



BATCH : BATCH 150 DATA SCIENCE

LESSON : DEEP LEARNING

DATE : 29.08.2023

SUBJECT : CNN and Computer Vision

- techproeducation
- techproeducation
- techproeducation
- techproeducation
- techproedu

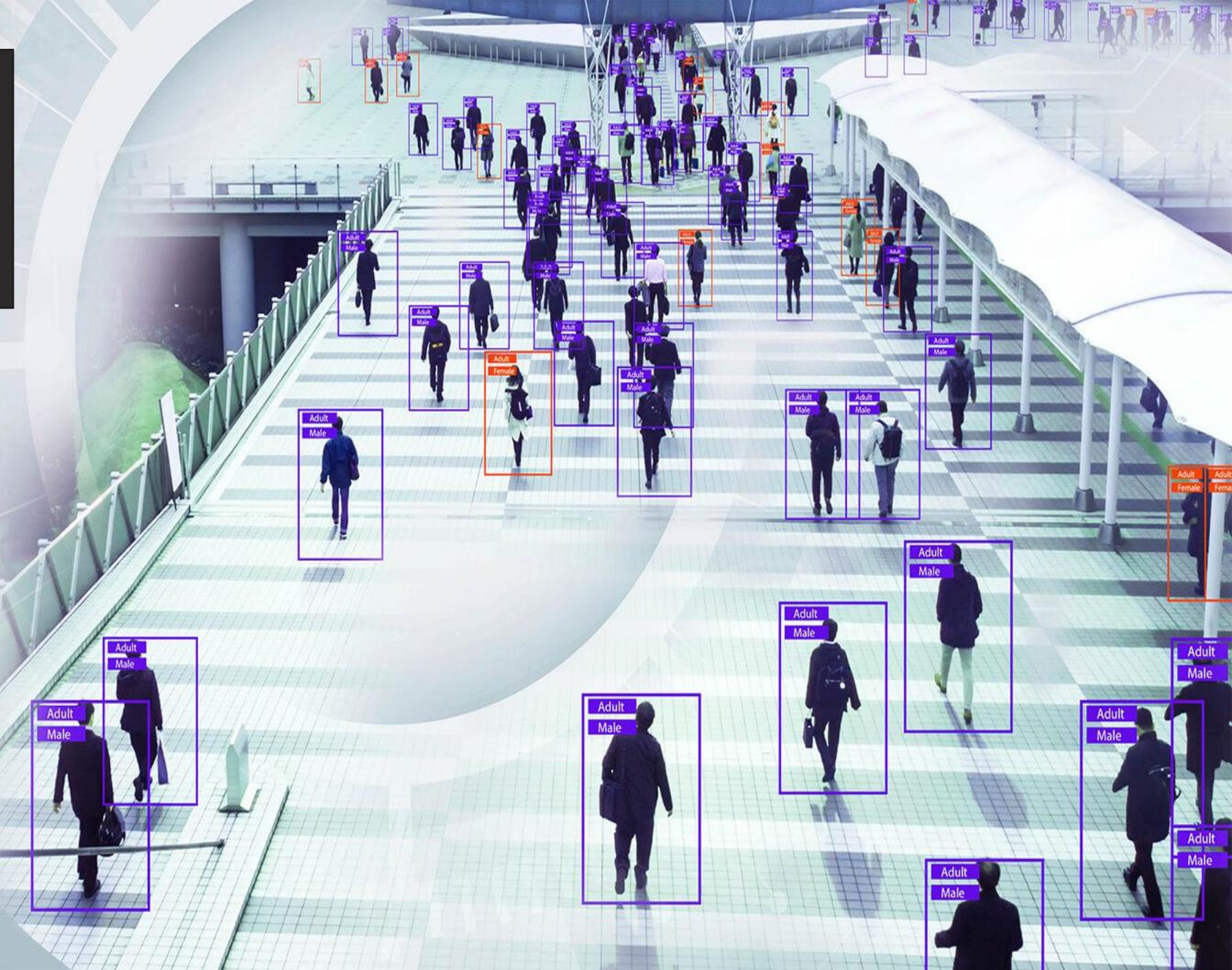
*The Perception World of Computers:
Pixel Counts and Color Codes*



Contents

- ✓ **The Perception World of Computers: Pixel Counts and Color Codes**
- ✓ **CNN (Convolutional Neural Network) and Computer Vision**
- ✓ **Transfer Learning**
- ✓ **Most Popular Python Libraries for Computer Vision**
 - Pillow**
 - Scikit-image**
 - OpenCV**
- ✓ **Labeling**
- ✓ **Yolo**

The Perception World of Computers: Pixel Counts and Color Codes







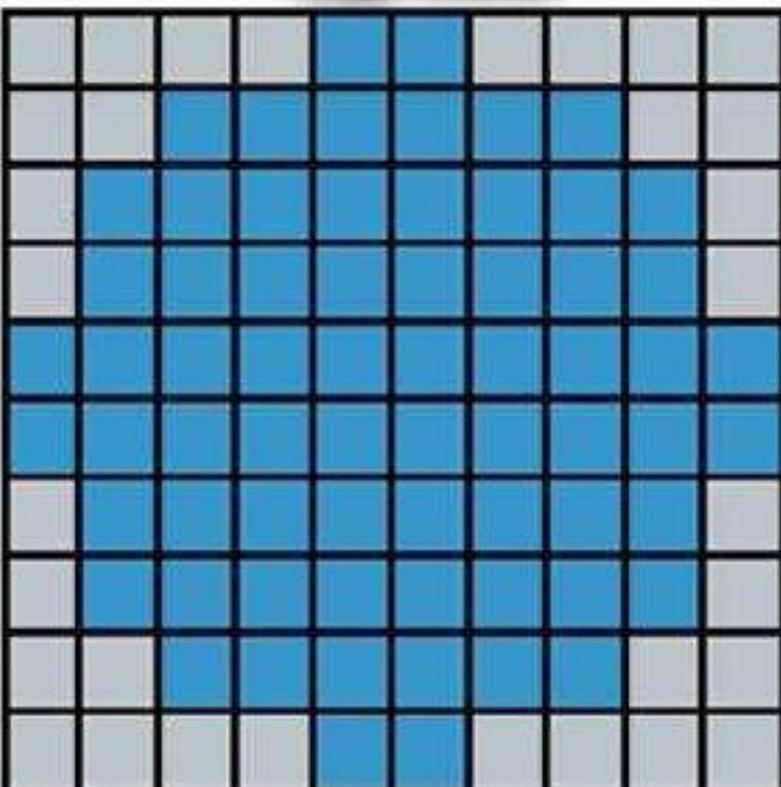
CNN and Computer Vision



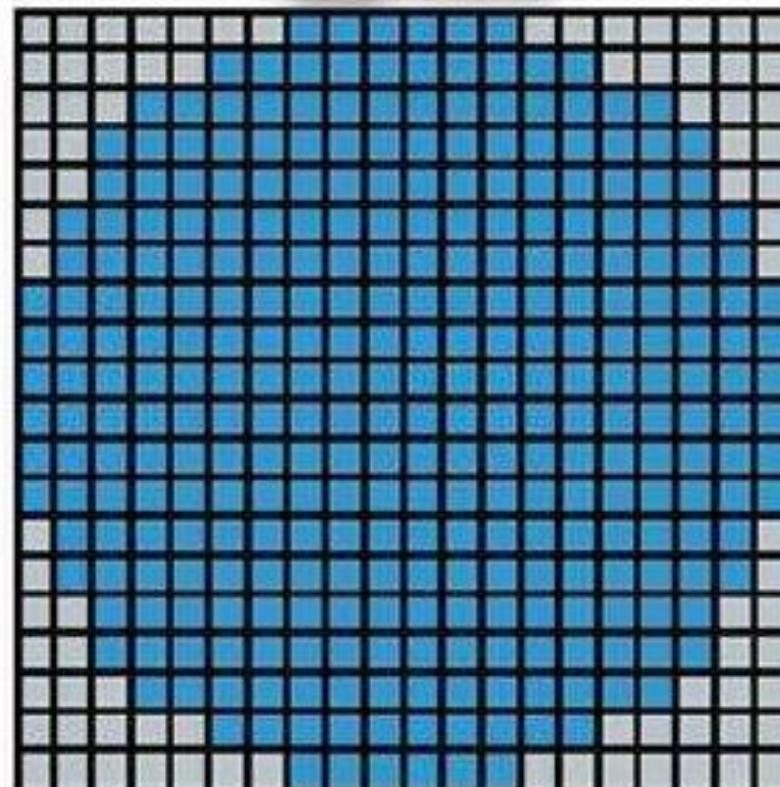


CNN and Computer Vision

10 PPI



20 PPI



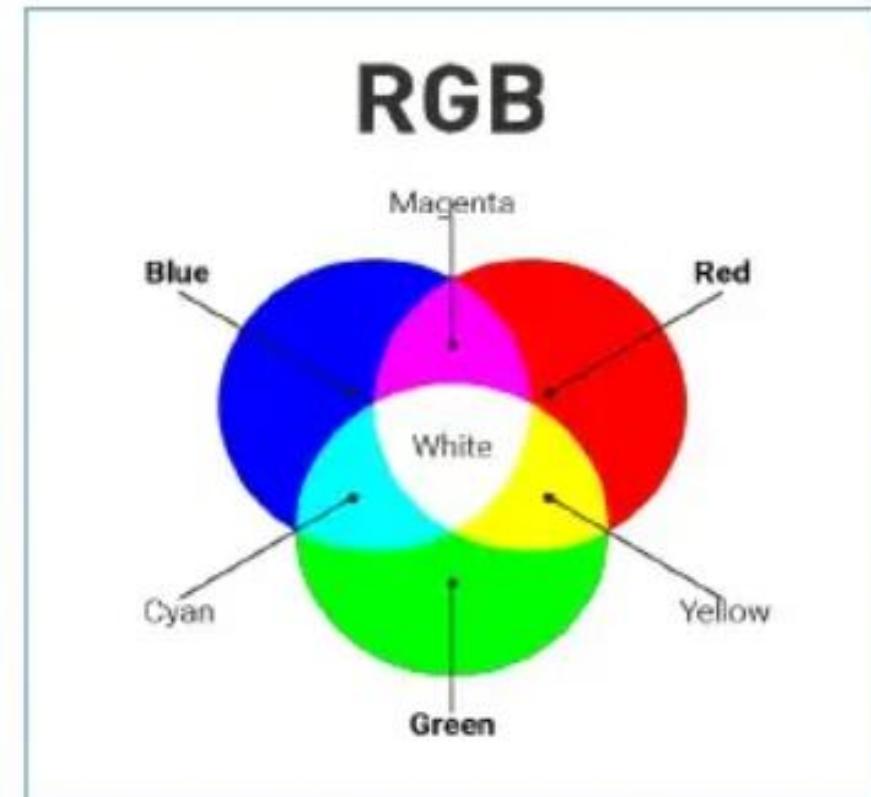
2,54 cm

2,54 cm



CNN and Computer Vision

Color Name	RGB Value (0 to 255)			Color
	B (Blue)	G (Green)	R (Red)	
Blue	255	0	0	
Green	0	255	0	
Red	0	0	255	
White	255	255	255	
Black	0	0	0	





HOW WE SEE





CNN and Computer Vision

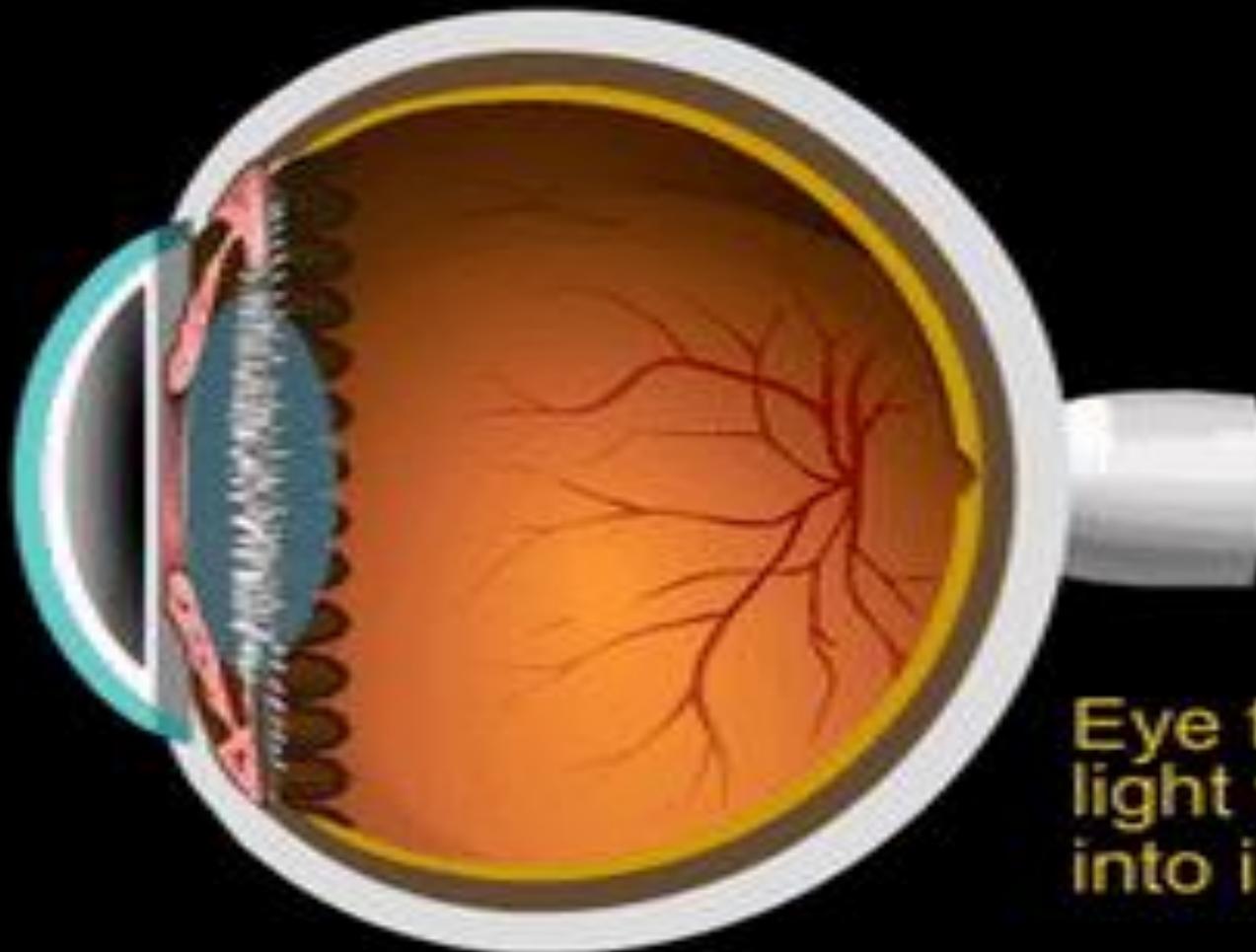




CNN and Computer Vision



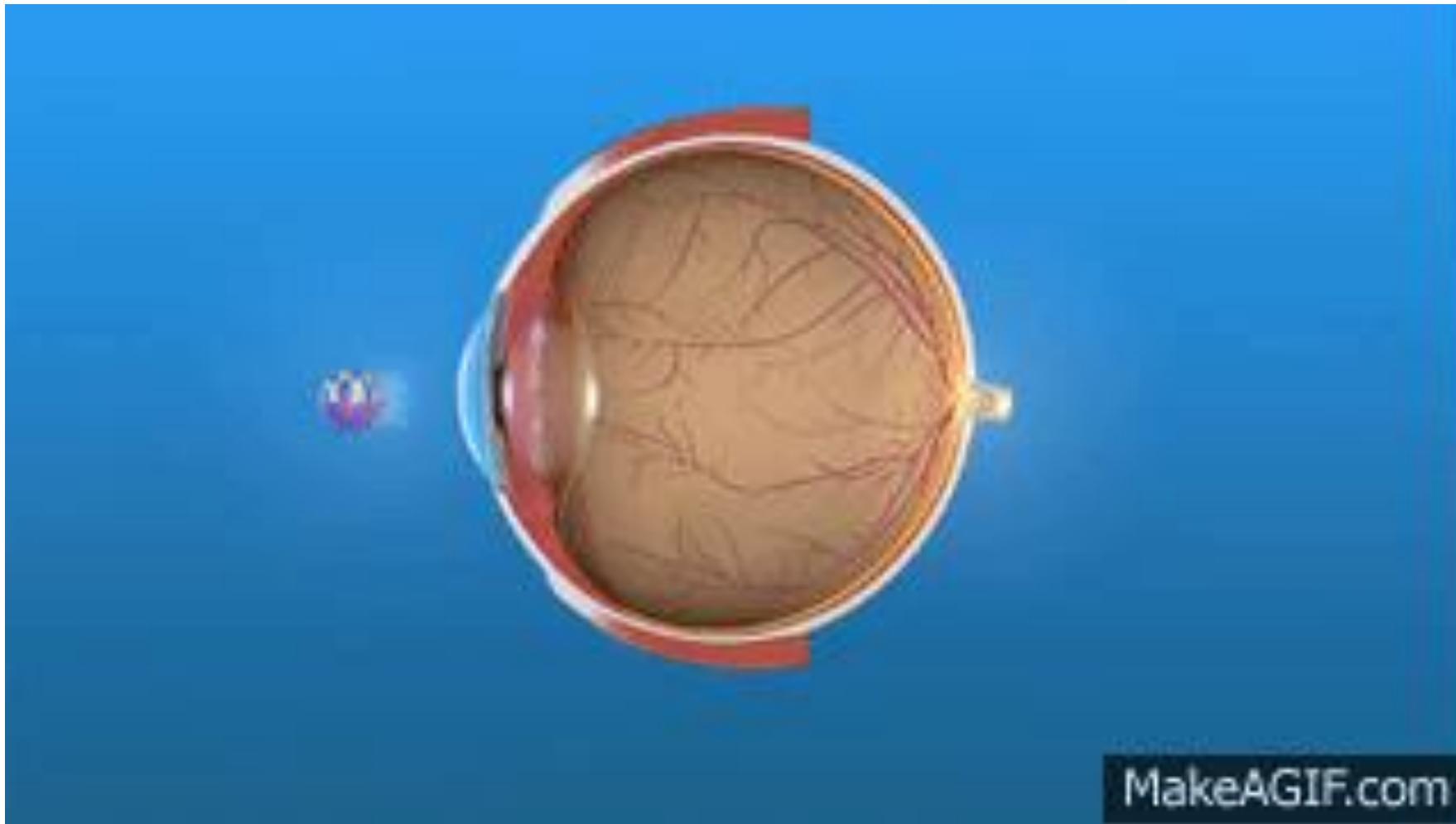
Light



Eye translates
light waves
into images.



