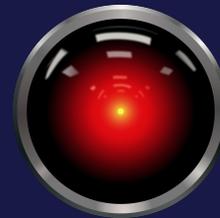




University of California
San Francisco

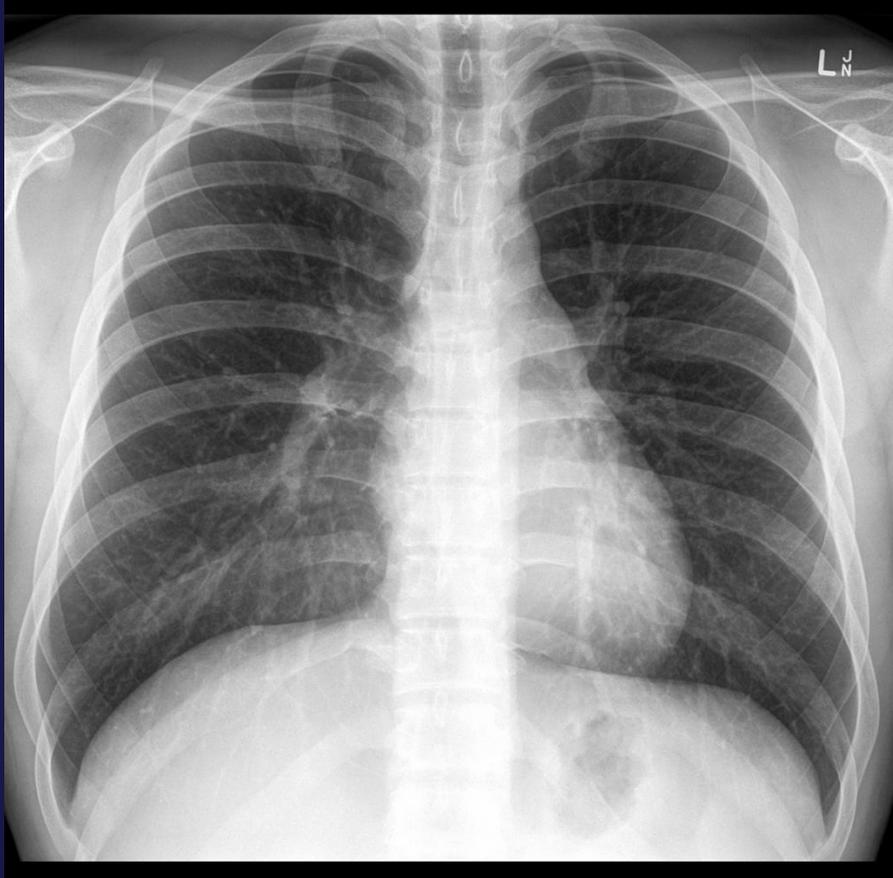
Training Computers to “Look” at X-rays Using Deep Learning

Andrew Taylor, MD PhD
Assistant Professor of Clinical Radiology
University of California, San Francisco

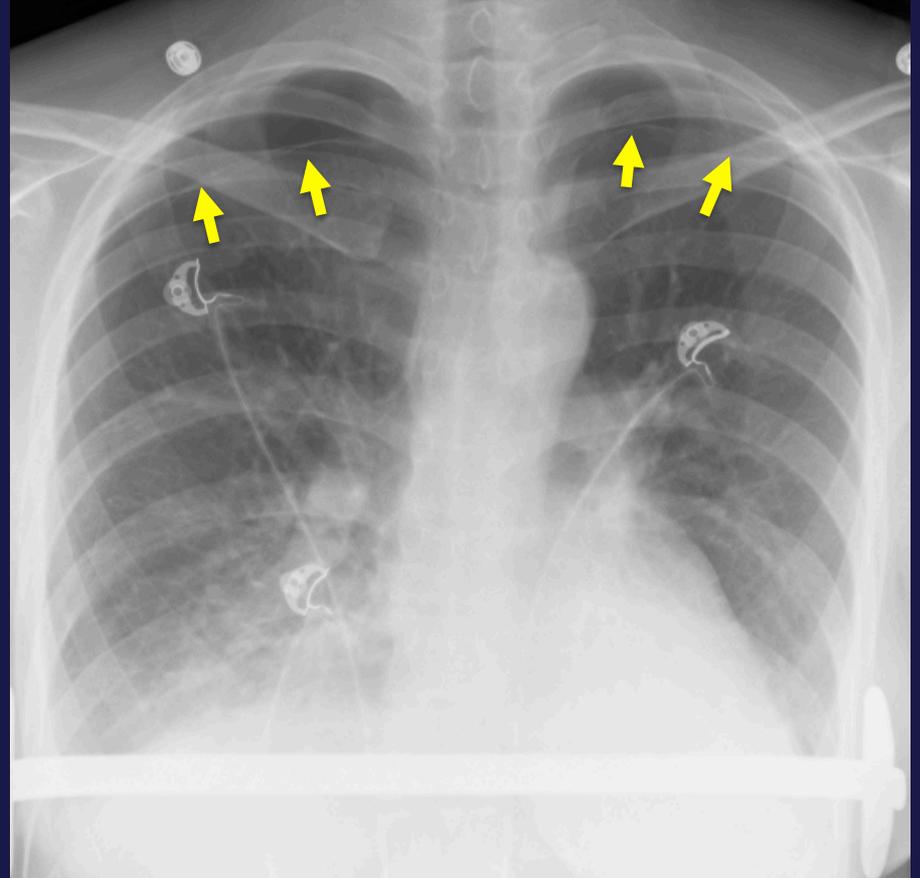


“I believe I’ve found
the problem, Doctor.”

The Problem - Pneumothorax

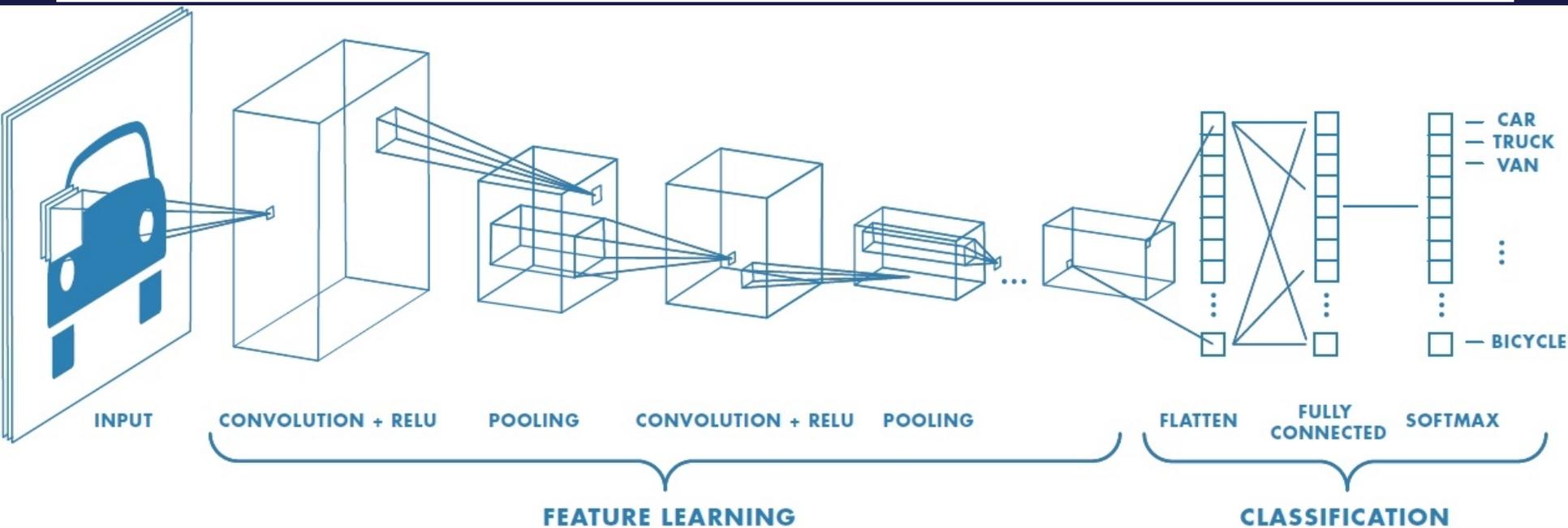
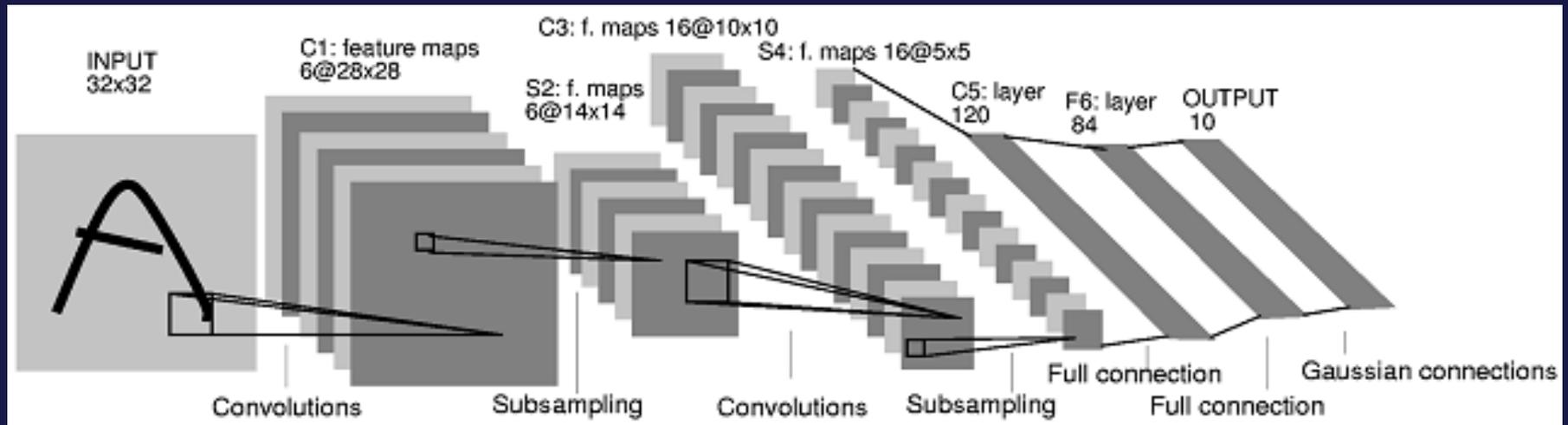


