  7
-  8
-  9

Capa de entrada



784

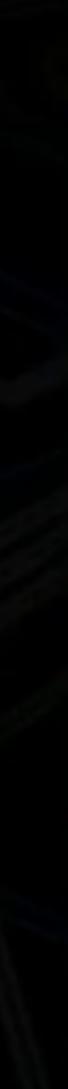
Capa de convolución



Extracción de
características

Capa de agrupación

Oculta



Oculta



Capa de salida

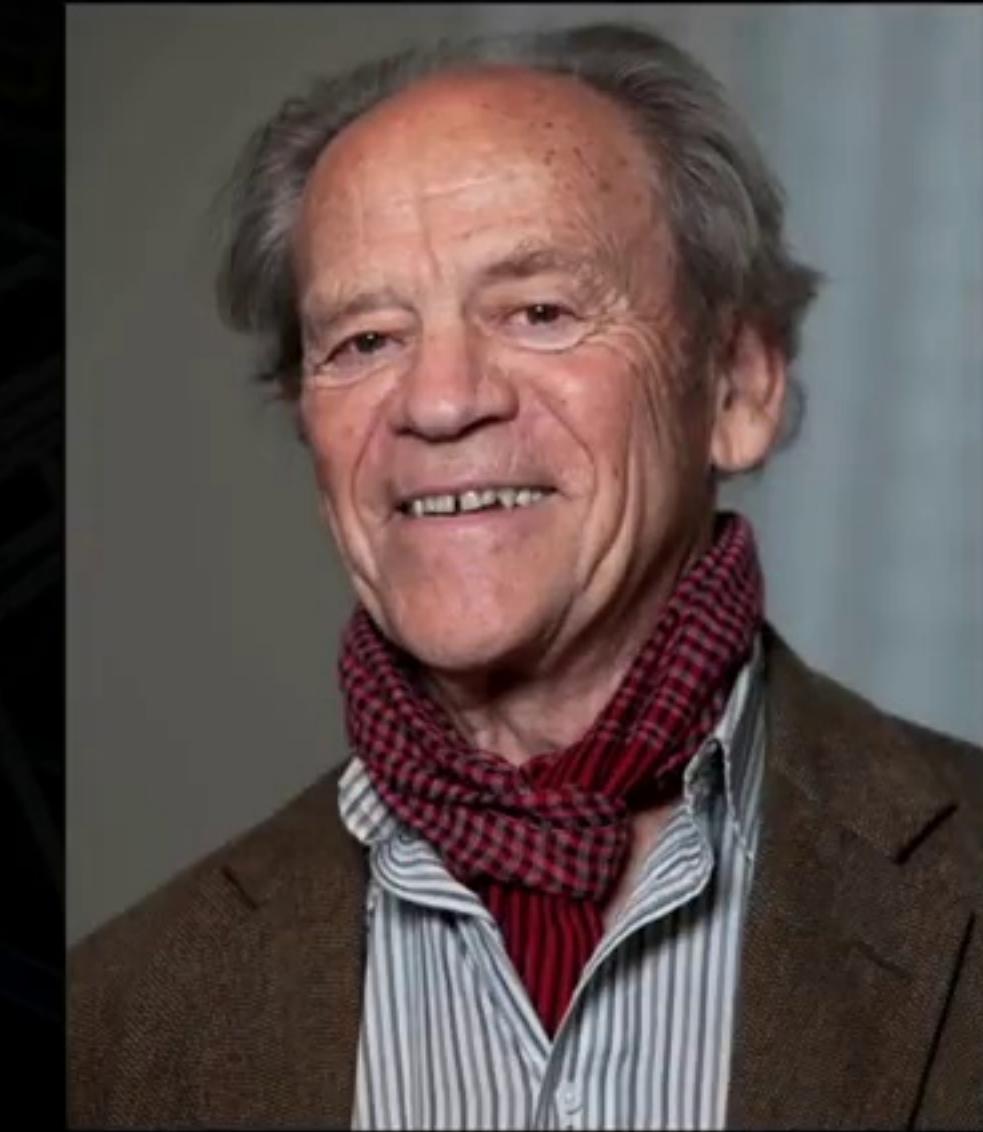
- 0
- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9



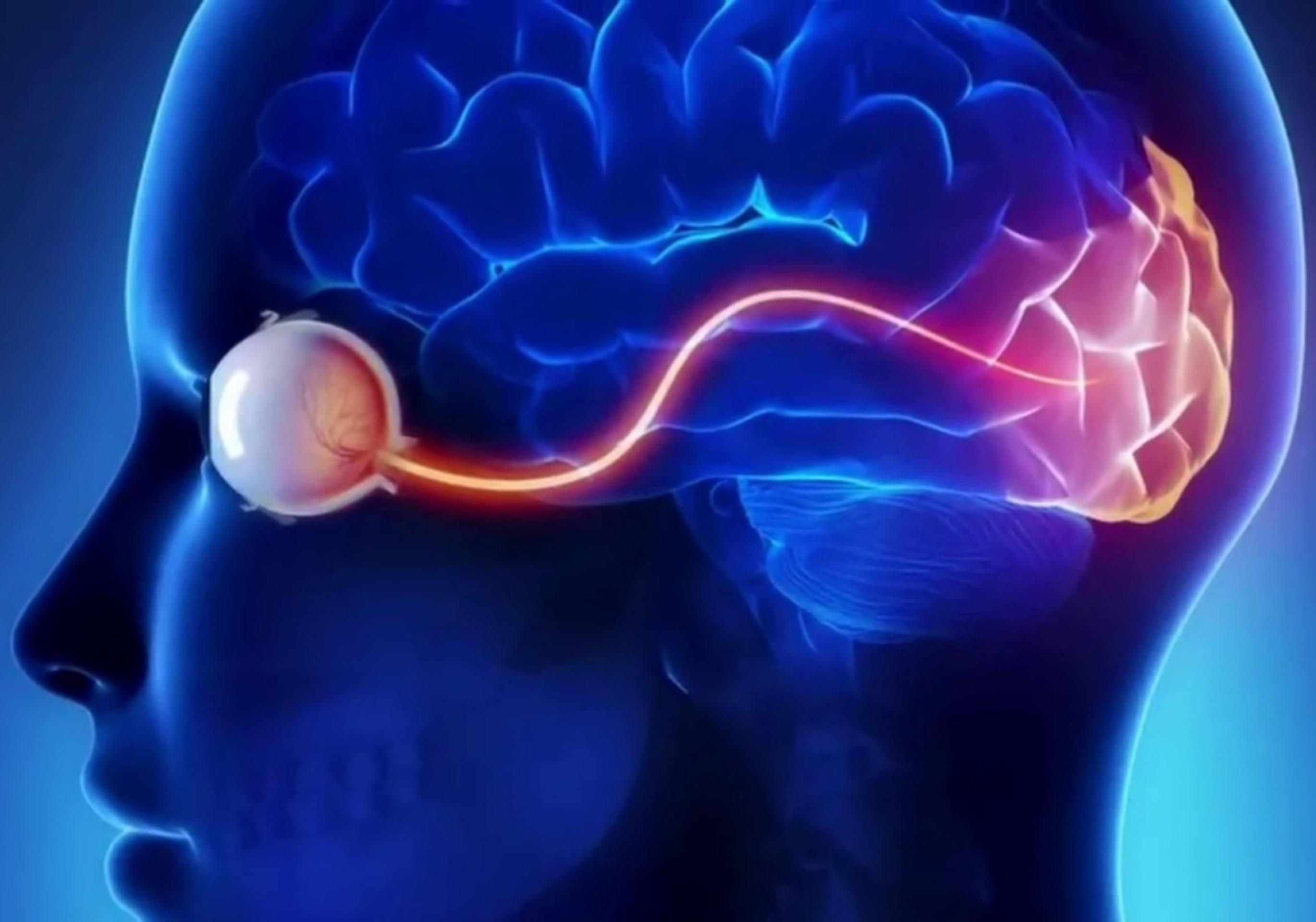
**David H.
Hubel**



**Gato
(no este)**



**Torsten
Wiesel**





Simple



Simple



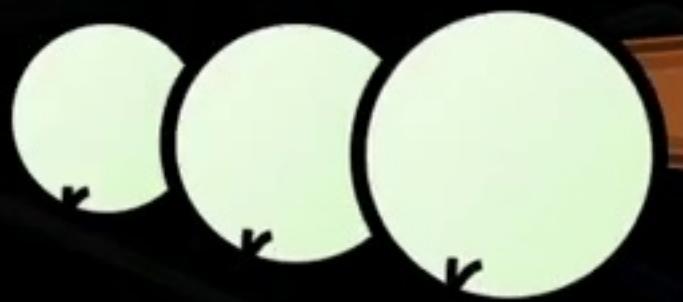
Compleja

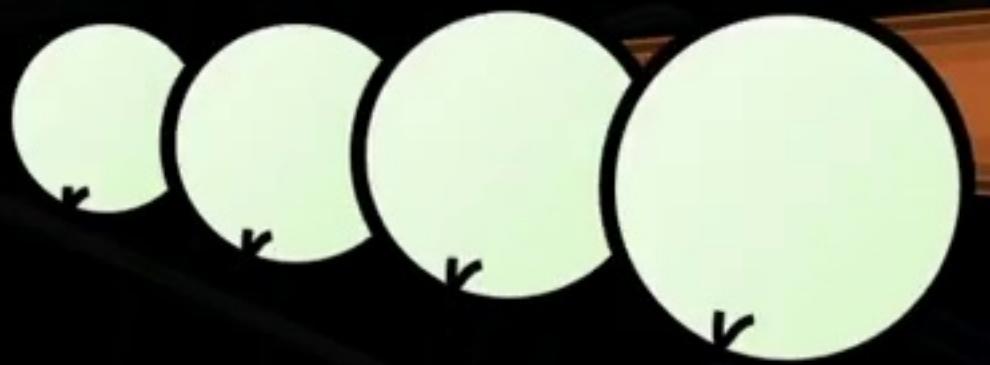
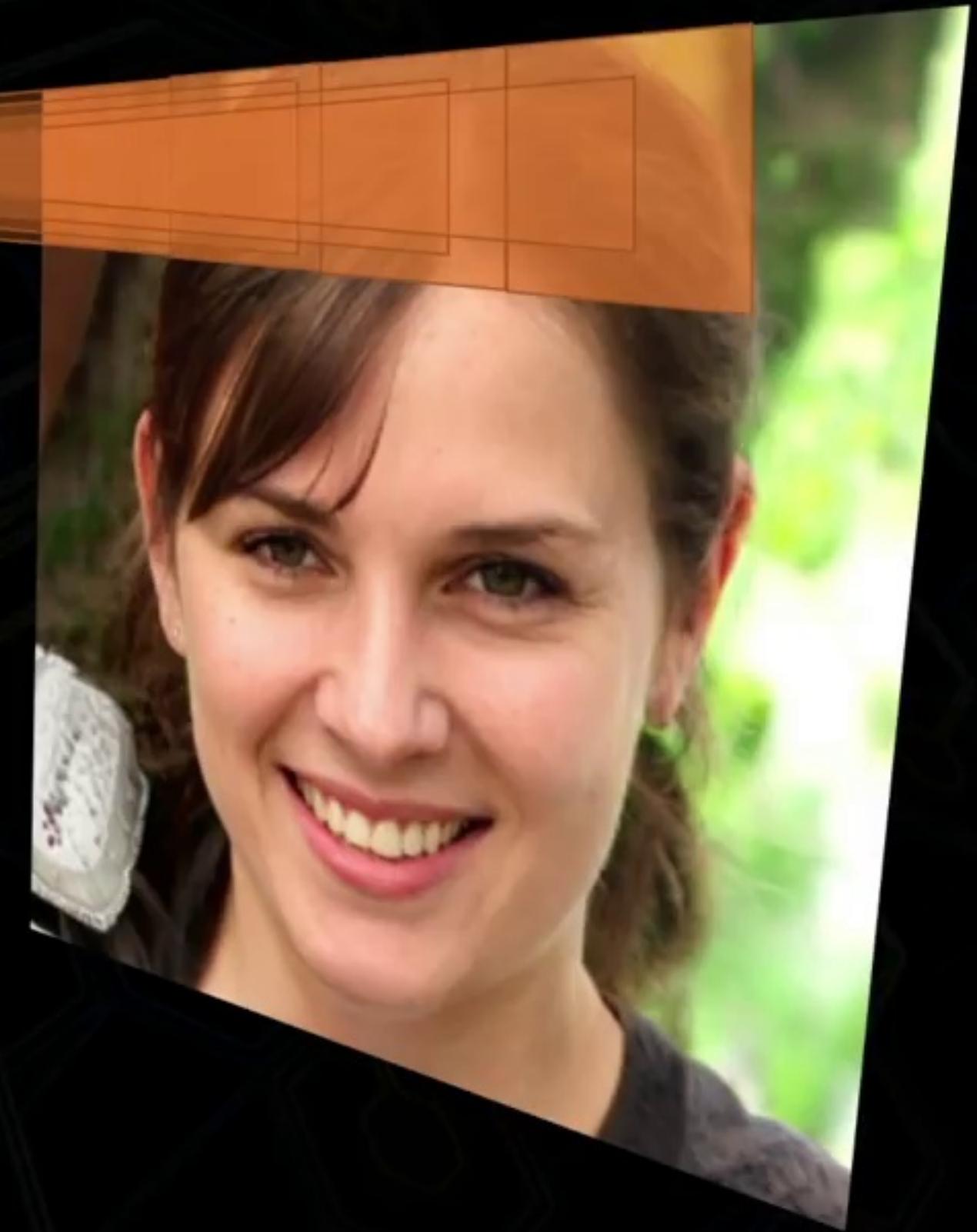


