Deep Learning for Remote Sensing

AI60002

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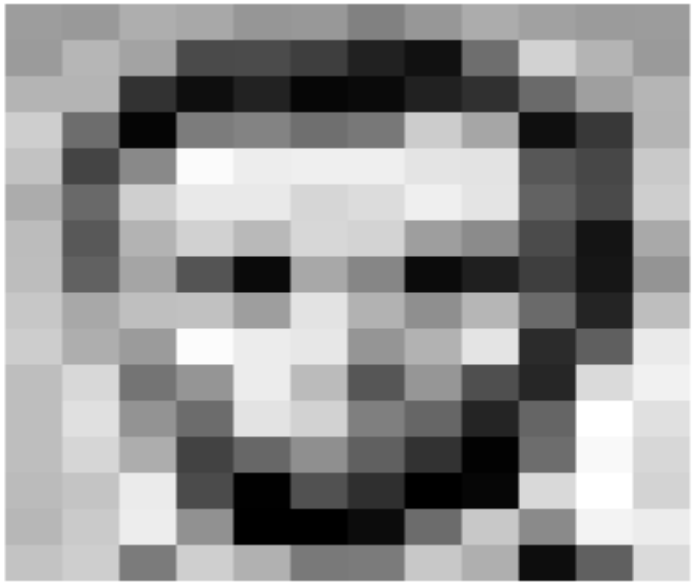
Deep Learning for Images

- Provided: images (2D or 3D matrices)
- X(i,j,k): a pixel on the i-th row, j-th column and k-th channel
- Information: neighboring pixels likely to have similar values (spatial autocorrelation)
- Further: neighboring pixels likely to belong to same object



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	105	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
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	215
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	123	200	175	13	96	218

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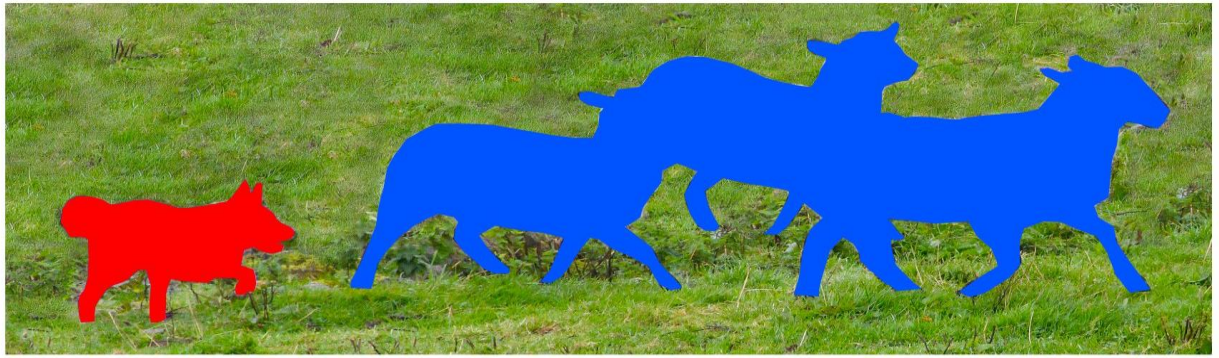
155	182	163	74	75	62	33	17	110	210	180	154
180	180	50	14	34	6	10	33	48	106	159	181
206	109	5	124	131	111	120	204	166	15	56	180
194	68	137	251	237	239	239	228	227	87	71	201
172	105	207	233	233	214	220	239	228	98	74	206
188	88	179	209	185	215	211	158	139	75	20	169
189	97	165	84	10	168	134	11	31	62	22	148
199	168	191	193	158	227	178	143	182	106	36	190
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	215
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	123	200	175	13	96	218

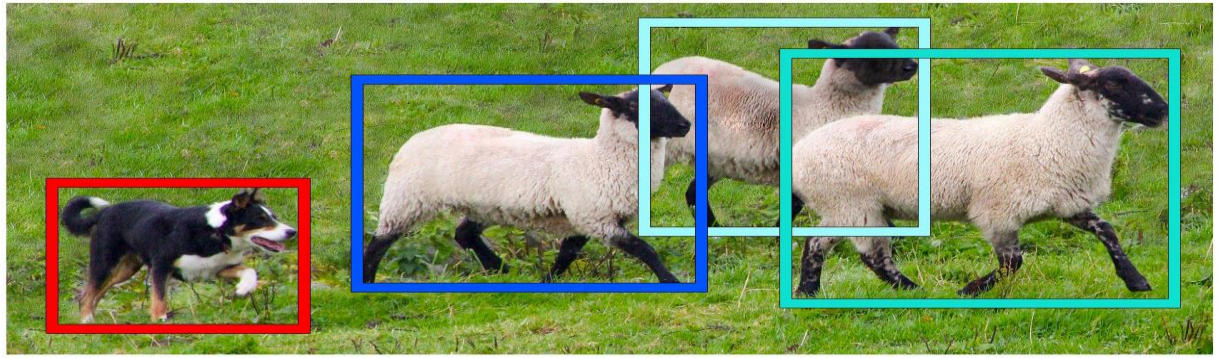
Deep Learning for Images

- Object Recognition
- Object Detection (for a particular object/set of objects)
- Image segmentation

