ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

**Computer Vision**
AS 2015

*Prof. M. Pollefeys (Computer Vision Group)*
*Prof. L. Van Gool (Computer Vision Lab)*

*F. Camposeco, P. Speciale, N. Savinov, C. Otesteanu, F. Oezdemir, Y. Chen, T. Koltukluoglu*

# Final Exam

8 February 2016

First and Last name: ______________________

ETH number: ______________________

Signature: ______________________

# General Remarks

- At first, please check that your exam questionnaire is complete (there are 3 pages total).
- Remove all material from your desk which is not allowed by examination regulations.
- Fill in your first and last name and your ETH number and sign the exam. Place your student ID in front of you.
- You have 2 hours for the exam. There are 6 questions, where you can earn a total of 120 points. You don't have to score all points to obtain a very good grade.
- Start each question on a separate sheet. Put your name and ETH number on top of each sheet. Only write on the question sheet where explicitly stated.
- Please do not use a pencil or red color pen to write your answers.
- You may provide at most one valid answer per question. Invalid solutions must be canceled out clearly.

| | Topic | Max. Points | Points Achieved | Visum |
|---|---|---|---|---|
| 1 | Motion Extraction | xx | | |
| 2 | Recognition Approaches | xx | | |
| 3 | Bag-of-Words | xx | | |
| 4 | Multi-View Geometry | 20 | | |
| 5 | Stereo Matching | 20 | | |
| 6 | Projective Geometry | 20 | | |
| Total | | 120 | | |

Grade: ........................................................................

## Question 1: Motion Extraction – Multiple Choice (18 pts.)

a) How does the particle filter (aka condensation algorithm) compare against the Kalman filter (in its simplest form)? Indicate all true statements: **9 pts.**

- The particle filter assumes the underlying models to be linear, but the Kalman filter does not
- The role of noise is exactly the same in the Kalman and the particle filters: allowing for deviations from the ideal models
- The Kalman filter assumes Gaussian probability distributions, but the particle filter can deal with more general ones
- If the assumptions apply, the Kalman filter gives an analytic and in principle correct solution, but the particle filter requires further interpretation of results to arrive only at an approximation
- The particle filter can keep multiple hypotheses alive, whereas the Kalman filter goes after one only Of the two, the particle filter is better equipped to deal with high-dimensional state spaces

b) For the Optical Flow (OF) algorithm that we saw (aka Horn & Shunck algorithm), indicate all true statements: **9 pts.**

- Regularization is used mainly to solve the problem of the result being overly sensitive to noise on the input
- The algorithm is intended to but not necessarily successful at producing the image projections of the true, relative 3D scene motion
- Suppose one has two subsequent frames of a video sequence, taken at time t and time t+1, resp. The OF extracted from frame t to t+1 only yields vectors opposite to those for t+1 to t, except at the image borders.
- The initial assumption, expressed by the OF Constraint Eq., expresses a constraint that really holds, but is unfortunately insufficient to then solve the full OF problem.
- If a camera moves through a static scene, the aperture problem may go away if 10 or more point correspondences between the image pair are known.

## Question 2: Recognition Approaches (21 pts.)

a) Local features: what are the aspects (or steps) needed to form them ? **7 pts.**

b) Describe why the use of local features allows one to strike a balance between the pro's (and con's) of model-based and appearance-based models for object recognition **7 pts.**

c) What are 'visual words'? **7 pts.**

## Question 3: Bag-of-Words (21 pts.)

a) Explain what the bag-of-words approach to object recognition is. **7 pts.**

b) What kind of step is usually added after BoW comparison to weed out false positives ? **7 pts.**

c) Would you use a larger set of words in the case of specific or of object class recognition ? Explain your answer. **7 pts.**

## Question 4: Multi-View Geometry (20 pts.)

a) Explain what epipolar geometry is. **5 pts.**

b) Two special points are associated with this concept, explain what they are and how they can be computed. **5 pts.**

c) Describe the matrix that is associated with this concept, both in general, as well as in the calibrated case. What is it used for? **5 pts.**

d) How would you compute this matrix (in the general uncalibrated case) given a pair of images? Provide pseudo-code. **5 pts.**

## Question 5: Stereo Matching (20 pts.)

a) Explain the relationship between baseline, focal length, disparity and depth for a standard (fronto-parallel) stereo setup. Can you explain how the accuracy of stereo varies with depth? Use a diagram to explain your answer. **10 pts.**

b) Stereo matching is often solved by minimizing an energy function. Provide an appropriate energy function. Indicate the importance of the different terms. What techniques do you know to perform this optimzation? **10 pts.**

## Question 6: Projective Geometry (20 pts.)

a) Fill in the following table. Write the degrees of freedom (DOF) of each Transformation Group, both for 2D and 3D. Indicate as well the Invariants and Fixed Entity of the transformations, for these last two you may chose to describe for 3D **or** for the 2D case (mention which one you chose). Recall that not all Transformation Groups have a Fixed Identity.
**5 pts. per row**

| Transformation Group | DOF (2D) | DOF (3D) | Invariants | Fixed Entity |
|---|---|---|---|---|
| Projective | | | | |
| Affine | | | | |
| Similarity | | | | |
| Euclidean | | | | |