

# Lecture 1

# **Introduction**

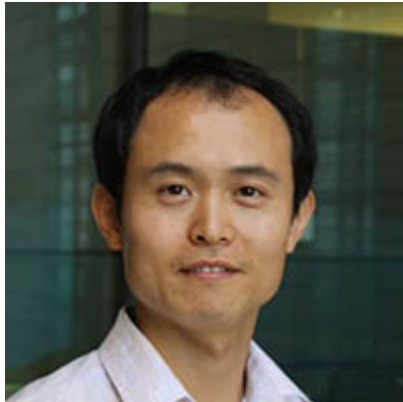
Liangliang Nan

# Agenda

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- The teachers
- Overview of the course
  - What the course is about
  - What you will learn
  - Topics/Lectures
  - Assignments
  - Final exam
  - Communication method
  - ...

# The teachers



[Liangliang Nan](#)

LiangliangNan#0976



[Nail Ibrahimli](#)

nibrahimli#5857



[Shenglan Du](#)

Shenglan Du#2136

# What the course is about

- Photogrammetry
- Computer Vision
- 3D Computer Vision

What are the differences?



# What the course is about

- Photogrammetry
  - General
    - Obtaining info about objects or environment
      - Recording: digital image capturing
      - Measuring: generating 2D or 3D measurements
      - Interpreting: detecting interested objects
    - Output can be
      - A map
      - A drawing
      - 3D model
      - ...

# What the course is about

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- Photogrammetry
  - General
  - Specific
    - Extracting 3D geometry from images
    - Goal: generating 3D digital models of an object
    - Using well defined photogrammetric methods
      - e.g., bundle adjustment

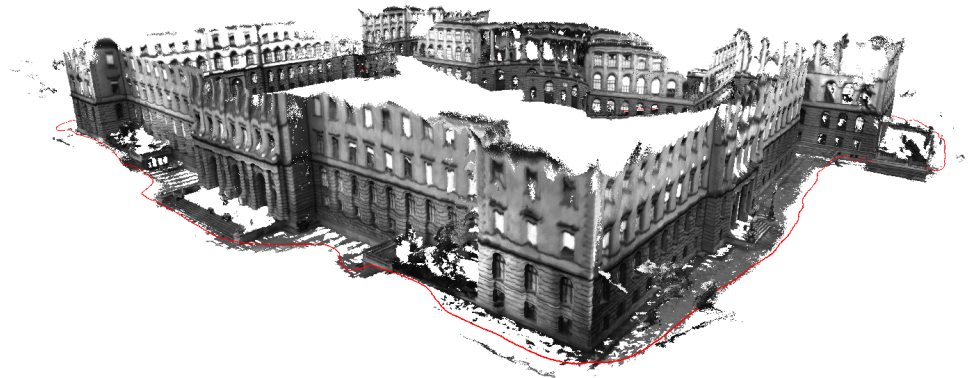
# What the course is about

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- Photogrammetry
- Computer vision
  - Using digital images or videos
  - Training computers to interpret and understand the visual world
  - Mimics the human visual system
    - Video tracking
    - Object detection/recognition
    - Scene reconstruction
    - ...

# What the course is about

- Photogrammetry
- Computer vision
- 3D computer vision
  - Scene reconstruction/modeling
  - 3D data processing (e.g., semantic segmentation, classification)





