Improving Spatial Codification in Semantic Segmentation (Supplementary Material)

Contents

1 Introduction

The aim of this section is to explain how the suppplementary material is structured.

First, Section 2 presents the results obtained by categories when ideal object candidates (ground truth masks) are used. Results are shown for different spatial configurations by means of bar graphs and tables.

Second, Section 3 shows an analysis of the results using CPMC object candidates detailed by categories. Results for the baseline configuration (Figure-Ground spatial pooling) and for the proposed Figure-Border-Ground spatial pooling are presented by means of bar graphs and tables for *comp5* challenge.

Then, Section 4 also shows the results by categories when MCG object candidates are used. For such object candidates, only the experiments using train subset for training and validation subset for test have been performed and, therefore, analyzed by categories.

Finally, Sections 5 and 6 show visual results for CPMC and MCG, respectively. Regarding CPMC, we compare the baseline Figure-Ground spatial pooling [1] with our proposed Figure-Border-Ground spatial pooling, which gave us the best average accuracy classification. Regarding MCG, the comparison is performed between the baseline Figure-Ground spatial pooling [1] and the combination of our two proposed spatial configurations: Figure-Border-Ground spatial pooling with a cartesian-based Spatial Pyramid applied over the Figure region pool. The results have been filtered to only show meaningful examples. This selection has been performed by choosing the results that fullfill the following requirement:

$$\frac{N_d}{N_d + N_s} > 0.5 \tag{1}$$

where N_d is the number of pixels which have been assigned different category labels for the two configurations being compared, and N_s is the number of pixels which have not been assigned to the *background* category but to the same category for both configurations. Notice that the fact of not considering the pixels assigned to the *background* category allows us to detect examples where the detected objects are small with respect to the whole image size. This way, the measure is normalized by the area of the pixels labeled with one out of the 20 visual categories. One more post-processing step has been performed: a filtering to remove the examples where both configurations being compared failed the object recognition, i.e. neither of both labels were correct. Results are shown by categories to make easier the analysis.

2 Accuracy Classification by Categories using ideal object candidates (ground truth masks)

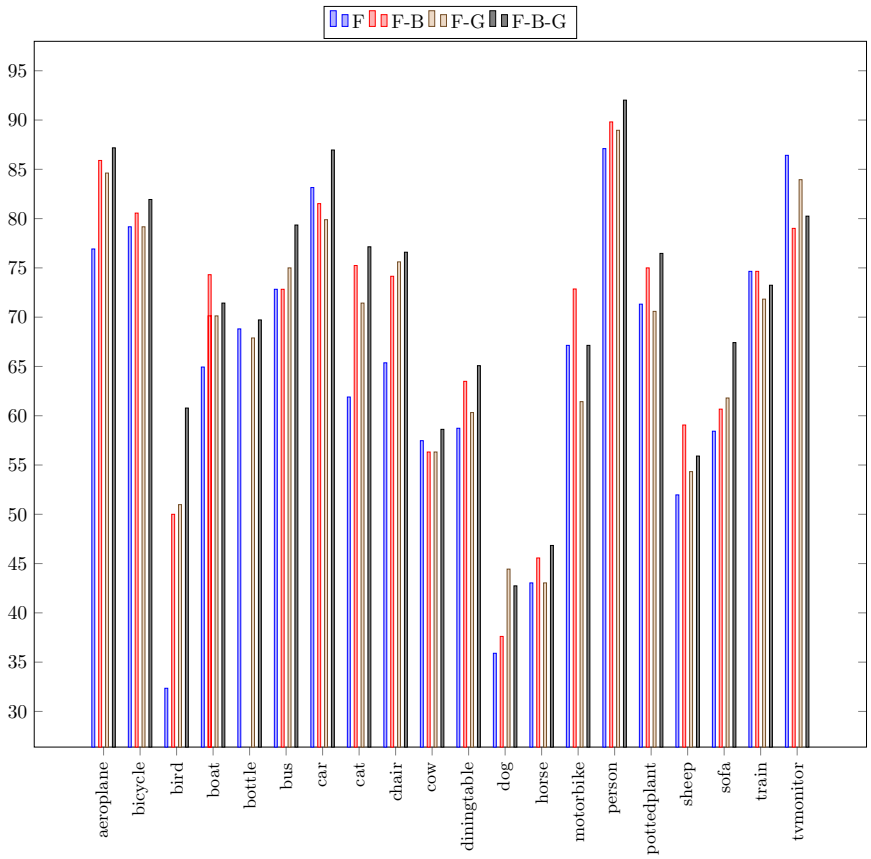

Figure 1: Accuracy Classification by Categories using ground truth masks. Results by categories for different image spatial representations using eMSIFT descriptor. Training over train11 and evaluation over val11. F refers to Figure, B refers to Border and G refers to Ground. This figure is related to Table 1 from the main paper.

	F [1]	F-B	F-G [1]	F-B-G
aeroplane	76.9	85.9	84.6	**87.2**
bicycle	79.2	80.6	79.2	**81.9**
bird	32.4	50.0	51.0	**60.8**
boat	64.9	70.1	70.1	**71.4**
bottle	68.8	**74.3**	67.9	69.7
bus	72.8	72.8	75.0	**79.4**
car	83.2	81.5	79.9	**87.0**
cat	61.9	75.2	71.4	**77.1**
chair	65.4	74.2	75.6	**76.6**
cow	57.5	56.3	56.3	**58.6**
diningtable	58.7	63.5	60.3	**65.1**
dog	35.9	37.6	**44.4**	42.7
horse	43.0	45.6	43.0	**46.8**
motorbike	67.1	**72.9**	61.4	67.1
person	87.1	89.8	89.0	**92.0**
pottedplant	71.3	75.0	70.6	**76.5**
sheep	52.0	**59.1**	54.3	55.9
sofa	58.4	60.7	61.8	**67.4**
train	**74.7**	**74.7**	71.8	73.2
tvmonitor	**86.4**	79.0	84.0	80.3
Average	64.81	68.93	67.59	**70.84**

Table 1: Accuracy Classification by Categories using ground truth masks. Results by categories for different image spatial representations using eMSIFT descriptor. Training over train11 and evaluation over val11. F refers to Figure, B refers to Border and G refers to Ground. This table is related to Table 1 from the main paper.

3 Accuracy Classification by Categories using CPMCs

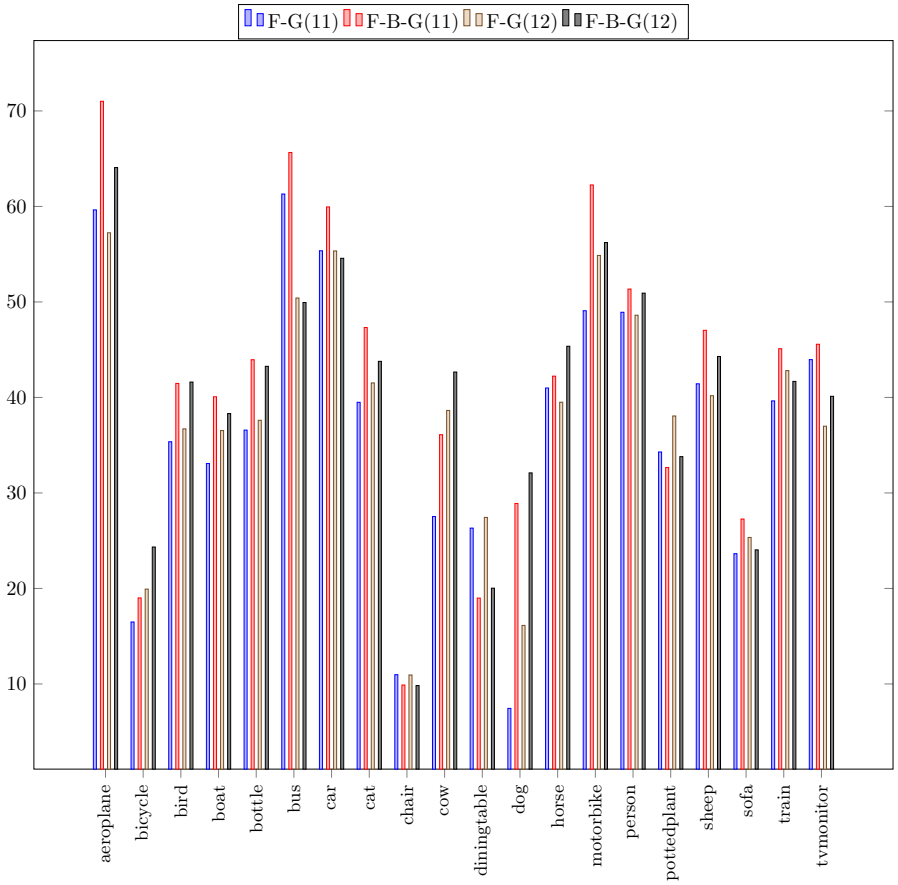

Figure 2: Accuracy Classification by Categories using CPMCs in *comp5*. Results by categories for baseline (Figure-Ground representation) and Figure-Border-Ground representation for VOC2011 and VOC2012 *comp5*. This figure is related to Table 5 from the main paper.

	VOC2011			VOC2012		
	F-G [1]	F-B-G	SP(F)-B-G	F-G [1]	F-B-G	SP(F)-B-G
aeroplane	59.6	**71.0**	65.1	57.2	**64.1**	56.2
bicycle	16.5	**19.0**	12.6	19.9	**24.3**	15.6
bird	35.4	**41.5**	39.6	36.7	41.6	**43.0**
boat	33.1	**40.1**	37.5	36.5	**38.3**	29.2
bottle	36.6	44.0	**45.1**	37.6	43.3	**51.4**
bus	61.3	**65.7**	59.0	**50.4**	49.9	50.2
car	55.4	**60.0**	58.6	55.3	54.6	**58.5**
cat	39.5	47.3	**48.9**	41.5	43.8	**49.7**
chair	**11.0**	9.9	9.7	**10.9**	9.8	9.2
cow	27.5	36.1	**41.8**	38.6	42.7	**44.6**
diningtable	**26.3**	19.0	18.5	**27.4**	20.0	13.5
dog	7.4	**28.9**	23.5	16.1	**32.1**	26.2
horse	41.0	**42.2**	27.0	39.5	**45.4**	39.0
motorbike	49.1	**62.3**	49.5	54.9	**56.2**	52.8
person	48.9	**51.4**	49.1	48.6	**50.9**	50.2
pottedplant	**34.3**	32.7	32.6	**38.1**	33.8	37.6
sheep	41.4	**47.0**	44.5	40.2	44.3	**46.8**
sofa	23.6	**27.3**	10.8	**25.3**	24.0	11.8
train	39.6	**45.1**	42.9	42.8	41.7	**44.0**
tvmonitor	44.0	45.6	**45.9**	37.0	40.1	**42.5**
Average	38.8	**43.8**	40.3	39.9	**42.2**	40.8

Table 2: Accuracy Classification by Categories using CPMCs in *comp5*. Results by categories for baseline (Figure-Ground representation), Figure-Border-Ground and SpatialPyramid(Figure)-Border-Ground representation for VOC2011 and VOC2012 *comp5*. This table is related to Table 5 from the main paper.

4 Accuracy Classification by Categories using MCGs

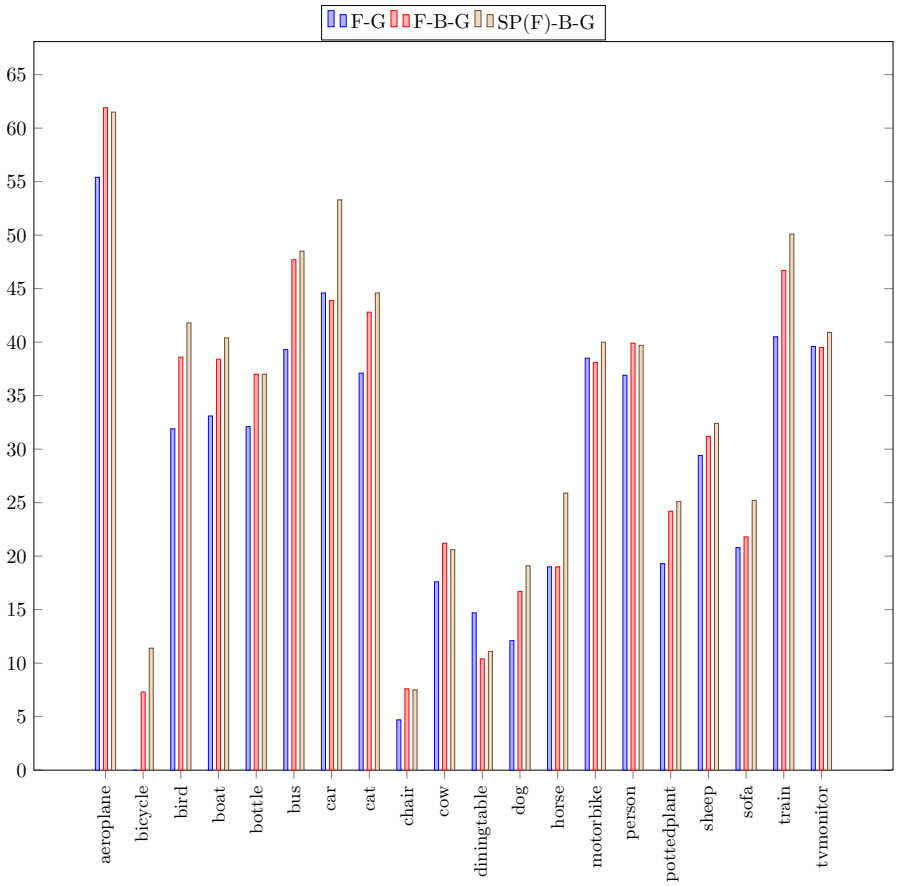

Figure 3: Accuracy Classification by Categories using MCGs. Results by categories for baseline (Figure-Ground representation), Figure-Border-Ground representation and SpatialPyramid(Figure)-Border-Ground representation using MCG object candidates. Training over train11 and evaluation over val11.

	F-G	F-B-G	SP(F)-B-G
aeroplane	55.4	**61.9**	61.5
bicycle	0.0	7.3	**11.4**
bird	31.9	38.6	**41.8**
boat	33.1	38.4	**40.4**
bottle	32.1	**37.0**	**37.0**
bus	39.3	47.7	**48.5**
car	44.6	43.9	**53.3**
cat	37.1	42.8	**44.6**
chair	4.7	**7.6**	7.5
cow	17.6	**21.2**	20.6
diningtable	**14.7**	10.4	11.1
dog	12.1	16.7	**19.1**
horse	19.0	19.0	**25.9**
motorbike	38.5	38.1	**40.0**
person	36.9	**39.9**	39.7
pottedplant	19.3	24.2	**25.1**
sheep	29.4	31.2	**32.4**
sofa	20.8	21.8	**25.2**
train	40.5	46.7	**50.1**
tvmonitor	39.6	39.5	**40.9**
Average	30.9	34.1	**36.1**

Table 3: Accuracy Classification by Categories using MCGs. Results by categories for baseline (Figure-Ground representation), Figure-Border-Ground and SpatialPyramid(Figure)-Border-Ground representation using MCG object candidates. Training over train11 and evaluation over val11.

5 Visual Results by Categories using CPMCs

5.1 Aeroplane

Figure 4: Example of ground truth annotation for the *aeroplane* class.

Figure 5: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling.

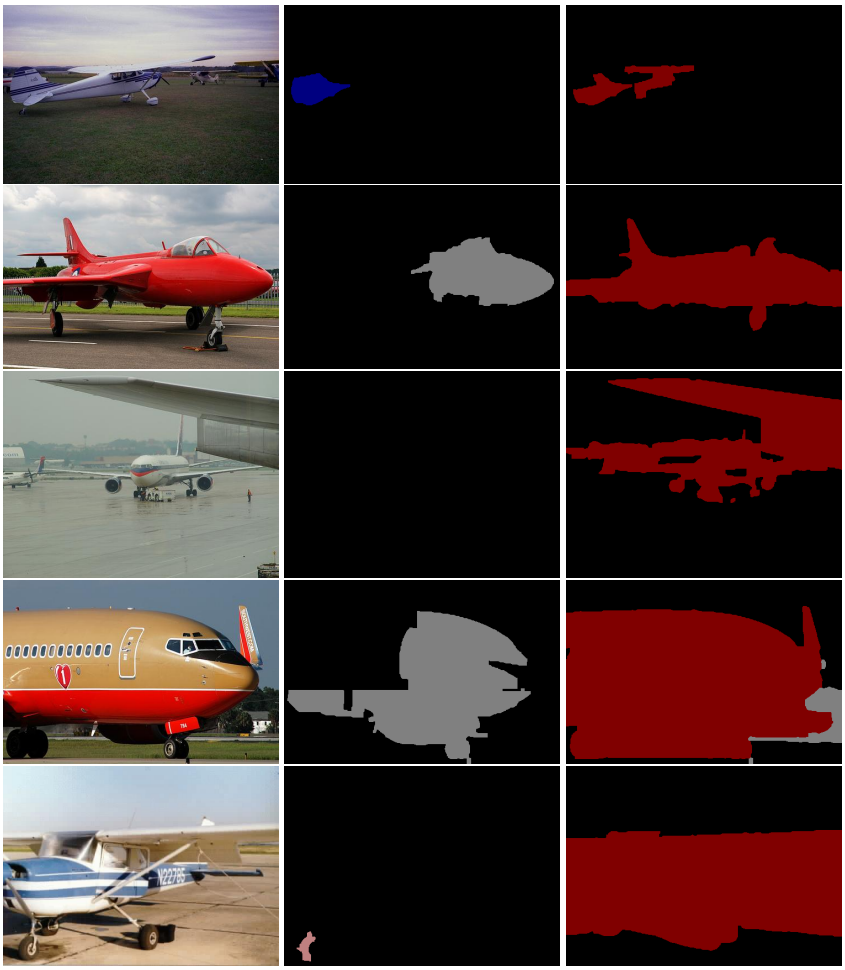

Figure 6: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling.

5.2 Bicycle

Figure 7: Example of ground truth annotation for the *bicycle* class.

Figure 8: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling.

Figure 9: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling.

5.3 Bird

Figure 10: Example of ground truth annotation for the *bird* class.

Figure 11: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling.

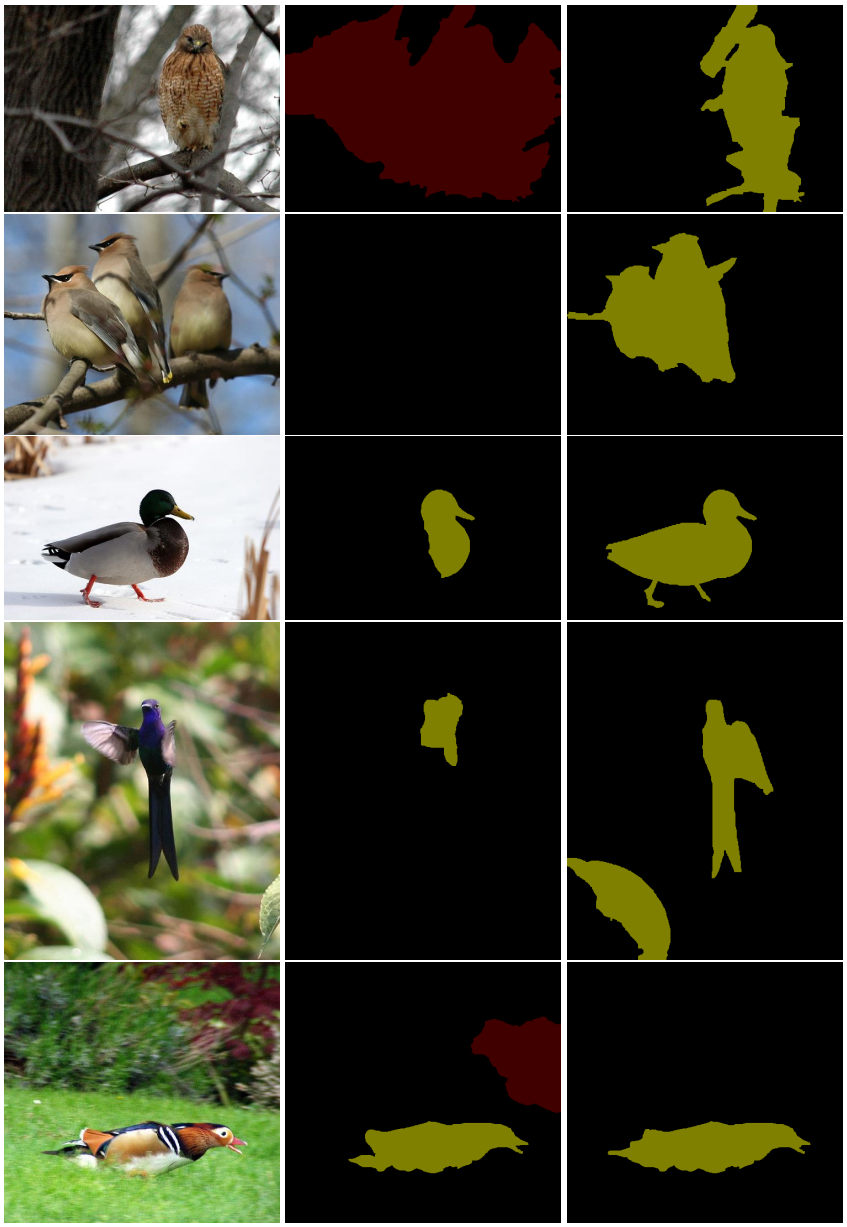

Figure 12: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling.

Figure 13: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling.

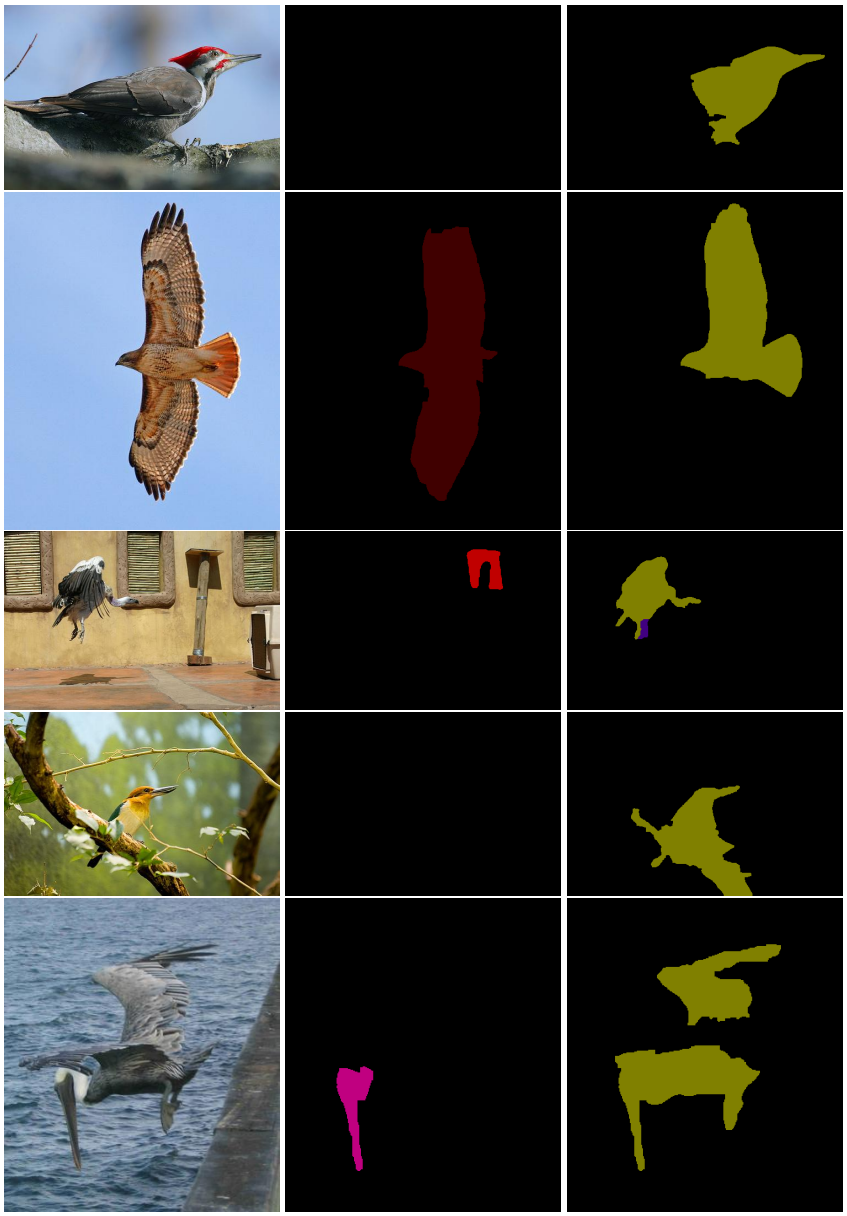

Figure 14: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling.

5.4 Boat

Figure 15: Example of ground truth annotation for the *boat* class.

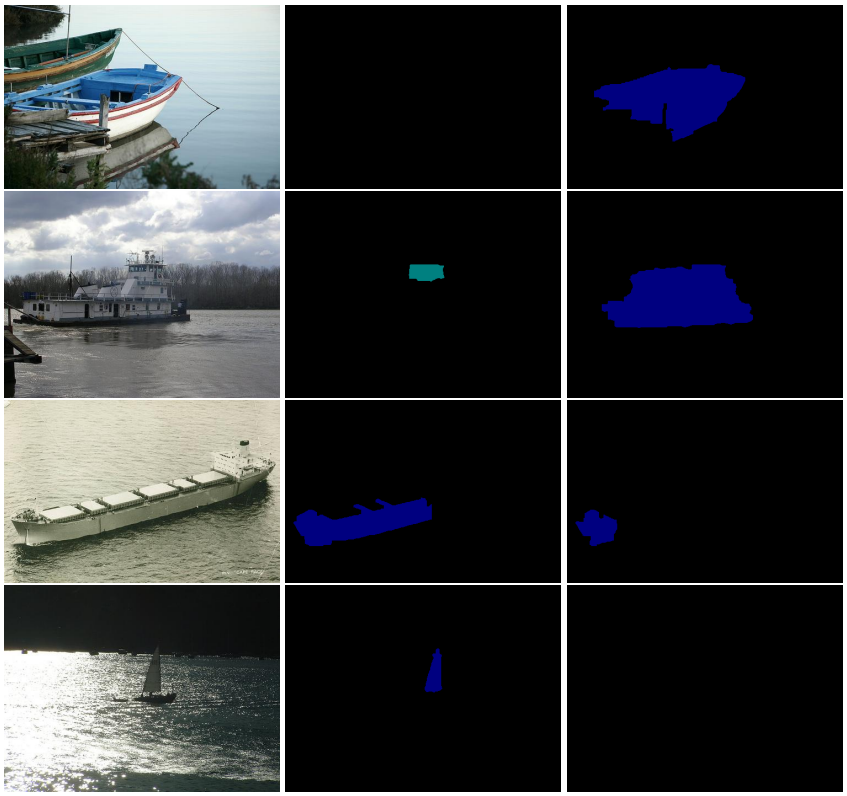

Figure 16: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling.