Normal Chest X-ray



Pneumothorax

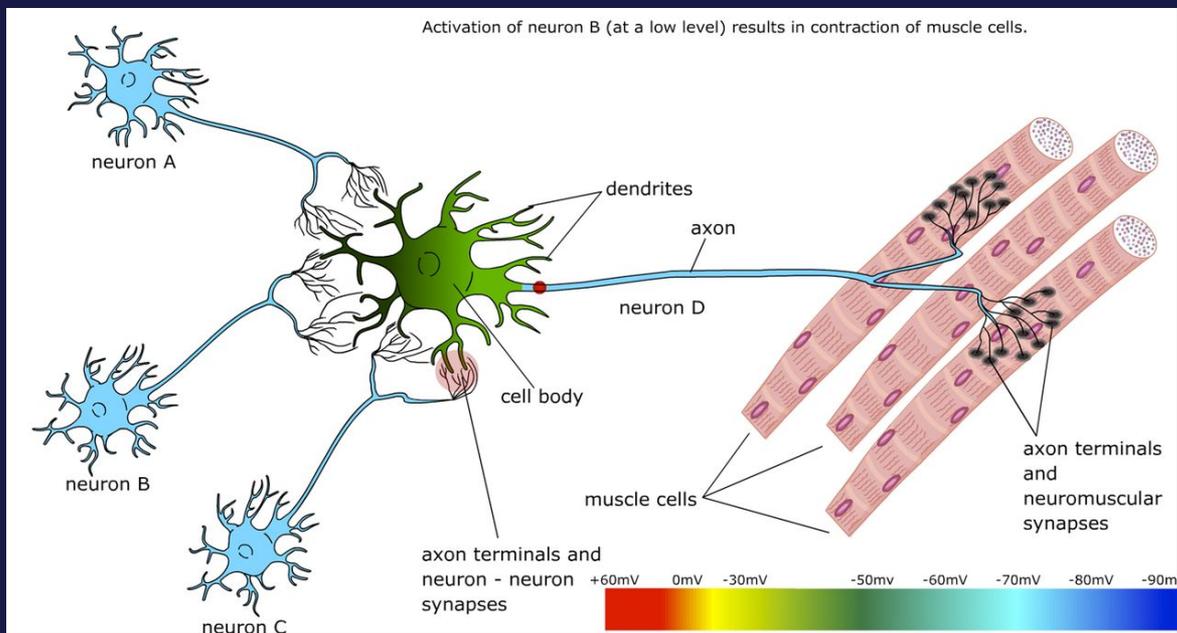
The Convolutional Neural Network



The Convolutional **Neural** Network

“What do I think the picture is?”

Biology



Neurons receive input (excitation or inhibition)

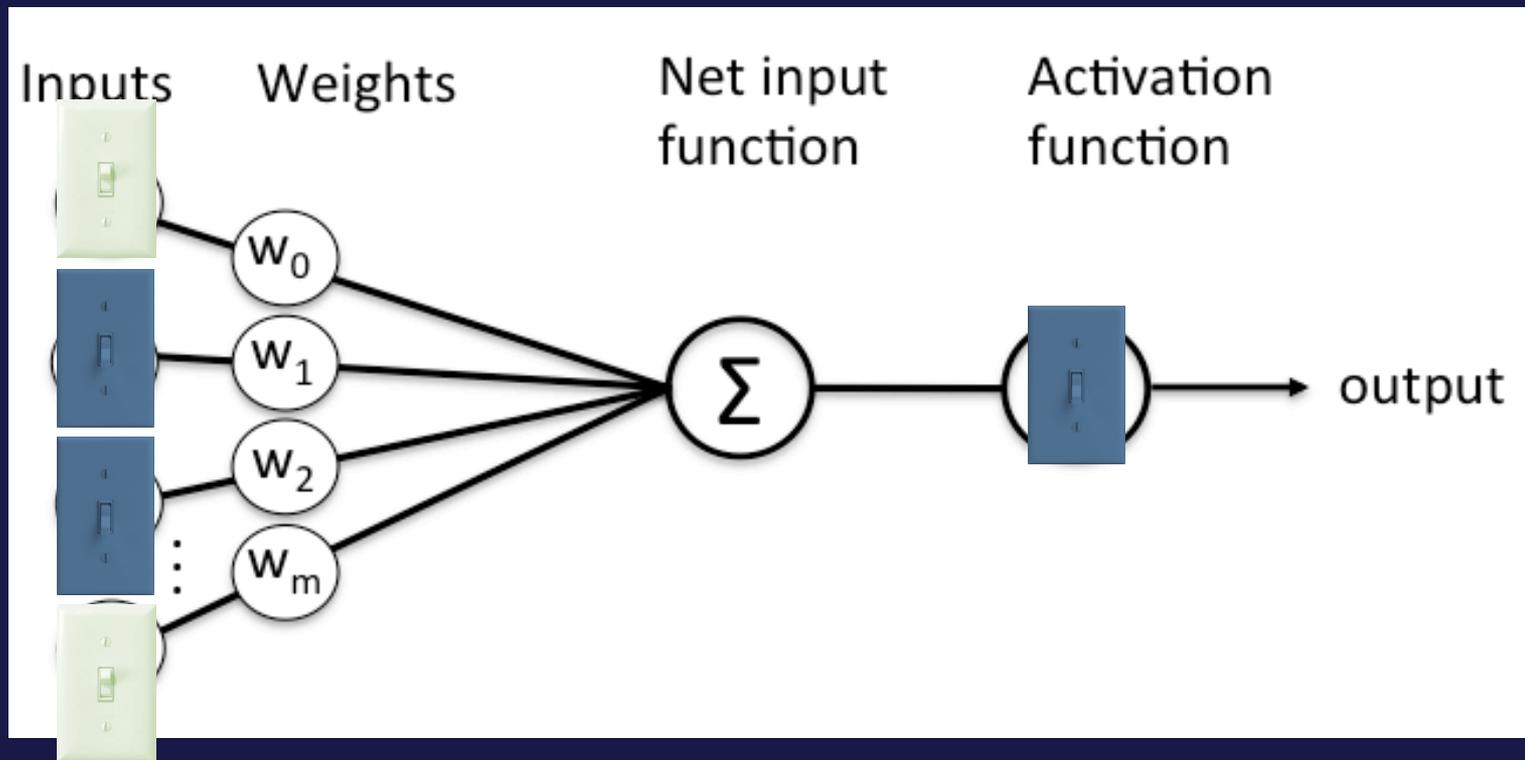
When excitation signals cross a threshold, the neuron fires

This is input to other neurons further along

The Convolutional **Neural** Network

“What do I think the picture is?”

