Robot Vision: Introduction

Prof. Friedrich Fraundorfer

SS 2023

About me

- Prof. Dr. Friedrich Fraundorfer
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- Institut für Maschinelles Sehen und Darstellen
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- Consultation hours after email-appointment

Course schedule

- 14 lecture slots
  - Tuesdays, 14:30-16:00, lecture room i11
  - Pre-recorded lectures from 2021 are additionally available

- Course grade
  - Exams multiple times per term (written and oral exams offered)
  - Main exam at the end of the semester will be written

- Accompanied by practical

- Lecture webpage
  - https://www.tugraz.at/institute/icg/teaching/coursepages/710088-robotvision/

Practical

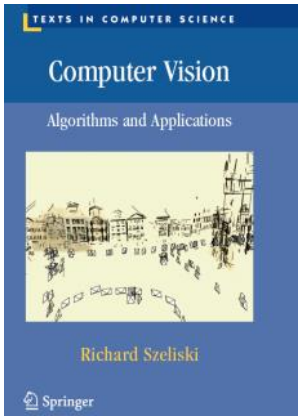
- Practical consists of 3 programming assignments
- Groups of 2 students -> group enrollment in TC
- Programming in C/C++ and OpenCV and Python

- Assignments:
  - Camera calibration and stereo
  - Feature matching and epipolar geometry
  - Deep learning for depth estimation

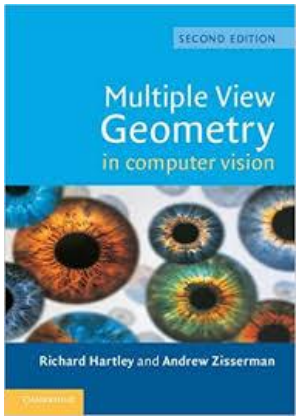
- Deliverables (submitted via TC):
  - Source code
  - Report (PDF)

Lecture material

- Slides will be made available on the web-page



Richard Szeliski. Computer Vision: Algorithms and Applications. Springer. 2010



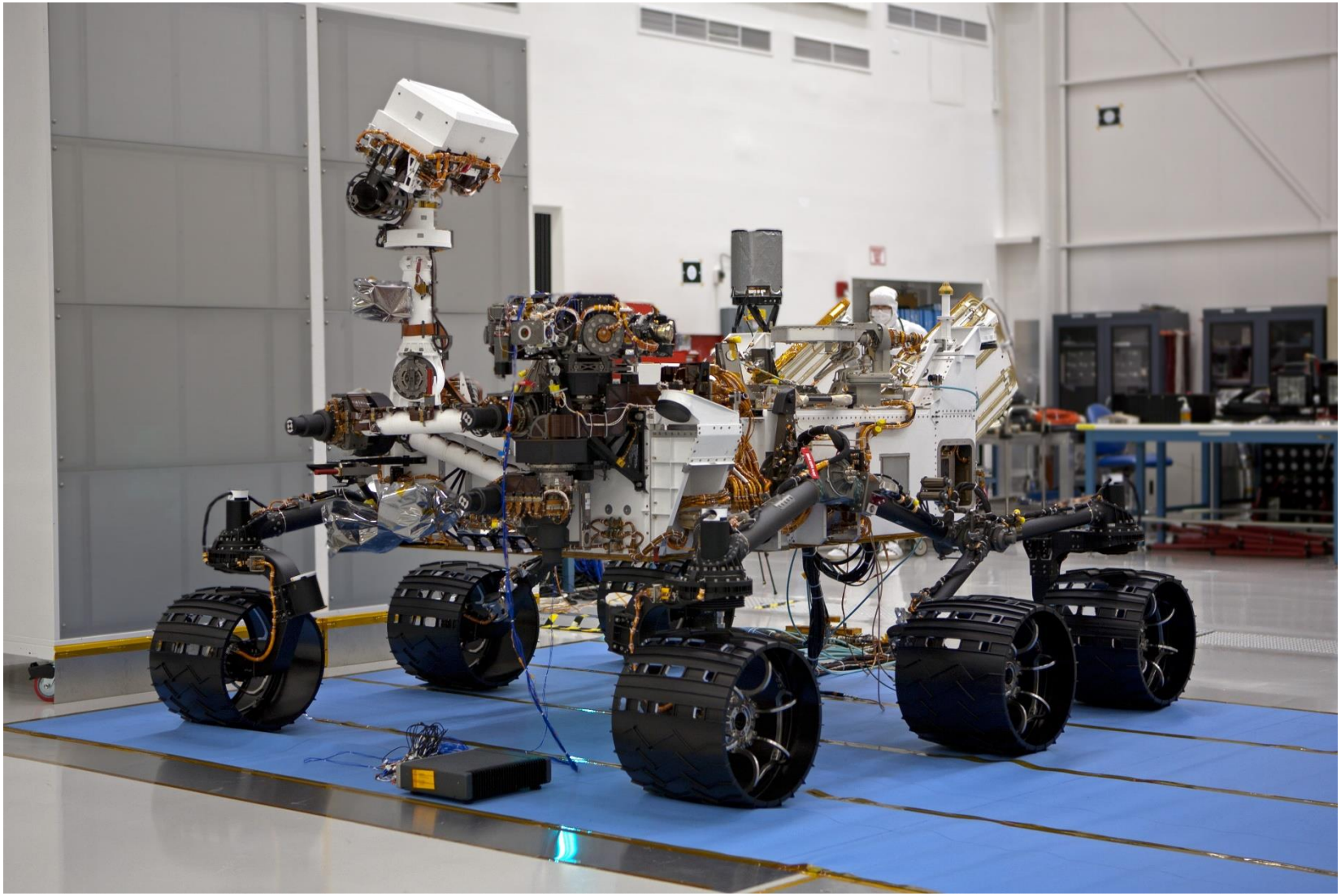
Richard Hartley and Andrew Zisserman. Multiple View Geometry in Computer Vision. 2004