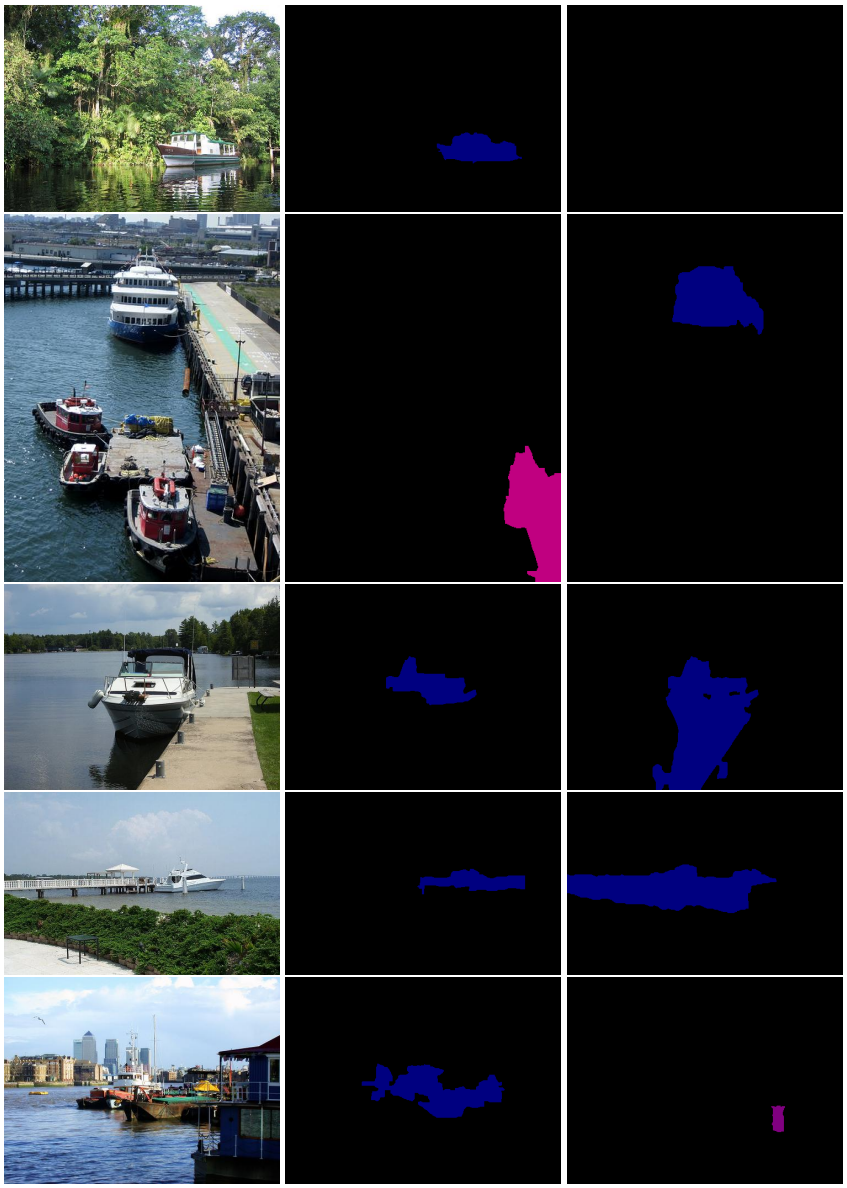

Figure 17: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling.

5.5 Bottle

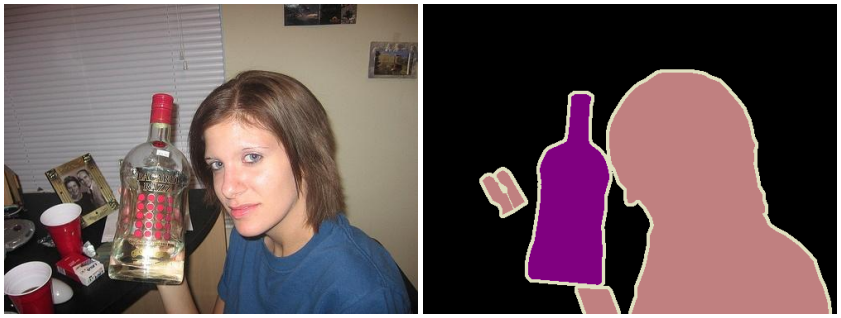

Figure 18: Example of ground truth annotation for the *bottle* class.

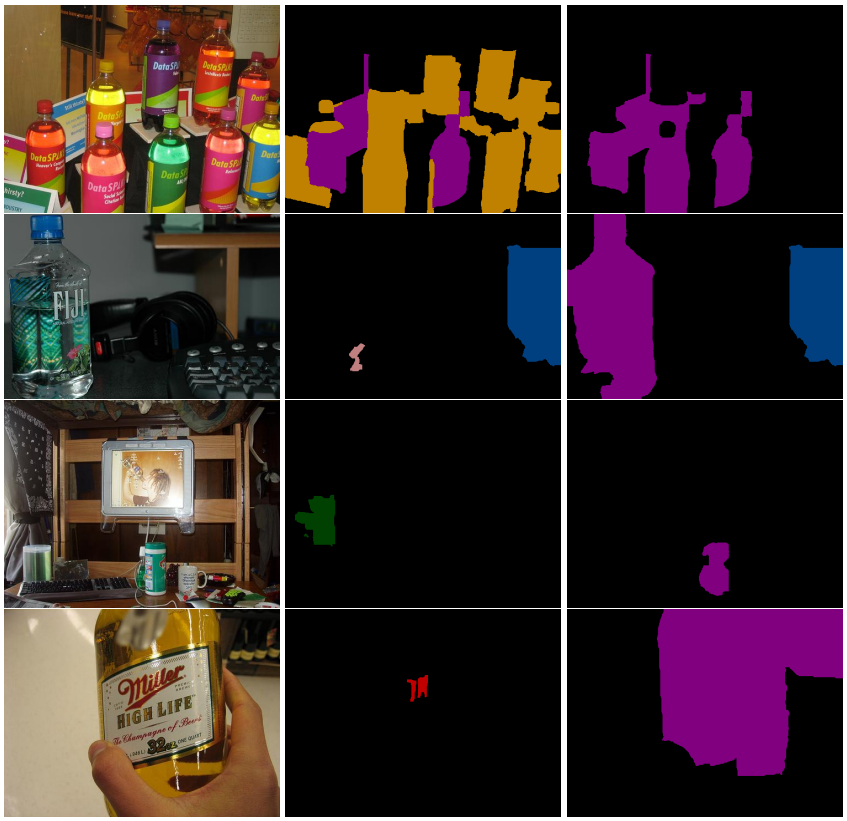

Figure 19: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling.

Figure 20: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling.

5.6 Bus

Figure 21: Example of ground truth annotation for the *bus* class.

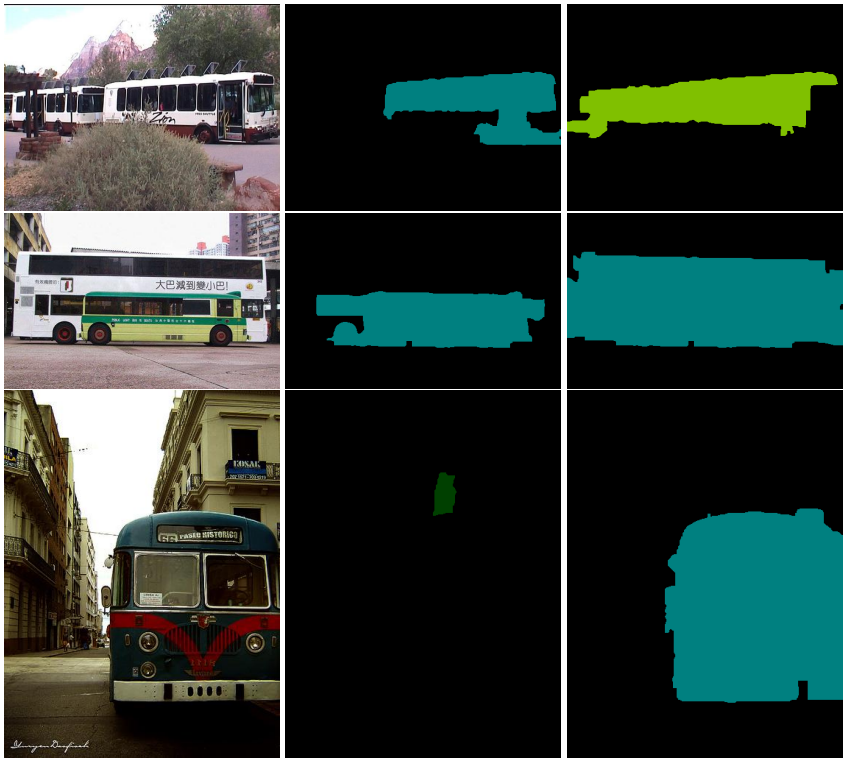

Figure 22: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling.

Figure 23: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling.

5.7 Car

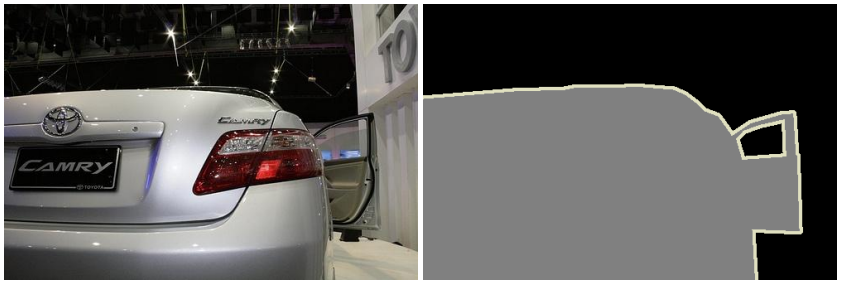

Figure 24: Example of ground truth annotation for the *car* class.

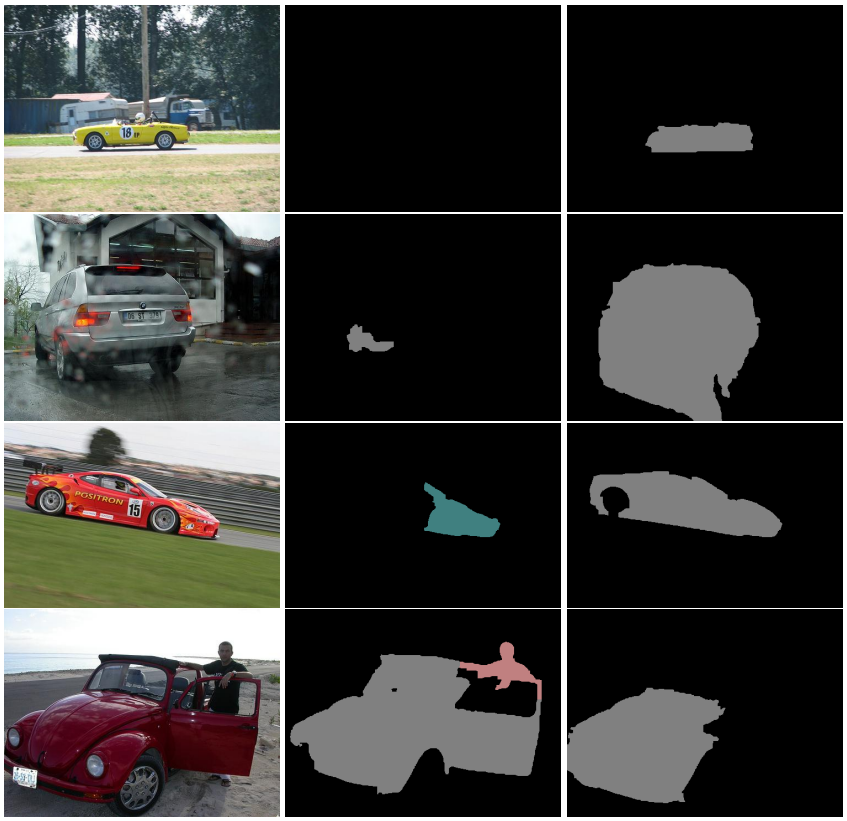

Figure 25: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling.

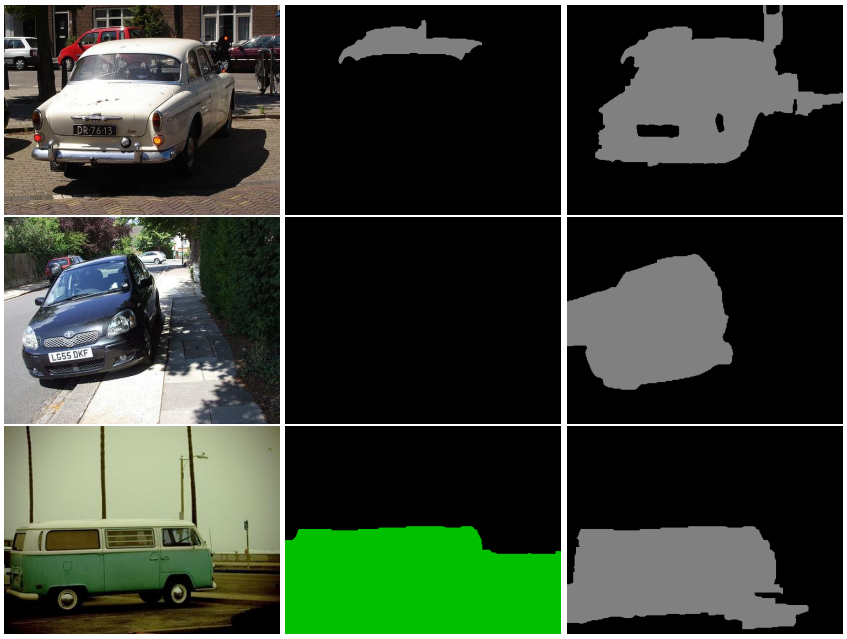

Figure 26: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling.

5.8 Cat

Figure 27: Example of ground truth annotation for the *cat* class.

Figure 28: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling.

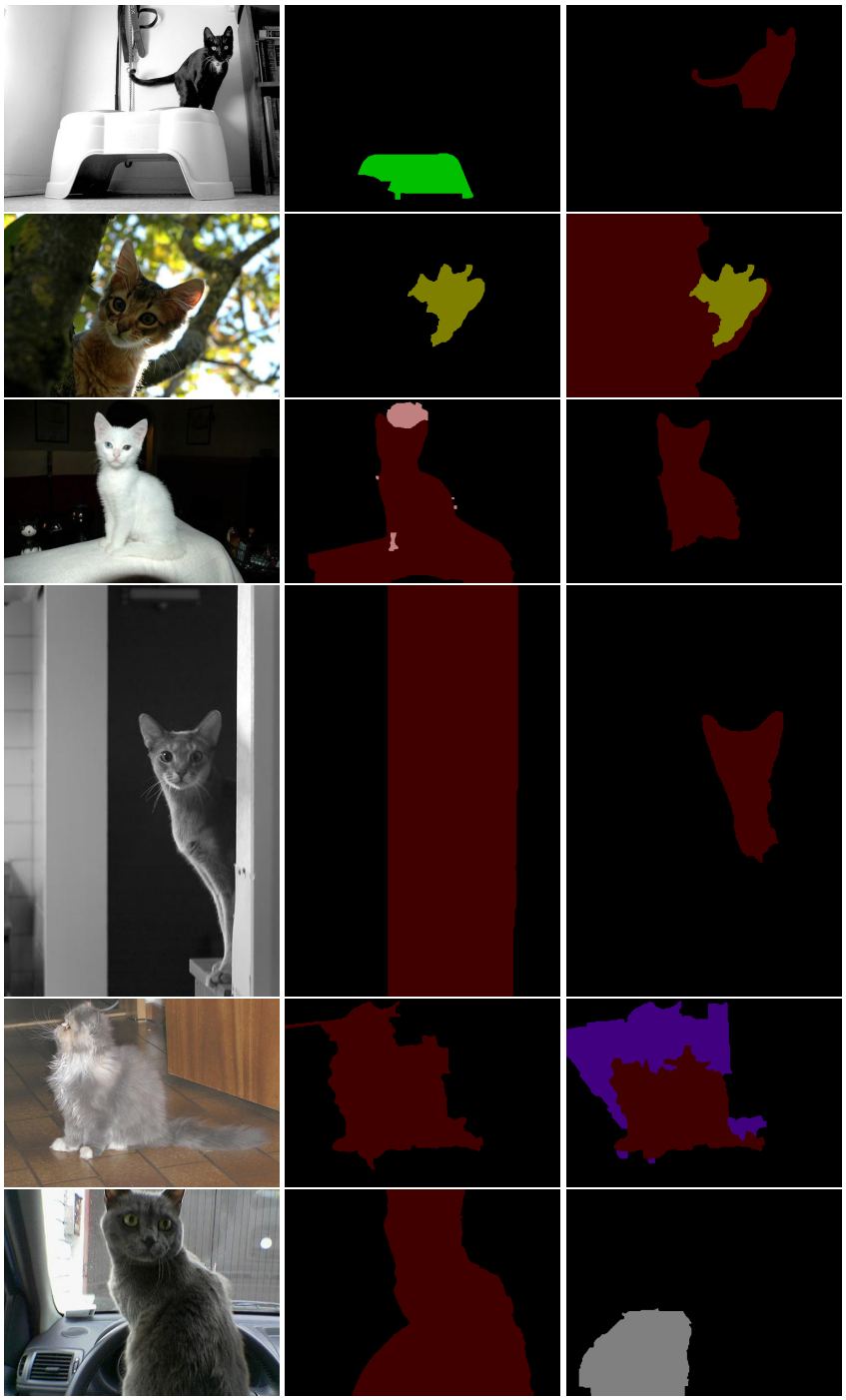

Figure 29: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling.

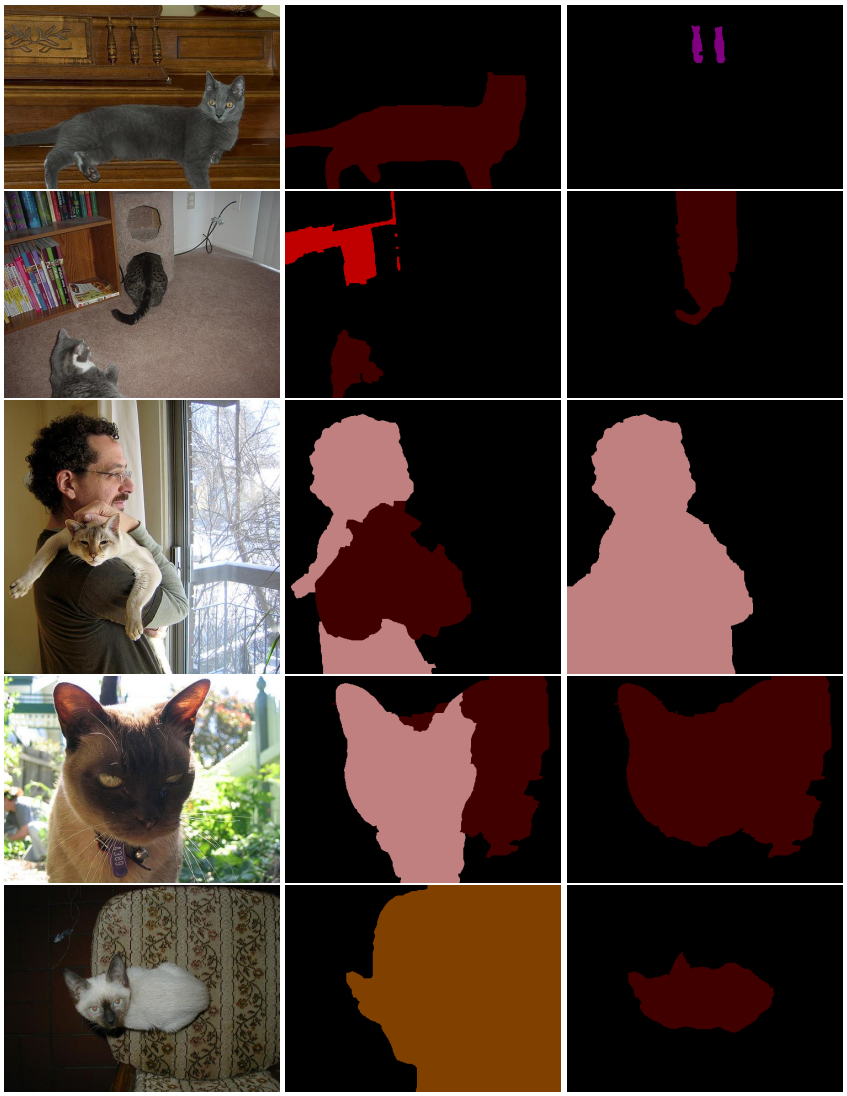

Figure 30: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling.

5.9 Chair

Figure 31: Example of ground truth annotation for the *chair* class.

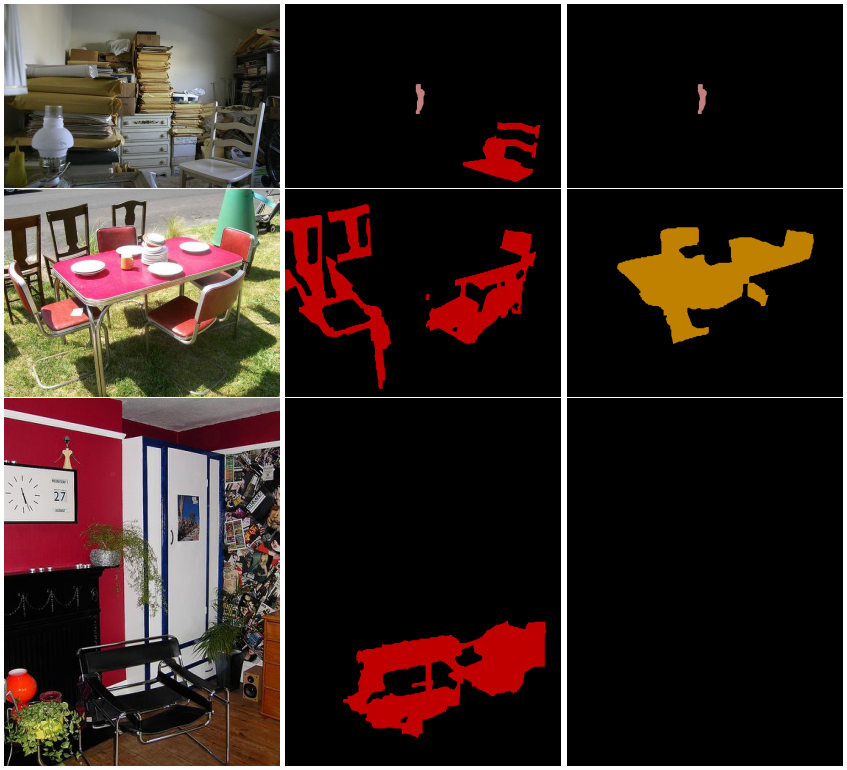

Figure 32: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling.

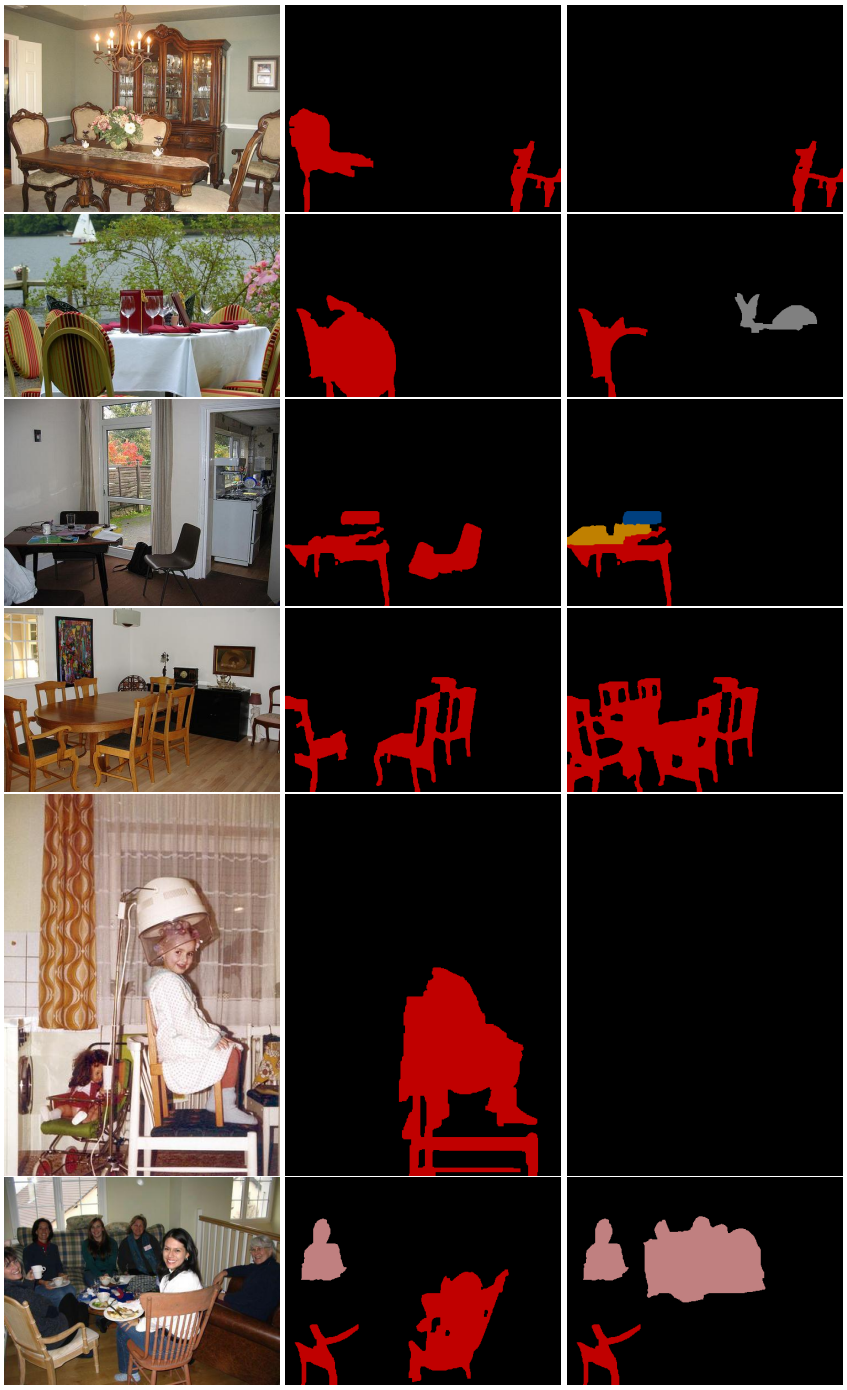

Figure 33: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling.

