CS4277 / CS5477
3D Computer Vision

Assoc. Prof. Lee Gim Hee

AY 2022/23

Semester 2

Course Information

Lecturer:

Dr. Lee Gim Hee,

Department of Computer Science

Office: COM2-03-54,

Email: gimhee.lee@comp.nus.edu.sg

Time: Every Wednesday, 1830hrs – 2130hrs

Venue: LT 15 (In-Person Lectures)

Teaching Assistants

Chen Yu
Department of Computer Science
Email: e0917620@u.nus.edu
Lab: AS6-05-02

Yan Zhiwen
Department of Computer Science
Email: e0148832@u.nus.edu
Lab: AS6-05-02

Mode of Assessments

- This grades of this module is based on **60% CA + 40% Final Exam**:

1. 4x coding assignments (10% each; individual work)

2. 20% mid-term quiz (**in-person**, closed-book)

3. 40% final exam (**in-person**, closed-book, one A4 cheat sheet)

- Same assessment for CS4277 and CS5477, but final grades will be moderated independently.

Logistics - Assignments

- We will use Python as the programming language for the assignments.

- Nonetheless, you can use any programming language of your choice.

- But the helper functions and our support will be given only in Python.

- Ask my TAs on all questions regarding the assignments.

Assignment Late Policy

- All assignments are due at 2359hrs of the dates specified on the module schedule.

- 25% of the total marks will be deducted for each day of late submission.

- Deduction of marks does not apply to the late submissions with valid reasons. Please email me your reasons to seek for approval.

Logistics: In-Person Mid-Term Quiz

- Mid-term quiz is conducted in-person at a fixed date and time (see course schedule).

- Please arrange your schedule and make sure you are **physically at NUS**, make-up only possible with valid reasons.

- **Mid-term quiz format:**

1. Consists of two questions;
2. Write your answers on the blank space in the question sheet;
3. Closed book quiz.

Logistics: In-Person Final Exam

- Final exam is conducted in-person at a fixed date and time (see NUS exam timetable).

- Please arrange your schedule and make sure you are **physically at NUS**, NO make-up final exam is possible.

- **Final exam format:**

1. Consists of four questions;

2. Write your answers on the provided answer booklet(s);

3. Closed book exam, one A4 cheat sheet is allowed.

Honor Code

- **Assignments:** You may discuss and/or refer to online references, but plagiarism is strictly not allowed.

- **Online quiz:** Discussions with anyone and copying of solutions are strictly not allowed.

- **Violation of rules:** Zero will be given, and disciplinary actions that could lead to your expulsion from NUS will be taken!

No Tutorial

- No formal tutorials, no "ten-year series"§ practice questions.

- Short questions and solutions will be provided (at the end of every three lectures) to reinforce the content of the lectures.

§https://en.wikipedia.org/wiki/Ten_year_series

Consultations

- Please send all questions to me **via email** and/or **Canvas Discussions (Preferred)**.

- To make sure your email gets my attention, use "[CS4277/CS5477] xxx" as the title of your email.

- Access NUS Canvas Discussions:

Left panel to enter discussions
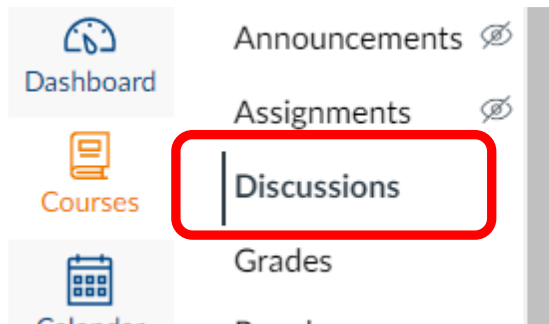
Add discussion (Top right tab)
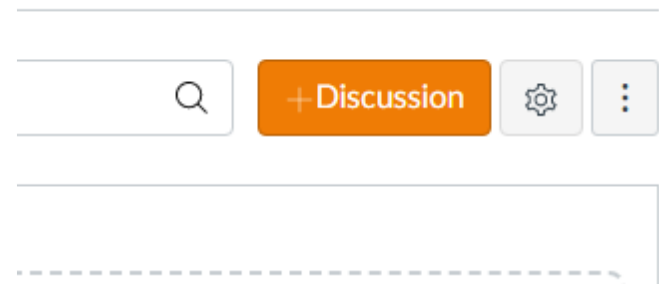
Consultations

- Please send all your questions on the assignments to my TAs.