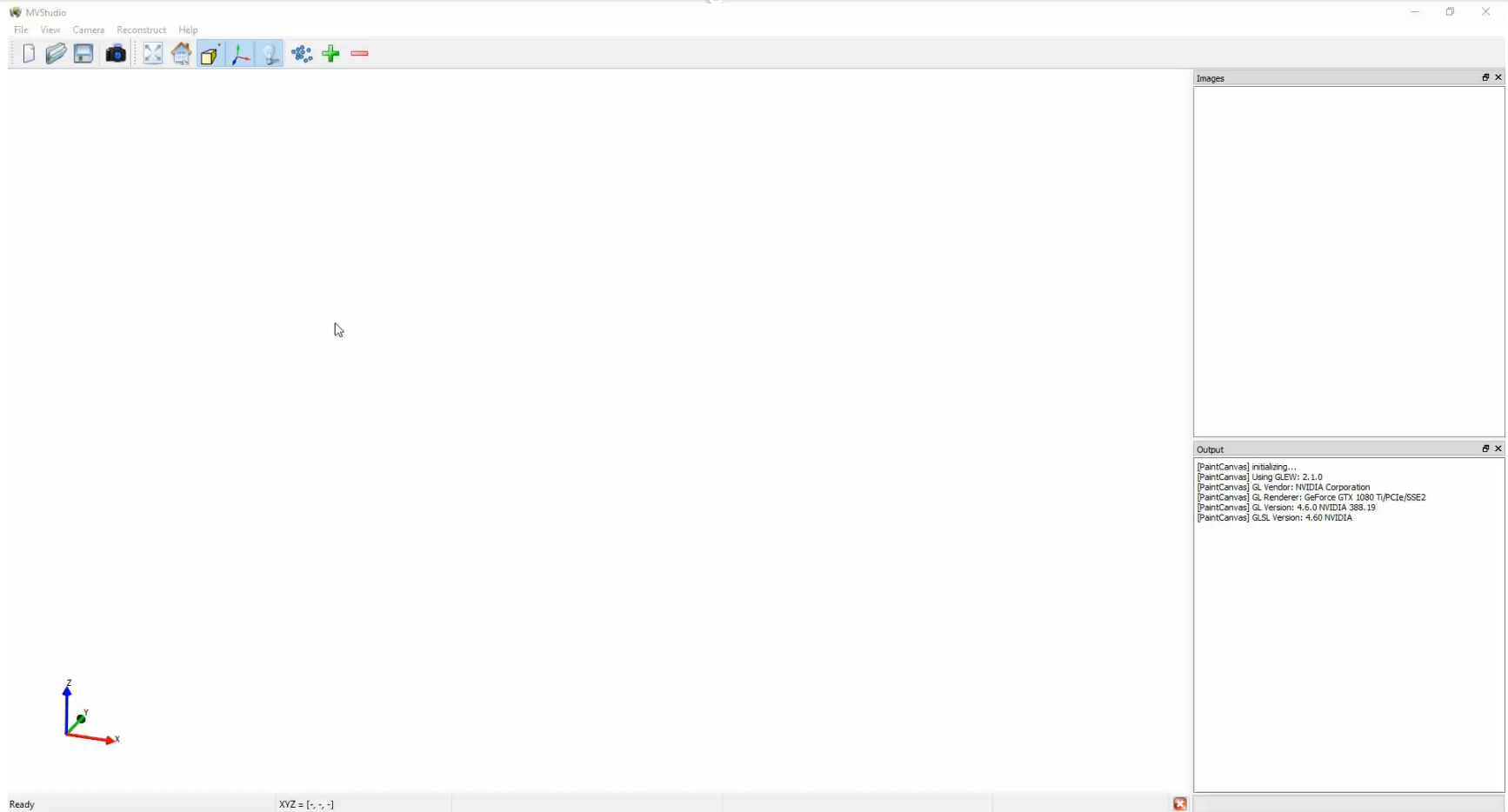
# What the course is about

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- Photogrammetry
- Computer vision
- 3D computer vision
  - Scene reconstruction/modeling
  - 3D data processing (e.g., semantic segmentation, classification)