5.10 Cow

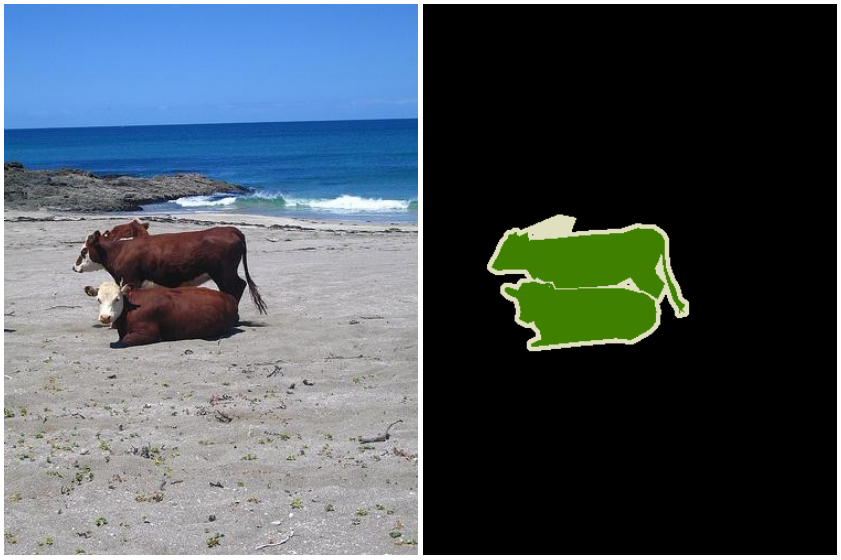

Figure 34: Example of ground truth annotation for the *cow* class.

Figure 35: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling.

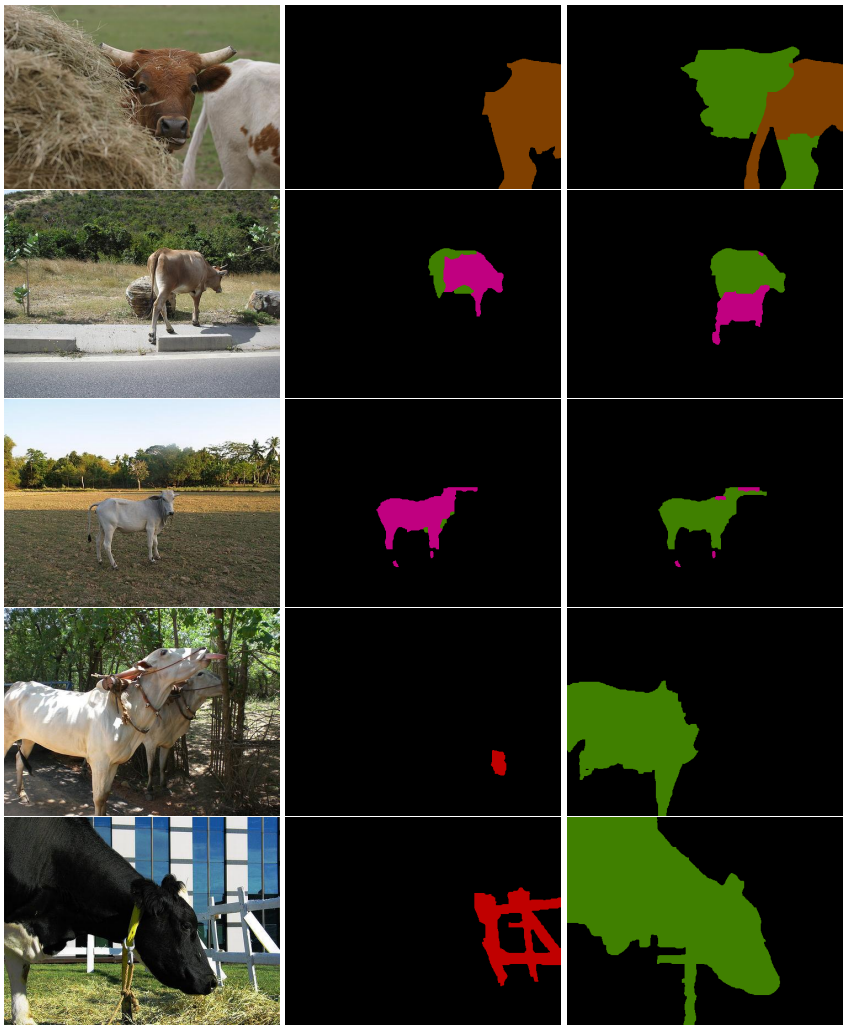

Figure 36: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling.

5.11 Diningtable

Figure 37: Example of ground truth annotation for the *diningtable* class.

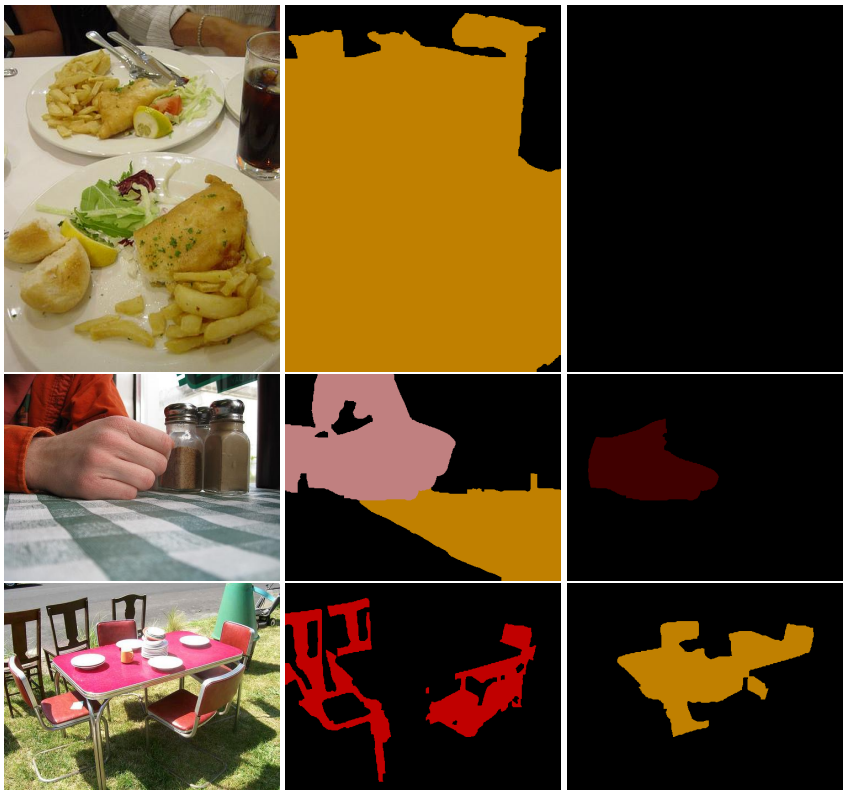

Figure 38: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling.

5.12 Dog

Figure 39: Example of ground truth annotation for the *dog* class.

Figure 40: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling.

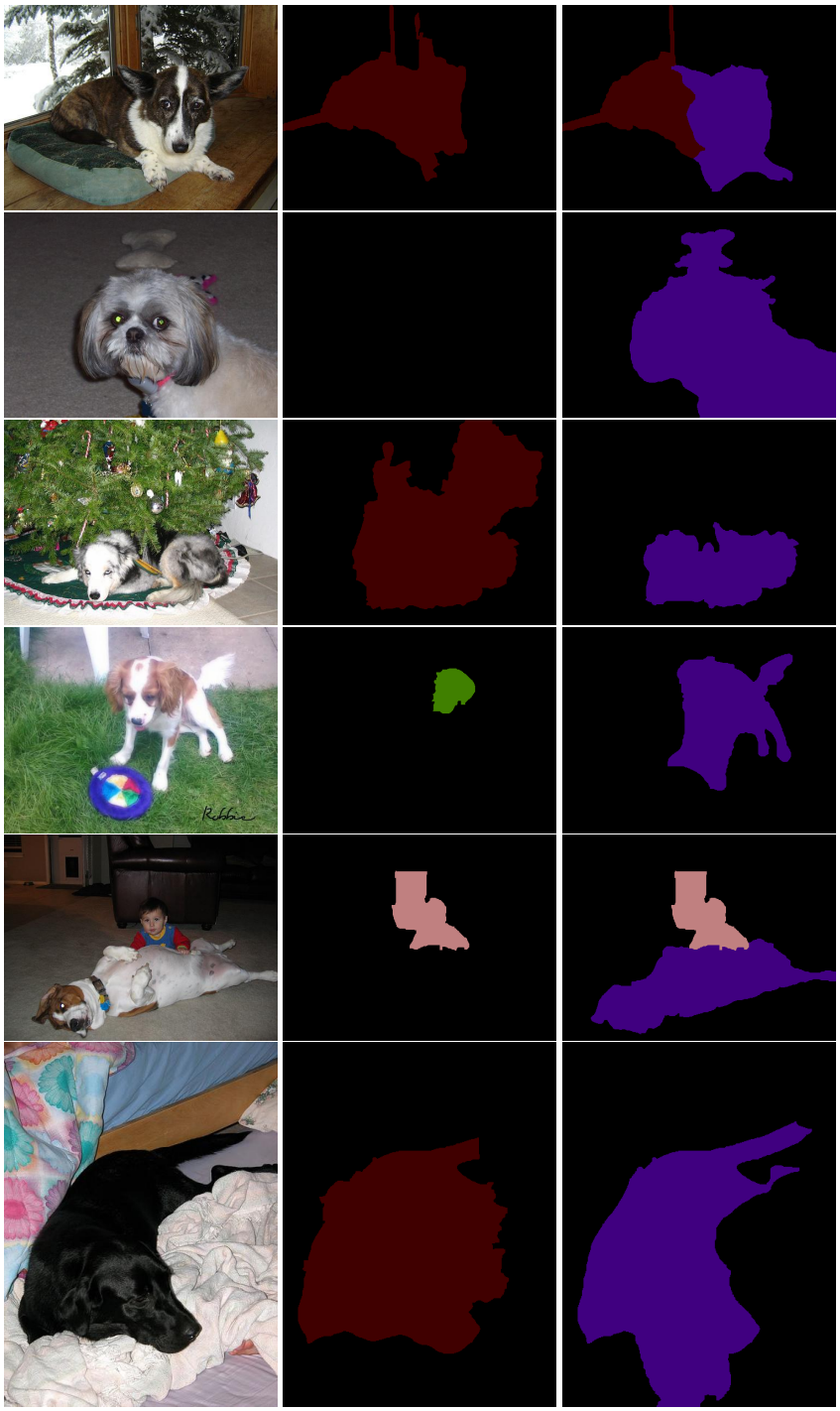

Figure 41: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling.

Figure 42: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling.

Figure 43: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling.

Figure 44: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling.

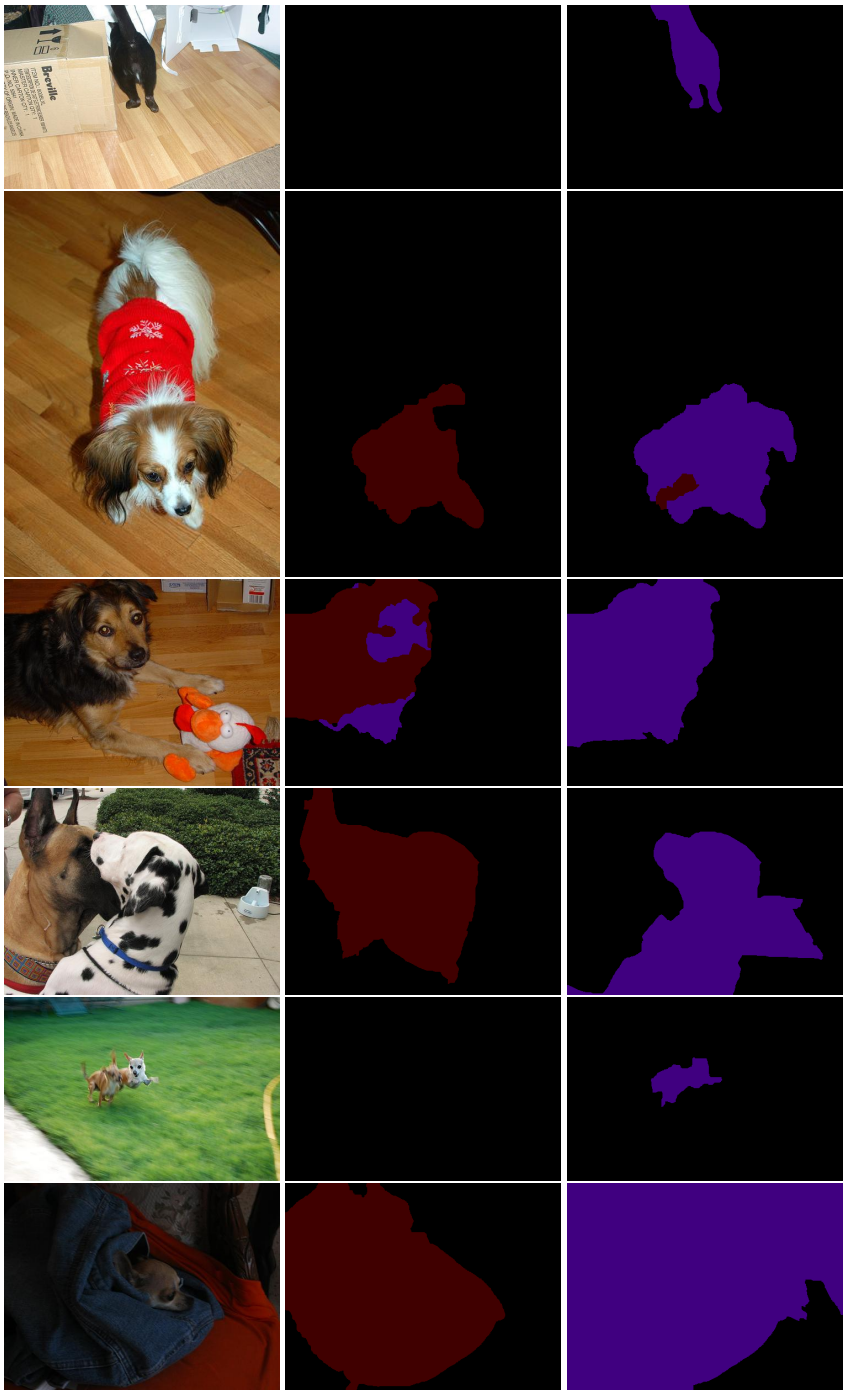

Figure 45: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling.

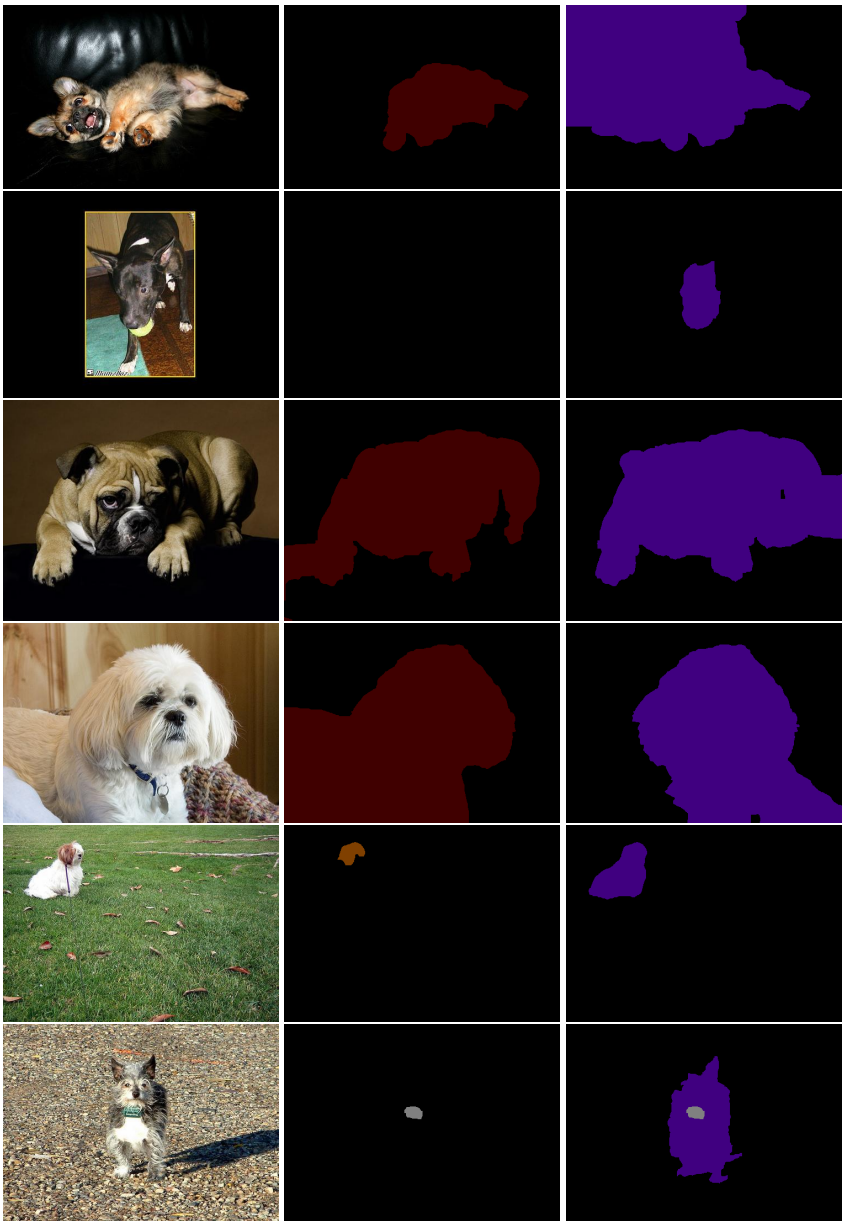

Figure 46: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling.

5.13 Horse

Figure 47: Example of ground truth annotation for the *horse* class.

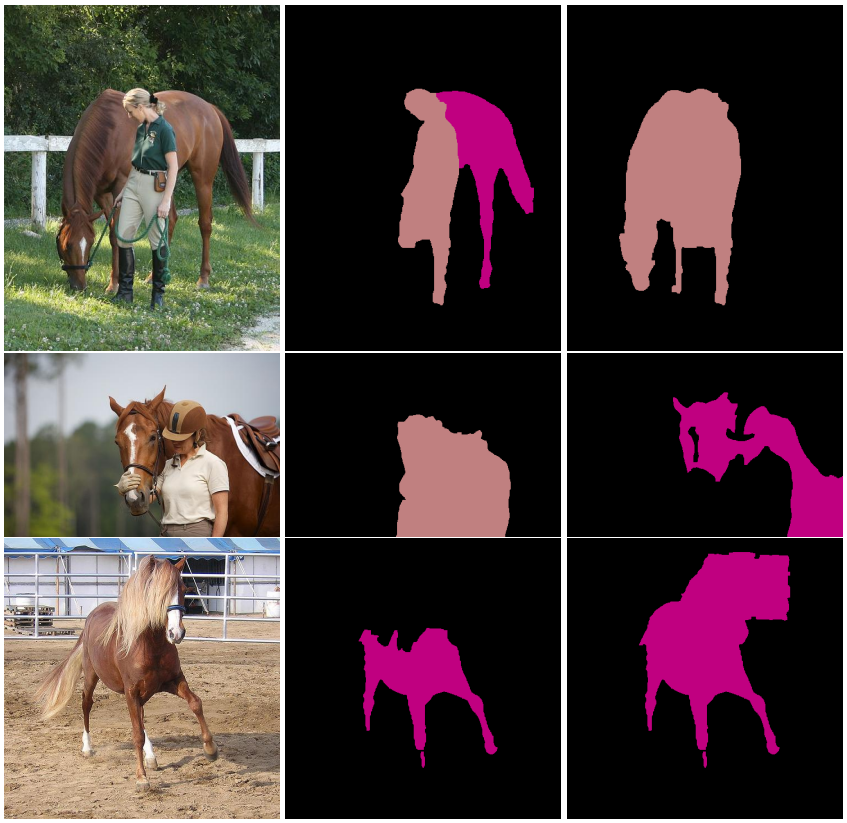

Figure 48: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling.

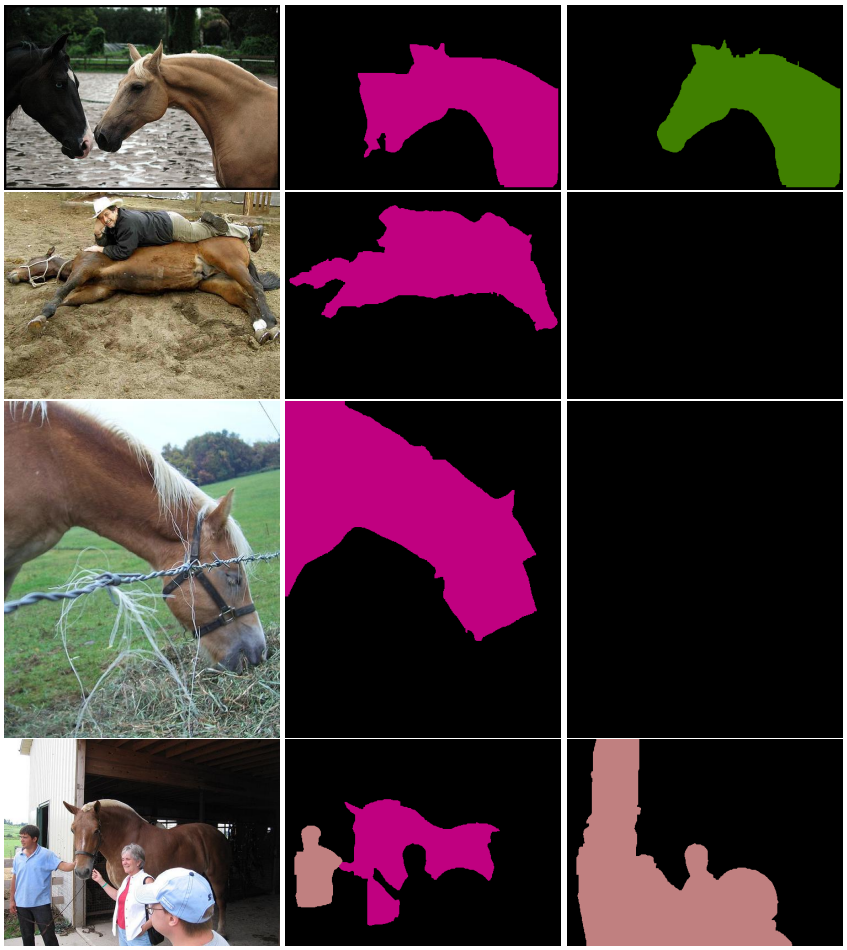

Figure 49: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling.

5.14 Motorbike

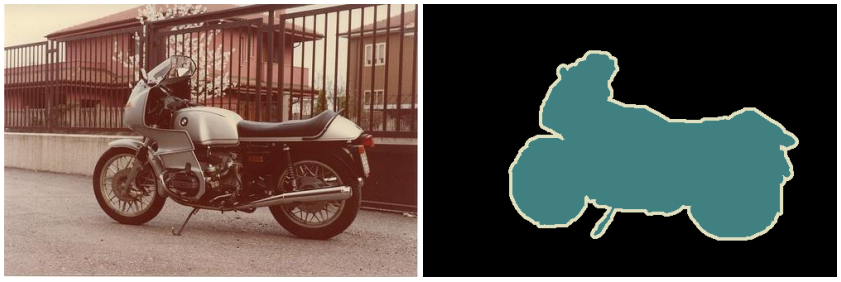

Figure 50: Example of ground truth annotation for the *motorbike* class.

Figure 51: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling.

Figure 52: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling.

5.15 Person

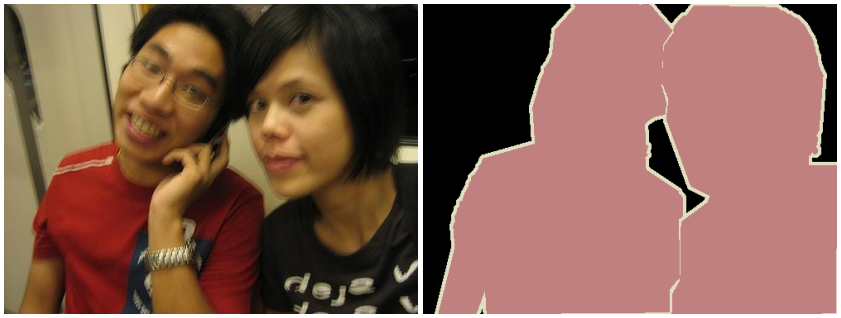

Figure 53: Example of ground truth annotation for the *person* class.

Figure 54: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling.

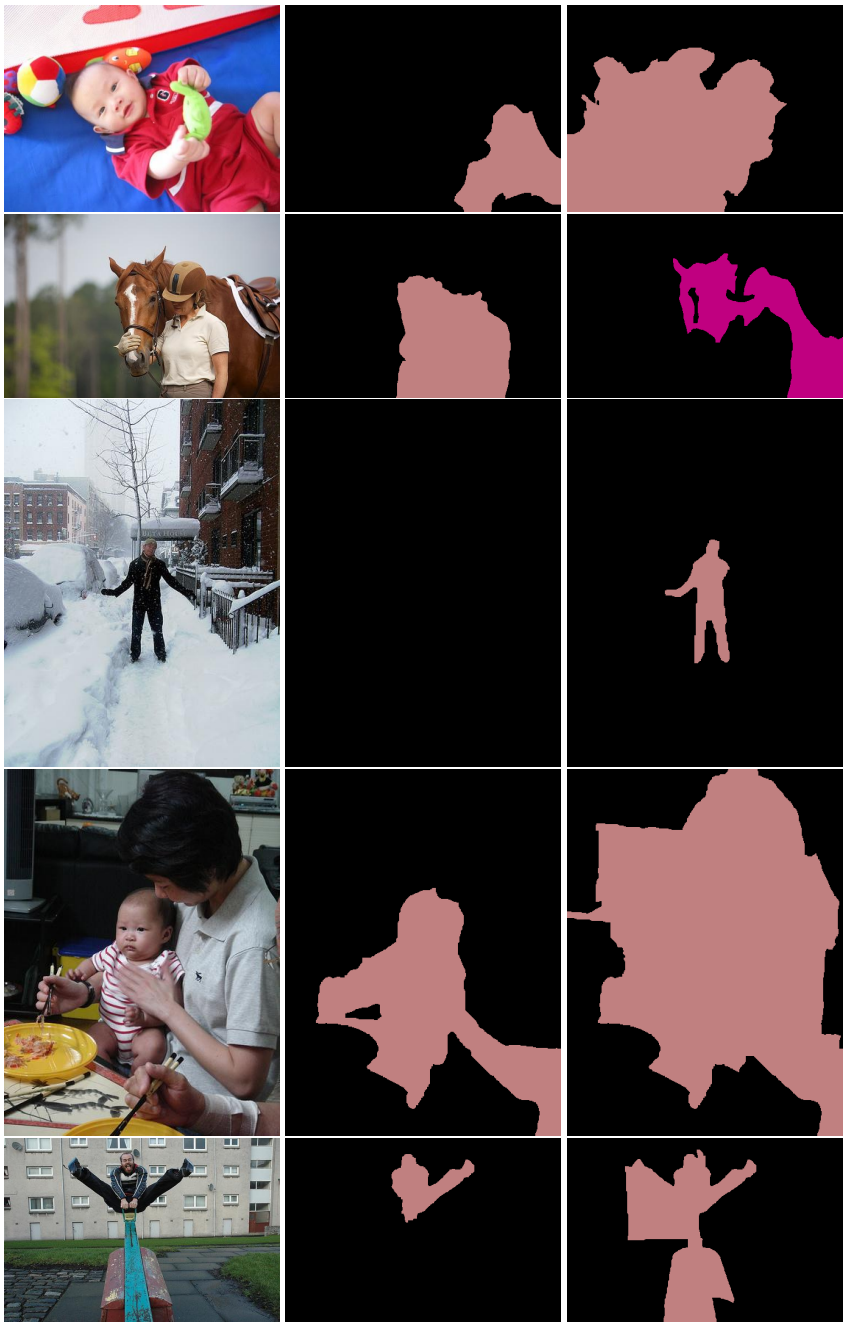

Figure 55: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling.