- Use the discussions in Canvas. Use "[Assignment X]: Question Title" as the heading of your question to get the attention of my TAs.
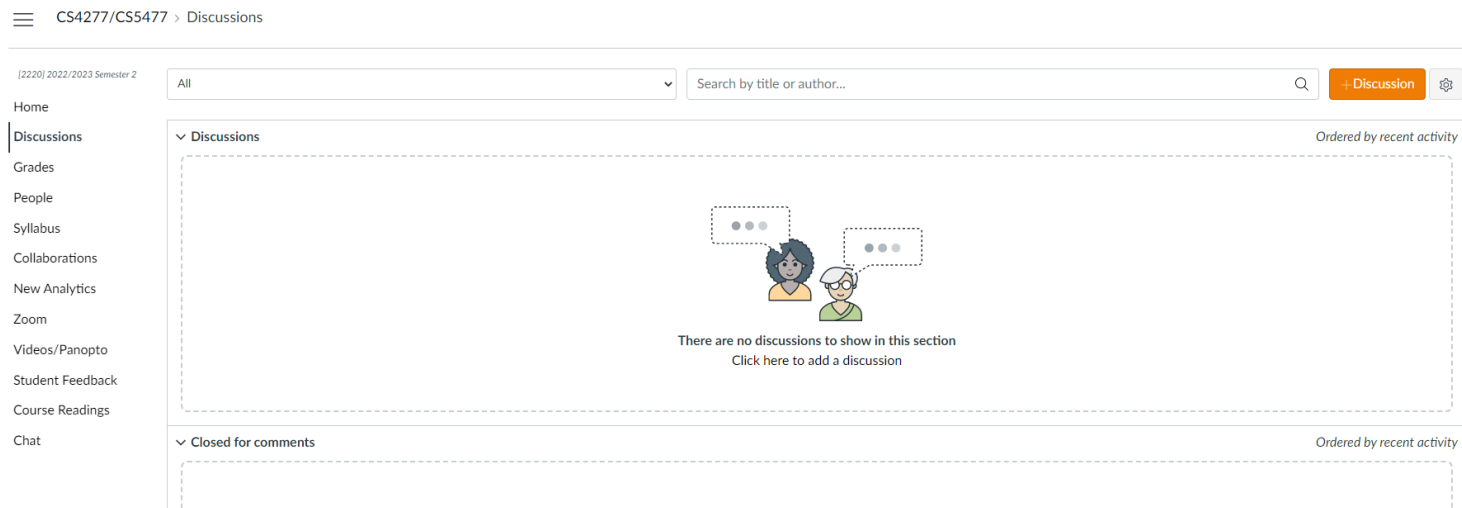
Course Schedule

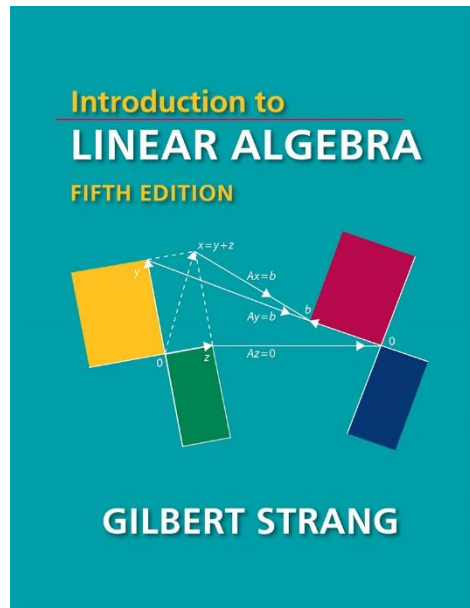| Week	Date	Topic	Assignments
1	11 Jan	2D and 1D projective geometry	**Assignment 0:** Getting started with Python (Ungraded)
2	18 Jan	3D projective geometry, Circular points and Absolute conic	
3	25 Jan	Rigid body motion and Robust homography estimation	
4	01 Feb	Camera models and calibration	**Assignment 1:** Metric rectification and robust homography (10%) **Due:** 2359hrs, 07 Feb
5	08 Feb	Single view metrology	**Assignment 2:** Affine 3D measurement from vanishing line and point (10%) **Due:** 2359hrs, 14 Feb
6	15 Feb	The Fundamental and Essential matrices	
-	22 Feb	Semester Break	No lecture
7	01 Mar	Mid-term Quiz (20%)	In-person Quiz (LT 15, 1900hrs – 2000hrs)
8	08 Mar	Absolute pose estimation from points or lines	
9	15 Mar	Three-view geometry from points and/or lines	
10	22 Mar	Structure-from-Motion (SfM) and bundle adjustment	**Assignment 3:** SfM and Bundle adjustment (10%) **Due:** 2359hrs, 28 Mar
11	29 Mar	Two-view and multi-view stereo	**Assignment 4:** Dense 3D model from multi-view stereo (10%) **Due:** 2359hrs, 04 Apr
12	05 Apr	3D Point Cloud Processing	
13	12 Apr	Neural Field Representations	