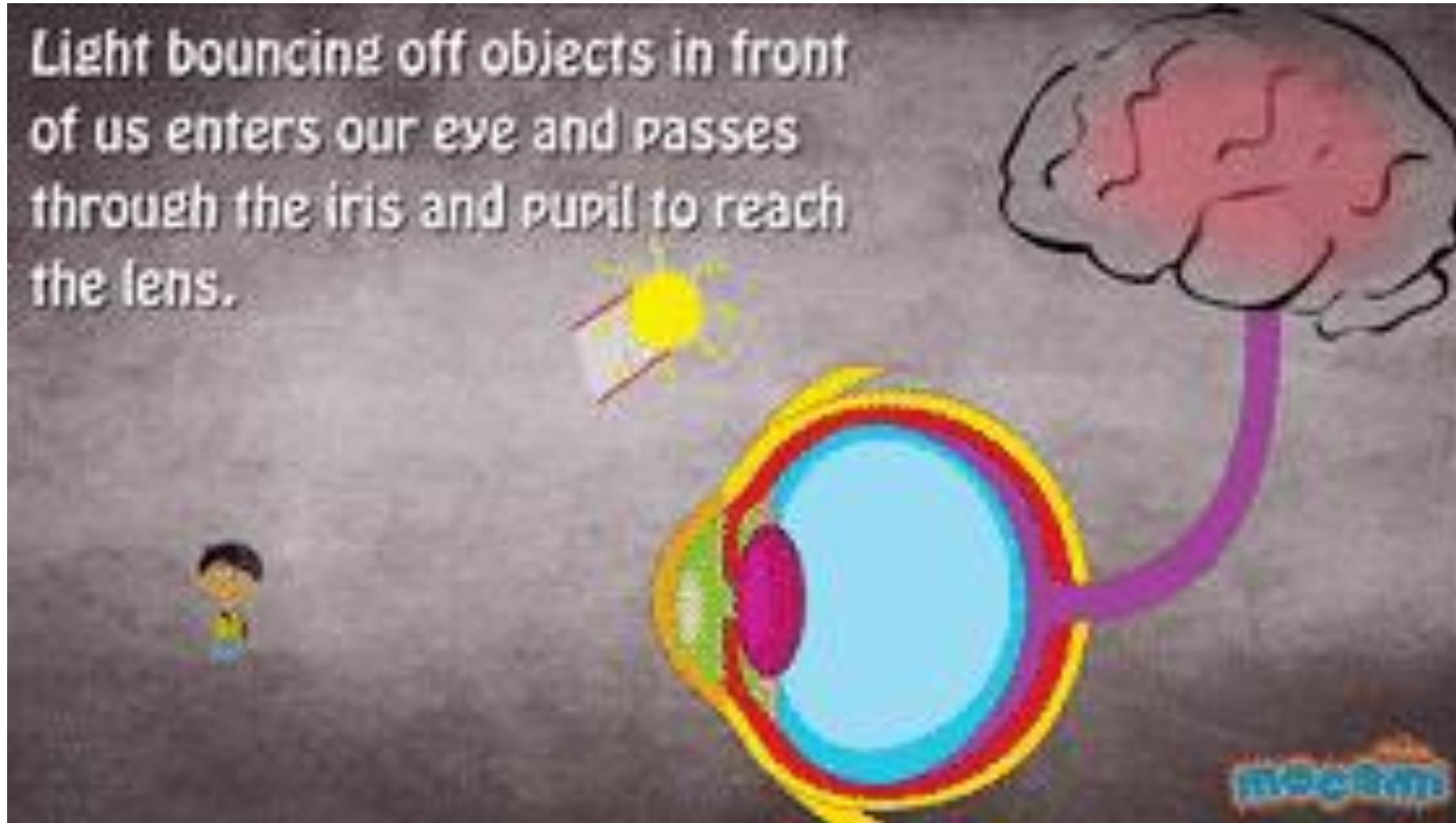
CNN and Computer Vision

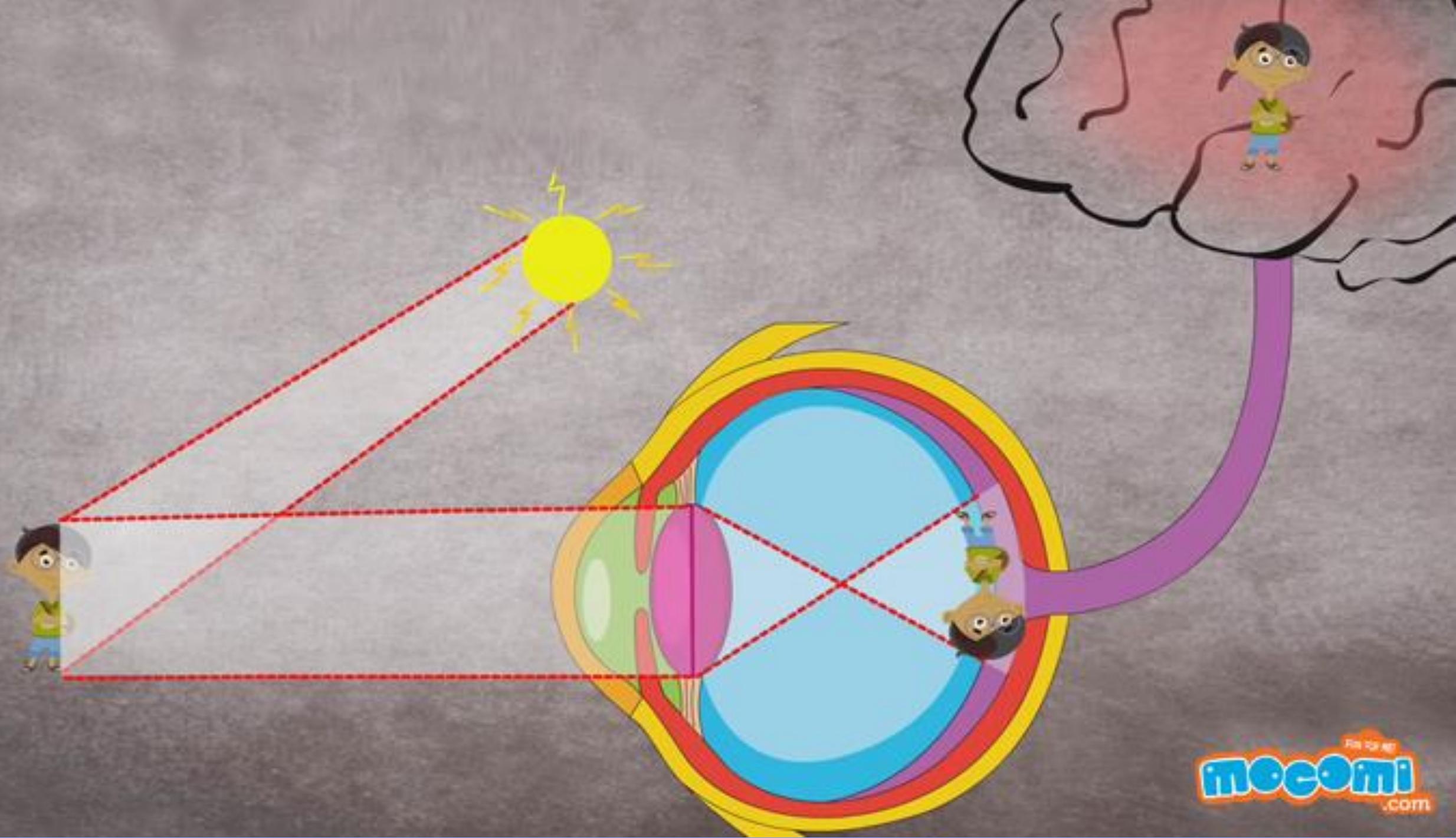


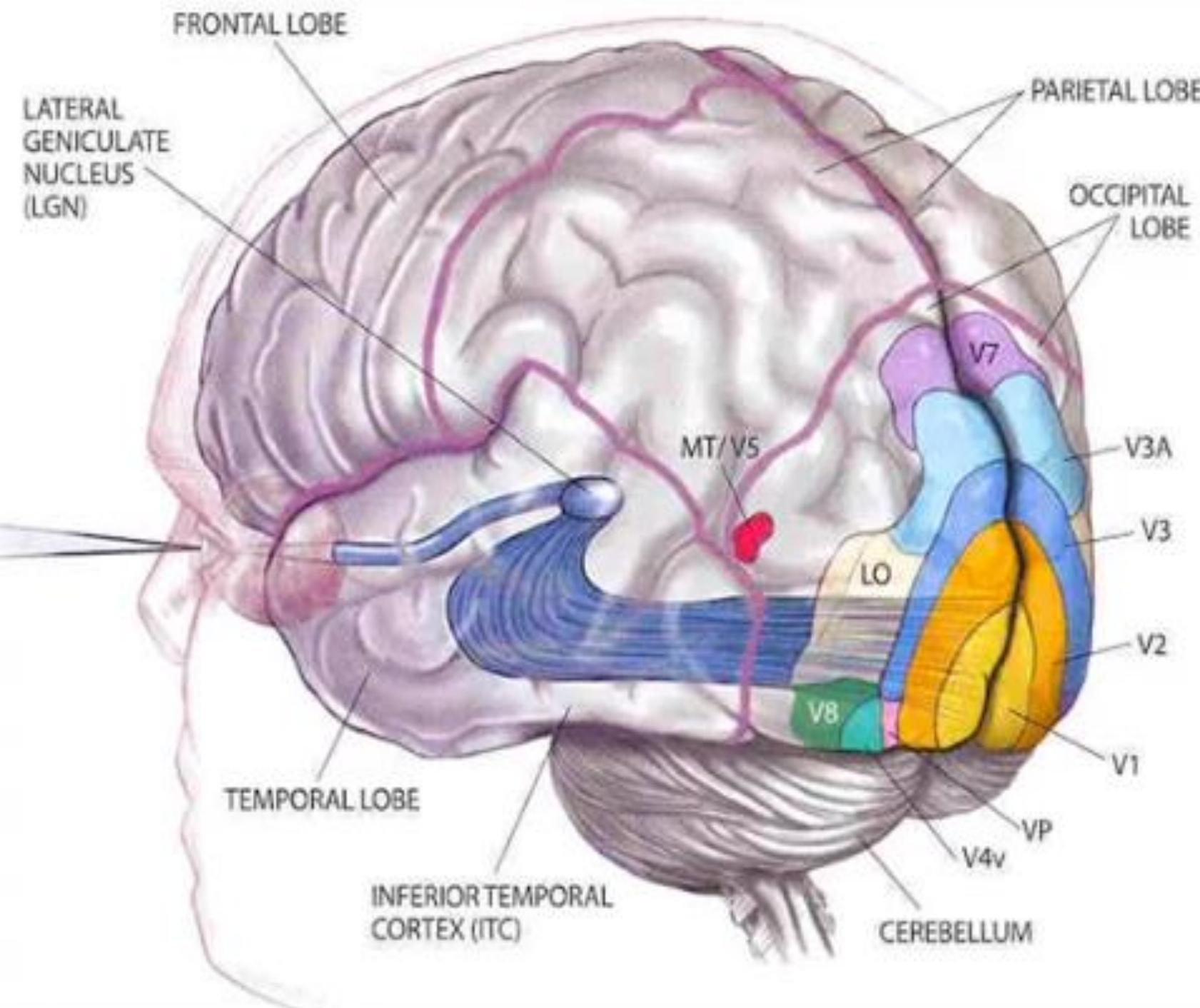


CNN and Computer Vision

Light bouncing off objects in front of us enters our eye and passes through the iris and pupil to reach the lens.







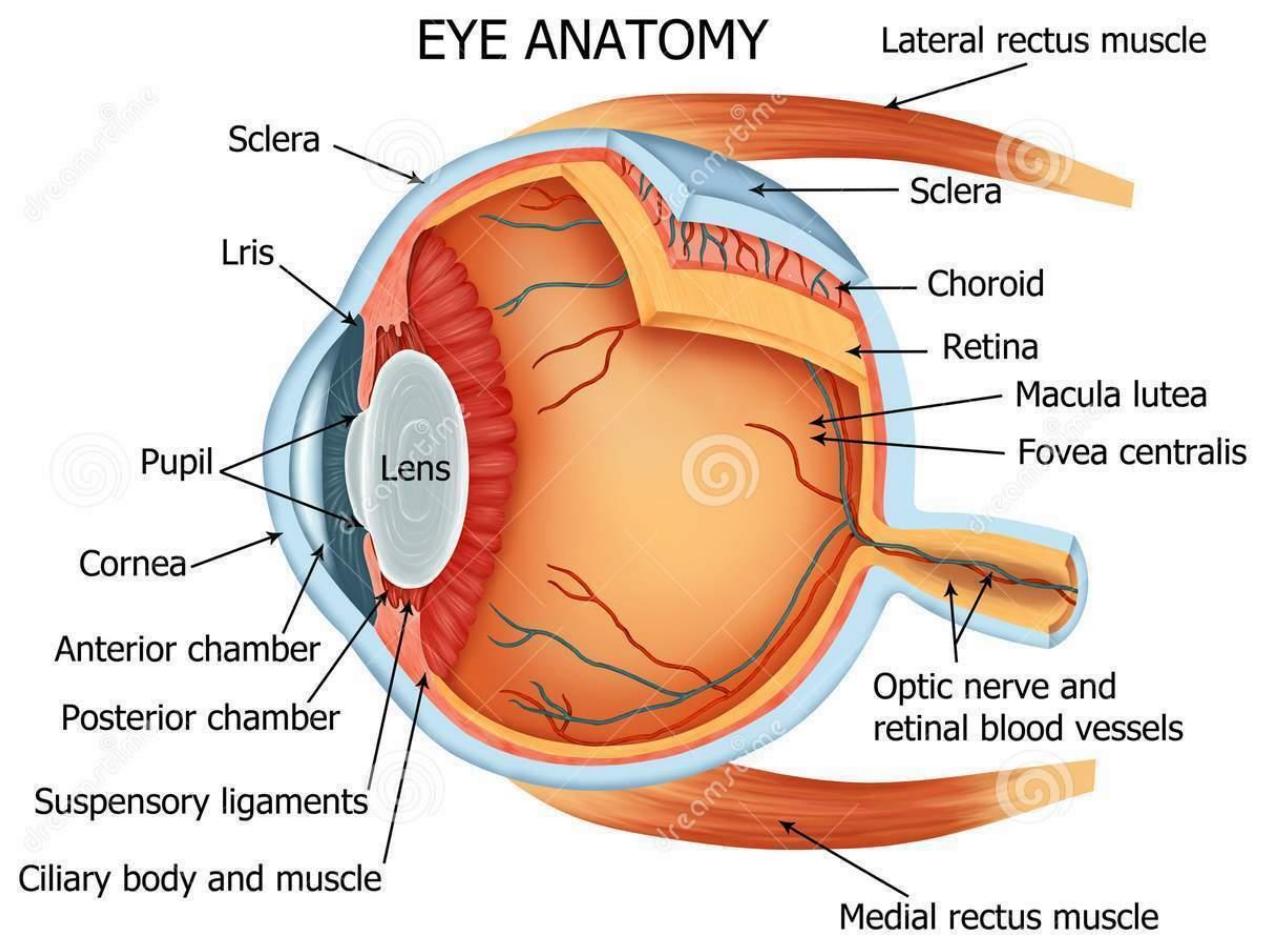
KEY TO FUNCTION

- V1:** Primary visual cortex; receives all visual input. Begins processing of color, motion and shape. Cells in this area have the smallest receptive fields.
- V2, V3 and VP:** Continue processing; cells of each area have progressively larger receptive fields.
- V3A:** Biased for perceiving motion.
- V4v:** Function unknown.
- MT/VS:** Detects motion.
- V7:** Function unknown.
- V8:** Processes color vision.
- LO:** Plays a role in recognizing large-scale objects.

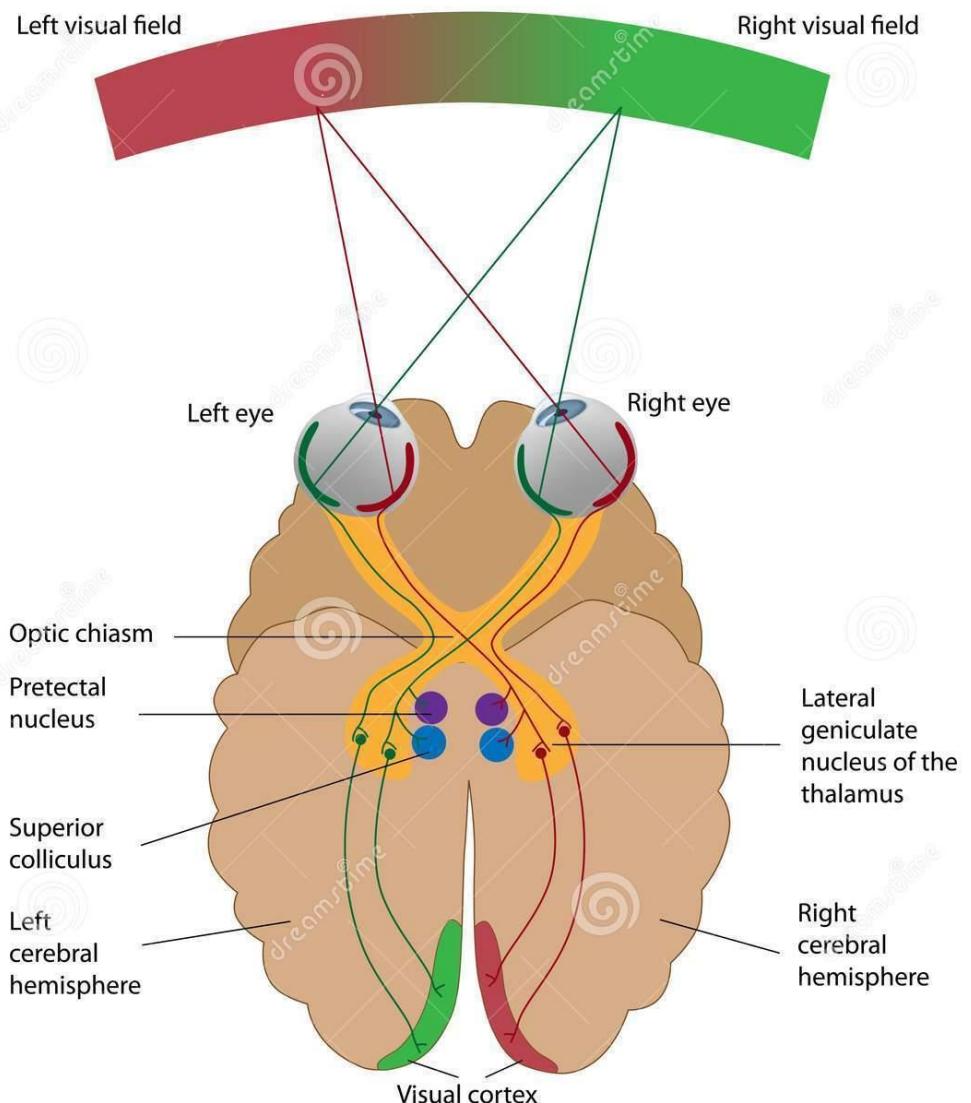
Note: A V6 region has been identified only in monkeys.

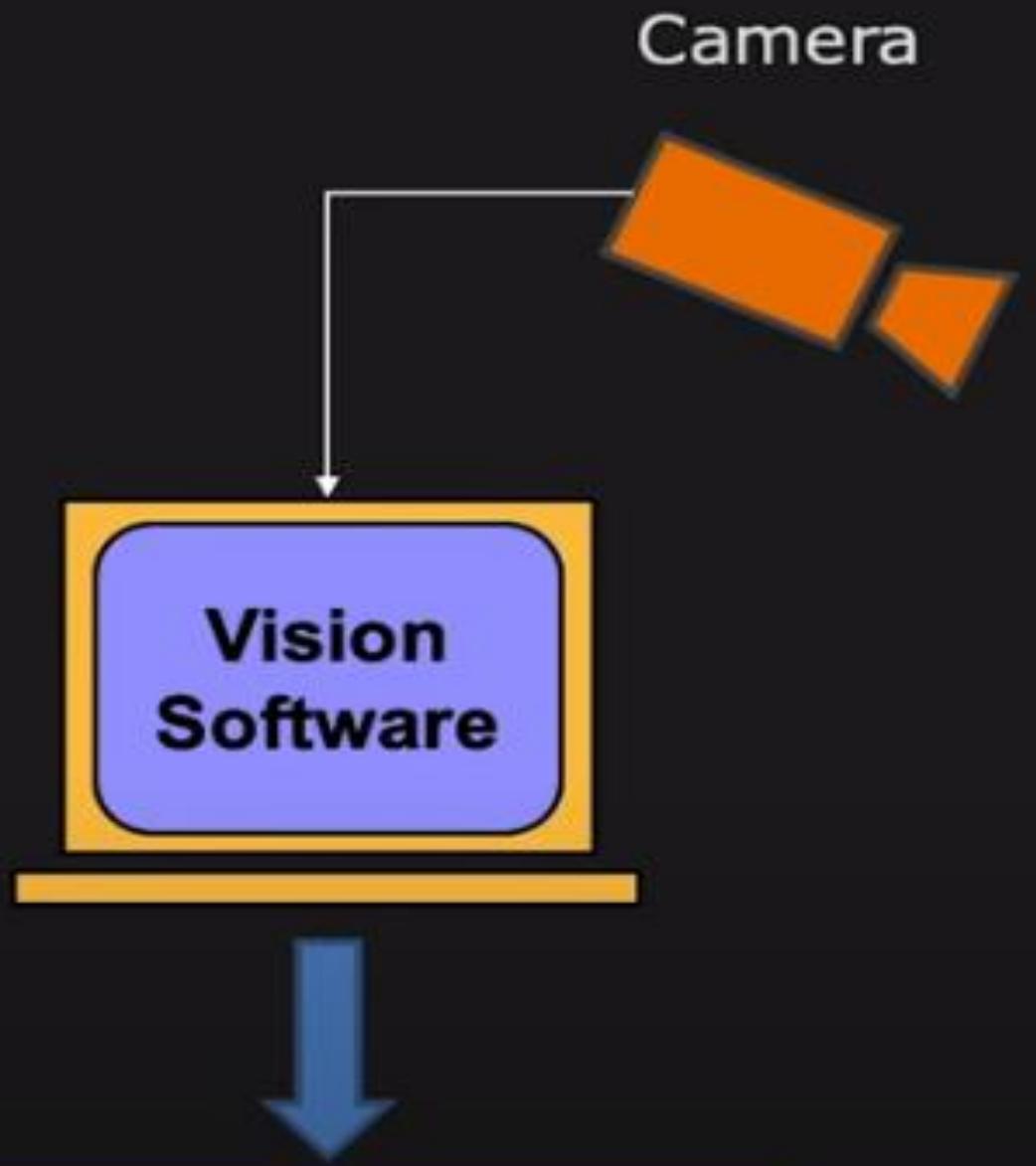


CNN and Computer Vision



The Visual Projection Pathway





Lighting



I.36

Scene Description

Scene

Human Vision System



(sensing device responsible for capturing images of the environment)

(interpreting device responsible for understanding the image content)

bowl, oranges,
bananas, lemons,
peaches

Computer Vision System



Input



Sensing device

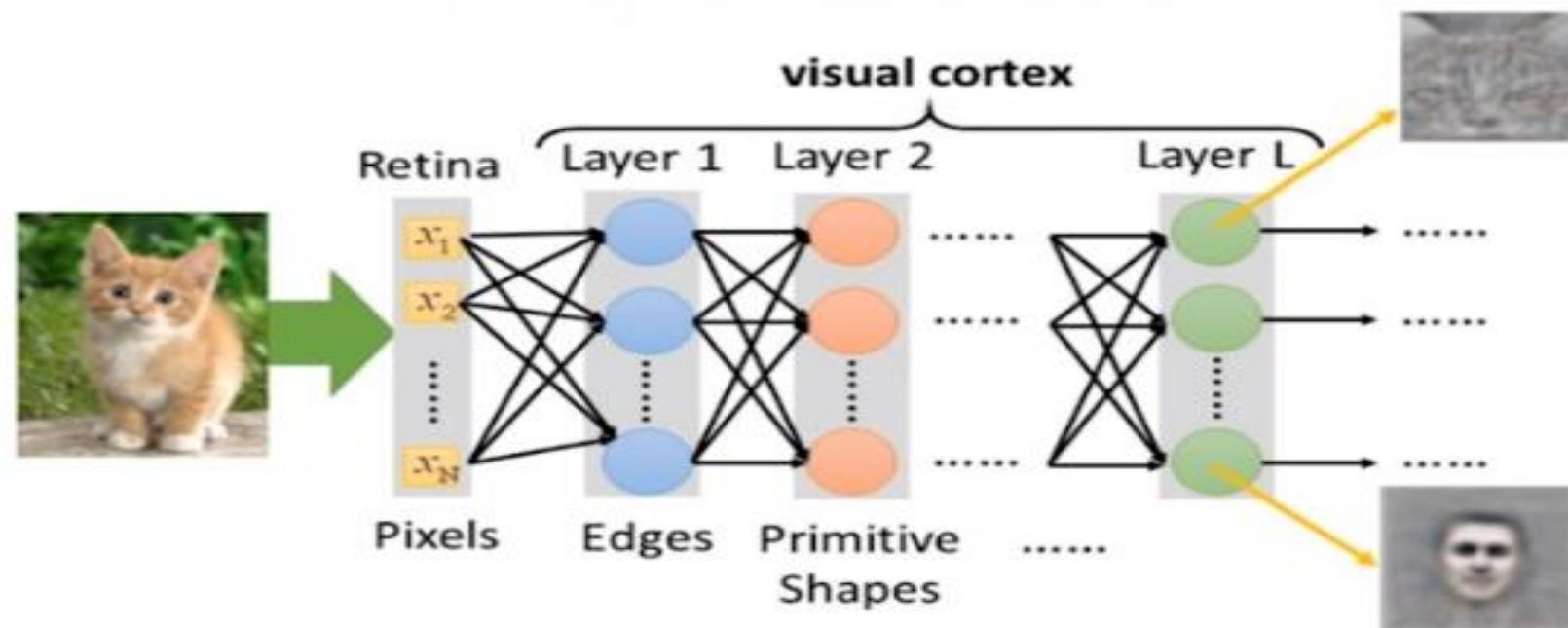
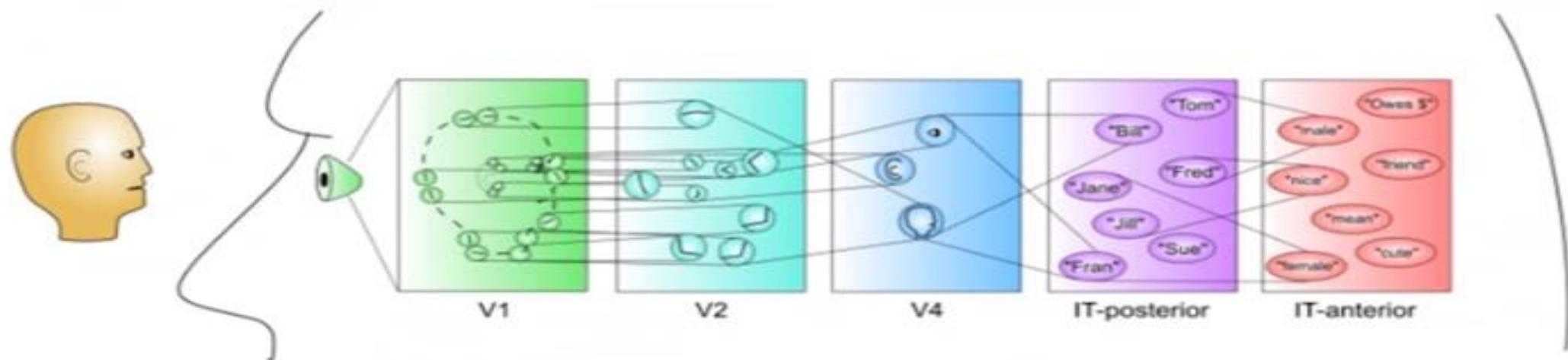
Interpreting device

bowl, oranges,
bananas, lemons,
peaches

Output

Visual Cortex

(Its Structure is Instructive and Inspiring)