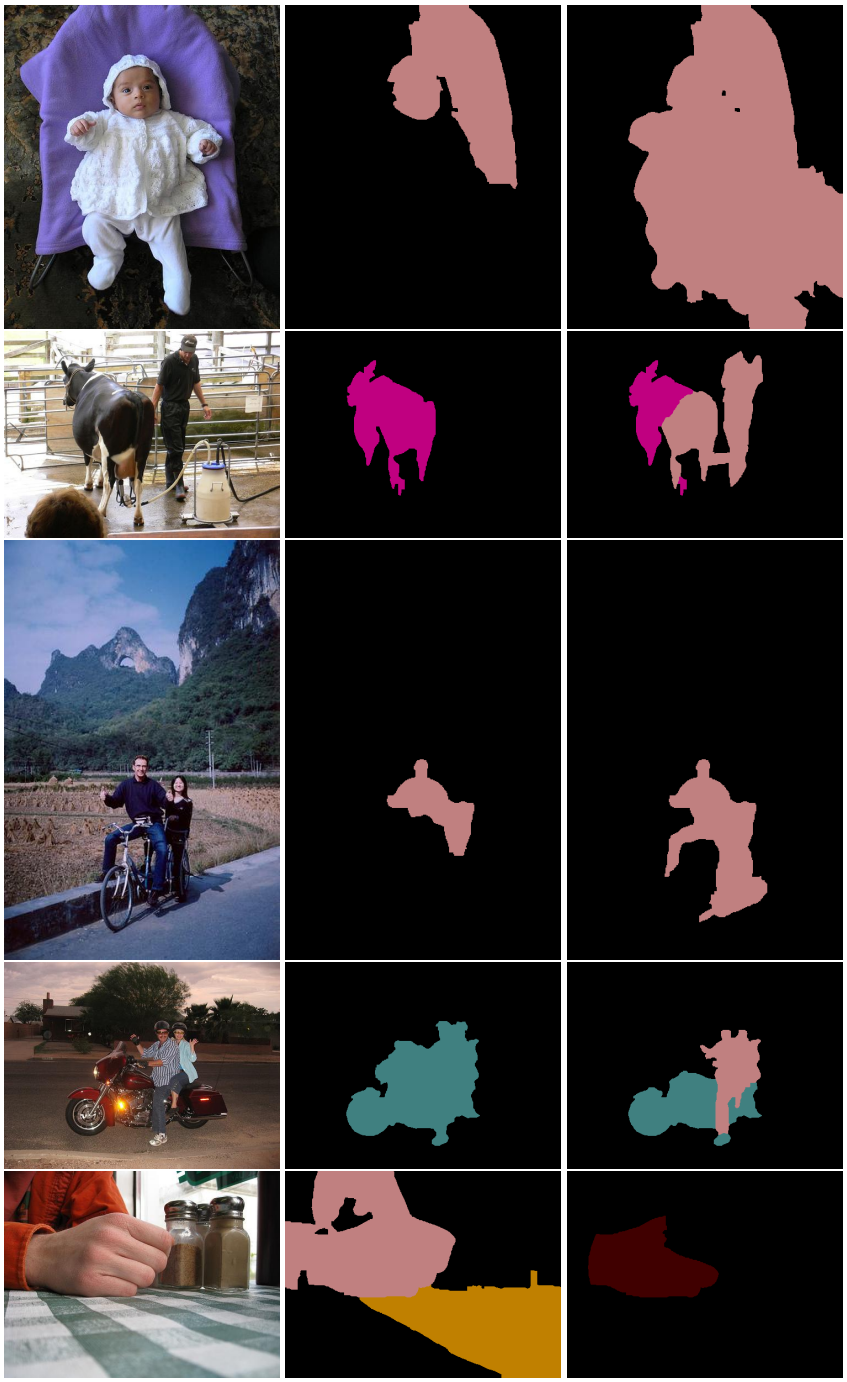

Figure 56: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling.

Figure 57: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling.

Figure 58: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling.

5.16 Pottedplant

Figure 59: Example of ground truth annotation for the *pottedplant* class.

Figure 60: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling.

5.17 Sheep

Figure 61: Example of ground truth annotation for the *sheep* class.

Figure 62: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling.

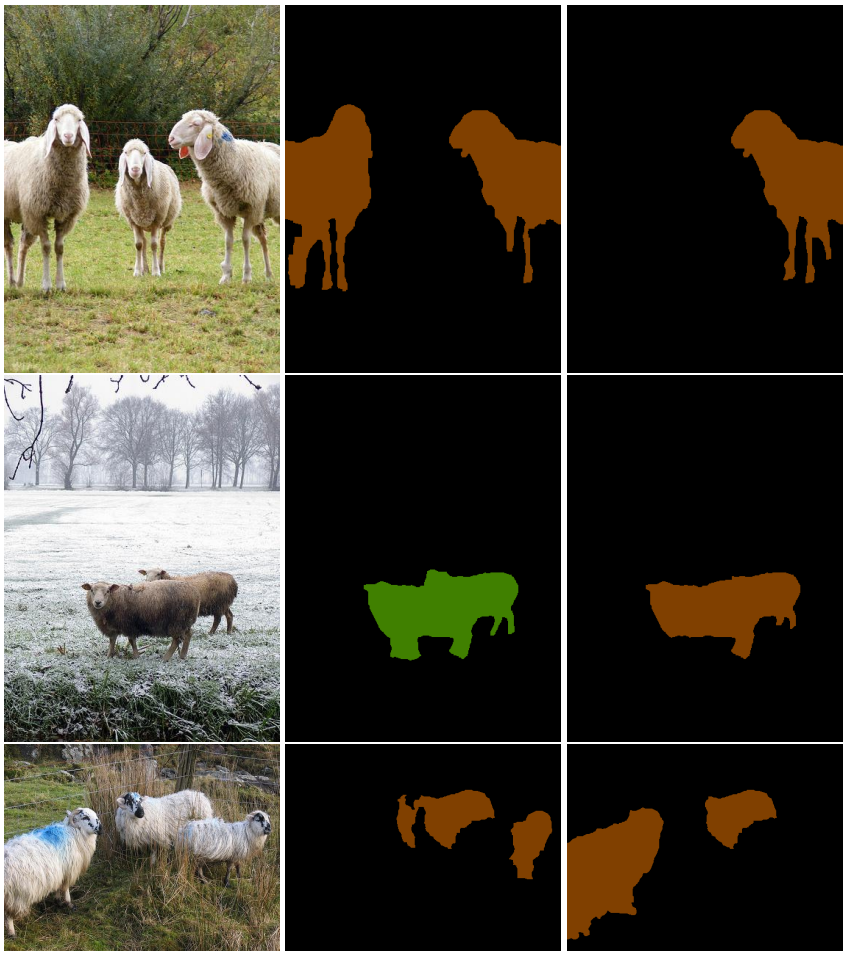

Figure 63: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling.

5.18 Sofa

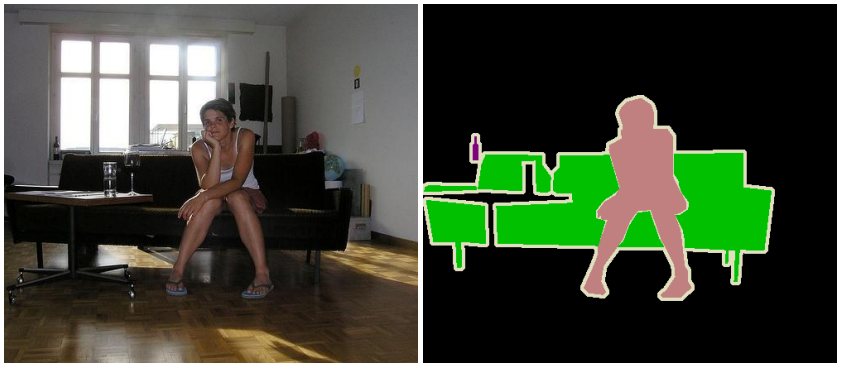

Figure 64: Example of ground truth annotation for the *sofa* class.

Figure 65: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling.

5.19 Train

Figure 66: Example of ground truth annotation for the *train* class.

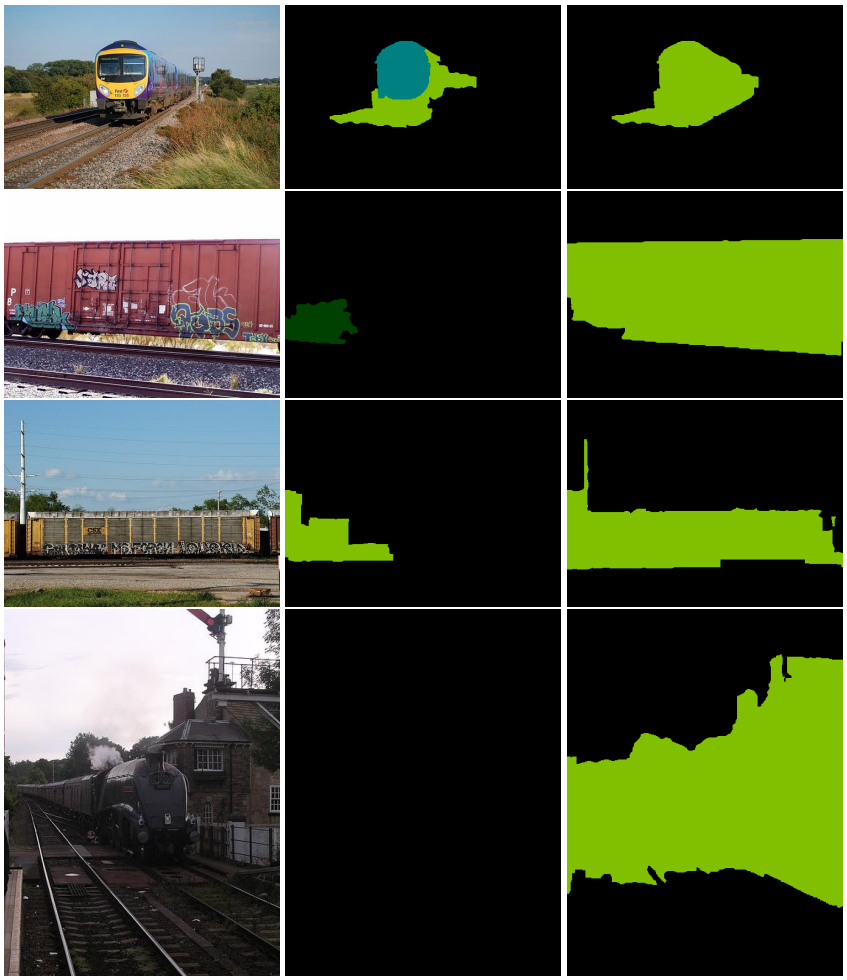

Figure 67: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling.

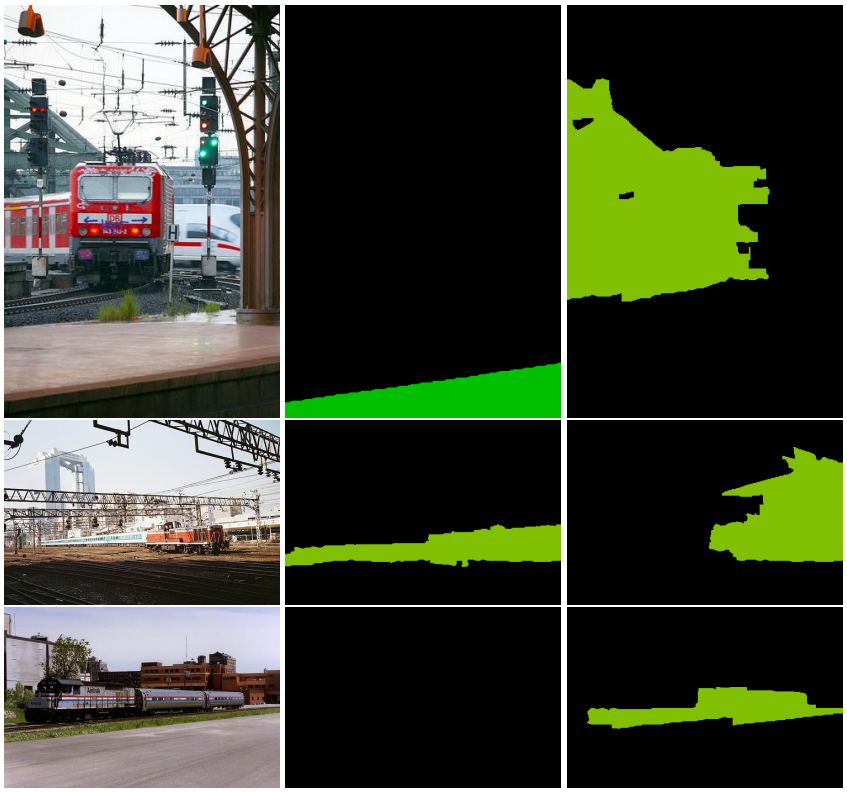

Figure 68: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling.

5.20 Tvmonitor

Figure 69: Example of ground truth annotation for the *tvmonitor* class.

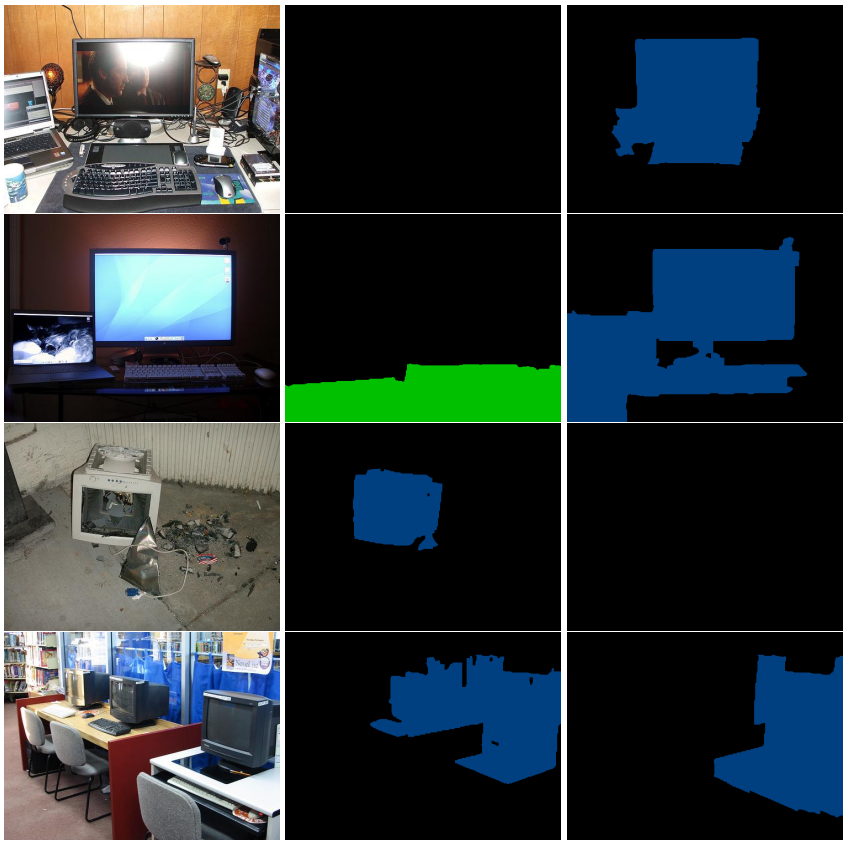

Figure 70: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling.

6 Visual Results by Categories using MCGs

6.1 Aeroplane

Figure 71: Example of ground truth annotation for the *aeroplane* class.

Figure 72: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling and cartesian-based Spatial Pyramid over Figure.

6.2 Bicycle

Figure 73: Example of ground truth annotation for the *bicycle* class.

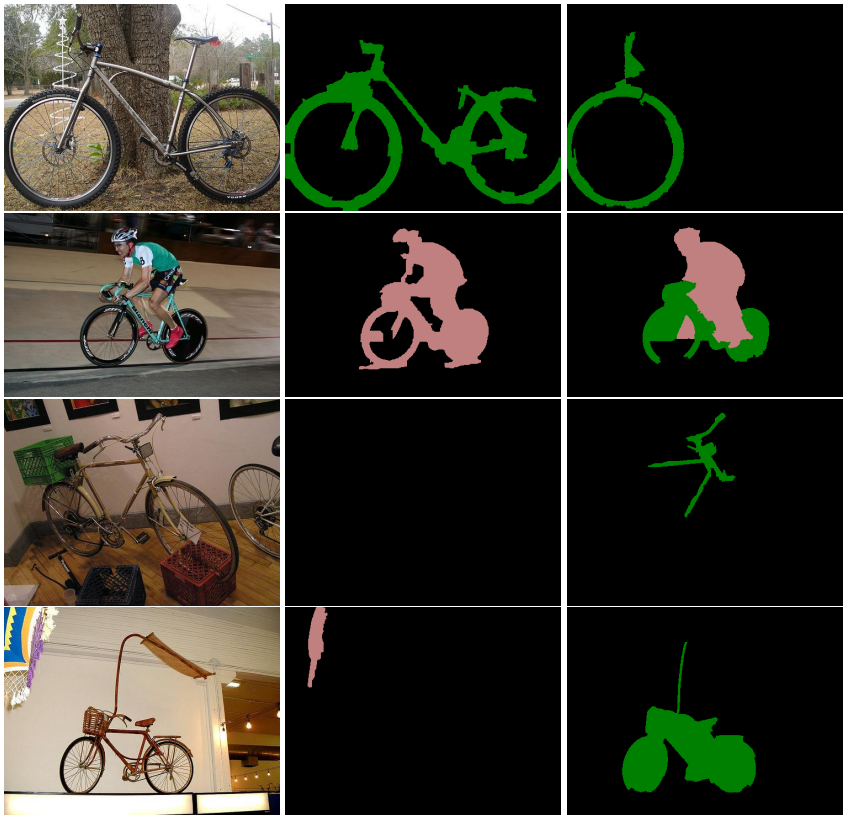

Figure 74: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling and cartesian-based Spatial Pyramid over Figure.

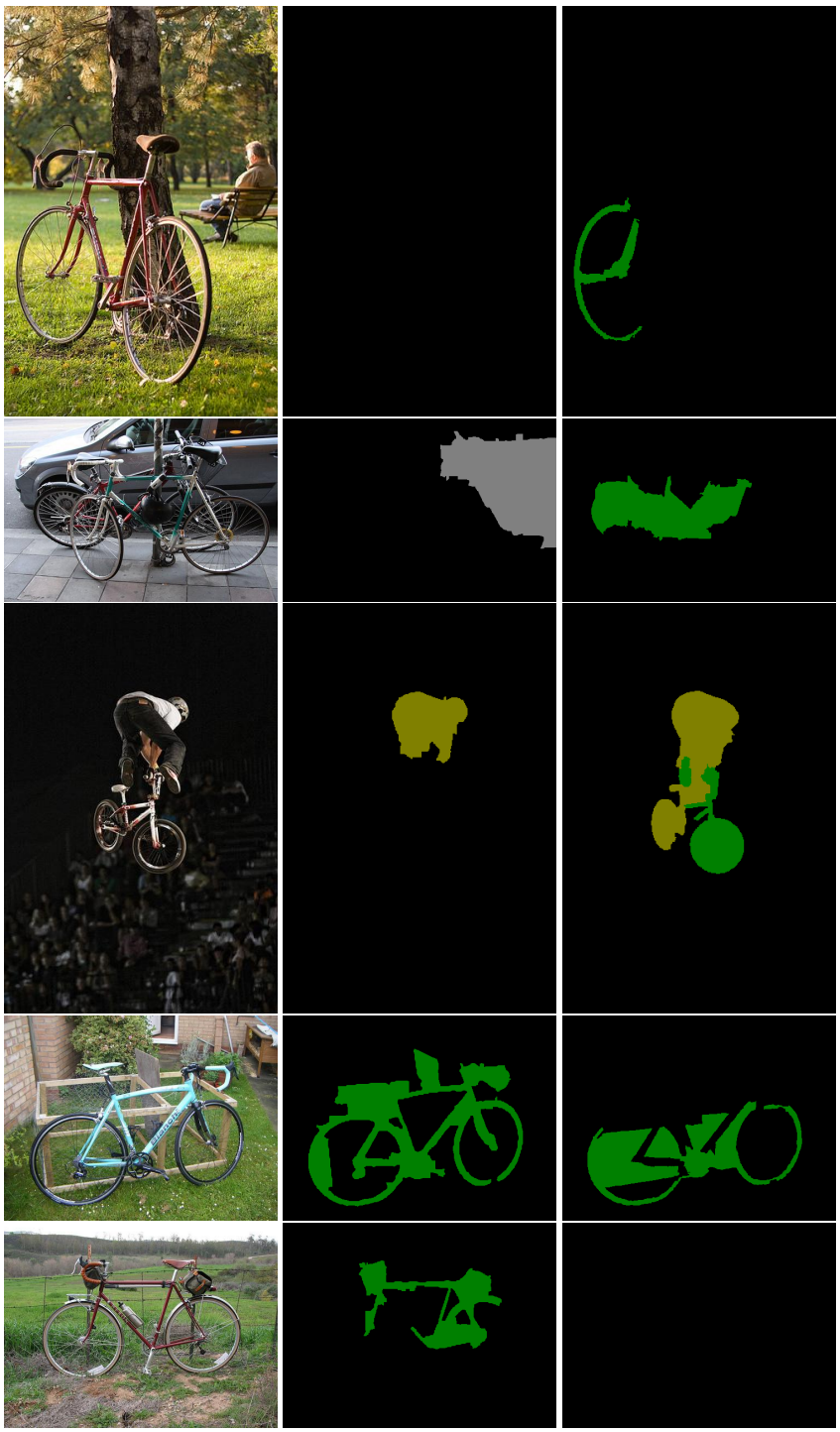

Figure 75: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling and cartesian-based Spatial Pyramid over Figure.

Figure 76: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling and cartesian-based Spatial Pyramid over Figure.

6.3 Bird

Figure 77: Example of ground truth annotation for the *bird* class.

Figure 78: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling and cartesian-based Spatial Pyramid over Figure.

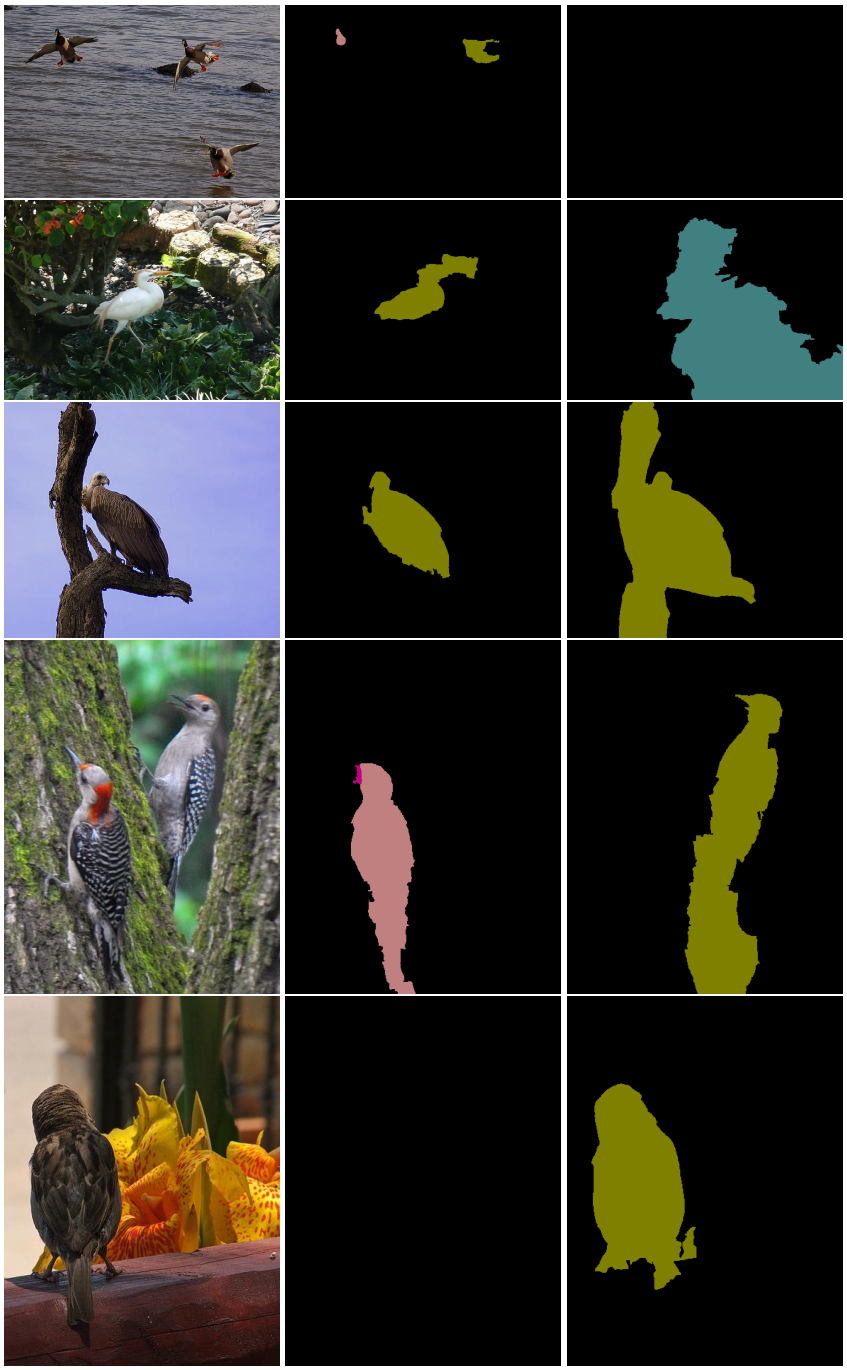

Figure 79: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling and cartesian-based Spatial Pyramid over Figure.