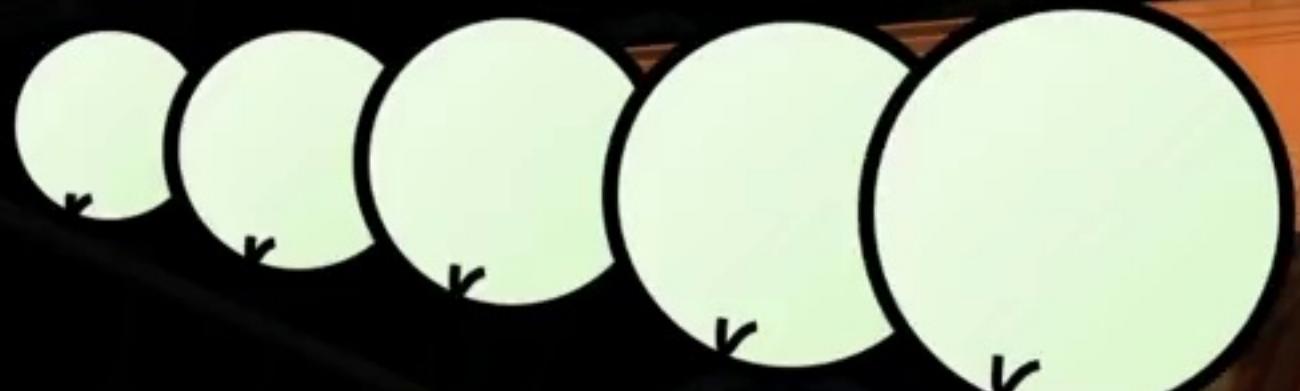


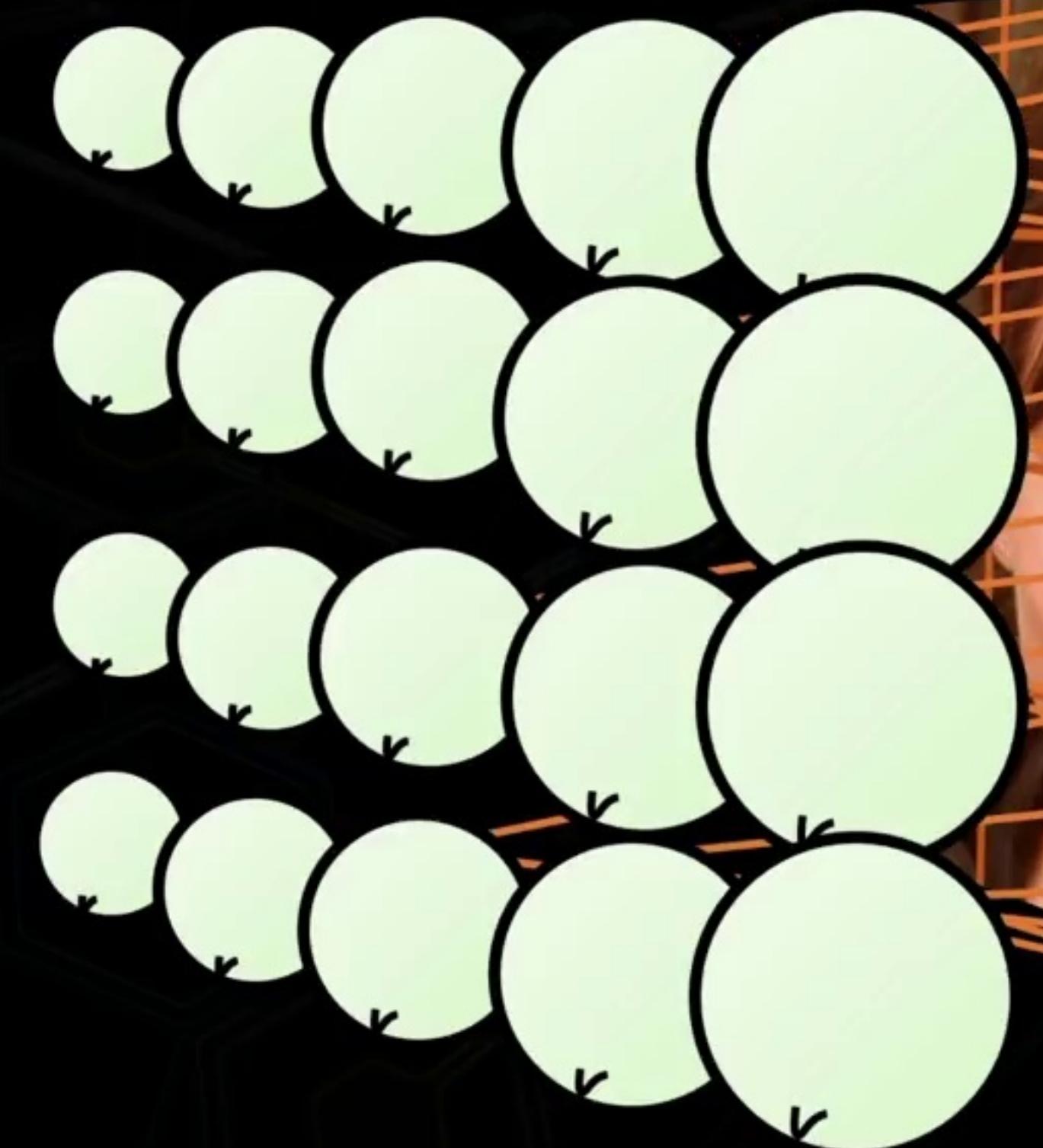






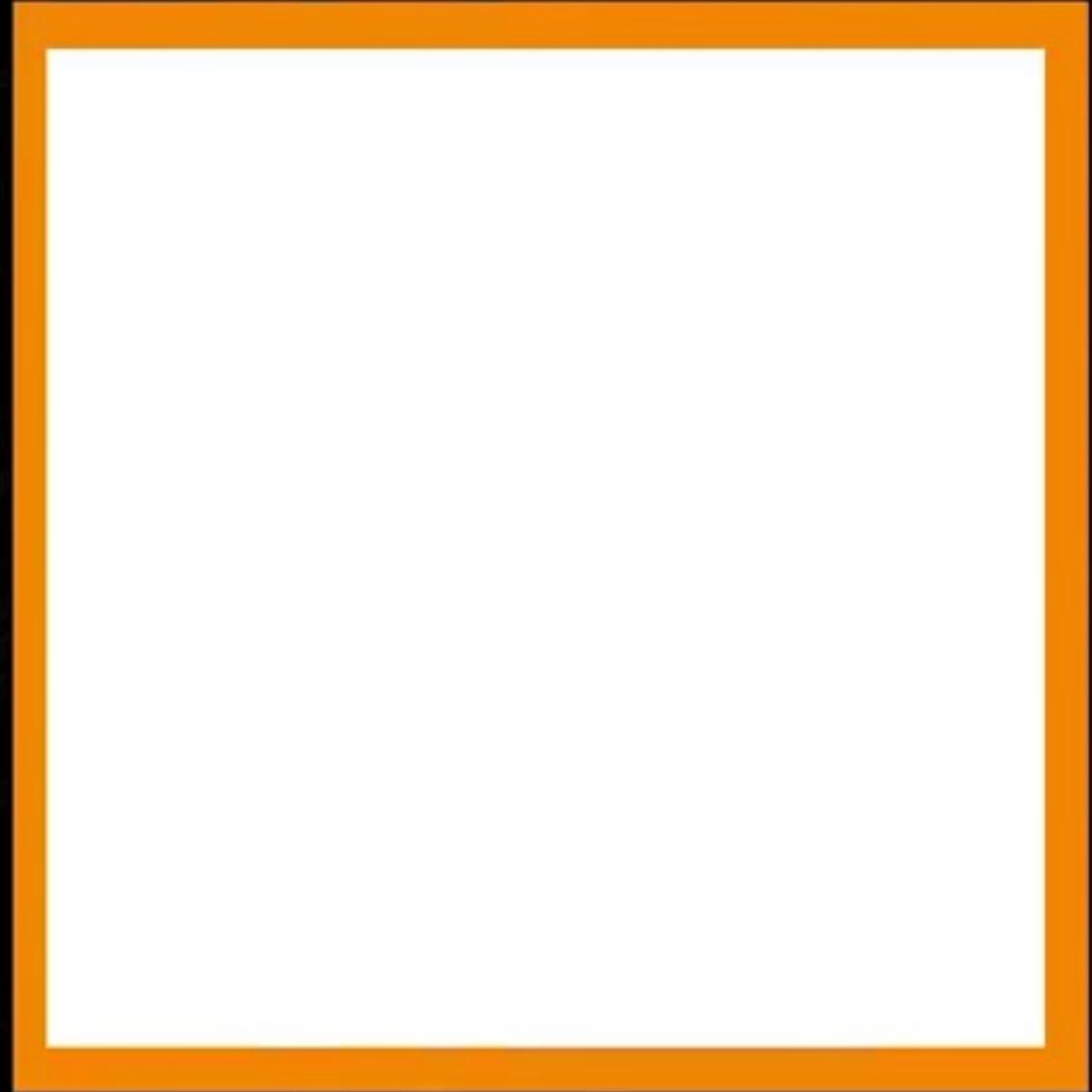








Simple





Simple





Simple





Simple



ACTIVADA



Simple



ACTIVADA



Simple





Simple

NO ACTIVADA



Simple



NO ACTIVADA



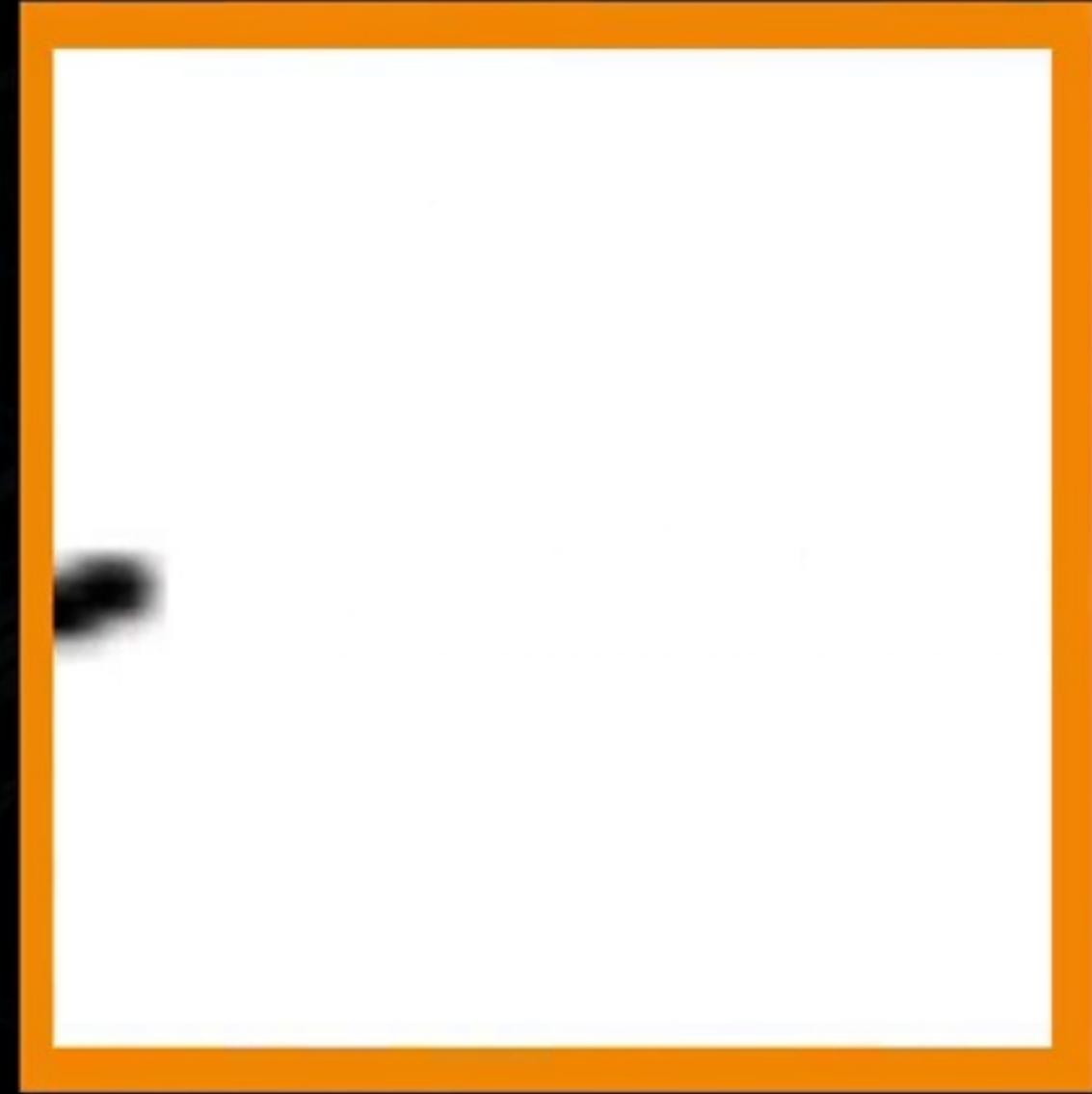
Simple

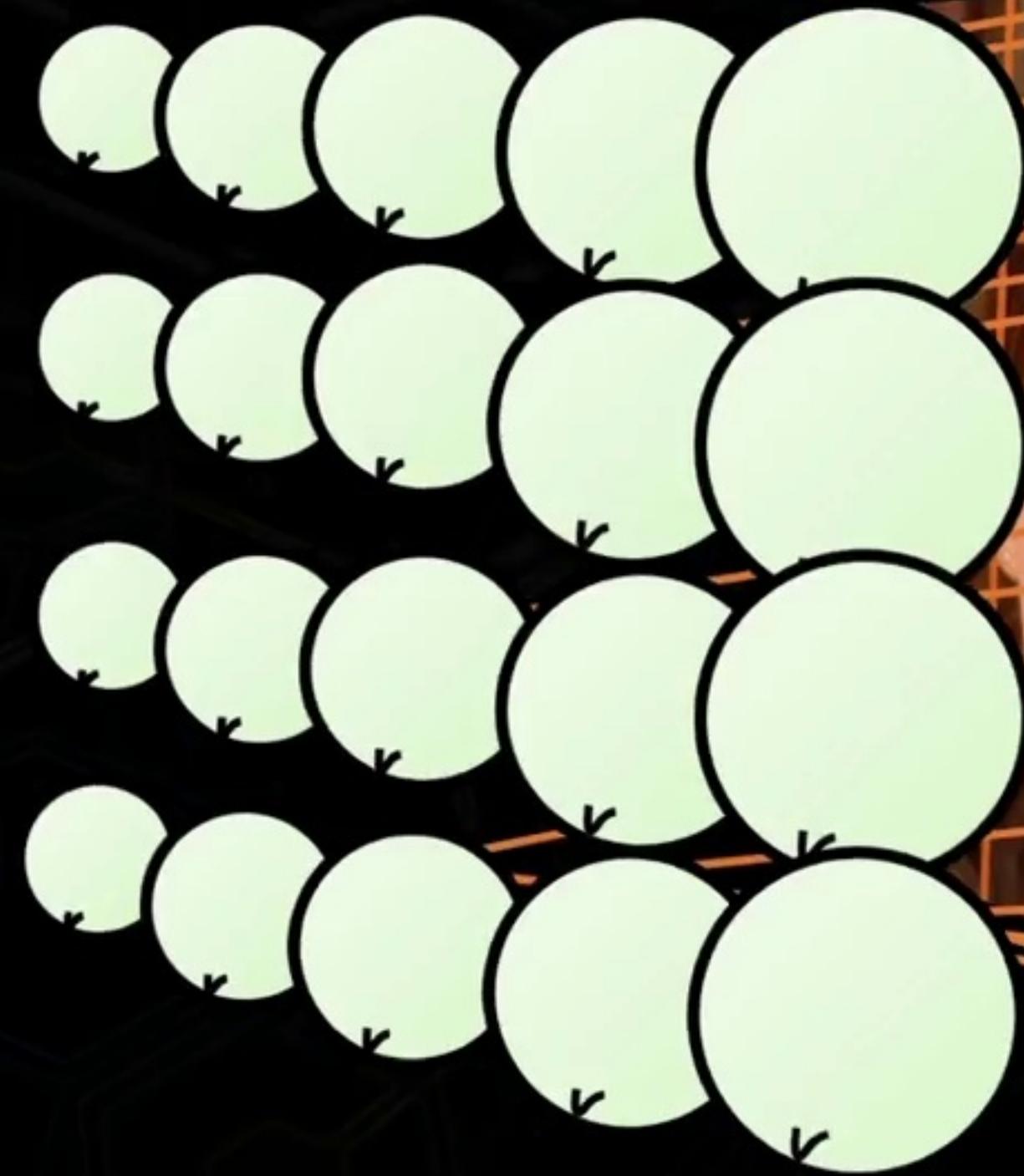
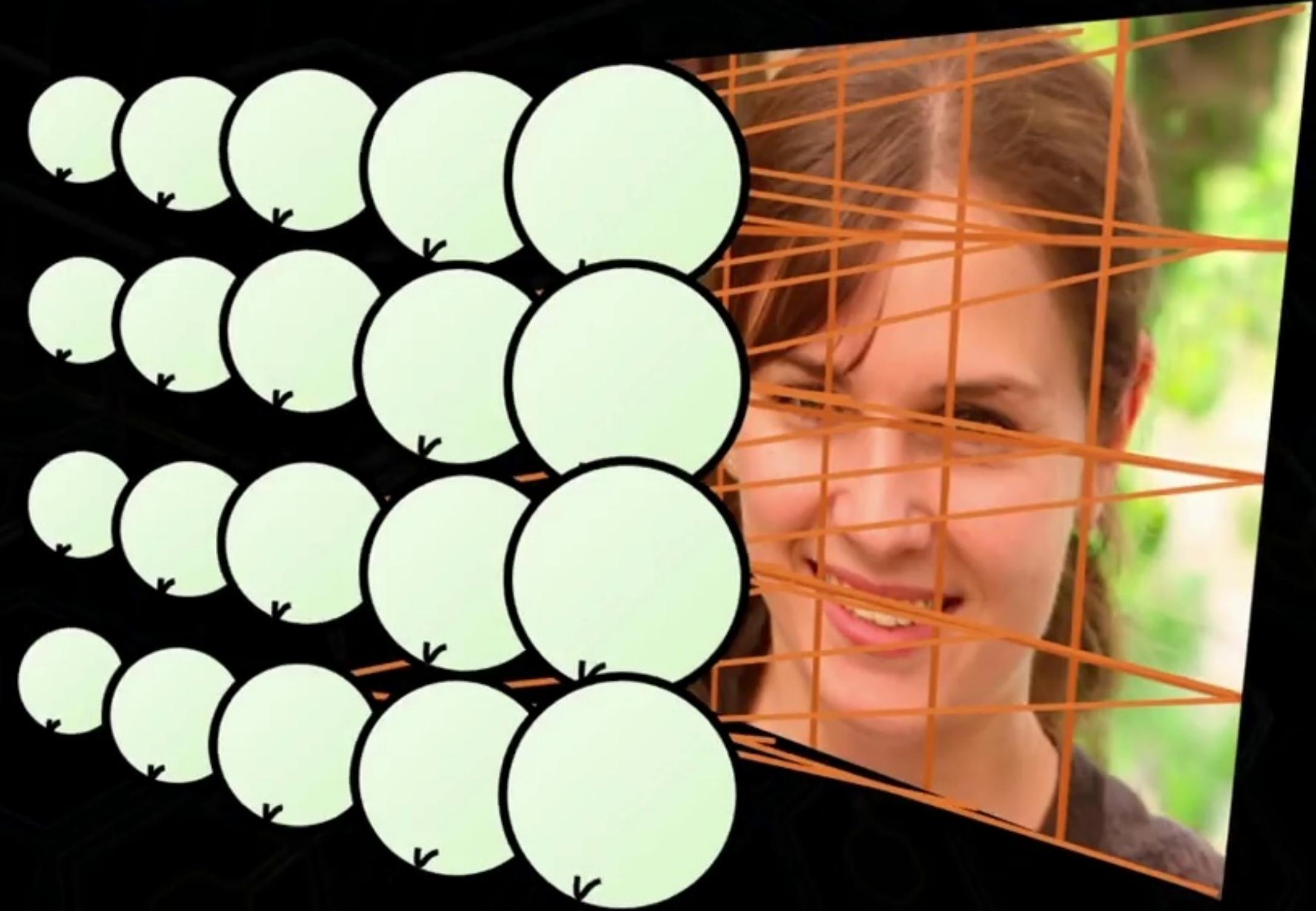


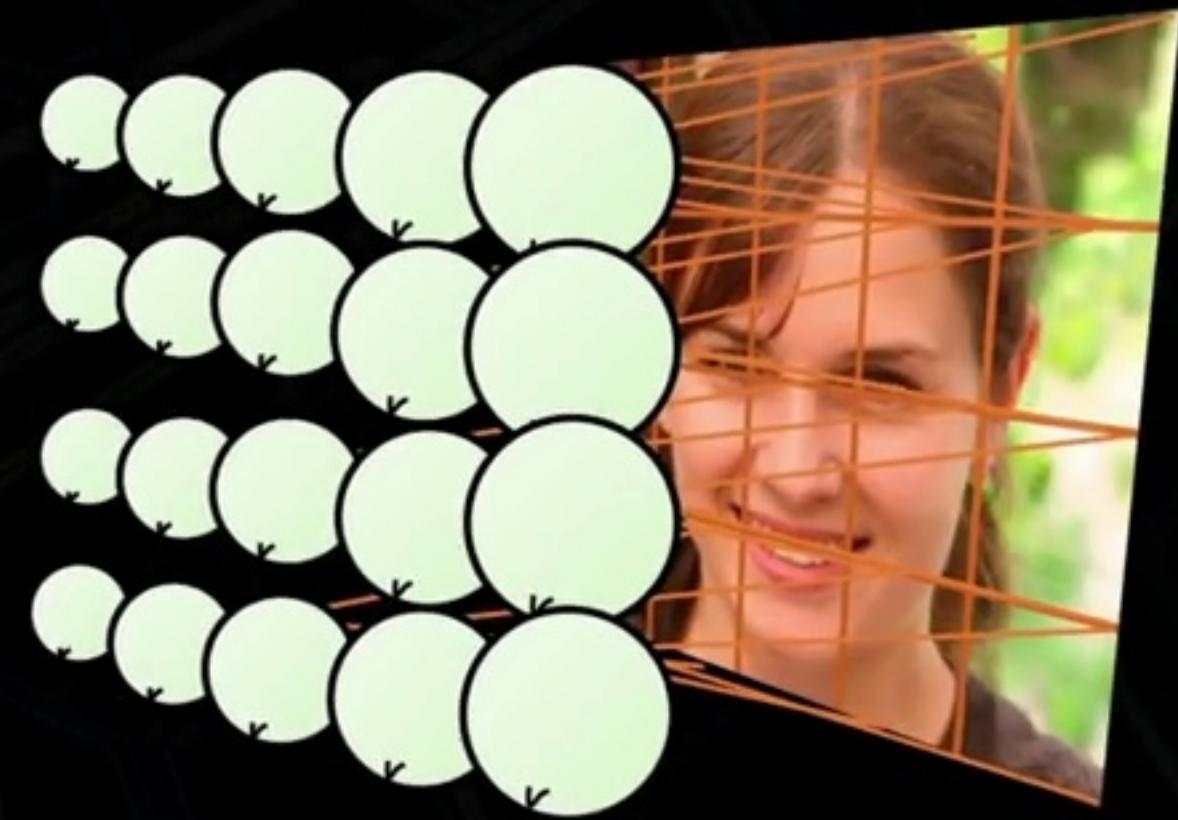
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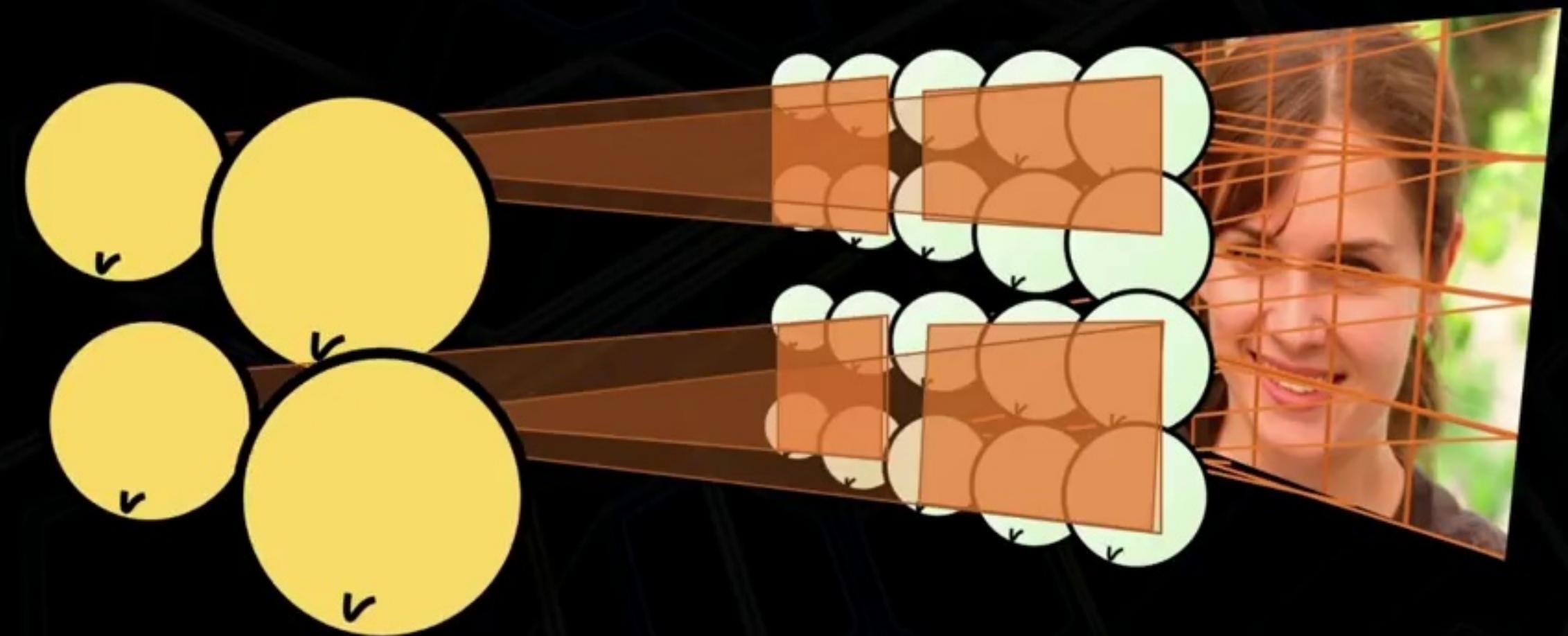


