Weekly Exercise 7

Dr. Csaba Domokos and Lingni Ma
Technische Universität München, Computer Vision Group
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Fast Primal-Dual Schema (2 points)

Exercise 1 (**Complementary slackness,** 2 Points)**.** Let (x, y) be a pair of integral primal and dual feasible solutions to the linear programming relaxation of the multilabel problem:

$$\min_x \ \langle c, x\rangle \qquad\qquad \max_y \ \langle b, y\rangle$$
$$Ax = b, x \geq 0. \qquad\qquad A^T y \leq c.$$

If (x, y) satisfy the relaxed primal complementary slackness conditions

$$\forall x_j > 0 \Rightarrow \sum_{i=1}^{m} a_{ij} y_i \geq c_j / \varepsilon_j ,$$

show that then x is an ε-approximation to the optimal integral solution x^* with $\varepsilon = \max_j \varepsilon_j$.

Programming (9 points)

Exercise 2 (**Multi-class image segmentation via FastPD algorithm**, 9 points)**.** In Exercise 6, we have implemented the α-expansion algorithm to solve the image segmentation for the images shown in figure 1. In this exercise, we consider the same settings, but the goal is to implement the PD1 algorithm in order to solve the segmentation. Again, consider the energy function

$$E(\mathbf{y}, \mathbf{x}) = \sum_{i \in \mathcal{V}} E_i(y_i; x_i) + w \sum_{i,j \in \mathcal{E}} E_{ij}(y_i, y_j; x_i, x_j) \quad , \tag{1}$$

for the multi-class labeling problem, i.e. $\mathbf{y} \in \mathcal{L}^{\mathcal{V}}$, where $\mathcal{L}$ stands for the label set. The test images come from a subset of the MSRC image understanding dataset, which contains 21 classes, i.e. $\mathcal{L} = \{1, 2, \ldots, 21\}$.

To define the unary energy functions E_i, use the provided `*.c_unary` files. Each test image has its own unary file, specified by the same filename. In each unary file, you can read out a $K \times H \times W$ array of float numbers. The H and W are the image height and width, and $K = 21$ is the number of possible classes. This array contains the 21-class probability distribution for each pixel. We provide the `multilabel_demo.cpp` to demonstrate how to load the unary file and read out the corresponding probability values. The unary energy functions E_i for all $i \in \mathcal{V}$ are then defined as

$$E_i(y_i = l) = -\log(p_l) \ . \tag{2}$$

The pairwise energy is again defined by the contrast sensitive Potts-model,

$$E_{ij}(y_i, y_j; x_i, x_j) = \exp(-\lambda \|x_i - x_j\|^2)[\![y_i \neq y_j]\!] \ . \tag{3}$$

- Choose different w for Equation (1) and compare the segmentation results.
- The meaning of the classes are specified in the `21class.txt` file. Use it to check if your results make sense.
- Compare the results to the ones that you obtained earlier with α-expansion.

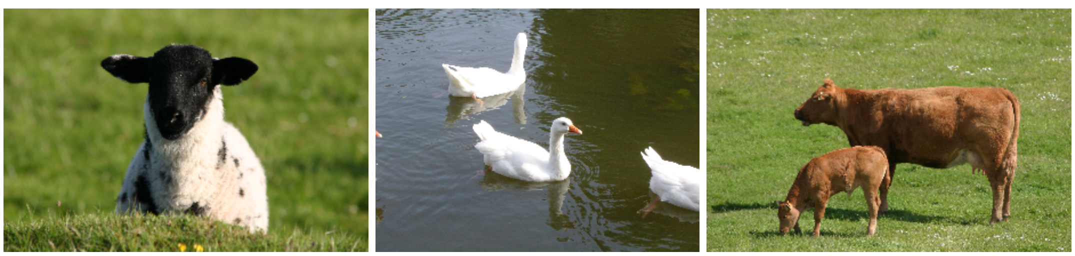

Figure 1: The target images for multi-class image segmentation.