Computer Vision II: Multiple View Geometry (IN2228)

Exam Information and Knowledge Review

Dr. Haoang Li

13 July 2023  11:00-11:45
Announcements Before Class

✓ Regular Q&A

✓ At the end of semester, I received a relatively large number of emails/message to ask various questions.

✓ Some tips for you:
  • I am generally busy with some research projects. So, I may miss your email/message. I suggest that you ask questions on Moodle. I promise that I will reply to you within 3 days.

  • Try to clearly describe your questions using concise sentences. If you feel it is very difficult to describe your questions, you can send email/message to me, or visit my office this afternoon (2:00 pm—6:00 pm).

  • Some questions are self-explanatory. I strongly suggest that you first watch the course recordings if you did not attend our lectures before.
Announcements Before Class

- Documents for Knowledge Review

- I have uploaded two documents to highlight important knowledge of Chapters 01—10.

- Today, I will upload the third document for Chapters 11-13.

- For Chapter 14 (on 19 July), I will highlight important knowledge in class. You can check slides if you cannot attend that lecture.
Announcements Before Class

- Online Q&A Session on 20 July

- On 20 July, I will hold an online session for Q&A. If you have any questions, you can attend this session via the following link:

  [https://tum-conf.zoom.us/j/3145249779](https://tum-conf.zoom.us/j/3145249779) (no password)

- It will start from 11:00 AM.

- This session will be automatically recorded. I will upload the recording to Google Drive and share the link below a related post on Moodle (please check it on 20 July).
Announcements Before Class

➢ Online Q&A Session on 20 July

✓ Please note that in this session, only questions regarding knowledge and algorithms are expected. **No exam information will be provided unless there is any update.**

✓ All the necessary information about the exam will be provided in TODAY’s class.

✓ Please regularly check the pinned post on Moodle to see if there is any update. For important updates, I will inform you by email.
Today’s Outline

- Exam Information
- Knowledge Review
Exam Information

➢ Time

✔ Summer Semester Exam
  • Our exam will take place on 04 August from 8:00 am to 10:00 am.
  • Registration for our exam is possible between 22 May and 30 June.
  • Deadline for grading of exams: 06 September 2023.

✔ Winter Semester Exam (Retake Exam)
  • The exam dates and locations are determined centrally by the Department of Studies. It will take a while until the dates are visible to us.
  • We will provide any update in time.
  • Currently, we do not receive any update.
Exam Information

- Policy of Retake Exam

- If a student fails the exam in the summer semester, he/she can take the repeat exam.

- If a student cannot take the exam in the summer semester (due to time conflict, sick or any other reasons), he/she can directly take the repeat exam.

- As to the assignment bonus, as far as I know, it is only applicable to the summer semester exam. If necessary, please double-check with our teaching assistants.
Exam Information

Exam Questions

- Structure of each exam
  - You have 120 minutes to solve the exam, which contains 22 multiple-choice questions and 3 calculation questions.
  - There is not proof questions.
  - You can achieve a maximum of 100 points.
  - Multiple-choice questions have 44 credits.
  - Three calculations questions have the remaining 56 credits.
Exam Information

Exam Questions

✓ Summer semester vs. winter semester

• Summer semester exam’s questions are relatively straightforward and even “boring”, given that you have limited time for knowledge review.

• Winter semester exam’s questions have not been finalized. Overall, questions will be more insightful and meaningful. If it involves any new knowledge that is not mentioned in the review document, I will update you in time.
Exam Information

- Cheat Sheet

✓ Given that the review scope is significantly narrowed down, cheat sheet is not allowed.

✓ As I mentioned before, you have three documents highlighting the important knowledge.

✓ I have also provided the formulas to memorize on Moodle. Please refer to the related post. I will also talk about some of them later.
Exam Information

Calculator

✓ To save you time, the calculator is allowed in the exam.

✓ You can use the calculator for matrix multiplication, vector operations (e.g., dot product and cross product), basic algebraic operations, etc.

✓ You will NOT be required to perform matrix decomposition (e.g., SVD) in the exam. You can directly retrieve the decomposition results from a look-up table provided in the exam paper.
Exam Information

- Previous/Mock Exam Questions

  ✓ We officially do not provide previous/mock exam questions.

  ✓ When designing the questions of summer semester exam, I barely referred to the questions of previous year’s exam.