Classroom activity

What is robot vision?

What do you think you will learn about?

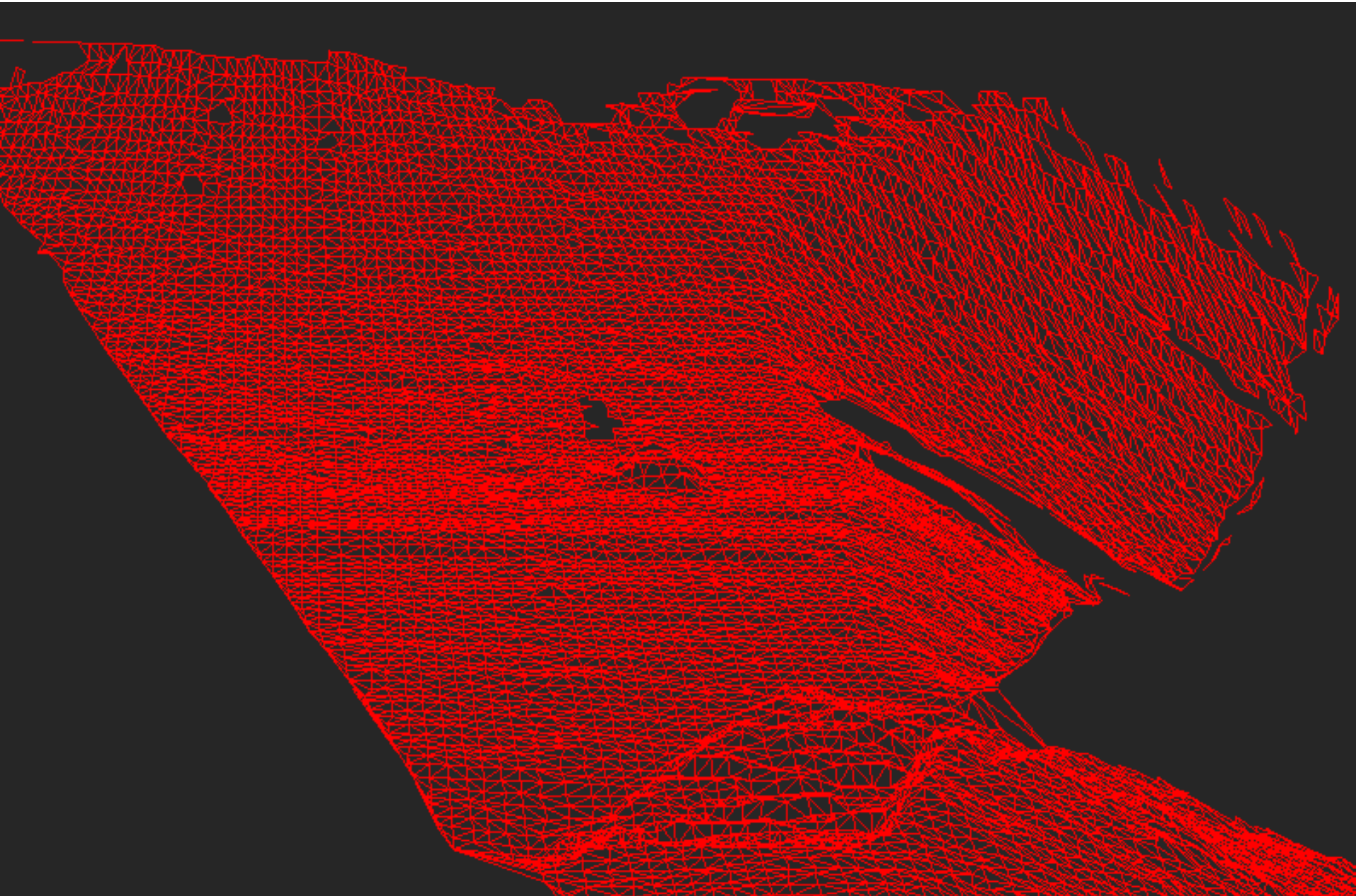
Cameras for safe navigation



[Image credit: NASA (public domain)]

