# Exercise 3D Machine Vision

**Prof. Dr.-Ing. Volker Willert**

thws
Technical University
of Applied Sciences
Würzburg-Schweinfurt

Sheet 4

In this exercise we cover the *correspondence problem*, the *feature matching* and *descriptors*, as well as *scale spaces* (image pyramids) and the *optical flow*. The questions are small-scale and can be seen as examples of potential exam questions.

## Task 4.1: Correspondence problem

### 4.1a)

Name two applications of image processing where the correspondence problem can occur.

### 4.1b)

In which pattern can a correspondence clearly be found?

- ☐ edge
- ☐ homogeneous surface
- ☐ repeating pattern
- ☐ corner
- ☐ transparent surface
- ☐ Patterns with strong depth differences of the individual pixels
- ☐ point

### 4.1c)

For which categories does it make sense to choose between discrete and differential correspondence search algorithms?

- ☐ Object moves vs. camera moves
- ☐ small base distance vs. large base distance when viewing static scene
- ☐ single pixels in the image (sparse) vs. all pixels in the image (dense)
- ☐ small displacements vs. large displacements

4.1d)

What else is the correspondence problem called?

**Task 4.2: Feature matching**

4.2a)

What does the autocorrelation function measure?

4.2b)

To what range of values is the normalized autocovariance function limited?

4.2c)

Which measures are invariant to differences in brightness?

- ☐ autocorrelation
- ☐ cross covariance
- ☐ cross correlation
- ☐ normalized autocovariance
- ☐ autocovariance
- ☐ normalized cross-covariance
- ☐ SSD matching

4.2d)

Which measures are invariant to contrast differences?

- ☐ autocorrelation
- ☐ cross covariance
- ☐ cross correlation
- ☐ normalized autocovariance
- ☐ autocovariance
- ☐ normalized cross-covariance
- ☐ SSD matching

4.2e)

What statistical measure is needed to compensate for contrast differences? How to mathematically combine this measure with the pattern so that the pattern is contrast-normalized?

## Task 4.3: Interest Points & Descriptors

4.3a)

Which detectors or descriptors can be used to measure coordinates accurately?

- ☐ SIFT descriptor
- ☐ Shi-Tomasi corner detector
- ☐ HoG descriptor
- ☐ threshold to determinant of the Hessian matrix
- ☐ Harris corner detector

4.3b)

Explain how the SIFT descriptor generates a feature vector from HoGs. You can also make a sketch.

4.3c)

Name two variations between views that feature search based on the SIFT descriptor does well with.

4.3d)

How must features be distributed in feature space to be discriminative? Show this with an example in 2D feature space for features of three different classes.

## Task 4.4: Scale spaces

4.4a)

Which image pyramids are used in image processing?

- ☐ Cheops-Pyramid
- ☐ Laplace-Pyramid
- ☐ Tensor-Pyramid
- ☐ Gaussian-Pyramid
- ☐ Pixel-Pyramid

4.4b)

Explain how a Gauß pyramid is recursively computed and which theorem must not be violated in the process? What is the memory requirement of the pyramid compared to the original image?

4.4c)

What is the filter property of the Laplace pyramid? How can you create a Laplace pyramid from a Gaussian pyramid?

## Task 4.5: Optical flow

4.5a)

What is the name of the best known classical optical flow method?

4.5b)

What is the difference between the motion field (displacement vector field) and the optical flow?

4.5c)

What two assumptions are made in SSD matching to calculate a displacement vector?

4.5d)

What correlation measure does the Lucas-Kanade method use as a measure of goodness?

- ☐ SAD matching
- ☐ local cross correlation function
- ☐ SSD matching
- ☐ local cross covariance function
- ☐ SPD matching

4.5e)

Which 1D subspace results for a 2D displacement vector from the constant brightness assumption? At what location in the subspace is the normal flow vector? Draw a sketch to explain.