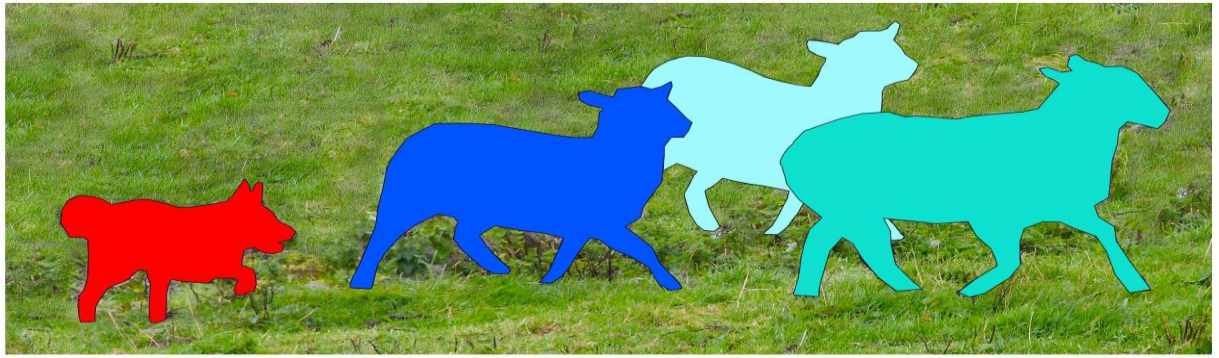
Image Recognition



Semantic Segmentation



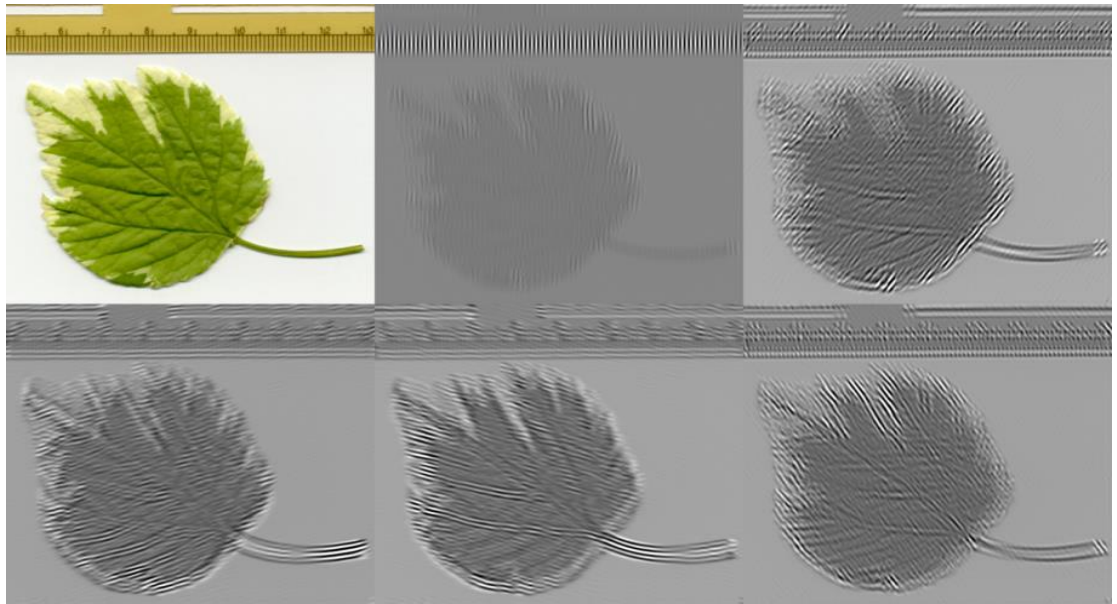
Object Detection

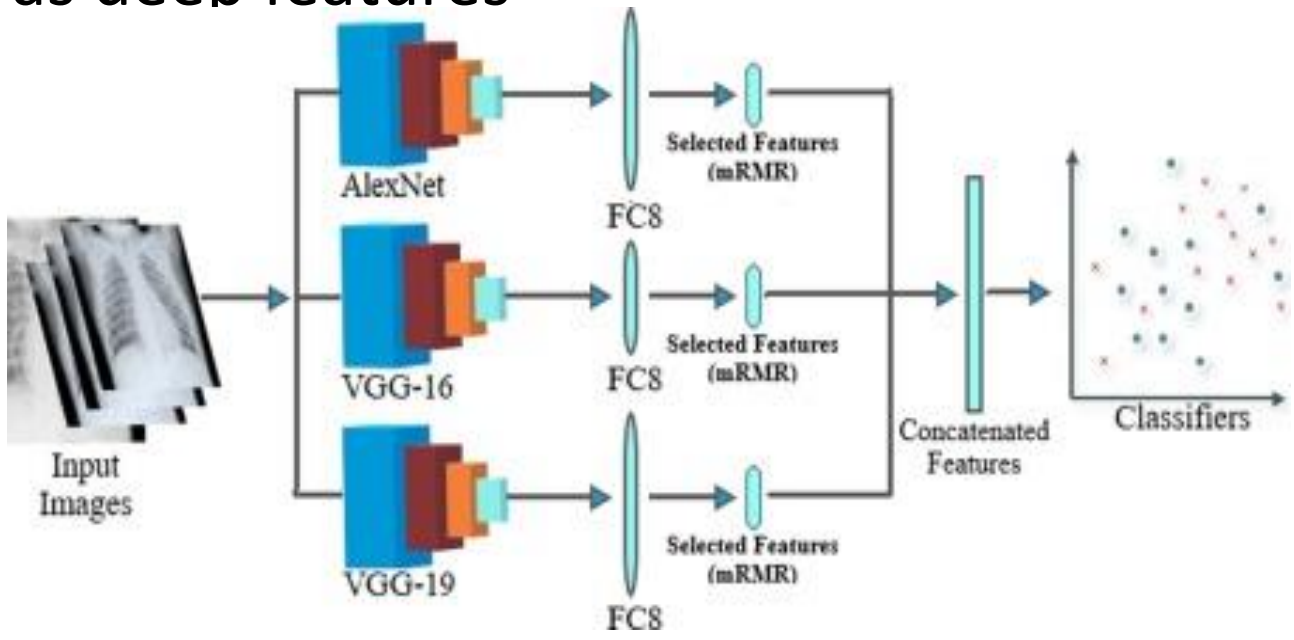


Instance Segmentation

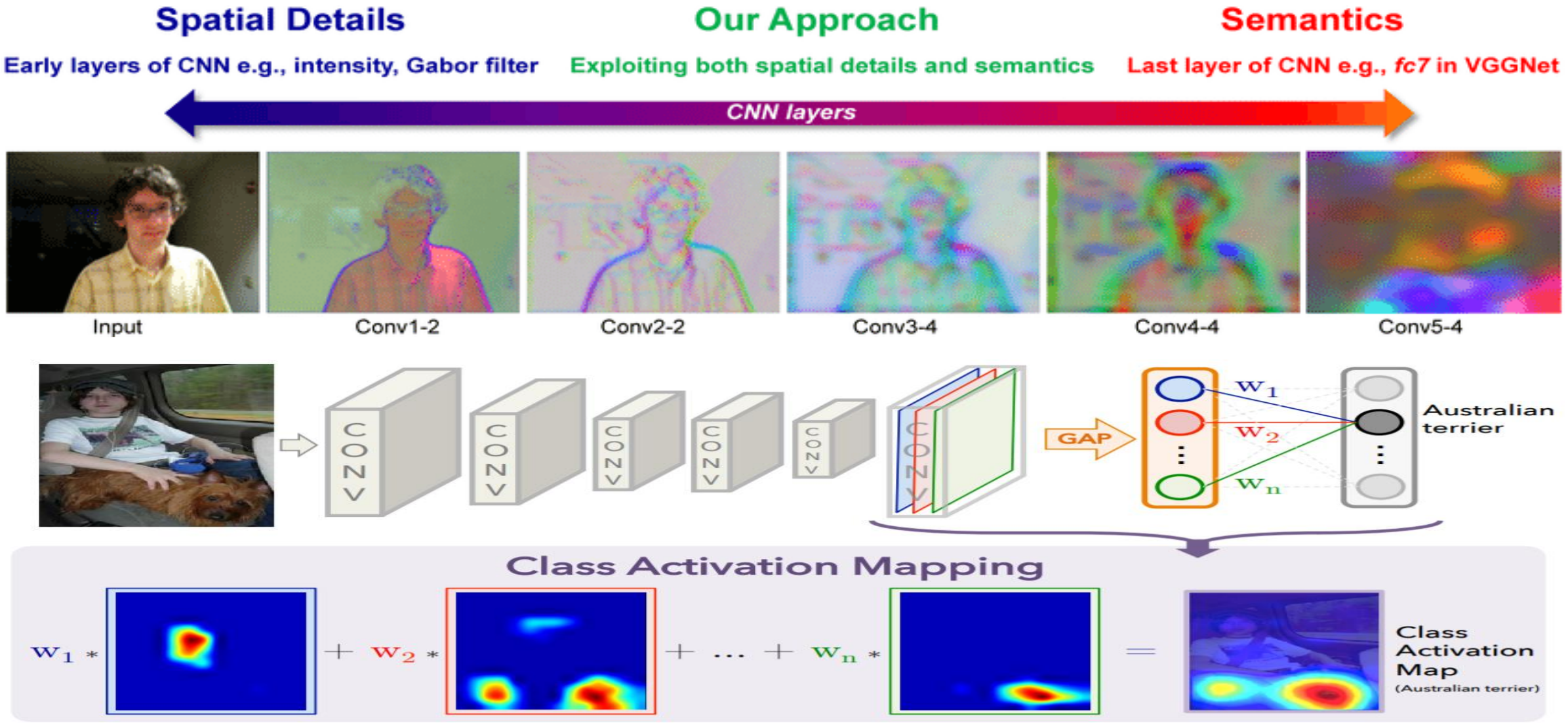
Deep Learning for Images

- Image representation – each image must be represented, as a whole and in parts
- Representation may be using raw pixel values, filter outputs
- Deep features: an image/sub-image provided as input to a neural network
- Each layer of the neural network creates a new representation of the image
- These representations can be used as deep features





