Variational Methods for Computer Vision
Lecture: M. Möller
Exercises: J. Geiping
Winter Semester 17/18

Visual Scene Analysis
Institute for Computer Science
University of Siegen

Weekly Exercises 12

Room: H-C 6336
Friday, 26.01.2018, 14:15-15:45
Submission deadline: Tuesday, 23.01.2018, 14:15
Programmming: Email your solution to `jonas.geiping@uni-siegen.de`

Theory:

Exercise 1 (4 points)**.** Consider the variational formulation for stereo matching from the lecture

$$\sum_{(x,y)\in\tilde{\Omega}} (f_1(x,y) - f_2(x + v(x,y), y))^2 + \sum_{(x,y)\in\tilde{\Omega}} \sqrt{(D_x v(x,y))^2 + (D_y v(x,y))^2 + \epsilon^2}$$

in which f_2 has to remain a function on Ω in order to give sense to all real values $v(x,y)$.

- Derive a formula for the *gradient descent* iteration for the minimization for v.
- Your formula will contain a partial derivative of f_2 with respect to the first component. How would you discretize and treat this part numerically?

Exercise 2 (4 Points)**.** Consider a two region segmentation method, that optimizes for the grey values $c_o \in \mathbb{R}$ and $c_b \in \mathbb{R}$ of the object and background on its own during the optimization of u. To do so, consider the function

$$E(u, c_o, c_b) = \sum_i (c_0 - f_i)^2 u_i + (c_b - f_i)^2 (1 - u_i) + \alpha \sqrt{(D_x u)_i^2 + (D_y u)_i^2 + \epsilon^2}$$

as an energy in u, c_o, and c_b.
Derive the optimality conditions for c_o and c_b for a fixed u. Then find explicit formulas, that compute c_o and c_b for a fixed u.

Programming: Semi- and fully-automatic segmentation

Exercise 3 (4 Points)**.** The goal of this exercise is to extend your previous (semi-automatic) implementation of the two region segmentation method to an automatic

segmentation method, as derived in exercise 2:
We consider the function

$$E(u, c_o, c_b) = \sum_i (c_0 - f_i)^2 u_i + (c_b - f_i)^2 (1 - u_i) + \alpha \sqrt{(D_x u)_i^2 + (D_y u)_i^2 + \epsilon^2}$$

as an energy in u, c_o, and c_b.

- Implement an algorithm that alternates between 10 steps of the gradient descent algorithm to find u and updating the constant values c_o and c_b.

- Test your algorithm with the microscope image in the supplementary material and try to find parameters to segment all three cells. The result is possibly bad at first glance, as the pixel intensity f_i might be inconsitent.
  Try to find a simple heuristic replacement for f_i, that could improve your results.
  Hint: For this kind of pre-processing you might want to think about filtering the image f.