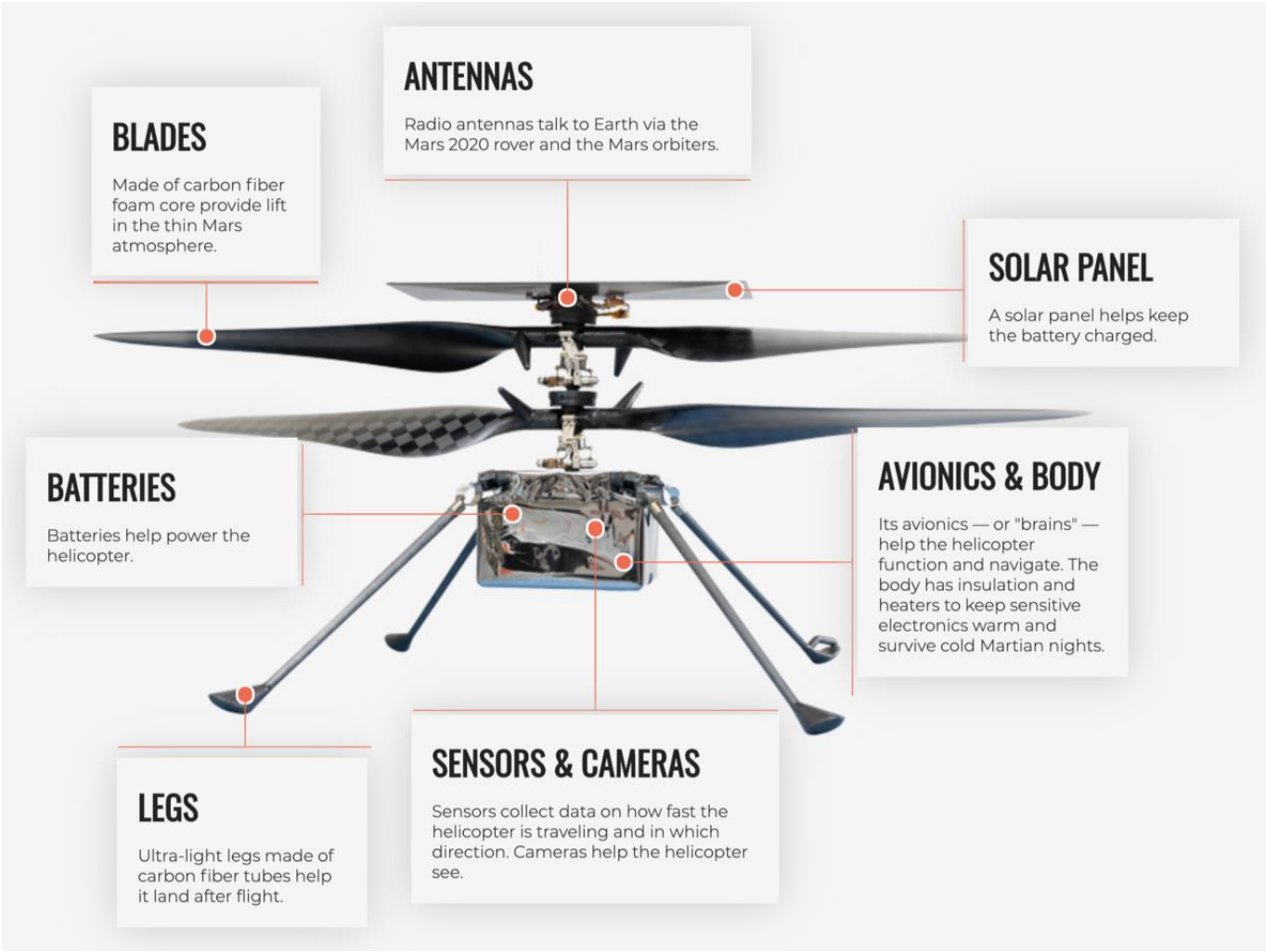
Cameras for safe navigation

Cameras for safe navigation



Perseverance and Ingenuity