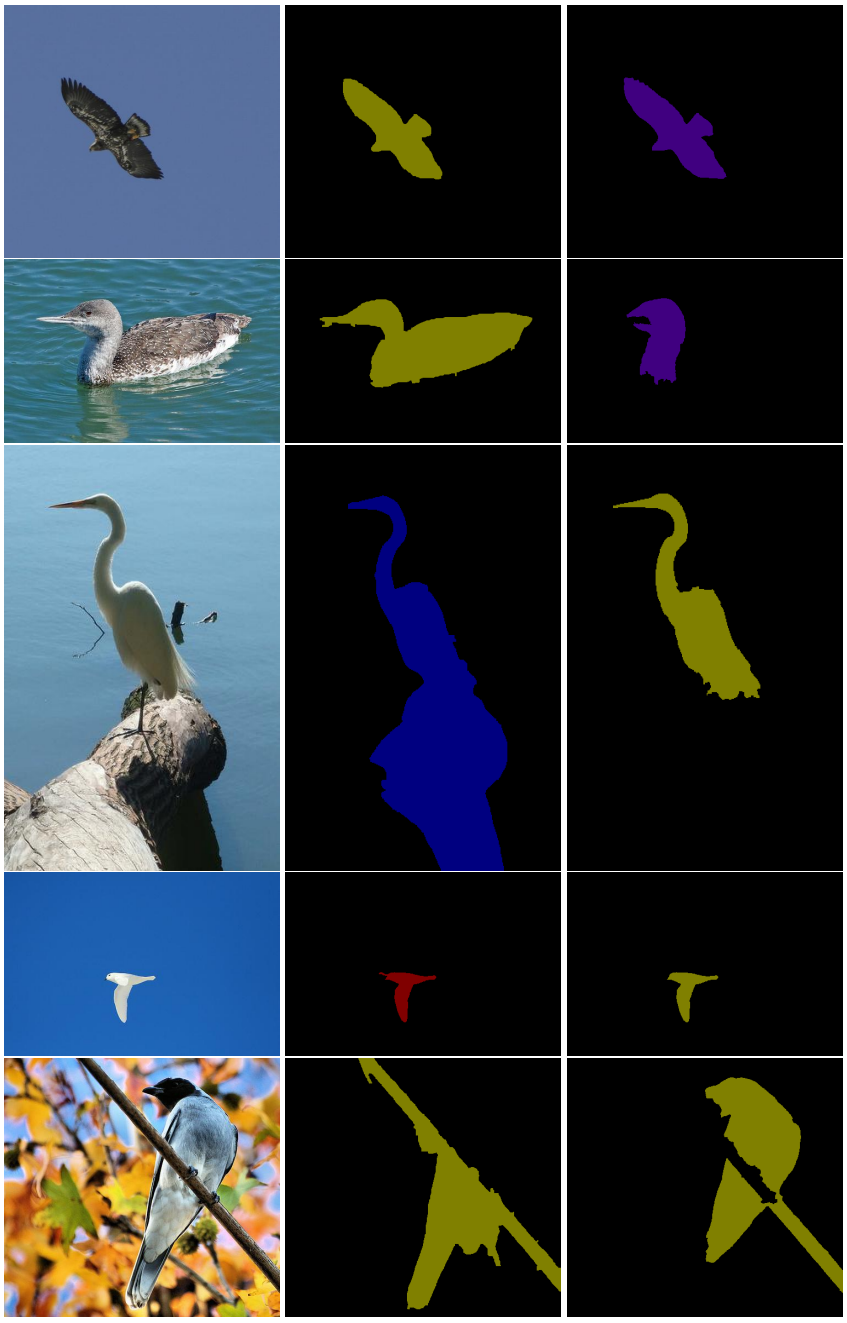

Figure 80: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling and cartesian-based Spatial Pyramid over Figure.

Figure 81: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling and cartesian-based Spatial Pyramid over Figure.

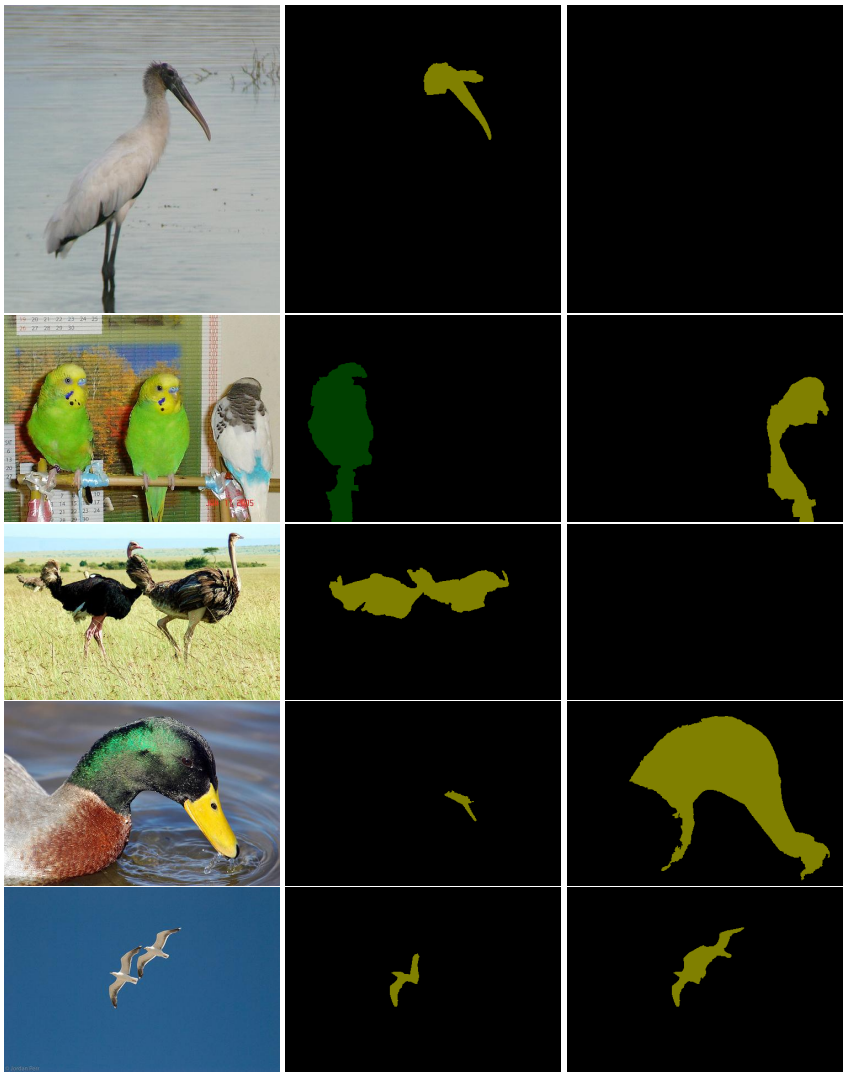

Figure 82: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling and cartesian-based Spatial Pyramid over Figure.

6.4 Boat

Figure 83: Example of ground truth annotation for the *boat* class.

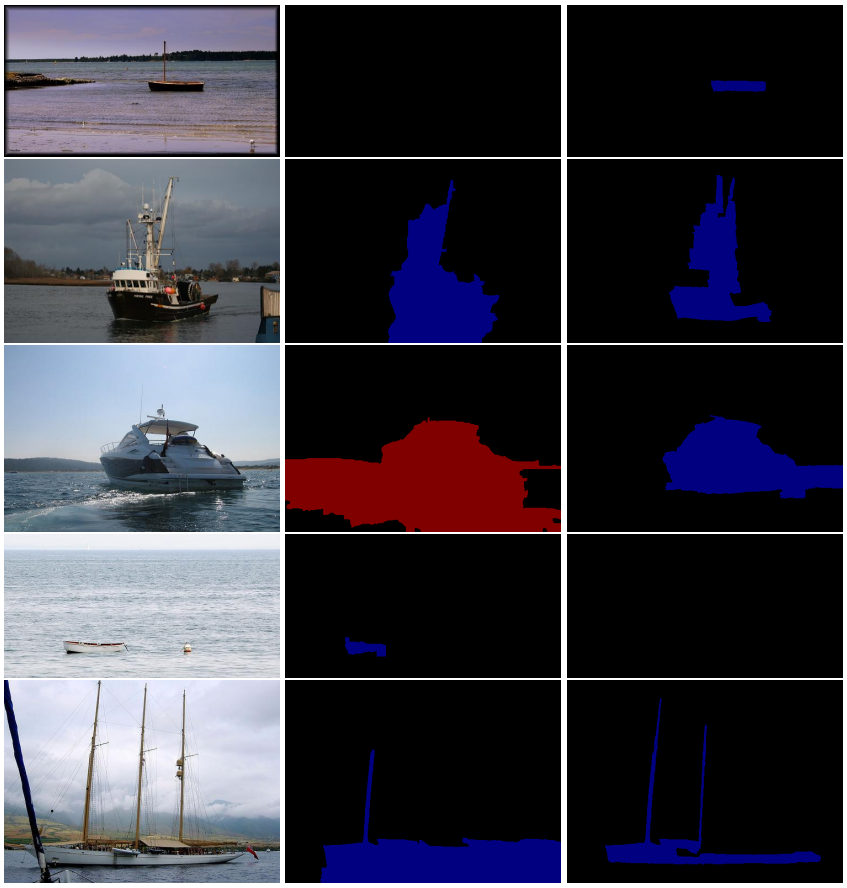

Figure 84: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling and cartesian-based Spatial Pyramid over Figure.

6.5 Bottle

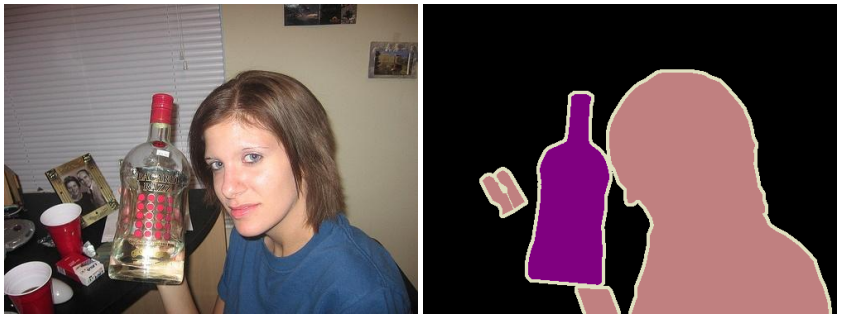

Figure 85: Example of ground truth annotation for the *bottle* class.

Figure 86: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling and cartesian-based Spatial Pyramid over Figure.

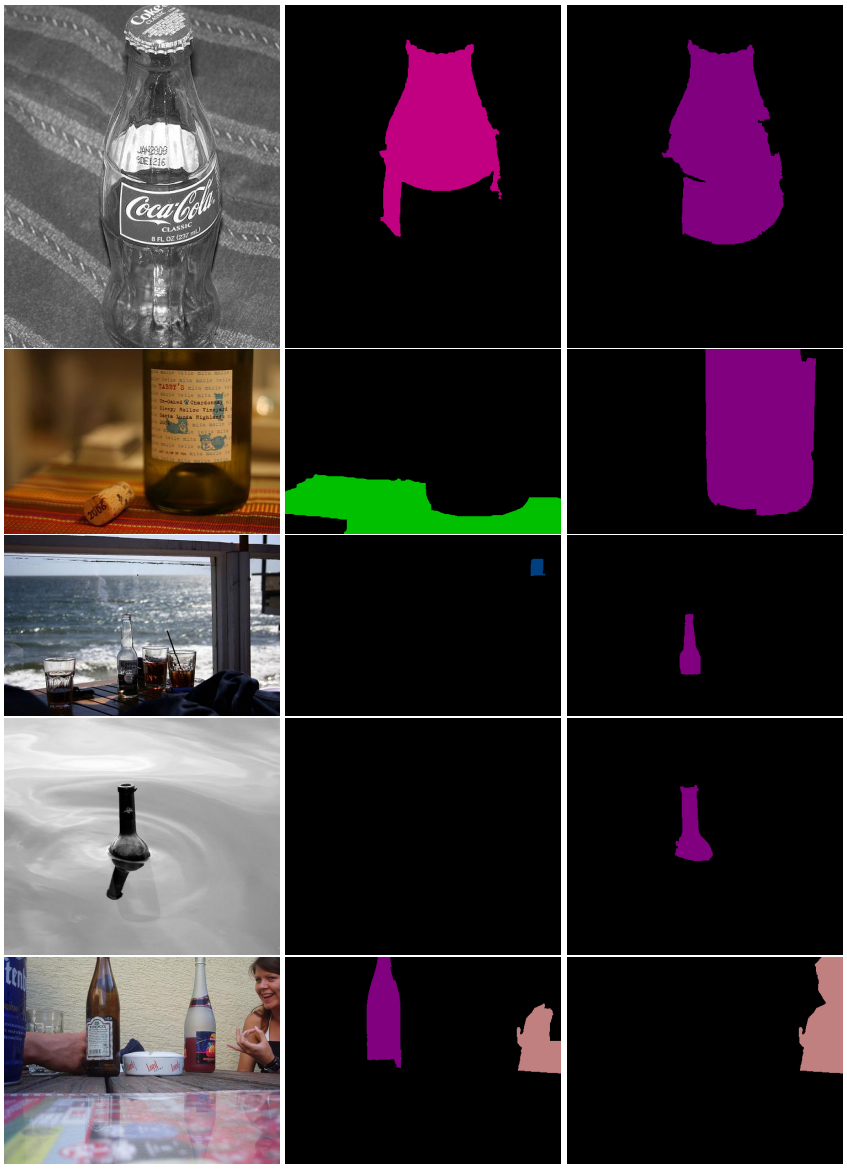

Figure 87: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling and cartesian-based Spatial Pyramid over Figure.

6.6 Bus

Figure 88: Example of ground truth annotation for the *bus* class.

Figure 89: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling and cartesian-based Spatial Pyramid over Figure.

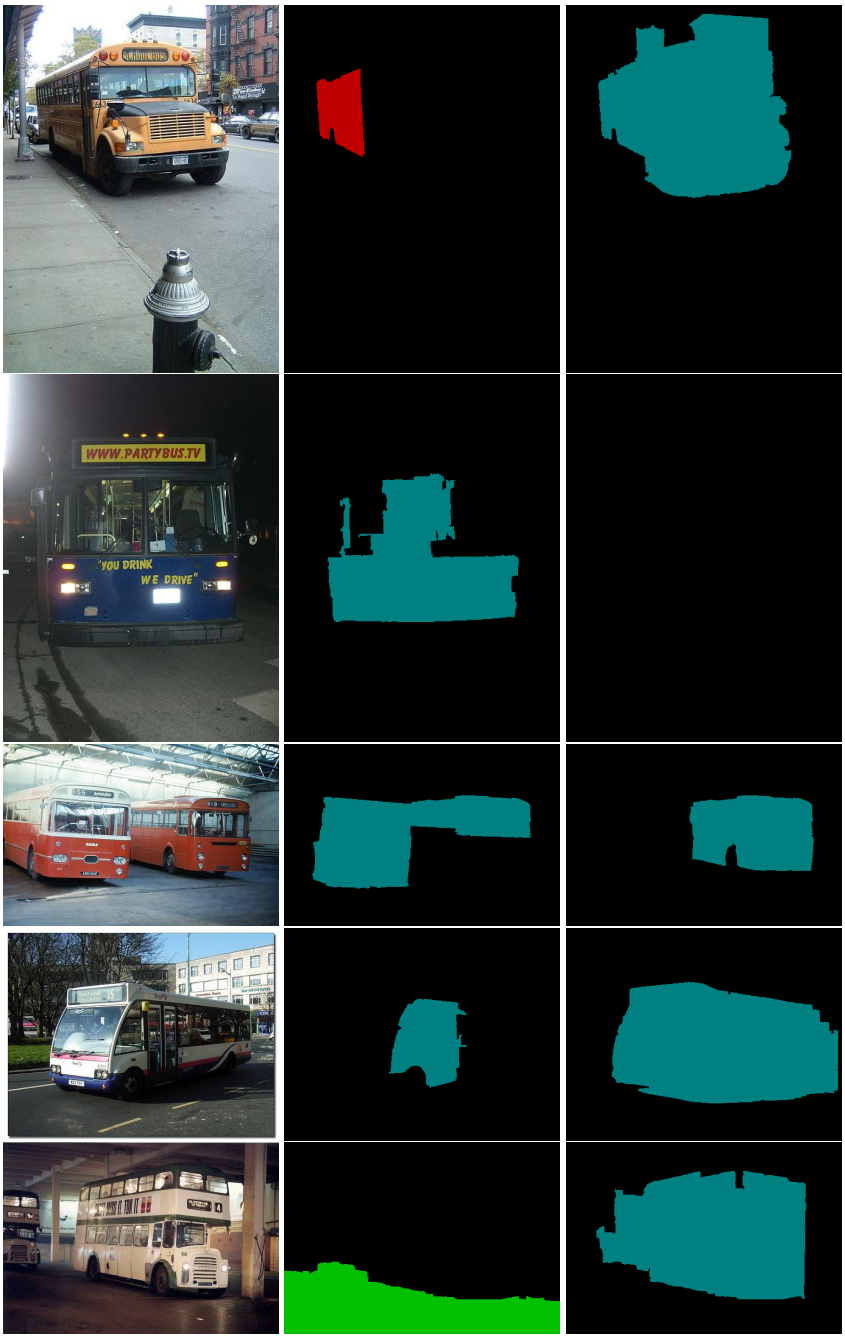

Figure 90: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling and cartesian-based Spatial Pyramid over Figure.

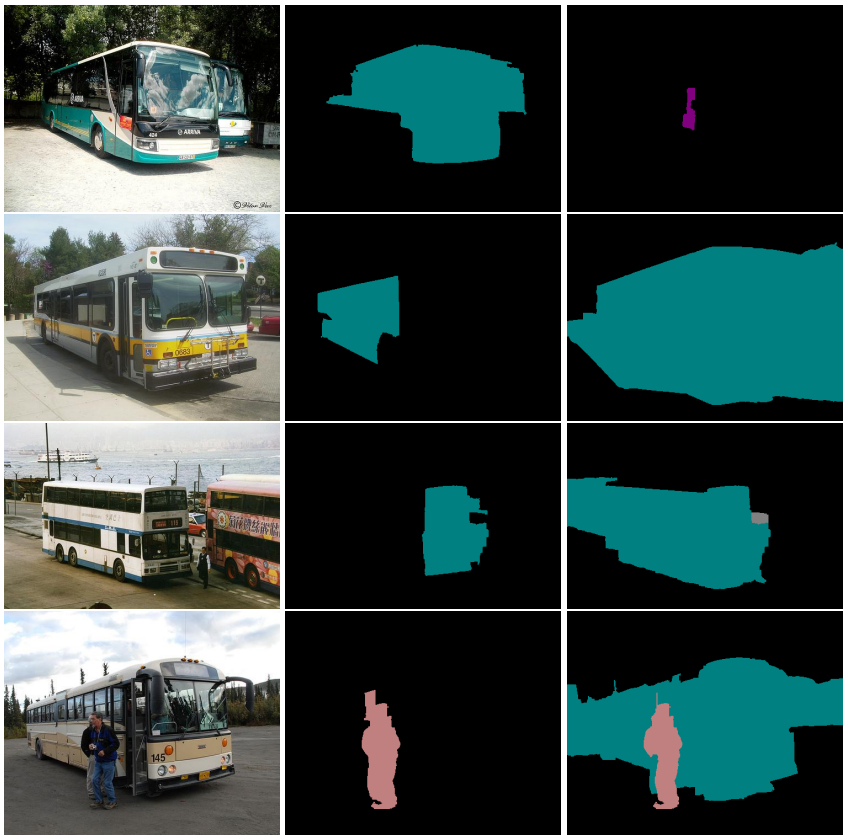

Figure 91: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling and cartesian-based Spatial Pyramid over Figure.

6.7 Car

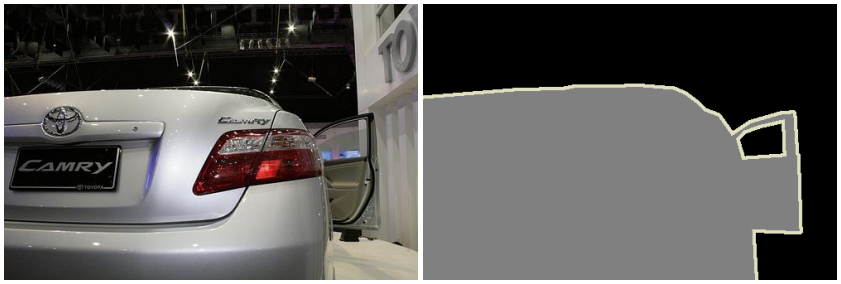

Figure 92: Example of ground truth annotation for the *car* class.

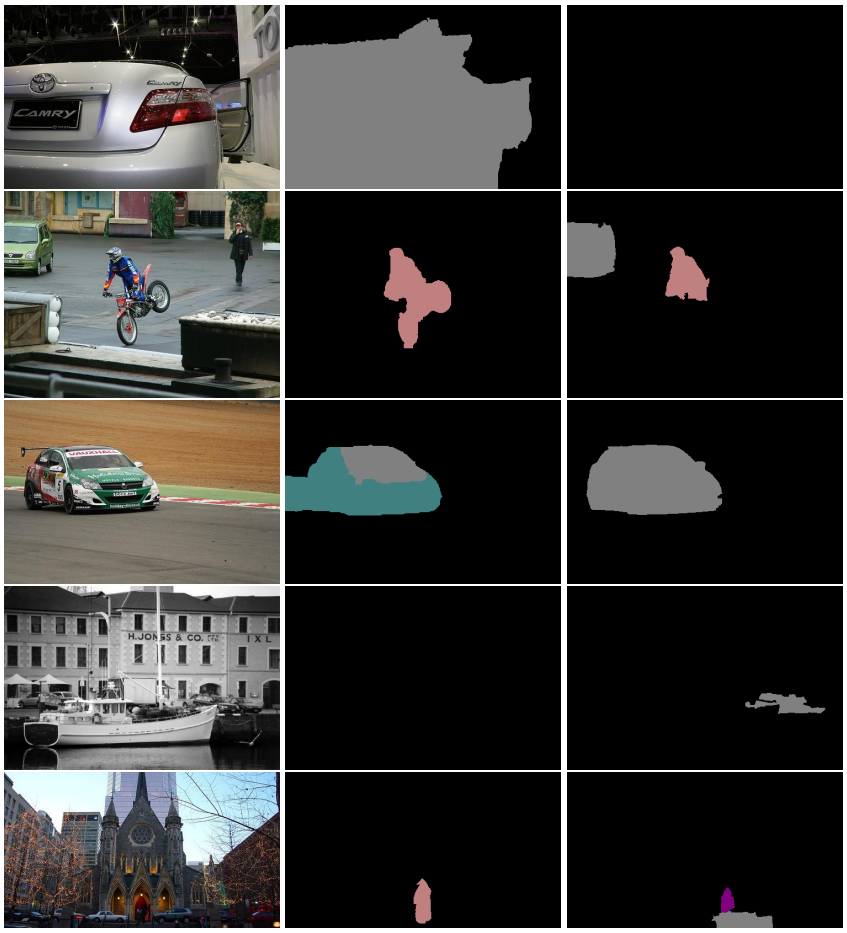

Figure 93: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling and cartesian-based Spatial Pyramid over Figure.

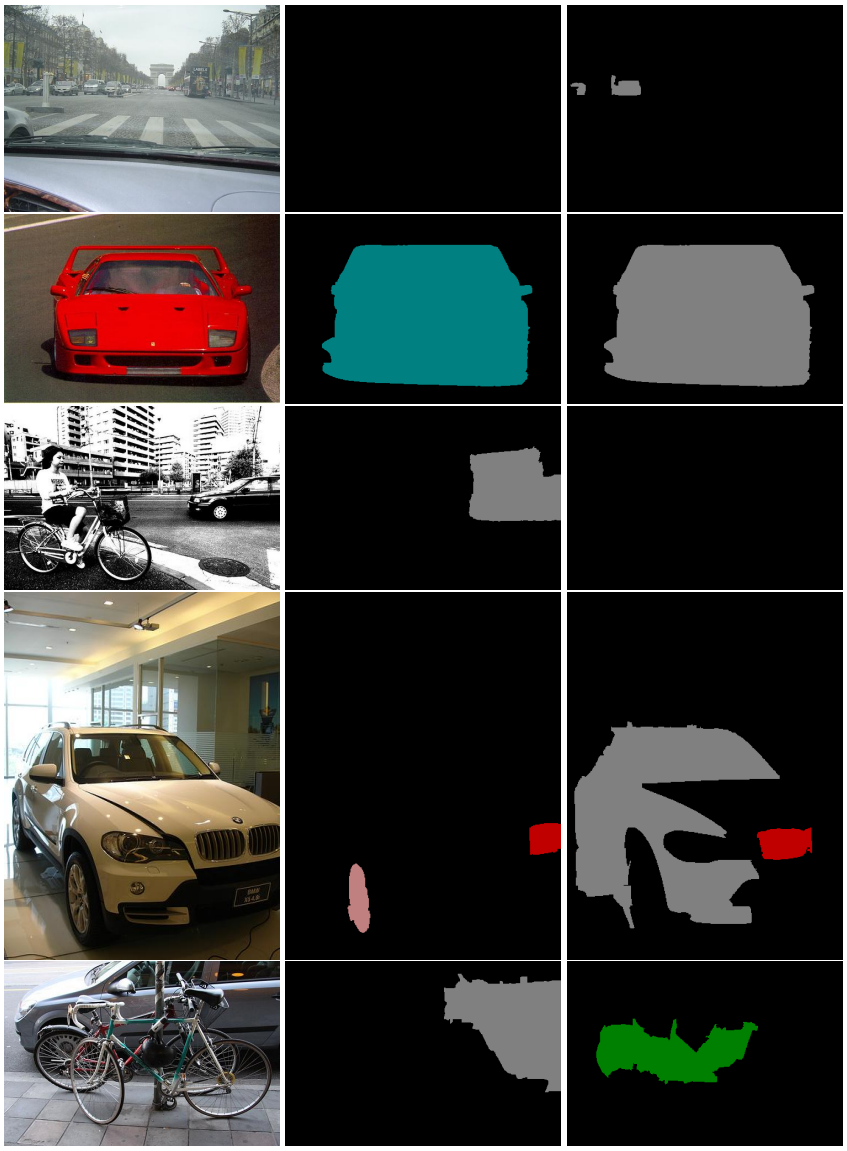

Figure 94: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling and cartesian-based Spatial Pyramid over Figure.