CNN and Computer Vision



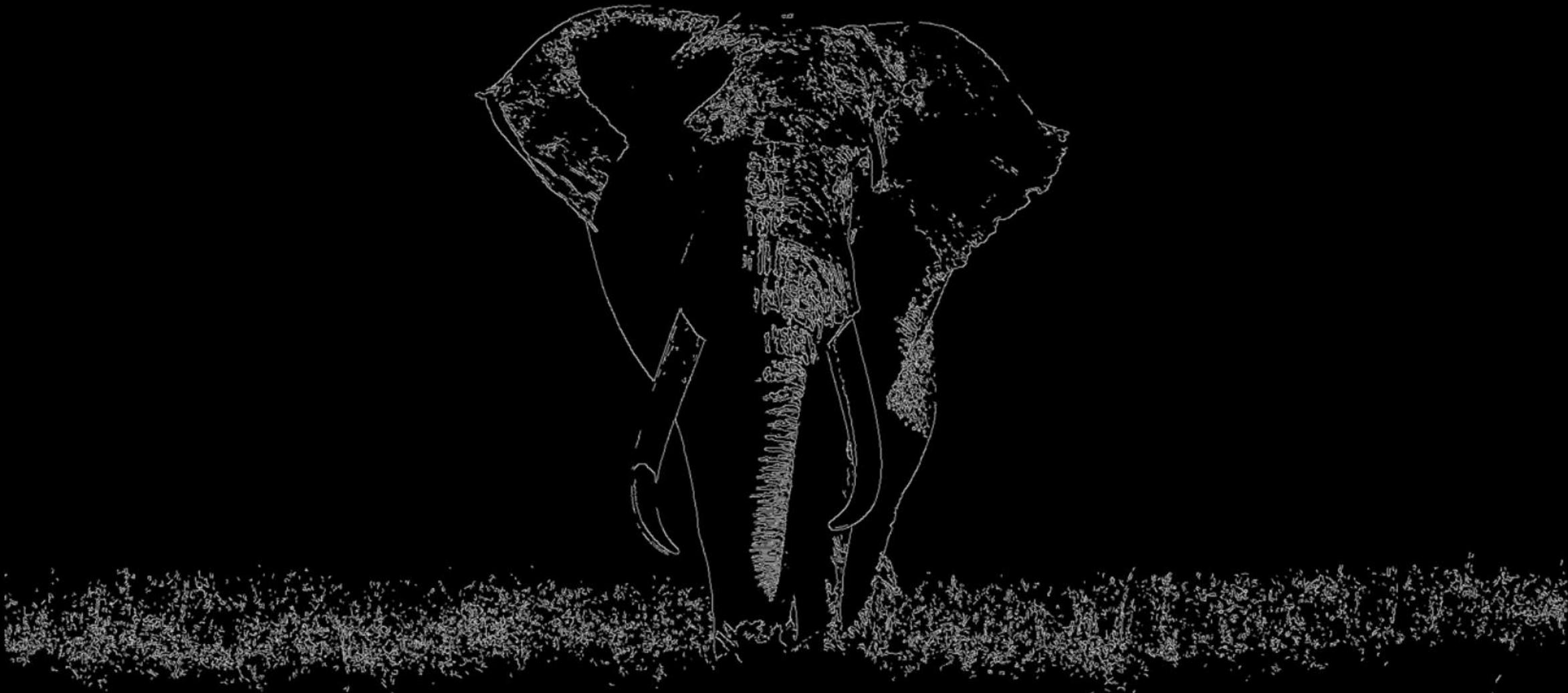


CNN and Computer Vision





CNN and Computer Vision





Fei-Fei Li:

How we're teaching computers to understand pictures

TED2015 · 17:58 · Filmed Mar 2015

Subtitles available in 15 languages

 View interactive transcript



car: 66%

car: 97%

car: 95%

car: 86%

car: 94%

car: 98%

car: 97%

car: 89%

car: 85%

person: 59%
person: 92%
person: 91%

car: 71%

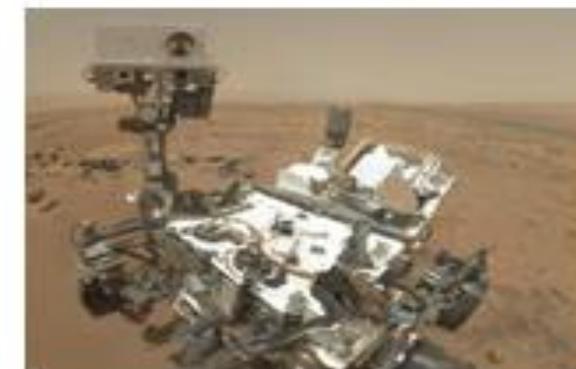
car: 69%





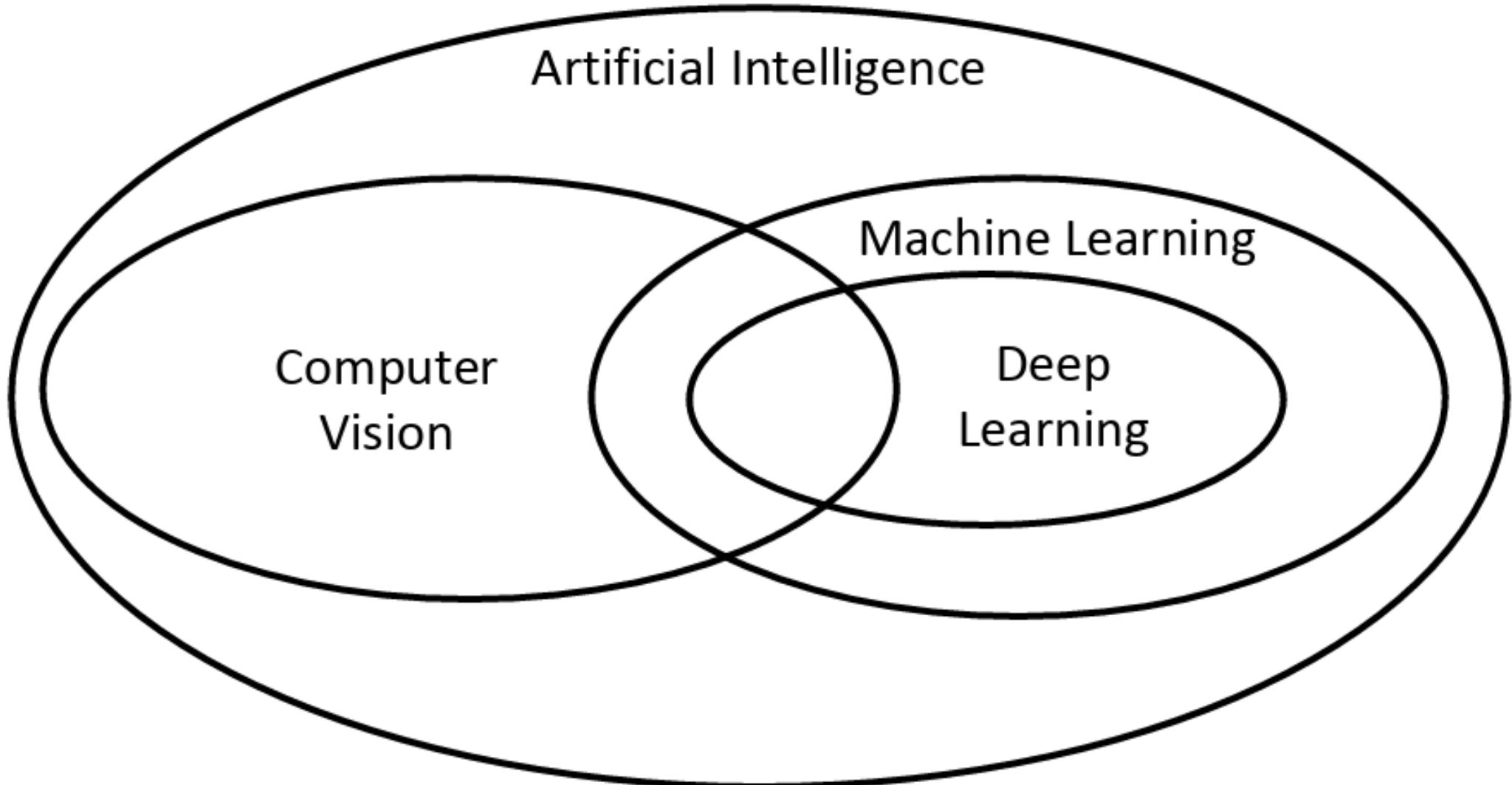
**What is the role of computer
vision in our daily lives?**

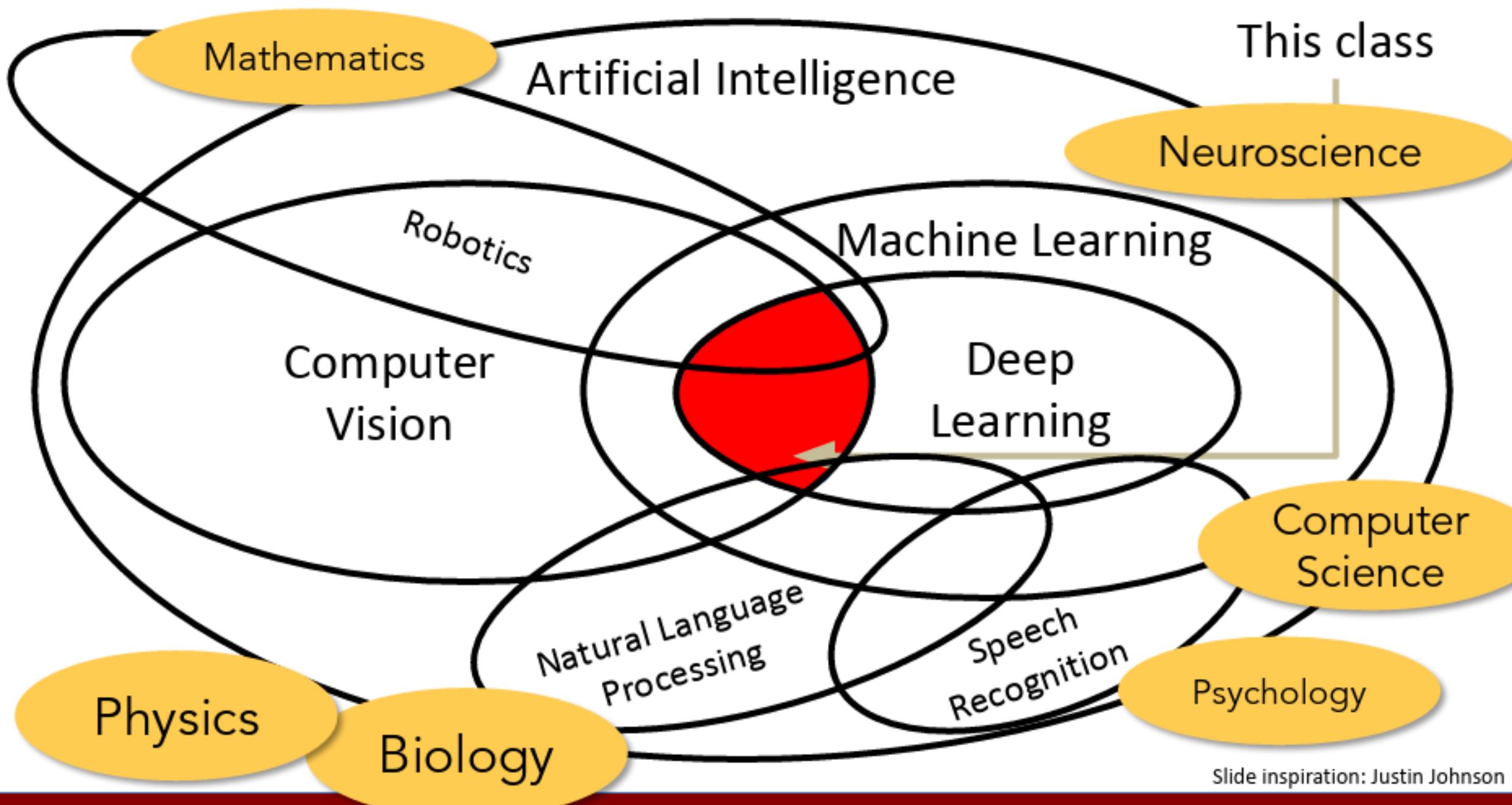
Computer Vision is everywhere!





CNN and Computer Vision





Slide inspiration: Justin Johnson

Object Tracking



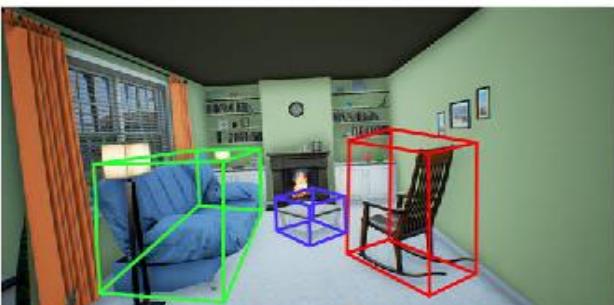
● ● ● / ●

Pose Estimation



● ● / ● ●

Object Detection



● ● / ● ●

Action Recognition



● ● ● / ● ●

Autonomous Navigation



● ● ● / ● ●

3D Reconstruction



● ● ● / ●

Crowd Understanding



● ● / ● ● ●

Urban Scene Understanding



● ● / ● ●

Indoor Scene Understanding



● ● ● / ●

Multi-agent Collaboration



● ● / ● ● ●

Human Training



● ● ● ●

Aerial Surveying



● ● ● / ● ●

● Image

● Image Label

● Depth/Multi-View

● User Input

● Video

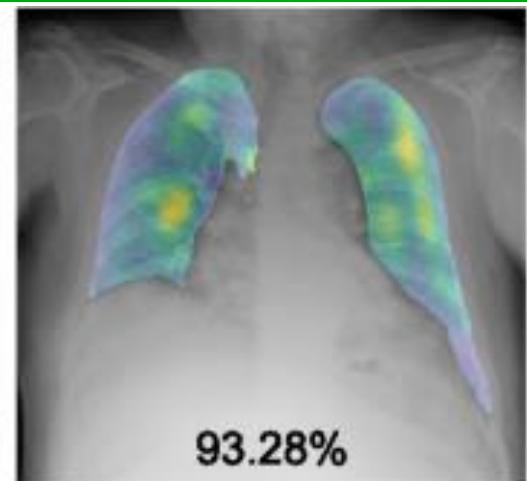
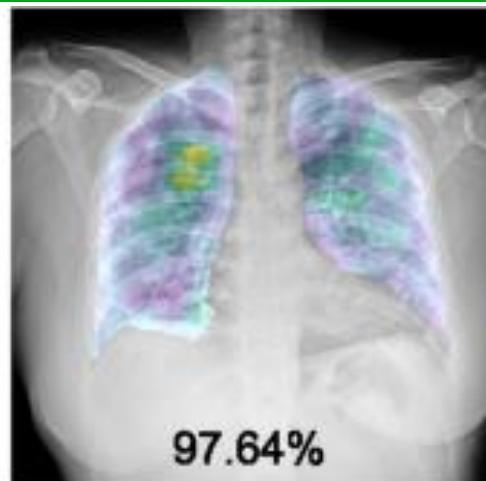
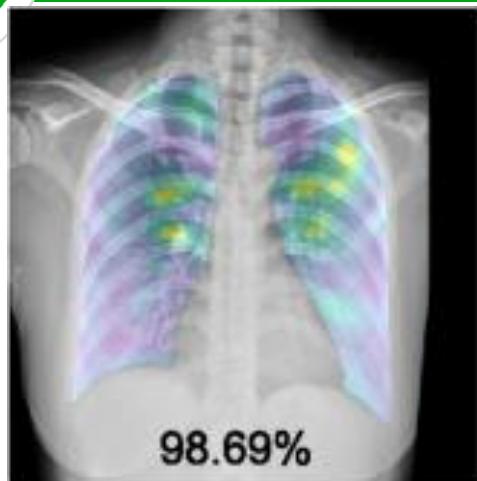
● Physics

● Segmentation/Bounding Box

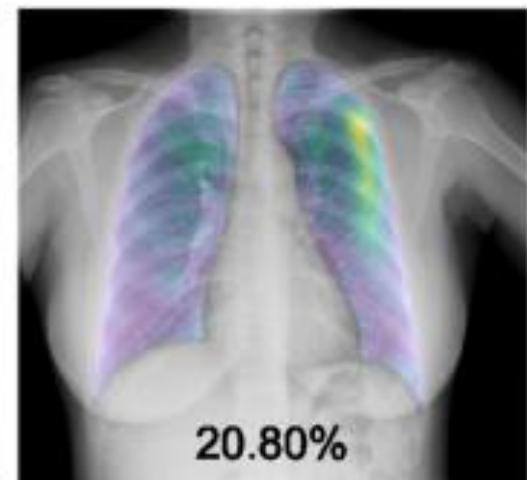
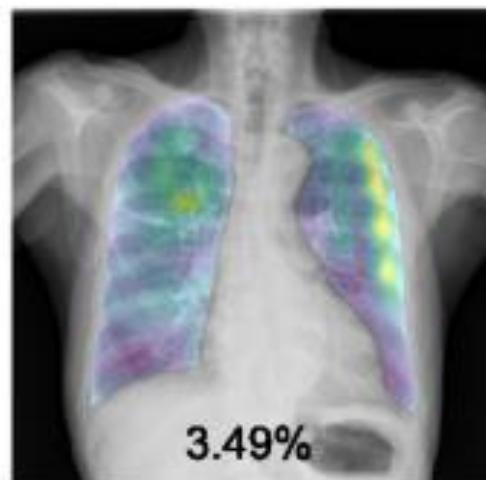
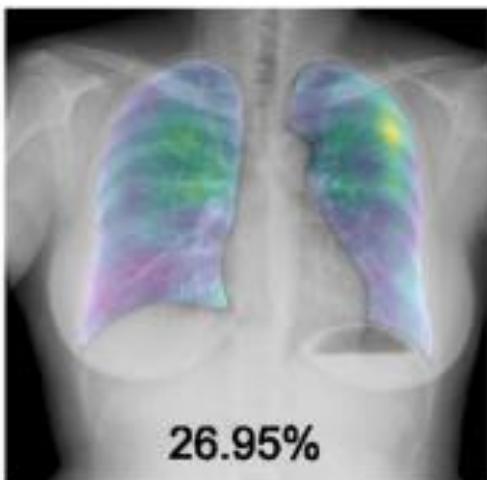
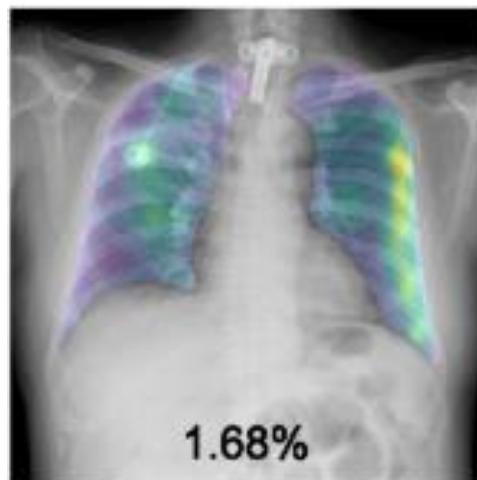
● Camera Localization



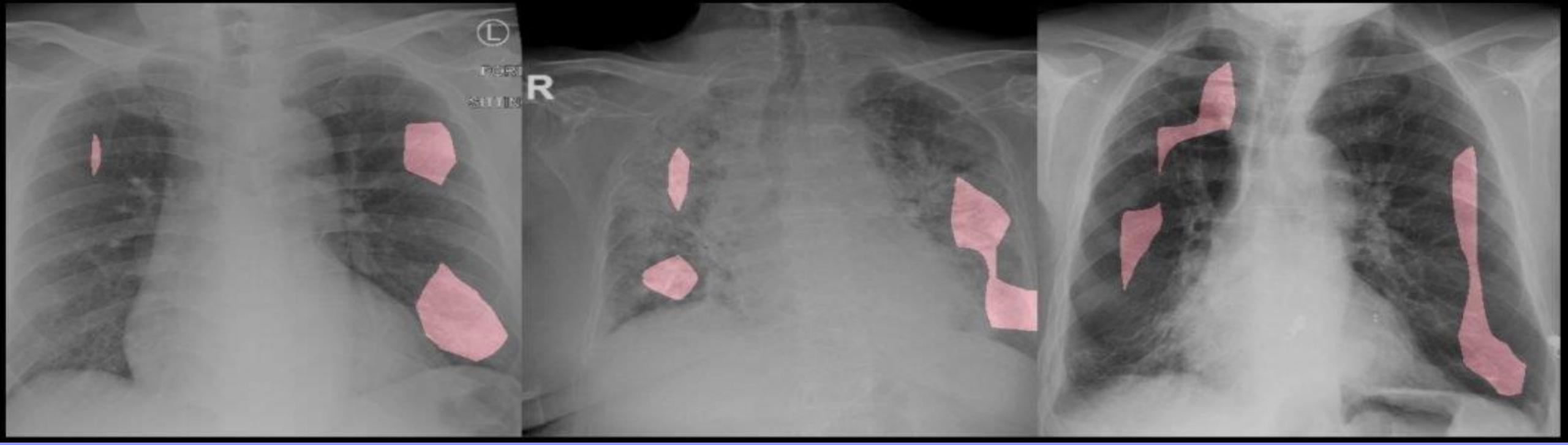
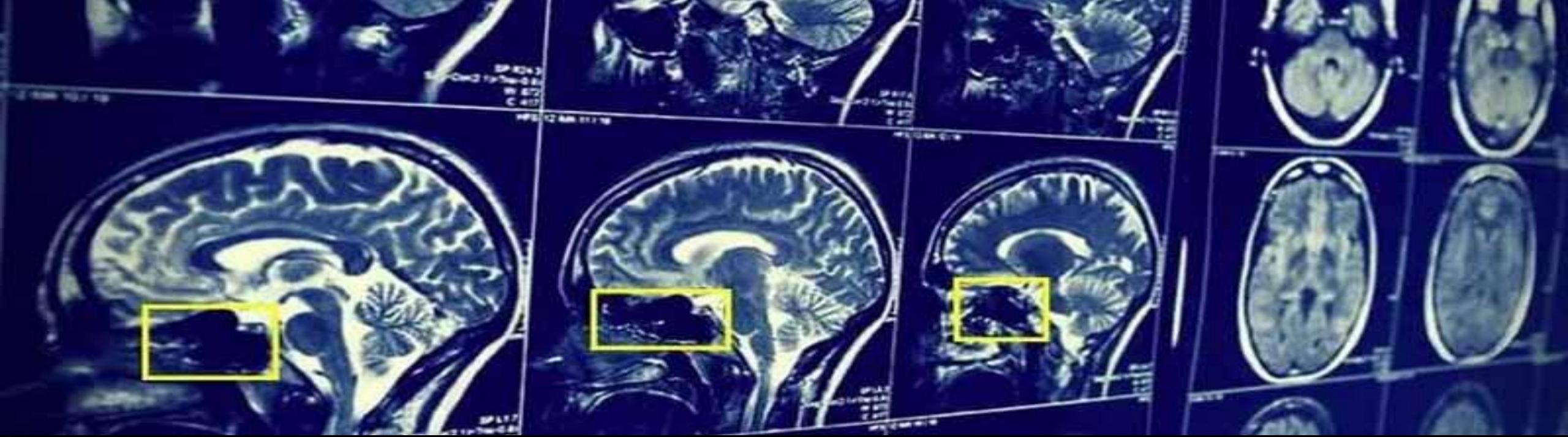
CNN and Computer Vision