**3D computer vision == Photogrammetry**

# What the course is about

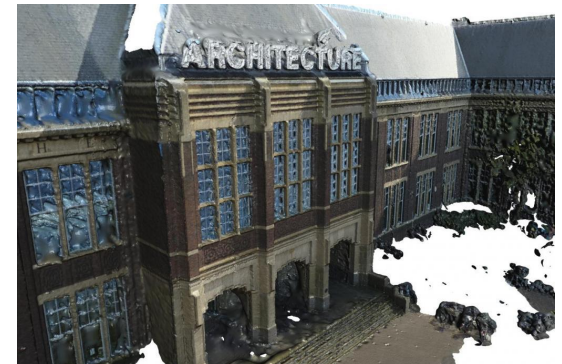


**Code & data available:**

<https://github.com/LiangliangNan/MVStudio>

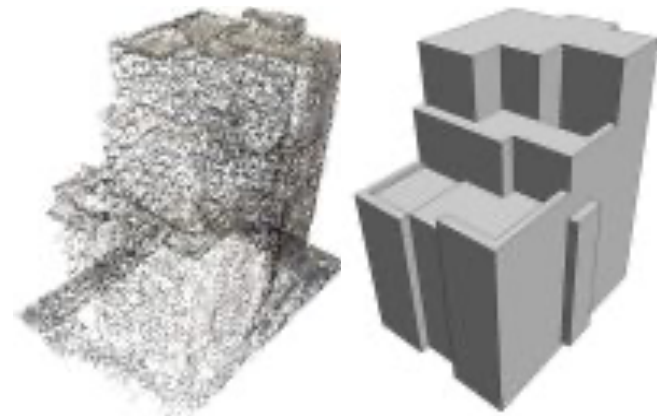
# What the course is about

- Photogrammetry
- Computer vision
- 3D computer vision
  - Scene reconstruction/modeling
  - 3D data processing (e.g., semantic segmentation, classification)
  - Urban objects