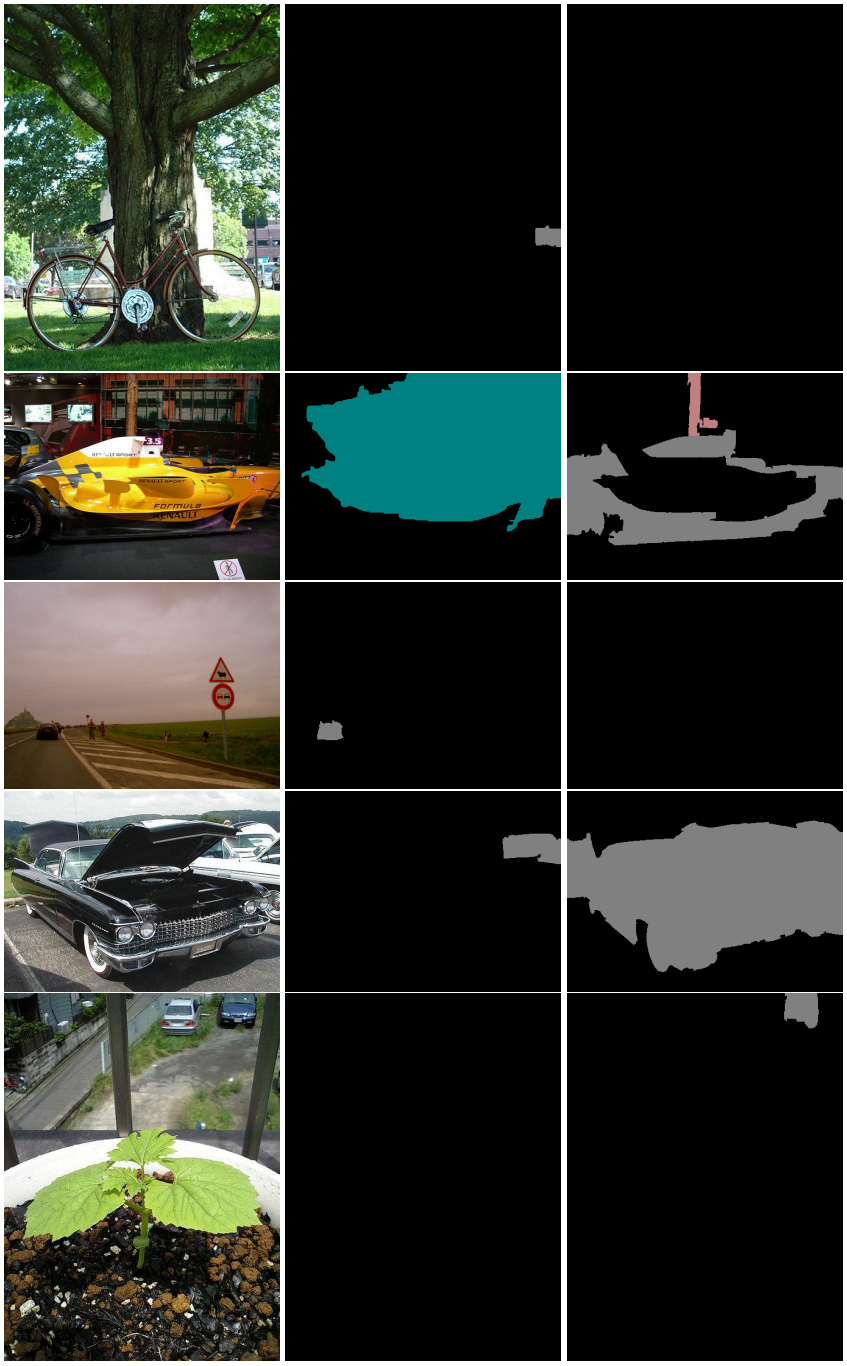

Figure 95: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling and cartesian-based Spatial Pyramid over Figure.

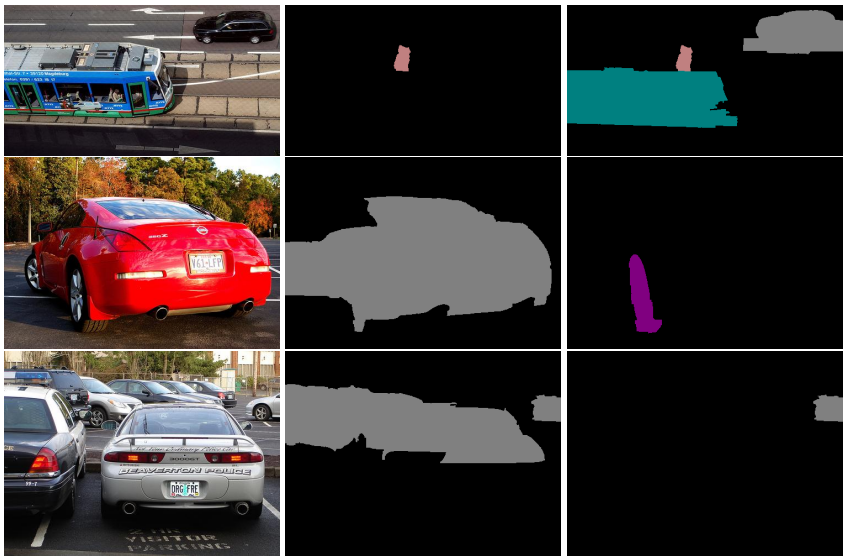

Figure 96: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling and cartesian-based Spatial Pyramid over Figure.

6.8 Cat

Figure 97: Example of ground truth annotation for the *cat* class.

Figure 98: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling and cartesian-based Spatial Pyramid over Figure.

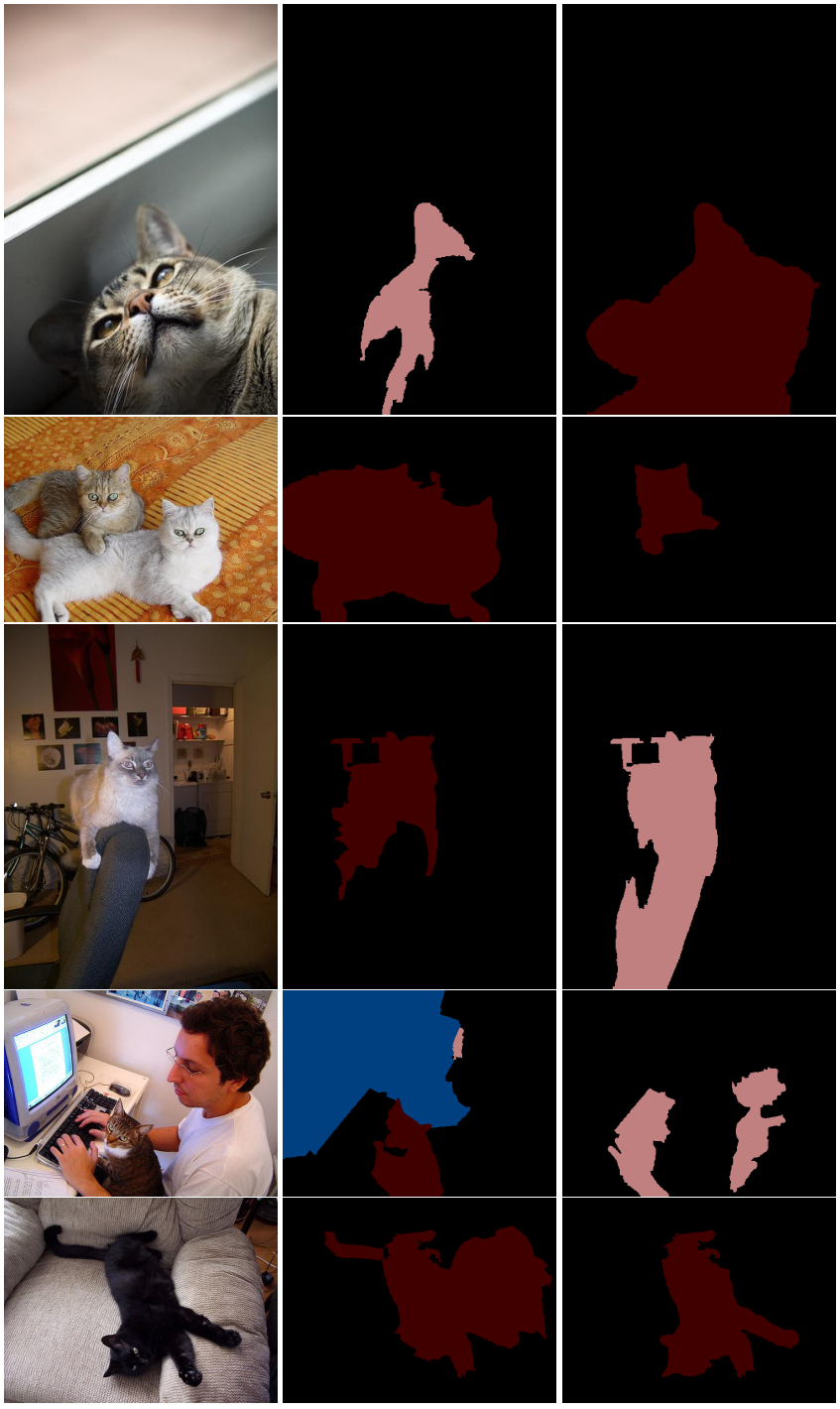

Figure 99: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling and cartesian-based Spatial Pyramid over Figure.

6.9 Chair

Figure 100: Example of ground truth annotation for the *chair* class.

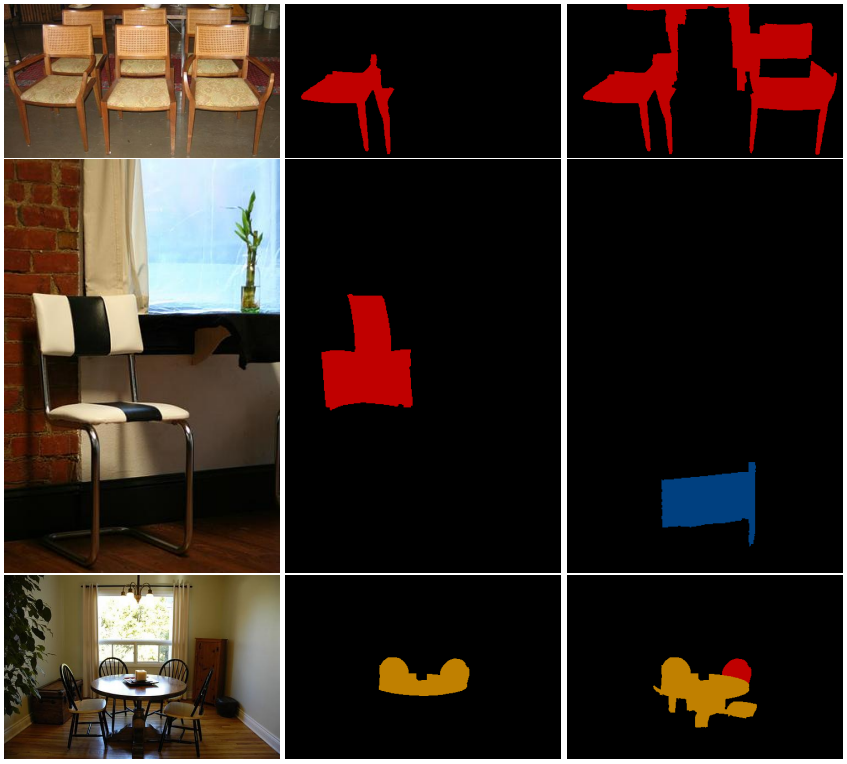

Figure 101: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling and cartesian-based Spatial Pyramid over Figure.

Figure 102: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling and cartesian-based Spatial Pyramid over Figure.

6.10 Cow

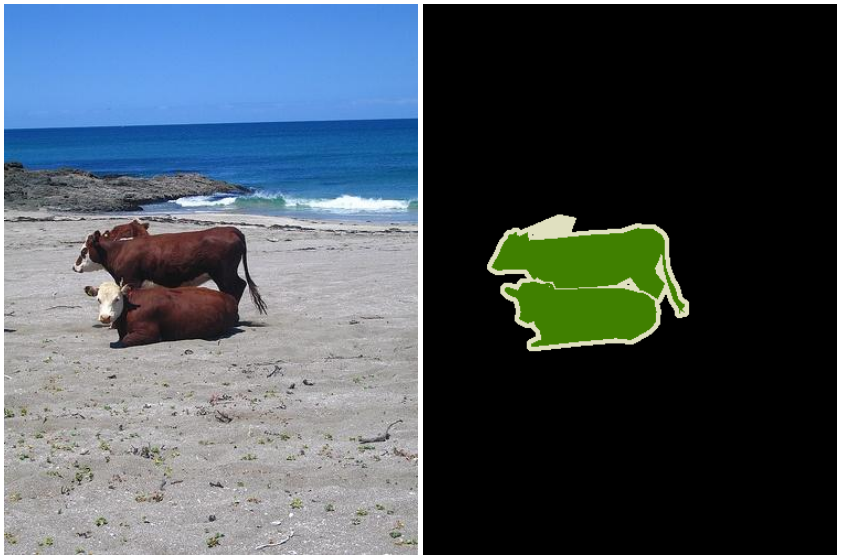

Figure 103: Example of ground truth annotation for the *cow* class.

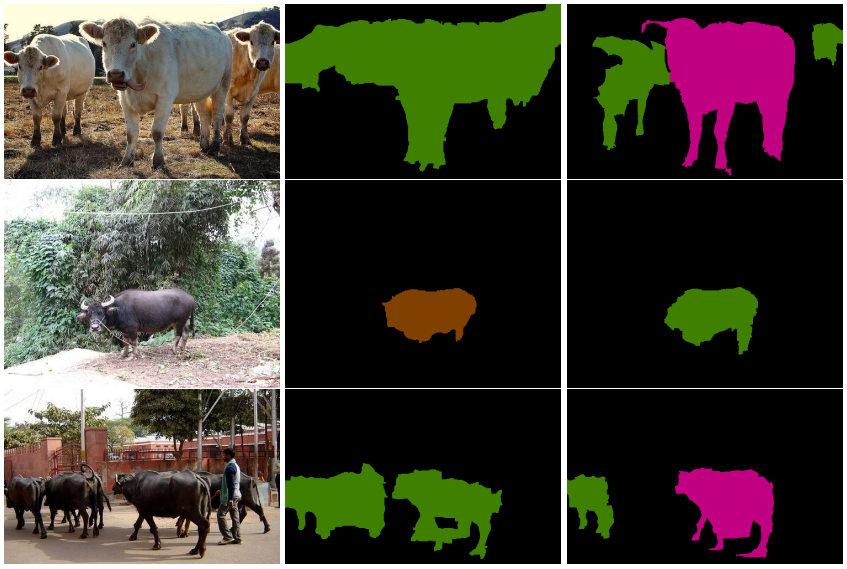

Figure 104: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling and cartesian-based Spatial Pyramid over Figure.

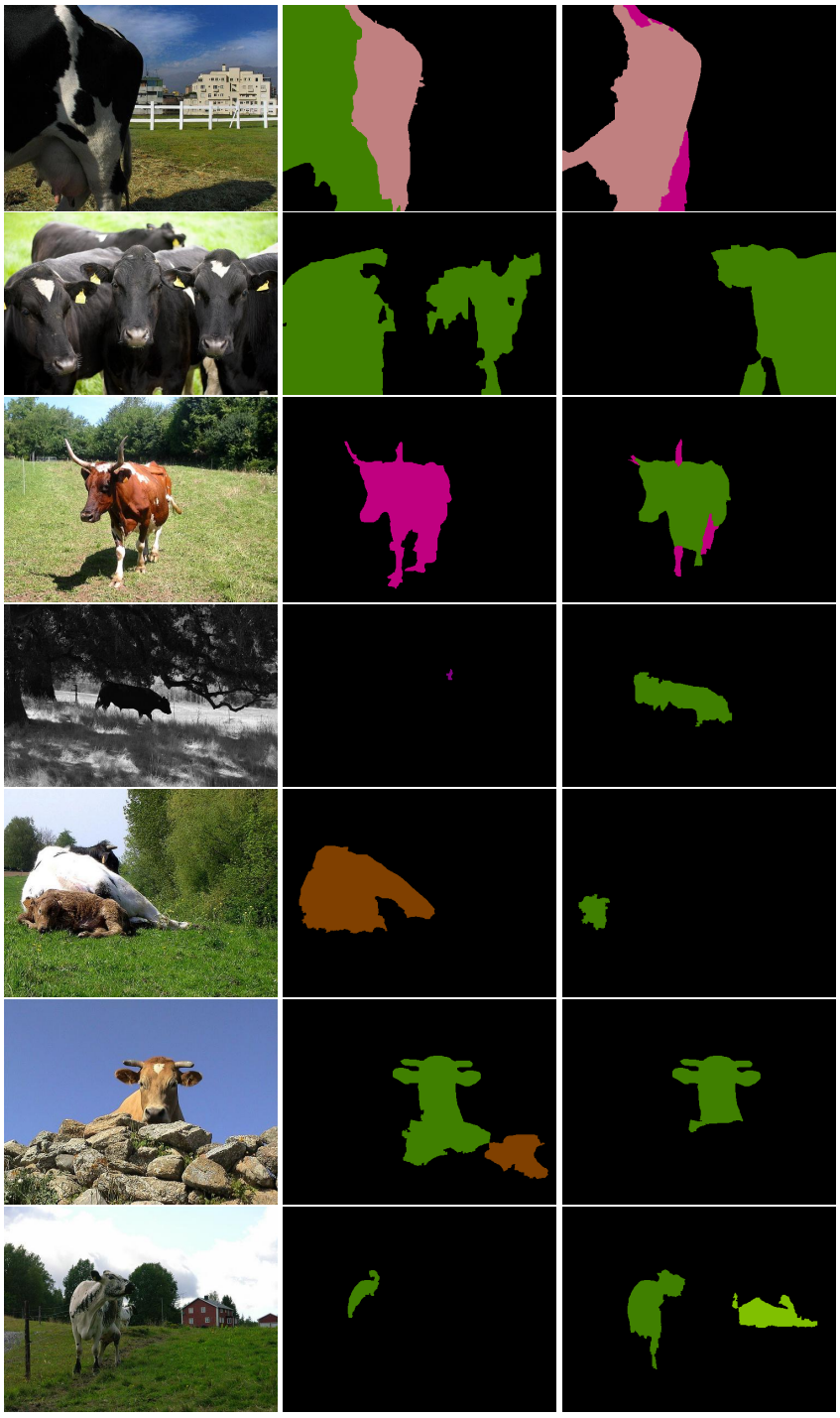

Figure 105: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling and cartesian-based Spatial Pyramid over Figure.

Figure 106: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling and cartesian-based Spatial Pyramid over Figure.

6.11 Diningtable

Figure 107: Example of ground truth annotation for the *diningtable* class.

Figure 108: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling and cartesian-based Spatial Pyramid over Figure.

Figure 109: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling and cartesian-based Spatial Pyramid over Figure.

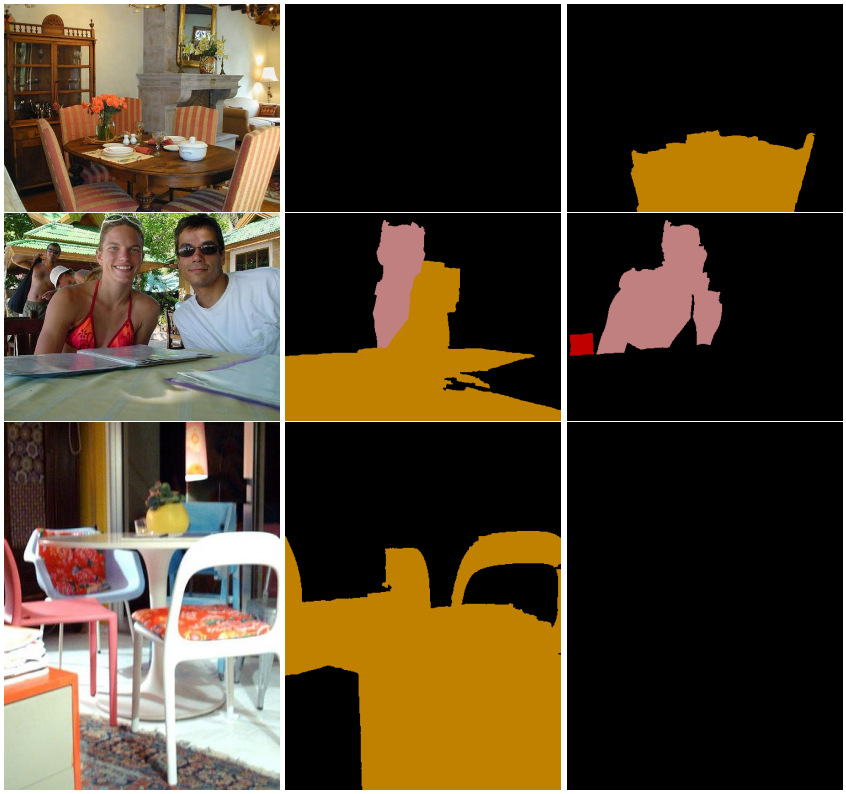

Figure 110: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling and cartesian-based Spatial Pyramid over Figure.

6.12 Dog

Figure 111: Example of ground truth annotation for the *dog* class.

Figure 112: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling and cartesian-based Spatial Pyramid over Figure.

Figure 113: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling and cartesian-based Spatial Pyramid over Figure.

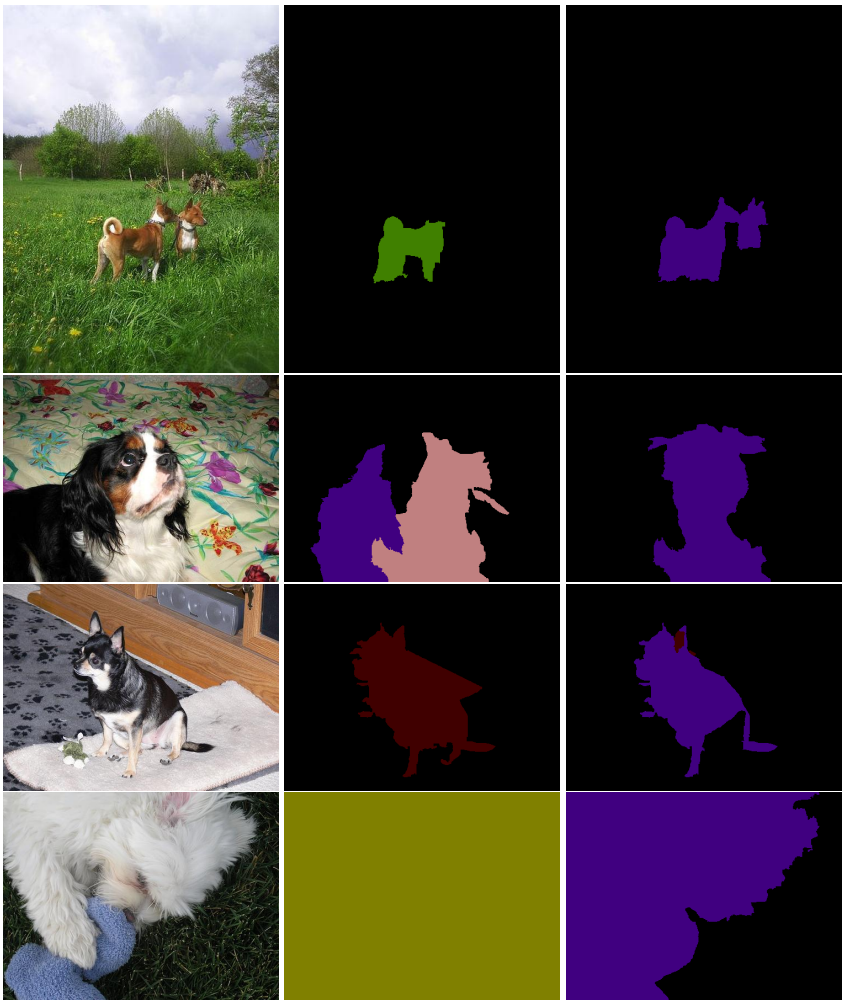

Figure 114: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling and cartesian-based Spatial Pyramid over Figure.

6.13 Horse

Figure 115: Example of ground truth annotation for the *horse* class.

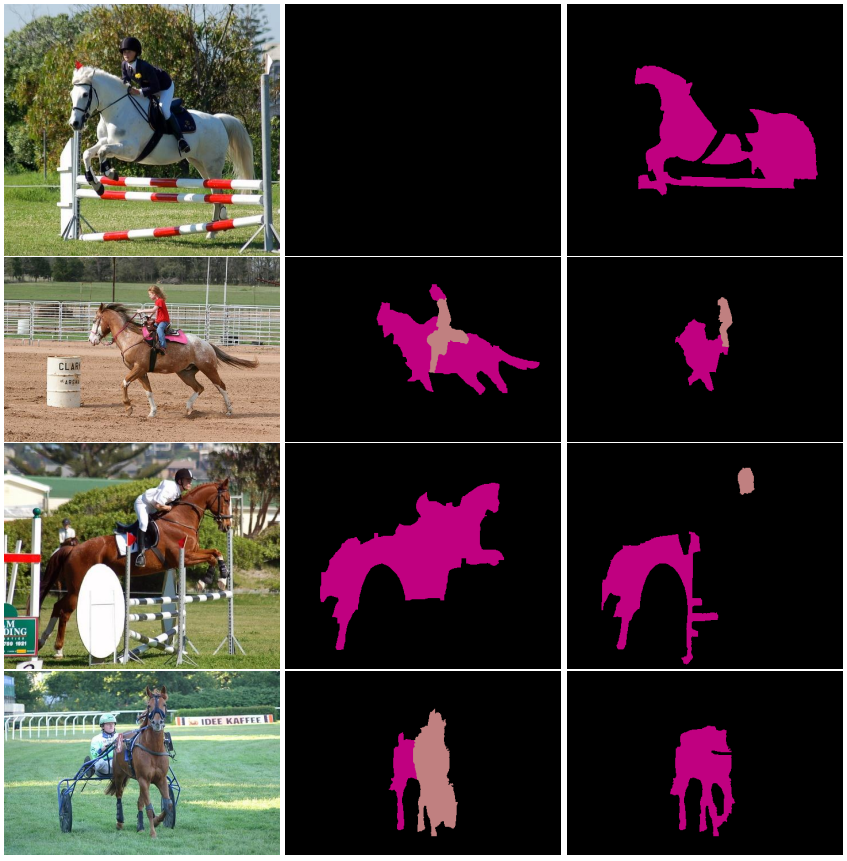

Figure 116: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling and cartesian-based Spatial Pyramid over Figure.

Figure 117: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling and cartesian-based Spatial Pyramid over Figure.

Figure 118: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling and cartesian-based Spatial Pyramid over Figure.

6.14 Motorbike

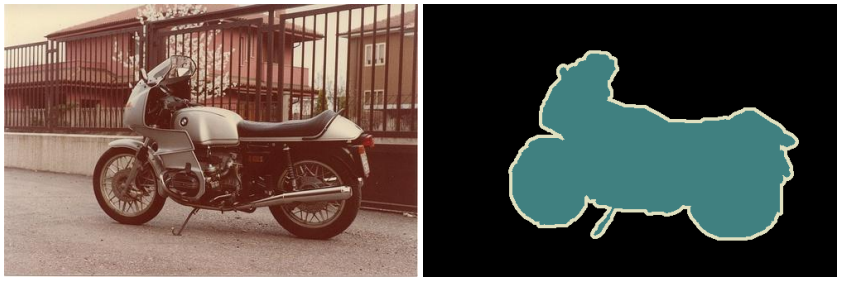

Figure 119: Example of ground truth annotation for the *motorbike* class.

Figure 120: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling and cartesian-based Spatial Pyramid over Figure.