(a)

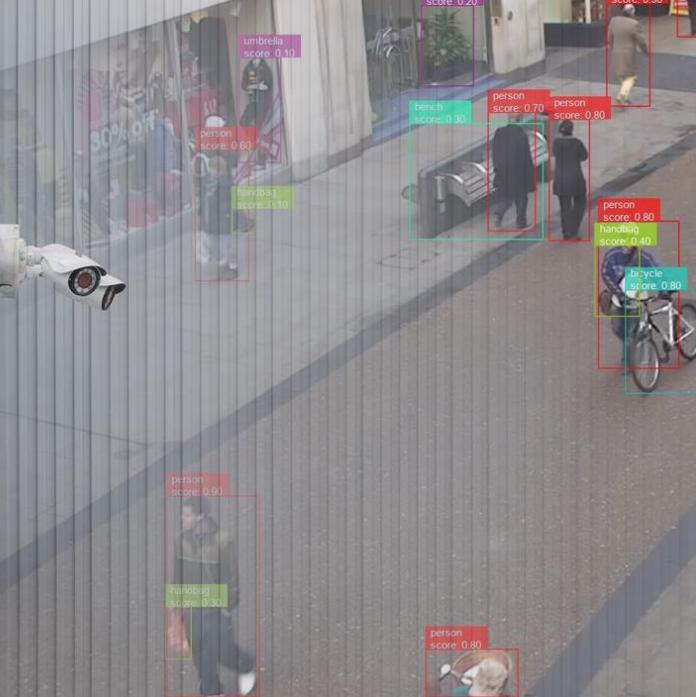


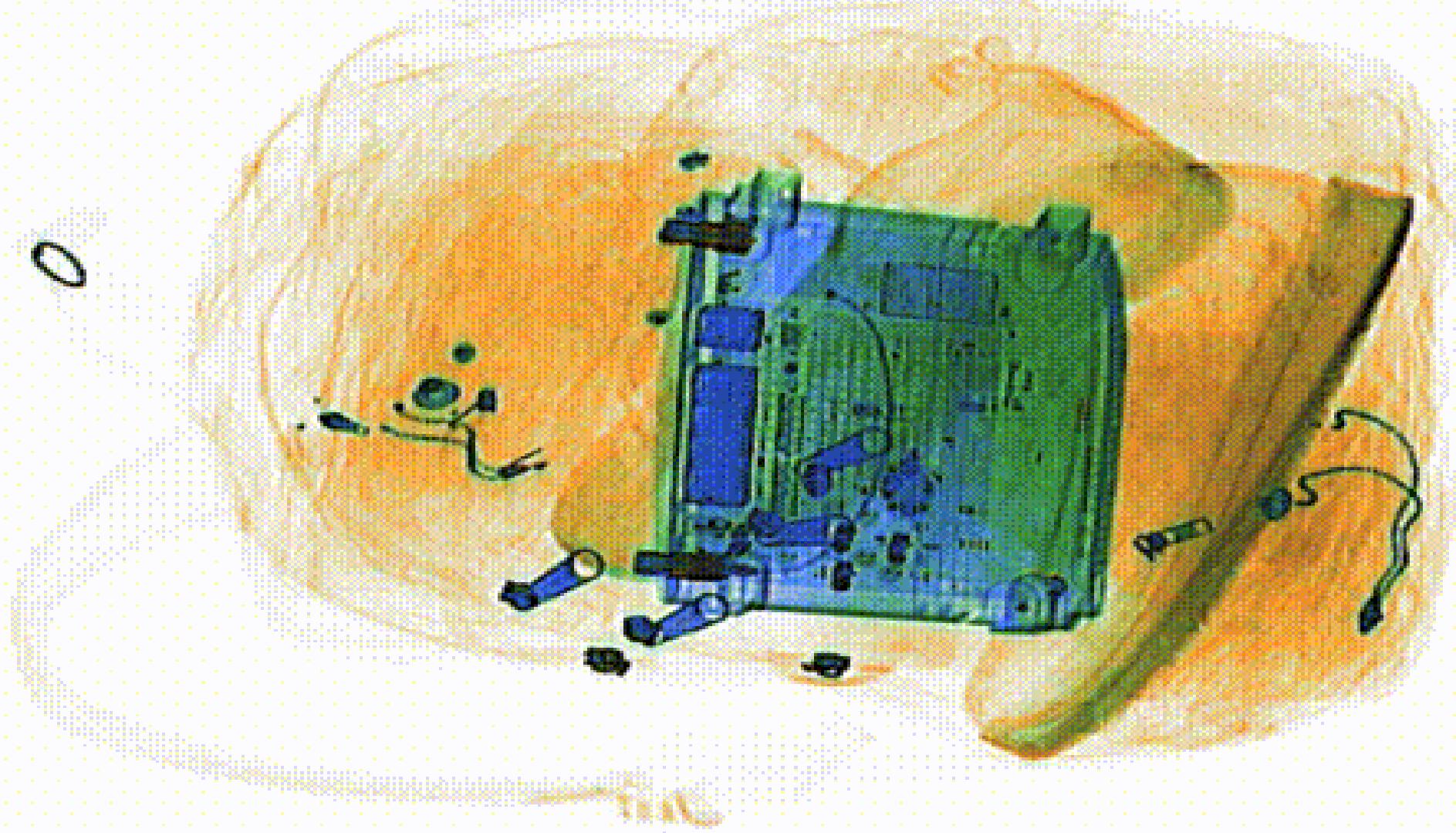
(b)





CNN and Computer Vision







Login without a password...



Fingerprint scanners on
many new laptops,
other devices



Face recognition systems now
beginning to appear more widely
<http://www.sensiblevision.com/>



CNN and Computer Vision

Object recognition (in mobile phones)





CNN and Computer Vision

Special effects: shape capture



Computer Vision
in Media &
Entertainment

Pirates of the Caribbean, Industrial Light and Magic



CNN and Computer Vision

►► manufacturer products consumer products ◀◀

Our Vision. Your Safety.

rear looking camera forward looking camera
side looking camera

> EyeQ Vision on a Chip



[read more](#)

> Vision Applications



Road, Vehicle,
Pedestrian Protection
and more

[read more](#)

> AWS Advance Warning System



[read more](#)

News

> Mobileye Advanced Technologies Power Volvo Cars World First Collision Warning With Auto Brake System

> Volvo: New Collision Warning with Auto Brake Helps Prevent Rear-end

[all news](#)



Events

> Mobileye at Equip Auto, Paris, France

> Mobileye at SEMA, Las Vegas, NV

[read more](#)



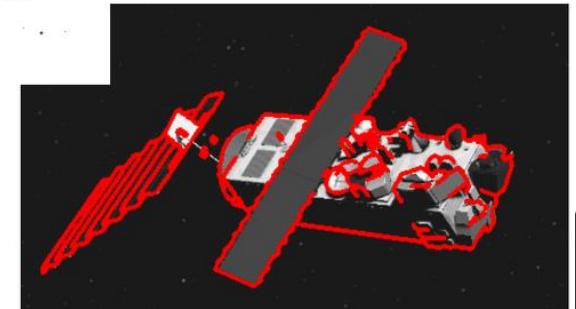
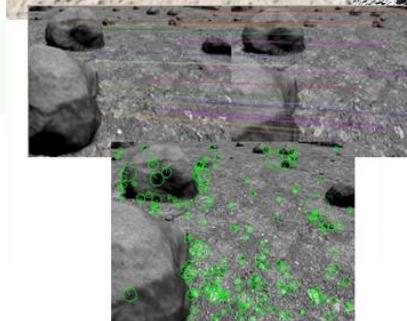


CNN and Computer Vision

Vision in space

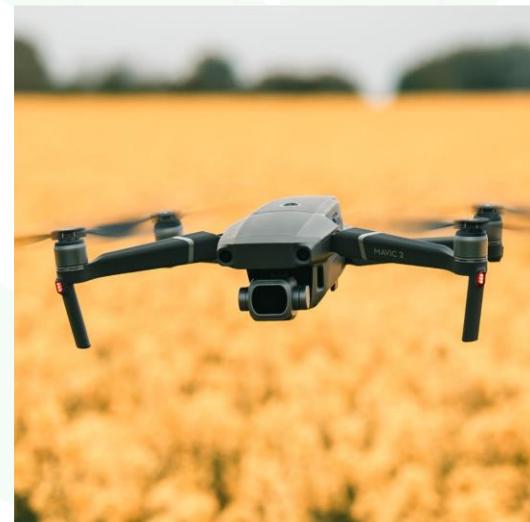
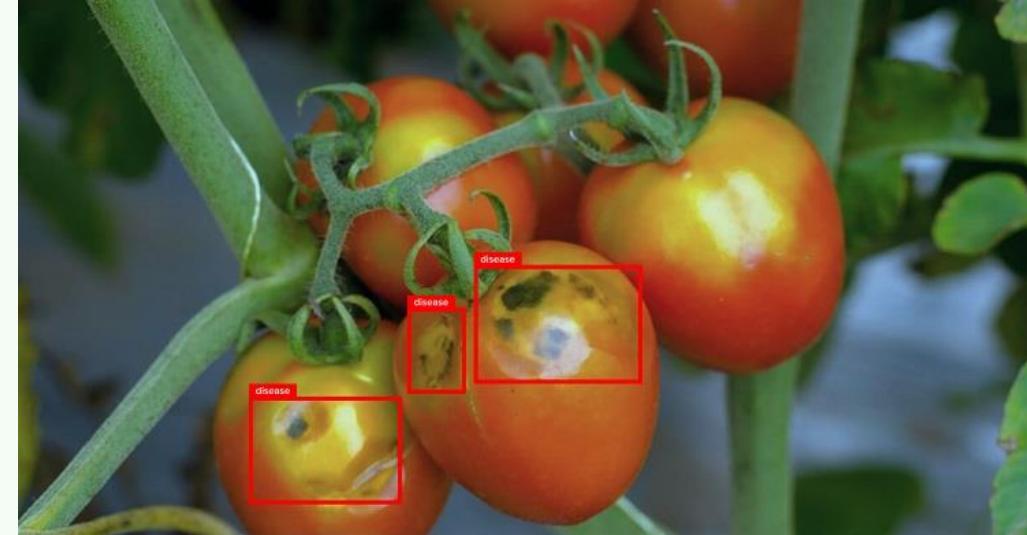
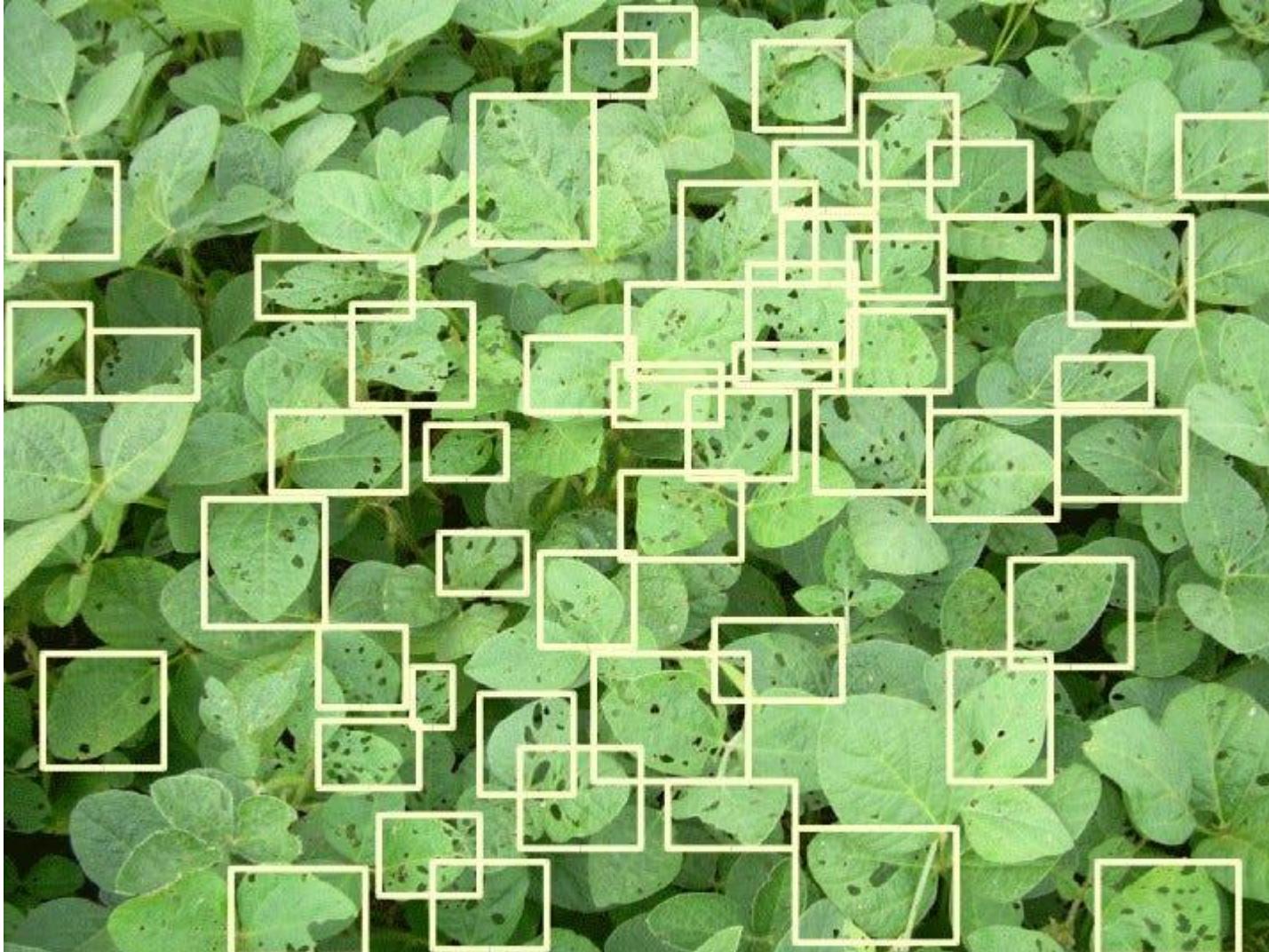


[NASA's Mars Exploration Rover Spirit](#) captured this westward view from atop a low plateau where Spirit spent the closing months of 2007.





CNN and Computer Vision



CNN and Computer Vision





WHAT COMPUTERS SEE



CNN and Computer Vision

What computers 'see': Images as Numbers

What you see



Input Image

What you both see

157	153	174	168	160	152	129	153	172	161	155	156
155	182	163	74	75	62	33	17	110	210	180	154
180	180	50	14	34	6	10	33	48	106	159	181
206	109	6	124	131	111	120	204	166	15	56	180
194	68	137	251	237	239	239	228	227	87	71	201
172	106	207	233	233	214	220	239	228	98	74	206
188	88	179	209	185	215	211	158	129	75	20	169
189	97	165	84	10	168	134	11	31	62	22	148
199	168	191	193	158	227	178	143	182	106	36	190
205	174	155	252	236	231	149	178	228	43	95	234
190	216	116	149	236	187	86	150	79	38	218	241
190	224	147	108	227	210	127	102	36	101	255	224
190	214	173	66	103	143	96	50	2	109	249	216
187	196	235	75	1	81	47	0	6	217	255	211
183	202	237	145	0	0	12	108	200	138	243	236
195	206	123	207	177	121	129	200	175	13	96	218

Input Image + values

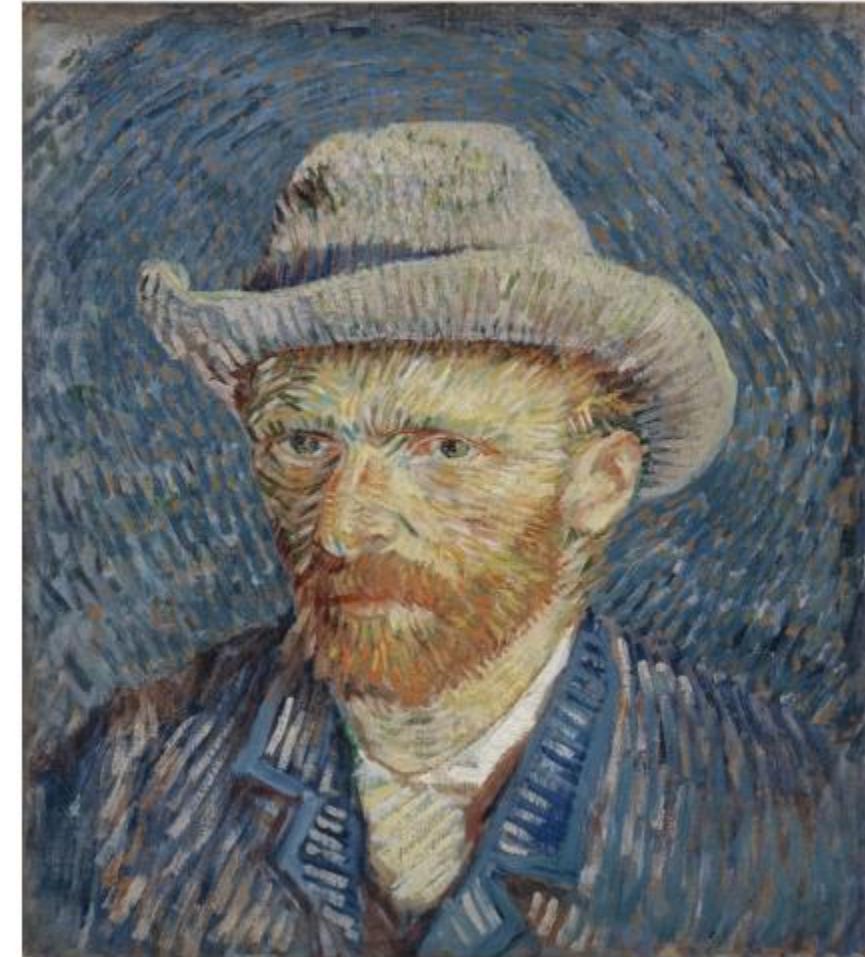
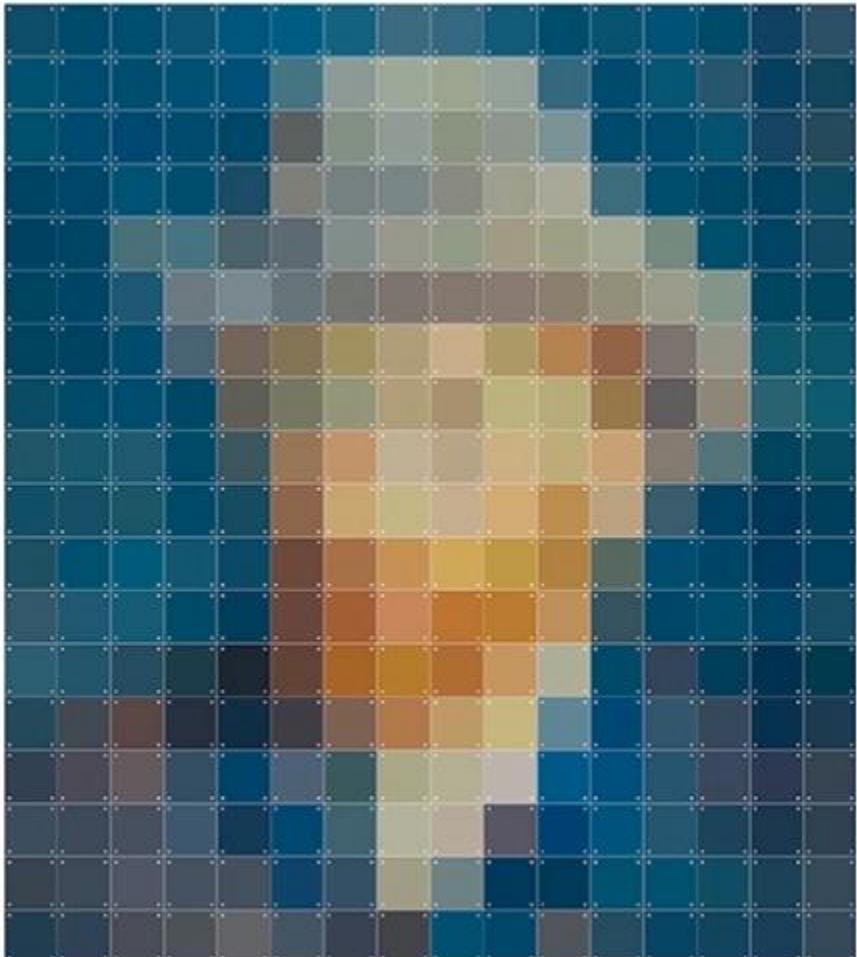
What the computer "sees"

157	153	174	168	150	152	129	151	172	161	155	156
155	182	163	74	75	62	33	17	110	210	180	154
180	180	50	14	34	6	10	33	48	106	159	181
206	109	6	124	131	111	120	204	166	15	56	180
194	68	137	251	237	239	239	228	227	87	71	201
172	106	207	233	233	214	220	239	228	98	74	206
188	88	179	209	185	215	211	158	129	75	20	169
189	97	165	84	10	168	134	11	31	62	22	148
199	168	191	193	158	227	178	143	182	106	36	190
205	174	155	252	236	231	149	178	228	43	95	234
190	216	116	149	236	187	86	150	79	38	218	241
190	224	147	108	227	210	127	102	36	101	255	224
190	214	173	66	103	143	96	50	2	109	249	216
187	196	235	75	1	81	47	0	6	217	255	211
183	202	237	145	0	0	12	108	200	138	243	236
195	206	123	207	177	121	129	200	175	13	96	218

Pixel intensity values
("pix-el"=picture-element)