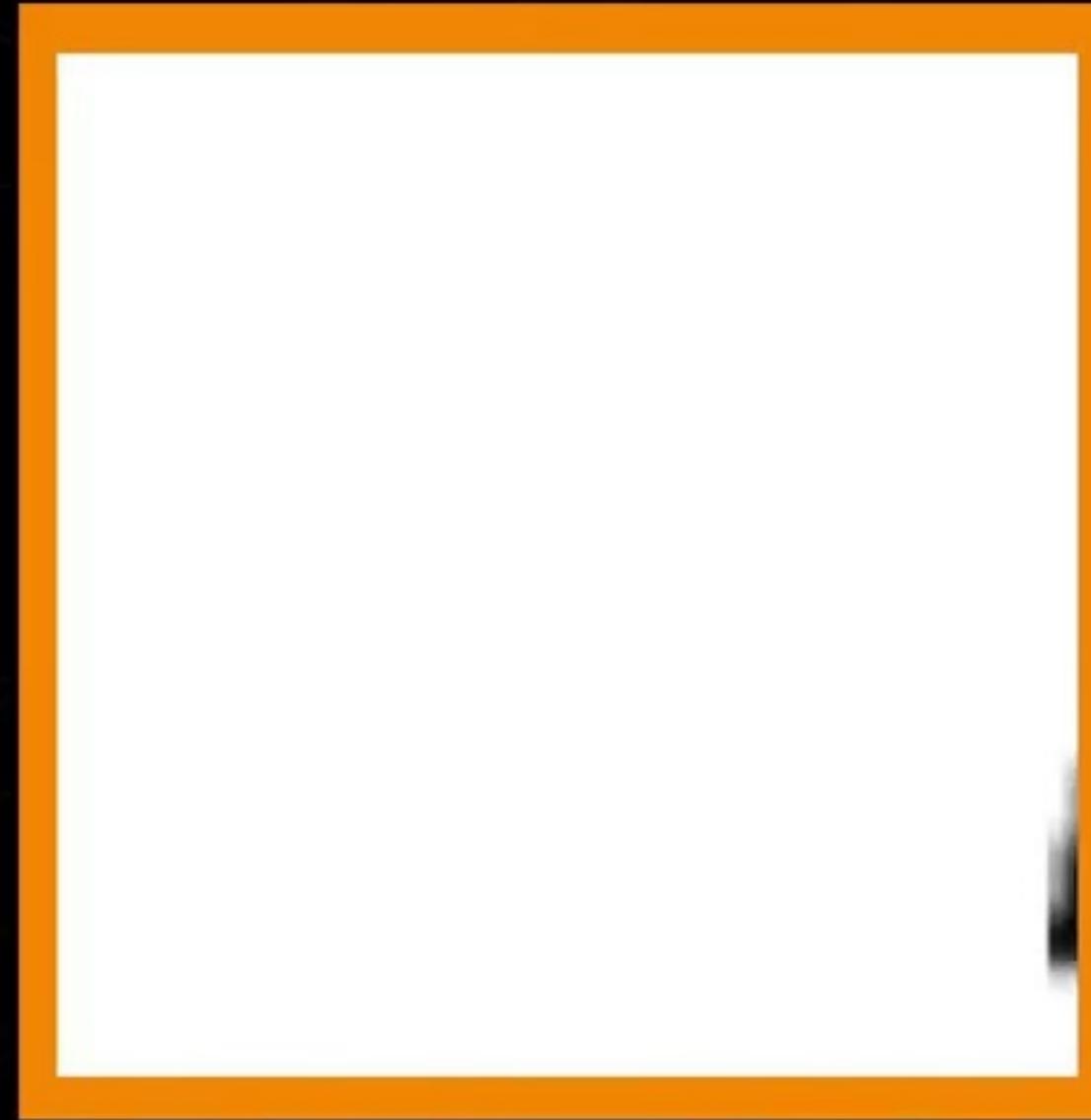
Simple











Compleja



Compleja



ACTIVADA



Compleja



ACTIVADA



Compleja



ACTIVADA



Compleja



Compleja



Compleja



ACTIVADA



Compleja



ACTIVADA



Compleja



Compleja



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Compleja



ACTIVADA



Compleja



ACTIVADA



Compleja



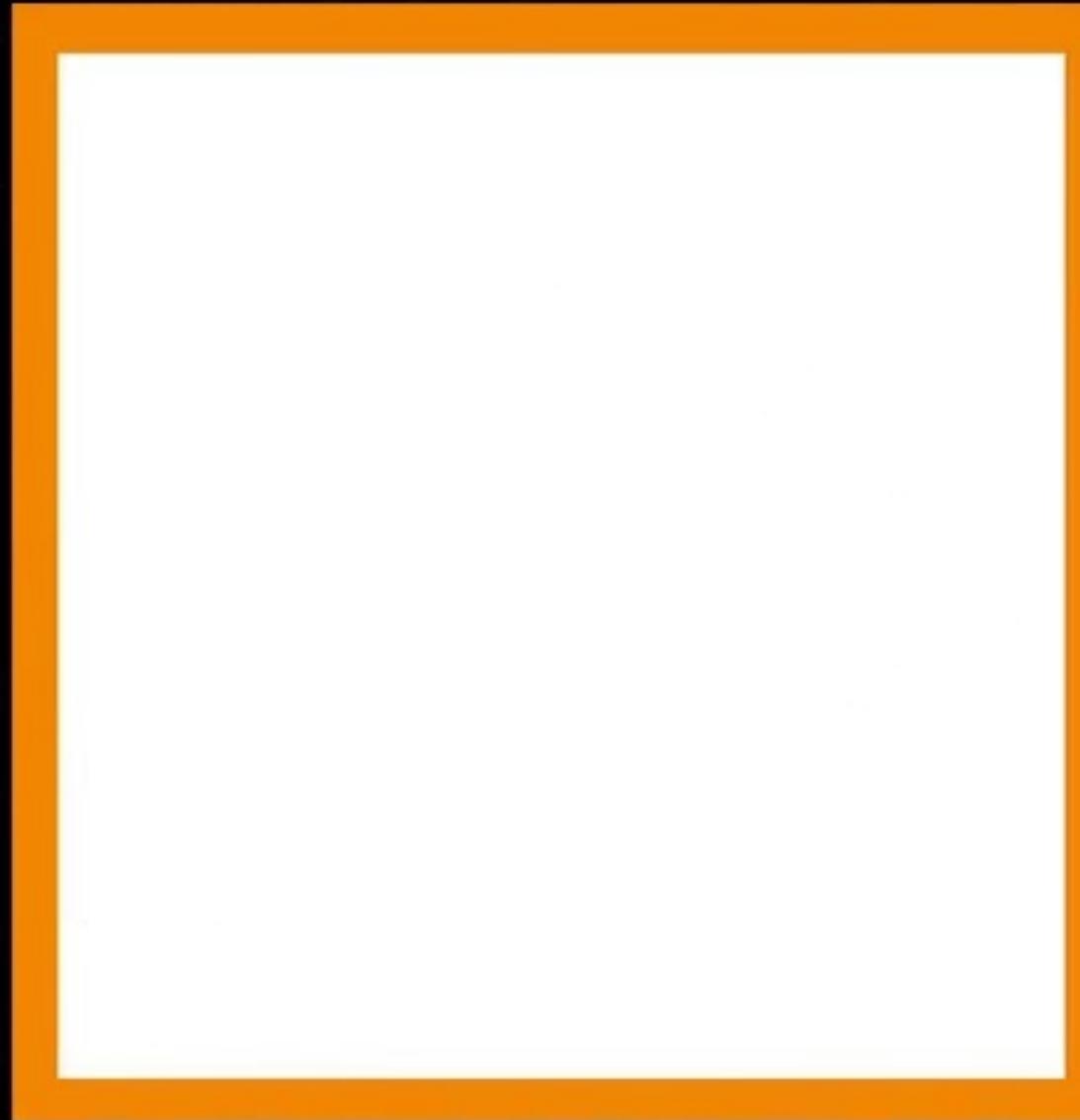
ACTIVADA



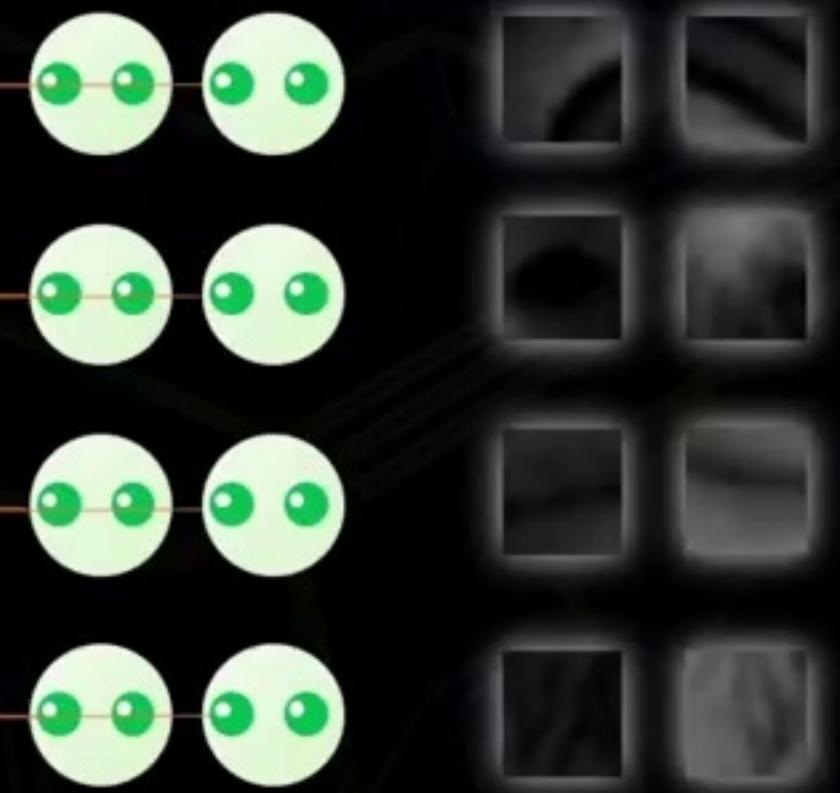
Compleja



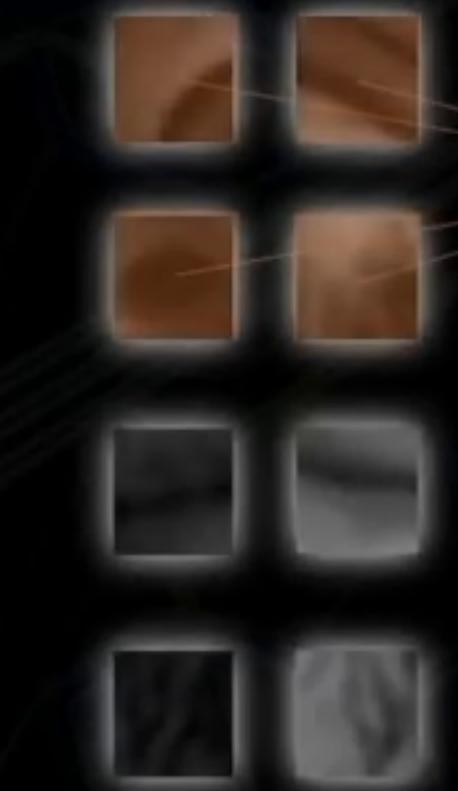
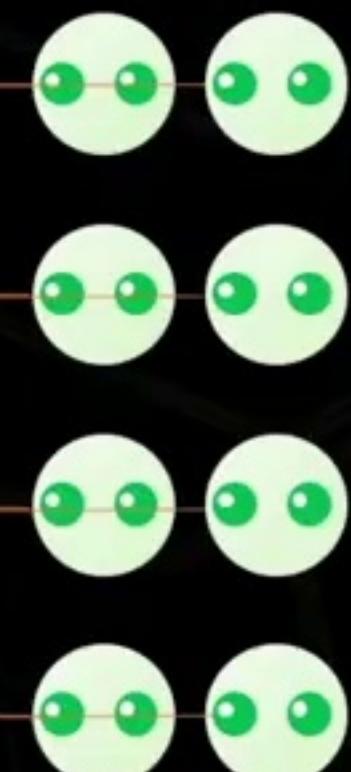
Compleja



Neuronas Simples

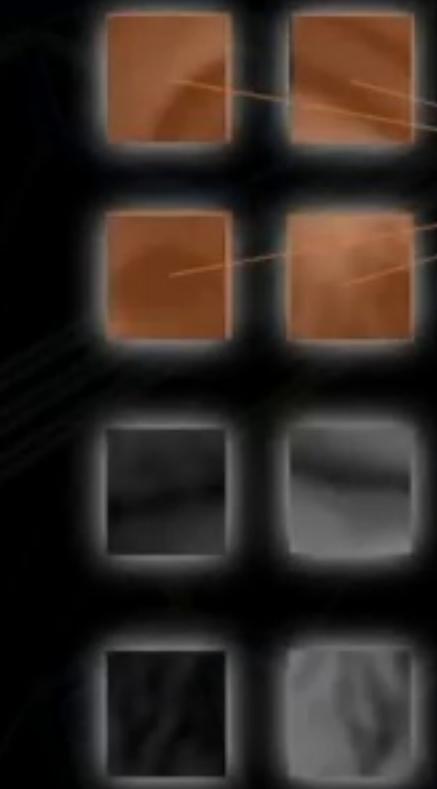
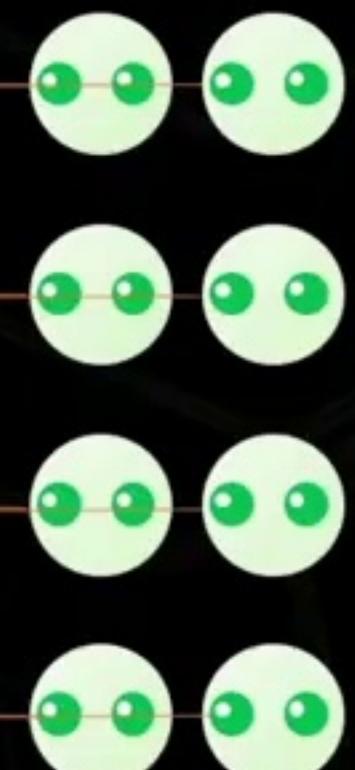


Neuronas Simples



Neuronas Complejas

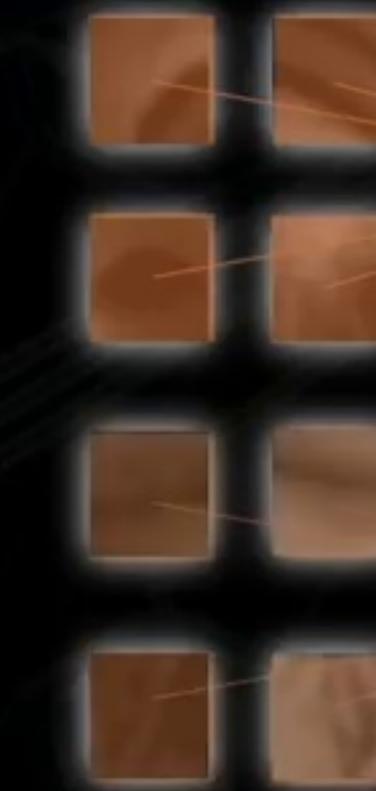
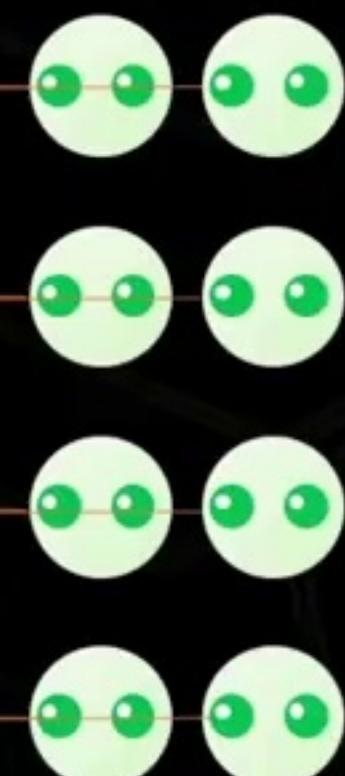
Neuronas Simples



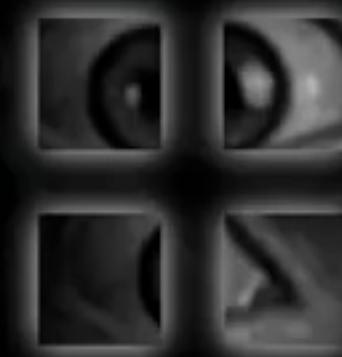
Neuronas Complejas



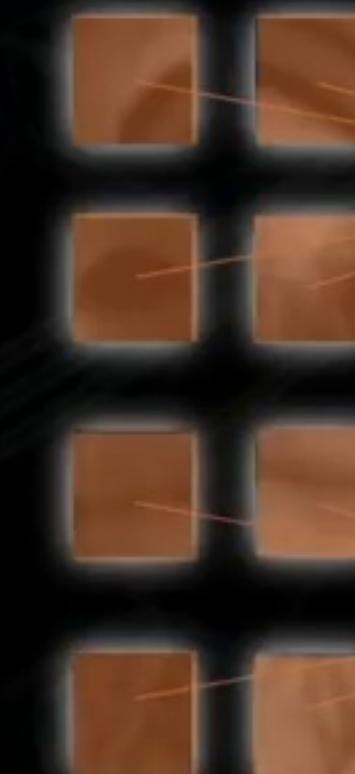
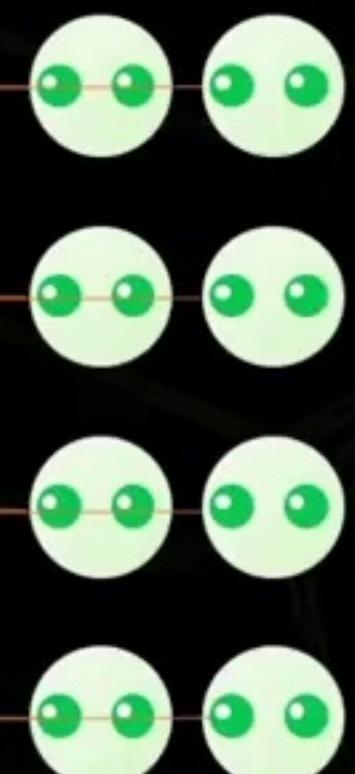
Neuronas Simples



Neuronas Complejas



Neuronas Simples



Neuronas Complejas







Neuronas Simples





Neuronas
Simples



Neuronas
Complejas

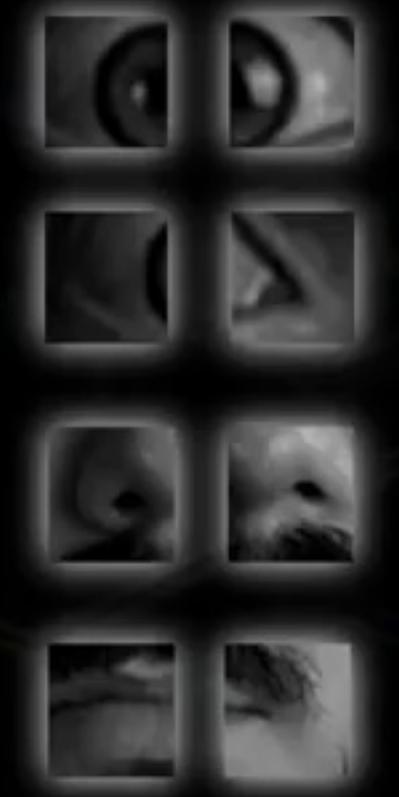




**Neuronas
Simples**



**Neuronas
Complejas**

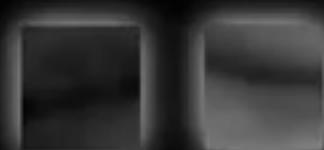
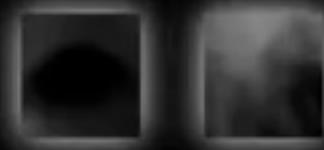


**Neuronas
Simples**





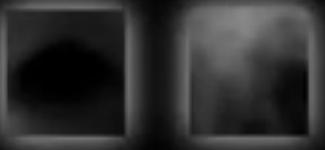
**Neuronas
Simples**



**Neuronas
Complejas**



**Neuronas
Simples**

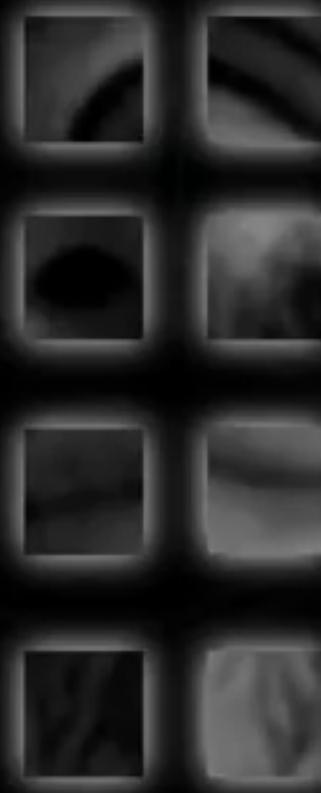


**Neuronas
Complejas**





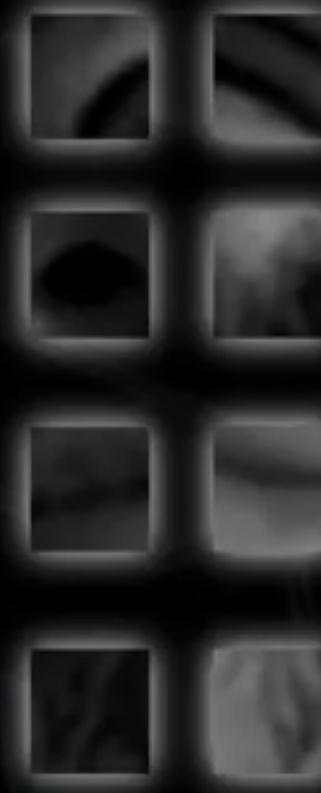
**Neuronas
Simples**



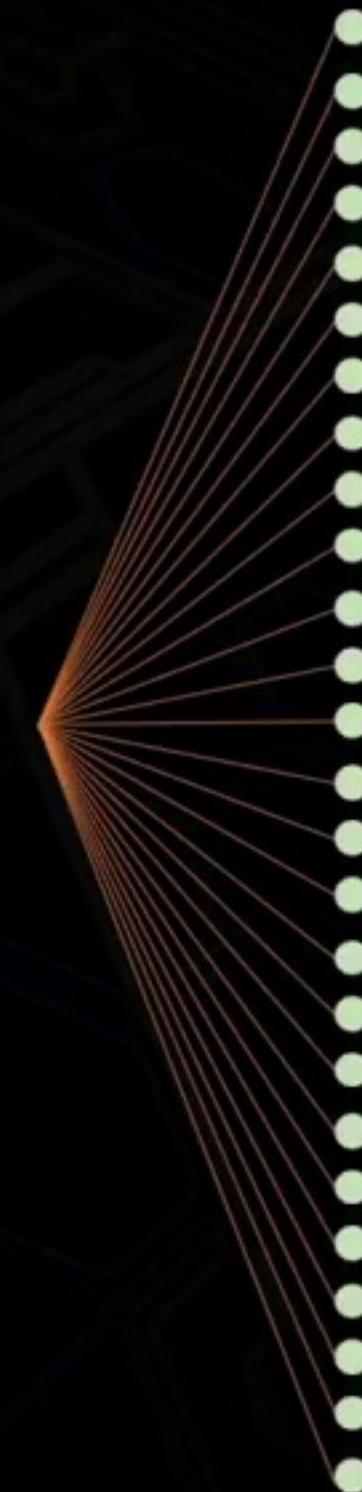
**Neuronas
Complejas**



**Neuronas
Simples**



**Neuronas
Complejas**



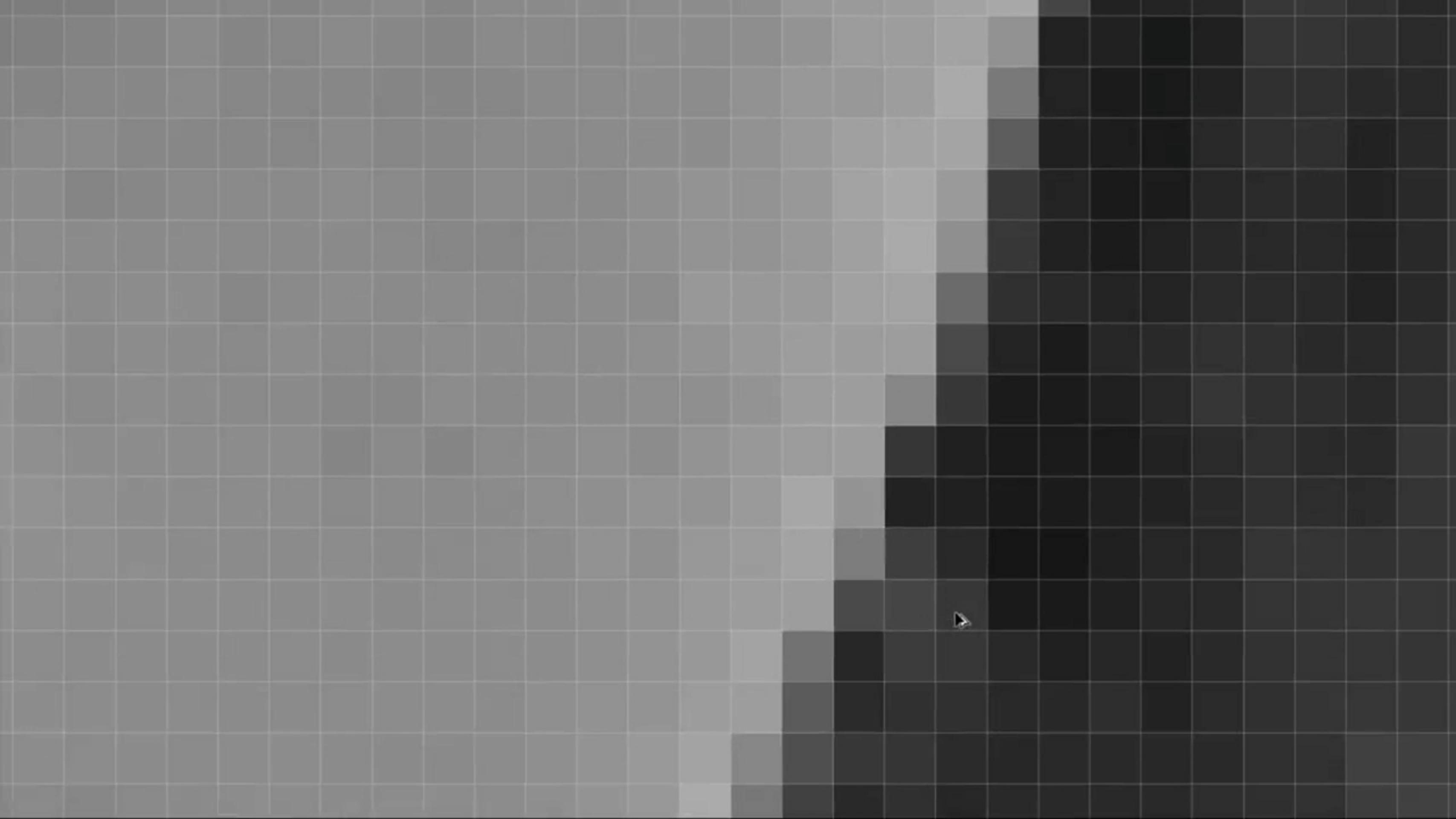














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172	175	176	181	191	175	66	62	53	57	62
175	172	180	181	188	157	97	75	48	49	62
172	175	180	182	184	110	106	+	90	55	54
172	176	179	188	147	72	96	90	73	62	71

175

182	183	88
191	175	66
188	157	97

139	138	135	128	127	121	115	110	97
138	<u>137</u>	137	133	126	120	118	112	98
135	138	135	132	126	122	118	113	104
134	135	135	128	127	122	119	113	107
134	134	133	133	124	120	115	110	107

0 139	0 138	0 135	128	127	121	115	110	97
0 138	1 <u>137</u>	0 137	133	126	120	118	112	98
0 135	0 138	0 135	132	126	122	118	113	104
134	135	135	128	127	122	119	113	107
134	134	133	133	124	120	115	110	107

139	138	135	128	127	121	115	110	97
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135	138	135	132	126	122	118	113	104
134	135	135	128	127	122	119	113	107
134	134	133	133	124	120	115	110	107

$$0 \times 139 = 0$$



0	139	0
0	138	137
0	135	138

A 3x3 grid of numbers. The first row contains 0, 139, and 0. The second row contains 0, 138, and 137, where 137 is underlined. The third row contains 0, 135, and 135. A yellow arrow points from the first row to the second row.