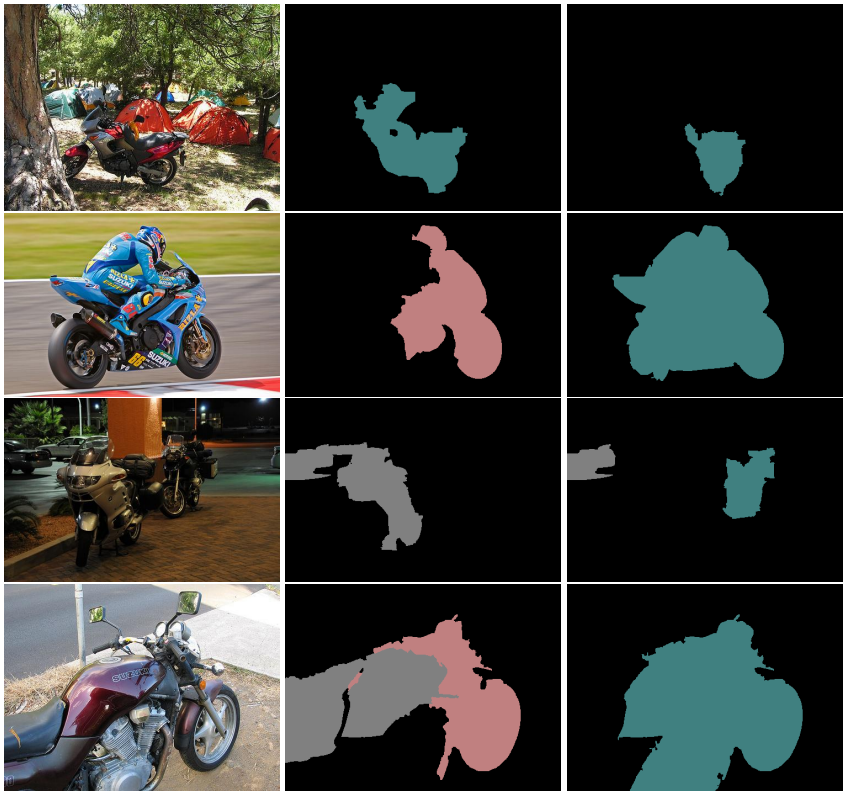

Figure 121: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling and cartesian-based Spatial Pyramid over Figure.

6.15 Person

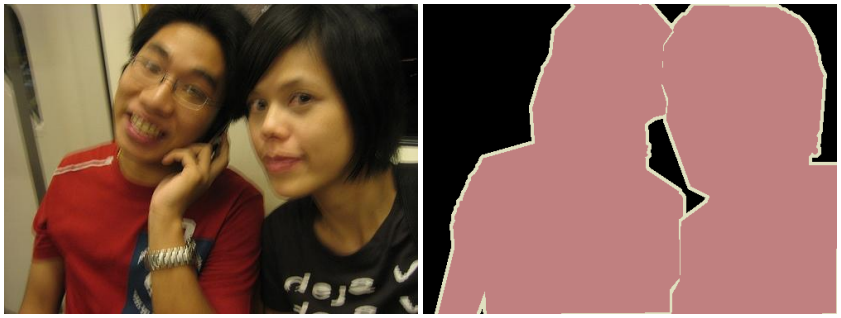

Figure 122: Example of ground truth annotation for the *person* class.

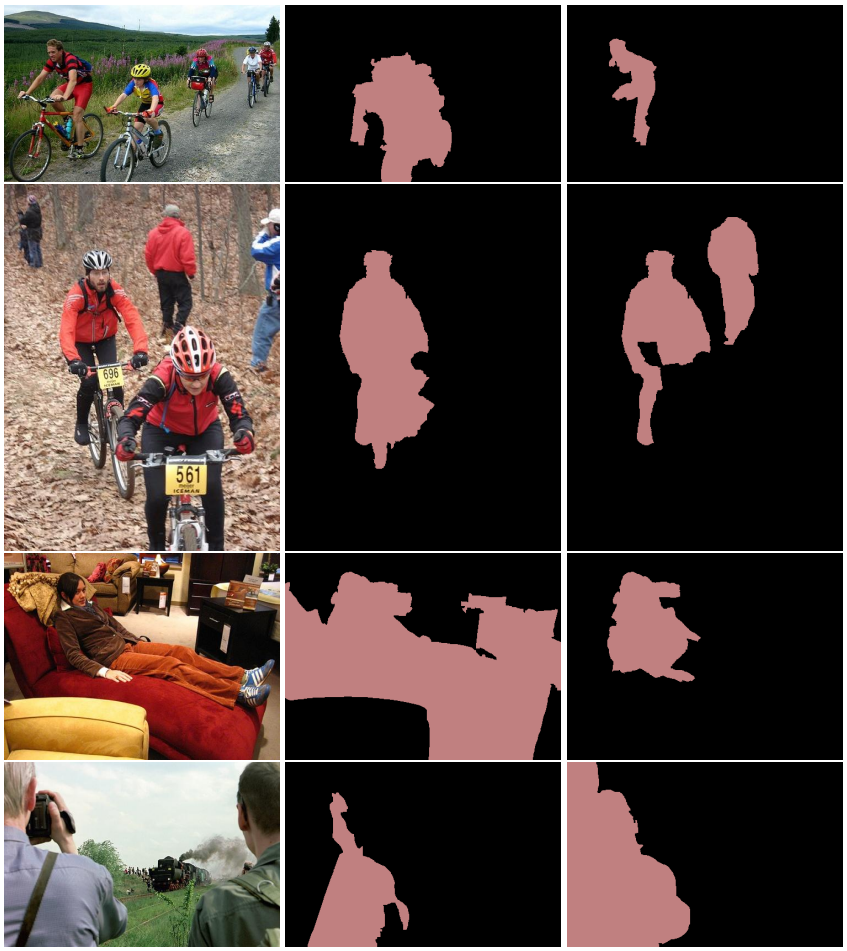

Figure 123: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling and cartesian-based Spatial Pyramid over Figure.

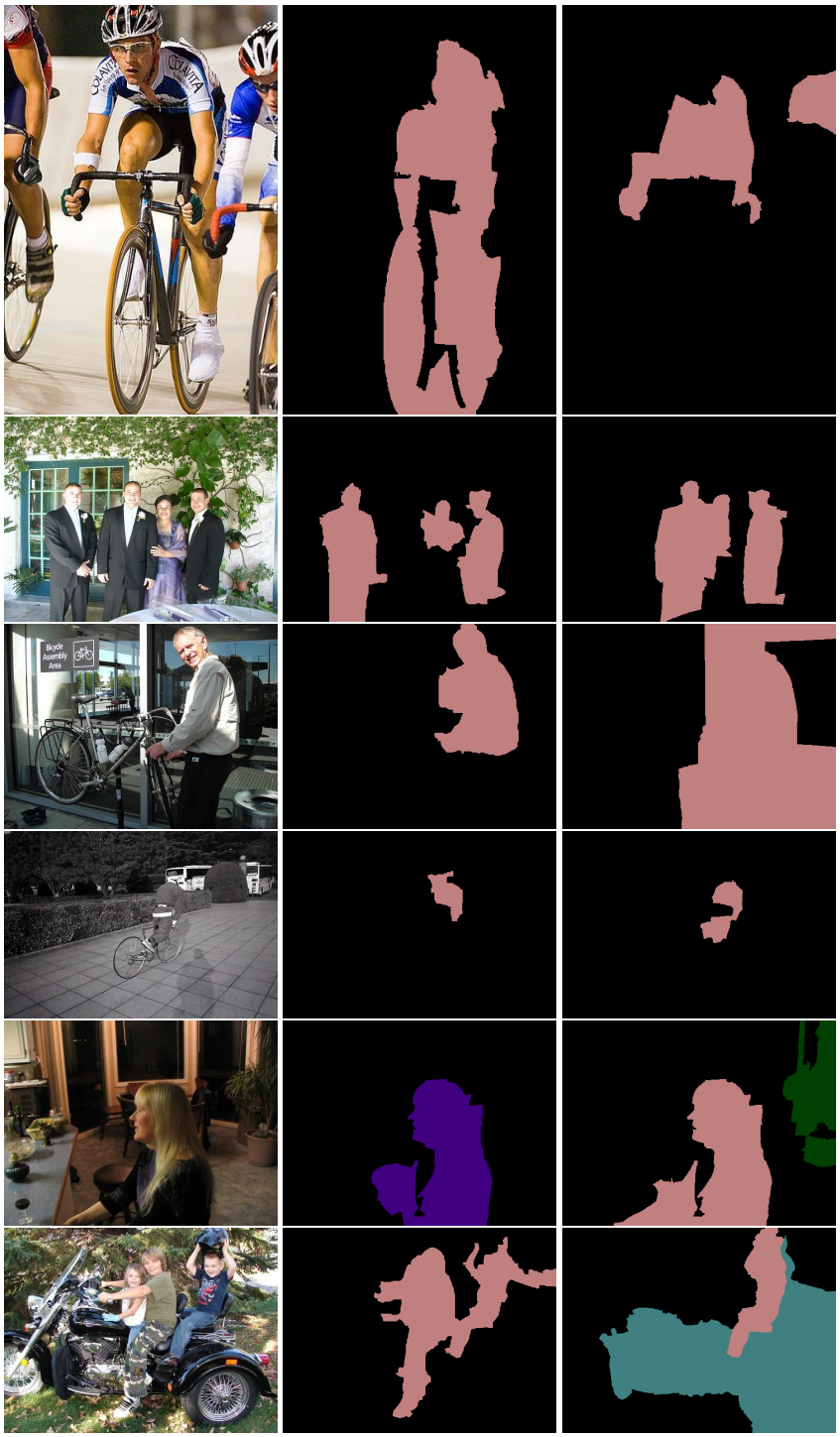

Figure 124: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling and cartesian-based Spatial Pyramid over Figure.

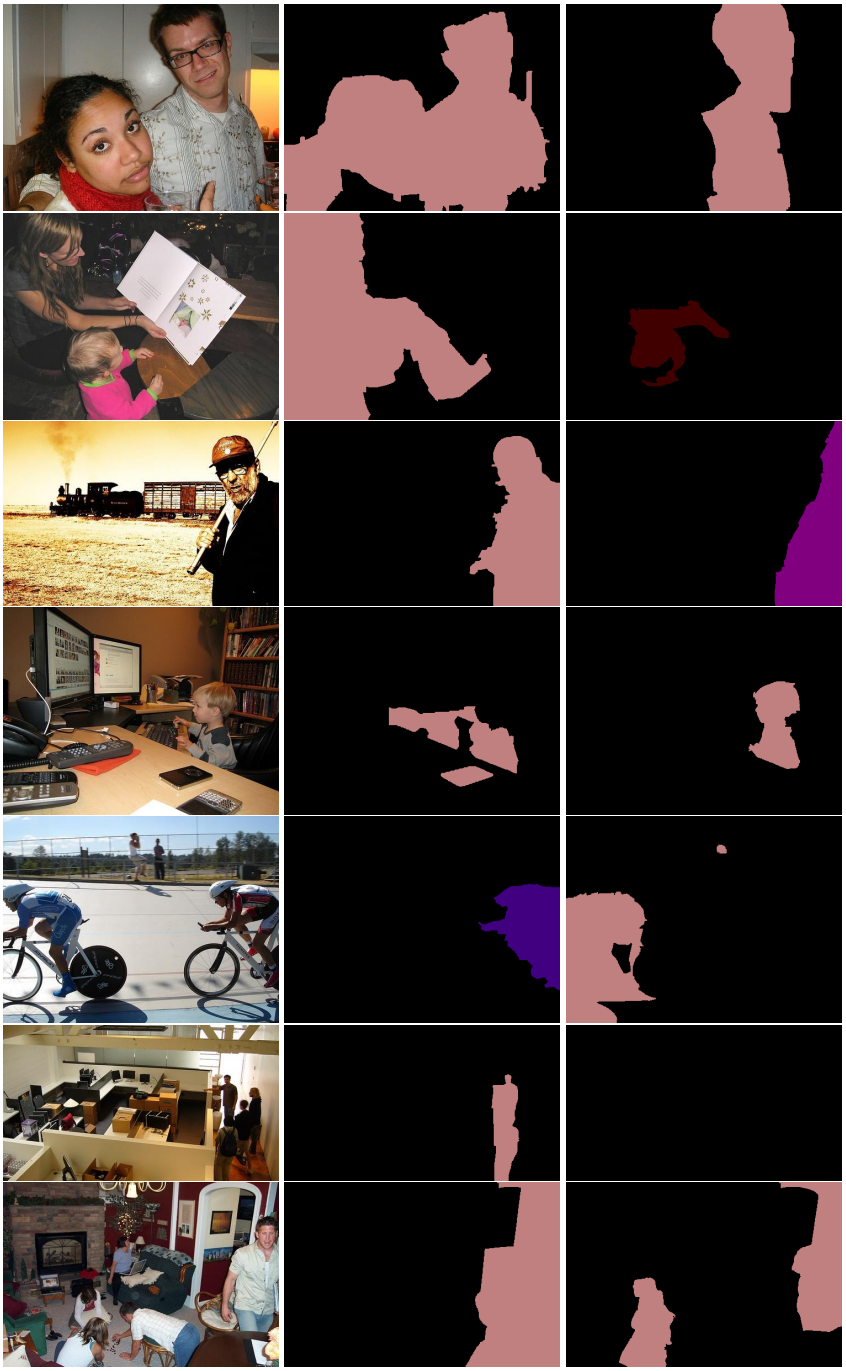

Figure 125: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling and cartesian-based Spatial Pyramid over Figure.

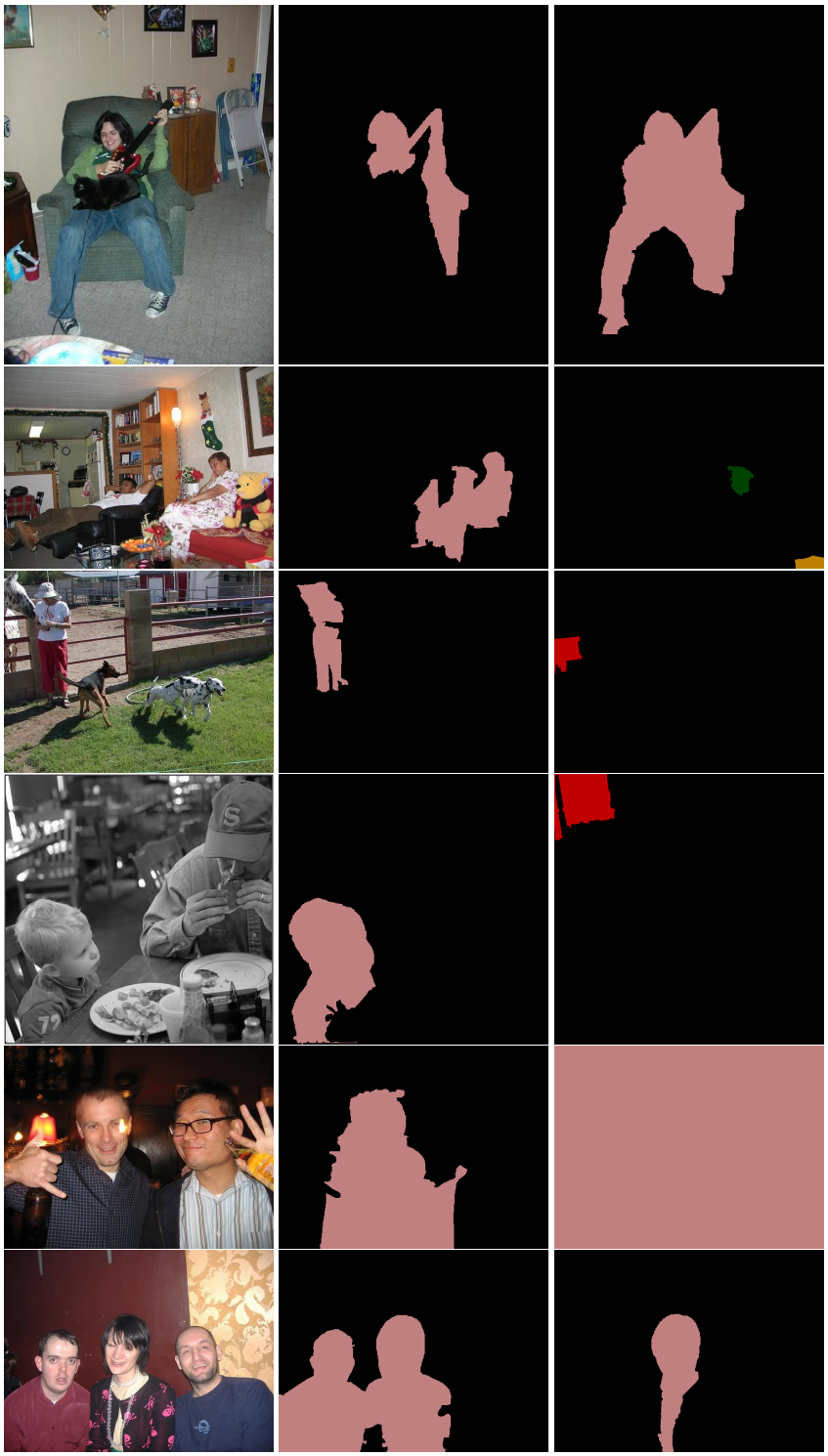

Figure 126: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling and cartesian-based Spatial Pyramid over Figure.

Figure 127: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling and cartesian-based Spatial Pyramid over Figure.

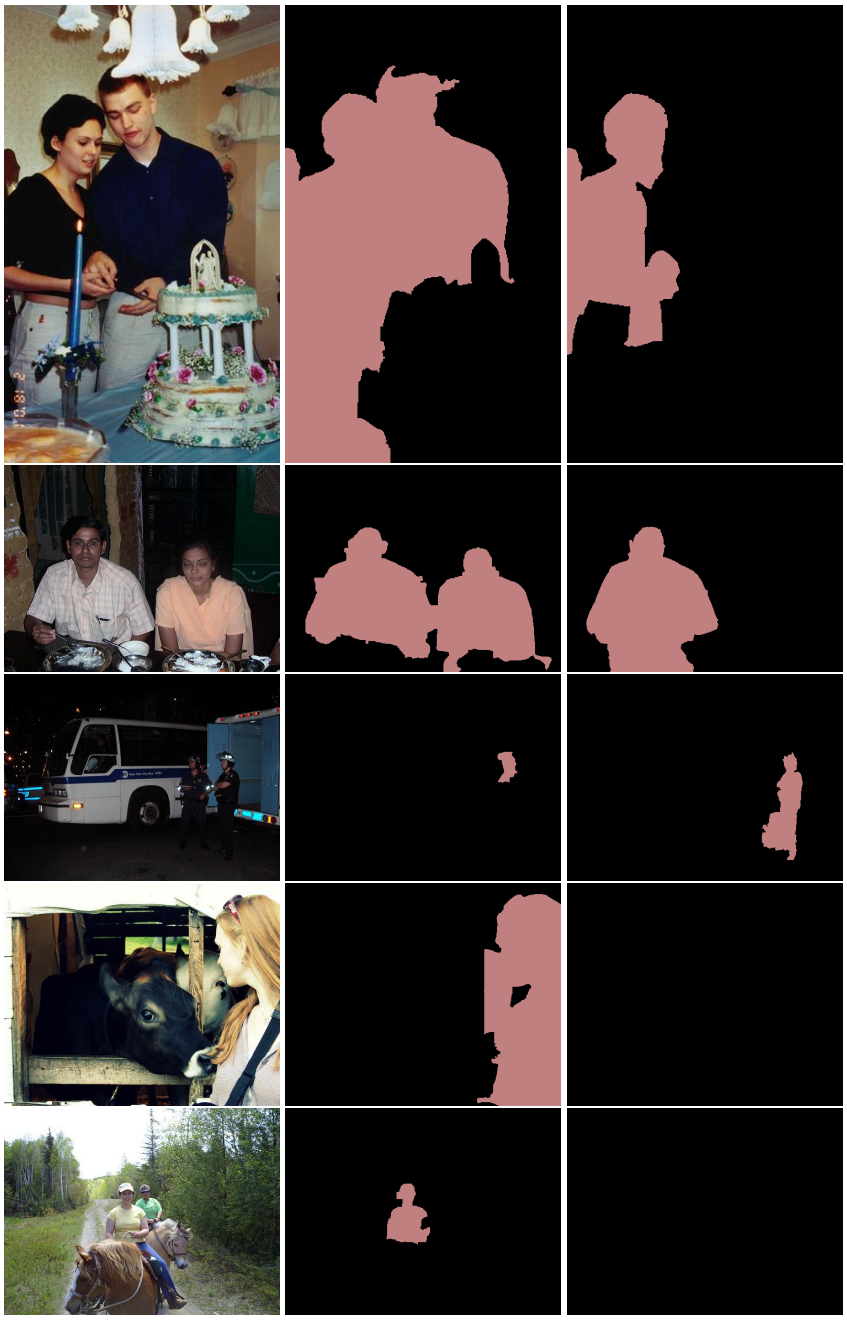

Figure 128: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling and cartesian-based Spatial Pyramid over Figure.

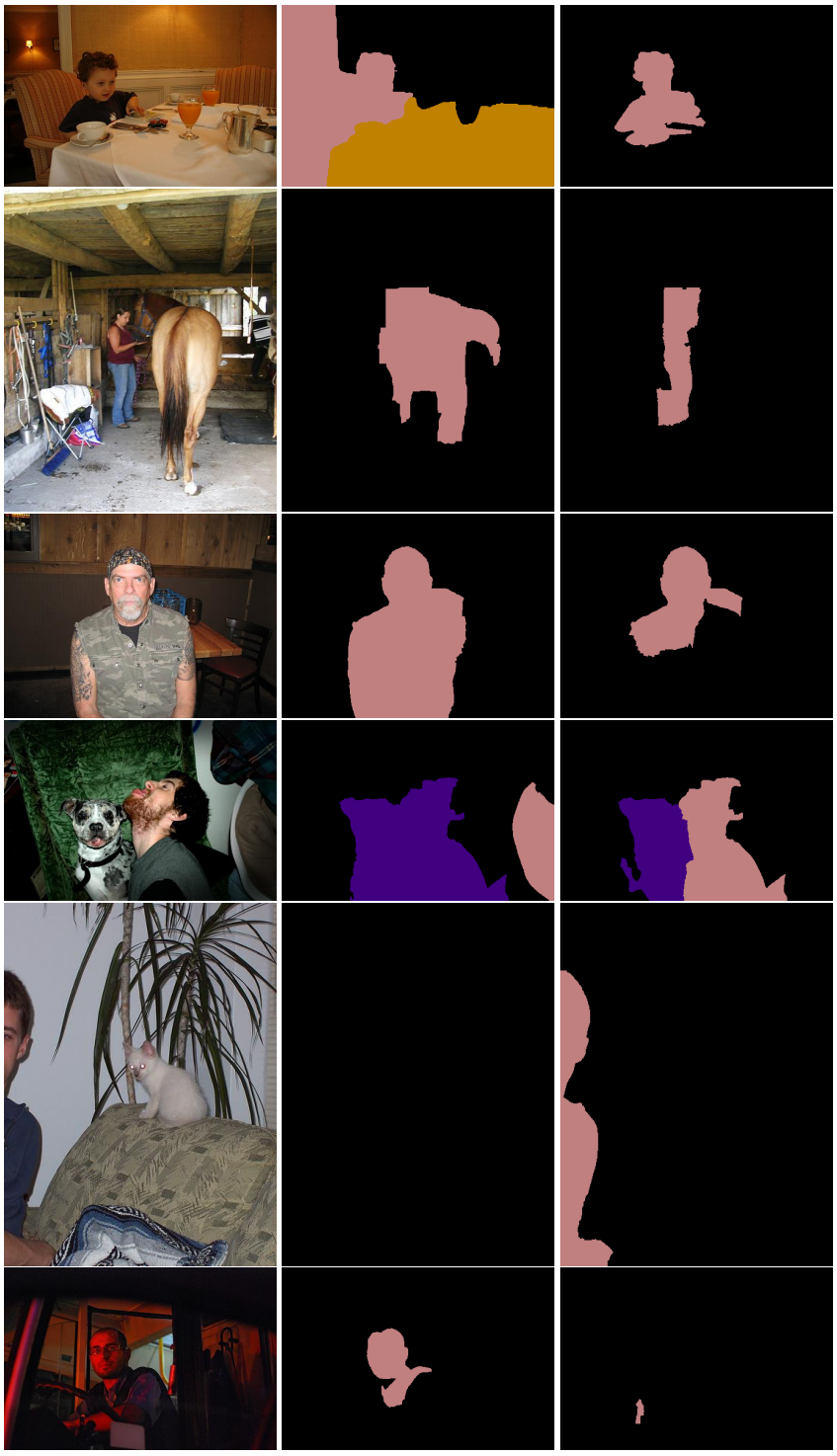

Figure 129: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling and cartesian-based Spatial Pyramid over Figure.

Figure 130: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling and cartesian-based Spatial Pyramid over Figure.

Figure 131: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling and cartesian-based Spatial Pyramid over Figure.

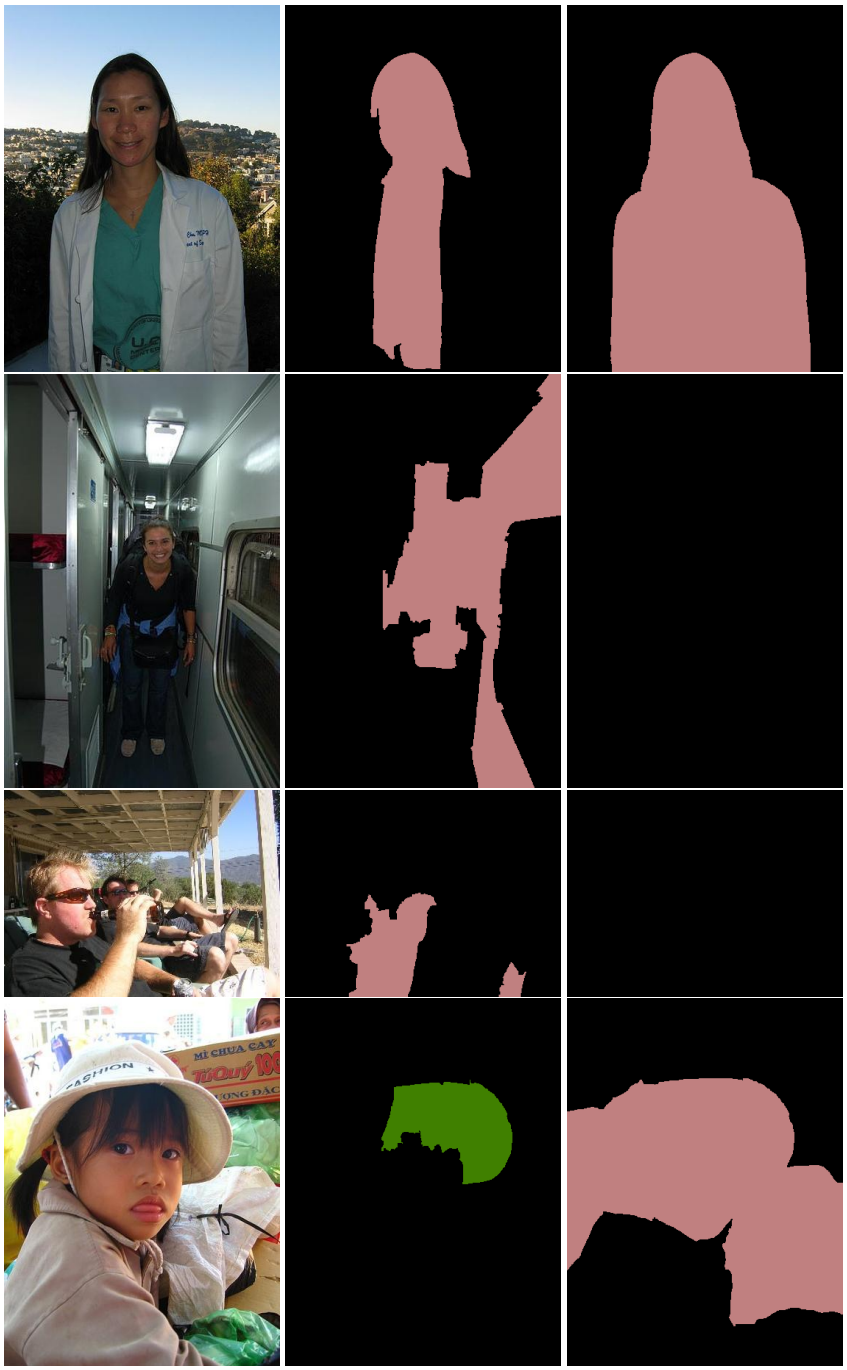

Figure 132: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling and cartesian-based Spatial Pyramid over Figure.

