COMP0130 Robot Vision and Navigation
Module Overview and General Housekeeping

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Module Aims

- This module will teach current techniques for 3D localization, mapping and navigation:
  - Filtering techniques and data fusion
  - Motion estimation and mapping using Simultaneous Localisation and Mapping (SLAM) techniques
  - 3D reconstruction

Localization (or Positioning) in Robotics

Naïo Technologies DINO vegetable weeding robot

C-Enduro (University of Exeter)

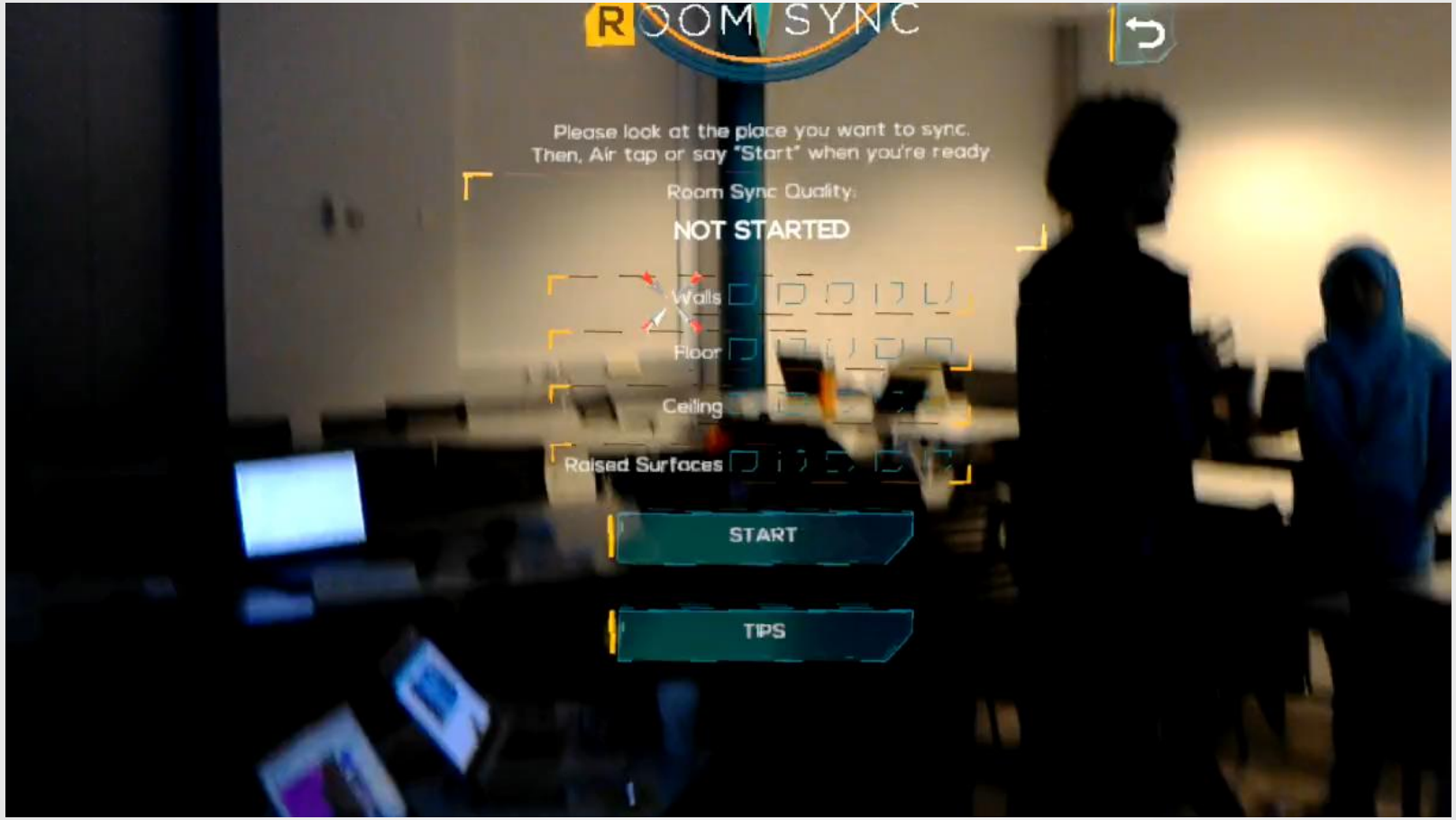
Warehouse Robots

Mapping, DARPA Grand Challenge Robots

Carnegie Melon Video “Autonomous Robots Map and Detect Objects in Mines”