Final Exam: 03 MAY 2023

Recommended Readings (Not Compulsory)
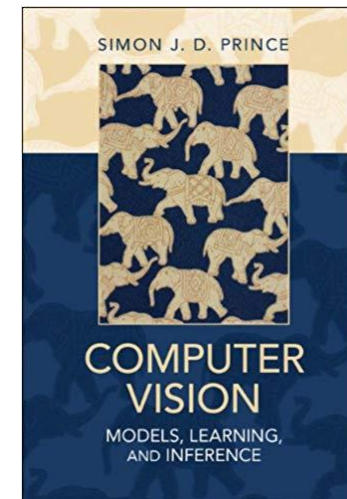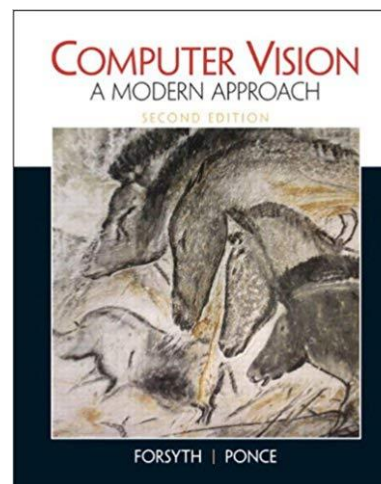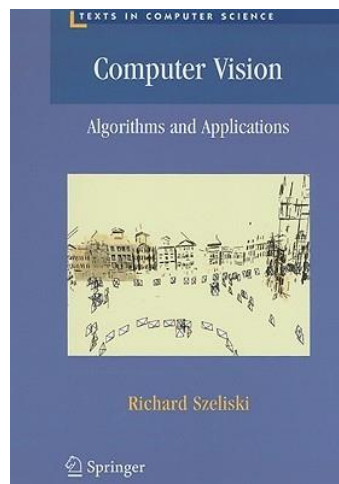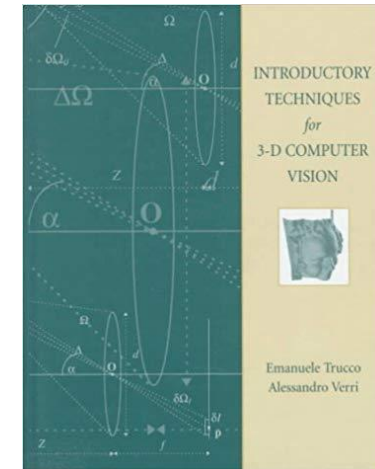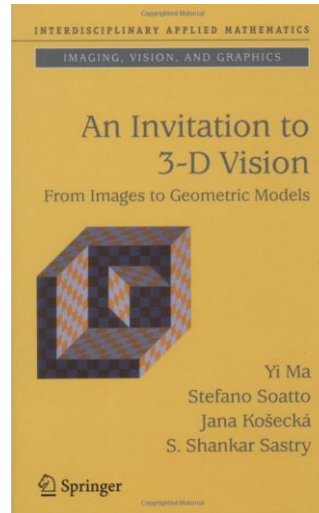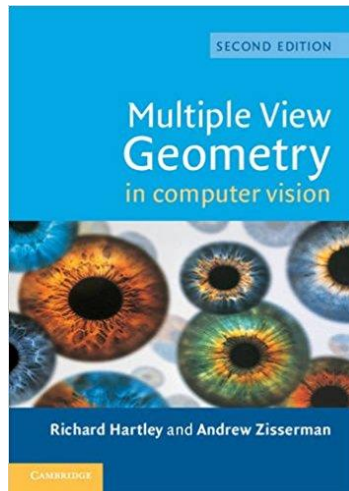
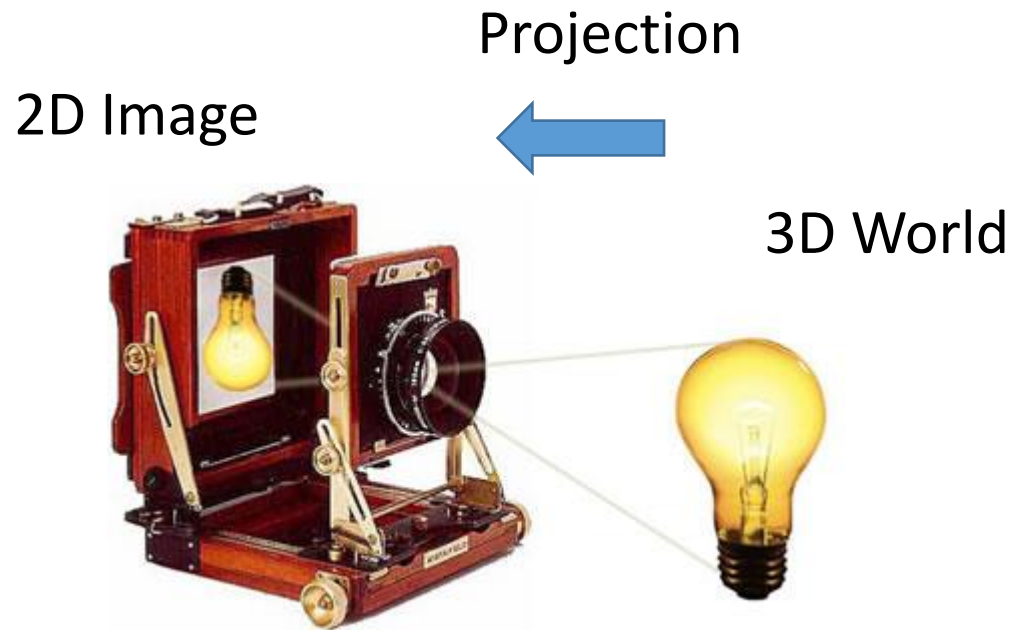# Linear Algebra Pre-requisite