Deep Learning for Images



Max-Pooling and Convolution Operations

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

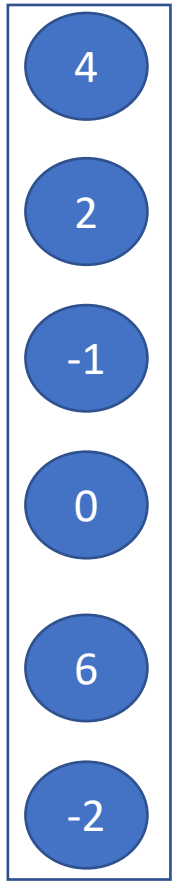
Block size:2
Stride: 2

6	8
3	4

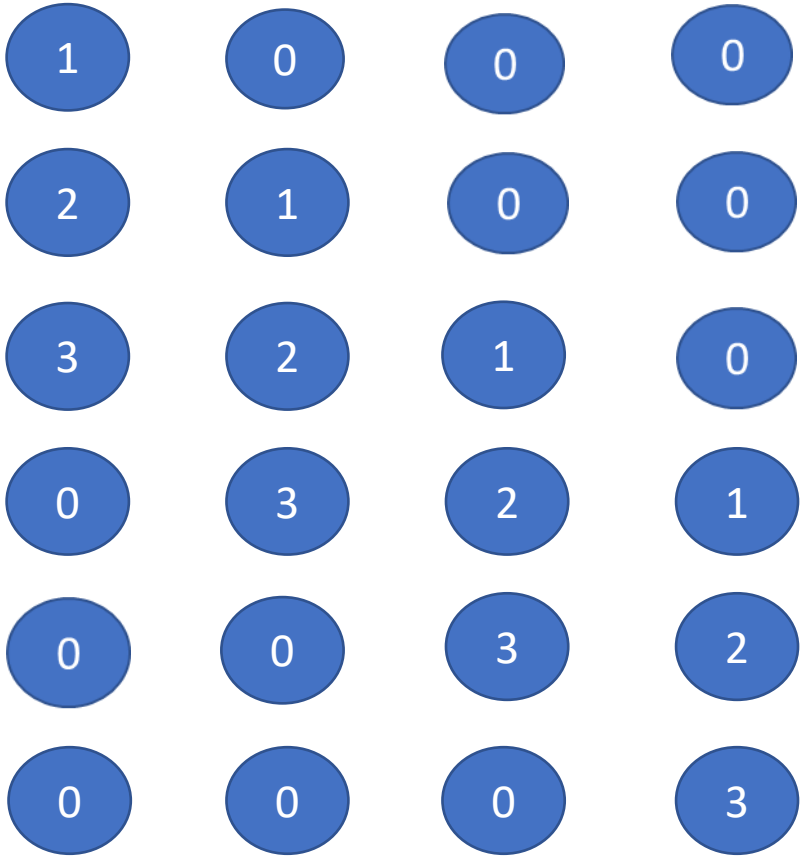
1	1	2	4
5	6	7	8
3	2	1	0
1	2	3	4

Block size:3
Stride: 1

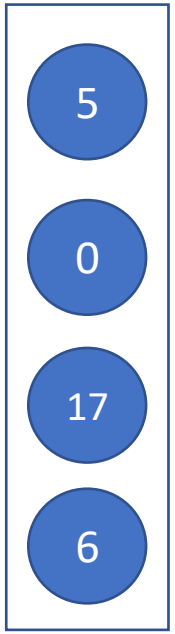
7	8
7	8



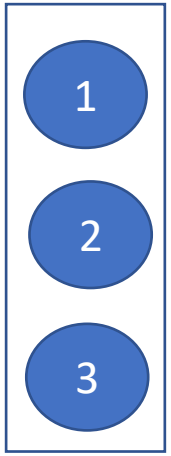
INPUT



WEIGHT MATRIX



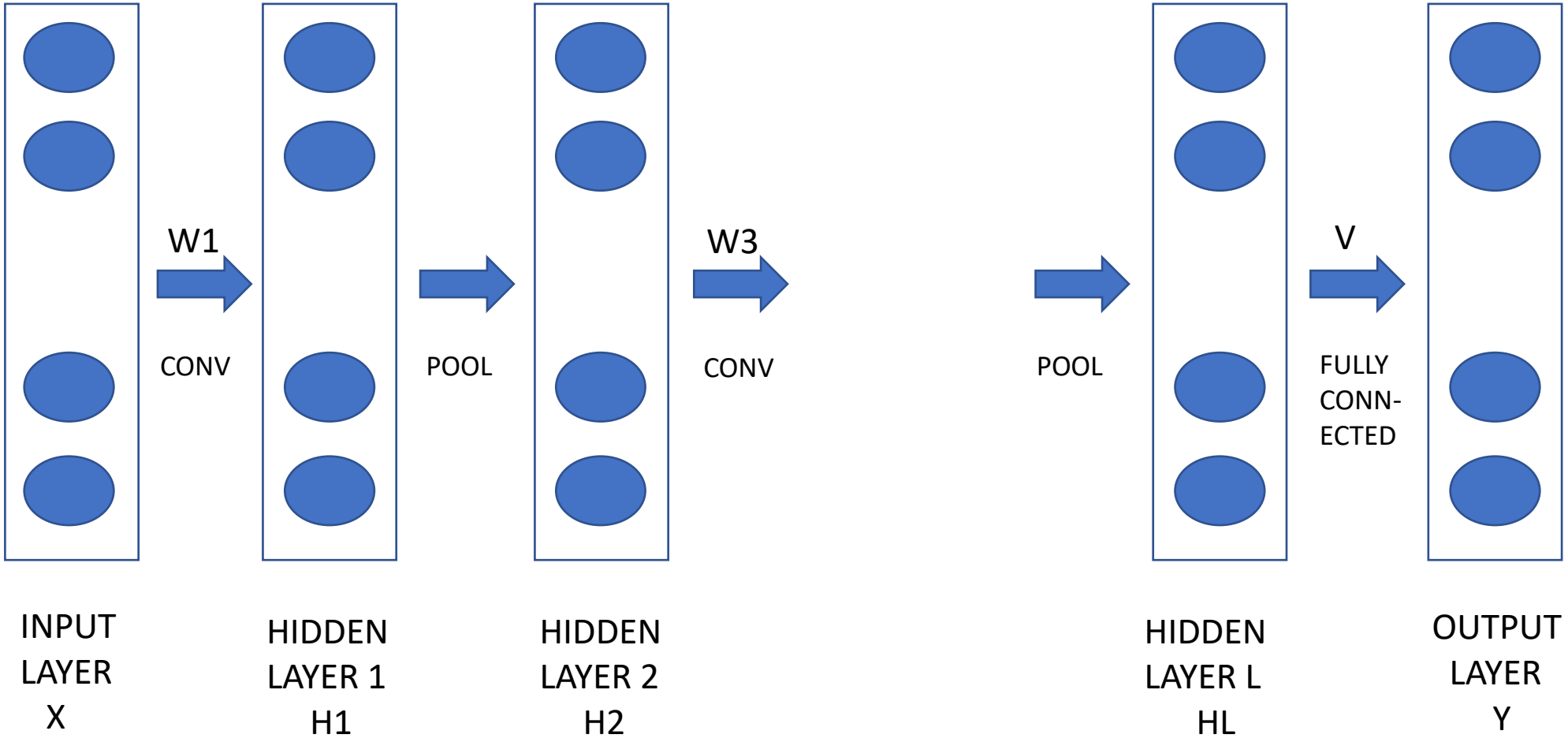
OUTPUT



REPEATING STRUCTURE

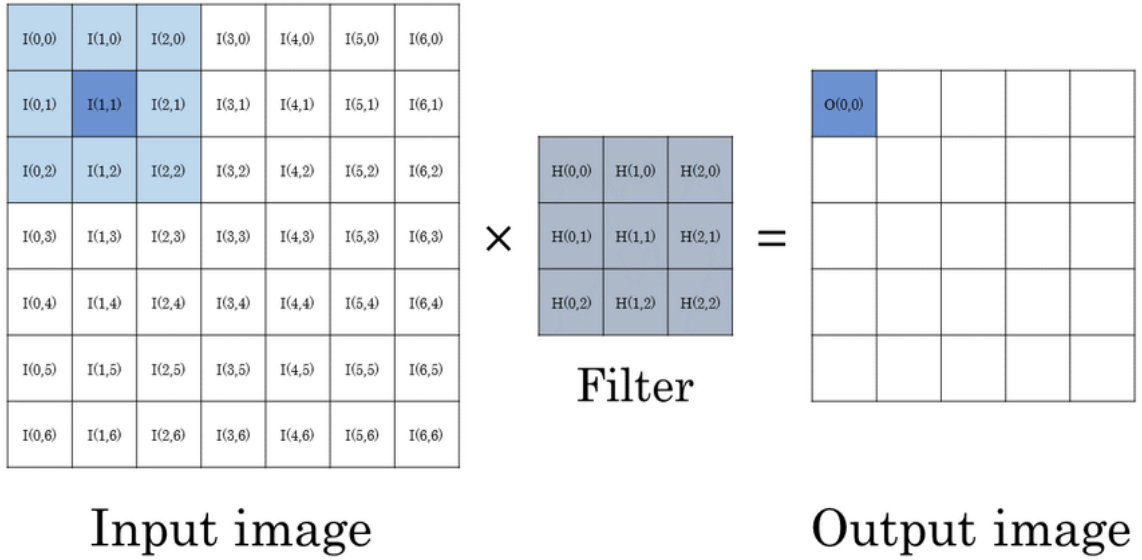
Convolutional Neural Network

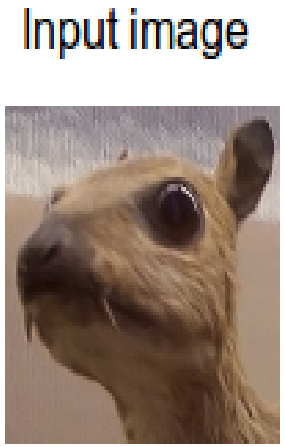
- A convolutional neural network has many “convolution layers”
- Usually, each convolutional layer is followed by a pooling layer



Deep Learning for Images

- Convolution – a standard operation on images
- Useful to identify local structures/orientations in images
- One pass of a convolution filter over the whole image provides the location of a certain kind of orientations