CNN and Computer Vision



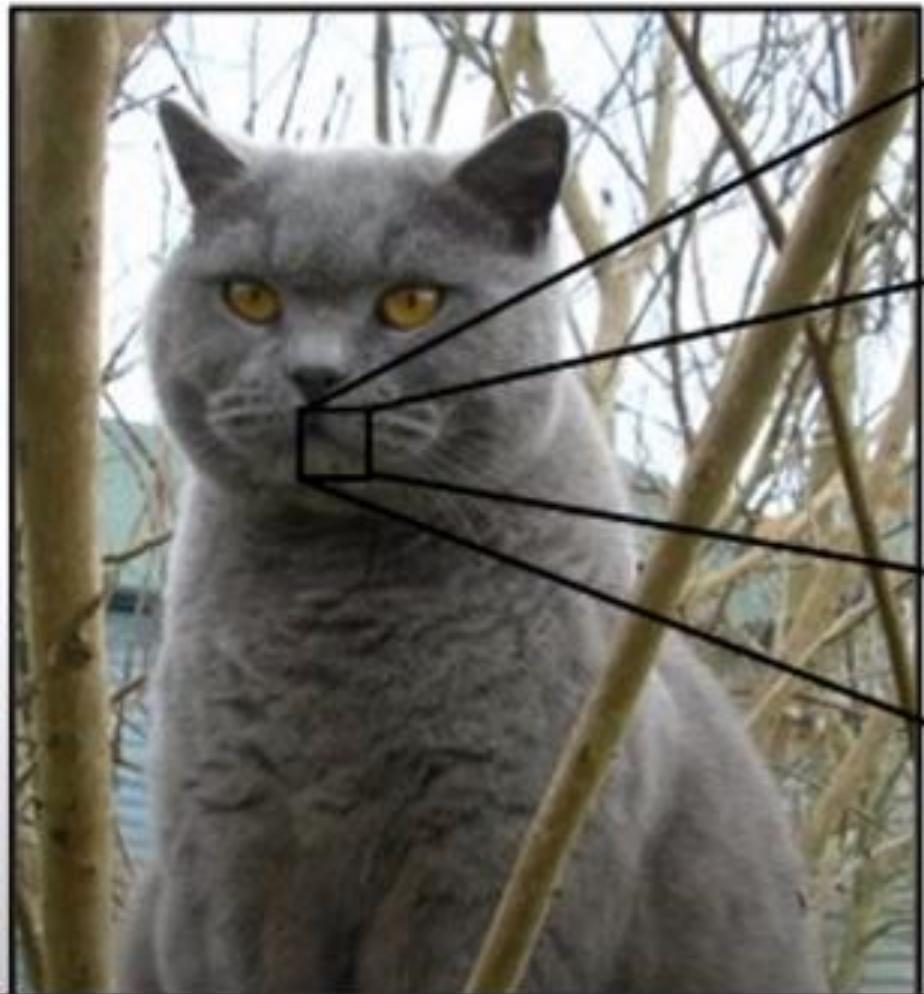
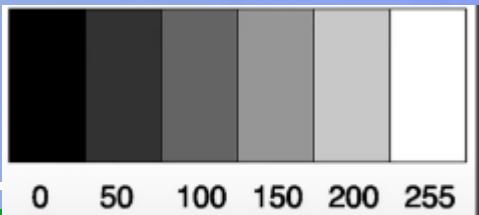


CNN and Computer Vision





CNN and Computer Vision

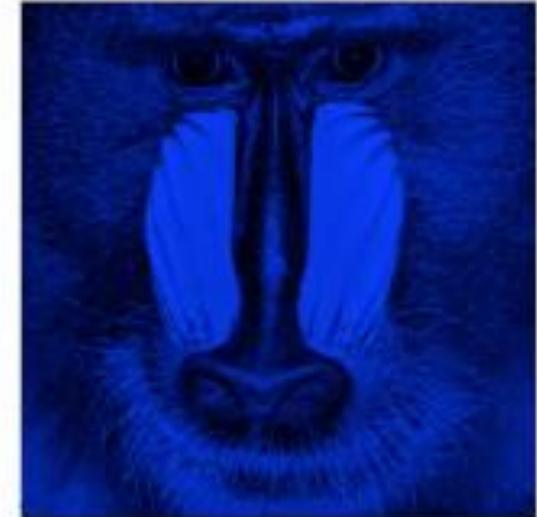
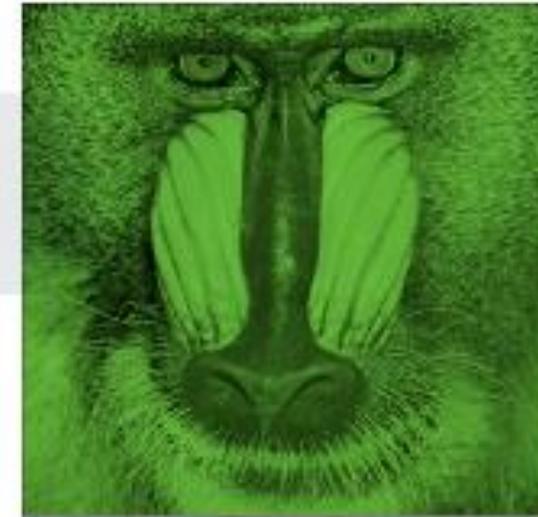
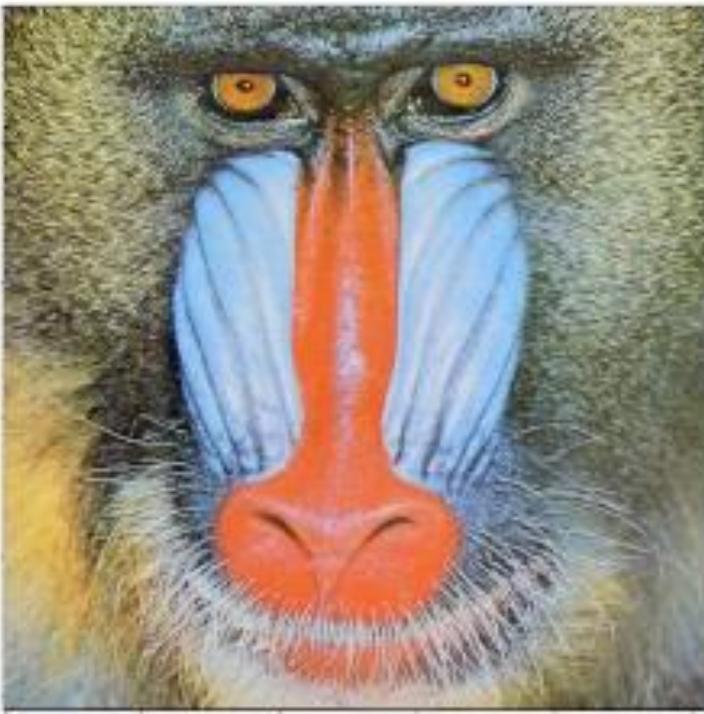


05	02	22	97	38	15	00	40	00	75	04	05	07	75	52	12	50	77	91	69
49	49	99	40	17	81	18	57	60	87	17	40	98	43	69	48	54	56	62	00
01	49	31	73	55	79	14	29	93	71	40	67	50	88	30	03	49	13	36	65
52	70	95	23	04	60	11	42	62	21	68	56	01	32	56	71	37	02	36	91
22	31	16	71	51	62	03	89	41	92	36	54	22	40	40	28	66	33	13	80
24	47	39	03	99	03	45	02	44	75	33	53	78	36	84	20	35	17	12	50
32	98	81	28	64	23	67	10	26	38	40	67	59	54	70	66	18	38	64	70
67	26	20	68	02	62	12	20	95	63	94	39	63	08	40	91	66	49	94	21
24	55	58	05	66	73	99	26	97	17	78	78	96	83	14	88	34	89	63	72
21	36	23	09	75	00	76	44	20	45	35	14	00	61	33	97	34	31	33	95
78	17	53	28	22	75	31	67	15	94	03	80	04	62	16	14	09	53	56	92
16	39	05	42	96	35	31	47	55	58	88	24	00	17	54	24	36	29	85	57
86	56	00	48	35	71	89	07	05	44	44	37	44	60	21	58	51	54	17	58
19	80	81	68	05	94	47	69	28	73	92	13	86	52	17	77	04	89	55	40
04	52	08	83	97	35	99	16	07	97	57	32	16	26	26	79	33	27	98	66
03	16	68	57	57	62	20	72	03	46	33	67	46	55	12	32	63	93	53	69
04	42	16	73	35	35	19	11	24	94	72	18	05	46	29	32	40	62	76	36
20	69	36	41	72	30	23	88	39	62	89	69	82	67	59	85	74	04	36	16
20	73	35	29	78	31	90	01	74	31	49	71	90	01	81	16	23	57	05	54
01	70	54	71	83	51	54	69	16	92	33	48	61	43	52	01	89	21	47	48

What the computer sees



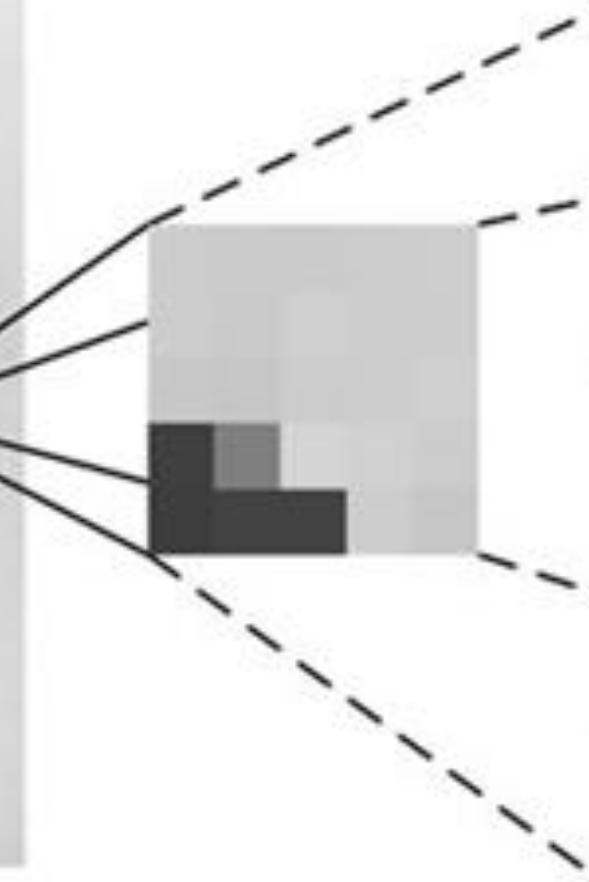
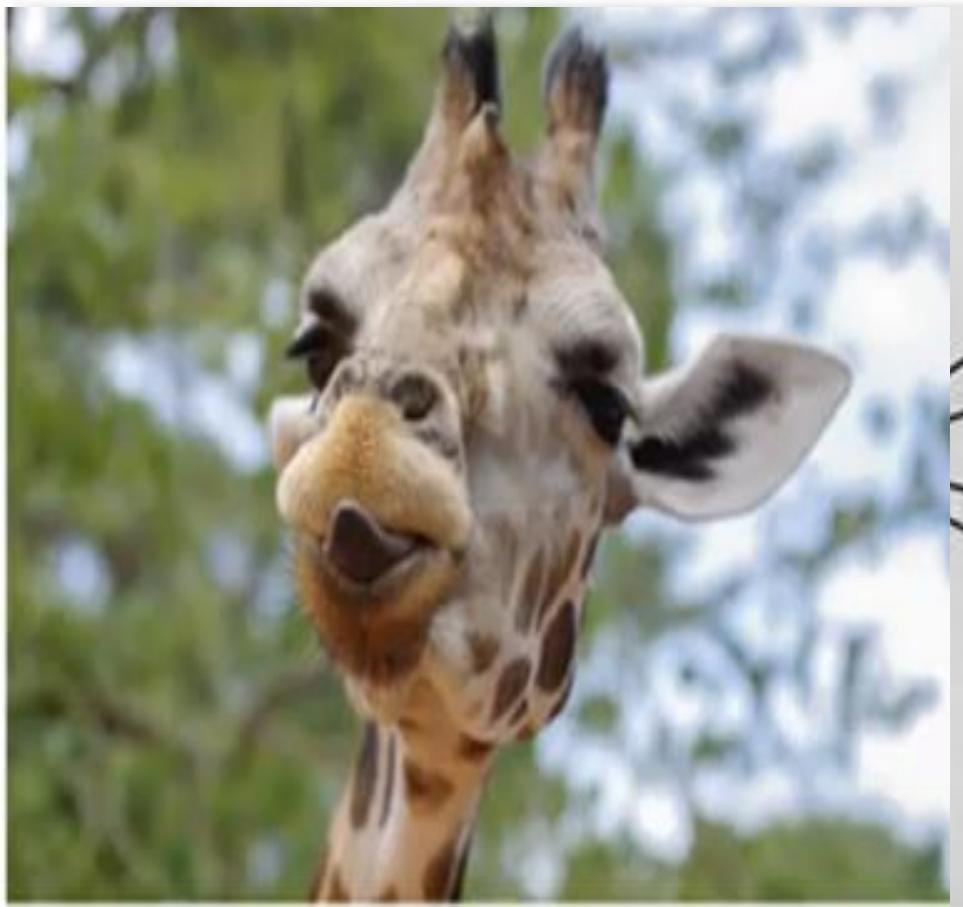
CNN and Computer Vision



$$\begin{bmatrix} 9 & 3 & \dots & 40 \\ 2 & 5 & 3 & \dots & 40 \\ 5 & 34 & \dots & 50 \\ 4 & 5 & 34 & \dots & 24 \\ \vdots & \vdots & \ddots & 50 \\ 5 & 34 & \dots & 24 \end{bmatrix}$$



CNN and Computer Vision



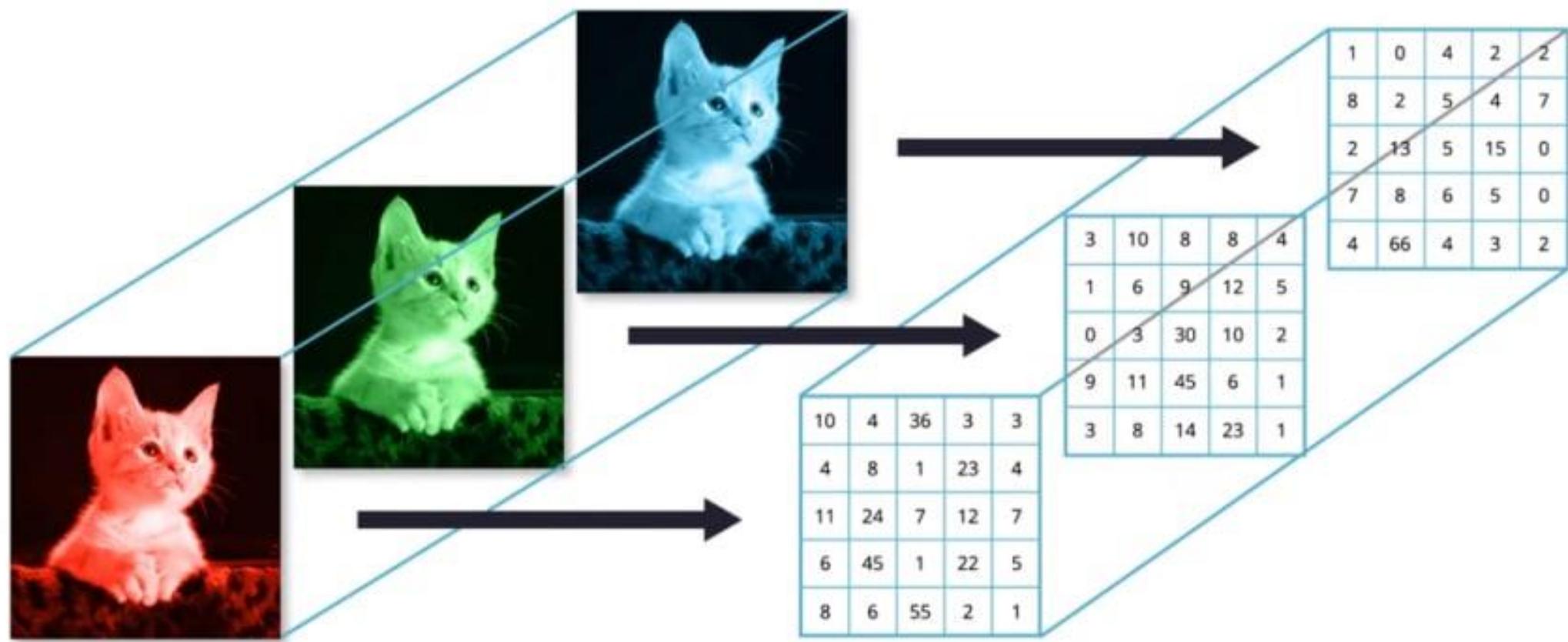
205	204	204	206	207
206	203	208	206	206
201	199	205	206	209
61	128	213	210	205
59	65	65	206	199



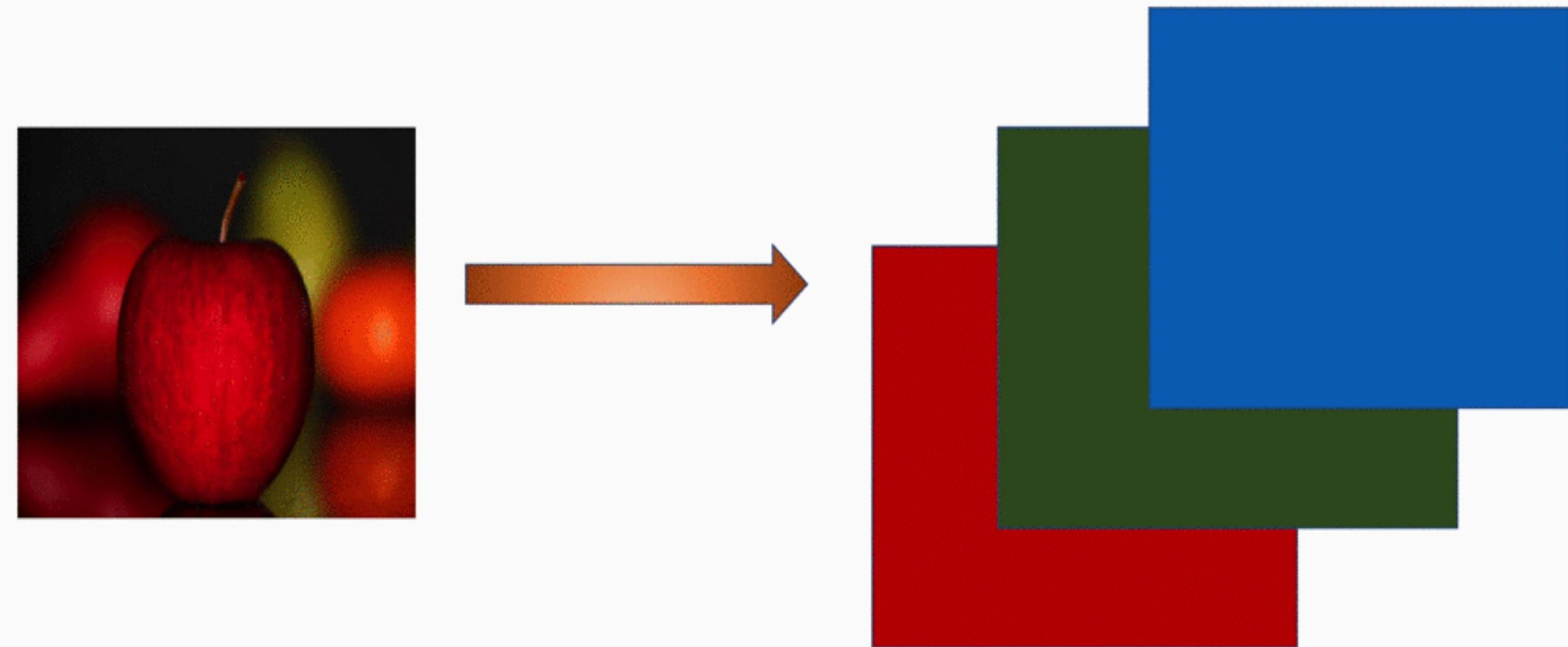
CNN and Computer Vision

IF

RGB Image



CNN and Computer Vision



CNN and Computer Vision

- | | |
|--|--|
| 1 bit renk derinliğine sahip bir noktacık | = 2 adet renk alabilir. (siyah ve beyaz) |
| 2 bit renk derinliğine sahip bir noktacık | = 4 adet renk alabilir. |
| 3 bit renk derinliğine sahip bir noktacık | = 8 adet renk alabilir. |
| 4 bit renk derinliğine sahip bir noktacık | = 16 adet renk alabilir. |
| 6 bit renk derinliğine sahip bir noktacık | = 64 adet renk alabilir. |
| 7 bit renk derinliğine sahip bir noktacık | = 128 adet renk alabilir. |
| 8 bit renk derinliğine sahip bir noktacık | = 256 adet renk alabilir. |
| 11 bit renk derinliğine sahip bir noktacık | = 4.096 adet renk alabilir. |
| 16 bit renk derinliğine sahip bir noktacık | = 65.536 adet renk alabilir. |
| 24 bit renk derinliğine sahip bir noktacık | = 16.777.216 adet renk alabilir. |

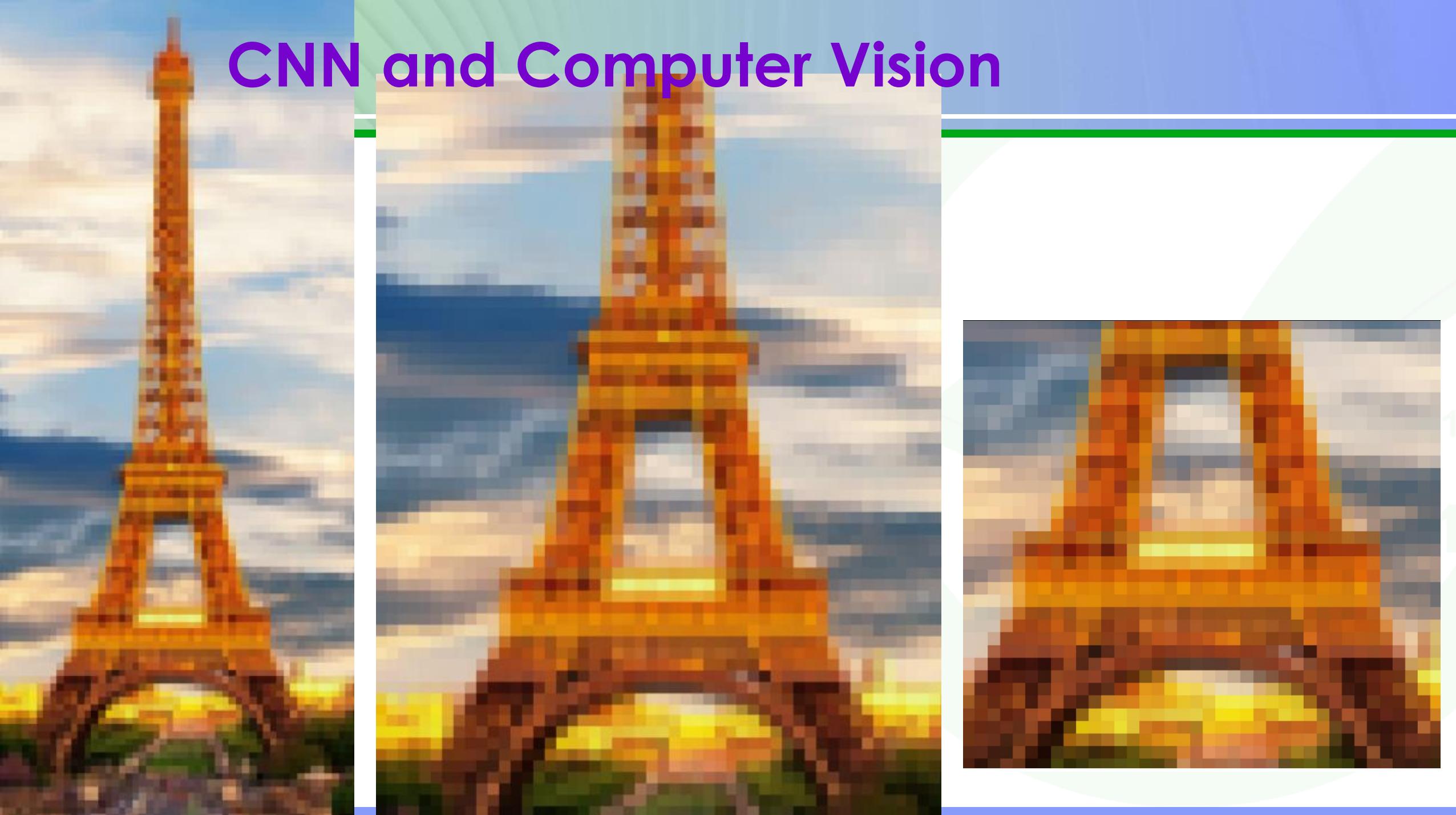
CNN and Computer Vision



CNN and Computer Vision

A photograph of the Eiffel Tower in Paris, France, taken from a distance. The tower is highly pixelated, giving it a blocky, digital appearance. It stands prominently against a sky filled with scattered clouds at what appears to be sunset or sunrise, with warm orange and yellow hues. In the foreground, there's a dark silhouette of trees and buildings.