- Recommended reading on Linear Algebra:

Video lectures by Prof. Gilbert Strang:

https://www.youtube.com/playlist?list=PL49CF3715CB9EF31D

How Does a Camera Work?

Forward Problem:

Projection

2D Image

3D World

Dimensionality reduction!

Image source: http://www.shortcourses.com/guide/guide1-3.html

Projection can be Tricky…

Slide source: Steve Seitz

Projection can be Tricky…

Slide source: Steve Seitz

Projective Geometry

What is lost?

- Length

Slide credit: J. Hayes
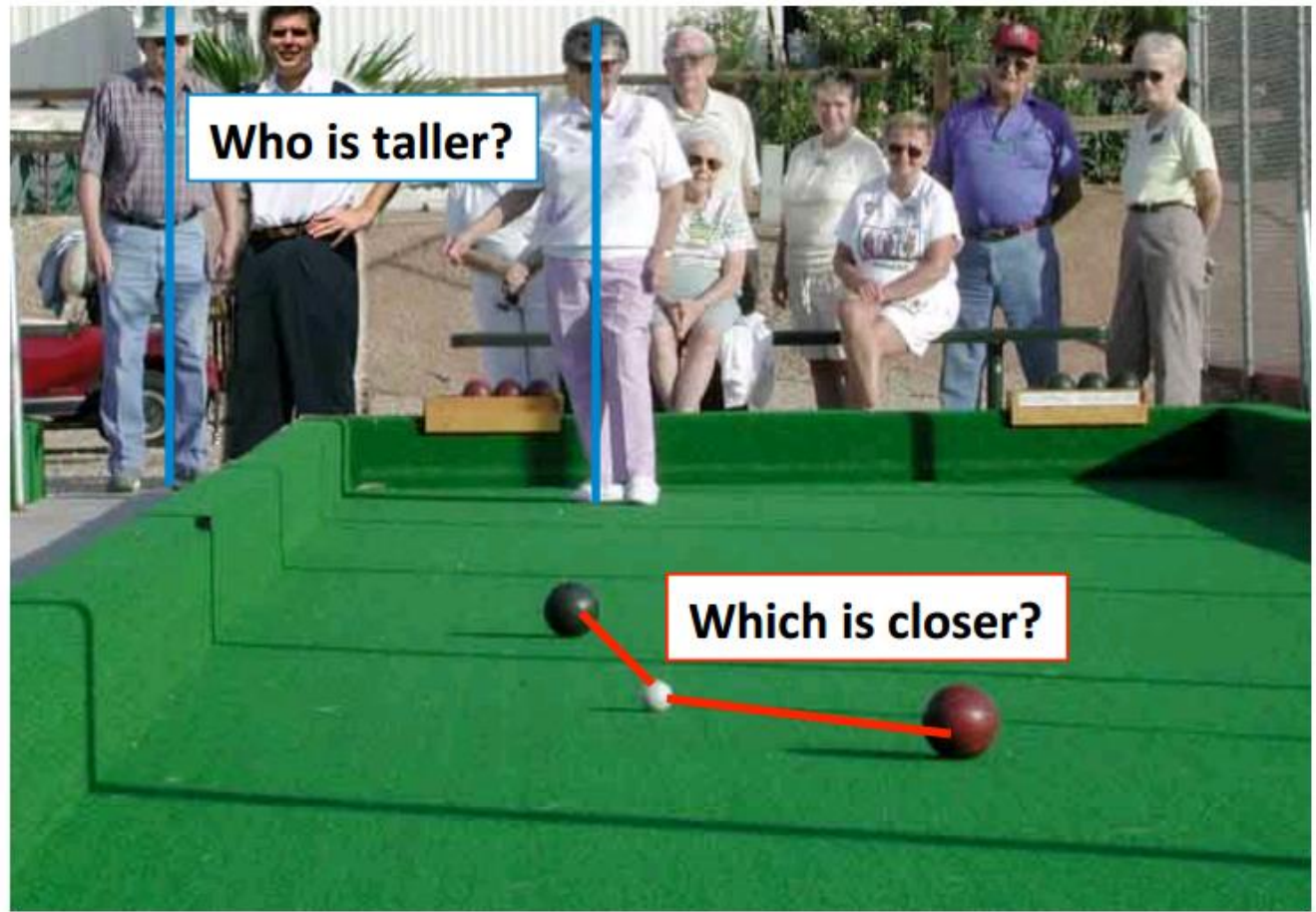
Length is Not Preserved