Mathematics

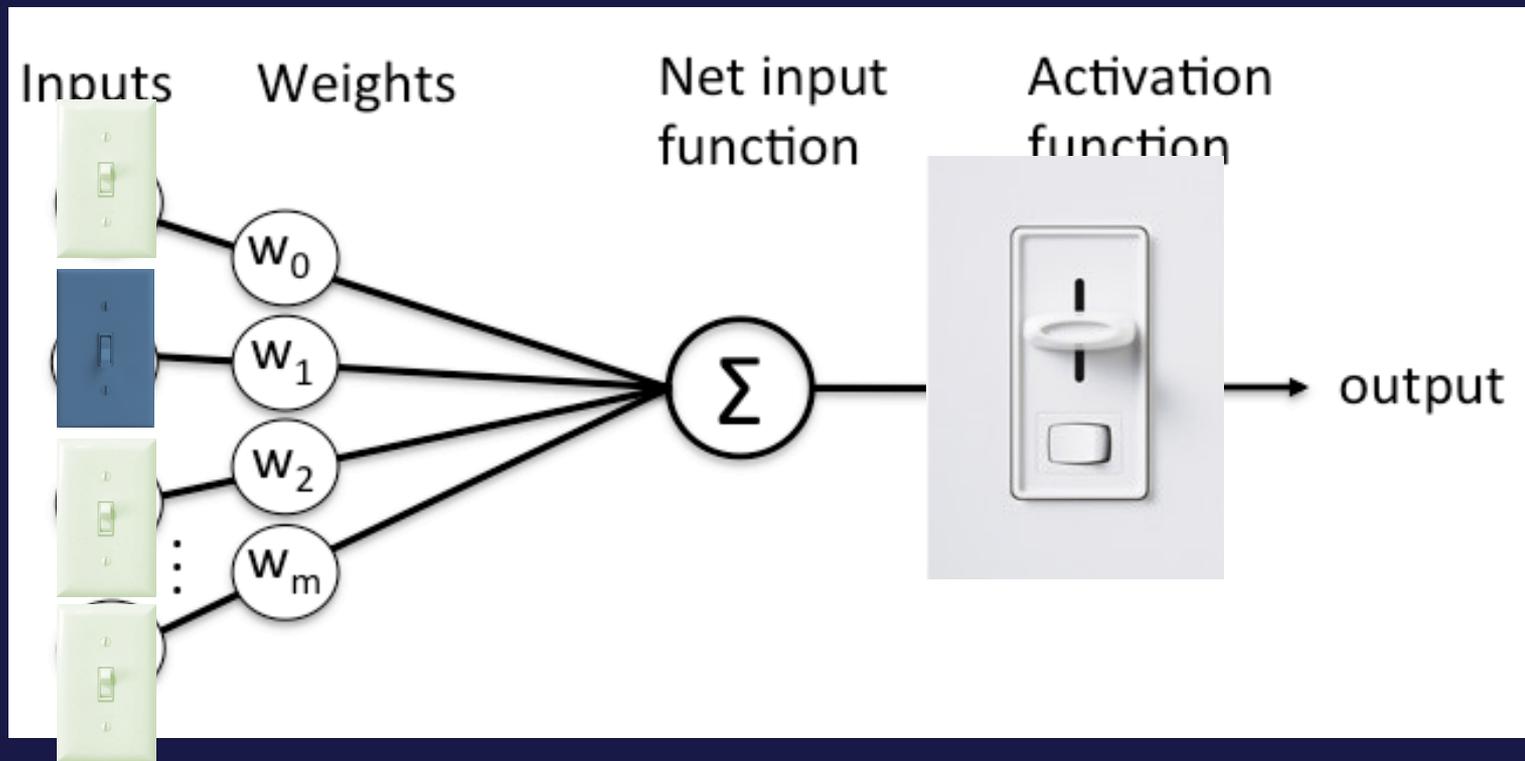


Perceptron Model – Frank Rosenblatt (1958)

The Convolutional **Neural** Network

“What do I think the picture is?”

Mathematics

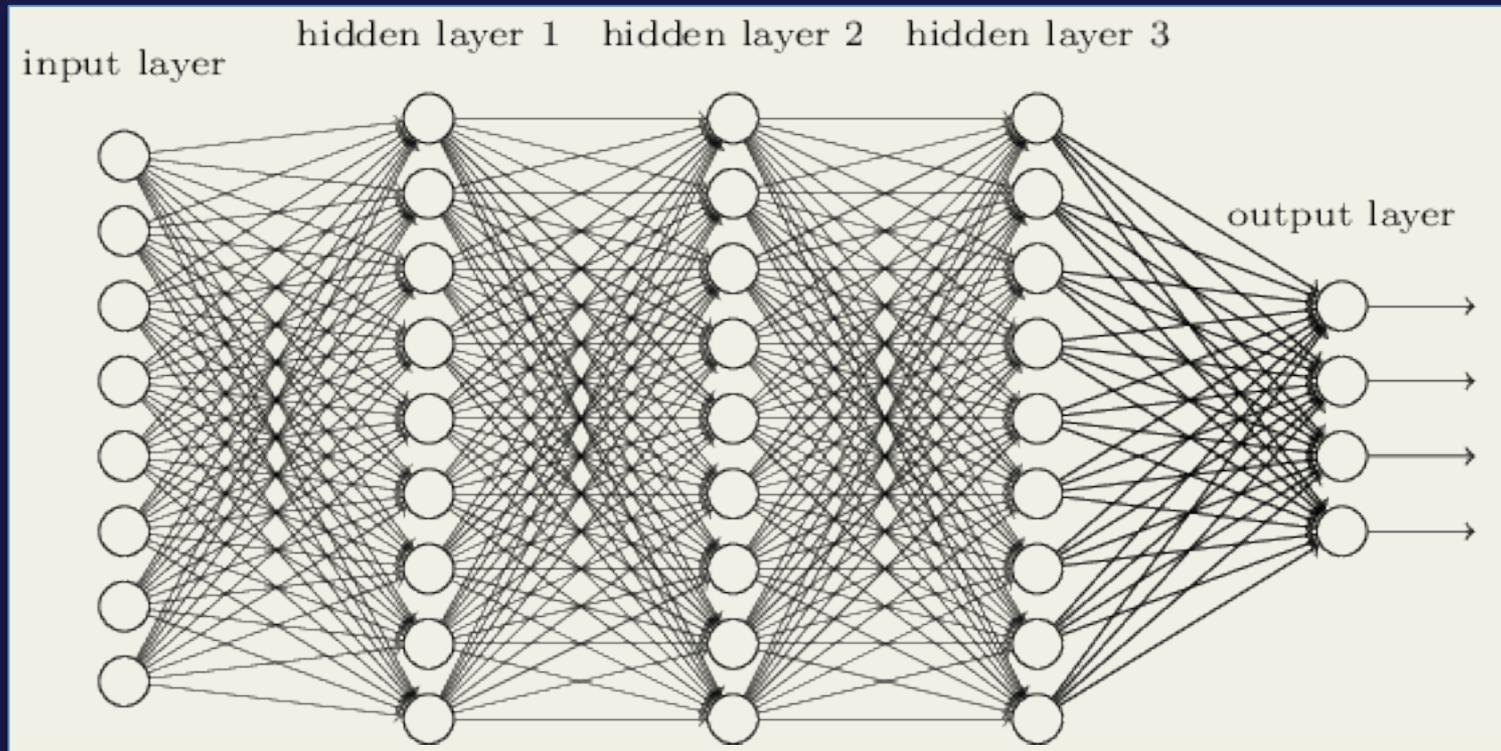


Perceptron Model – Frank Rosenblatt (1958)

The Convolutional **Neural** Network

“What do I think the picture is?”