$$0 \times 139 = 0$$

0 139	0 138	0 135
0 138	1 <u>137</u>	0 137
0 135	0 138	0 135



$$0 \times 139 = 0$$

$$0 \times 138 = 0$$

0 139	0 138	0 139
0 138	1 <u>137</u>	0 137
0 135	0 138	0 135



$$0 \times 139 = 0$$
$$0 \times 138 = 0$$
$$0 \times 135 = 0$$

0 139	0 138	0 135
0 138	1 <u>137</u>	0 137
0 135	0 138	0 135



0	0	0
139	138	135
0	138	<u>137</u>
0	135	138

$$0 \times 139 = 0$$
$$0 \times 138 = 0$$
$$0 \times 135 = 0$$
$$0 \times 138 = 0$$

0 139	0 138	0 135
0 138	1 <u>137</u>	0
0 135	0 138	0 135

$$\begin{aligned}
 0 \times 139 &= 0 \\
 0 \times 138 &= 0 \\
 0 \times 135 &= 0 \\
 0 \times 138 &= 0 \\
 1 \times 137 &= 137
 \end{aligned}$$

0 139	0 138	0 135
0 138	1 <u>137</u>	0 137
0 135	0 138	0 135

$$0 \times 139 = 0$$

$$0 \times 138 = 0$$

$$0 \times 135 = 0$$

$$0 \times 138 = 0$$

$$1 \times 137 = 137$$

$$0 \times 137 = 0$$

0	0	0
139	138	135
0	1	0
138	<u>137</u>	137
0	0	0
135		

$$0 \times 139 = 0$$
$$0 \times 138 = 0$$
$$0 \times 135 = 0$$
$$0 \times 138 = 0$$
$$1 \times 137 = 137$$
$$0 \times 137 = 0$$
$$0 \times 135 = 0$$

0 139	0 138	0 135
0 138	1 <u>137</u>	0 137
0 135	0 138	0 135



$$0 \times 139 = 0$$

$$0 \times 138 = 0$$

$$0 \times 135 = 0$$

$$0 \times 138 = 0$$

$$1 \times 137 = 137$$

$$0 \times 137 = 0$$

$$0 \times 135 = 0$$

$$0 \times 138 = 0$$

0 139	0 138	0 135
0 138	1 <u>137</u>	0 137
0 135	0 138	0 135



$$0 \times 139 = 0$$

$$0 \times 138 = 0$$

$$0 \times 135 = 0$$

$$0 \times 138 = 0$$

$$1 \times 137 = 137$$

$$0 \times 137 = 0$$

$$0 \times 135 = 0$$

$$0 \times 138 = 0$$

$$0 \times 135 = 0$$

0	0	0
139	138	135
0	1	0
138	<u>137</u>	137
0	0	0
135	138	135

$$0 \times 139 = 0$$

$$0 \times 138 = 0$$

$$0 \times 135 = 0$$

$$0 \times 138 = 0$$

$$1 \times 137 = 137$$

$$0 \times 137 = 0$$

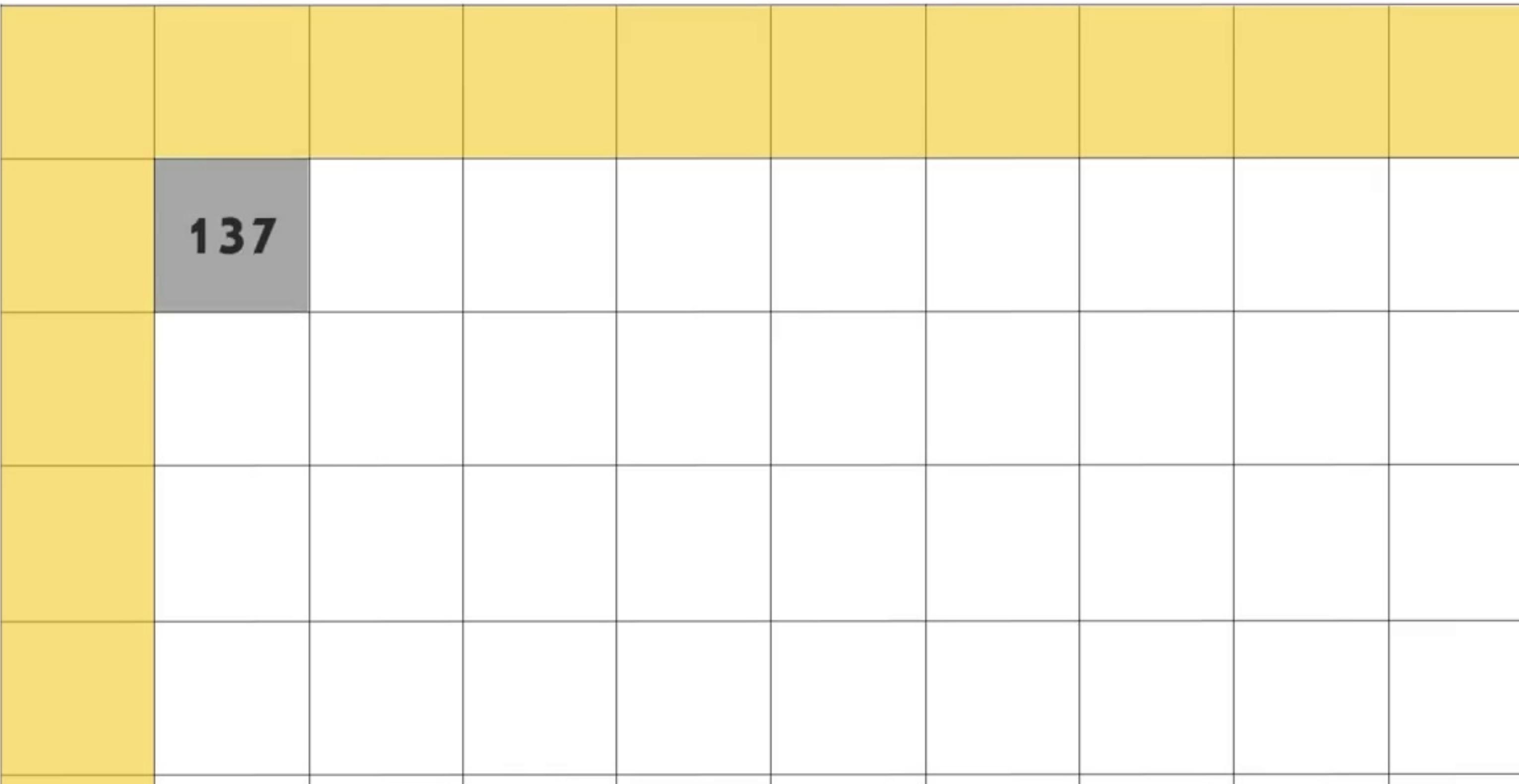
$$0 \times 135 = 0$$

$$0 \times 138 = 0$$

$$0 \times 135 = 0$$

137

Nueva imagen



0	0	0	128	127	121	115	110	97
0	1	0	133	126	120	118	112	98
0	0	0	132	126	122	118	113	104
135	138	135						

134 135 135 128 127 122 119 113 107

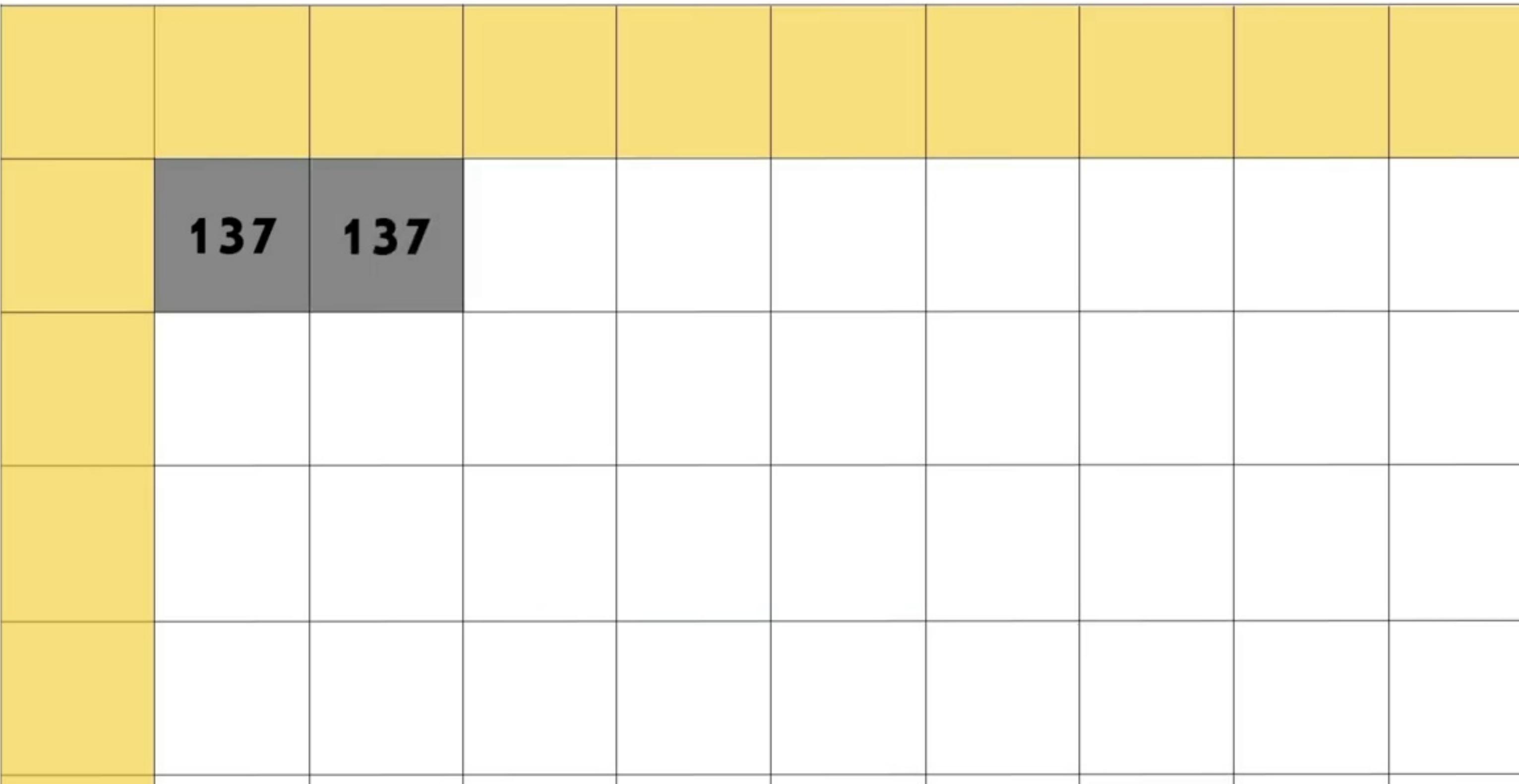
134 134 133 133 124 120 115 110 107

139	0	0	0	128	127	121	115	110	97
138	0	1	0	133	126	120	118	112	98
135	0	0	0	132	126	122	118	113	104

134 135 135 128 127 122 119 113 107

134 134 133 133 124 120 115 110 107

Nueva imagen



139	0 138	0 135	0 128	127	121	115	110	97
138	0 137	1 <u>137</u>	0 133	126	120	118	112	98
135	0 138	0 135	0 132	126	122	118	113	104

134 135 135 128 127 122 119 113 107

134 134 133 133 124 120 115 110 107

139	138	0 135	0 128	0 127	121	115	110	97
138	137	0 137	1 <u>133</u>	0 126	120	118	112	98
135	138	0 135	0 132	0 126	122	118	113	104

134	135	135	128	127	122	119	113	107
134	134	133	133	124	120	115	110	107

Nueva imagen

137

139	138	0 135	0 128	0 127	121	115	110	97
138	137	0 137	1 <u>133</u>	0 126	120	118	112	98
135	138	0 135	0 132	0 126	122	118	113	104
134	135	135	128	127	122	119	113	107
134	134	133	133	124	120	115	110	107

139	138	135	0	128	0	127	0	121	115	110	97
138	137	137	0	133	1	<u>126</u>	0	120	118	112	98
135	138	135	0	132	0	126	0	122	118	113	104
134	135	135	128	127	122	119	113	107			
134	134	133	133	124	120	115	110	107			

Nueva imagen

Imagen original



Nueva imagen

Núcleo

0	0	0
0	1	0
0	0	0



0 139	0 138	0 135
0 138	1 <u>137</u>	0 137
0 135	0 138	0 135

$$0 \times 139 = 0$$

$$0 \times 138 = 0$$

$$0 \times 135 = 0$$

$$0 \times 138 = 0$$

$$1 \times 137 = 137$$

$$0 \times 137 = 0$$

$$0 \times 135 = 0$$

$$0 \times 138 = 0$$

$$0 \times 135 = 0$$

137

Imagen original



Nueva imagen

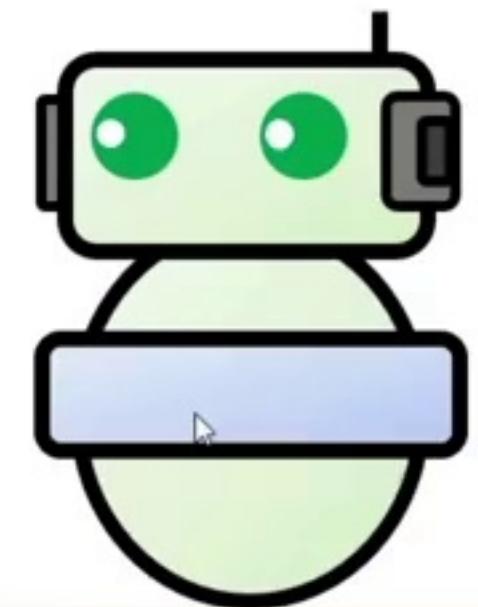
Núcleo

1	1	1
1	1	1
1	1	1



-1	-1	-1
-1	8	-1
-1	-1	-1

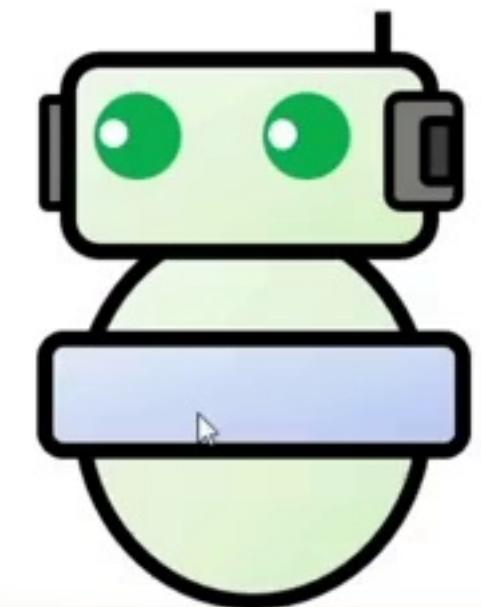
Núcleo (Kernel)



-1	-1	-1
-1	8	-1
-1	-1	-1



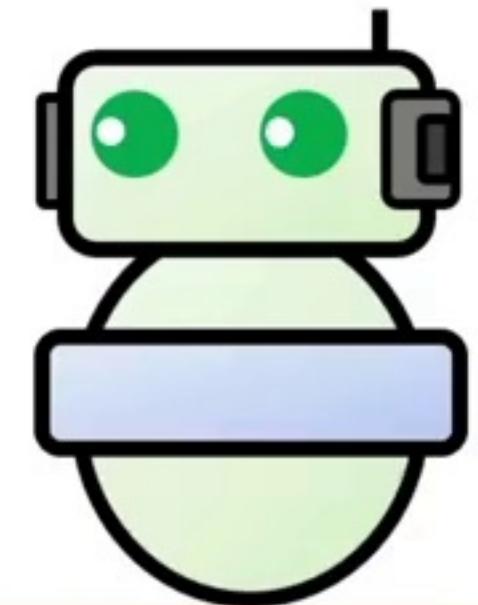
Núcleo (Kernel)



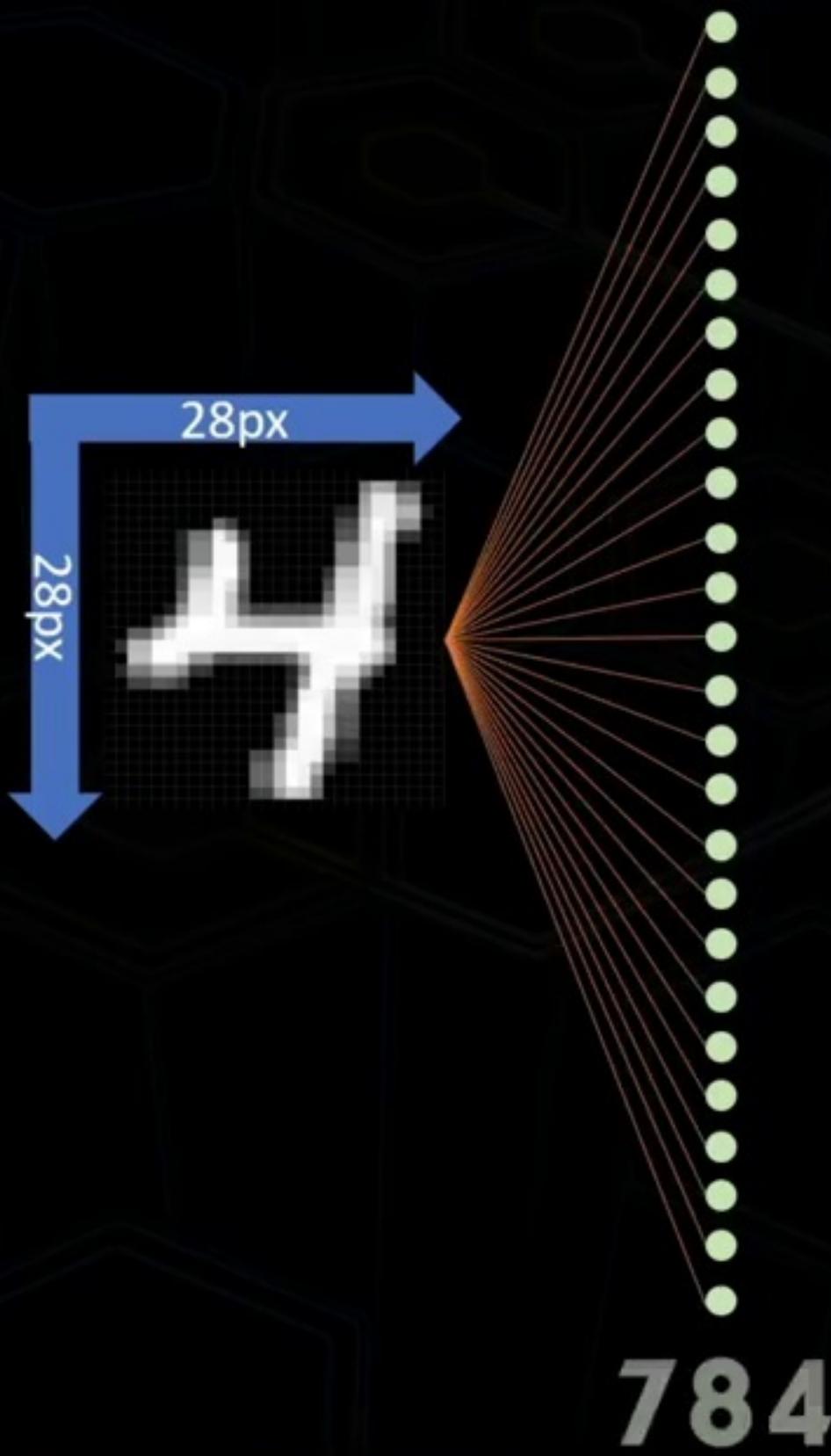
-1	-1	-1
-1	8	-1
-1	-1	-1



Núcleo (Kernel)