CNN and Computer Vision





CNN and Computer Vision

51	G 161	G 140	G 97	G 103	G 68	G 89	G 128	G 129	G 157	G 160	G 165	G 167	G 164	G 168	G 139	G 188	G 79
58	B 134	B 39	B 31	B 21	B 10	B 11	B 14	B 93	B 155	B 159	B 164	B 166	B 164	B 165	B 97	B 12	B 12
62	R 195	R 179	R 144	R 158	R 153	R 200	R 211	R 145	R 123	R 114	R 139	R 126	R 127	R 136	R 146	R 201	R 159
67	G 156	G 85	G 54	G 59	G 51	G 98	G 125	G 116	G 122	G 118	G 130	G 123	G 125	G 132	G 117	G 118	G 59
51	B 184	B 15	B 22	B 16	B 10	B 13	B 23	B 93	B 129	B 126	B 132	B 129	B 131	B 135	B 100	B 16	B 18
32	R 199	R 187	R 174	R 201	R 176	R 164	R 208	R 153	R 140	R 123	R 155	R 169	R 193	R 187	R 165	R 184	R 154
67	G 148	G 180	G 73	G 83	G 65	G 75	G 125	G 120	G 128	G 116	G 135	G 146	G 164	G 160	G 134	G 92	G 47
41	B 69	B 45	B 18	B 14	B 14	B 8	B 31	B 100	B 125	B 121	B 127	B 132	B 140	B 140	B 116	B 15	B 11
21	R 216	R 182	R 284	R 198	R 152	R 175	R 288	R 197	R 198	R 183	R 193	R 328	R 243	R 238	R 228	R 181	R 130
65	G 139	G 95	G 94	G 81	G 53	G 95	G 125	G 155	G 161	G 157	G 163	G 191	G 207	G 201	G 187	G 105	G 44
43	B 43	B 54	B 17	B 14	B 24	B 12	B 49	B 122	B 138	B 137	B 139	B 151	B 157	B 155	B 142	B 34	B 11
31	R 225	R 208	R 288	R 199	R 179	R 233	R 221	R 242	R 236	R 232	R 214	R 237	R 233	R 233	R 214	R 195	R 192
37	G 130	G 100	G 92	G 77	G 70	G 127	G 146	G 205	G 196	G 198	G 179	G 201	G 195	G 196	G 177	G 125	G 91
34	B 29	B 35	B 28	B 14	B 16	B 18	B 69	B 151	B 149	B 153	B 142	B 153	B 148	B 151	B 137	B 52	B 12
25	R 190	R 181	R 174	R 178	R 206	R 220	R 197	R 192	R 225	R 229	R 226	R 241	R 241	R 222	R 213	R 200	R 203
57	G 82	G 74	G 67	G 62	G 92	G 126	G 130	G 160	G 185	G 208	G 189	G 207	G 209	G 187	G 179	G 138	G 103
2	B 16	B 16	B 12	B 10	B 13	B 14	B 69	B 132	B 142	B 149	B 147	B 156	B 159	B 147	B 142	B 73	B 13
22	R 173	R 184	R 199	R 167	R 178	R 219	R 215	R 218	R 229	R 234	R 234	R 233	R 236	R 232	R 229	R 211	R 185
48	G 82	G 70	G 76	G 62	G 87	G 189	G 122	G 160	G 174	G 186	G 184	G 181	G 184	G 177	G 162	G 130	G 83
2	B 41	B 16	B 13	B 11	B 13	B 18	B 67	B 114	B 122	B 129	B 128	B 120	B 124	B 121	B 115	B 74	B 12
98	R 171	R 183	R 184	R 143	R 183	R 195	R 217	R 215	R 217	R 218	R 216	R 218	R 218	R 217	R 218	R 207	R 179
33	G 74	G 94	G 100	G 76	G 104	G 118	G 161	G 170	G 167	G 175	G 172	G 167	G 178	G 171	G 172	G 139	G 103
1	B 21	B 19	B 22	B 24	B 23	B 27	B 48	B 57	B 51	B 53	B 58	B 53	B 57	B 57	B 54	B 29	B 22
59	R 120	R 145	R 158	R 103	R 159	R 286	R 234	R 234	R 234	R 243	R 233	R 234	R 235	R 234	R 234	R 216	R 166
5	G 25	G 43	G 61	G 30	G 62	G 145	G 226	G 236	G 229	G 239	G 239	G 239	G 235	G 235	G 235	G 163	G 70
2	B 9	B 12	B 17	B 13	B 18	B 42	B 111	B 132	B 143	B 119	B 157	B 138	B 135	B 133	B 149	B 41	B 14
91	R 153	R 190	R 201	R 179	R 183	R 228	R 229	R 230	R 227	R 230	R 230	R 229	R 230	R 233	R 227	R 222	R 200
3	G 67	G 87	G 101	G 82	G 89	G 145	G 167	G 171	G 162	G 162	G 172	G 169	G 169	G 176	G 168	G 140	G 98
7	B 8	B 12	B 13	B 9	B 12	B 26	B 49	B 55	B 45	B 47	B 53	B 46	B 46	B 55	B 59	B 20	B 11
30	R 214	R 207	R 213	R 203	R 222	R 205	R 212	R 214	R 197	R 226	R 203	R 212	R 217	R 198	R 222	R 284	R 210
3	G 101	G 98	G 103	G 92	G 110	G 97	G 103	G 102	G 93	G 106	G 95	G 98	G 100	G 92	G 102	G 94	G 97
2	B 8	B 9	B 10	B 8	B 8	B 9	B 10	B 9	B 12	B 5	B 13	B 8	B 7	B 11	B 9	B 9	B 8
13	R 231	R 228	R 223	R 216	R 232	R 218	R 225	R 225	R 212	R 233	R 214	R 222	R 226	R 210	R 233	R 216	R 219
19	G 140	G 129	G 132	G 123	G 139	G 125	G 135	G 132	G 121	G 141	G 120	G 127	G 131	G 113	G 137	G 119	G 129
6	B 7	B 8	B 9	B 9	B 7	B 8	B 11	B 8	B 11	B 3	B 14	B 6	B 7	B 12	B 7	B 10	B 8
18	R 212	R 223	R 224	R 212	R 212	R 208	R 212	R 211	R 216	R 206	R 212	R 210	R 210	R 211	R 210	R 209	R 208



R 176	R 164	R 208	R 153	R 140	R 123	R 155	R 169	R 193	R 187
G 65	G 75	G 125	G 120	G 128	G 116	G 135	G 146	G 164	G 160
B 14	B 8	B 31	B 100	B 125	B 121	B 127	B 132	B 140	B 140
R 152	R 175	R 208	R 197	R 190	R 183	R 193	R 228	R 243	R 238
G 53	G 95	G 125	G 155	G 161	G 157	G 163	G 191	G 207	G 201
B 24	B 12	B 49	B 122	B 138	B 137	B 139	B 151	B 157	B 155
R 179	R 213	R 221	R 242	R 236	R 232	R 214	R 237	R 233	R 233
G 70	G 127	G 146	G 205	G 196	G 198	G 179	G 201	G 195	G 196
B 16	B 10	B 69	B 151	B 149	B 153	B 142	B 153	B 148	B 151
R 206	R 220	R 197	R 192	R 225	R 239	R 226	R 241	R 241	R 222
G 92	G 126	G 130	G 160	G 185	G 200	G 189	G 207	G 209	G 187
B 13	B 14	B 69	B 132	B 142	B 150	B 147	B 156	B 159	B 147
R 170	R 219	R 215	R 218	R 229	R 234	R 234	R 233	R 236	R 232
G 87	G 109	G 122	G 160	G 174	G 186	G 184	G 181	G 184	G 177
B 13	B 18	B 67	B 114	B 122	B 129	B 120	B 120	B 124	B 121
R 183	R 195	R 217	R 215	R 217	R 218	R 216	R 218	R 218	R 217
G 104	G 118	G 161	G 170	G 167	G 175	G 172	G 167	G 170	G 171
B 23	B 27	B 48	B 57	B 51	B 53	B 58	B 53	B 57	B 57
R 159	R 206	R 234	R 233	R 234	R 233	R 235	R 234	R 235	R 235
G 62	G 145	G 226	G 238	G 229	G 228	G 239	G 233	G 235	G 241
B 18	B 42	B 111	B 132	B 113	B 119	B 137	B 118	B 125	B 133



CNN and Computer Vision

How to create colors with RGB?

Combine parts of the three primary colors **red**, **green** and **blue**.

Each of the primary colors can have a value in the range from 0 to 255.



R:	255	0	0	0	255
G:	0	255	0	0	255
B:	0	0	255	0	255

CNN and Computer Vision

Red - Currently set to

0
32
64
96
128
159
191
223
255

Green - Currently set to

0
32
64
96
128
159
191
223
255

Blue - Currently set to

0
32
64
96
128
159
191
223
255

rgb(255, 0, 0)







G 243	G 244	G 238	G 190	G 125	G 141	G 108	G 199	G 130	G 110	G 57	G 157	G 194	G 244	G 241
B 243	B 244	B 238	B 190	B 125	B 141	B 108	B 199	B 130	B 110	B 57	B 157	B 194	B 244	B 241
R 244	R 244	R 231	R 203	R 120	R 73	R 126	R 102	R 93	R 116	R 134	R 135	R 117	R 241	R 241
G 244	G 244	G 231	G 203	G 120	G 73	G 126	G 102	G 93	G 116	G 134	G 135	G 117	G 241	G 241
B 244	B 244	B 231	B 203	B 120	B 73	B 126	B 102	B 93	B 116	B 134	B 135	B 117	B 241	B 241
R 245	R 244	R 200	R 147	R 165	R 136	R 59	R 134	R 143	R 108	R 66	R 128	R 138	R 236	R 240
G 245	G 244	G 200	G 147	G 165	G 136	G 59	G 134	G 143	G 108	G 66	G 128	G 138	G 236	G 240
B 245	B 244	B 200	B 147	B 165	B 136	B 59	B 134	B 143	B 108	B 66	B 128	B 138	B 236	B 240
R 244	R 245	R 179	R 204	R 139	R 78	R 147	R 235	R 120	R 121	R 86	R 127	R 91	R 225	R 238
G 244	G 245	G 179	G 204	G 139	G 78	G 147	G 235	G 120	G 121	G 86	G 127	G 91	G 225	G 238
B 244	B 245	B 179	B 204	B 139	B 78	B 147	B 235	B 120	B 121	B 86	B 127	B 91	B 225	B 238
R 245	R 240	R 181	R 189	R 119	R 140	R 70	R 227	R 42	R 110	R 100	R 127	R 164	R 200	R 238
G 245	G 240	G 181	G 189	G 119	G 141	G 70	G 227	G 42	G 110	G 100	G 127	G 164	G 200	G 238
B 245	B 240	B 181	B 189	B 119	B 140	B 70	B 227	B 42	B 110	B 100	B 127	B 164	B 200	B 238
R 246	R 231	R 195	R 162	R 138	R 108	R 133	R 186	R 135	R 95	R 83	R 117	R 199	R 174	R 245
G 246	G 231	G 195	G 162	G 138	G 108	G 133	G 186	G 135	G 95	G 83	G 117	G 199	G 174	G 245
B 246	B 231	B 195	B 162	B 138	B 108	B 133	B 186	B 135	B 95	B 83	B 117	B 199	B 174	B 245
R 247	R 224	R 200	R 211	R 172	R 130	R 221	R 190	R 120	R 110	R 171	R 184	R 143	R 157	R 243
G 247	G 224	G 200	G 211	G 172	G 130	G 221	G 190	G 120	G 110	G 171	G 184	G 143	G 157	G 243
B 247	B 224	B 200	B 211	B 172	B 130	B 221	B 190	B 120	B 110	B 171	B 184	B 143	B 157	B 243
R 248	R 172	R 205	R 213	R 176	R 111	R 175	R 174	R 160	R 69	R 162	R 88	R 218	R 196	R 236
G 248	G 172	G 205	G 213	G 176	G 111	G 175	G 174	G 160	G 69	G 162	G 88	G 218	G 196	G 236
B 248	B 172	B 205	B 213	B 176	B 111	B 175	B 174	B 160	B 69	B 162	B 88	B 218	B 196	B 236
R 241	R 189	R 172	R 129	R 184	R 163	R 198	R 134	R 205	R 114	R 186	R 122	R 185	R 150	R 197
G 241	G 189	G 172	G 129	G 184	G 163	G 198	G 134	G 205	G 114	G 186	G 122	G 185	G 150	G 197
B 241	B 189	B 172	B 129	B 184	B 163	B 198	B 134	B 205	B 114	B 186	B 122	B 185	B 150	B 197
R 223	R 211	R 214	R 86	R 167	R 153	R 202	R 161	R 162	R 139	R 85	R 158	R 154	R 156	R 157
G 223	G 211	G 214	G 86	G 167	G 153	G 202	G 161	G 162	G 139	G 85	G 158	G 154	G 156	G 157
B 223	B 211	B 214	B 86	B 167	B 153	B 202	B 161	B 162	B 139	B 85	B 158	B 154	B 156	B 157
R 197	R 189	R 185	R 108	R 170	R 117	R 141	R 157	R 119	R 84	R 171	R 173	R 173	R 209	R 175
G 197	G 189	G 185	G 108	G 170	G 117	G 141	G 157	G 119	G 84	G 171	G 173	G 173	G 209	G 175
B 197	B 189	B 185	B 108	B 170	B 117	B 141	B 157	B 119	B 84	B 171	B 173	B 173	B 209	B 175
R 201	R 194	R 183	R 116	R 235	R 208	R 161	R 185	R 226	R 155	R 130	R 117	R 192	R 180	R 136
G 201	G 194	G 183	G 115	G 235	G 208	G 161	G 185	G 226	G 155	G 130	G 117	G 192	G 180	G 136
B 201	B 194	B 183	B 115	B 235	B 208	B 161	B 185	B 226	B 155	B 130	B 117	B 192	B 180	B 136



Exploring Visual Processing Tasks: From CNNs to Computer Vision



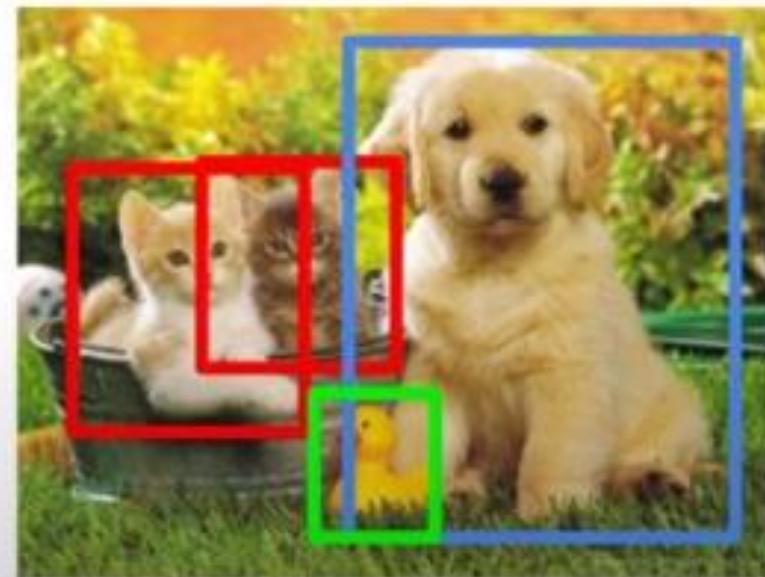
CNN and Computer Vision

Classification



CAT

Object Detection



CAT, DOG, DUCK



CNN and Computer Vision

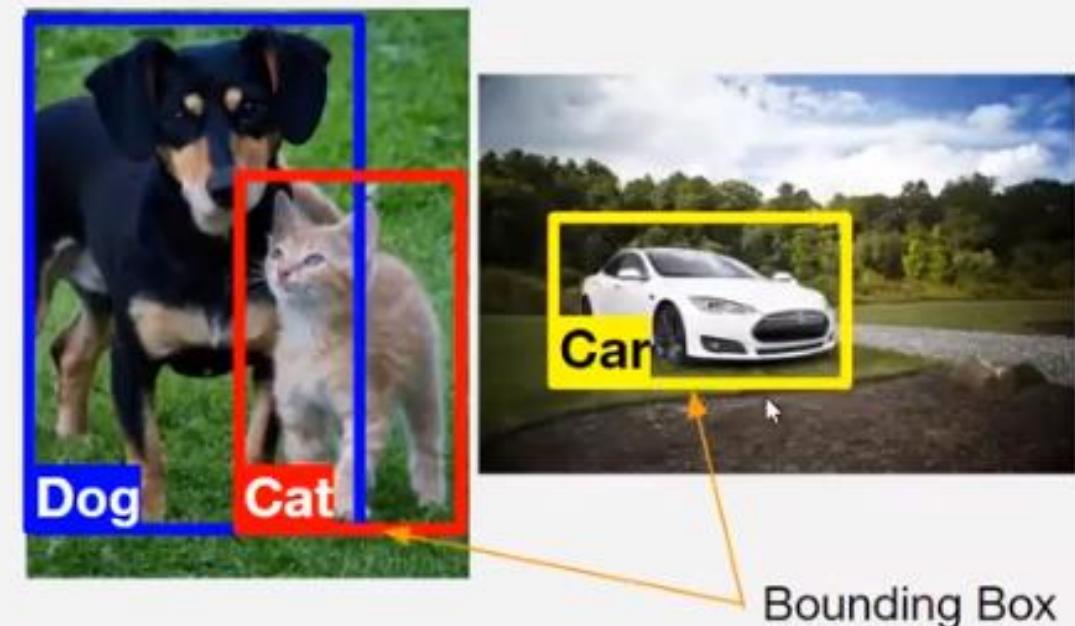
Classification

- One object and label per image



Object Detection

- Multiple objects per image
- Determine objects' location



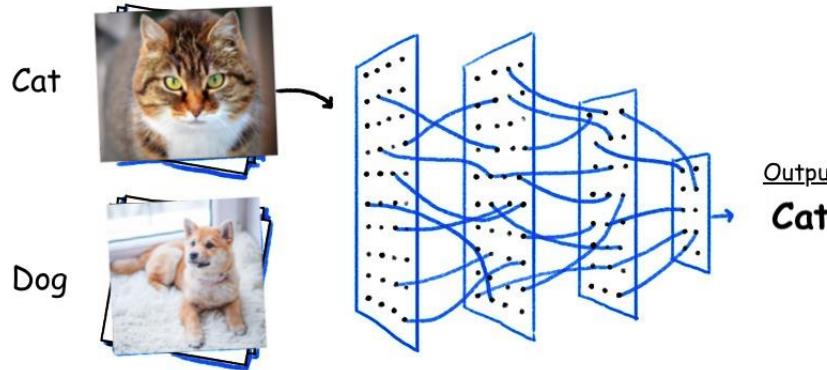
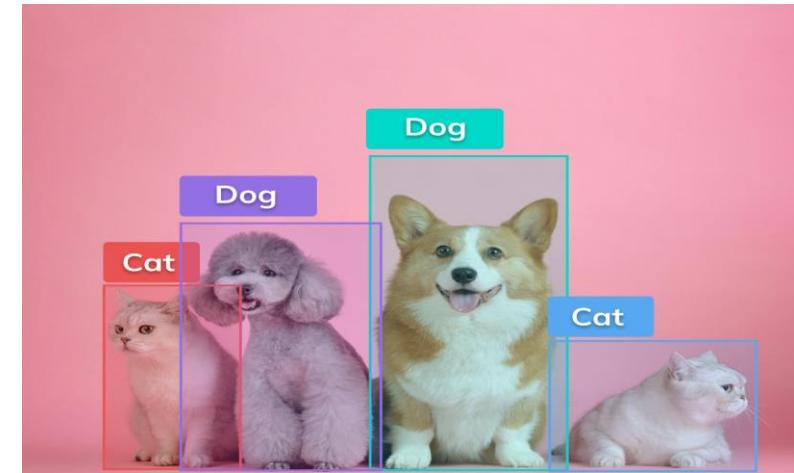
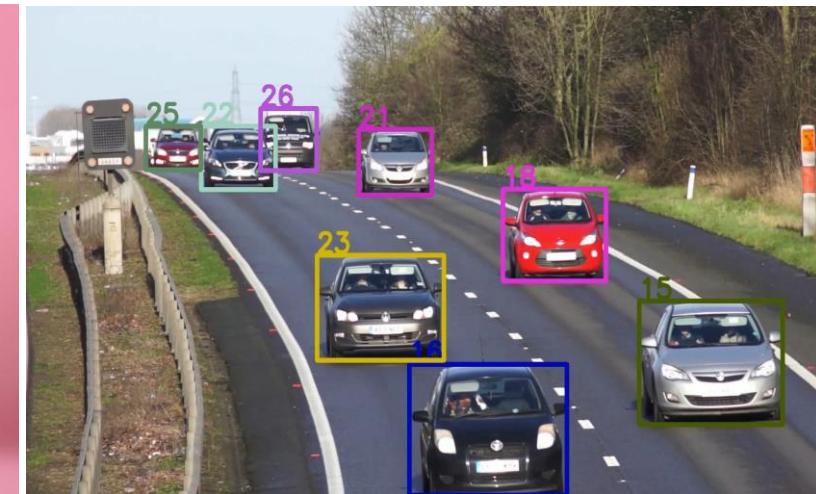


