Prof. Dr.-Ing. A. Bruhn
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Homework Assignment 4

H 4.1 (Isotropic flow-driven optical flow) 12 Points

Consider the following energy functional for optical flow computation

$$E(u,v) = \int_{\Omega} (f_x u + f_y v + f_t)^2 + \alpha \Psi\left(|\nabla u|^2 + |\nabla v|^2\right)\, dx dy \tag{1}$$

(a) Compute the Euler-Lagrange equations.

(b) Compute an analytical expression for the arising derivative $\Psi'(s^2)$ for

$$\Psi(s^2) = \lambda^2 \log\left(1 + \frac{s^2}{\lambda^2}\right)$$

(c) What is the relation to the isotropic nonlinear diffusion studied in Lecture 13?

(d) What is the effect of the function Ψ considering flow edges?

(e) How would the Euler-Lagrange equations change, if Ψ was applied to the data term instead?

(f) What could be the impact of this modification?

P 4.2 (Coherence-Enhancing Diffusion Filtering)

Please download the required file `cv19_ex04.tgz` from ILIAS. To unpack the data, use `tar xvfz cv19_ex04.tgz` .

(a) Supplement the file `diff_tensor.c` with the missing code. You may use the included routines for principle axis transformation and backtransformation. Compile the programme with

`gcc -O3 -o ced ced32.o diff_tensor.c -lm` (on 32-bit machines),
`gcc -O3 -o ced ced64.o diff_tensor.c -lm` (on 64-bit machines).

(b) Use the programme `ced` for enhancing the fingerprint image `finger.pgm` with the paramters $C = 1$, $\sigma = 0.5$, $\rho = 4$, $\alpha = 0.001$, $\tau = 0.2$, 40 iterations. You will observe that the extremum principle is violated by the standard discretisation that is used in this algorithm.

(c) Use `ced` for creating your own Christmas postcards. Its easy: just take `xmas.pgm` and filter it with the same parameters as for the fingerprint.

(d) Use `ced` to visualise all stripes of `fabric.pgm` at different scales. Use the standard parameters and increase the number of iterations.

Submission:

The theoretical problem(s) have to be submitted in handwritten form before the next tutorial (December 20th).

Deadline for Submission is: Friday, December 20th, 11:30 am (before the tutorial)

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Classroom Assignment 4

C 4.1 (Mumford-Shah Cartoon Model)

Let $\Omega_i, \Omega_j \subset \Omega$ denote two segments with mean u_i resp. u_j. Furthermore, let $\partial(\Omega_i, \Omega_j)$ denote the common boundary between Ω_i and Ω_j.

Show that for the Mumford-Shah cartoon model, merging these two regions results in the following change of energy:

$$E\left(K \setminus \partial\left(\Omega_i, \Omega_j\right)\right) - E\left(K\right) \;=\; \frac{|\Omega_i| \cdot |\Omega_j|}{|\Omega_i| + |\Omega_j|} \cdot \left(u_i - u_j\right)^2 - \lambda\, l\left(\partial\left(\Omega_i, \Omega_j\right)\right) \;.$$