CS-E4850 Computer Vision

Exam 13th of December 2019, Lecturer: Juho Kannala

There are plenty of questions, answer as many as you can in the available time. The number of points awarded from different parts is shown in parenthesis in the end of each question. The maximum score from the whole exam is 42 points.

You need pen and paper, also calculator is allowed but should not be necessary.

1. Explain briefly the following terms and concepts:
   - (a) Separable filter (2 p)
   - (b) RANSAC algorithm (2 p)
   - (c) Precision and recall (2 p)
   - (d) Inverted index (2 p)
   - (e) Camera calibration (2 p)
   - (f) Structure from motion (2 p)

2. Local feature detection and description using SIFT
   - (a) Describe the detector part of the Scale Invariant Feature Transform (SIFT). In particular, explain the motivation and idea of the scale selection. (2 p)
   - (b) Describe the descriptor part of SIFT. That is, describe how the pixel neighborhood around a detected keypoint is converted to a 128 dimensional feature vector. (2 p)
   - (c) Mention at least two computer vision tasks or applications where SIFT is commonly used. Explain also what is the benefit of using SIFT in the applications (e.g. when compared to earlier methods which are not scale invariant). (2 p)

3. Lucas-Kanade optical flow

   The brightness constancy constraint that is utilized in optical flow computation can be written as follows
   $$(u\ v)^\top \cdot \nabla I + \frac{dI}{dt} = 0$$
   and it relates the flow to the spatial and temporal gradients of the image sequence.
   - (a) Assuming that neighboring pixels have the same flow vector $(u\ v)^\top$, the brightness constancy constraint provides a set of linear equations for a given image patch in two consecutive frames of an image sequence (i.e. one equation per pixel). Write the system of linear equations in matrix form. (1 p)
   - (b) Compute an expression for the flow vector $(u\ v)^\top$ by minimizing the sum of squared residuals. (Hint: Set the gradient of the cost function to zero.) (1 p)
   - (c) When is the minimizing solution $(u\ v)^\top$ unique? How is the uniqueness of the solution related to the so called aperture problem? (2 p)
   - (d) What are the pros and cons of Lucas-Kanade method when compared to template matching? (Template matching computes flow by comparing image patches explicitly using some similarity measure like normalised cross-correlation.) (2 p)