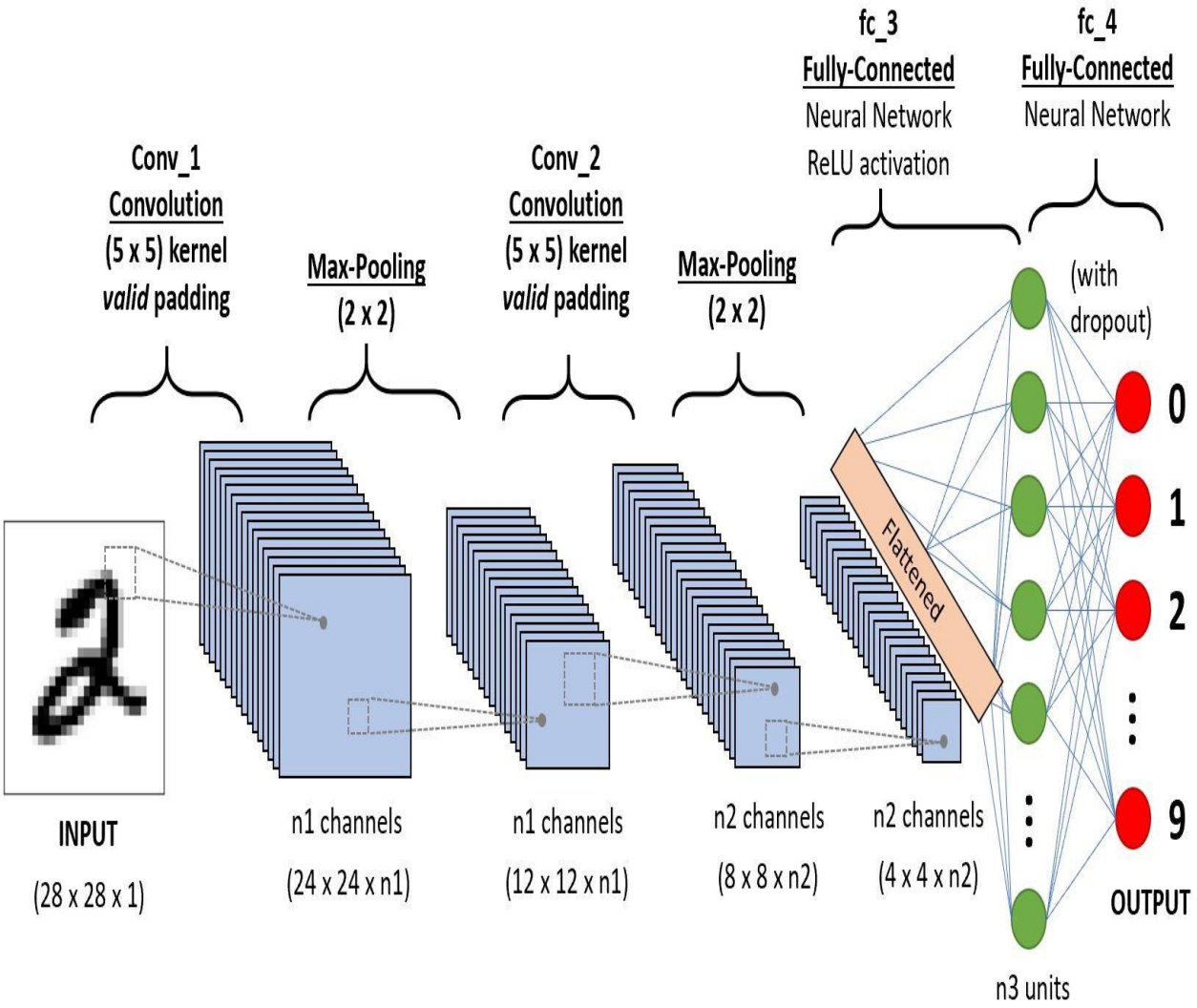


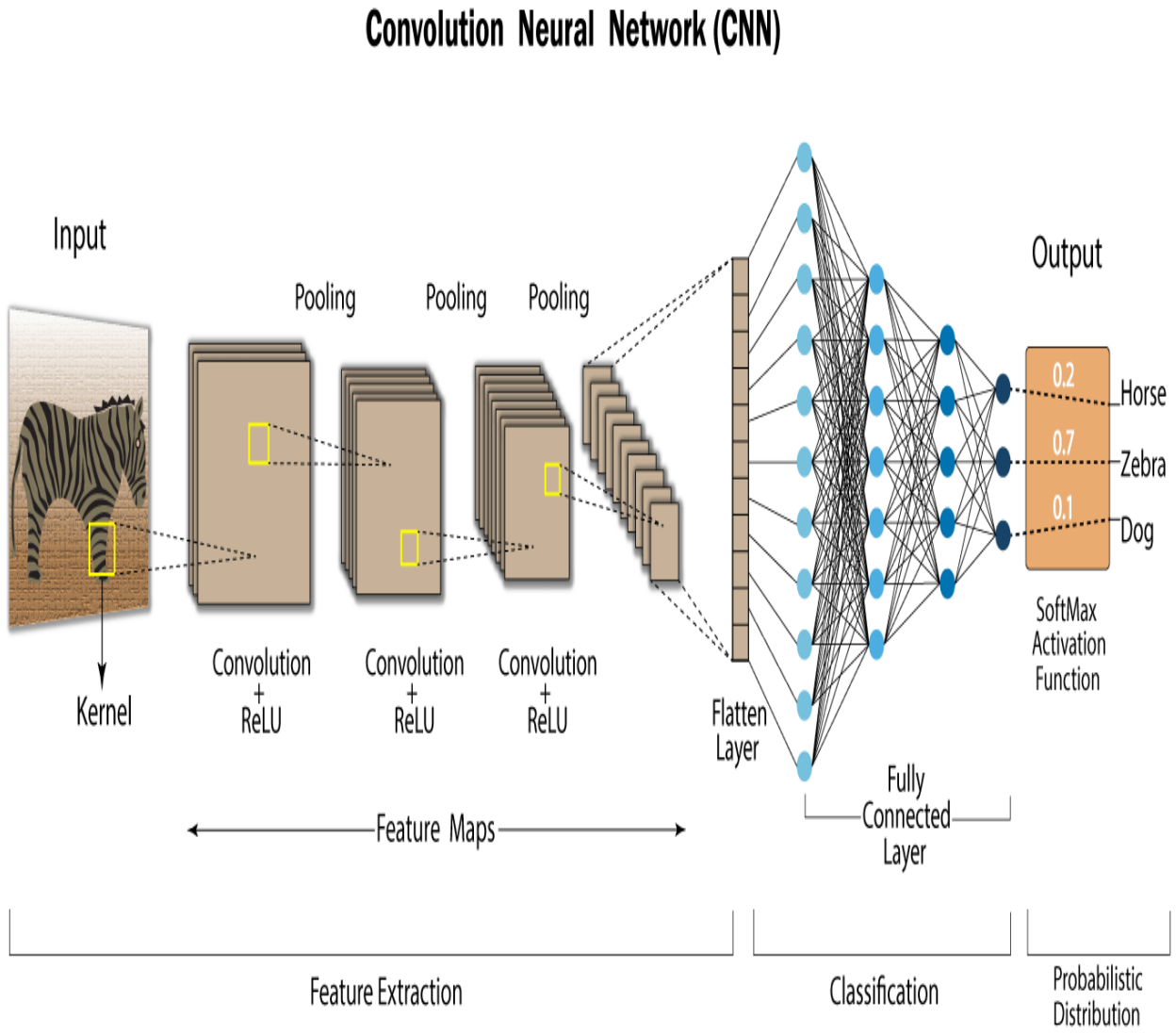
Convolution Kernel

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

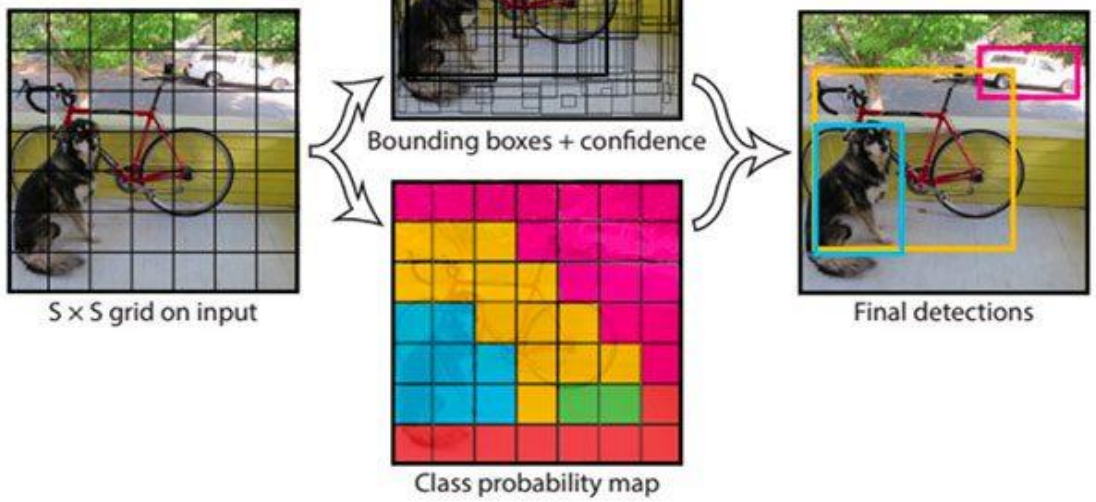
- Can be done with a specially structured neural network (repeating edge weights)