Mathematics



The Multilayer Perceptron- increased output complexity

The Convolutional **Neural** Network

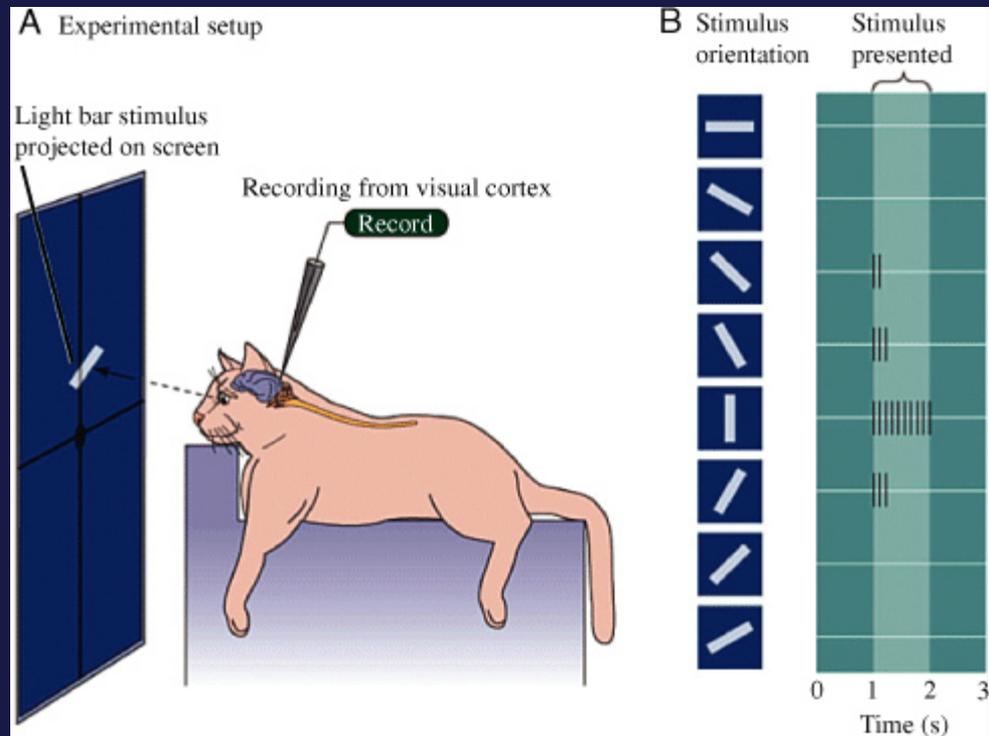
“What key features are in the picture?”

Hubel and Wiesel (1959)

Pioneering work in the structure and function of the visual cortex

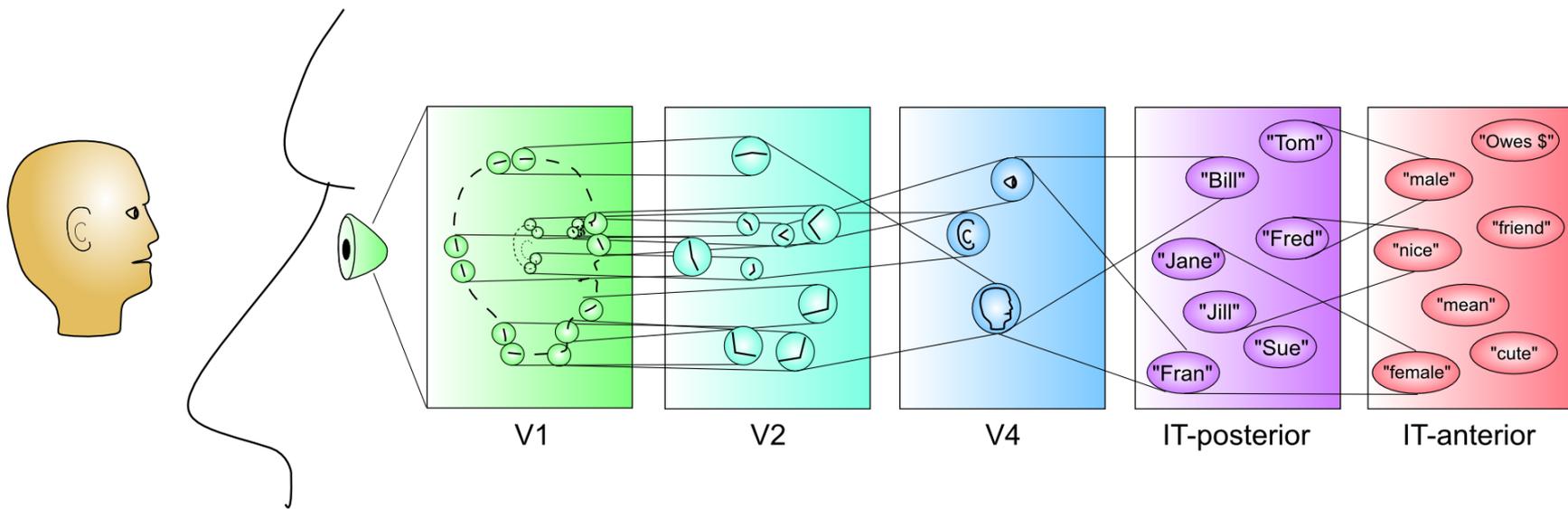
1981- Nobel Prize

<https://www.youtube.com/watch?v=p0ugn5sHdCk>



The Convolutional **Neural** Network

“What key features are in the picture?”



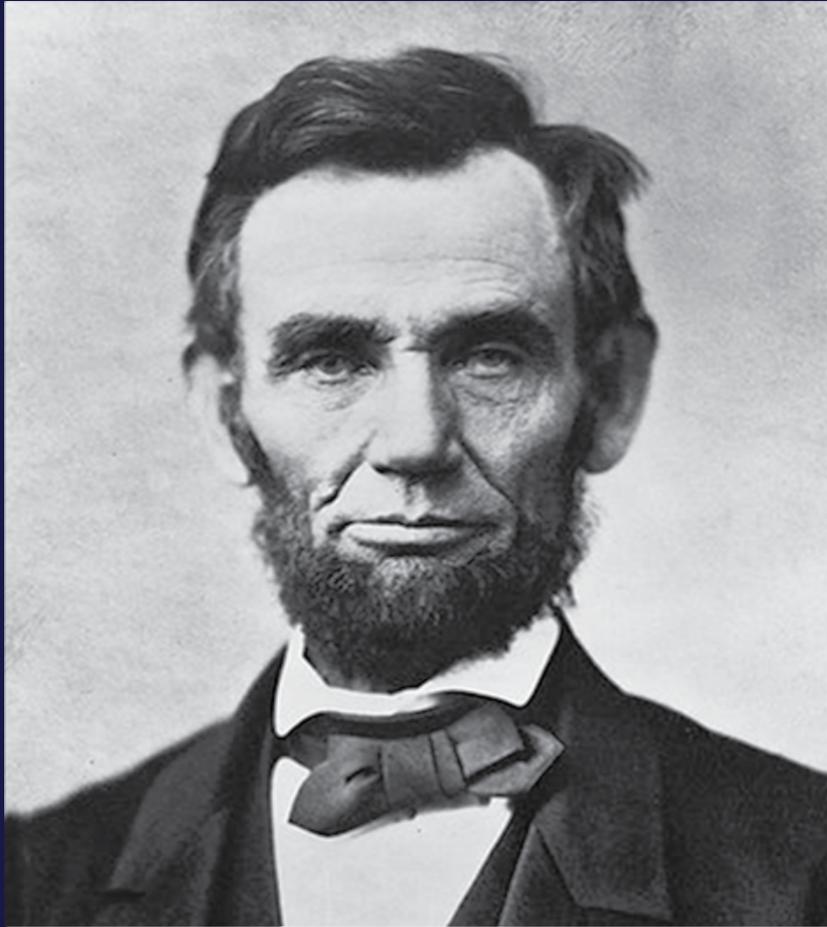
Hierarchical connections

Increasingly abstract/complex forms

Increasingly spatially independent

The **Convolutional** Neural Network

“Can I highlight important features?”