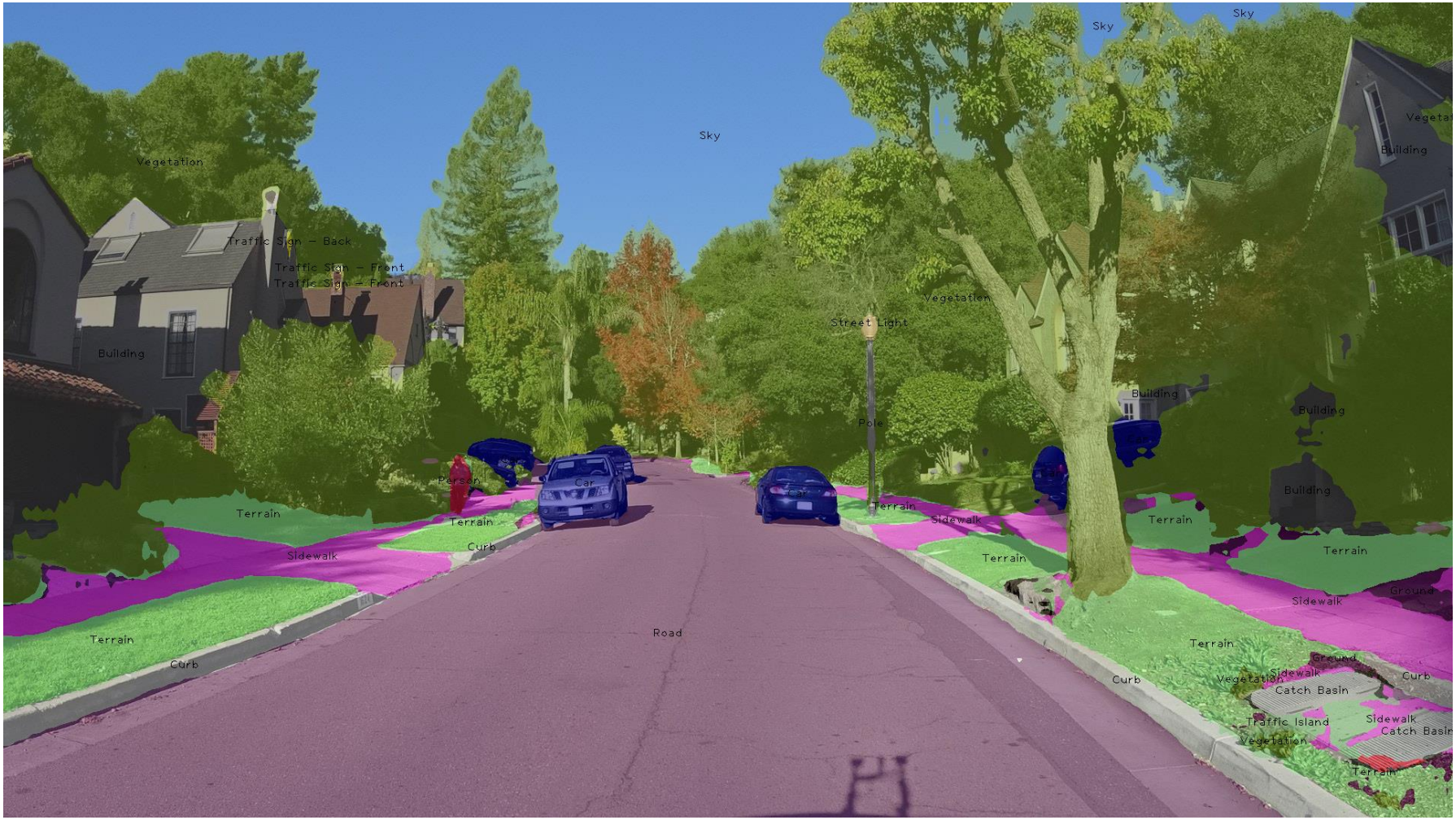
- Landed on 18th February 2021



[Image credit: NASA (public domain)]