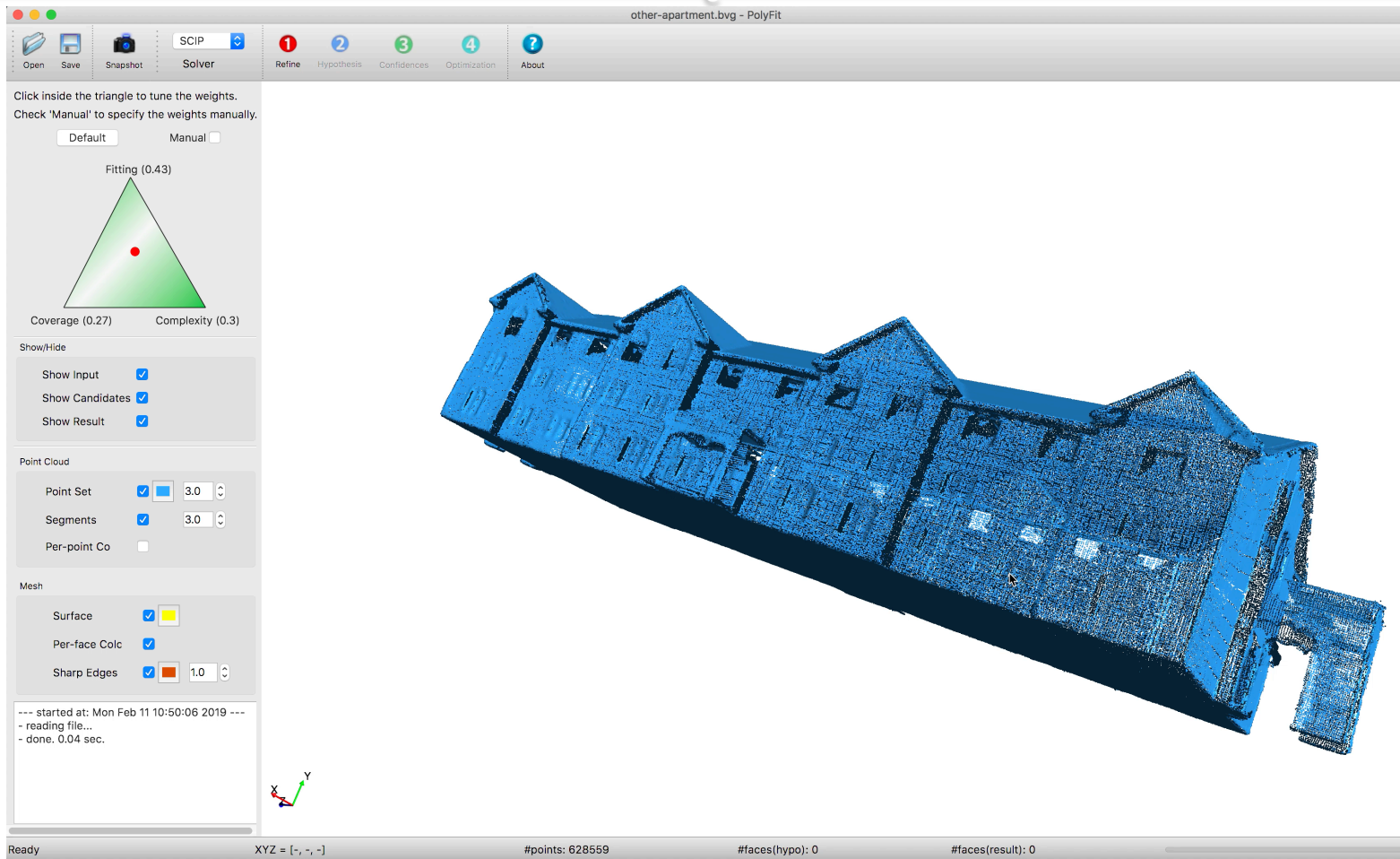


# What the course is about

- Photogrammetry
- Computer vision
- 3D computer vision
  - Scene reconstruction/modeling
  - 3D data processing (e.g., semantic segmentation, classification)
  - Urban objects
  - Point clouds vs. Surface models



# What the course is about



**Code & data available:**

<https://github.com/LiangliangNan/PolyFit>

# What you will learn

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- Theory, methodology, and algorithms
- The complete pipeline for modelling real-world objects (mainly buildings)
  - Data acquisition
  - Processing
  - Reconstruction

# Topics/Lectures

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- 1: Introduction
- 2: Camera models
- 3: Camera calibration
- 4: Two view geometry
- 5: Structure from motion
- 6: Multi-view stereo
- 7: Smooth surface reconstruction
- 8: Piecewise planar surface reconstruction
- 9: Point cloud classification/segmentation

# Learning activities

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- Lectures
  - 2 x 45min (usually on each Friday)
- Assignments
  - Twice per week (Tuesday and Friday afternoons)
    - Data acquisition
    - Install/Use software
    - Programming
    - Debugging
    - Discussion with teammates and with teachers



# Time to spend

- 140 hours for 5 ECTS (5 x 28)
  - 9 lectures: 18 hours
  - 13 guided sessions: 26 hours
  - 1 Q&A: 2 hours
  - Self study: 94 hours
    - Watching the lecture recordings (skip this?)
    - Reading materials
      - Book chapters
      - Scientific papers
    - Assignments

# Ultimate goal

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- Well prepared in the related fields
  - Career
    - Working in the Cadastre or other companies
  - Research
    - To do your PhD, working as research assistant ...

# Assessment

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- 3 group assignments (40 %)
  - Group performance
  - Personal contribution/Peer reviews
- Final exam (60%):
  - Lectures, handouts, assignments
    - Multiple-choice questions
    - Open questions

# Assessment

- 3 group assignments (40 %)
- Final exam (60 %)
- Pass?
  - Assignments  $\geq 5.5$
  - Exam  $\geq 5.5$
  - Total of 6.0 or above

# Assignments

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- Programming
  - 3D reconstruction and point cloud processing
- Each assignment released after the lecture
- Work in groups (ideally 3 students per group)

# Assignments

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- Programming
- Each assignment released after the lecture
- Work in groups (ideally 3 students per group)
- C++ source code framework provided
- If you fail one of the assignment?
  - Depending code and data will be provided

# Assignments

- What to submit?
  - Report
    - < 3 pages (excluding figures, tables, references)
    - Individual contribution
    - See a template on Course Website.

## Isaac Newton (75 %)

- Compared the reconstruction results from method [1] and method [2];
- Implemented the function `reorient_normals ()`;
- Came up with a novel reconstruction method and implemented it in function `reconstruct()`;
- Wrote the “Methodology” section of the report.

## Albert Einstein (20 %)

- Preparing and pre-processing of the point clouds, i.e., taking photos, run SfM and MVS, cropping the buildings from the messy point clouds, and normal estimation;
- Wrote the “Implementation Details” section of the report.

## Thomas Edison (5 %)

- Wrote the “Abstract” section of the report.