Virtual and Mixed Reality Systems

HoloLens


ROOM SYNC
Please look at the place you want to sync.
Then, Air tap or say "Start" when you're ready
Room Sync Quality:
NOT STARTED
Walls
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START
TIPS

Sparse City-Scale Mapping

Learning Outcomes

- Develop understanding of the algorithms, principles and techniques
- Develop appreciation of strengths and weaknesses of approaches, and when it is most appropriate to use them
- Acquire experience in implementing and testing these algorithms

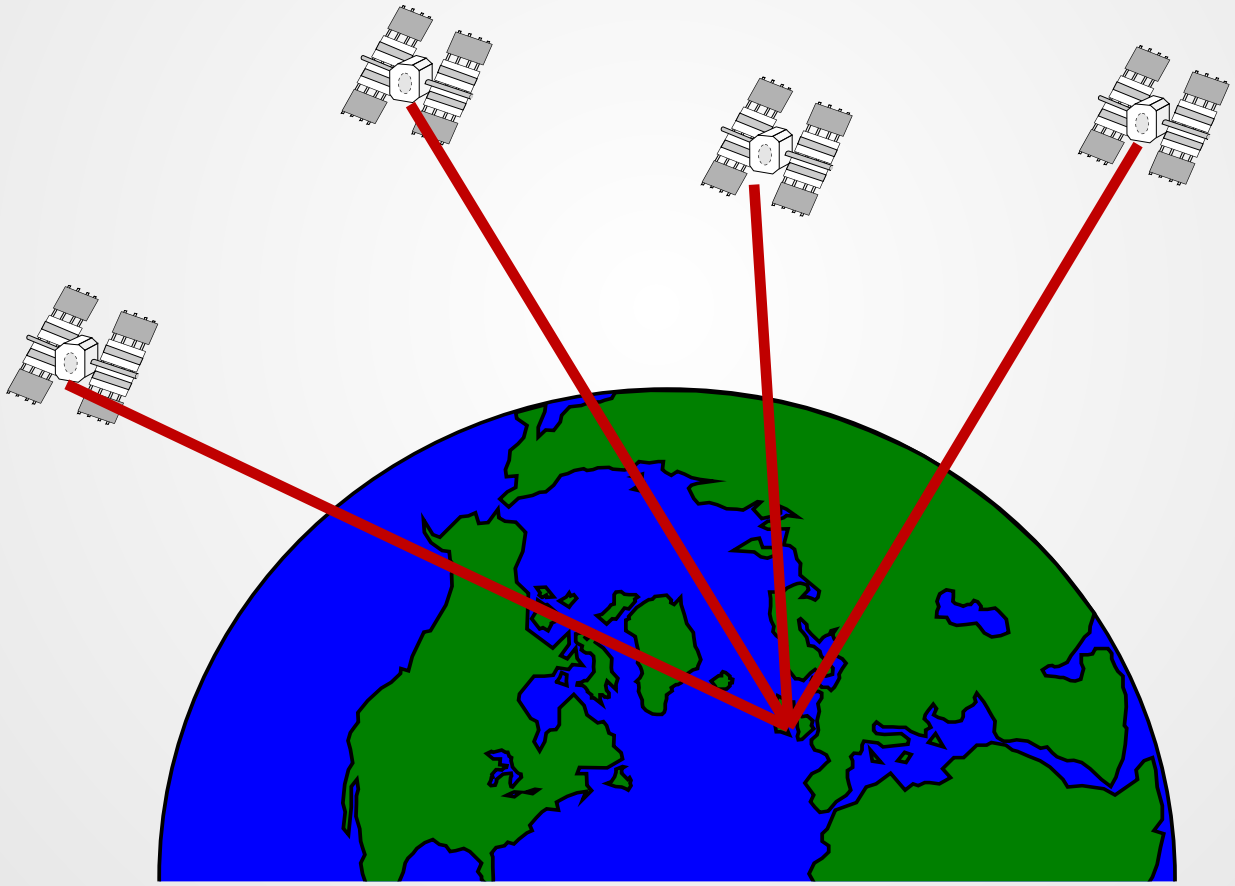