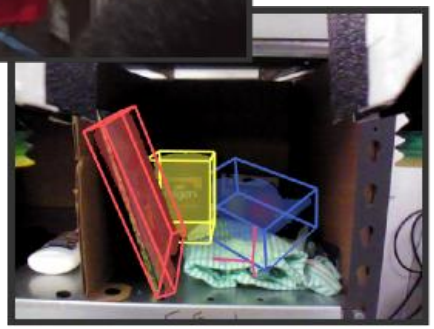
Self driving cars

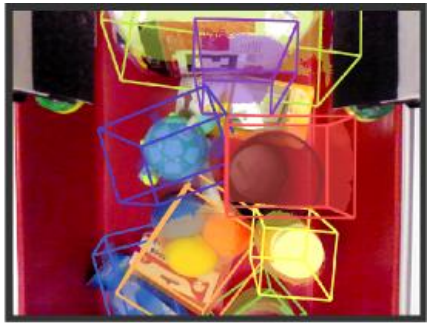
Self driving cars

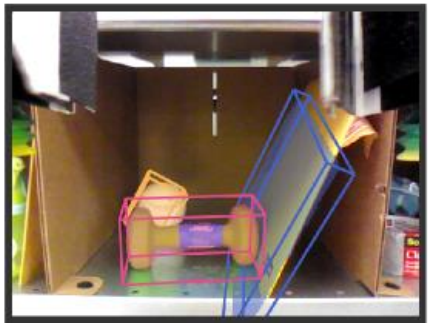


[Image credit: Mapilliary]

Robotic grasping & household robotics



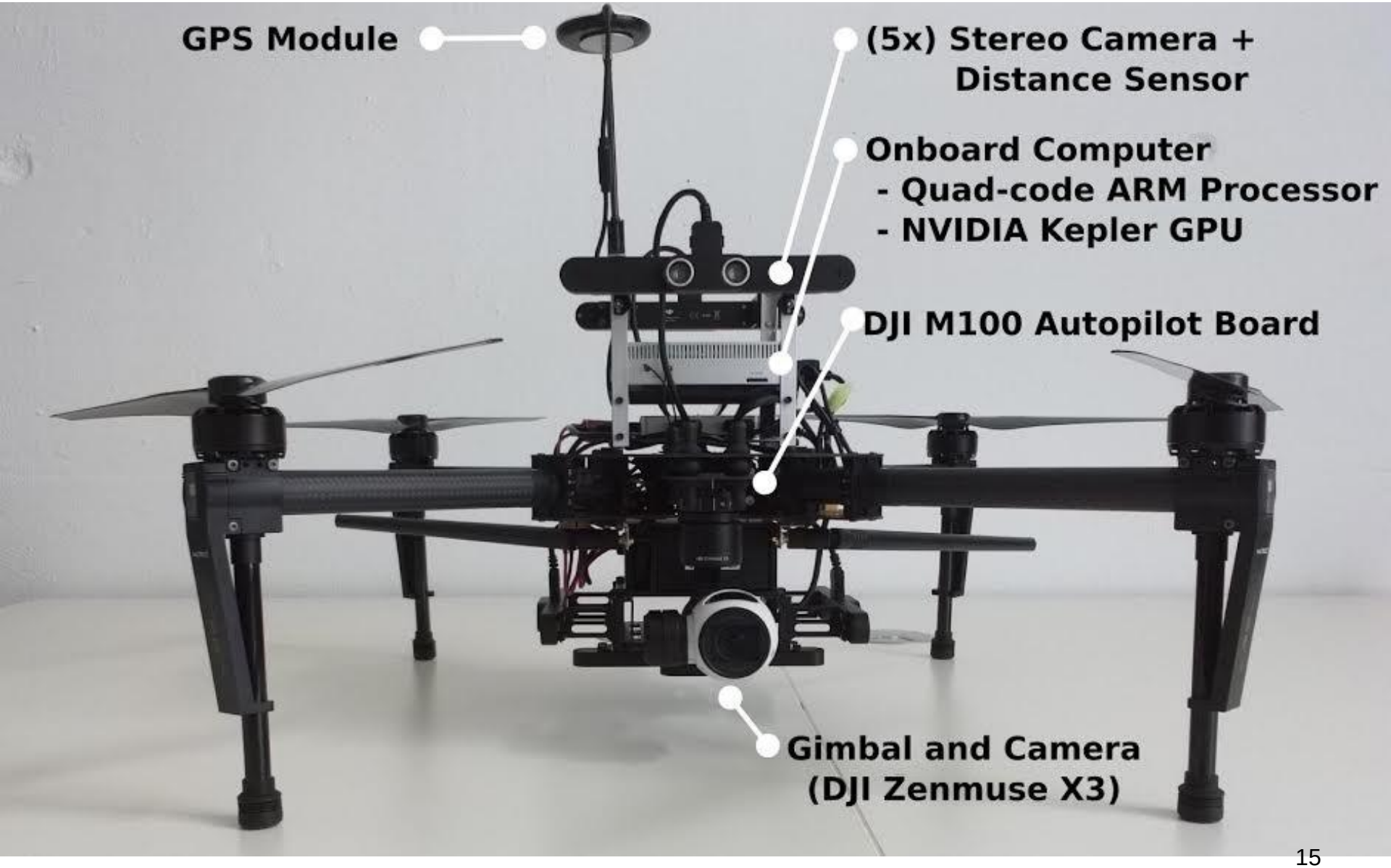




[Image credit: Andy Zeng MIT]