# Assignments

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- What to submit?
  - Report
  - Code
    - Collaboration using GitHub
    - Include the link to the GitHub repository in the report



# Assignments

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- What to submit?
  - Report
  - Code
    - Collaboration using GitHub
    - Include the link to the GitHub repository in the report
    - Reproduce the results
      - **Doesn't compile:** -10%
      - **Doesn't reproduce the result:** -10%

# Assignments

- What to submit?
- We allow multiple submissions
  - Incorporating comments from teachers/peers
  - Evaluation based on 1<sup>st</sup> submission + 0.5 maximum

Example:

First submission 6, then final mark will be  $\leq 6.5$

# Assignments

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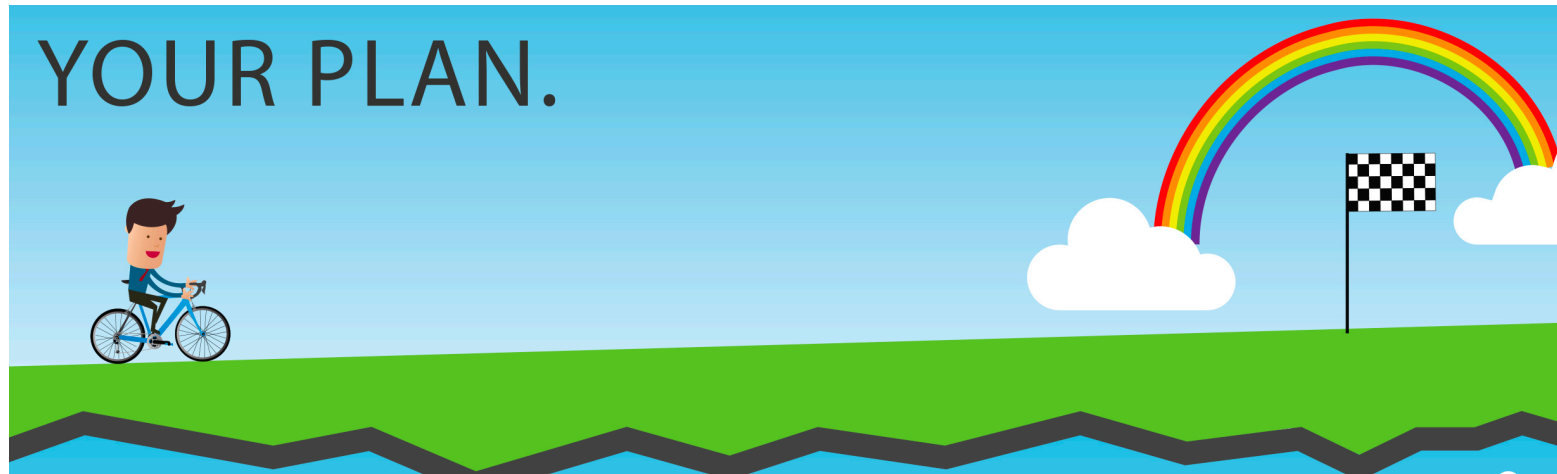
- What to submit?
- We allow multiple submissions
- Strict deadline
  - Late submission
    - - 10%/day
    - Note acceptable after 3 days late.

# Assignments

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- What to submit?
- We allow multiple submissions
- Strict deadline
- Teamwork
  - Everyone: writing codes **AND** writing report
  - **We strongly discourage**
    - A division of tasks based on handing the role of report writing to one person and code writing to another