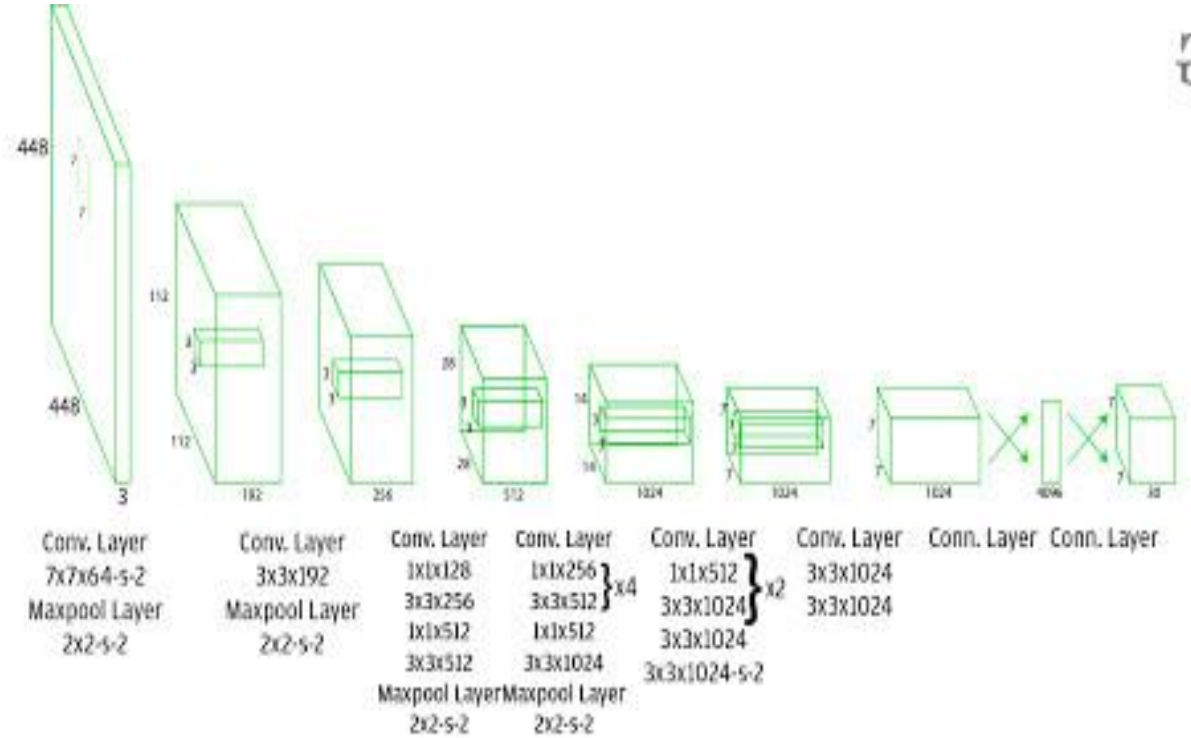
Deep Learning for Images





Object Detection with YOLO – You Only Look Once





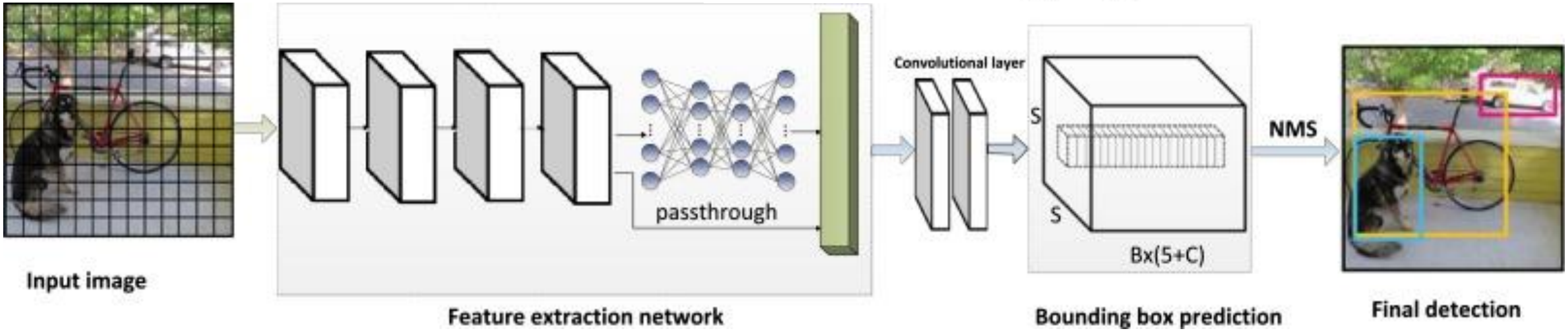
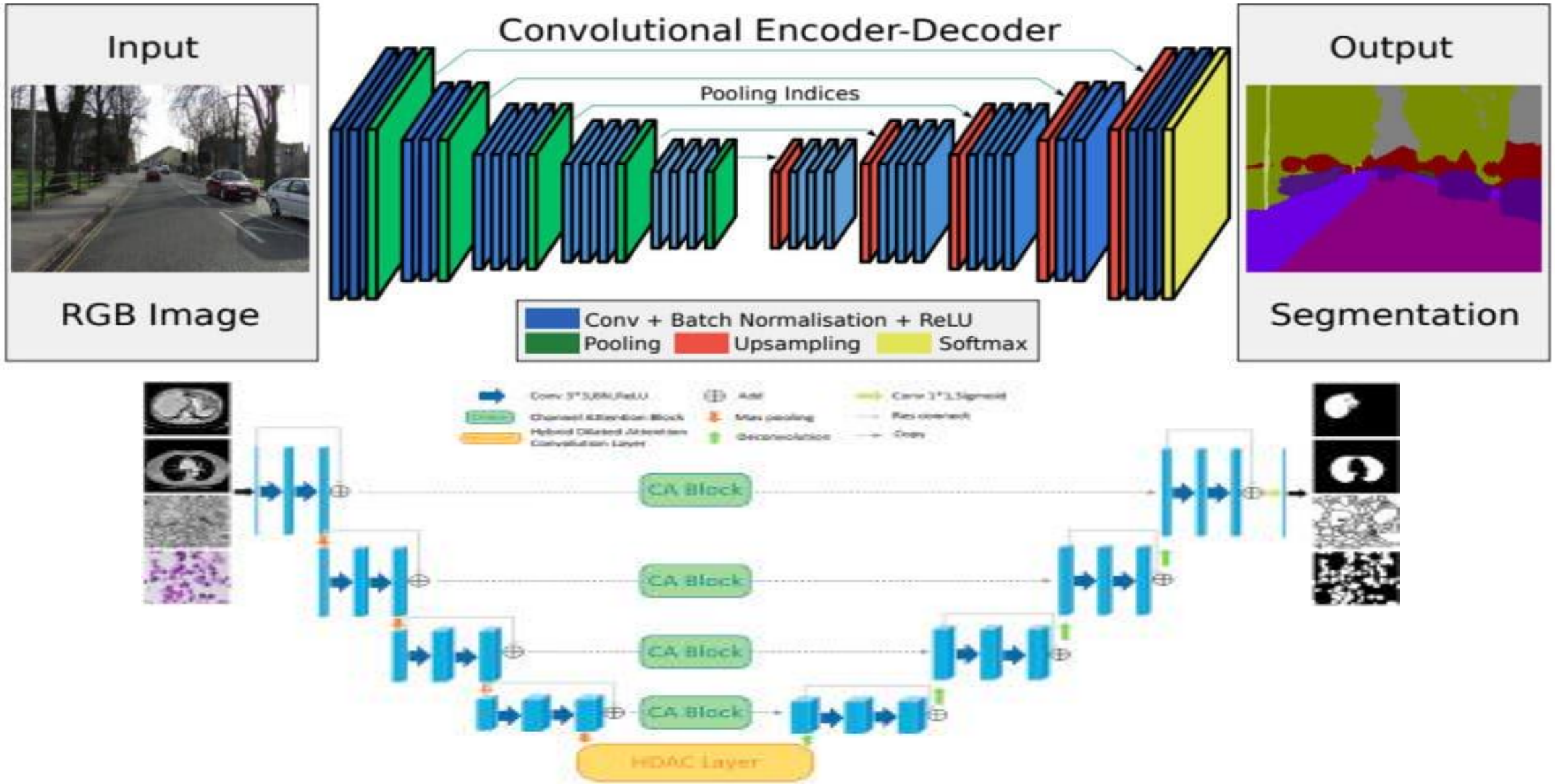


