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Homework Assignment H3

Problem 1 (Variational Methods) — 10 Points

Instead of using the grey value constancy assumption, let us assume that the y-derivative of the image f remains constant over time, i.e.

$$f_y(x+u, y+v, t+1) = f_y(x, y, t) \tag{1}$$

(a) Linearise the constancy assumption (1) w.r.t the flow functions u and v.

(b) Write down an energy functional similar to Horn and Schunck based on the linearised constancy assumption from (a).

(c) Compute the Euler-Lagrange equations for this energy functional.

(d) Discretise the Euler-Lagrange equations from (c).

(e) Starting from the discrete equations computed in (d), derive an iterative scheme that computes the minimiser.

Problem 2 (Stereo) — 6 Points

Consider a camera with focal distance 2. Its image coordinate system is orthogonal with square pixels of size 1. The principal point in this coordinate system is located in $(2, 3)^\top$. Furthermore, the position of the world coordinate system relative to the camera coordinate system is given by a rotation around the z-axis by an angle of 90° and a translation by the vector $(5, 0, -1)^\top$.

(a) Compute the intrinsic matrix.

(b) Compute the extrinsic matrix.

(c) Compute the full projection matrix.

Problem 3 (Horn and Schunck) **8 Points**

Please download the required file `cv13_ex04.tgz` from the lecture webpage. To unpack the data, use `tar xvfz cv13_ex04.tgz` .

In the routine `flow`, supplement the missing code such that it computes one Jacobi iteration step. Make sure the image boundaries are treated correctly. To compile the program, type

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

The filling-in effect that is characteristic for variational methods can be studied with the image pair `pig1.pgm`, `pig2.pgm`. To this end, investigate the result for different numbers of iterations. What is a good value for the regularisation parameter α in this case?

Submission:

The theoretical Problems 1 and 2 have to be submitted in handwritten form before the next tutorial (December 04). For the practical Problem 3, please submit you files as follows: Rename the main directory `cv13_ex04` to `cv13_ex04_<your_name>` and use the command

```
tar cvfz cv13_ex04_<your_name>.tgz cv13_ex04_<your_name>
```

to pack the data. The directory that you pack should contain the following files:

- the source code of Problem 3
- the created images
  - for at least two different numbers of iteration
  - for at least two different values of α
- a text file `readme.txt` that contains
  - information on all people working together for this assignment
  - selected parameters for part (c)
  - answers to the question in part (c)

Please make sure that only the final version of the code files and the images are included. Submit the archive via e-mail to your tutor via the address `volz@vis.uni-stuttgart.de` .

Deadline for Submission is Thursday, December 5th, 2:00 pm (before the tutorial)

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Classroom Assignment C4

Problem 1 (Eigenvalue Analysis)

Let $\mathbf{J} \in \mathbb{R}^{n\times n}$ be a symmetric $(n \times n)$ matrix with real components. We consider its corresponding quadratic form given by

$$E : \mathbb{R}^n \longrightarrow \mathbb{R}, \qquad E(\mathbf{v}) = \mathbf{v}^\top \mathbf{J} \mathbf{v}$$

Show that among all vectors $\mathbf{v} \in \mathbb{R}^n$ with $|\mathbf{v}| = 1$, the function value $E(\mathbf{v})$ is minimal for the eigenvector of $\mathbf{J}$ corresponding to its smallest eigenvalue. What can we say about E if $\mathbf{J}$ is positive definite?