

Contents

Preface	ix
Author	xi
I Backgrounds	1
1 Deep learning background	3
1.1 What is deep learning?	3
1.2 Convolution	5
1.3 Pooling	6
1.4 Activation functions	7
1.5 Challenges ahead for deep learning with remote sensing images	8
2 Software	9
2.1 Orfeo ToolBox	9
2.1.1 Applications	10
2.1.2 Streaming mechanism	10
2.1.3 Remote modules	10
2.1.4 The Python API	10
2.2 TensorFlow	11
2.2.1 APIs	11
2.2.2 Computations	11
2.2.3 Graphs	12
2.3 Orfeo ToolBox + TensorFlow = OTBTF	12
2.3.1 Installation	13
2.3.2 Featured applications	14
2.3.3 Principle	14
2.3.4 Multiple input sources and outputs	16
2.4 QGIS	17
II Patch-based classification	19
3 Introduction	21

4 Data used: the Tokyo dataset	23
4.1 Description	23
4.2 Remote sensing imagery	23
4.3 Terrain truth	25
5 A simple convolutional neural network	27
5.1 Normalization	27
5.2 Sampling	29
5.2.1 Selection	29
5.2.2 Extraction	30
5.3 Training	32
5.3.1 Principle	32
5.3.2 Model architecture	33
5.3.2.1 Input	34
5.3.2.2 Layers	34
5.3.2.3 Estimated class	34
5.3.2.4 Loss function	34
5.3.2.5 Optimizer	35
5.4 Generate the model	35
5.5 Train the model from scratch	37
5.6 Comparison with Random Forest	40
5.7 Inference	41
6 Fully Convolutional Neural Network	45
6.1 Using the existing model as an FCN	45
6.2 Pixel-wise fully convolutional model	46
6.3 Training	49
6.4 Inference	50
7 Classifiers on deep features	51
7.1 Principle	51
7.2 Overview of composite applications in OTB	52
7.3 Training	53
7.4 Inference	54
8 Dealing with multiple sources	55
8.1 More sources?	55
8.2 Model with multiple inputs	56
8.3 Normalization	59
8.4 Sampling	60
8.5 Training	61
8.5.1 Inference	62
8.5.1.1 Patch-based mode	62
8.5.1.2 Fully convolutional mode	62
9 Discussion	65

III Semantic segmentation	67
10 Semantic segmentation of optical imagery	69
10.1 Introduction	69
10.2 Overview	69
11 Data used: the Amsterdam dataset	73
11.1 Description	73
11.2 Spot-7 image	73
11.3 OpenStreetMap data	74
11.3.1 OSM downloader plugin	75
11.3.2 Download OSM data	75
11.3.3 Prepare the vector layer	77
12 Mapping buildings	83
12.1 Input data pre-processing	83
12.1.1 Satellite image pansharpening	83
12.1.2 Image normalization	84
12.1.3 Sample selection	84
12.1.3.1 Patch position seeding	84
12.1.3.2 Patch position selection	86
12.1.3.3 Patches split	87
12.1.4 Rasterization	88
12.1.5 Patch extraction	89
12.2 Building the model	90
12.2.1 Architecture	91
12.2.2 Implementation	92
12.2.2.1 Exact output	94
12.2.2.2 Expression field	95
12.2.2.3 Generate the SavedModel	95
12.3 Training the model	96
12.4 Inference	96
13 Discussion	99
IV Image restoration	101
14 Gapfilling of optical images: principle	103
14.1 Introduction	103
14.2 Method	103
14.3 Architecture	105
14.3.1 Encoder	106
14.3.2 Decoder	106
14.3.3 Loss	107

15 The Marmande dataset	109
15.1 Description	109
15.2 Sentinel-2 images	109
15.3 Sentinel-1 image	112
16 Pre-processing	115
16.1 Sentinel images	115
16.1.1 Optical images	115
16.1.2 SAR image	117
16.1.2.1 Calibration	117
16.1.2.2 Filtering values	118
16.1.2.3 Linear stretch	118
16.1.2.4 Spatial resampling	118
16.2 Patches	119
16.2.1 Patch position seeding	119
16.2.1.1 Sentinel-2 image masks	119
16.2.1.2 Merge masks	122
16.2.1.3 Grid generation	123
16.2.1.4 Grid filtering	124
16.2.1.5 Patch centroids	126
16.2.1.6 Training and validation datasets	126
16.2.2 Extraction of patches	127
16.3 More: automate steps with the OTB Python API	128
16.3.1 Build the pipeline	129
16.3.2 Run the pipeline	132
17 Model training	133
17.1 Training from Python	133
17.2 Get the code	134
17.3 Use the code	134
17.3.1 Description	134
17.3.2 Parameters	134
17.4 Export the model	135
18 Inference	137
18.1 Inputs and outputs	137
18.2 Generating the image	137
18.3 Postprocessing	139
19 Discussion	143
Bibliography	145
Index	149