Image Semantic Segmentation



Object Detection in Satellite Images

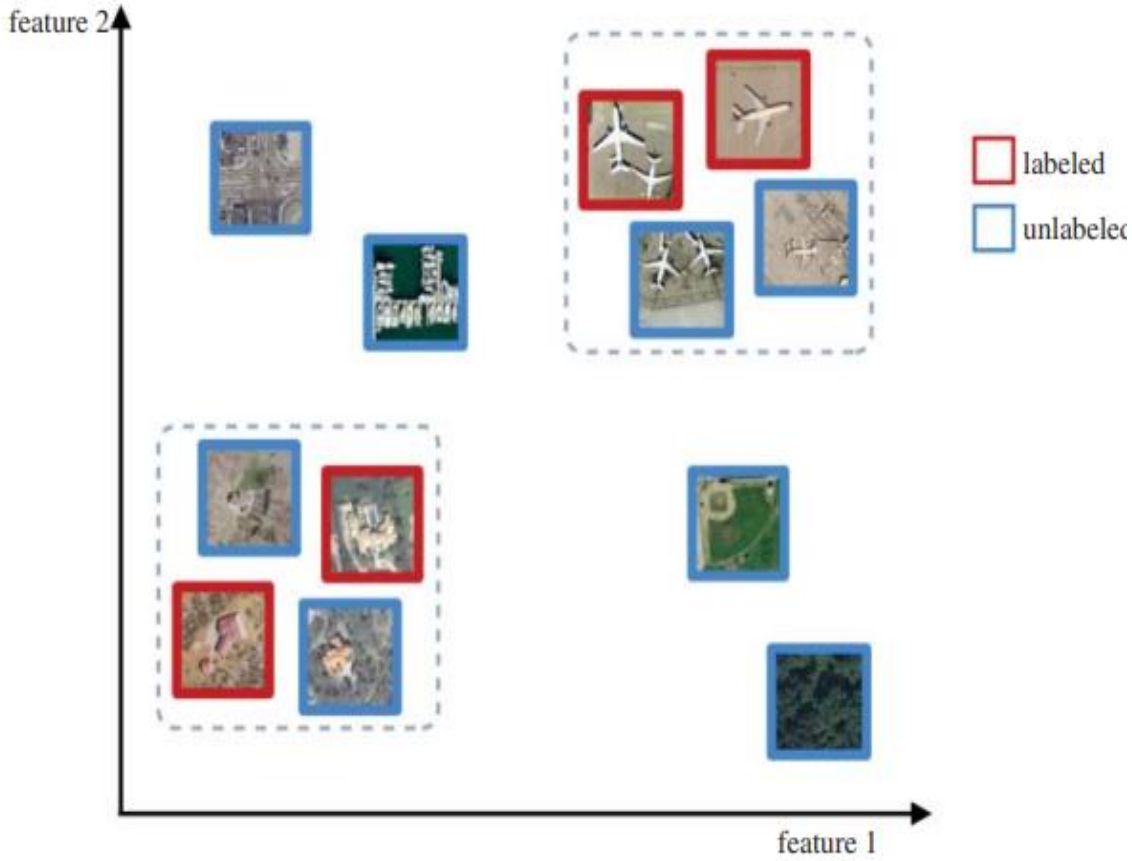


Figure 4.1 Schematic illustration of different learning paradigms and their use of labeled (red) and unlabeled (blue) data samples. In contrast to semi-supervised learning (data samples used shown in dotted boxes), self-taught learning also uses unlabeled data, which need not belong to the same classes as the labeled data. Images are from the UC Merced dataset (Yand and Newsam 2010).