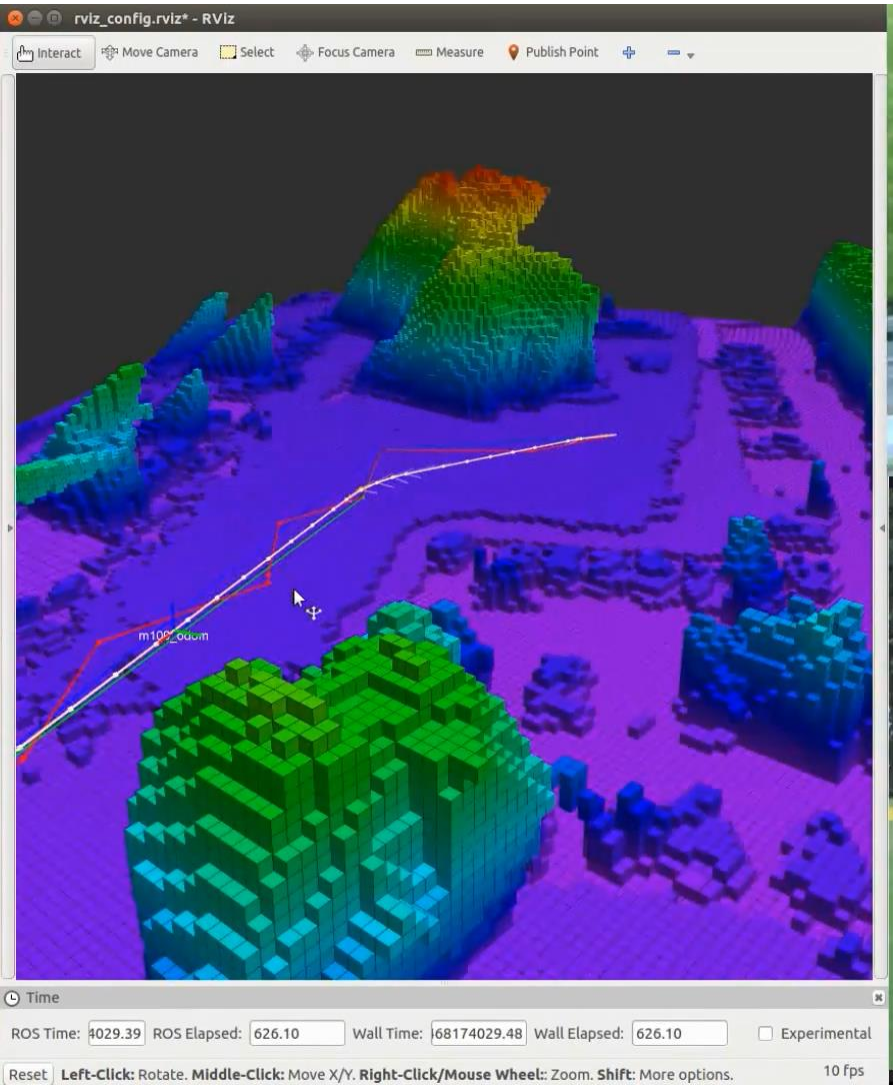
Robotic Grasping

Flying robots



Flying robots

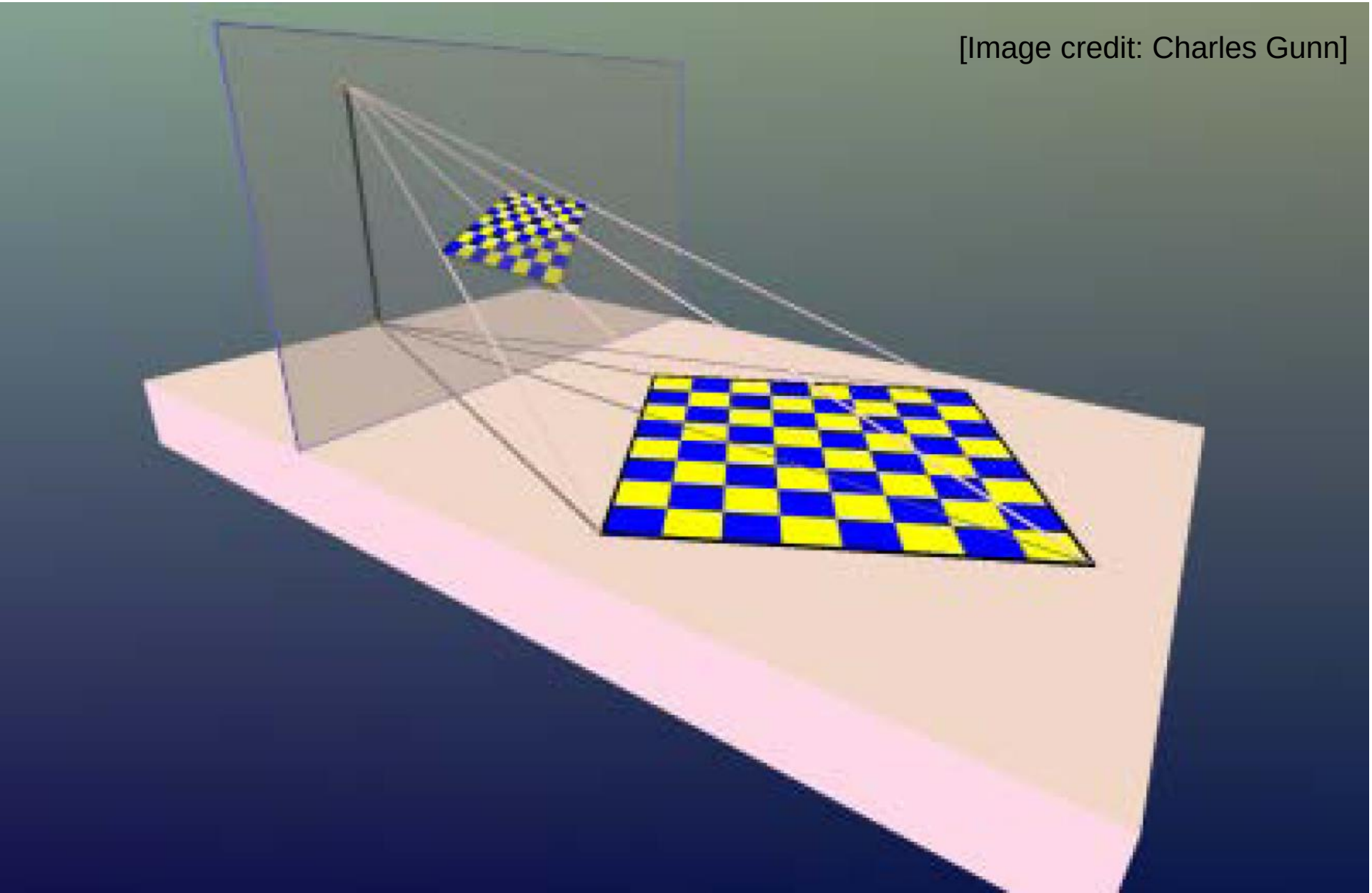
Flying robots



Lecture topics

- Projective geometry
- Image formation and camera calibration
- Geometric algorithms (Fundamental matrix, Essential Matrix, Triangulation)