Course Content

- In this module we will cover the following basic themes:
  - GNSS, Filtering and Motion Sensing (Weeks 1-3)
  - Factor graphs and SLAM (backend) (Weeks 4-6)
  - Feature matching and computer vision (frontend) (Weeks 7-10)

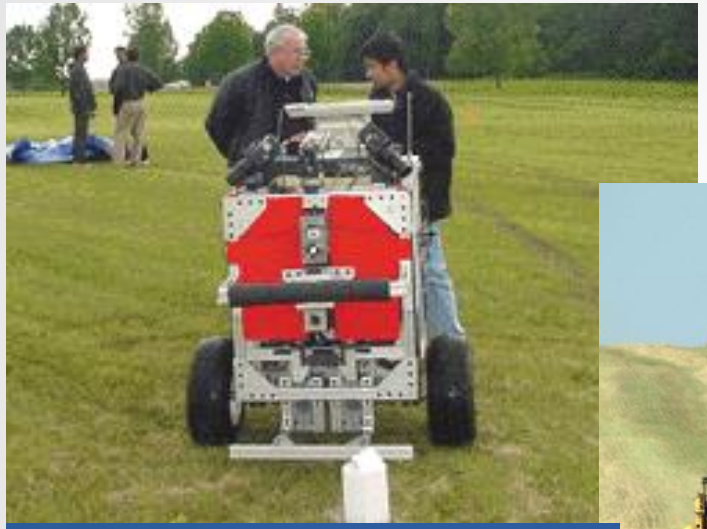
Part 01: Satellite and Inertial Navigation

- We first focus on how robots in relatively open environments can continuously estimate their position and orientation over time
- We will look at GNSS and inertial navigation systems
- Many of these systems can be very effectively implemented using Kalman filters