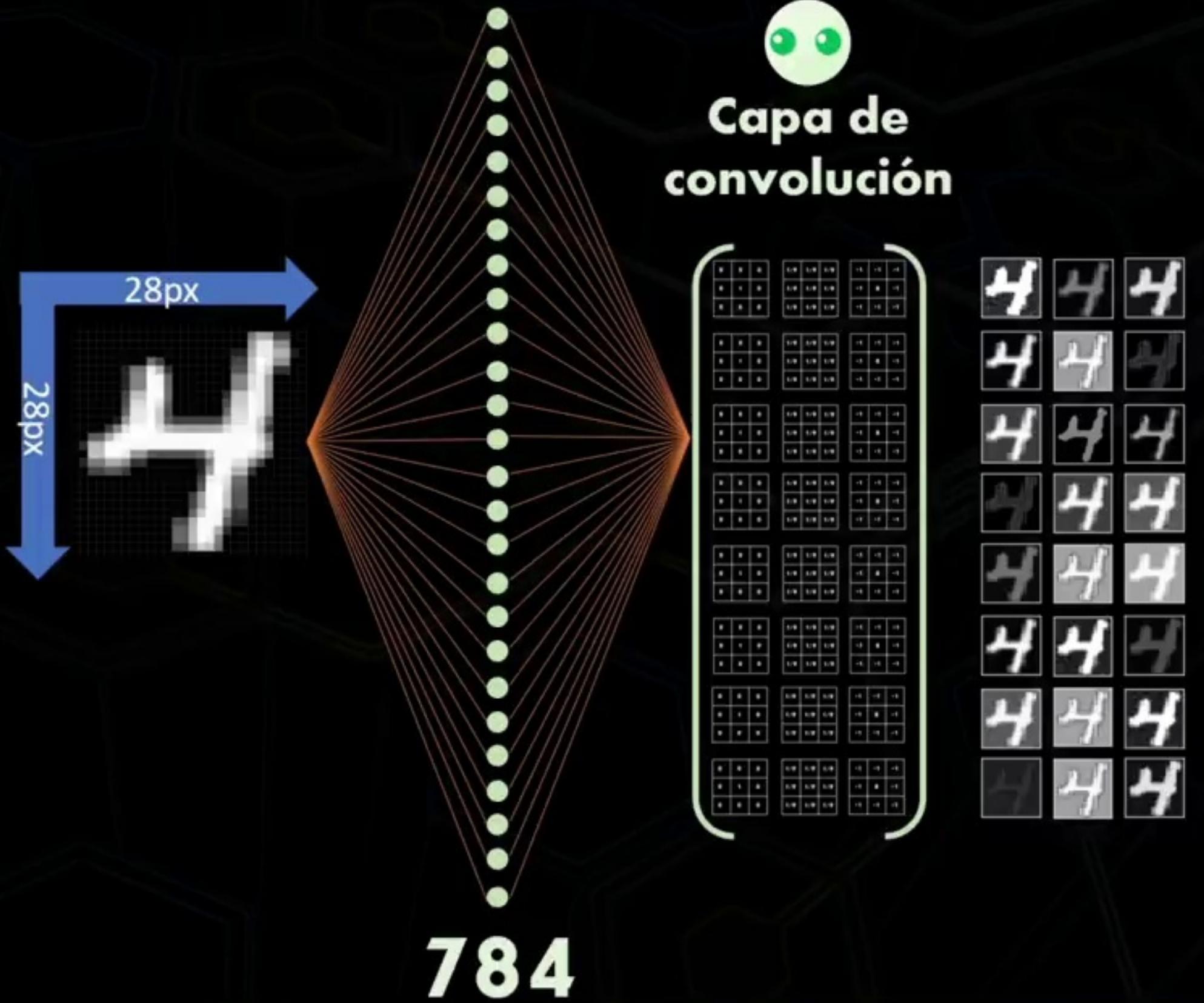
Capa de entrada



Capa de entrada

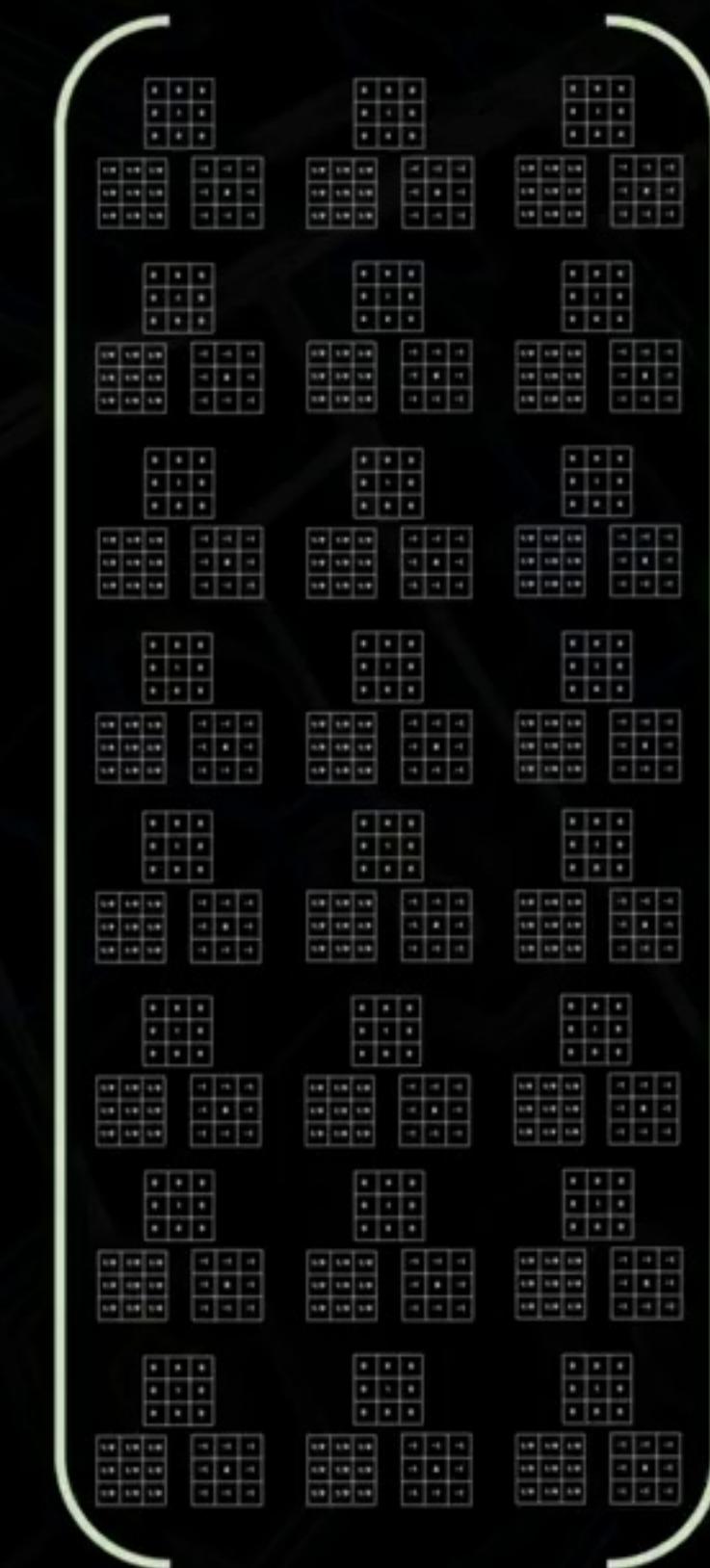
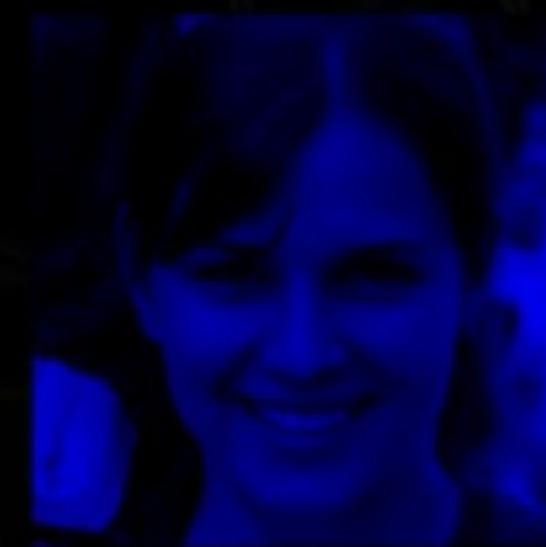


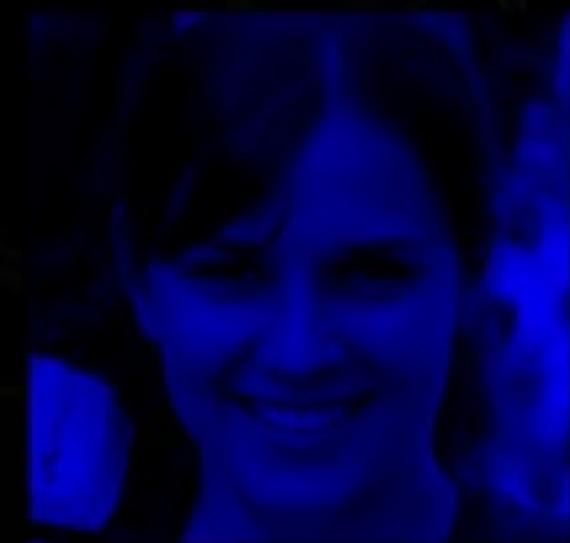
Capa de entrada











0	0	0
0	1	0
0	0	0

1/9	1/9	1/9
1/9	1/9	1/9
1/9	1/9	1/9

-1	-1	-1
-1	8	-1
-1	-1	-1





$$\begin{bmatrix} 1/9 & 1/9 & 1/9 \\ 1/9 & 1/9 & 1/9 \\ 1/9 & 1/9 & 1/9 \end{bmatrix}$$

$$\begin{bmatrix} 0 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 0 \end{bmatrix}$$

$$\begin{bmatrix} -1 & -1 & -1 \\ -1 & 8 & -1 \\ -1 & -1 & -1 \end{bmatrix}$$

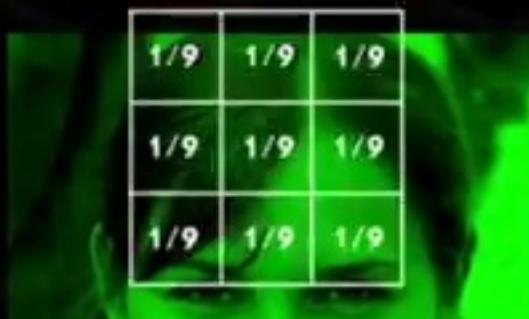
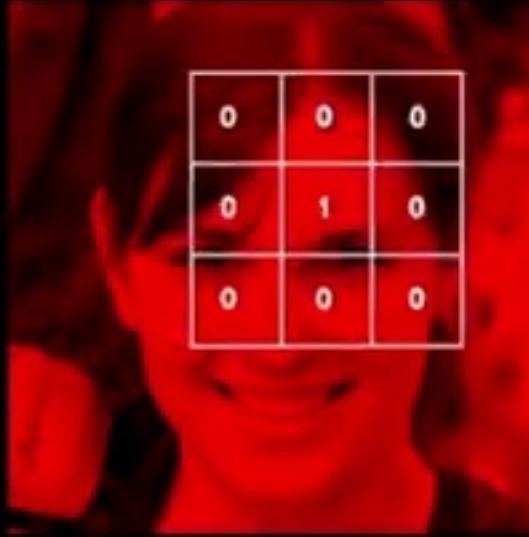
$$\begin{bmatrix} -1 & -1 & -1 \\ -1 & 8 & -1 \\ -1 & -1 & -1 \end{bmatrix}$$



0	0	0
0	1	0
0	0	0

1/9	1/9	1/9
1/9	1/9	1/9
1/9	1/9	1/9

-1	-1	-1
-1	8	-1
-1	-1	-1



0	0	0
0	1	0
0	0	0

1/9	1/9	1/9
1/9	1/9	1/9
1/9	1/9	1/9

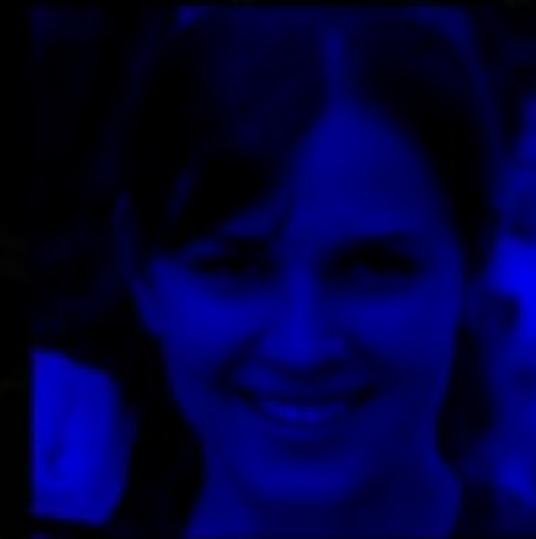
-1	-1	-1
-1	8	-1
-1	-1	-1



0	0	0
0	1	0
0	0	0



1/9	1/9	1/9
1/9	1/9	1/9
1/9	1/9	1/9



-1	-1	-1
-1	8	-1
-1	-1	-1

0	0	0
0	1	0
0	0	0



1/9	1/9	1/9
1/9	1/9	1/9
1/9	1/9	1/9



-1	-1	-1
-1	8	-1
-1	-1	-1



0	0	0
0	1	0
0	0	0



1/9	1/9	1/9
1/9	1/9	1/9
1/9	1/9	1/9



-1	-1	-1
-1	8	-1
-1	-1	-1



0	0	0
0	1	0
0	0	0



1/9	1/9	1/9
1/9	1/9	1/9
1/9	1/9	1/9



-1	-1	-1
-1	8	-1
-1	-1	-1



0	0	0
0	1	0
0	0	0



1/9	1/9	1/9
1/9	1/9	1/9
1/9	1/9	1/9



-1	-1	-1
-1	8	-1
-1	-1	-1



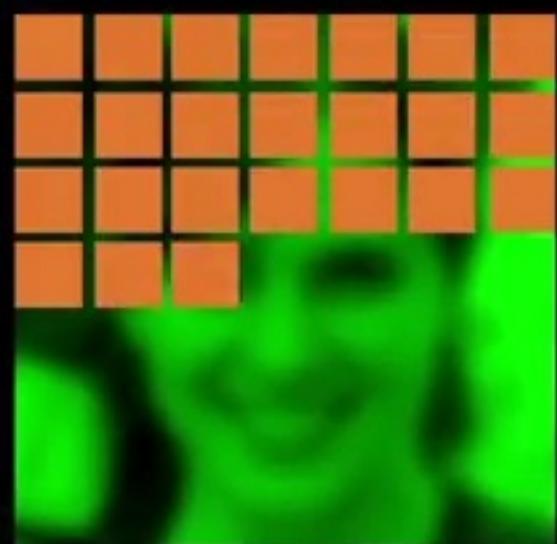
rojo + verde + azul + sesgo



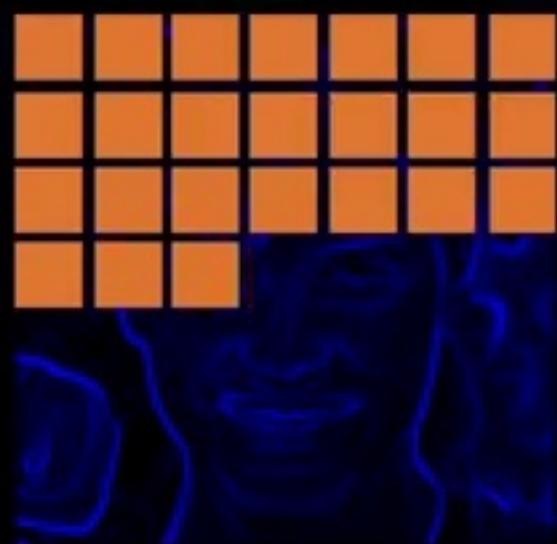
0	0	0
0	1	0
0	0	0



1/9	1/9	1/9
1/9	1/9	1/9
1/9	1/9	1/9



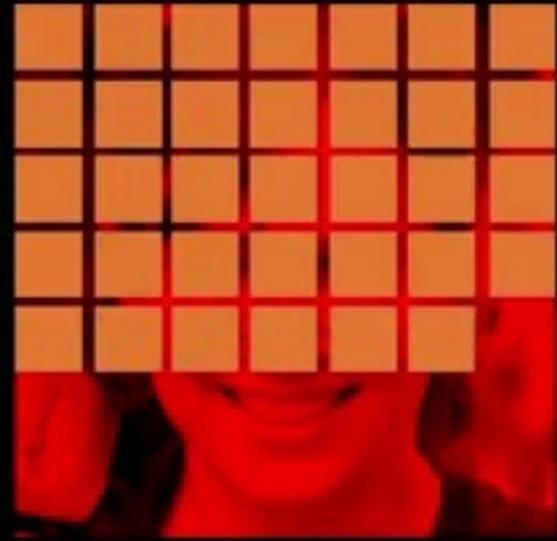
-1	-1	-1
-1	8	-1
-1	-1	-1



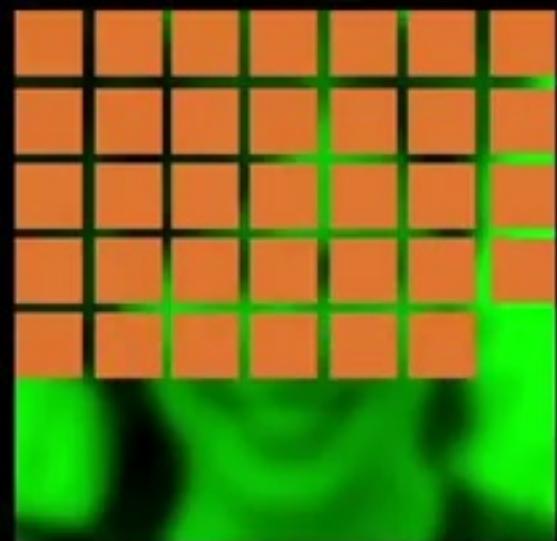
rojo + verde + azul + sesgo



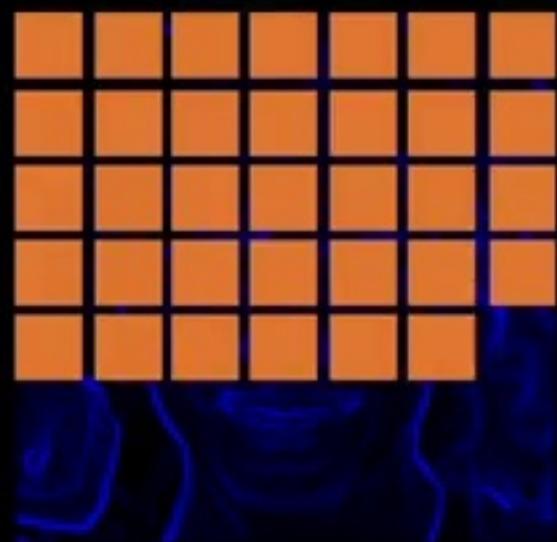
0	0	0
0	1	0
0	0	0



1/9	1/9	1/9
1/9	1/9	1/9
1/9	1/9	1/9



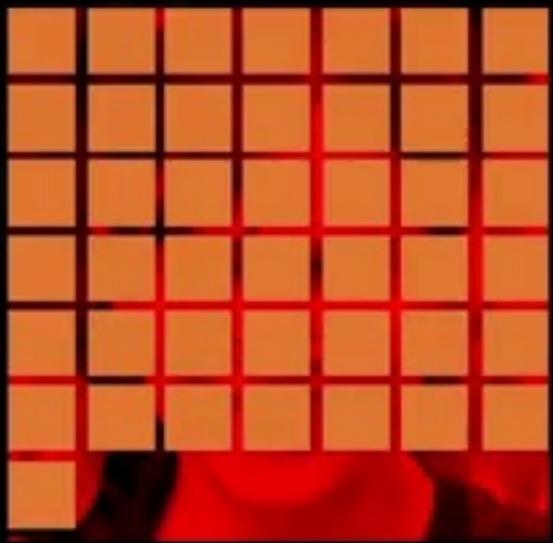
-1	-1	-1
-1	8	-1
-1	-1	-1



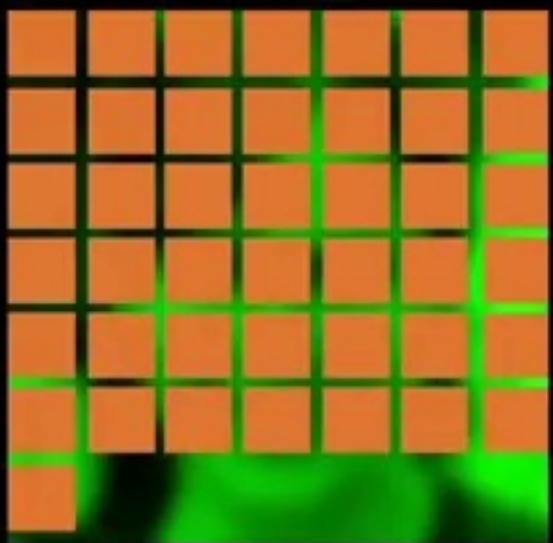
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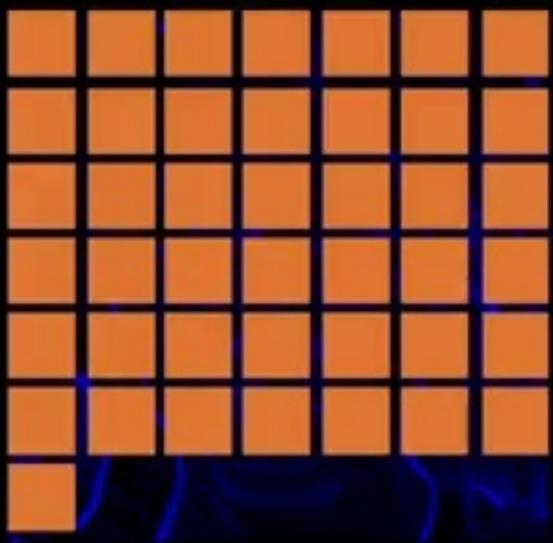
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0	0	0



1/9	1/9	1/9
1/9	1/9	1/9
1/9	1/9	1/9



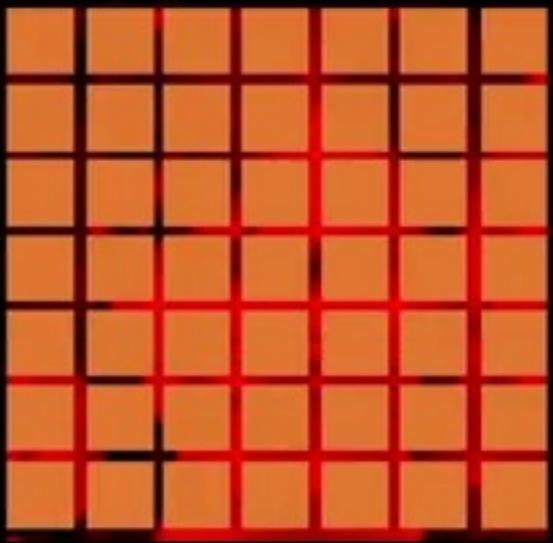
-1	-1	-1
-1	8	-1
-1	-1	-1



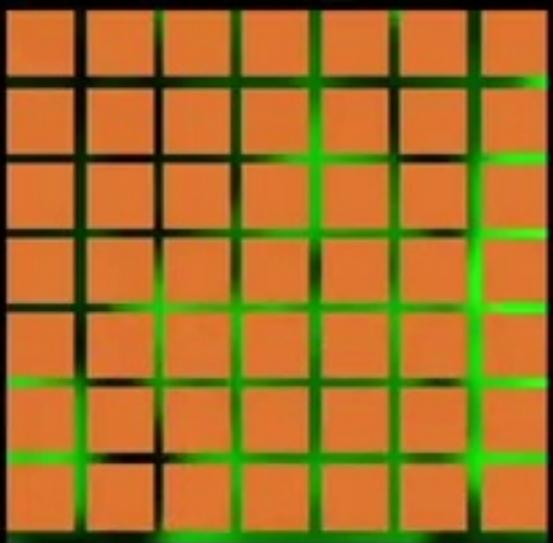
rojo + verde + azul + sesgo



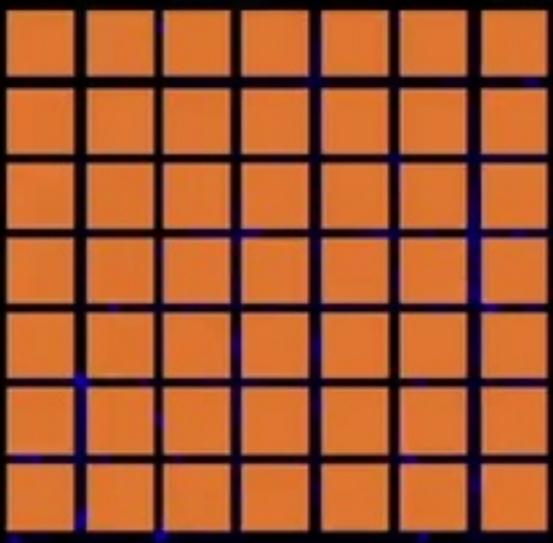
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0	1	0
0	0	0