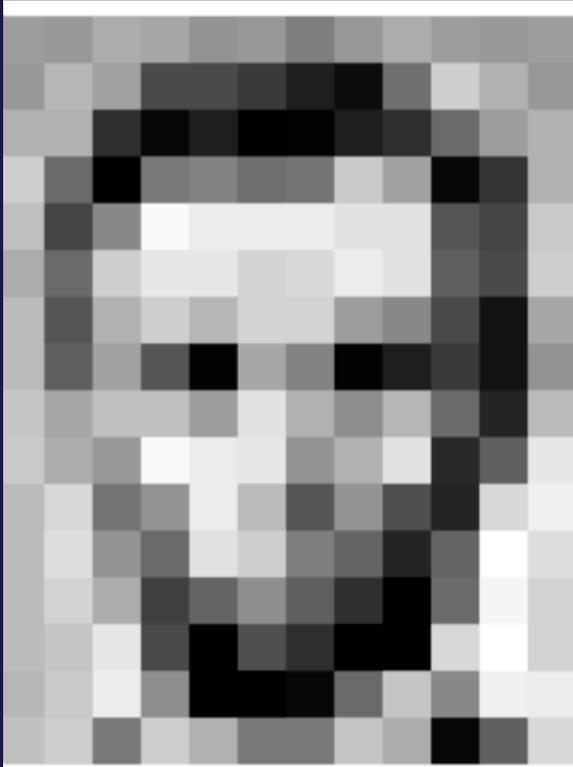
Human (analog)



Computer (digital)

The **Convolutional** Neural Network

“Can I highlight important features?”



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	5	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	139	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
206	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	215
187	196	236	75	1	81	47	0	6	217	255	211
183	202	237	145	0	0	12	108	200	138	243	236
196	206	123	207	177	121	123	200	175	13	96	218

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	5	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	139	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
206	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	215
187	196	236	75	1	81	47	0	6	217	255	211
183	202	237	145	0	0	12	108	200	138	243	236
196	206	123	207	177	121	123	200	175	13	96	218

The **Convolutional** Neural Network

“Can I highlight important features?”

The Convolutional Filter

A grid of numbers

Usually 3x3, 5x5, 7x7

0.77	0.82	0.06	0.33	0.51
0.99	0.22	0.47	0.34	0.01
0.07	0.43	0.86	0.67	0.25
0.37	0.41	0.05	0.18	0.63
0.28	0.83	0.12	0.93	0.08

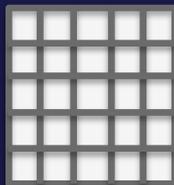
The **Convolutional** Neural Network

“Can I highlight important features?”

The Convolutional Filter

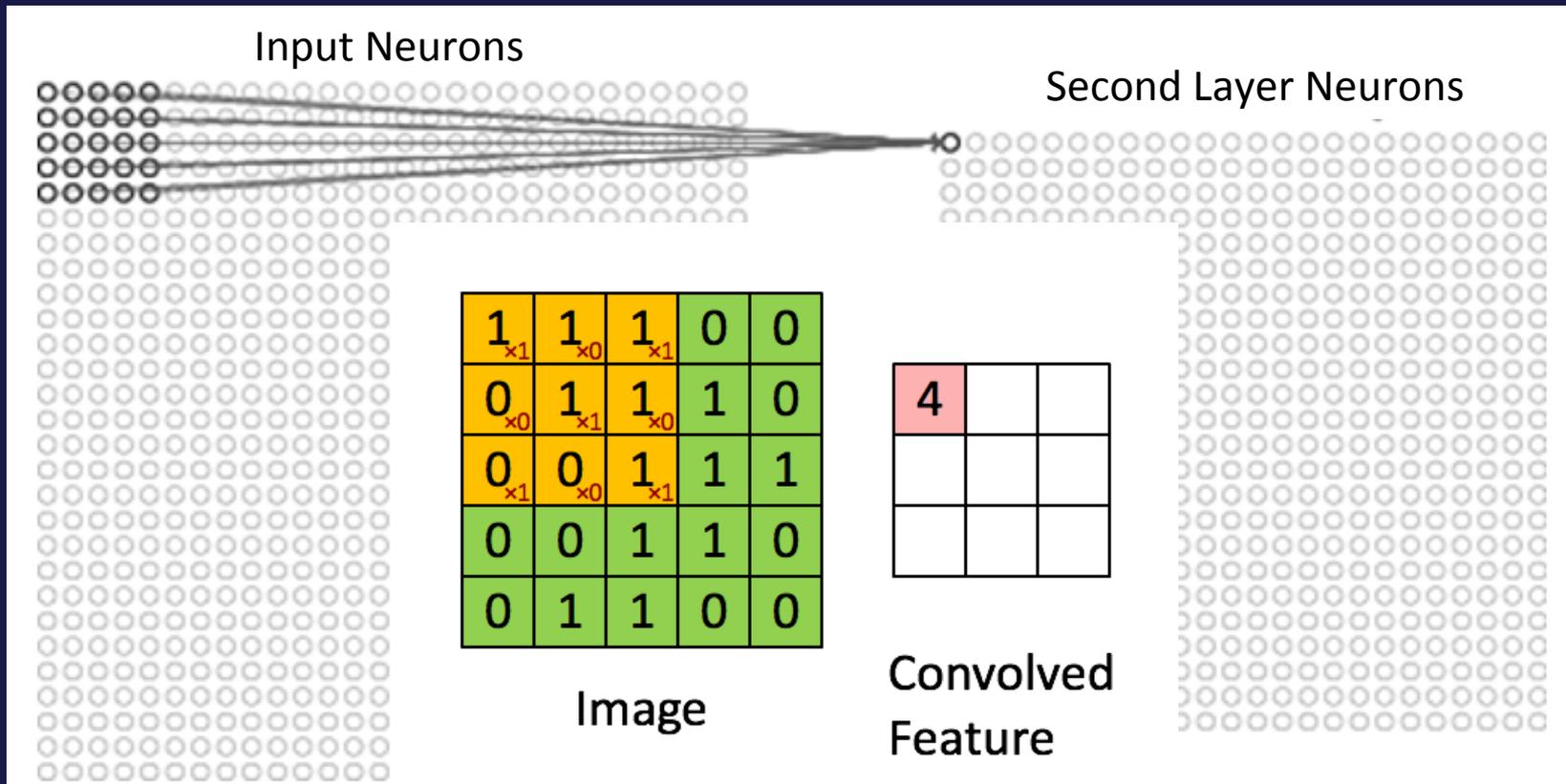
A grid of numbers

Usually 3x3, 5x5, 7x7



The **Convolutional** Neural Network

“Can I highlight important features?”