GNSS-Based Localization



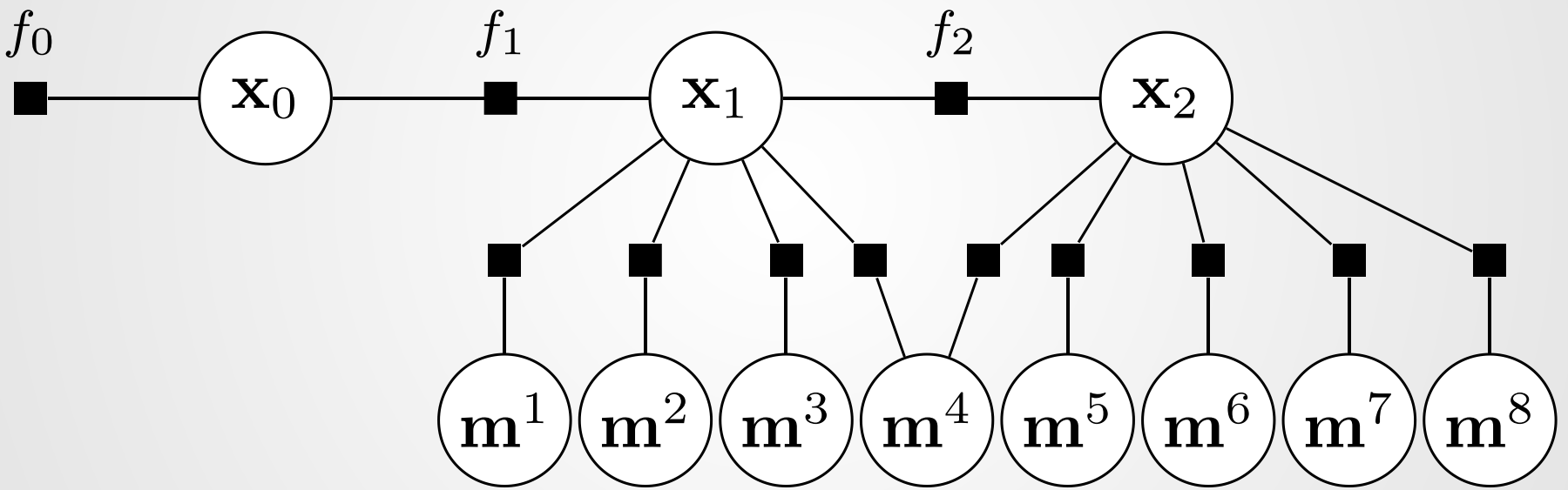
GNSS-Based Robot Localization



Part 02: Backend SLAM

- SLAM is a nonlinear high dimensional estimation problem
- The system has to deal with noisy sensors and errors
- Careful probabilistic approaches are used
- This part looks at the mathematical challenges
- We describes the dominant approach: factor graphs with maximum likelihood estimation

Factor Graphs



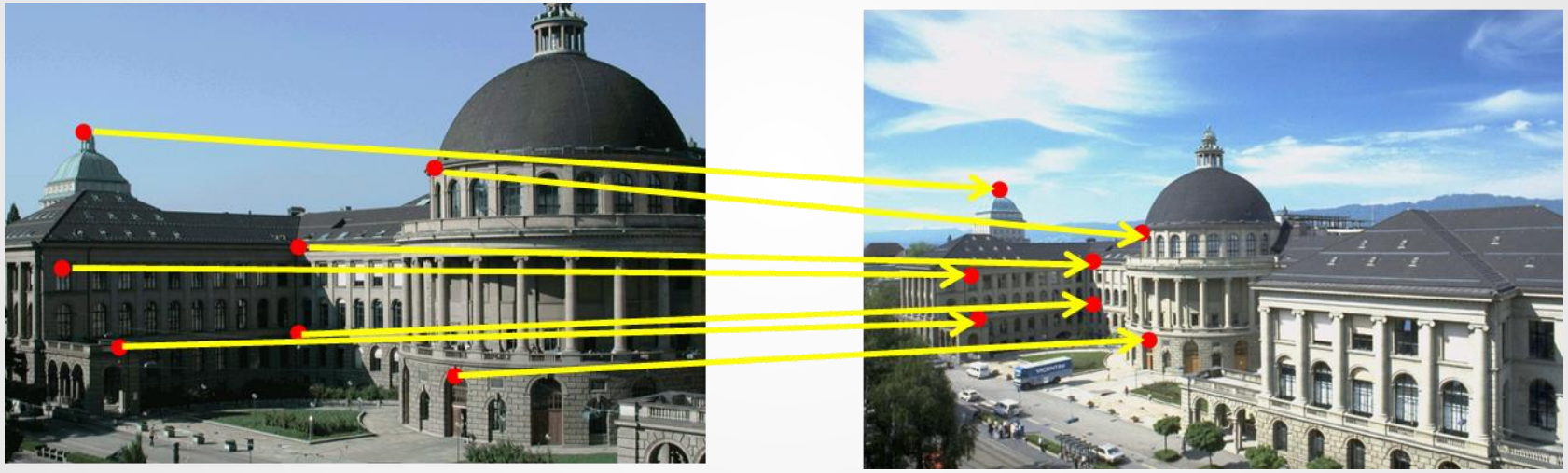
Part 03: Frontend SLAM

- To build a full SLAM system, it’s necessary to take in raw data and use it to identify features and track them over long periods of time

- In this part of the module we look at the definitions of those features and ways to match and track them over time