  ✓ You should focus on the knowledge highlighted in the review documents.
Knowledge Review

- Multiple-choice Questions

✓ All the knowledge required by multiple-choice questions have been mentioned in the knowledge review documents.

✓ Knowledge review documents are applicable to both summer semester exam and winter semester exam.

✓ These questions mainly focus on knowledge understanding.
Knowledge Review

- Multiple-choice Questions

✓ The most common form of questions is: “Which statement(s) about XXX is/are correct?”

- There are four choices. At least one choice is correct.

- Please consider each of the choices separately and select all that apply. Any number of choices can be correct, including 1, 2, 3, and 4.

- You will get full credits if all the selections are correct, and 0 otherwise.
Knowledge Review

- Calculation Questions

  ✓ Formulas required by these questions

  - FOV computation
  - Image normalization (reviewed later)
  - Conversion between vanishing point and vanishing direction (reviewed later)
  - SVD-based rotation and translation computation based on 3D-3D correspondences
  - Definitions and constraints of essential and fundamental matrices (epipolar geometry)
Knowledge Review

Calculation Questions

• Formulas required by these questions
  
  • Homography definition based on rotation, translation, and distance
  
  • Photometric error
  
  • Reprojection error
  
  • SSD for evaluation (see page 04/50 of Chapter 05 Part 3)
  
  • Relation between disparity and depth
Knowledge Review

- Image Normalization

Correct Geometric Illustration
Normalized image plane is a virtual image plane. The focal length is 1 and origin of the pixel coordinates is at the principal point.

- Geometric Illustration

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Ordinary image plane

Normalized image plane
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Knowledge Review

Image Normalization

Motivation and Application

The normalized image coordinates correspond to a 3D direction from the camera frame to the image point in the camera frame.

\[
\vec{p}_1 = \begin{bmatrix} u_1 \\ v_1 \\ 1 \end{bmatrix}, \quad \vec{p}_2 = \begin{bmatrix} u_2 \\ v_2 \\ 1 \end{bmatrix}
\]

Normalized image coordinates

Right camera frame

Orthogonality

Normal of epipolar plane

From dot product to matrix multiplication

\[
\vec{p}_2^T \cdot n = 0 \implies \vec{p}_2^T (T \times \vec{p}_1') = 0 \implies \vec{p}_2^T (T \times (R\vec{p}_1')) = 0
\]
Knowledge Review

Image Normalization

Computation

\[
\begin{bmatrix}
\bar{u} \\
\bar{v} \\
1
\end{bmatrix} = K^{-1} \begin{bmatrix}
\bar{u} \\
\bar{v} \\
1
\end{bmatrix} = \begin{bmatrix}
\frac{1}{\alpha} & 0 & -\frac{u_0}{\alpha} \\
0 & \frac{1}{\alpha} & -\frac{v_0}{\alpha} \\
0 & 0 & \frac{1}{\alpha}
\end{bmatrix} \begin{bmatrix}
u \\
v \\
1
\end{bmatrix} + \begin{bmatrix}
u - u_0 \\
v - v_0 \\
\alpha
\end{bmatrix}
\]

A sample code in MATLAB:
https://cvg.cit.tum.de/teaching/ss2023/mvg2023/supp_matlab_codes
Knowledge Review

Vanishing Point and Vanishing Direction

Definition
• A vanishing direction is defined by the connection between a vanishing point and camera center.
• Vanishing direction is parallel to a 3D dominant direction. We thus do not differentiate between them.
Knowledge Review

- Vanishing Point and Vanishing Direction

✓ Conversion

Based on intrinsic matrix $K$, we can compute vanishing direction $D$ based on vanishing point $v$.

$$v = KP_{\infty} = KD$$

Perspective projection

$$K^{-1}v = P_{\infty} = D$$

Image normalization
Knowledge Review

➢ Additional Knowledge

✓ LoG and DoG for blob detection
Some students are still confused about the roles of LoG and DoG. Please refer to my detailed reply to this post:
https://www.moodle.tum.de/mod/forum/discuss.php?d=431661

✓ Depth from disparity (stereo vision) vs. Triangulation
Please refer to my detailed reply to this post:
https://www.moodle.tum.de/mod/forum/discuss.php?d=440404
Summary

- Exam Information
- Knowledge Review
Thank you for your listening!
If you have any questions, please come to me :-}