The **Convolutional** Neural Network

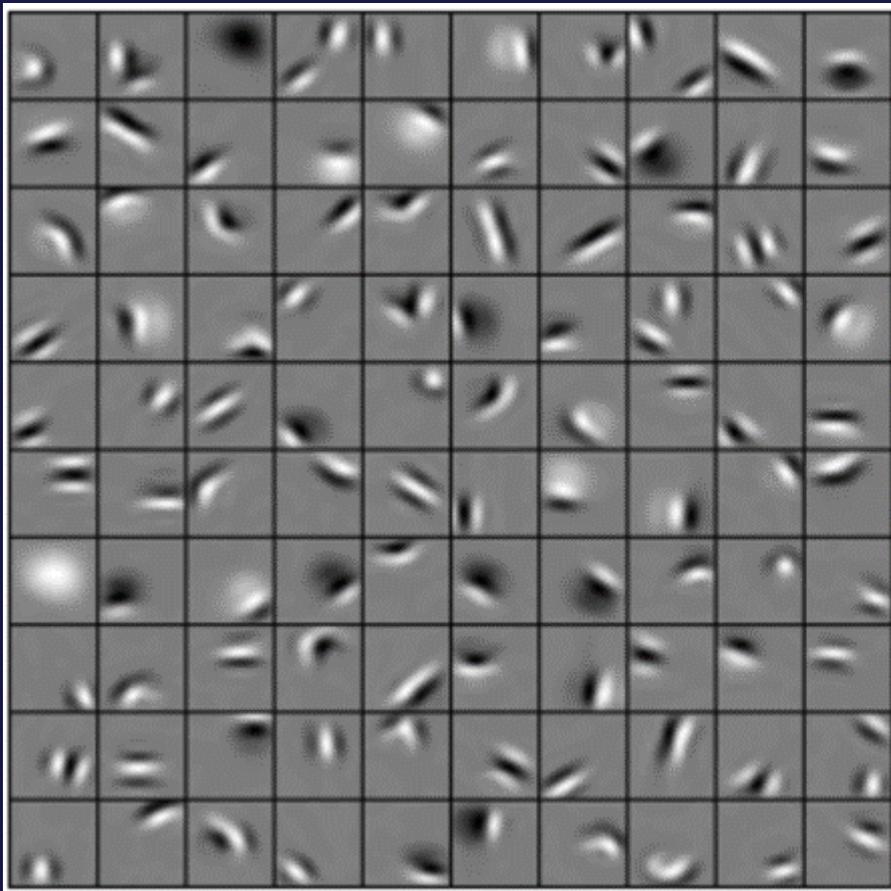
“Can I highlight important features?”



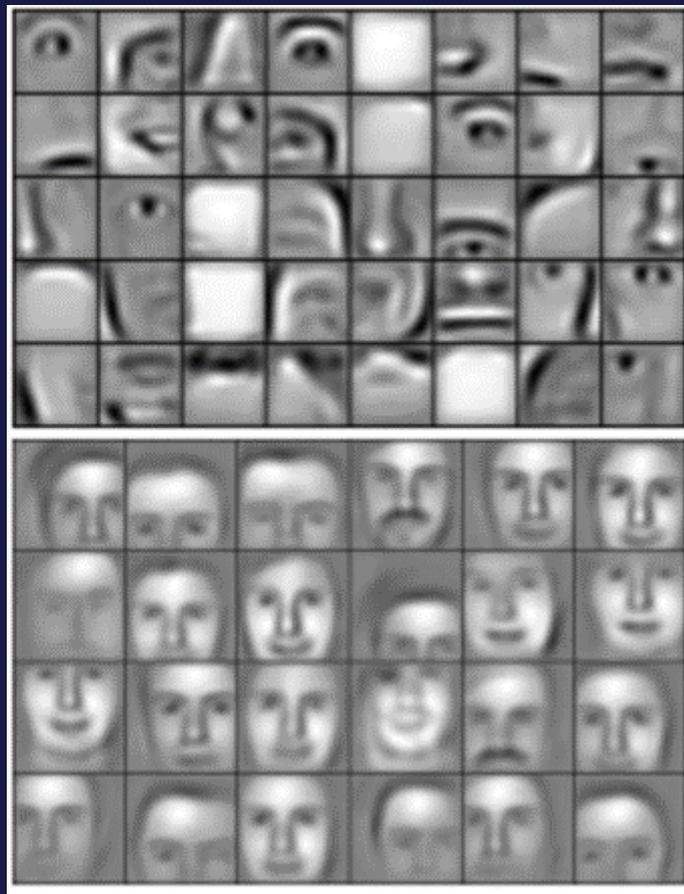
Input

The **Convolutional** Neural Network

“Can I highlight important features?”



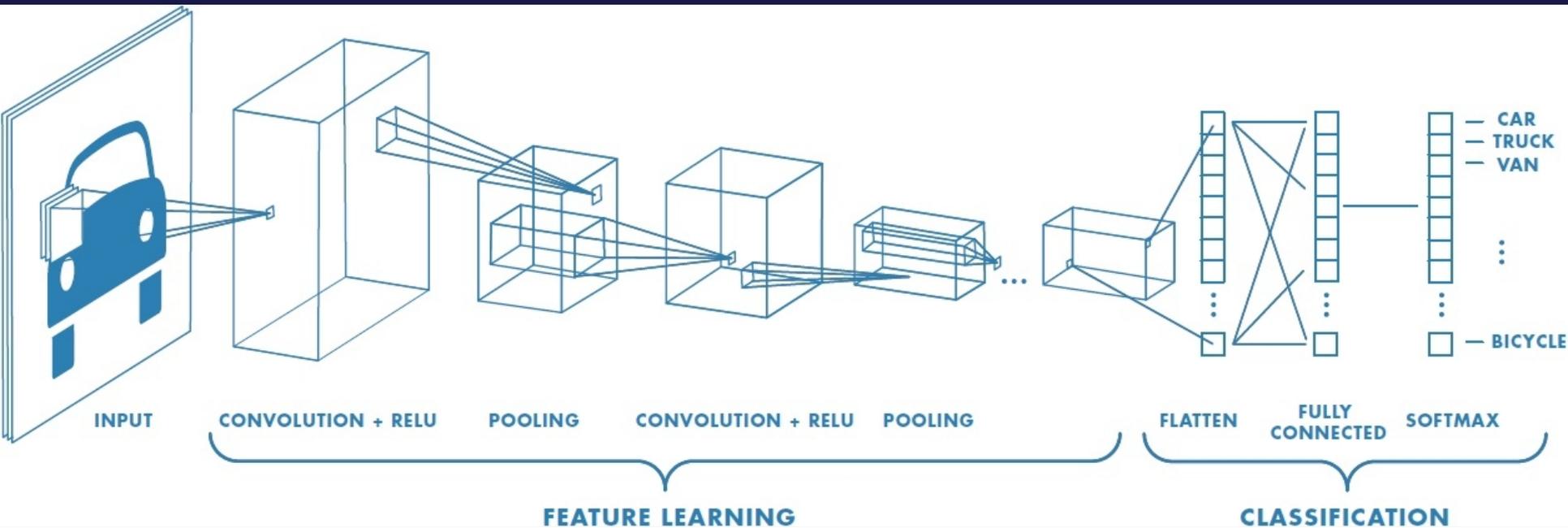
Lower Level



Higher Level

The Convolutional Neural Network

Assemble it all Together



“Can I highlight important features?”

“What do I think the picture is?”

Practice Makes (almost) Perfect

Humans are good at extending their experience



Practice Makes (almost) Perfect

Drinking from an electronic firehose



X 1000's!