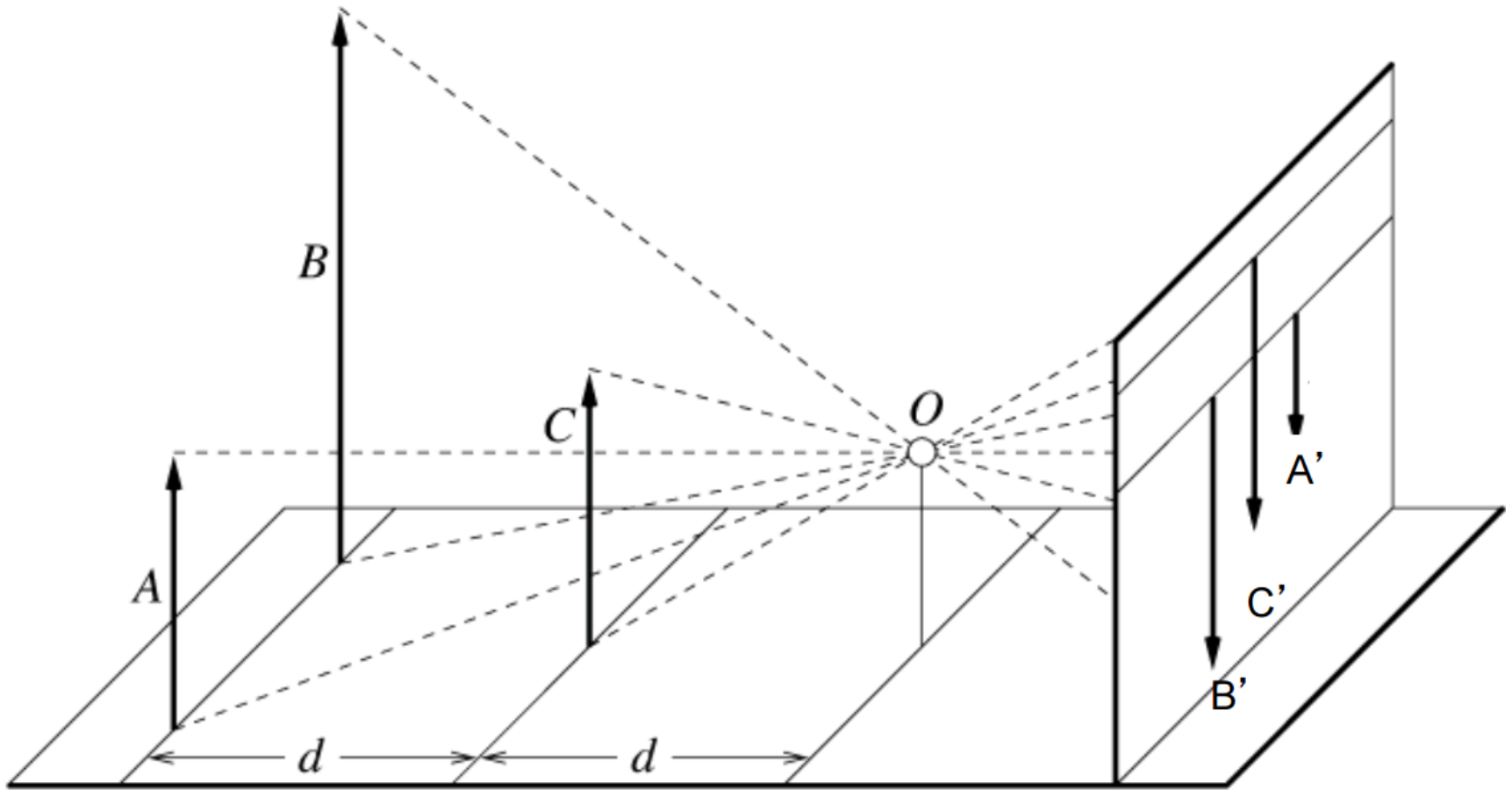Figure by David Forsyth

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