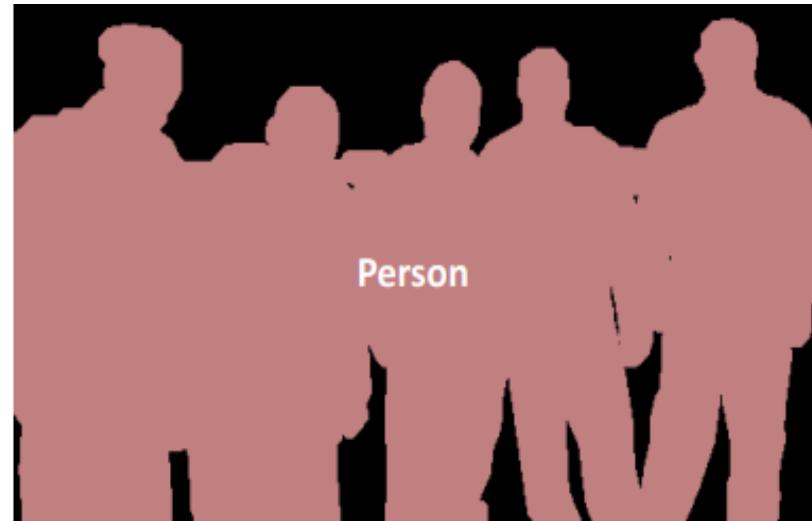
Image Classification



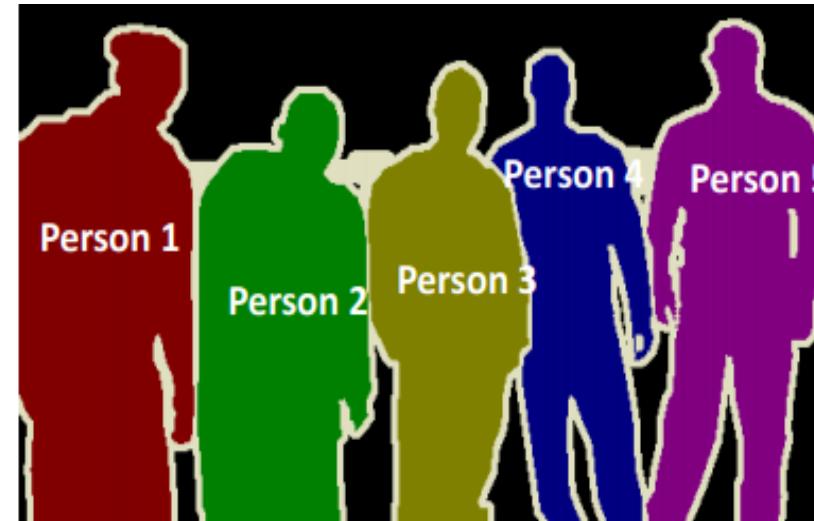
Object Detection



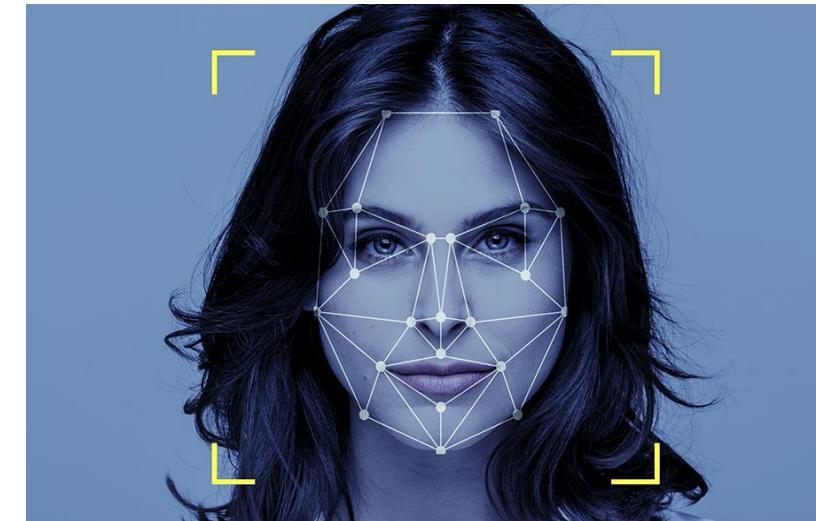
Object Tracking



Semantic Segmentation



Instance Segmentation



Face Detection and Recognition



CNN and Computer Vision

Semantic Segmentation



GRASS, CAT,
TREE, SKY

No objects, just pixels

Classification + Localization



CAT

Single Object

Object Detection



DOG, DOG, CAT

Multiple Object

Instance Segmentation



DOG, DOG, CAT

This image is CC0 public domain

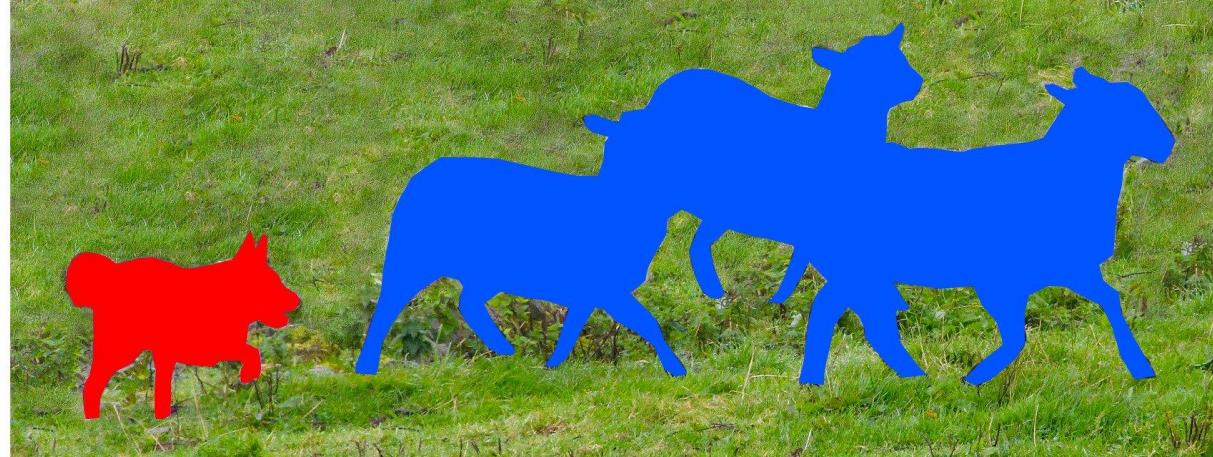


CNN and Computer Vision

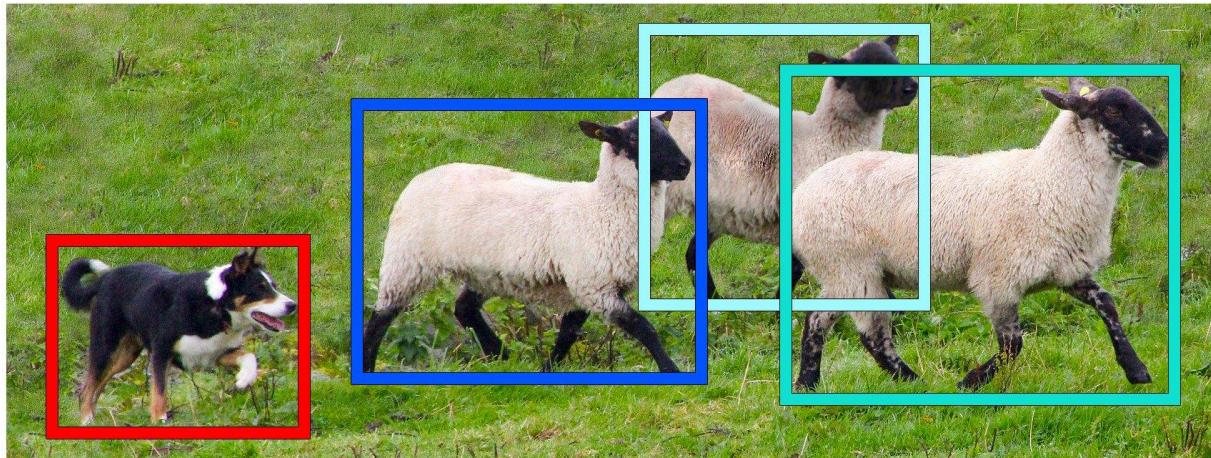
P 0.6 sheep
P 0.3 dog
P 0.1 cat
P 0.0 horse



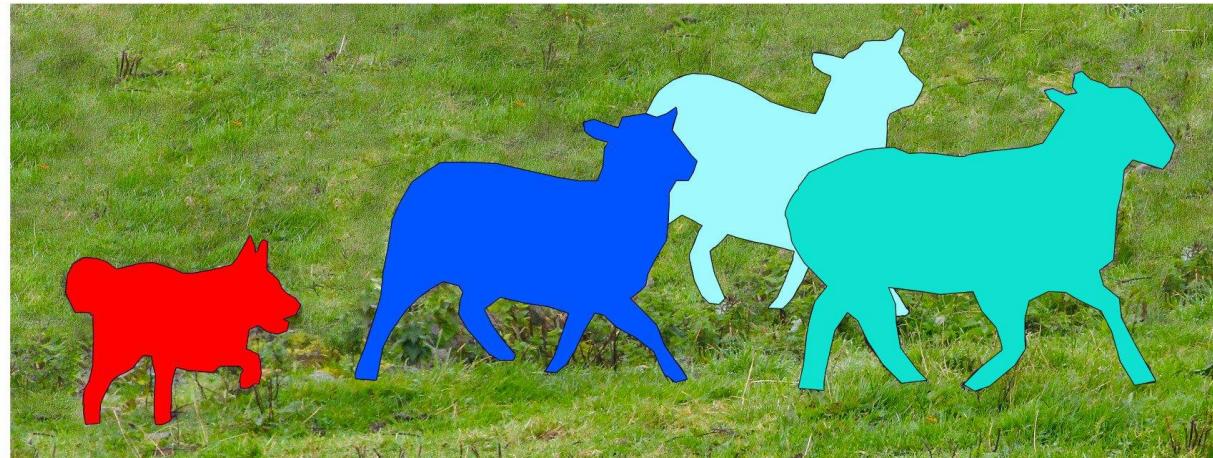
Image Recognition



Semantic Segmentation



Object Detection



Instance Segmentation



CNN and Computer Vision

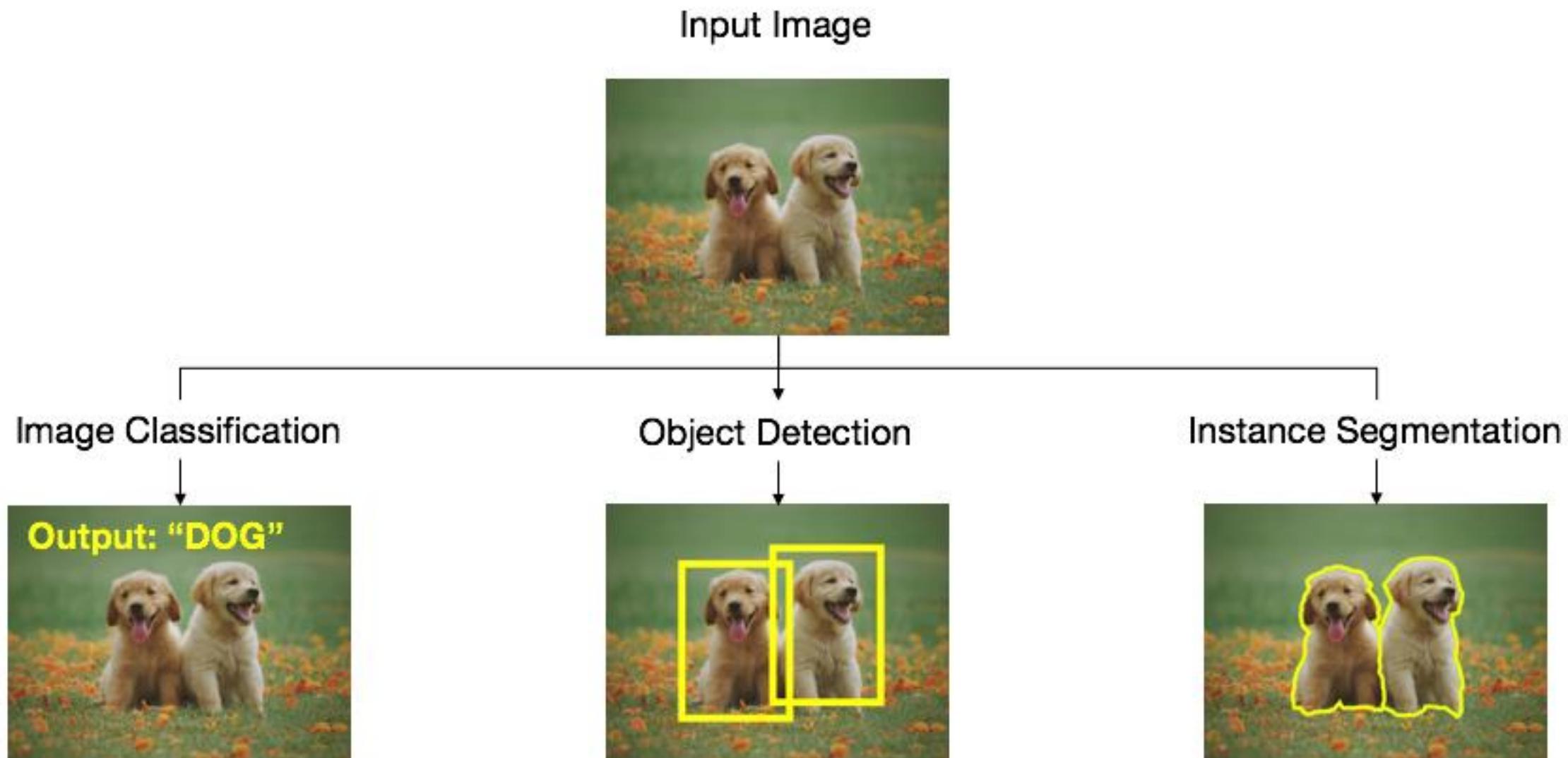




IMAGE CLASSIFICATION



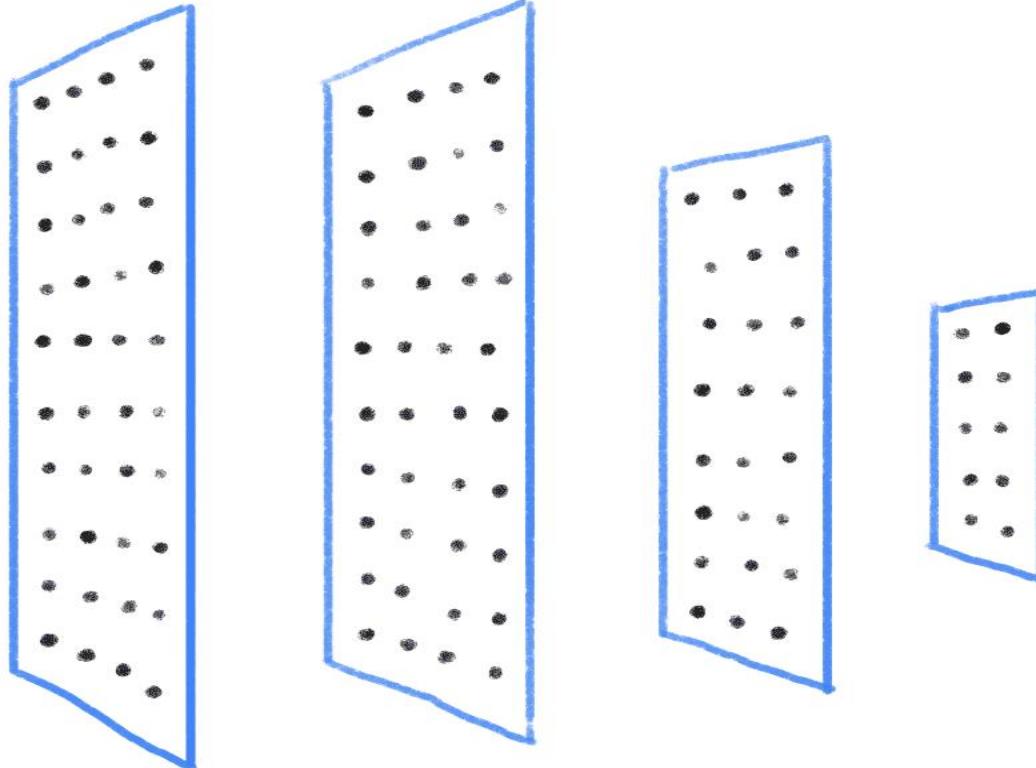
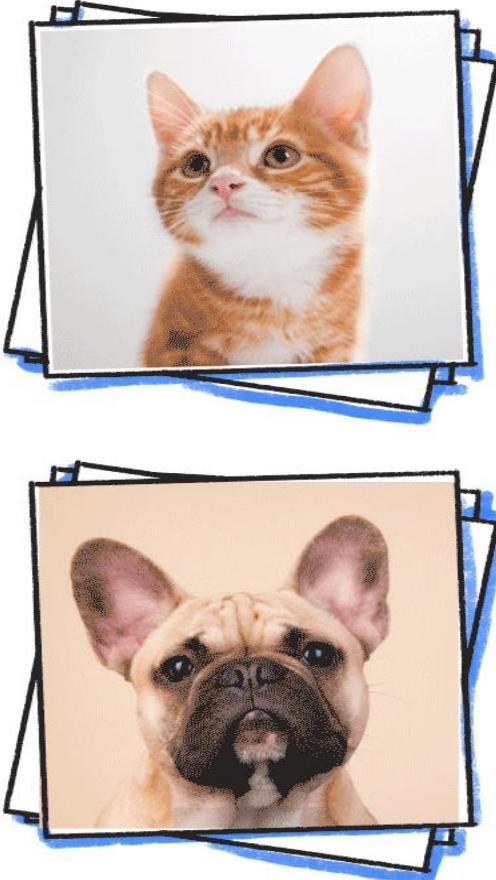


IMAGE CLASSIFICATION

CAT

(LABLED)
PHOTOS

DOG

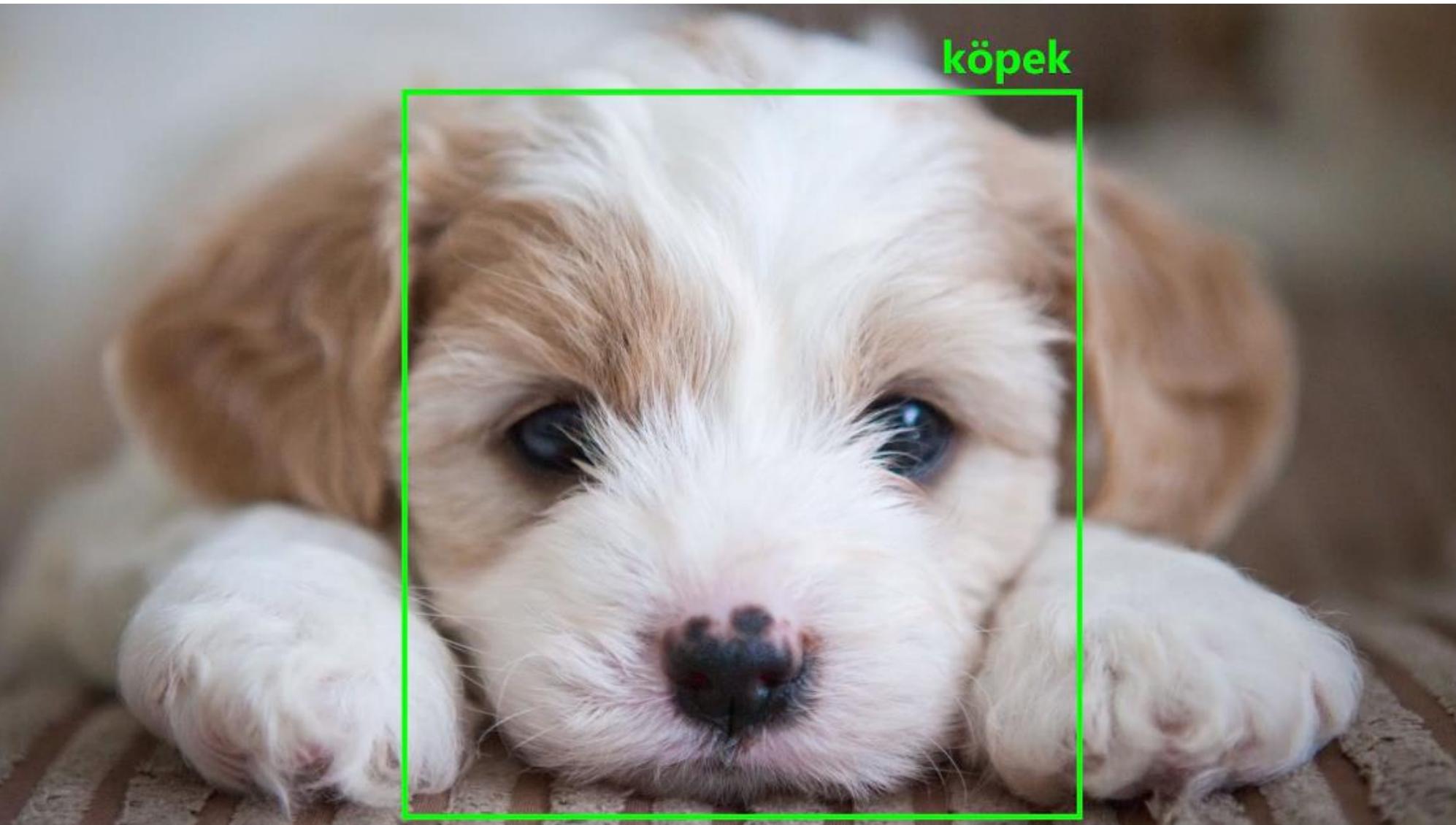


OUTPUT





OBJECT DETECTION



Cow

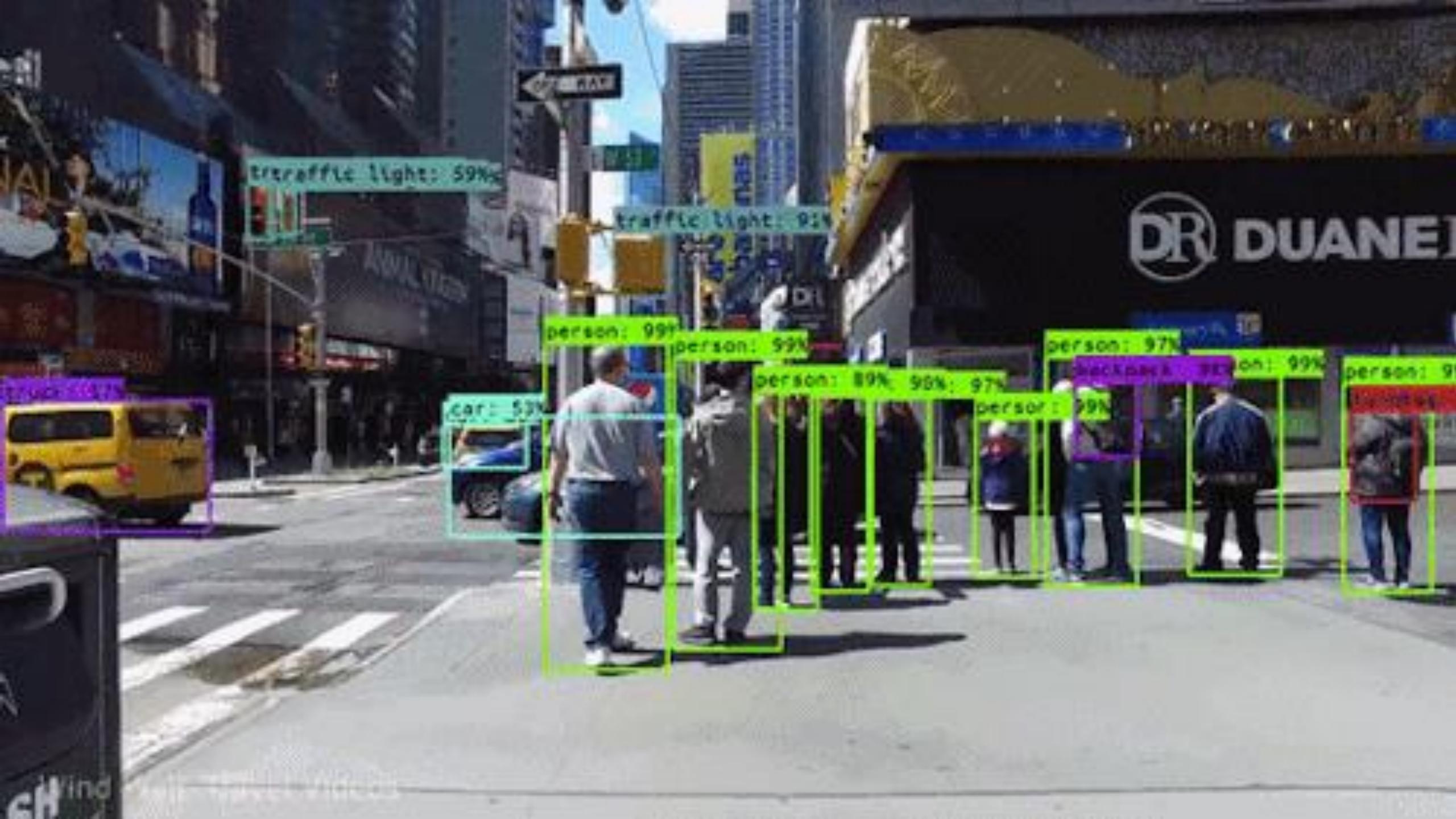
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Length: 5.2 meter