Visual Odometry 测距

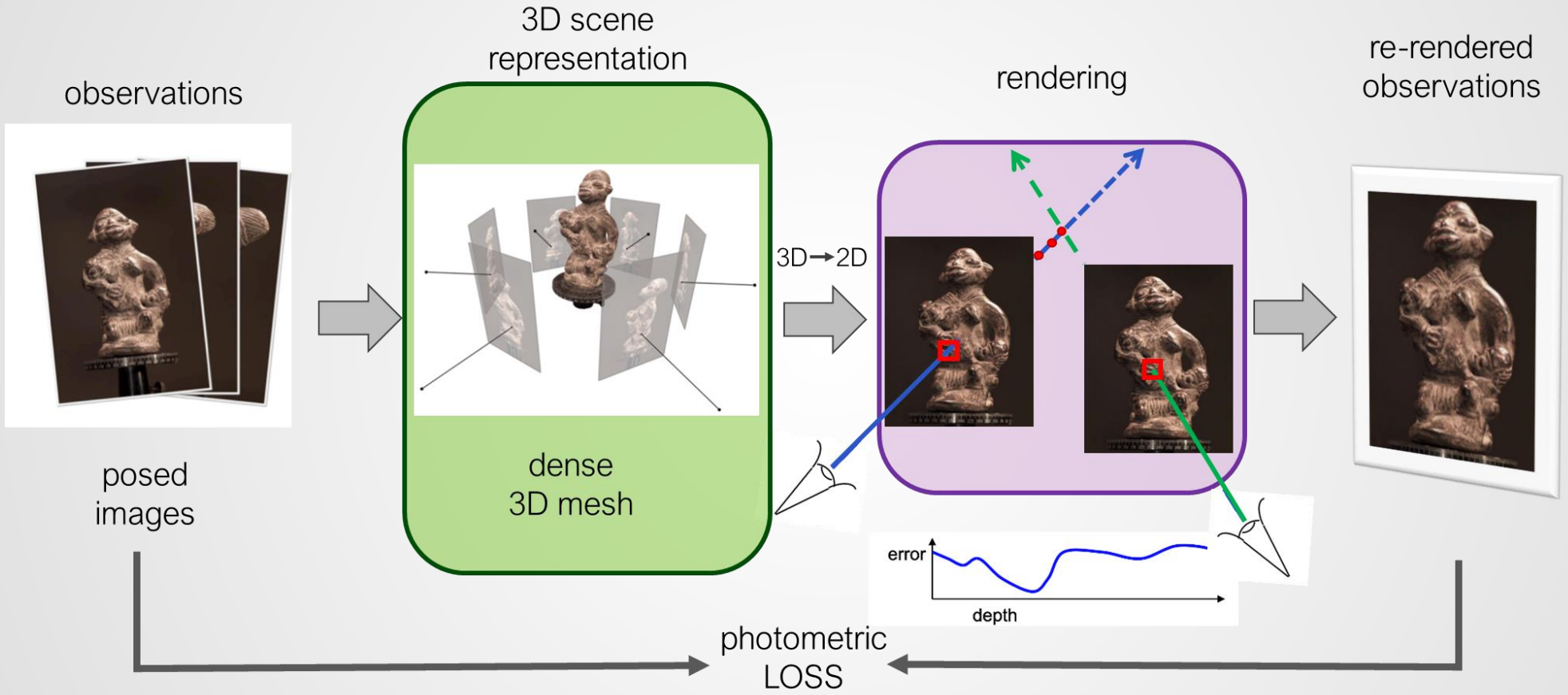
Feature Matching



Dense Reconstruction