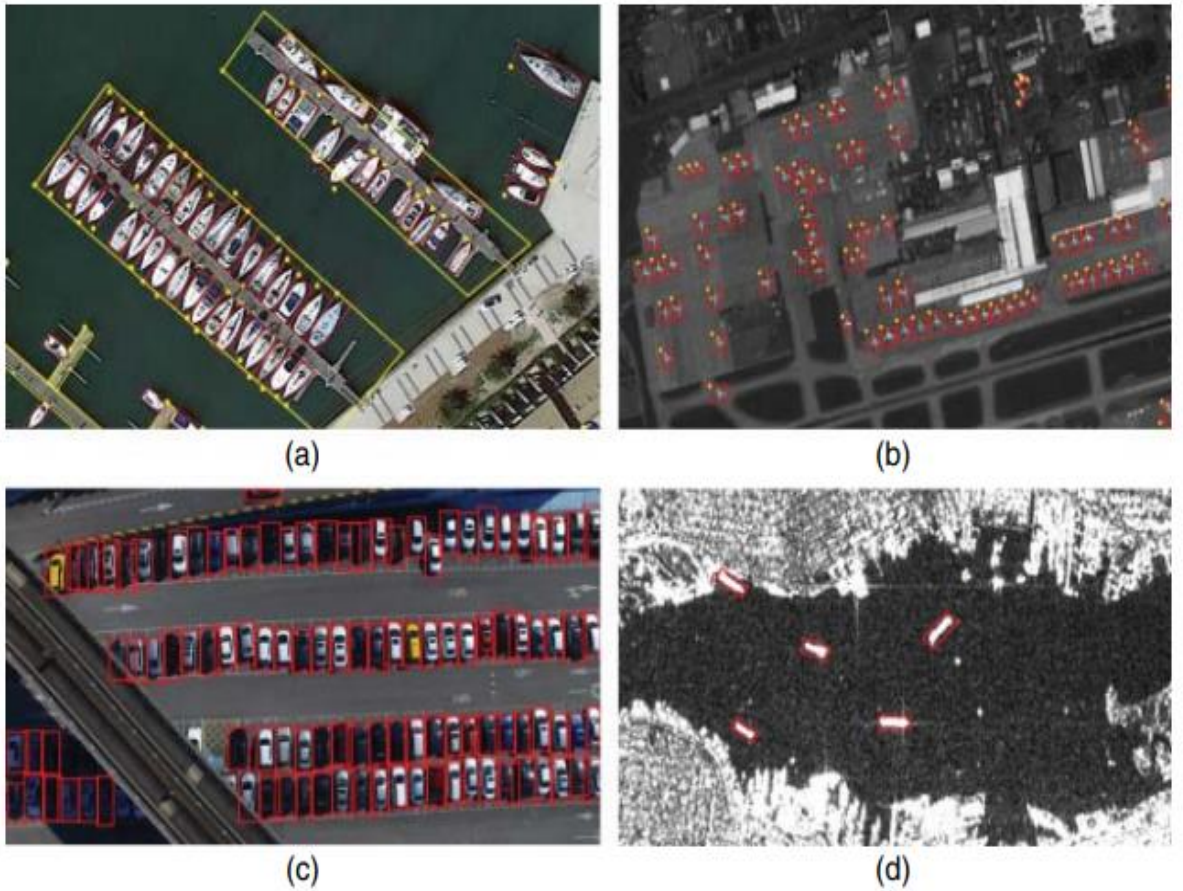


Figure 6.1 Examples of remote sensing images containing objects of interest. (a) An image from Google Earth, containing ships and harbors. (b) An image form JL-1 satellite, including planes. (c) An drone-based image containing many vehicles. (d) A SAR image, containing ships.

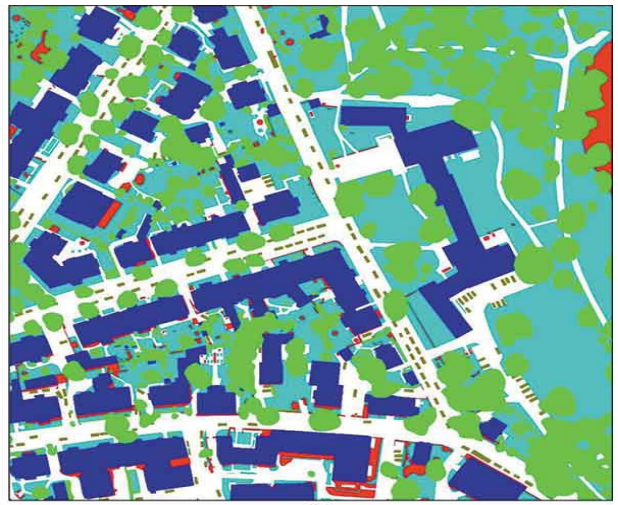
Segmentation of Satellite Images

(a) Original image

(b) Ground truth

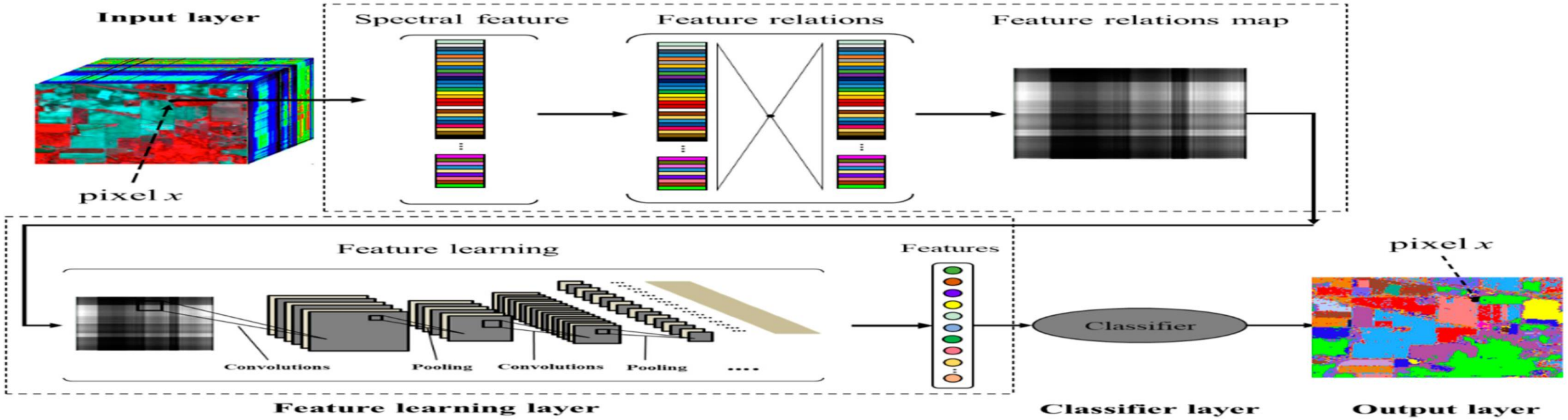
Land-Use Land Cover mapping

(a)