National University of Singapore
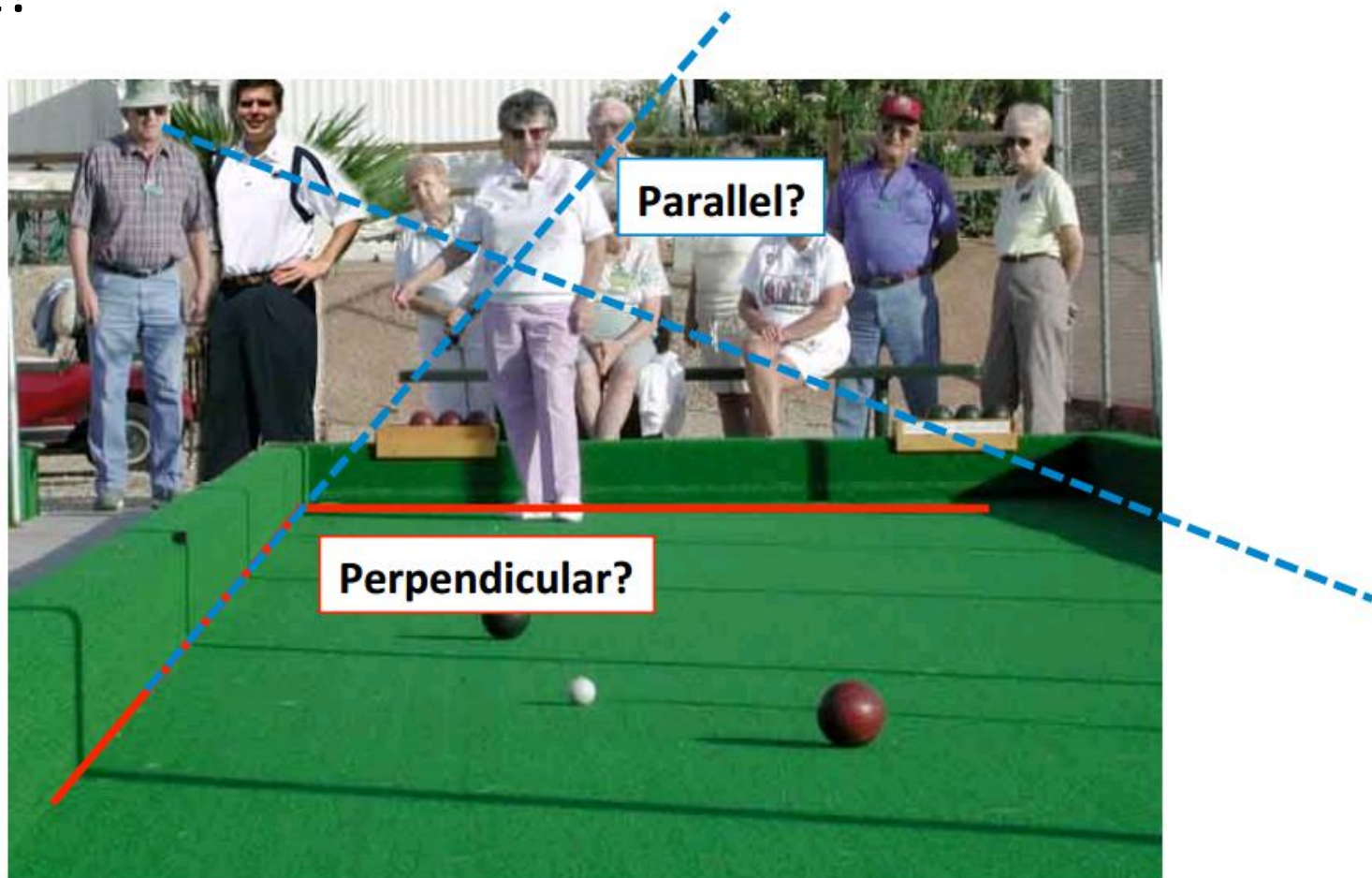
How to Make a Hobbit?