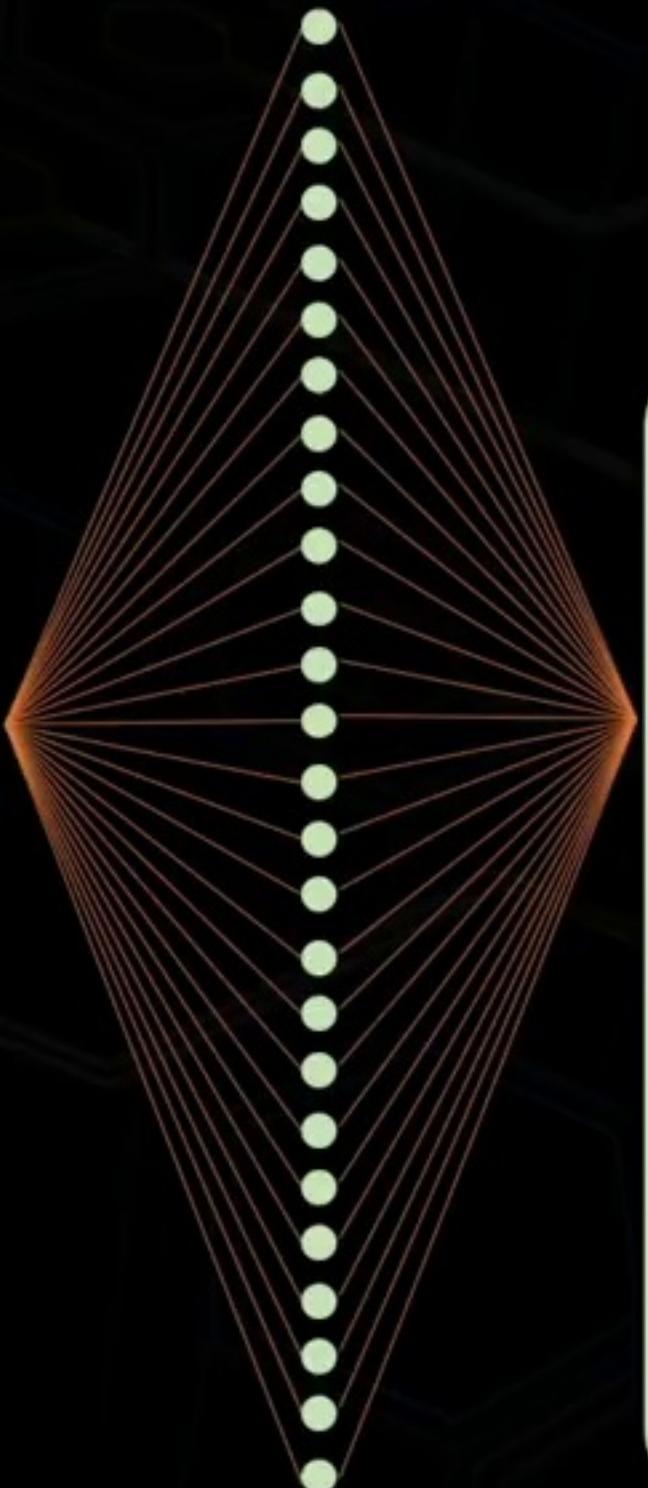
1/9	1/9	1/9
1/9	1/9	1/9
1/9	1/9	1/9



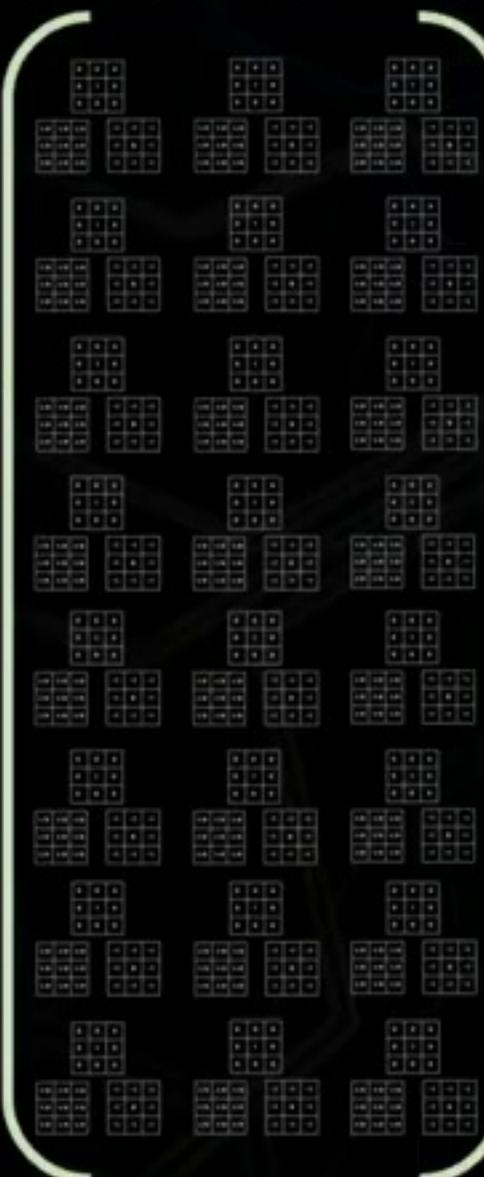
-1	-1	-1
-1	8	-1
-1	-1	-1



Capa de entrada



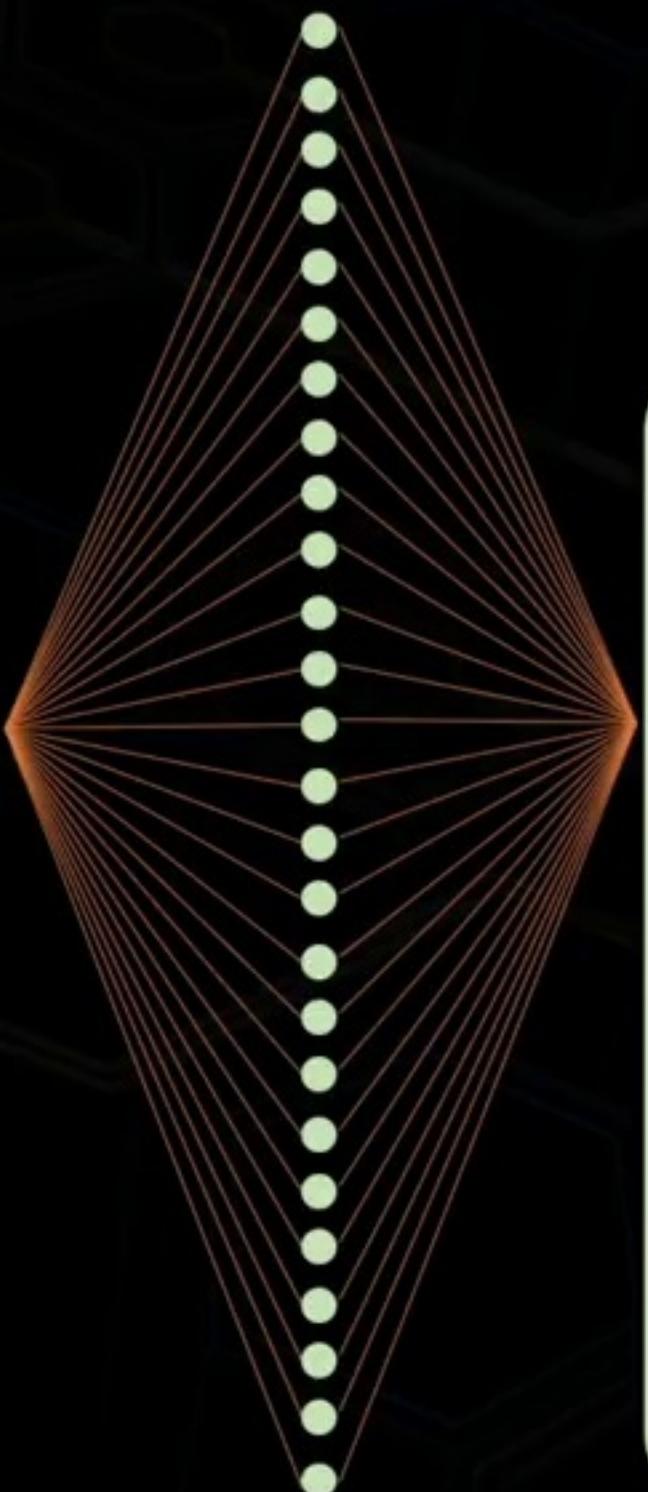
Capa de convolución



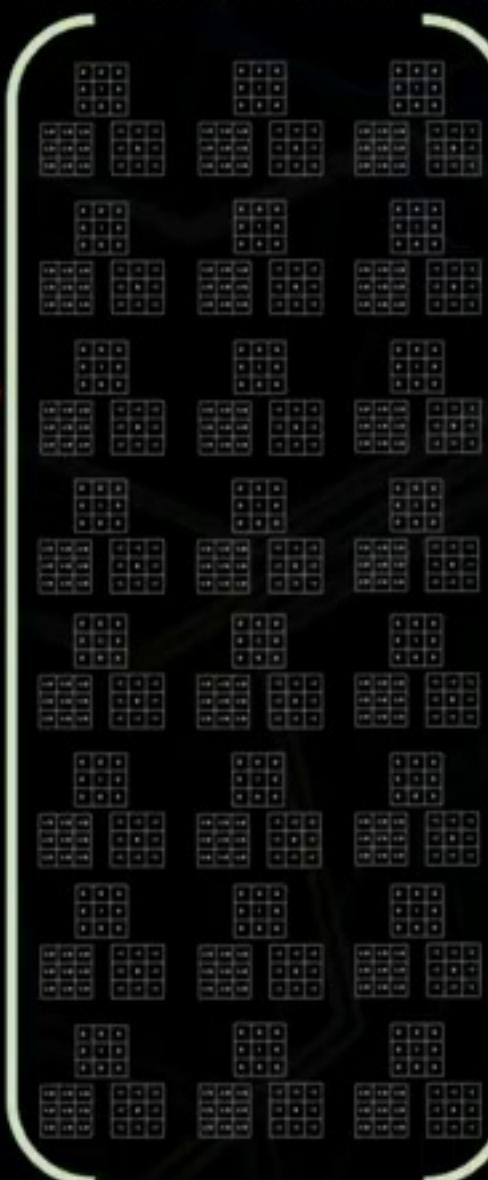
**32
núcleos**

**96
convoluciones**

Capa de entrada



Capa de convolución



**32
núcleos**

**96
convoluciones**





Compleja



Capa de agrupación



Capa de agrupación





Capa de agrupación





Capa de agrupación





Capa de agrupación











64	59	53	63	97	110
54	54	56	61	82	94
44	58	61	62	64	66
65	83	66	58	50	50
92	84	50	38	41	50
82	56	31	23	43	54



64	59	53	63	97	110
54	54	56	61	82	94
44	58	61	62	64	66
65	83	66	58	50	50
92	84	50	38	41	50
82	56	31	23	43	54

64	59	53	63	97	110
54	54	56	61	82	94
44	58	61	62	64	66
65	83	66	58	50	50
92	84	50	38	41	50
82	56	31	23	43	54

64		

64	59	53	63	97	110
54	54	56	61	82	94
44	58	61	62	64	66
65	83	66	58	50	50
92	84	50	38	41	50
82	56	31	23	43	54

64		

64	59	53	63	97	110
54	54	56	61	82	94
44	58	61	62	64	66
65	83	66	58	50	50
92	84	50	38	41	50
82	56	31	23	43	54

64		

ZANCADA = 2
STRIDE

64	59	53	63	97	110
54	54	56	61	82	94
44	58	61	62	64	66
65	83	66	58	50	50
92	84	50	38	41	50
82	56	31	23	43	54

64		

64	59	53	63	97	110
54	54	56	61	82	94
44	58	61	62	64	66
65	83	66	58	50	50
92	84	50	38	41	50
82	56	31	23	43	54

64	63	

64	59	53	63	97	110
54	54	56	61	82	94
44	58	61	62	64	66
65	83	66	58	50	50
92	84	50	38	41	50
82	56	31	23	43	54

64	63	

64	59	53	63	97	110
54	54	56	64	82	94
44	58	61	62	64	66
65	83	66	58	50	50
92	84	50	38	41	50
82	56	31	23	43	54

64	63	110

64	59	53	63	97	110
54	54	56	64	82	94
44	58	61	62	64	66
65	83	66	58	50	50
92	84	50	38	41	50
82	56	31	23	43	54

64	63	110
83		

64	59	53	63	97	110
54	54	56	64	82	94
44	58	64	62	64	66
65	83	66	58	50	50
92	84	50	38	41	50
82	56	31	23	43	54

64	63	110
83	66	

64	59	53	63	97	110
54	54	56	64	82	94
44	58	64	62	64	66
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92	84	50	38	41	50
82	56	31	23	43	54

64	63	110
83	66	66

64	59	53	63	97	110
54	54	56	64	82	94
44	58	64	62	64	66
65	83	66	58	50	50
92	84	50	38	44	50
82	56	34	23	43	54