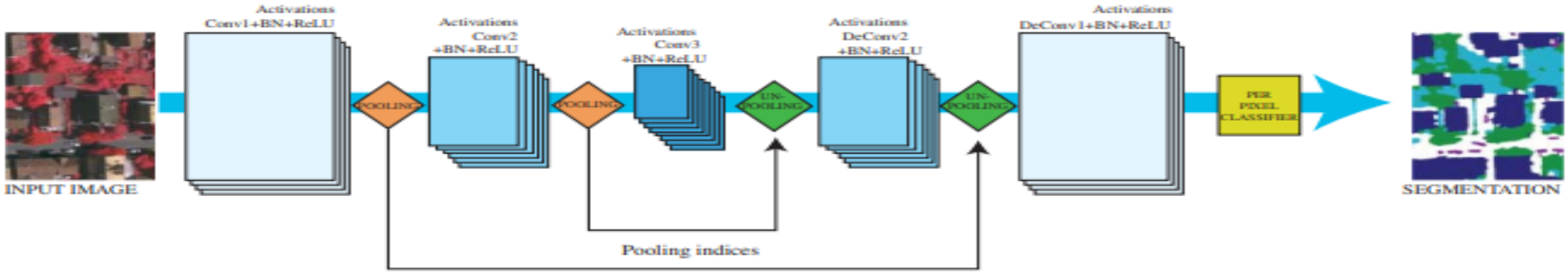


(b)

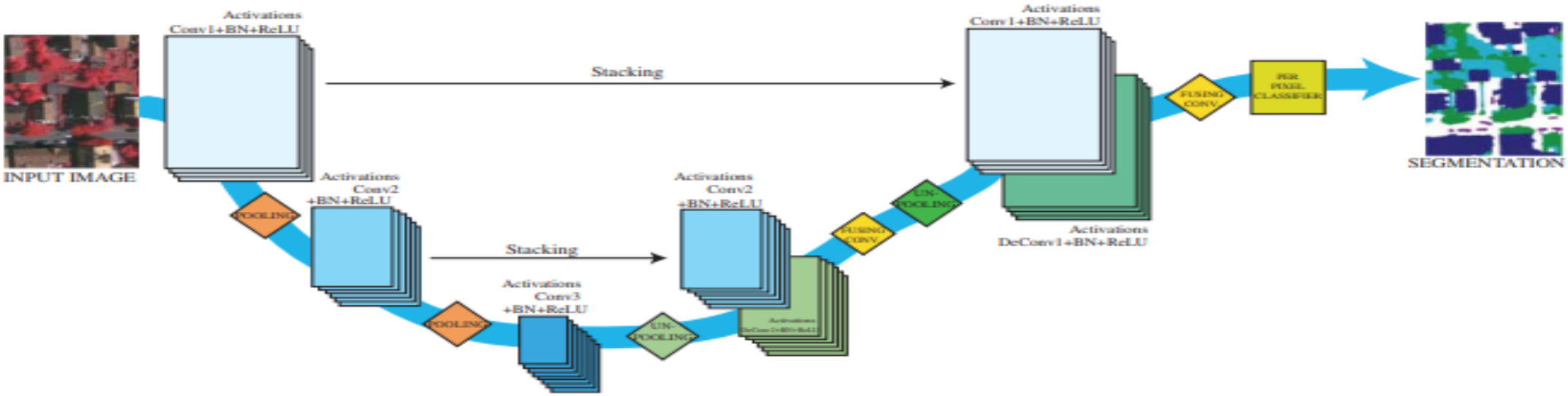
Road Network Extraction



Segmentation of Satellite Images



(a) SegNet (Badrinarayanan et al. 2017), propagating pooling indices.



(b) U-Net (Ronneberger et al. 2015a), propagating activation maps.

Figure 5.3 Semantic segmentation architectures learning the upsampling.

Deep Domain Adaptation

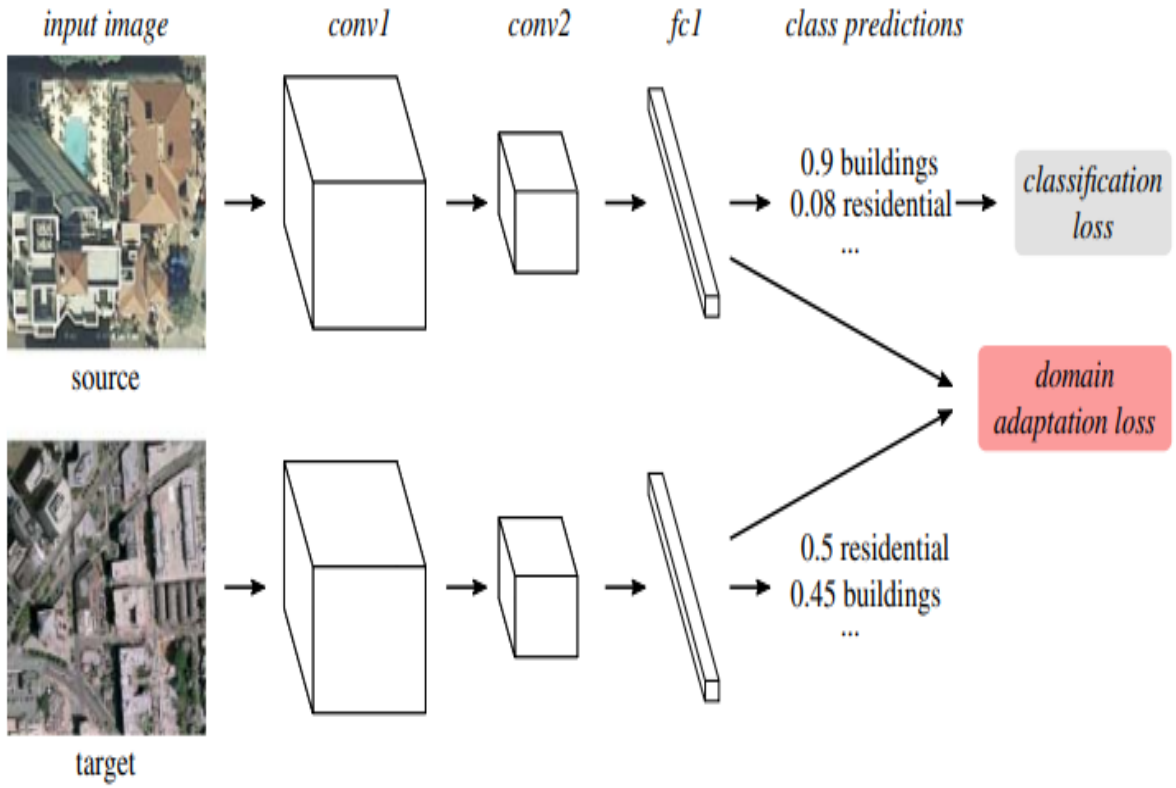


Figure 7.1 Domain adaptation loss (red) imposed on a CNN's feature vectors produced by the penultimate layer ("fc1").

Figure 7.2 Examples from the UC Merced (top) and WHU-RS19 (bottom) datasets.