# Assignments: start earlier



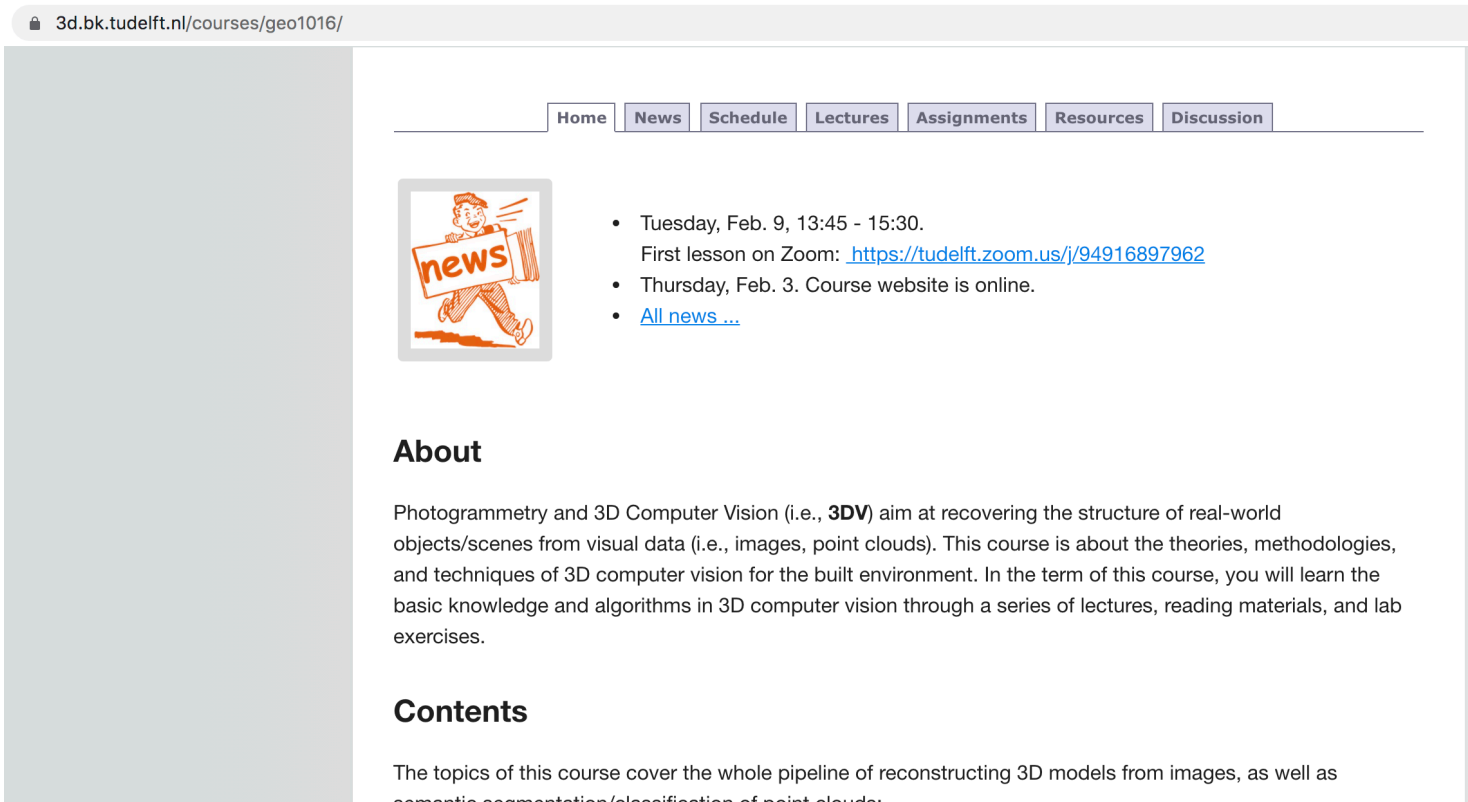
# Plagiarism

- Copy from others/internet
  - Code
  - Sentences
  - Figures
  - ...
- Plagiarism checker
  - <http://www.icto.tudelft.nl/tools/turnitin/check-for-originality/>
  - <https://smallseotools.com/plagiarism-checker/>
  - <https://www.quetext.com/>
  - <https://www.duplichecker.com/>

# Communication method

- Course website


- <https://3d.bk.tudelft.nl/courses/geo1016/>



The screenshot shows the course website at [3d.bk.tudelft.nl/courses/geo1016/](https://3d.bk.tudelft.nl/courses/geo1016/). The page features a navigation menu with links for Home, News, Schedule, Lectures, Assignments, Resources, and Discussion. A news icon is displayed next to a list of updates, including a Zoom link for the first lesson on Tuesday, Feb. 9, and a note that the course website is online on Thursday, Feb. 3. Below the news section, there are sections for 'About' and 'Contents'. The 'About' section describes the course's focus on photogrammetry and 3D computer vision, while the 'Contents' section lists the topics covered, such as the pipeline of reconstructing 3D models and semantic segmentation/classification of point clouds.

3d.bk.tudelft.nl/courses/geo1016/

Home News Schedule Lectures Assignments Resources Discussion

 • Tuesday, Feb. 9, 13:45 - 15:30.  
First lesson on Zoom: <https://tudelft.zoom.us/j/94916897962>

• Thursday, Feb. 3. Course website is online.

• [All news ...](#)

### About

Photogrammetry and 3D Computer Vision (i.e., **3DV**) aim at recovering the structure of real-world objects/scenes from visual data (i.e., images, point clouds). This course is about the theories, methodologies, and techniques of 3D computer vision for the built environment. In the term of this course, you will learn the basic knowledge and algorithms in 3D computer vision through a series of lectures, reading materials, and lab exercises.