- Robust estimation (Ransac)
- Features and matching
- SfM
- Bundle adjustment
- Stereo matching
- Multi-View Stereo
- Deep learning for monocular depth estimation
- Depth cameras

Projective geometry



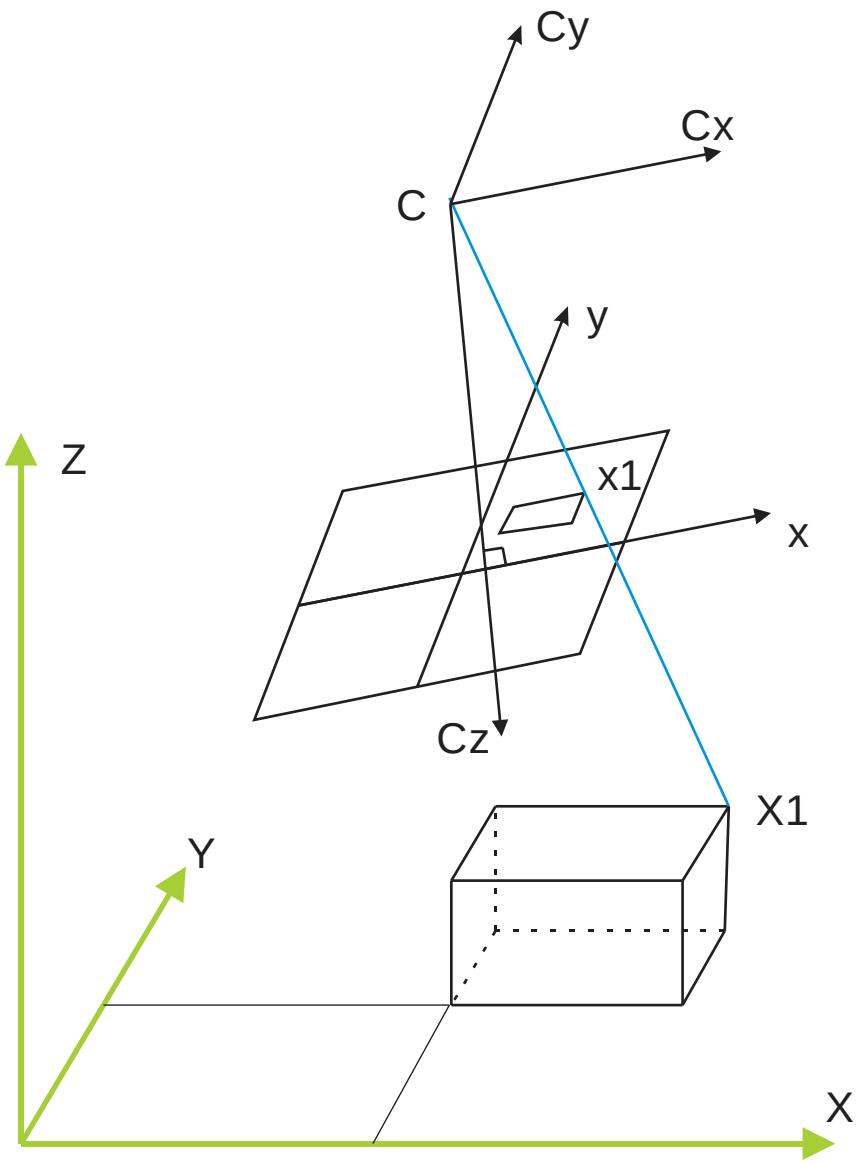
Projective geometry: Measuring in images