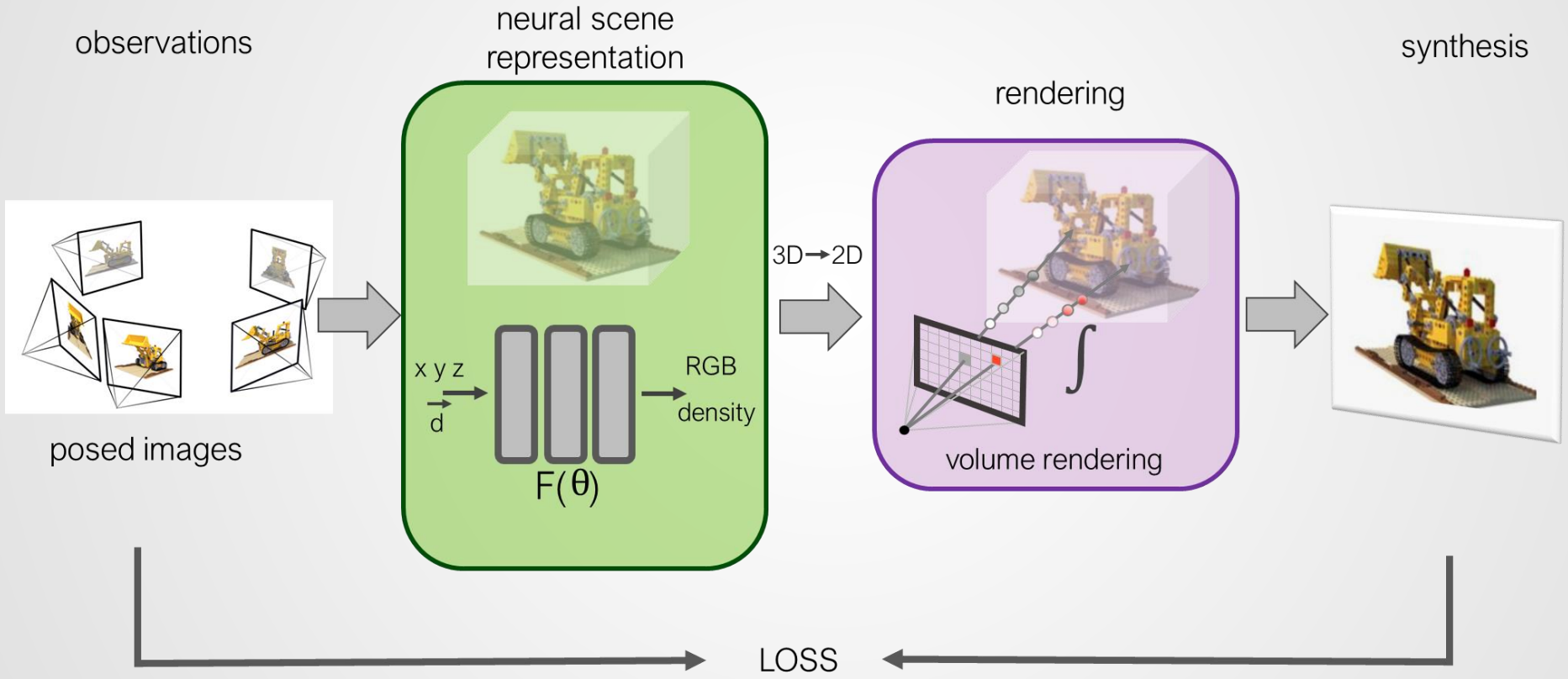
"3D Gaussian Splatting for Real-Time Radiance Field Rendering", Kerbl et al. 2023