Frodo appears smaller than Gandalf on screen

In reality, he was seated further away from the camera

Image source: "Lord of the rings – Fellowship of the rings"

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Projective Geometry

What is lost?

- Length
- Angles

Parallel?

Perpendicular?

CS4277-CS5477 :: G.H. Lee

Can We Recover the 3D Information from Image(s)?

Ill-posed and inverse problem!

2D Image

3D World

Image source: http://www.shortcourses.com/guide/guide1-3.html
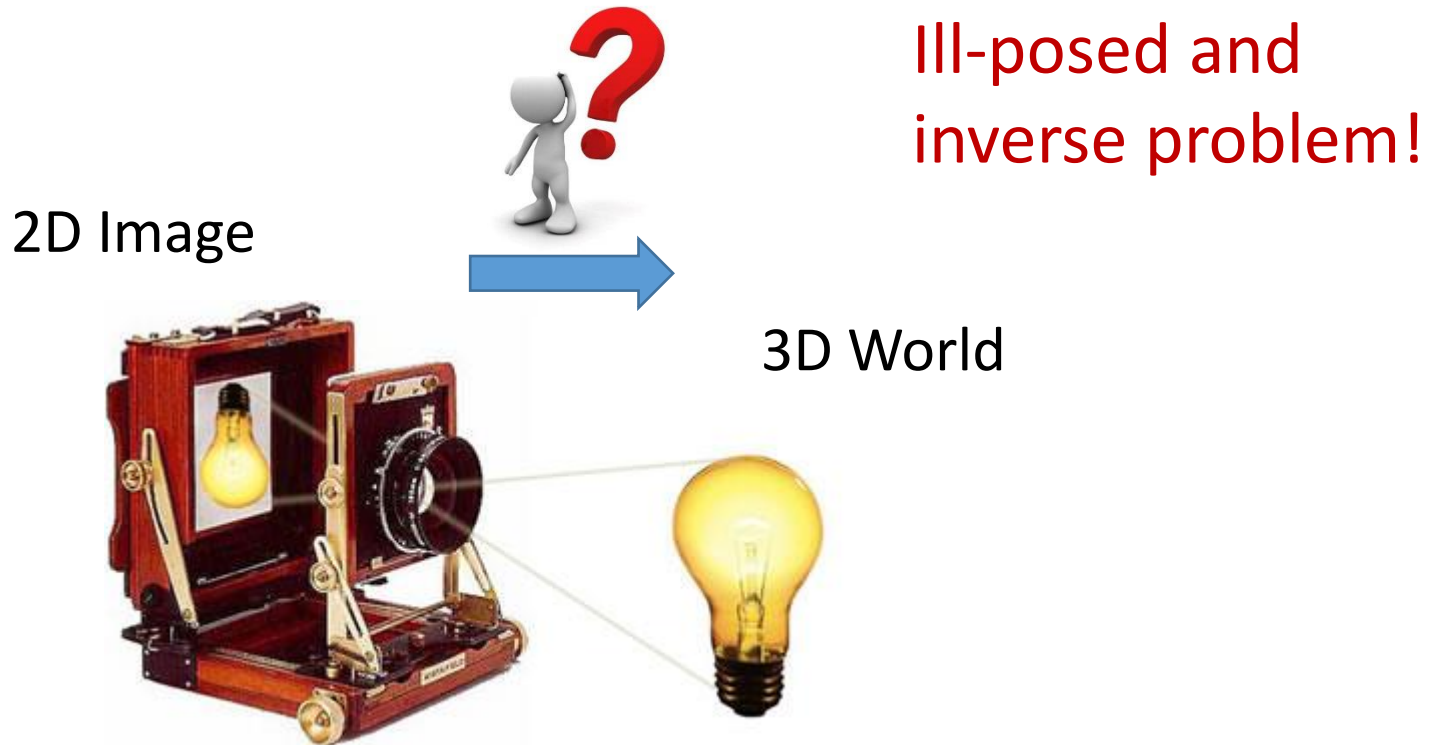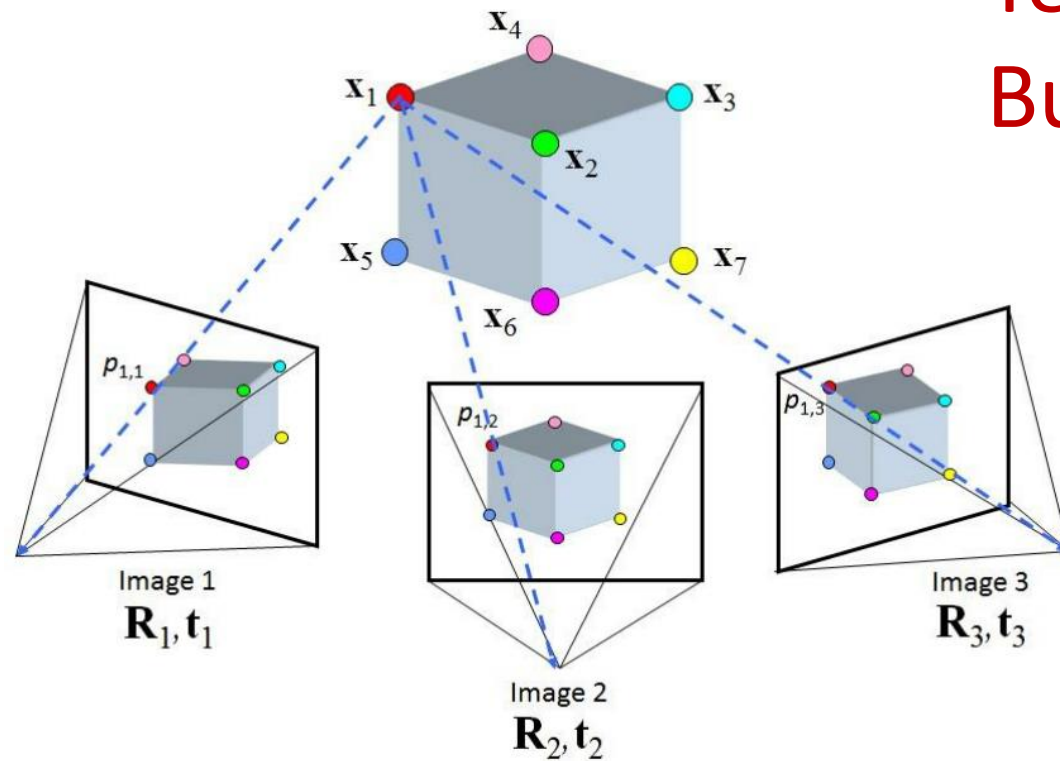
Can We Recover the 3D Information from Image(s)?

Yes!
But what's lost?

Yilmaz et al. 2013

Why do we Need 3D Computer Vision?

Why do we Need 3D Computer Vision?

Why Not Just Use Deep Learning?

Deep learning and 3D Computer Vision are complimentary!

In pure 3D Computer Vision, we should not learn from data when we already know the laws of Physics.

2D Image

3D World

Image source: http://www.shortcourses.com/guide/guide1-3.html