©Warren Photographic

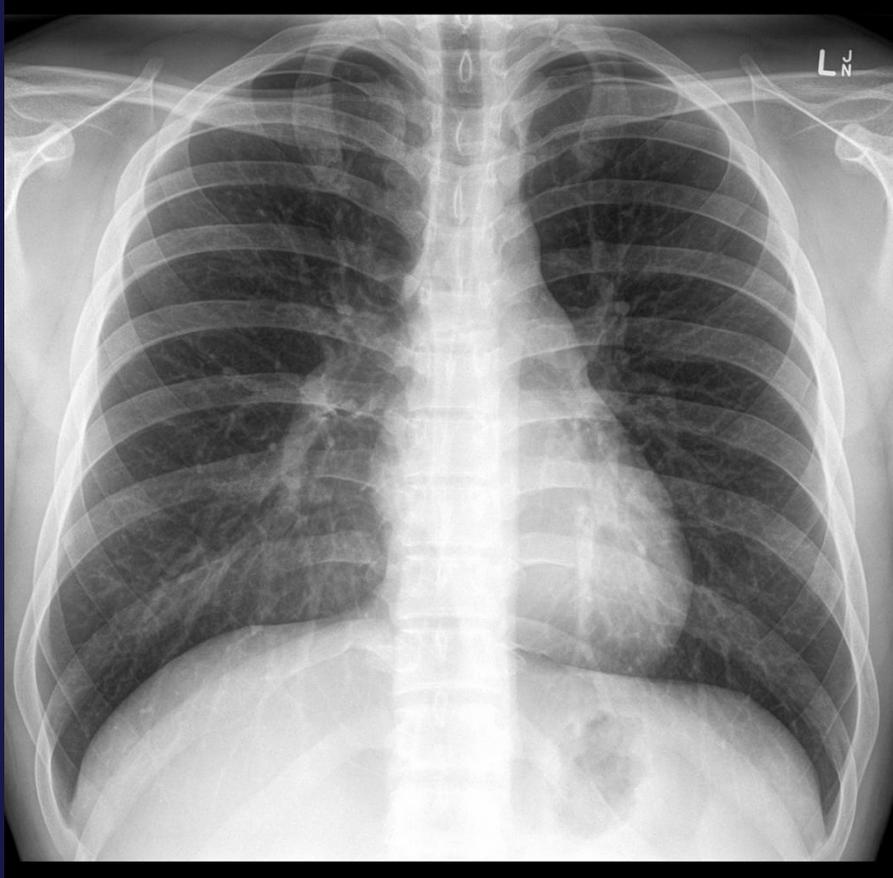


©Warren Pho

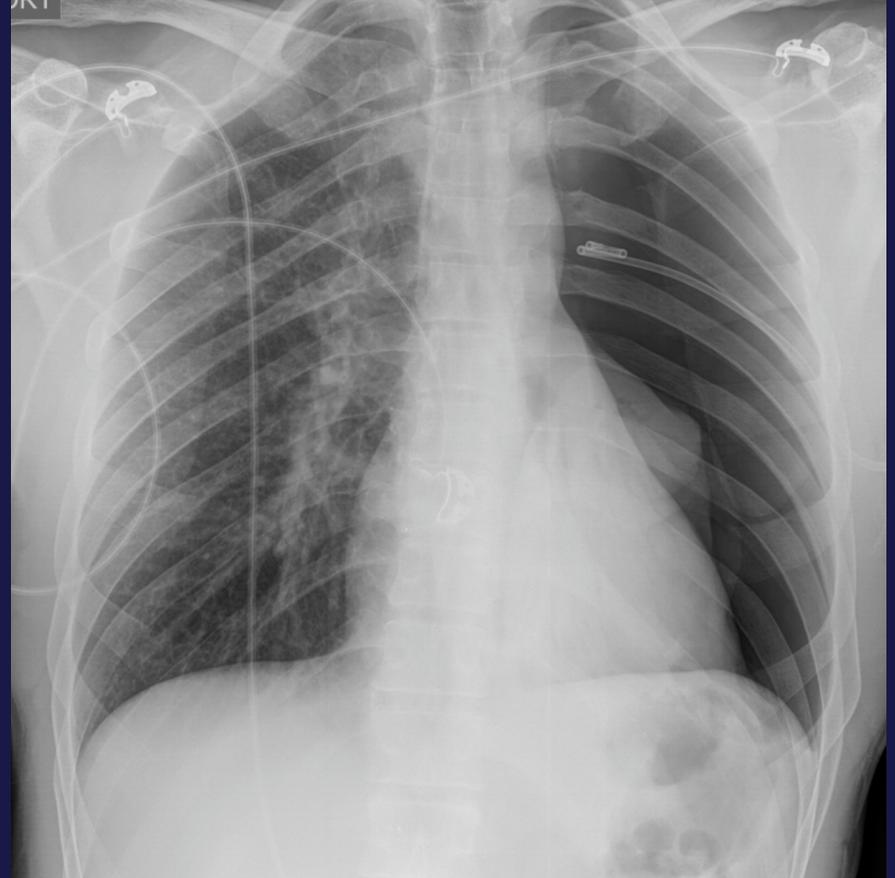


©Warren Photographic

Back to Pneumothorax

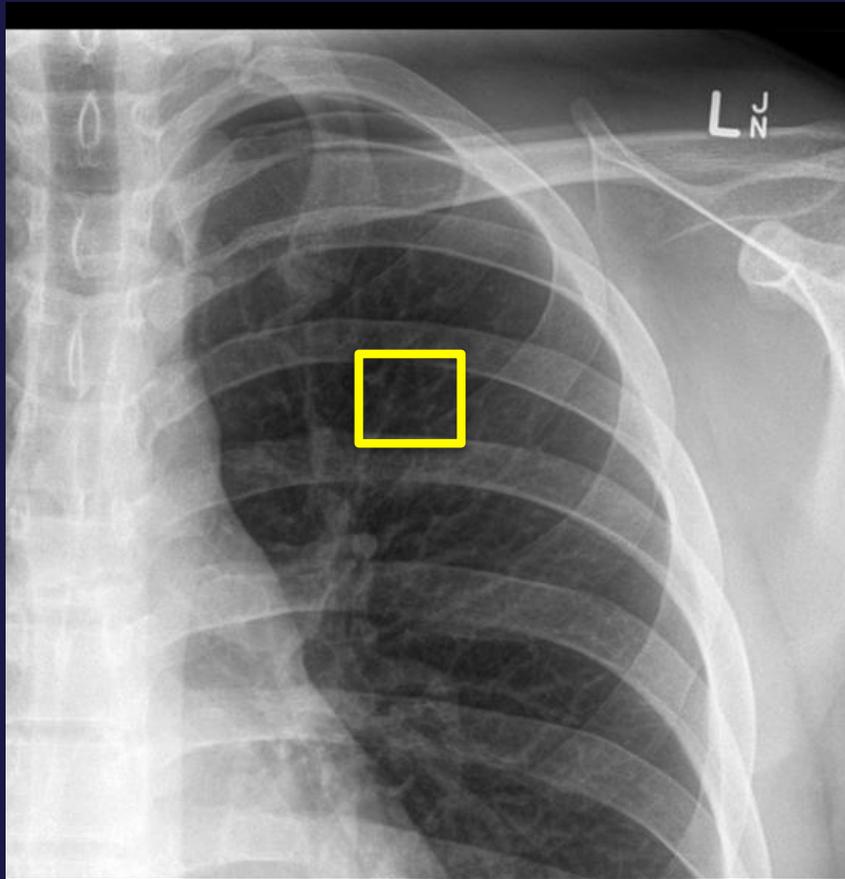


No Pneumothorax

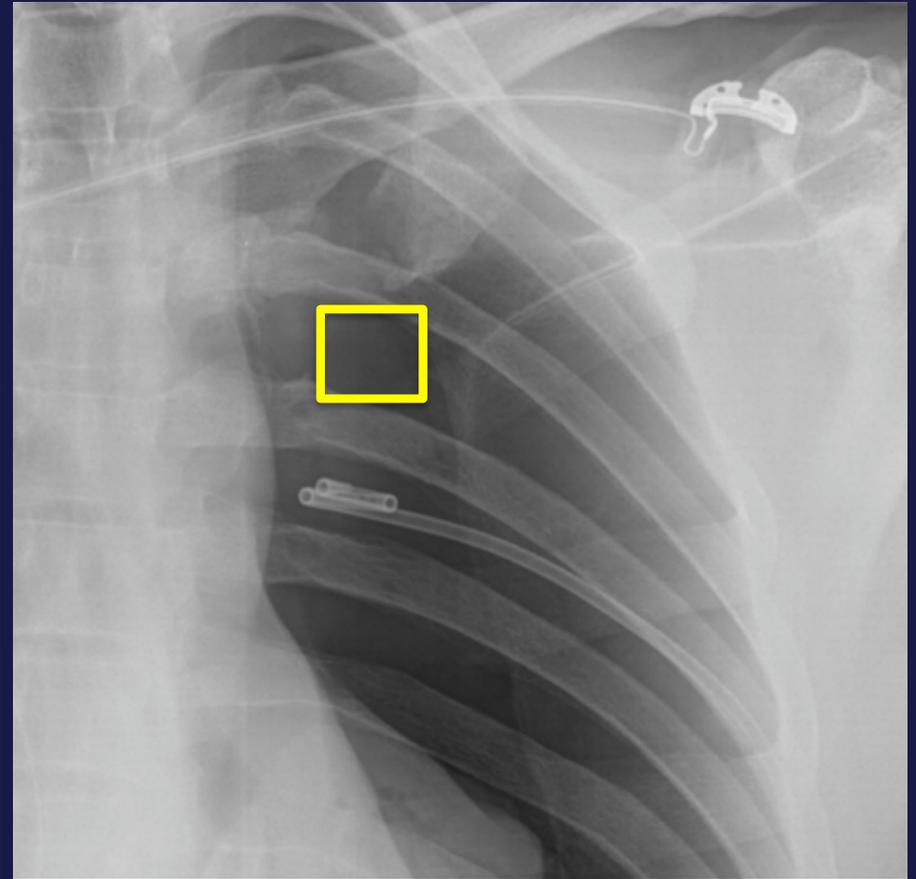


Pneumothorax

Detecting Pneumothorax

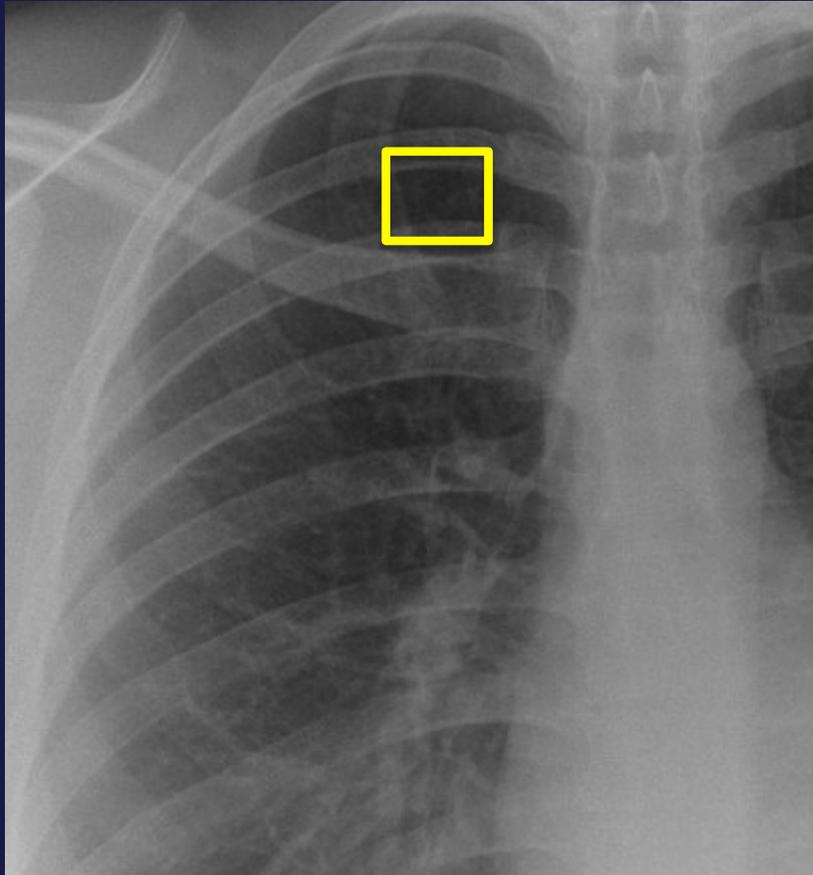


No Pneumothorax

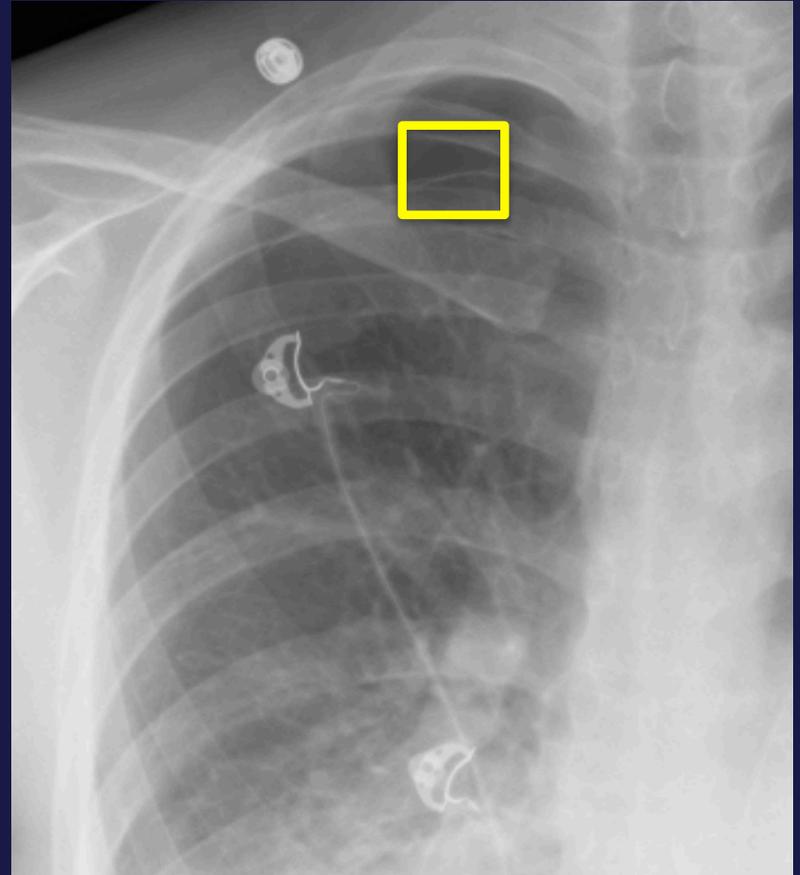


Pneumothorax