64	63	110
83	66	66
92	50	54



**Capa de
agrupación**





**Capa de
agrupación**





Capa de agrupación



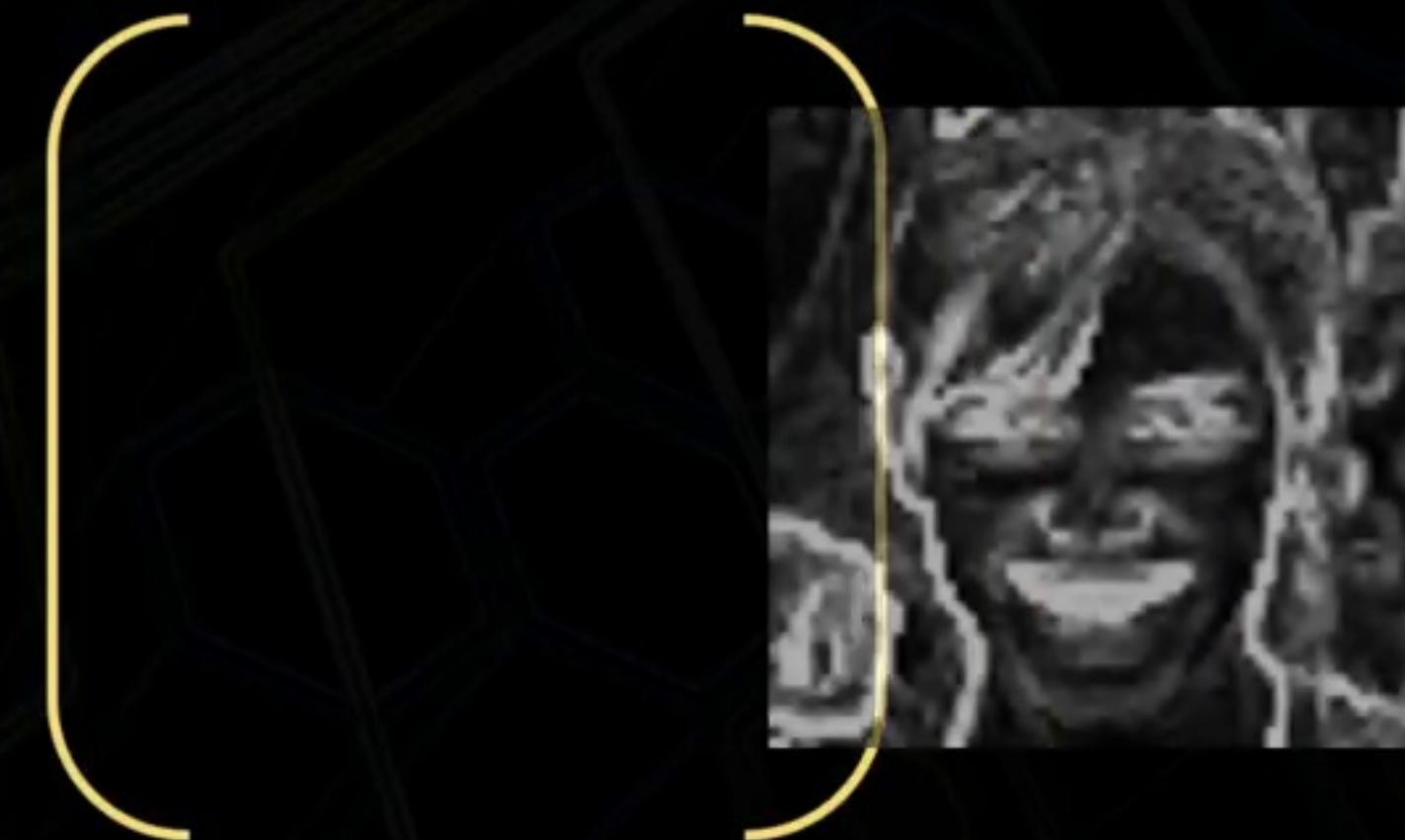


Capa de agrupación





Capa de agrupación



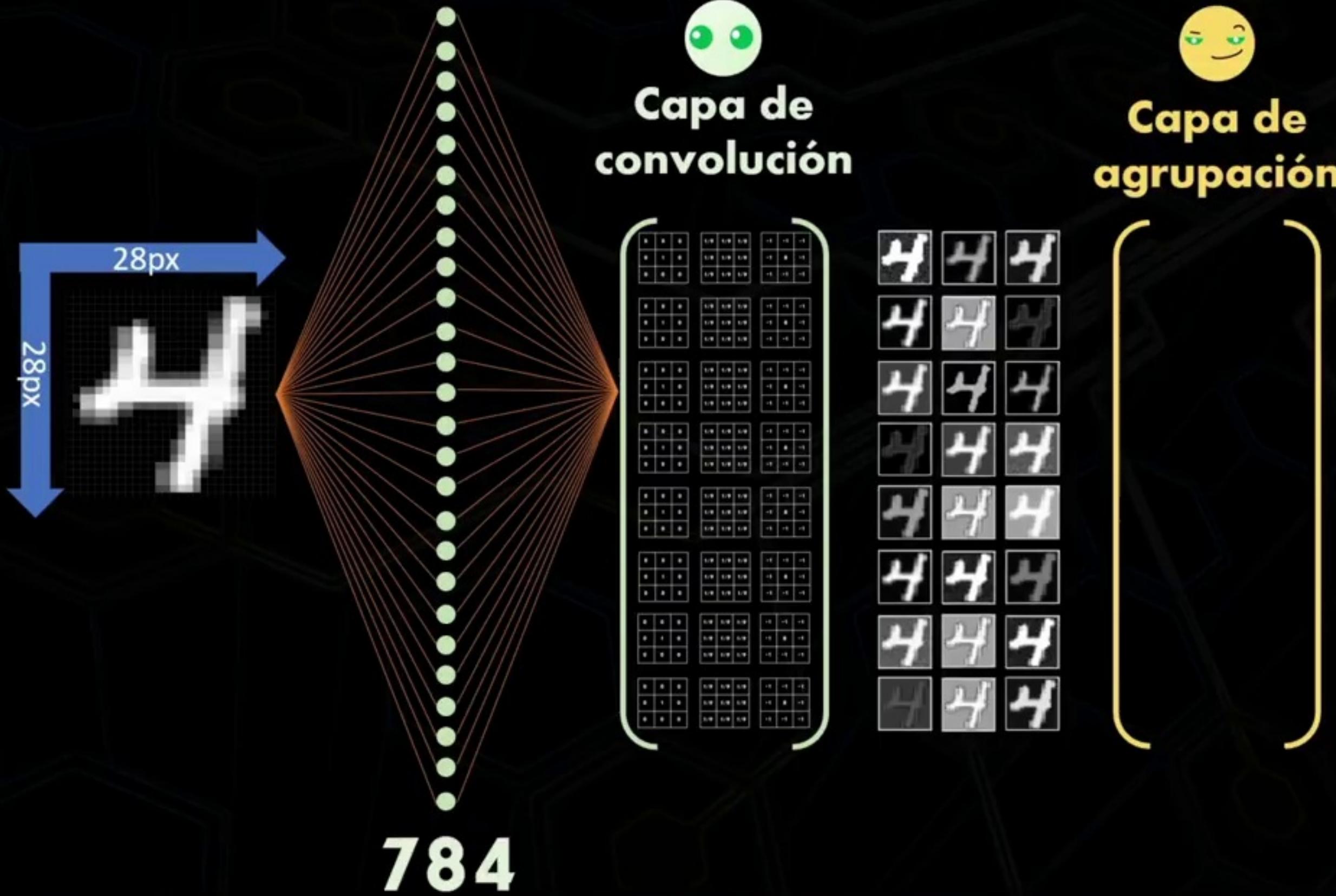


Capa de agrupación

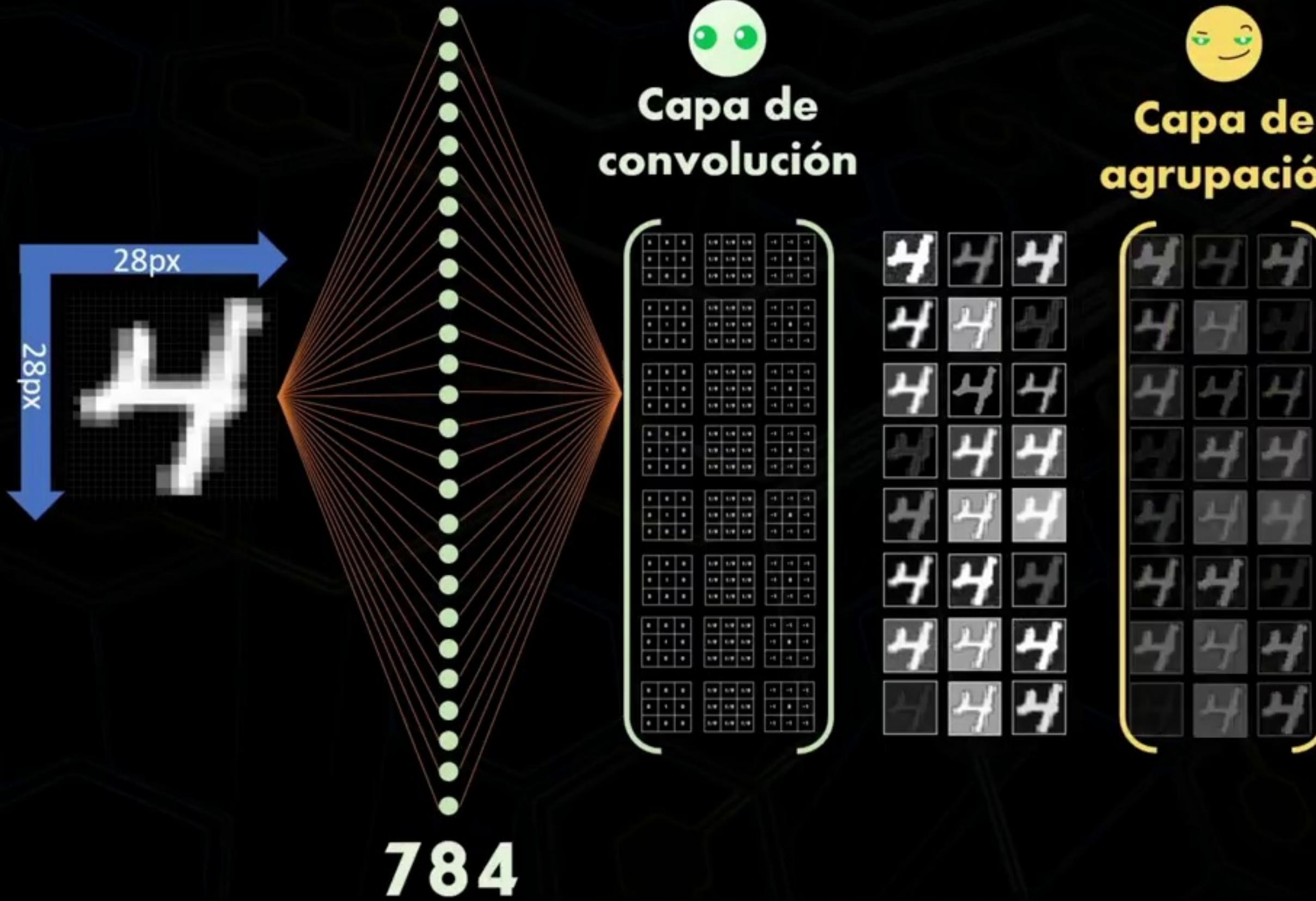




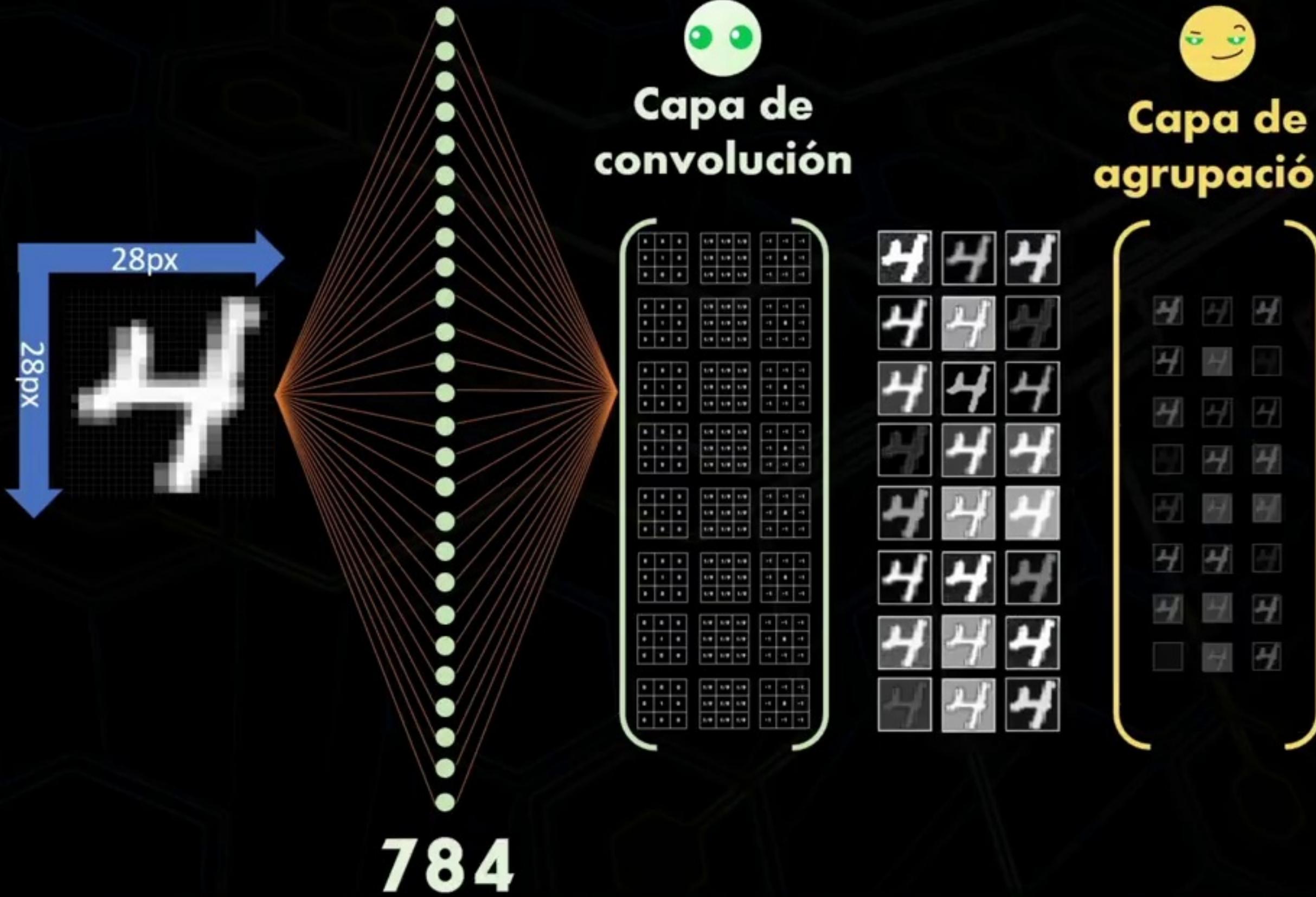
Capa de entrada



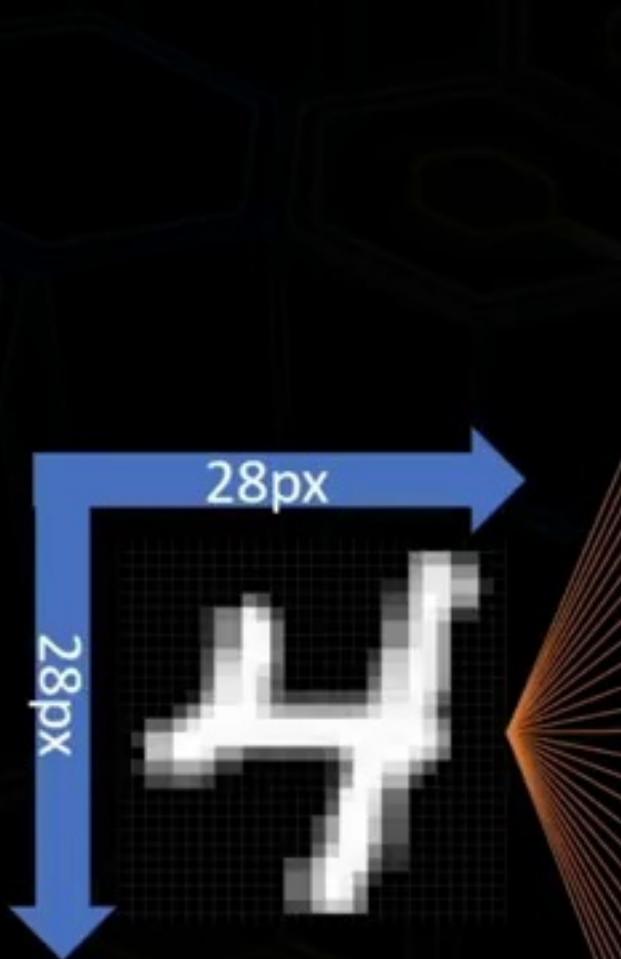
Capa de entrada



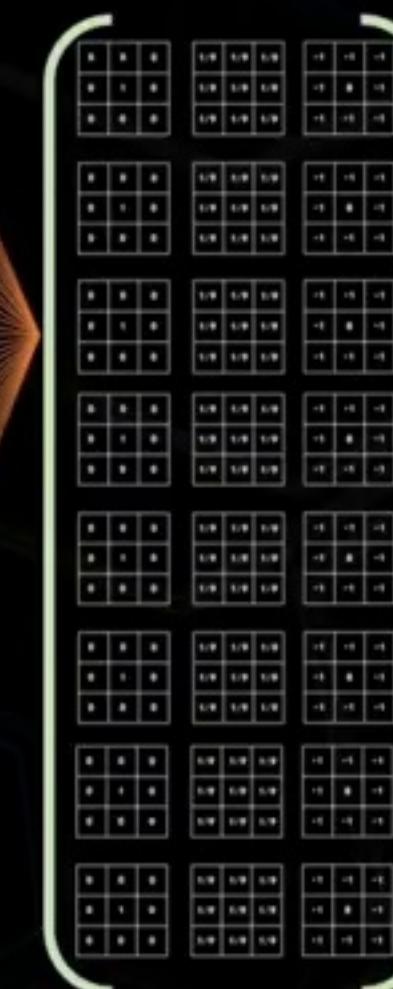
Capa de entrada



Capa de entrada



784





Capa de convolución





**Capa de
convolución**

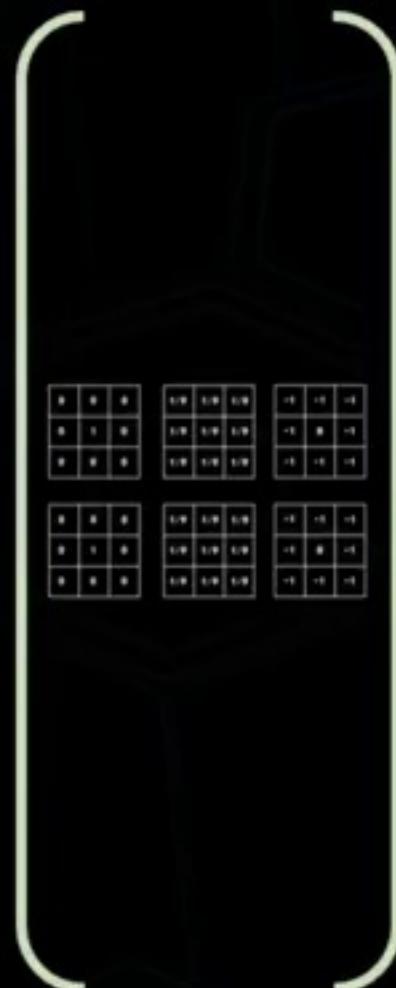


**Capa de
agrupación**





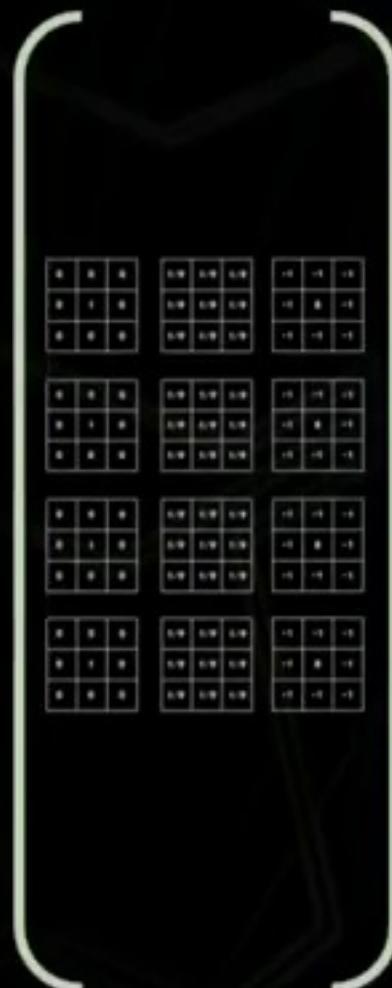
**Capa de
convolución**



**Capa de
agrupación**



**Capa de
convolución**





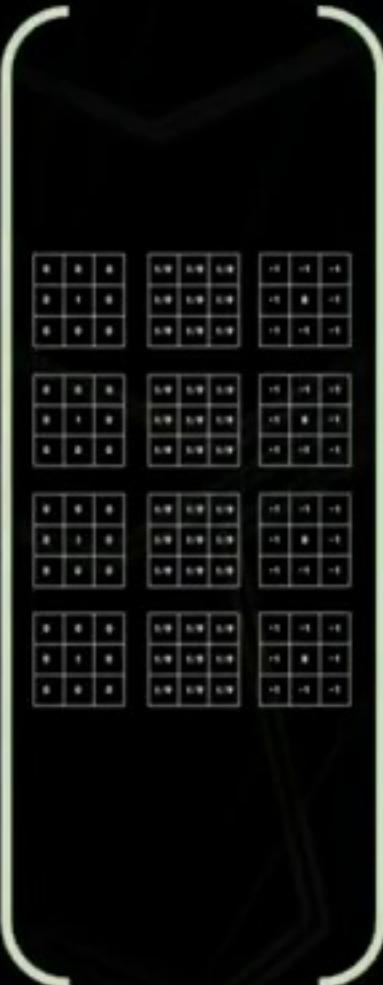
**Capa de
convolución**



**Capa de
agrupación**



**Capa de
convolución**

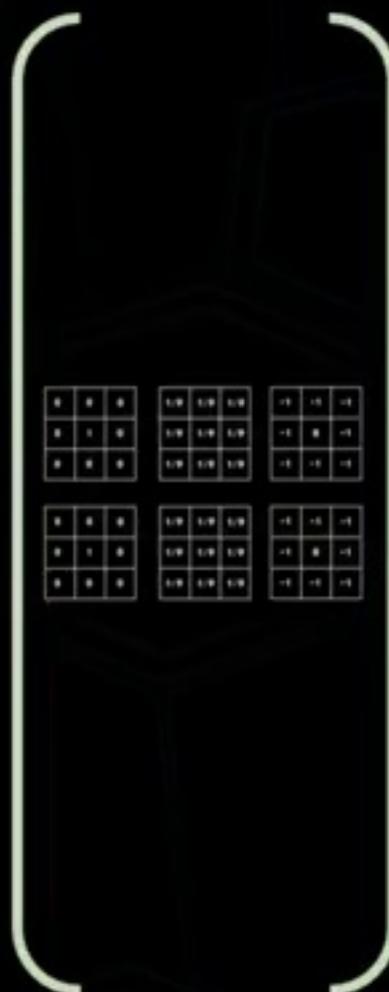


**Capa de
agrupación**





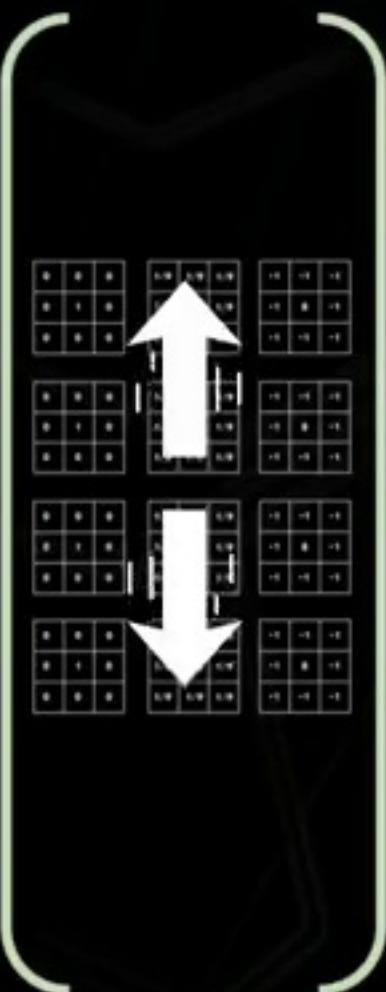
Capa de convolución



Capa de agrupación



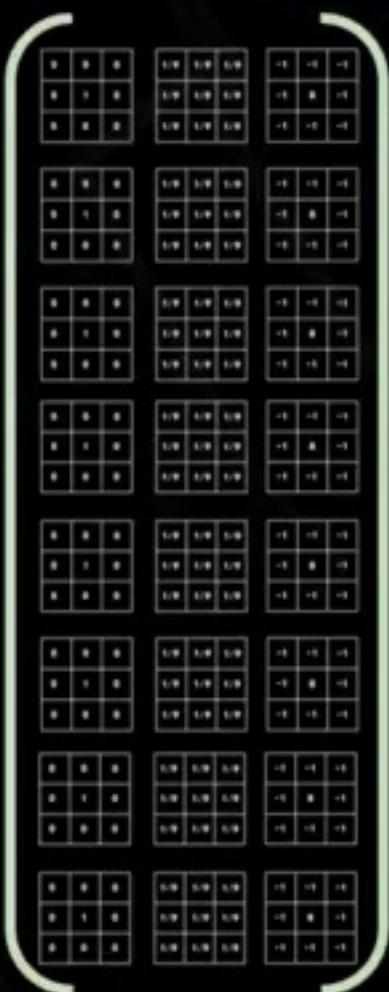
Capa de convolución



Capa de agrupación



Capa de convolución



Capa de agrupación





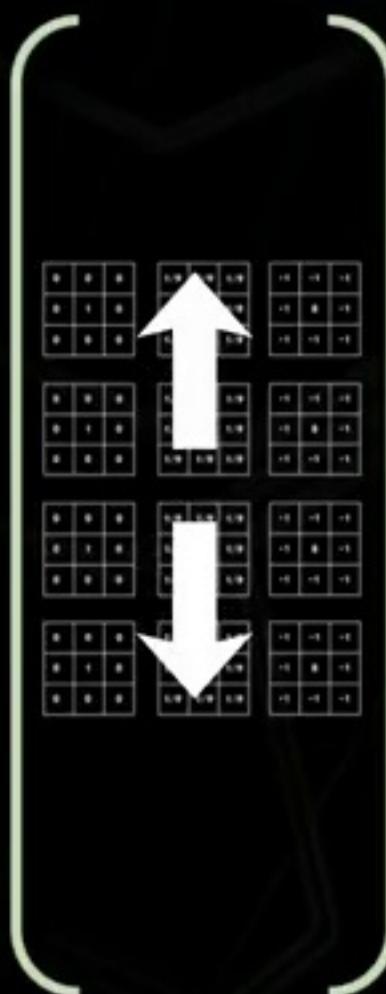
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**Capa de
agrupación**



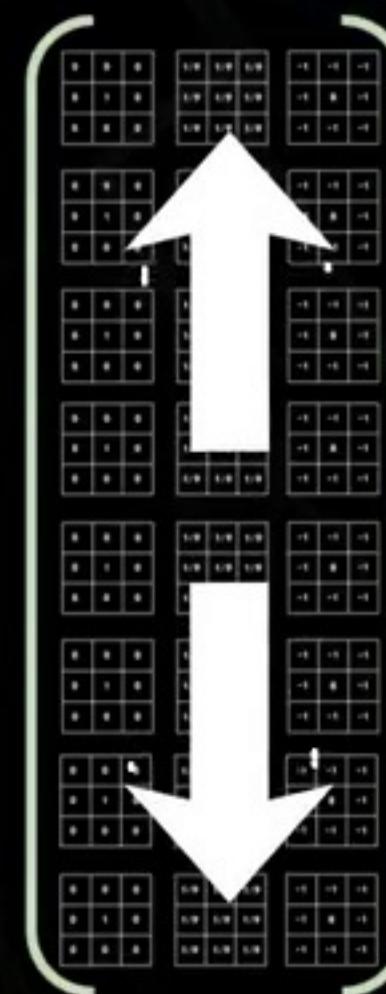
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**Capa de
agrupación**

