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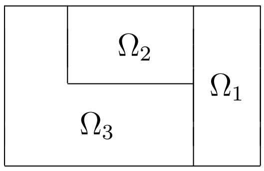
Homework Assignment 5

H 5.1 (Segmentation) 8 Points

Let the following 4×4 piecewise constant image with three regions be given:



$\Leftrightarrow$

14	6	6	2
14	6	6	2
14	14	14	2
14	14	14	2

where the size of each pixel is 1×1. Use the algorithm from Lecture 15 that approximates the solution of the *Mumford-Shah Cartoon model* for different scale parameters λ by successively increasing λ and merging adjacent regions. Specify all merging events, the corresponding scale parameters as well as the corresponding segmentations.

P 5.2 (PDE-based morphology - Dilation and Erosion)

Please download the required file `cv19_ex05.tgz` from ILIAS. To unpack the data, use `tar xvfz cv19_ex05.tgz` .

(a) In the file `pde_morphology.c`, supplement the routines `dilation_point` and `erosion_point` with the missing code such that they implement one iteration step for the pixel (i, j).

```
gcc -O3 -o pde_morphology pde_morphology.c -lm
```

(b) Use the program `pde_morphology` to perform dilation and erosion on the images `head.pgm` and `bank.pgm`.

(c) Why is it not possible to reconstruct the results from the lecture for `bank.pgm` with this implementation?

Remark: The program will be able to handle both color and gray images.

P 5.3 (PDE-based morphology - Shock Filter)

(a) In the same code file, supplement the routines `hessian` and `shock_filter` such that an implementation of the shock-filter is created. Since the program should be able to handle color images as well as gray value images, we extend our theoretical knowledge:

For color images, one could perform coherence enhancing shock filtering for each channel seperately. However, this would create shocks at different locations in each channel. Thus, Weickert [`http://www.mia.uni-saarland.de/Publications/weickert-dagm03.pdf`] proposed to synchronize the processes as follows:

i) Compute the joint structure tensor

$$J_{f_1,f_2,f_3} = \sum_{c=1}^{3} J_{f_c} = \sum_{c=1}^{3} K_\rho * \nabla f_c \nabla f_c^\top$$

ii) Compute the dominant direction η as dominant eigenvector of J_ρ

iii) Average second order derivatives in η direction: $v_{\eta\eta} = \sum_{c=1}^{3} v_{c\eta\eta}$

iv) Evolve the channels according to

$$\partial_t u_c = -\mathrm{sgn}(v_{\eta\eta})\, |\nabla u_c| \quad c = 1, 2, 3$$

Remark: We are interested in the sign of $v_{\eta\eta}$, so the factor $\frac{1}{3}$ is neglectible.
Remark: The second order derivatives should be computed using the hessian matrix:

$$v_{c\eta\eta} = \eta^\top H_{v_c} \eta; \qquad H_{v_c} = \begin{pmatrix} \partial_{xx} v_c & \partial_{xy} v_c \\ \partial_{xy} v_c & \partial_{yy} v_c \end{pmatrix}$$

Remark: Instead of averaging derivatives, one may average the Hessians (linearity).

(b) Check your implementation with the color image `baboon.ppm` and the gray image `finger.pgm`. You should be able to reproduce the results from the lecture slides.

(c) Take a photo of yourself and perform shock filtering with parameters at your taste. Most image formats can be converted to `ppm` using `convert image.xyz image.ppm`

Submission:

The theoretical problem(s) have to be submitted in handwritten form before the next tutorial (January 17th).

Deadline for Submission is: Friday, January 17th, 09:45 am (before the tutorial)

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Classroom Assignment 5

C 5.1 (Mean Curvature Motion)

Show that the various definitions of MCM on slide 5, lecture 17 are really equivalent.