Detecting Pneumothorax



No Pneumothorax



Pneumothorax

Train, Train, Train

“Quantity has a Quality All its Own”

1000's of labeled images

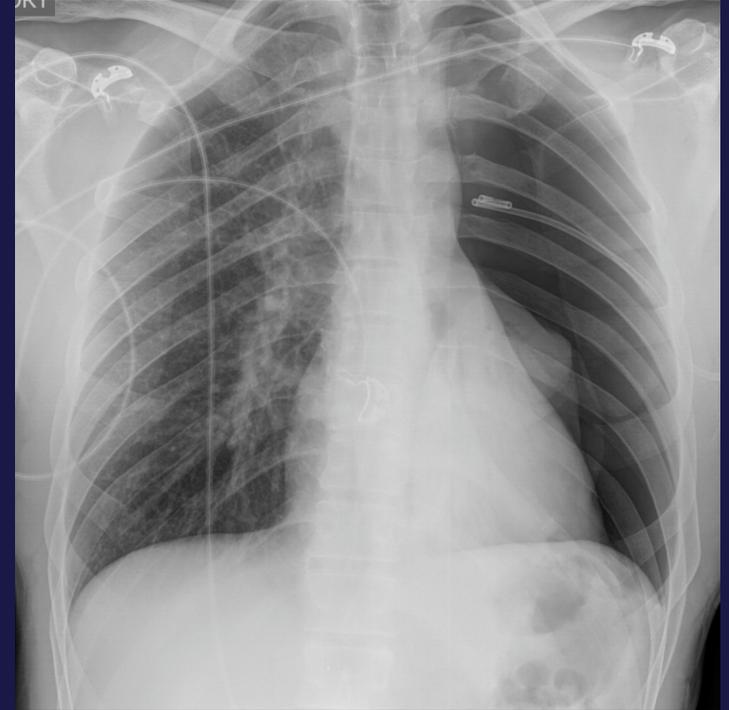
- Different Sizes.
- Different Orientations
- Different hospital settings
- Positives and Negatives

Increase to 100,000 or more

Achieves a reasonable
(minimum?) dataset



Results



Current Performance:
Detecting the majority of significant pneumothorax