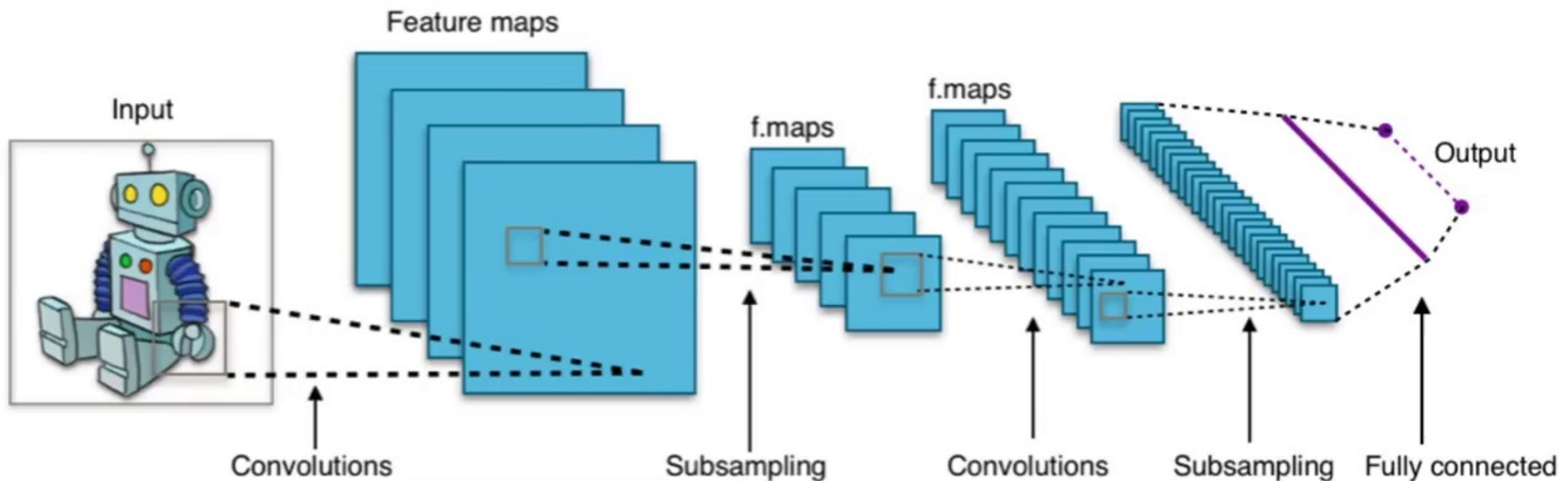


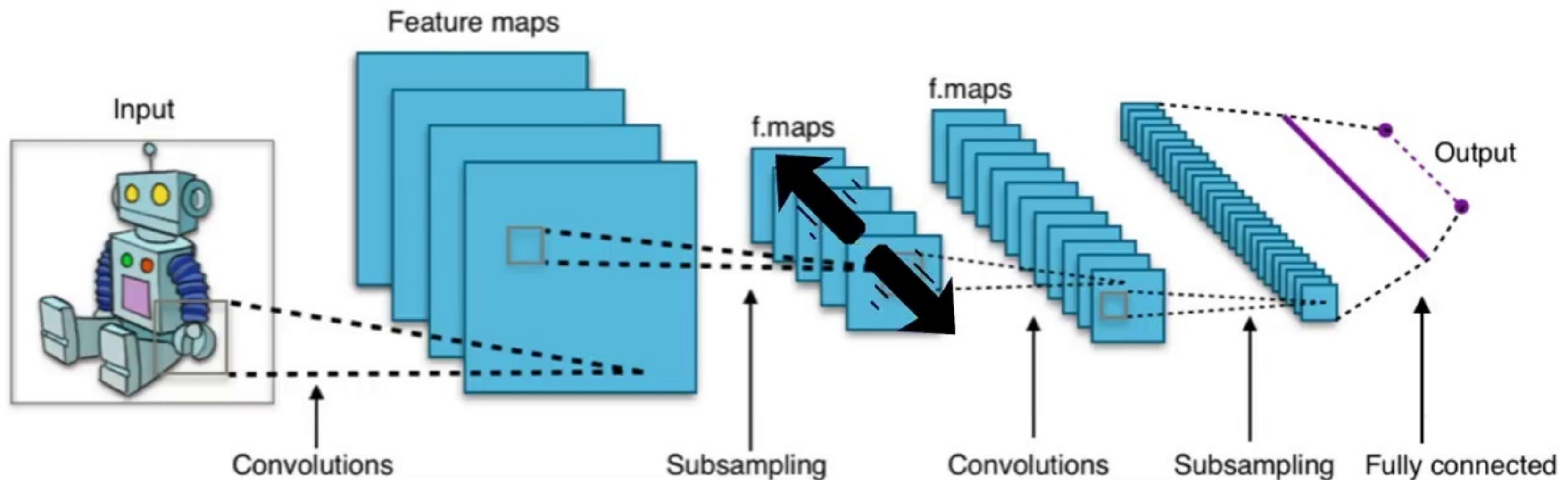
**Capa de
convolución**

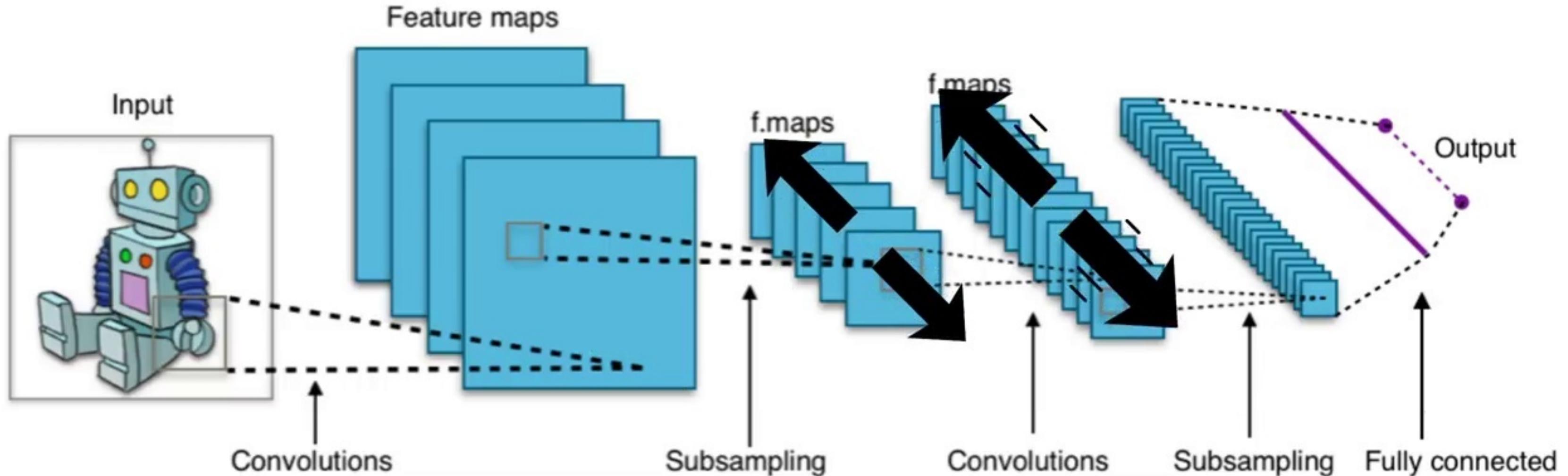


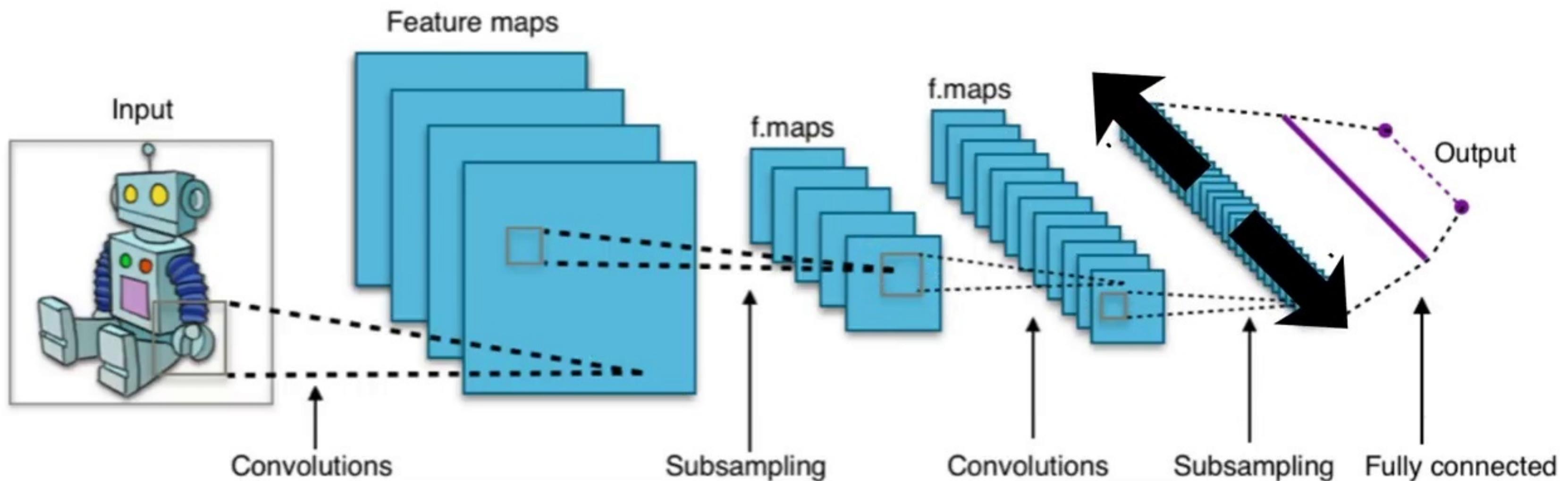
**Capa de
agrupación**







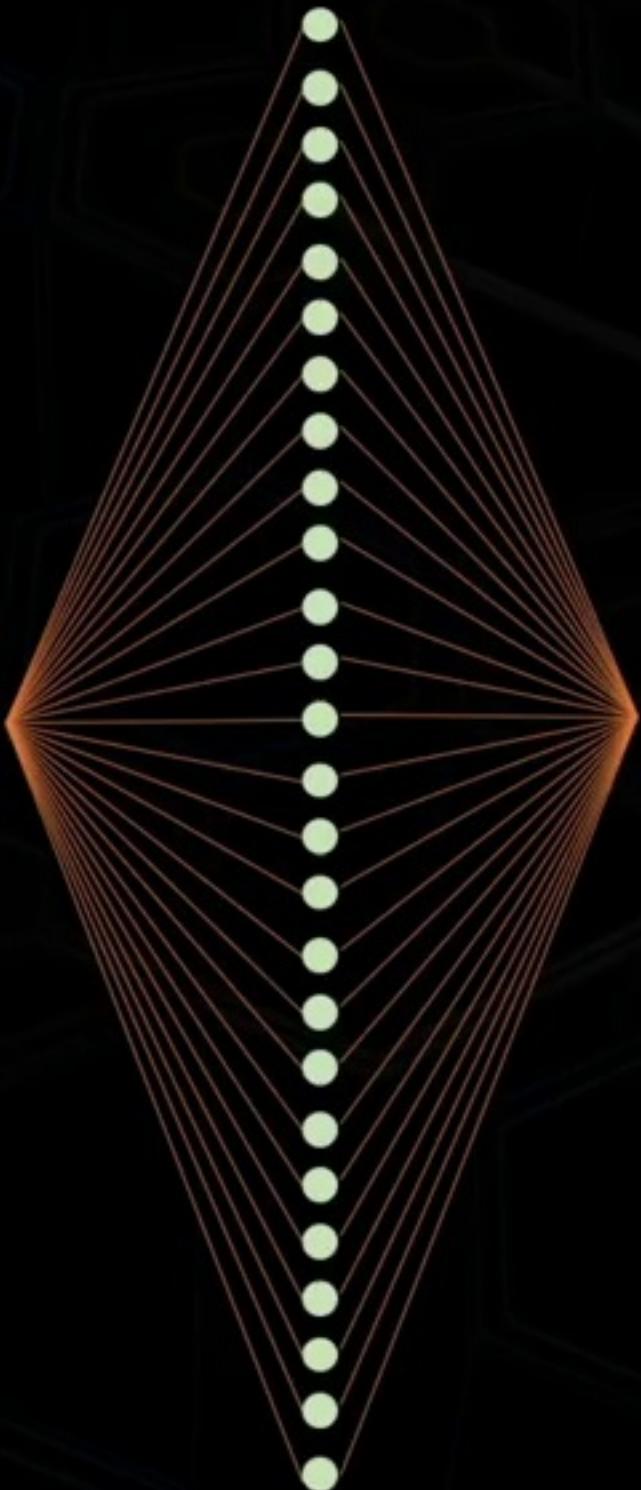




Capa de entrada

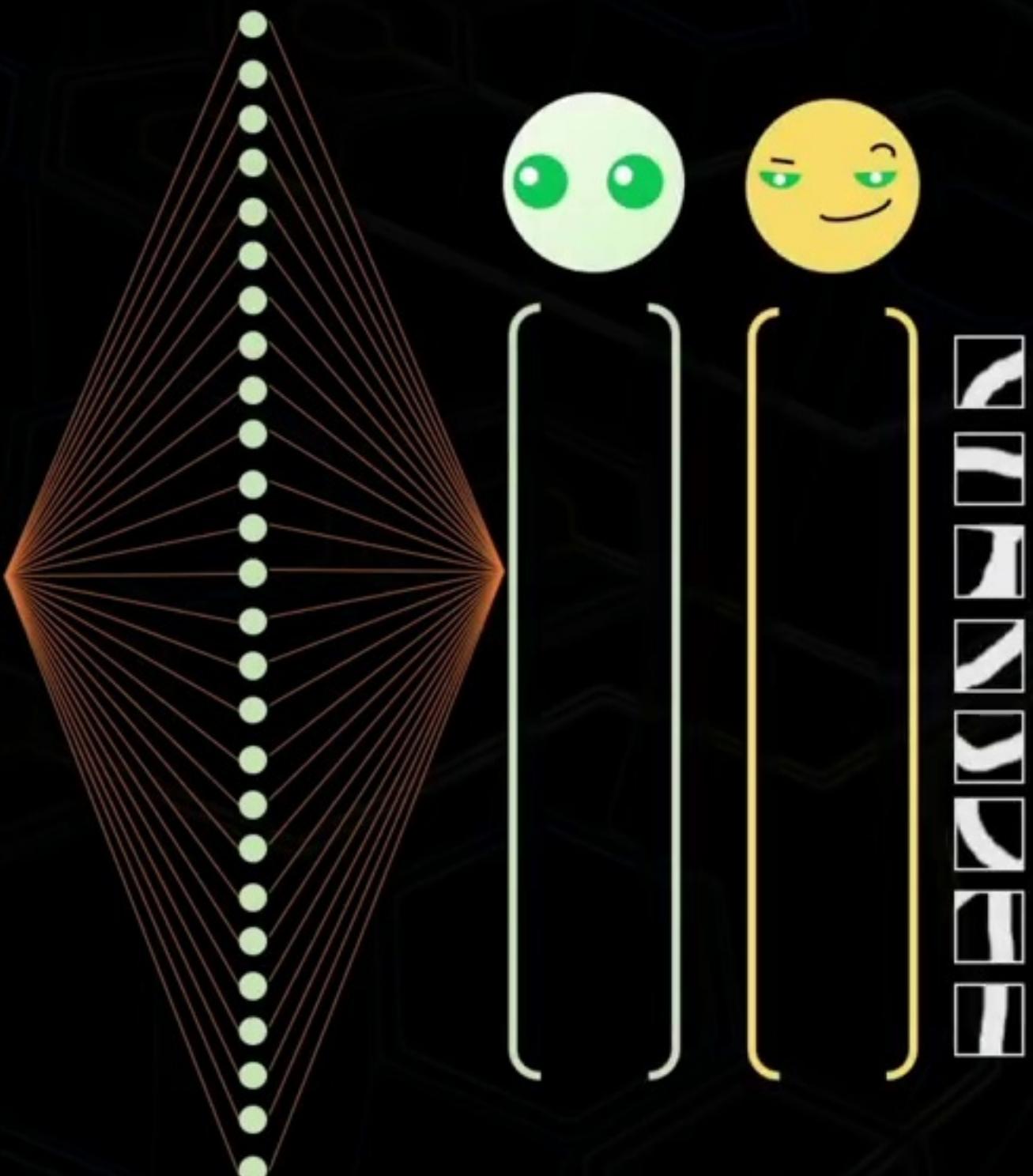
9

784



Capa de entrada

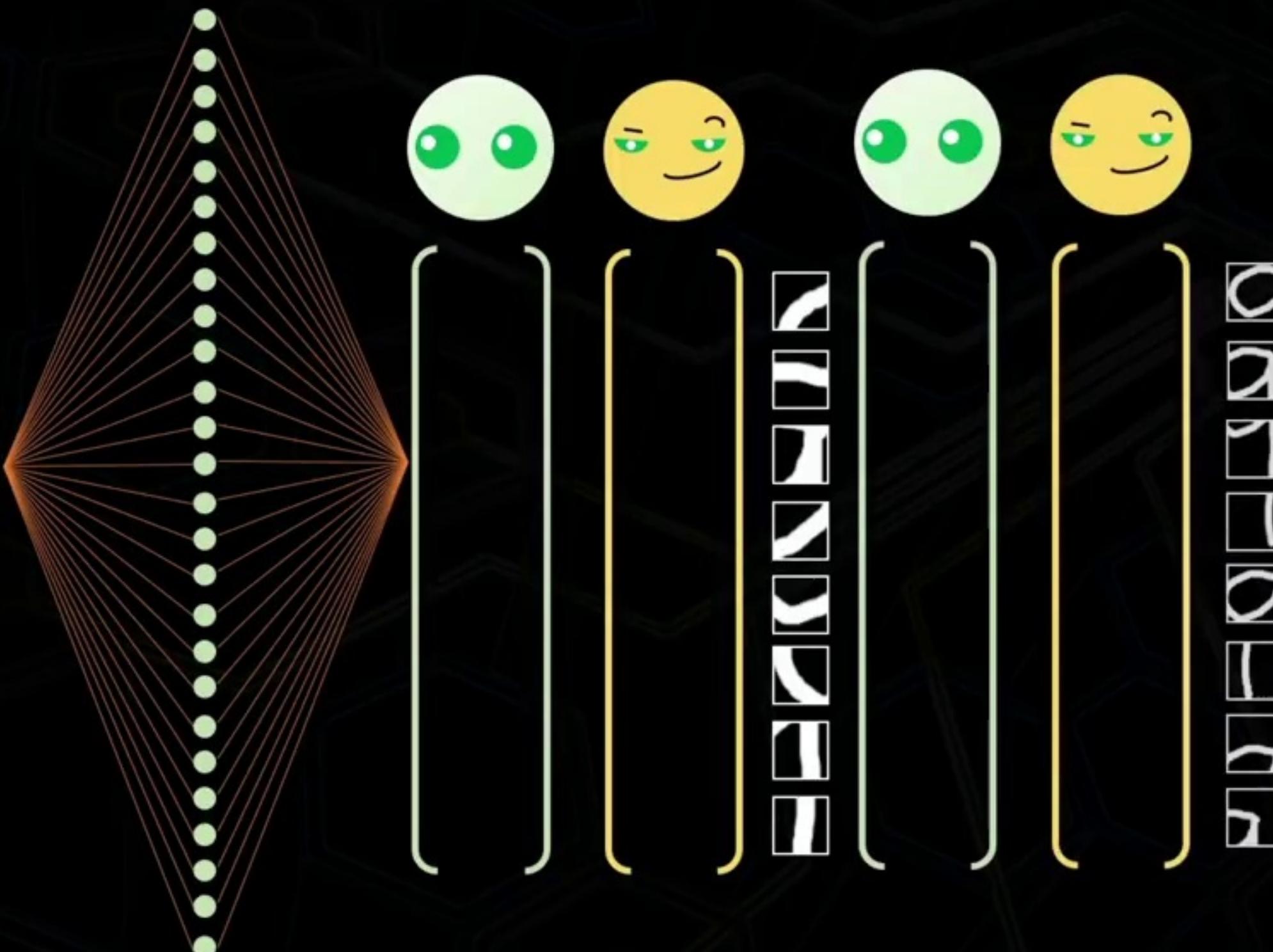
9



784

Capa de entrada

9



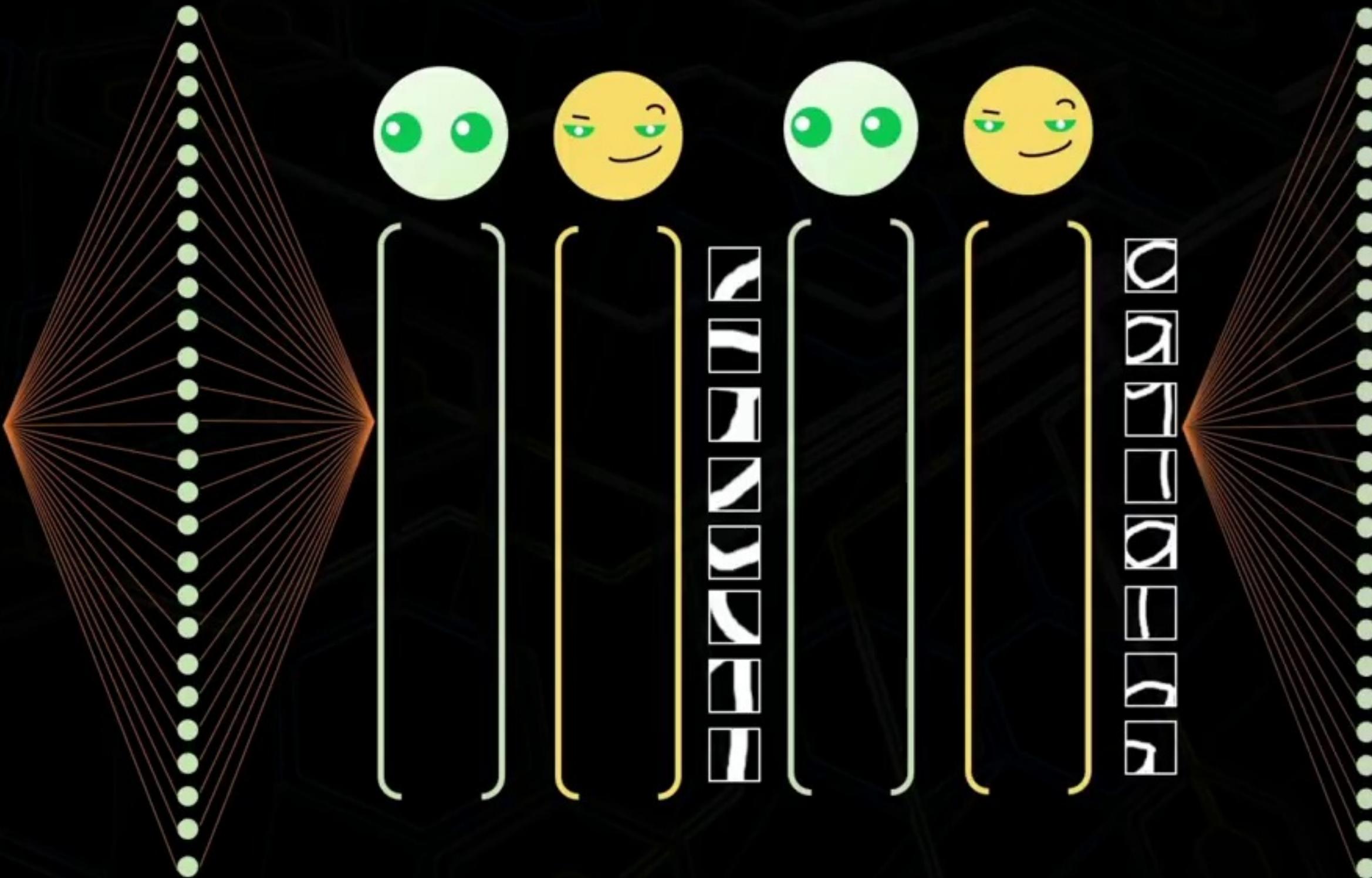
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Capa de entrada

Oculta

9

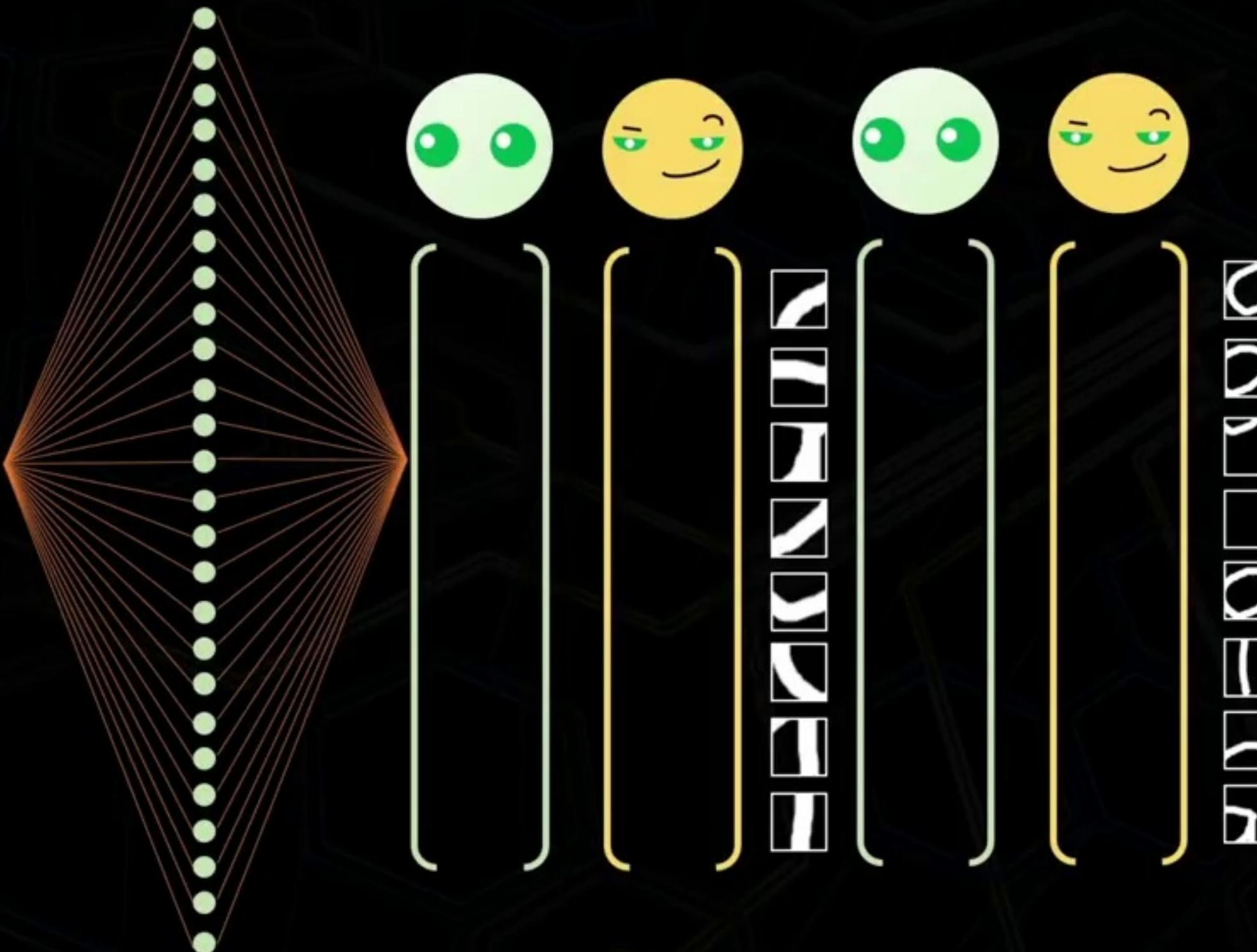
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Capa de entrada

9

784



Oculta