Dense Multi-View Stereo



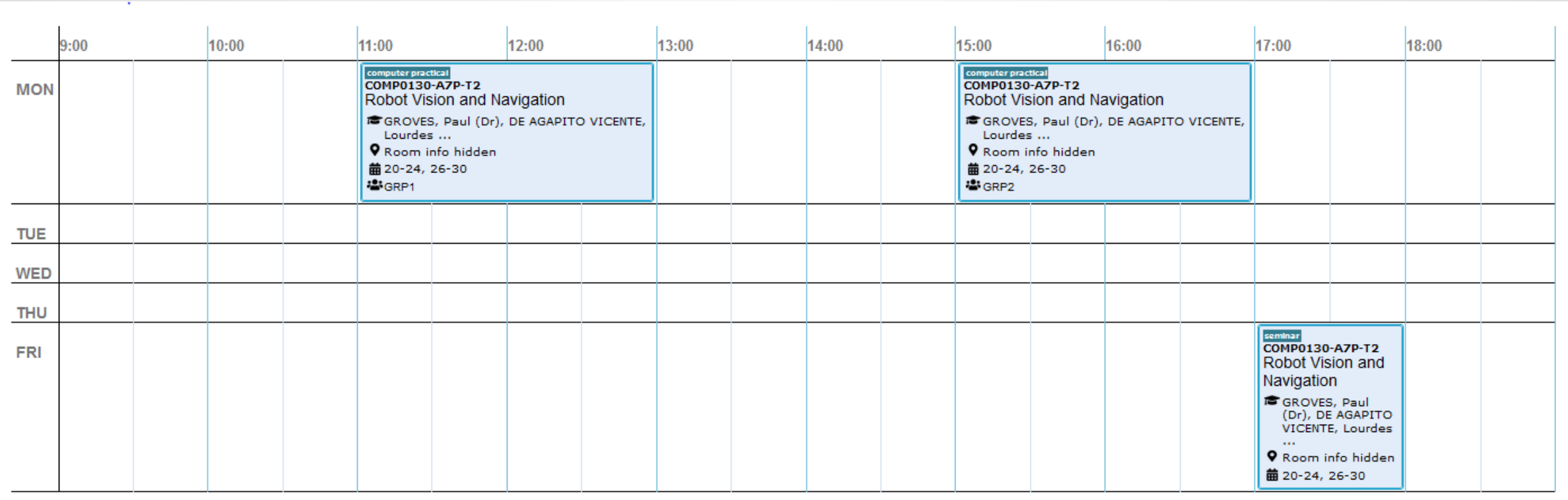
Multiview photometric stereo (Hernandez, Vogiatzis, Cipolla, PAMI 2009) …

Neural Radiance Fields



NeRF: Representing Scenes as Neural Radiance Fields for View Synthesis (Mildenhall, Srinivasan, Tancik et al. ECCV'20)

Timetable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MON
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computer practical
COMP0130-A7P-T2
Robot Vision and Navigation
GROVES, Paul (Dr), DE AGAPITO VICENTE, Lourdes ...
Room info hidden
20-24, 26-30
GRP1
computer practical
COMP0130-A7P-T2
Robot Vision and Navigation
GROVES, Paul (Dr), DE AGAPITO VICENTE, Lourdes ...
Room info hidden
20-24, 26-30
GRP2
seminar
COMP0130-A7P-T2
Robot Vision and Navigation
GROVES, Paul (Dr), DE AGAPITO VICENTE, Lourdes ...
Room info hidden
20-24, 26-30

Assessments

- **Coursework 01 33% (10/01 – 08/02):**
  - GNSS and IMU
- **Coursework 02 33% (14/02 – 06/03):**
  - Smoothers and Sparse SLAM
- **Coursework 03 34% (16/03 – 12/04):**
  - Dissecting SLAM Systems

Pulse Surveys

- Dates of issue / discussion:
  - 15/01/24 – 19/01/24
  - 19/02/24 – 23/02/24

Coursework Submissions

- All assessment is group coursework based
- Each coursework will involve a mix programming and evaluation using mostly Matlab (CWs 1 and 2) and C++ and Python (CW3)
- Submission will be a written report together with the developed code
- Late marking penalties start to apply at 16:01
- The only exception for a late submission penalty is an EC

Report Writing

- Please write it in something like LaTeX or Word
  - Reports produced from google docs are really, really, really bad
- Please use code to render figures directly to images rather than screen capture
  - Screen captures often are *very low quality* and critical values cannot be read
  - Use vector formats (e.g., eps or pdf) if possible
- Effective communication is important so clarity matters
  - Please spend time to make sure your descriptions are clear, etc.
  - Discuss your results, don't just stick graphs down

Groups and Lab Allocations

- All work will be carried out in groups of 1-3 people
- Everybody must be in a group to be able to submit coursework via moodle
- Group choices are open now
- Contact us if you have trouble finding a group
- As a group, pick which lab you are going to attend
- We expect all members of the same group to attend the same lab together

If Groups Go Wrong

- Because of limitations with moodle, groups can only changed in exceptional circumstances
- If there are problems with your group contact us; mechanisms exist to handle lack of participation
- Note that we reserve the right to allocate *different* marks to *different* members of the same group