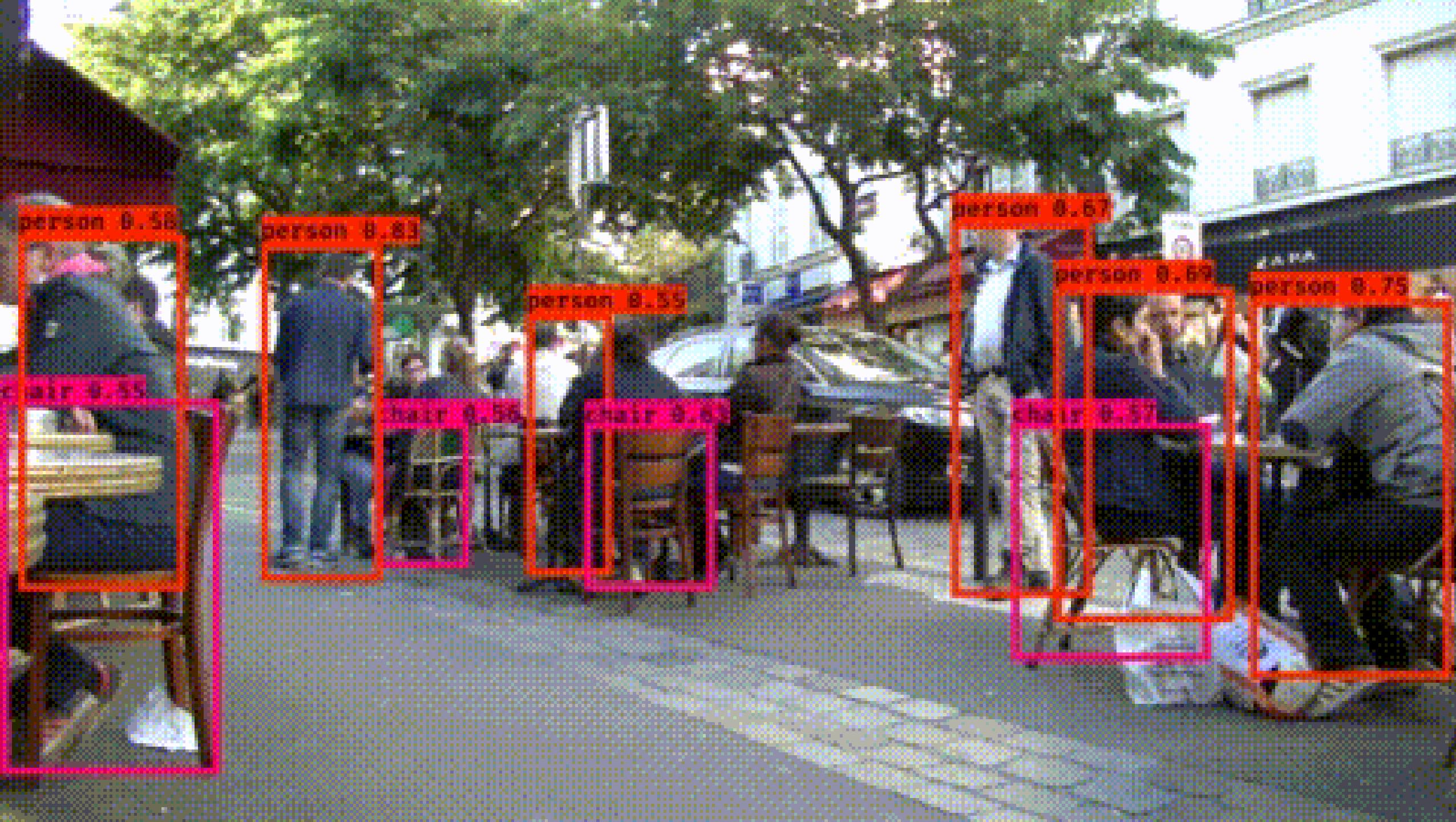


OBJECT DETECTION



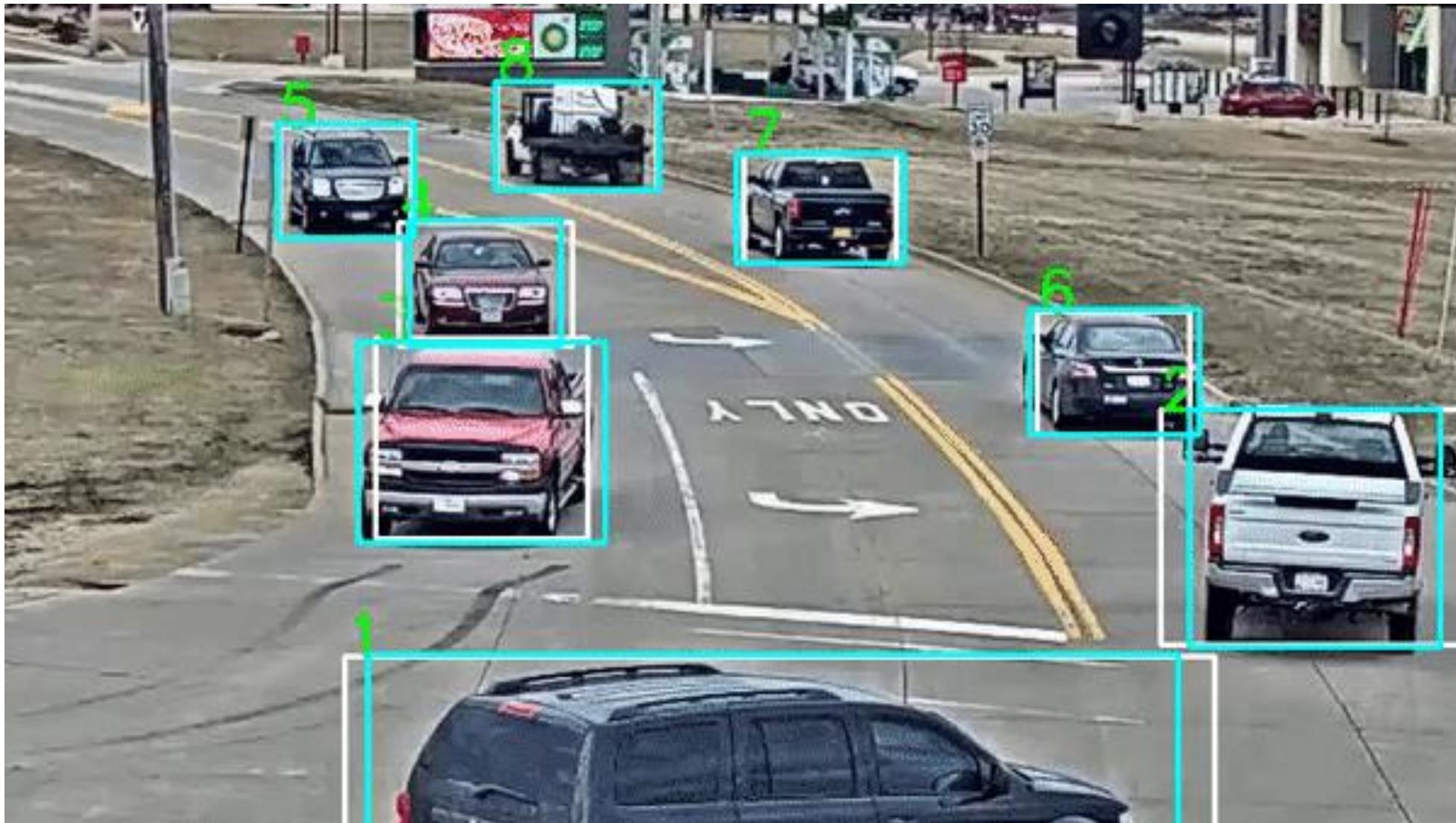






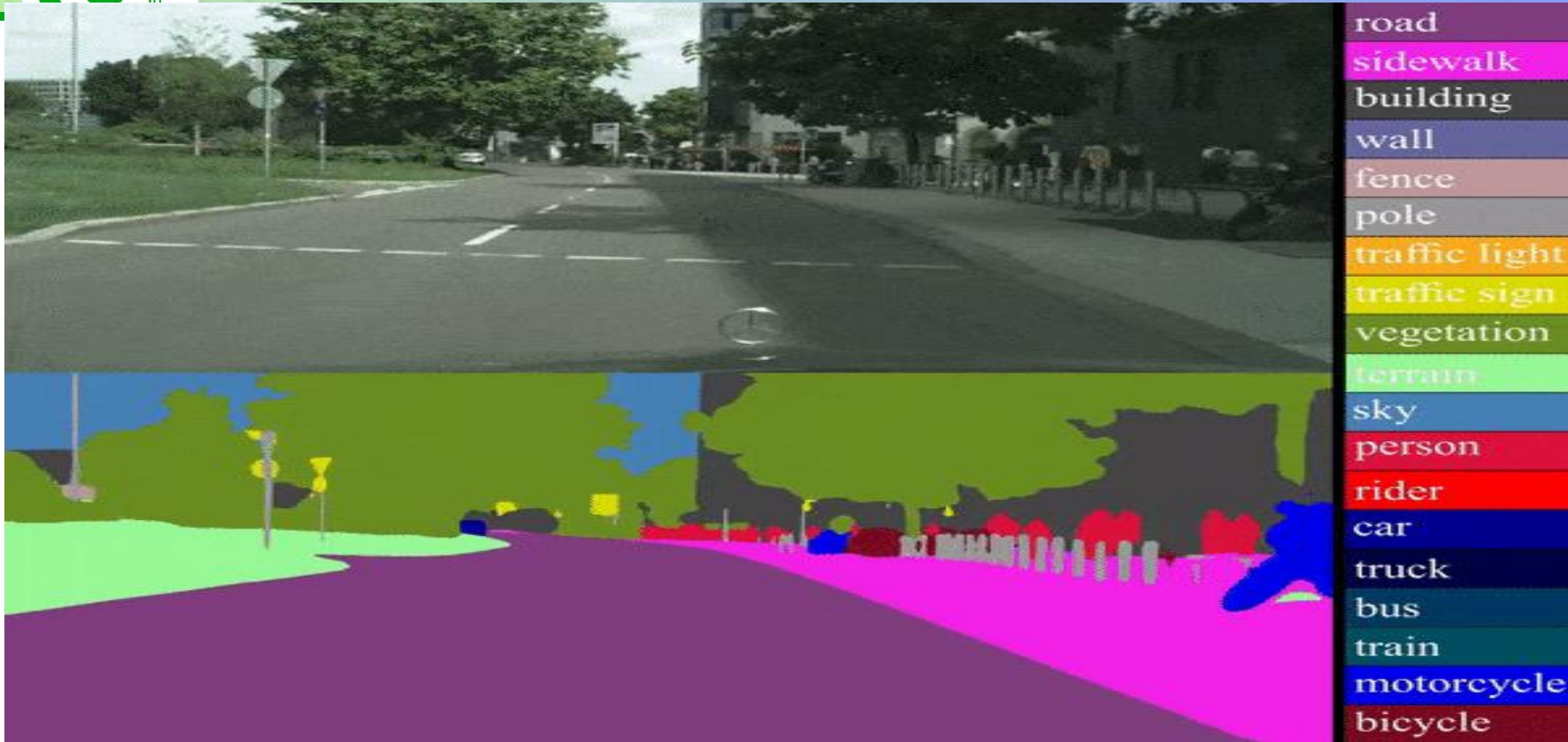


OBJECT TRACKING

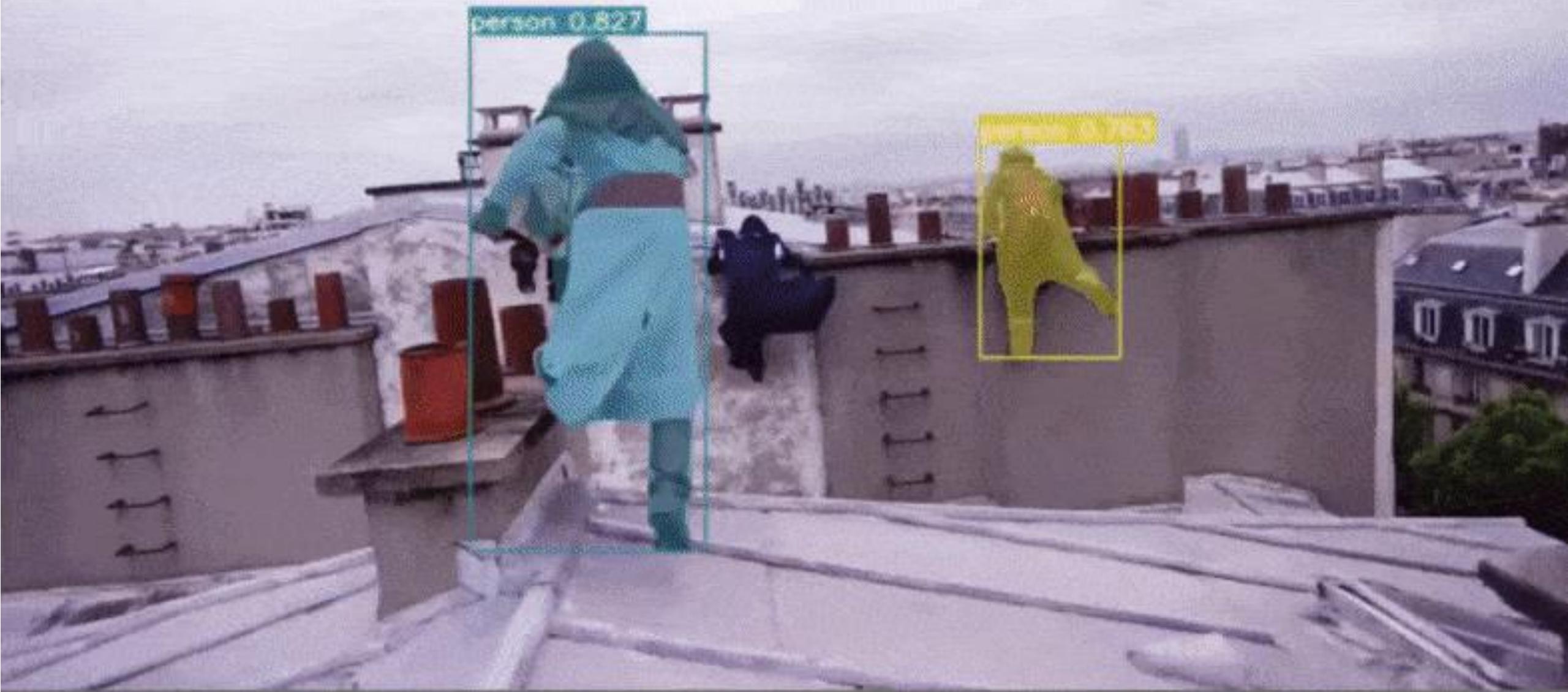




SEMANTIC SEGMENTATION



FPS: 8



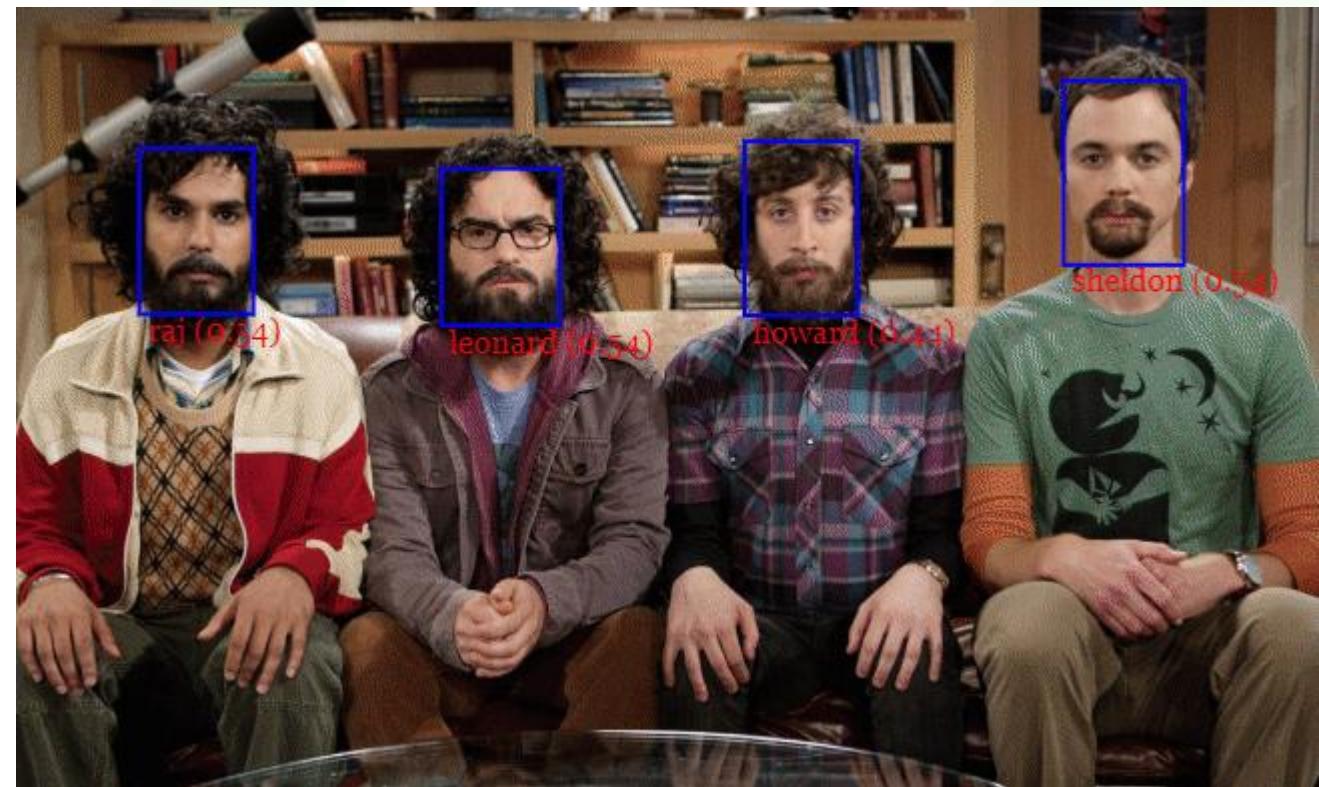
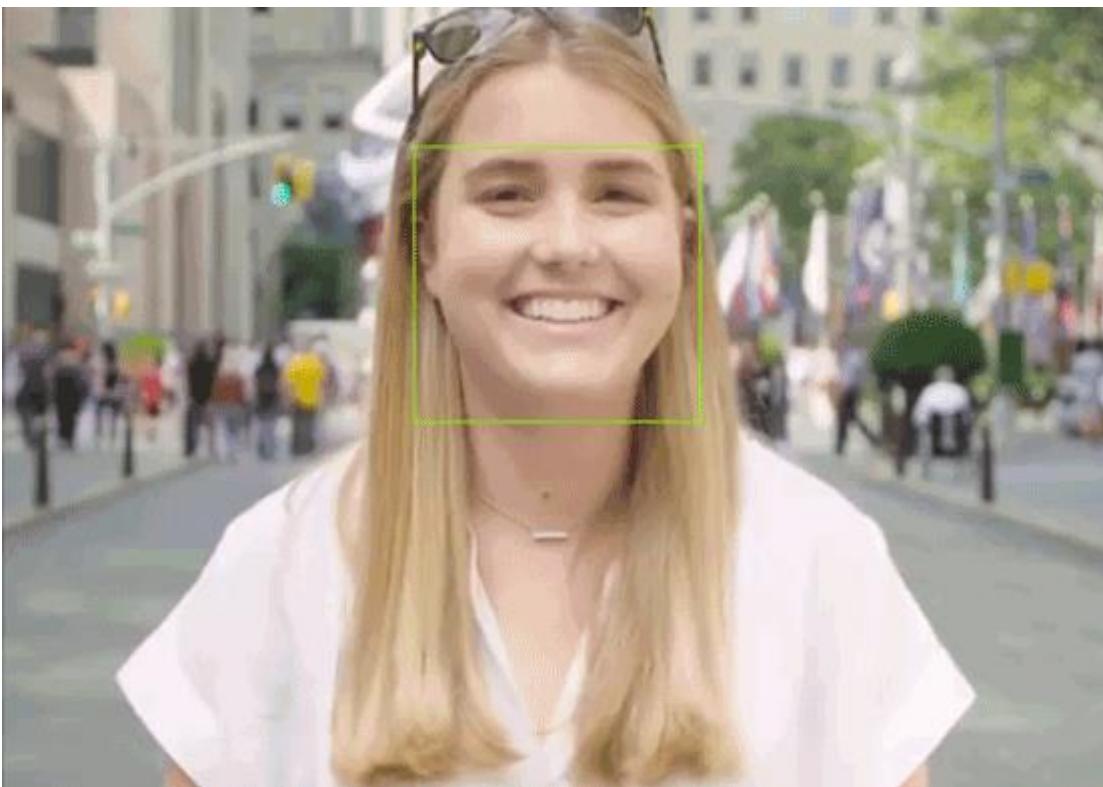


FACE DETECTION AND RECOGNITION





FACE DETECTION AND RECOGNITION





Despite the successes, computer vision still has a long way to go