6.16 Pottedplant

Figure 133: Example of ground truth annotation for the *pottedplant* class.

Figure 134: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling and cartesian-based Spatial Pyramid over Figure.

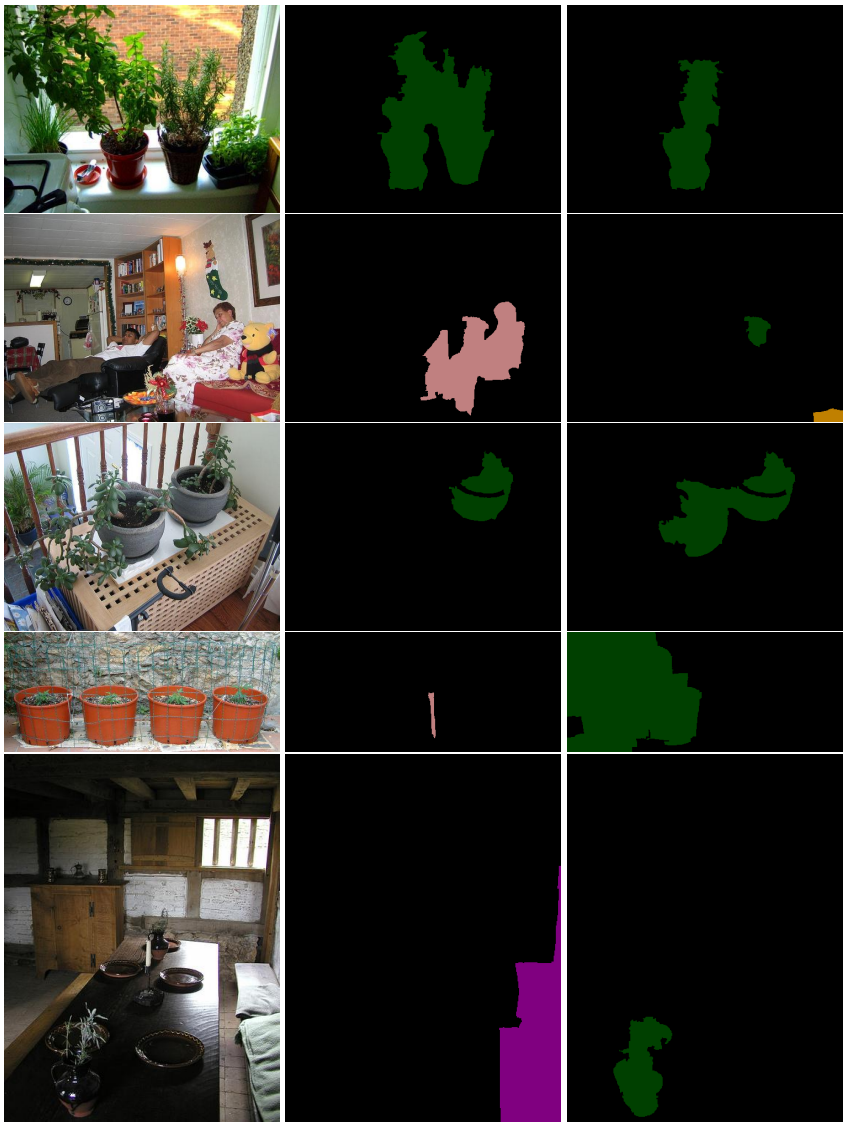

Figure 135: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling and cartesian-based Spatial Pyramid over Figure.

6.17 Sheep

Figure 136: Example of ground truth annotation for the *sheep* class.

Figure 137: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling and cartesian-based Spatial Pyramid over Figure.

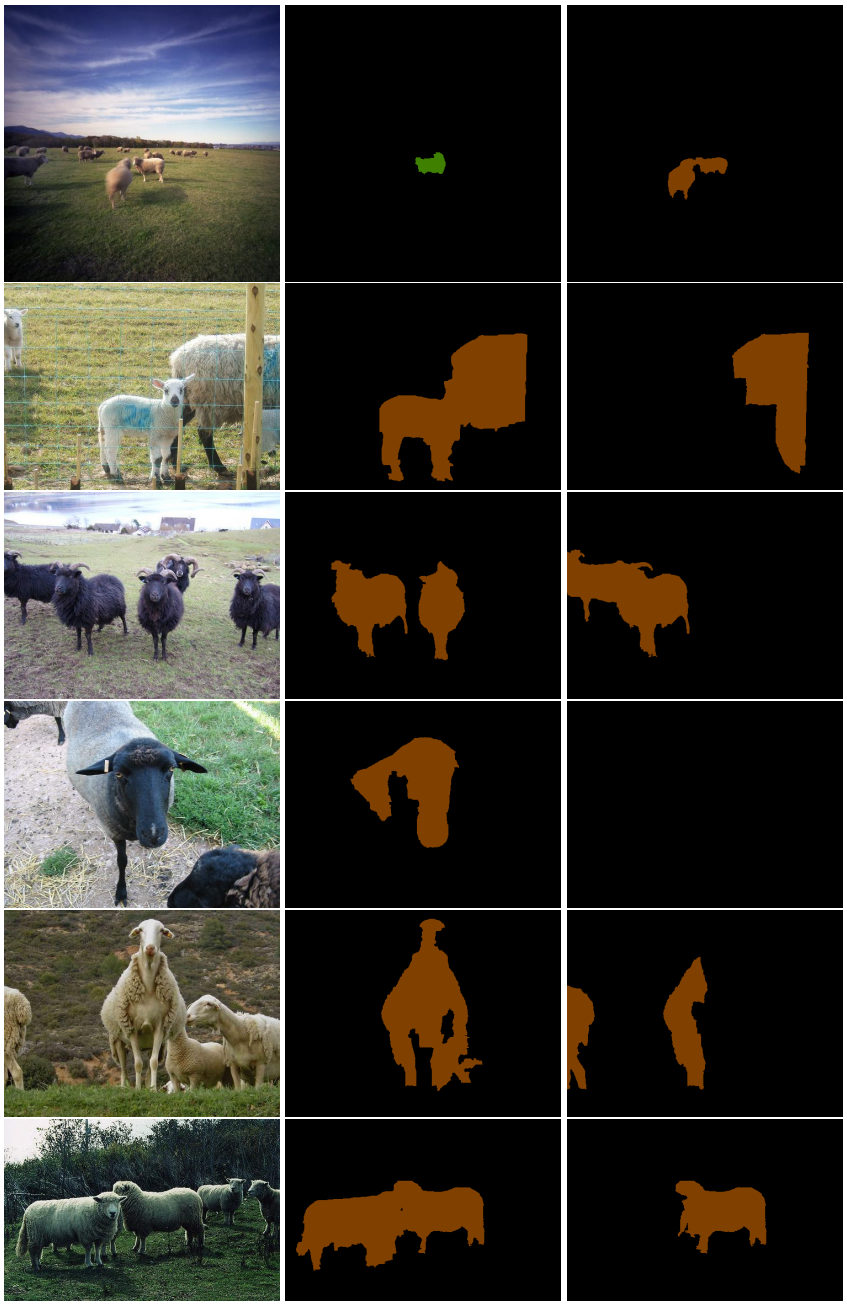

Figure 138: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling and cartesian-based Spatial Pyramid over Figure.

6.18 Sofa

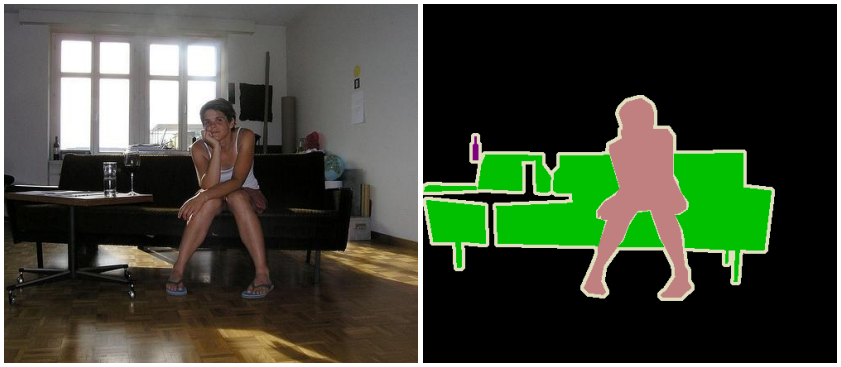

Figure 139: Example of ground truth annotation for the *sofa* class.

Figure 140: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling and cartesian-based Spatial Pyramid over Figure.

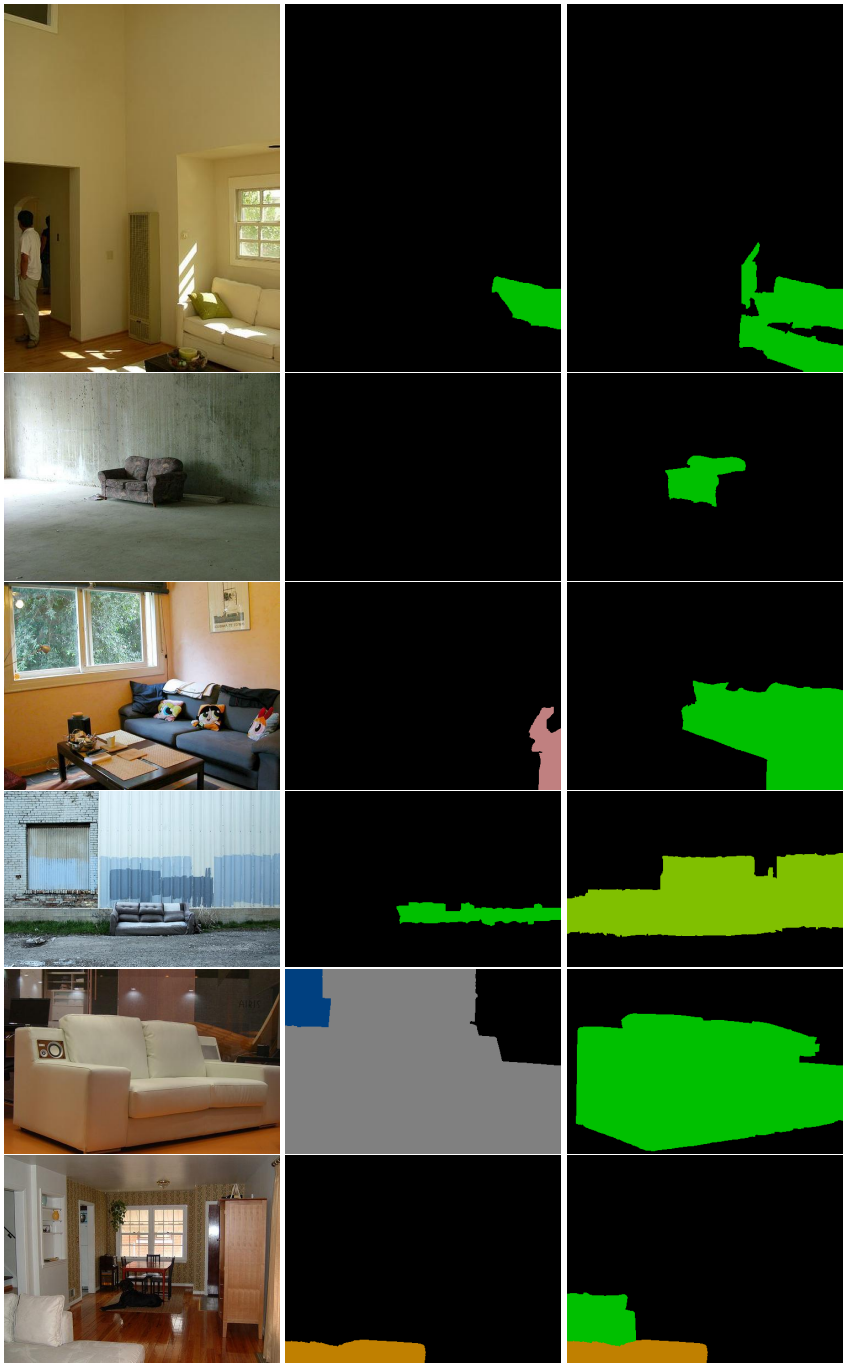

Figure 141: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling and cartesian-based Spatial Pyramid over Figure.

6.19 Train

Figure 142: Example of ground truth annotation for the *train* class.

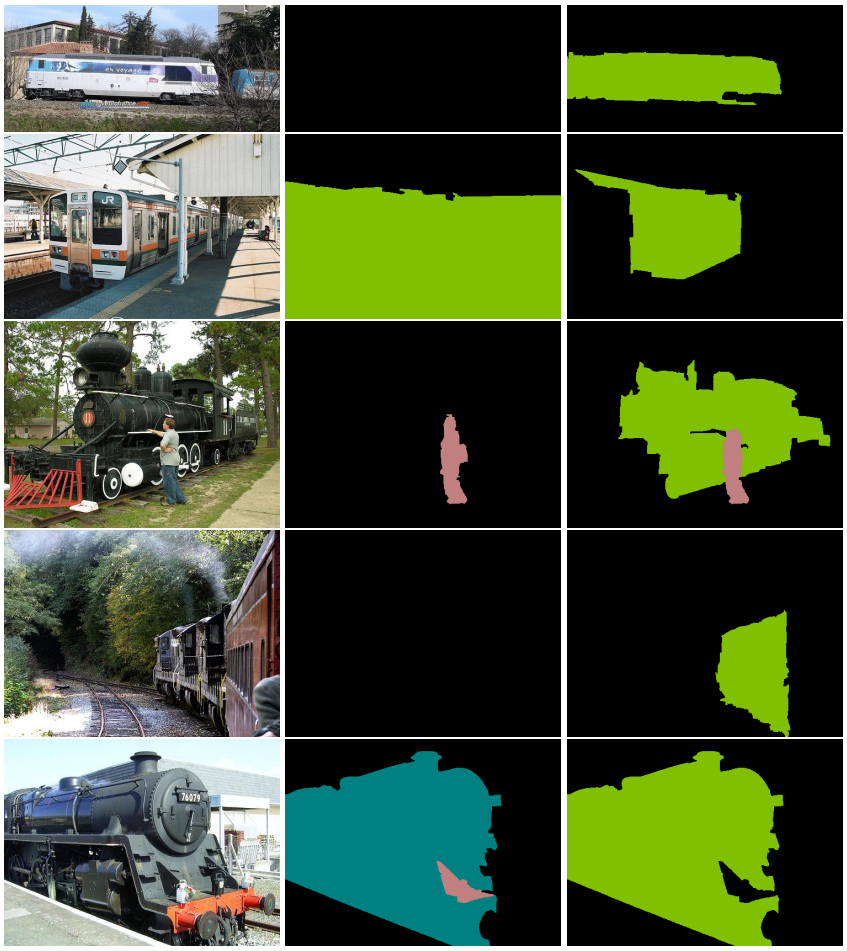

Figure 143: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling and cartesian-based Spatial Pyramid over Figure.

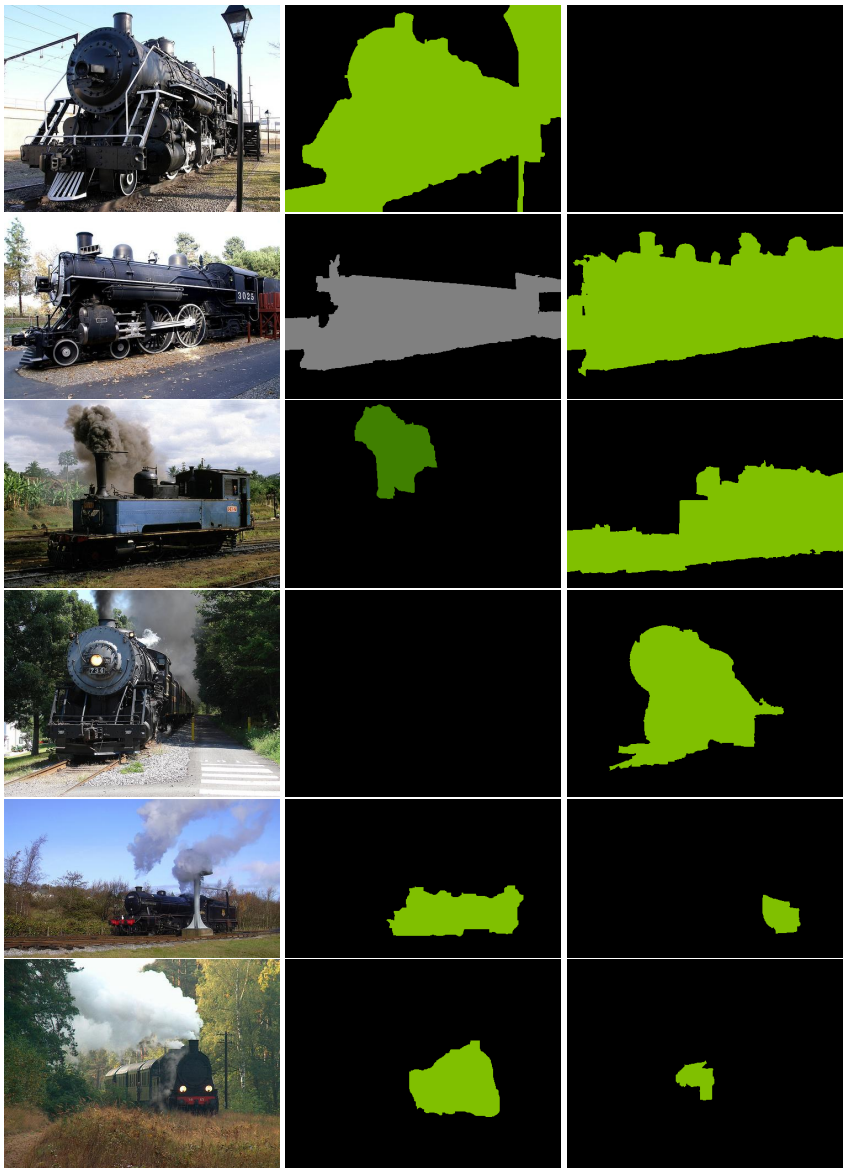

Figure 144: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling and cartesian-based Spatial Pyramid over Figure.

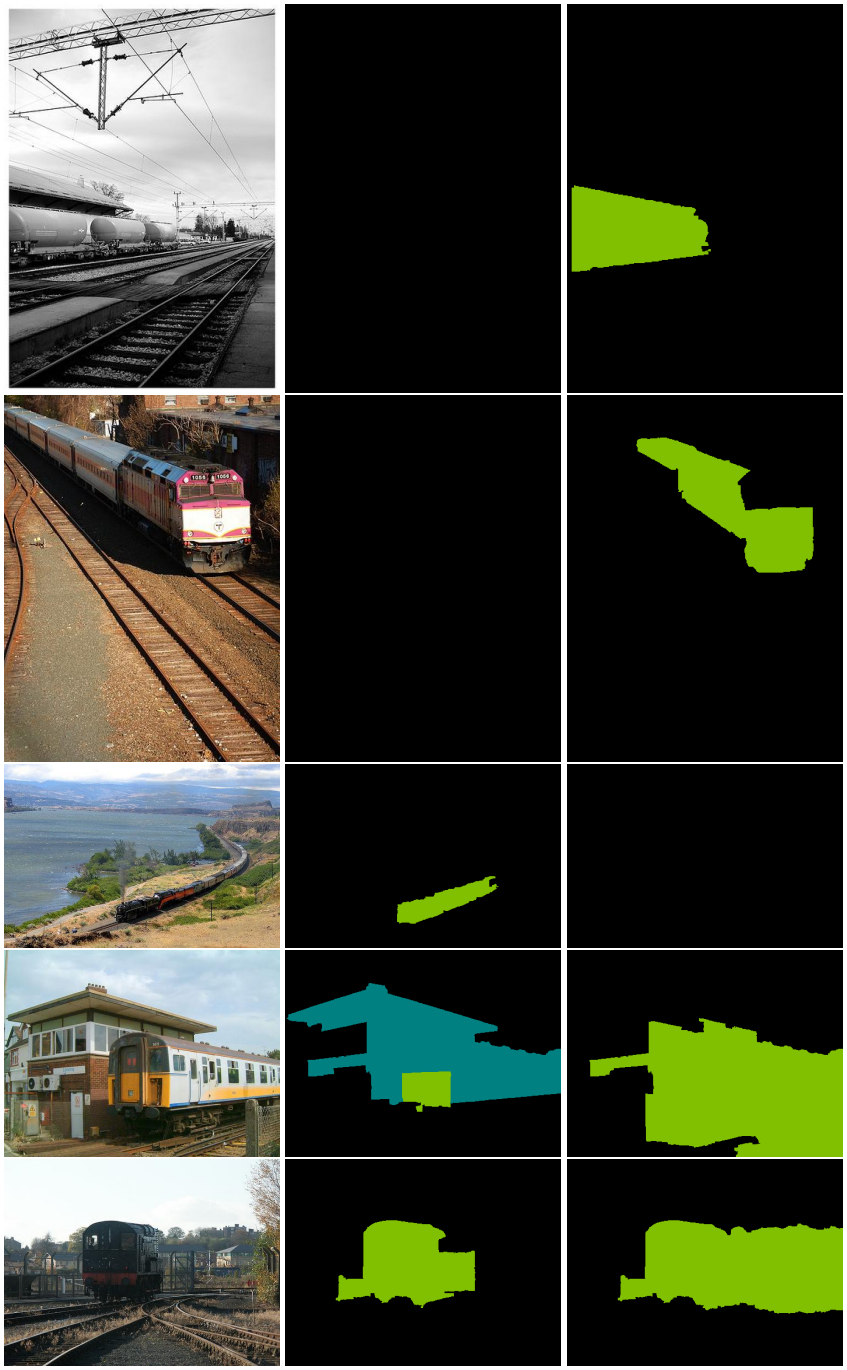

Figure 145: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling and cartesian-based Spatial Pyramid over Figure.

6.20 Tvmonitor

Figure 146: Example of ground truth annotation for the *tvmonitor* class.

Figure 147: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling and cartesian-based Spatial Pyramid over Figure.

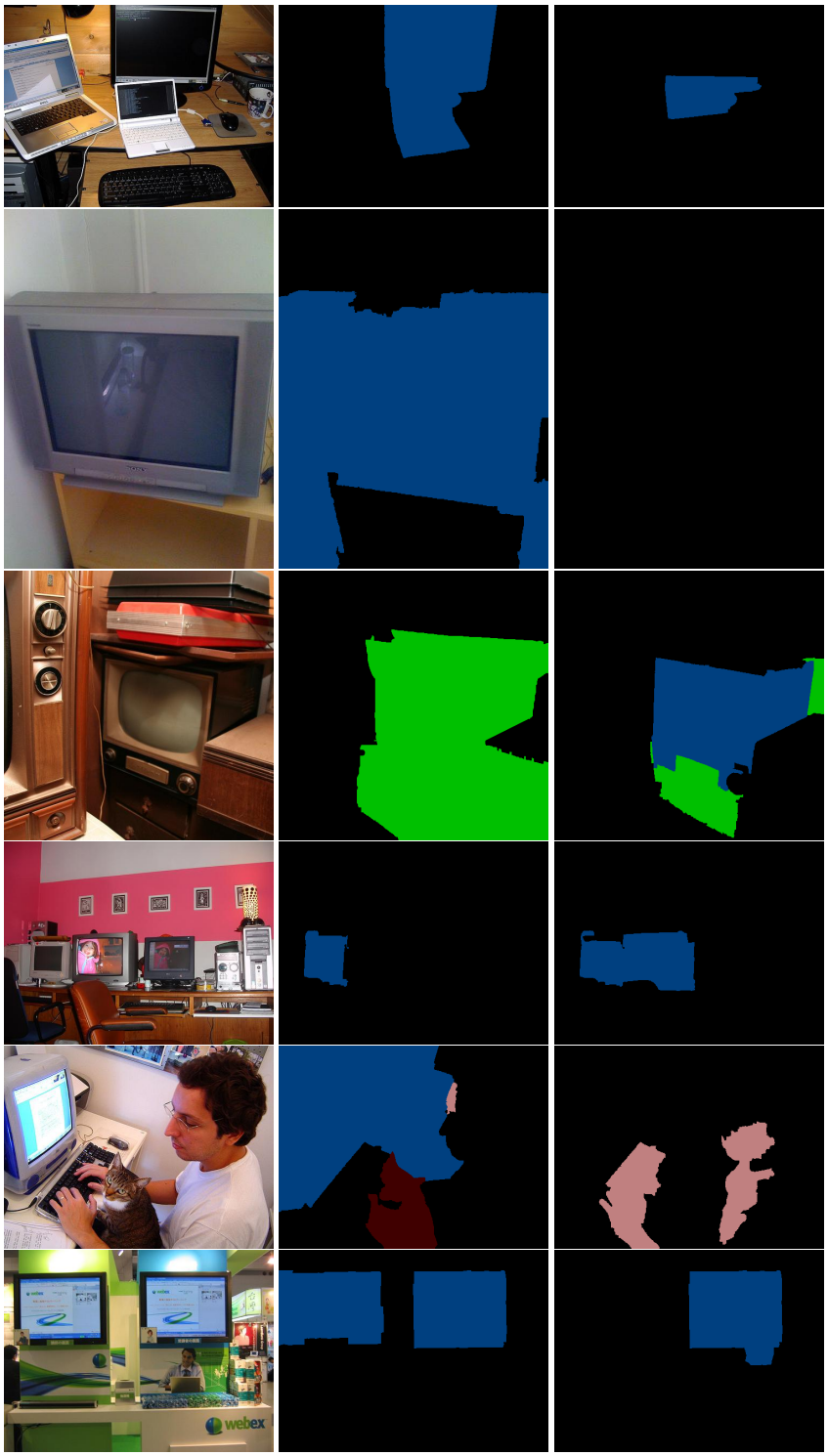

Figure 148: Left: images to be semantic segmented. Middle: solution based on a Figure-Ground spatial pooling [1]. Right: solution based on a Figure-Border-Ground spatial pooling and cartesian-based Spatial Pyramid over Figure.

References

[1] J. Carreira, R. Caseiro, J. Batista, and C. Sminchisescu. Semantic segmentation with second-order pooling. In A. Fitzgibbon, S. Lazebnik, P. Perona, Y. Sato, and C. Schmid, editors, *Computer Vision – ECCV 2012*, volume 7578 of *Lecture Notes in Computer Science*, pages 430–443. Springer Berlin Heidelberg, 2012.