### Contents

The topics of this course cover the whole pipeline of reconstructing 3D models from images, as well as semantic segmentation/classification of point clouds:

# Communication method

- Announcements
  - No BrightSpace

3d.bk.tudelft.nl/courses/geo1016/news.html

Home

News

Schedule

Lectures

Assignments

Resources

Discussion

- Tuesday, Feb. 9, 13:45 - 15:30. First lecture on Zoom: <https://tudelft.zoom.us/j/94916897962>
- Thursday, Feb. 3. Course website is online.



# Communication method

- All schedules

3d.bk.tudelft.nl/courses/geo1016/schedule.html

Home News Schedule Lectures Assignments Resources Discussion

**Attending lectures saves you many hours!**

Week	Time	Activity	Other to-dos
3.1 Feb 08 - Feb 12	13:45 - 15:30, Feb 09, Tue.	<a href="#">Lecture 1: Intro</a>	Read <a href="#">course</a> information
	10:45 - 12:30, Feb 12, Fri.	<a href="#">Lecture 2: Cameras</a>	
	13:45 - 15:30, Feb 12, Fri.	Guided self study	Read handout Lecture 2
3.2 Feb 15 - Feb 19	13:45 - 15:30, Feb 16, Tue.	Lab exercise	Setup development environments
	10:45 - 12:30, Feb 19, Fri.	<a href="#">Lecture 3: Calibration</a>	Start A1 (due Mar 5)
	13:45 - 15:30, Feb 19, Fri.	Group work on A1	Read handout Lecture 3
3.3 Feb 22 - Feb 26	13:45 - 15:30, Feb 23, Tue.	Group work on A1	
	10:45 - 12:30, Feb 26, Fri.	<a href="#">Lecture 4: 2view</a>	
	13:45 - 15:30, Feb 26, Fri.	Group work on A1	Read handout Lecture 4
3.4	13:45 - 15:30, Mar 02, Tue.	Group work on A1	
	10:45 - 12:30, Mar 05, Fri.	<a href="#">Lecture 5: SfM</a>	<b>Due A1.</b> Start A2 (due Mar 19)

# Communication method

- All lectures through Zoom

3d.bk.tudelft.nl/courses/geo1016/lectures.html

[Home](#) [News](#) [Schedule](#) [Lectures](#) [Assignments](#) [Resources](#) [Discussion](#)

### Attending lectures saves you many hours!

Lecture	Links			
1: Introduction	<a href="#">Classroom</a>	Slides	-	Recording
2: Camera models	<a href="#">Classroom</a>	Slides	Handout	Recording
3: Camera calibration	<a href="#">Classroom</a>	Slides	Handout	Recording
4: Two view geometry	<a href="#">Classroom</a>	Slides	Handout	Recording
5: Structure from motion	<a href="#">Classroom</a>	Slides	Handout	Recording
6: Multi-view stereo	<a href="#">Classroom</a>	Slides	Handout	Recording
7: Smooth surface reconstruction	<a href="#">Classroom</a>	Slides	Handout	Recording
8: Piecewise planar surface reconstruction	<a href="#">Classroom</a>	Slides	Handout	Recording
9: Point cloud classification/segmentation	<a href="#">Classroom</a>	Slides	Handout	Recording

# Communication method

- Assignments

3d.bk.tudelft.nl/courses/geo1016/assignments.html

Home News Schedule Lectures **Assignments** Resources Discussion

In the assignments and lab exercises, you will experiment and implement (and optionally improve) various 3D computer vision algorithms/techniques using open source libraries. Please note:

- There are 3 mandatory assignments designed to get you started with programming 3D reconstruction and point cloud processing workflows. Each assignment will be released/accessible after the related lectures are delivered.
- Groups of 3 (ideally) students will work on assignments together. It is essential that every group member plays an active role, including in writing codes AND in writing the report. A division of tasks based on handing the role of report writing to one person and code writing to another is strongly discouraged! C++ source code frameworks are provided and you only need to implement the core algorithms. You will get every support to accomplish the assignments successfully.
- The assignments together form a project, in which every subsequent assignment may depend on the previous ones. In case you fail in a previous assignment, the depending code and data will be provided for you to be able to continue on the project.  
Be creative with experiments; try different scenarios and discuss the pros and cons.
- Your report needs to include a brief description of how the tasks were distributed among the team. This is used to differentiate individual grades (see [here](#) for a template of report).
- You may submit an assignment multiple times, but it is mainly assessed based on your first submission. If you improve and resubmit your assignment based on feedback (from the teachers or from peer reviewing), you may receive a slightly higher mark, but no more than  $G0 + 0.5$  ( $G0$  denoting the mark of the first submission).
- Strict deadline: 10% deduction per day late, no more accepted after 3 days.

**Read instructions before you start!**

# Communication method

- Useful resources

3d.bk.tudelft.nl/courses/geo1016/resources.html

Home News Schedule Lectures Assignments Resources Discussion

## Reading materials

(Handouts will be distributed after each lecture)

The course involves quite some mathematics and computation. In addition to the lectures and handouts, you're advised to read chapters of books, e.g., linear algebra [1]. The basic theory and methodology of computer vision appear in books, e.g., [2], and surface reconstruction topics are discussed in scientific papers [3, 4, 5].

[1] D. Cherney, T. Denton, R. Thomas, and A. Waldron, [Linear Algebra](#). 2013

[2] R. Szeliski, [Computer Vision: Algorithms and Applications](#). London: Springer London, 2011.

[3] H. Hoppe, et al. [Surface reconstruction from unorganized points](#). SIGGRAPH, 1992

[4] M. Kazhdan, M. Bolitho, H. Hoppe. [Poisson surface reconstruction](#). SPG, 2006, 61-70

[5] L. Nan and P. Wonka. [PolyFit: Polygonal Surface Reconstruction from Point Clouds](#). ICCV 2017.

[6] Y. Furukawa and J. Ponce. [Accurate, Dense, and Robust Multiview Stereopsis](#). PAMI, 2010

## Programming resources and tools

### C++ Tutorials

[1] C++ Tutorial A: <http://www.cplusplus.com/doc/tutorial/>

# Communication method

- Discussion (mainly through Discord)

3d.bk.tudelft.nl/courses/geo1016/discussion.html

Home News Schedule Lectures Assignments Resources Discussion

### Join the Discord channels for discussions

- **GEO1016 text channel:** <https://discord.gg/zmaZDNkjjH>

This is a public text chat, which you can use to post questions, to discuss, or for general chatting. It's usually best to ask questions here, since everyone can benefit from the answers.
- **GEO1016 voice channel:** <https://discord.gg/KjrbK5p5qf>

This is a public voice chat, which you join manually by clicking on it. If you join it, you will listen to what the others in the voice channel are saying (unless you deafen it → headphones icon) and everything you say will be also heard by the others (unless you mute it → mic icon). You're free to use it anytime to discuss anything with the rest of your classmates (who are in the channel at that point).

Once you have joined the voice channel, you can also use it to share your screen (or a single window) with your classmates (→ Go Live icon with display and arrow). When you do so, a red LIVE icon will appear next to your username, and people will be able to click on your user and see your stream.

If you want to ask very detailed questions that are only relevant to your work, it's probably better to do a separate one-to-one or small group call (with possible video and/or screen sharing). For that, let the teachers know on the text channel. When one of us is free, we will add you as a friend (or you can do that anytime!), and we can then start the call.

### Individual meetings with the teacher(s)

In addition to the regular course hours, it is also possible to meet the teachers individually (by appointment only). When you make an appointment, please indicate two time slots and a link to the meeting room (could be Zoom, Teams, whatever).

# Grouping

- Find your teammates ...
  - 3 students per team
  - Click on following link and put your name and student ID

[https://docs.google.com/document/d/1WMPXgWD0\\_2F9oDSub1K-g6NdRKqIRyWj3sUFDCpfFSk/edit](https://docs.google.com/document/d/1WMPXgWD0_2F9oDSub1K-g6NdRKqIRyWj3sUFDCpfFSk/edit)

# Next Lecture

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## Lecture 2: Camera models

$$\rho \tilde{\mathbf{x}} = \mathbf{K}(\mathbf{R}\mathbf{X} + \mathbf{T})$$

See you on Friday morning!