Projective geometry: Measuring in images

[Source: KITTI]

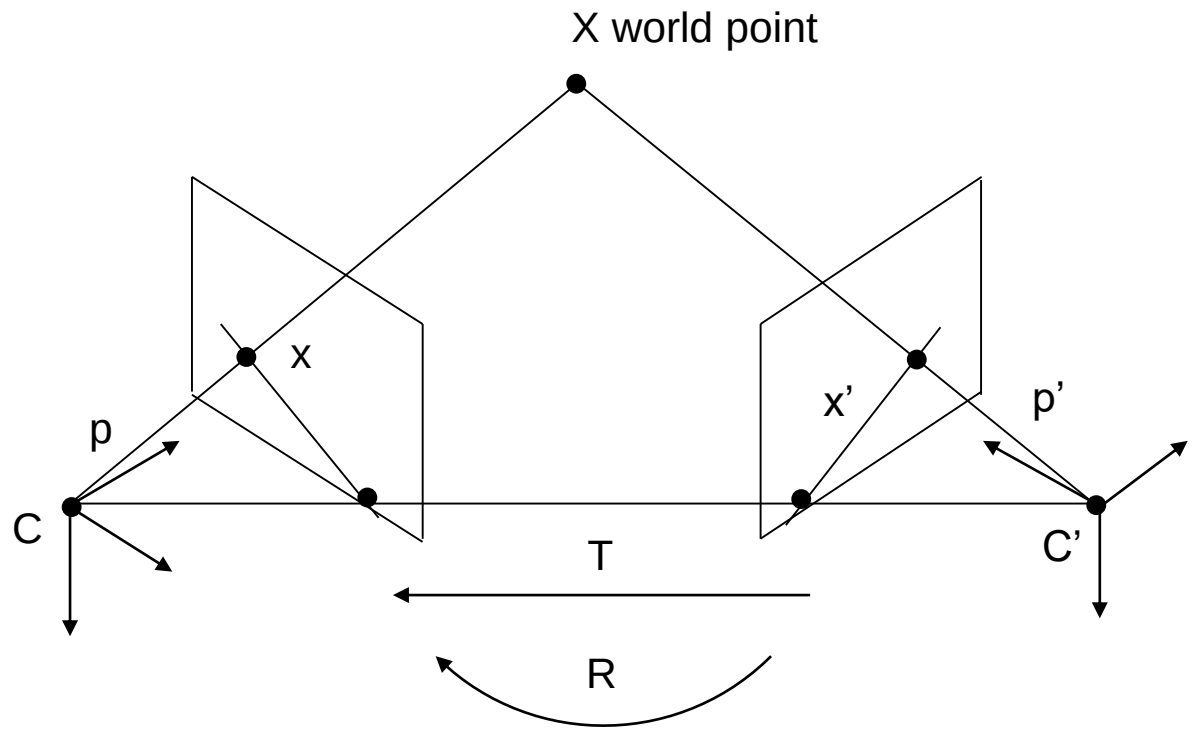
Projective geometry: Measuring in images

Image formation and camera calibration



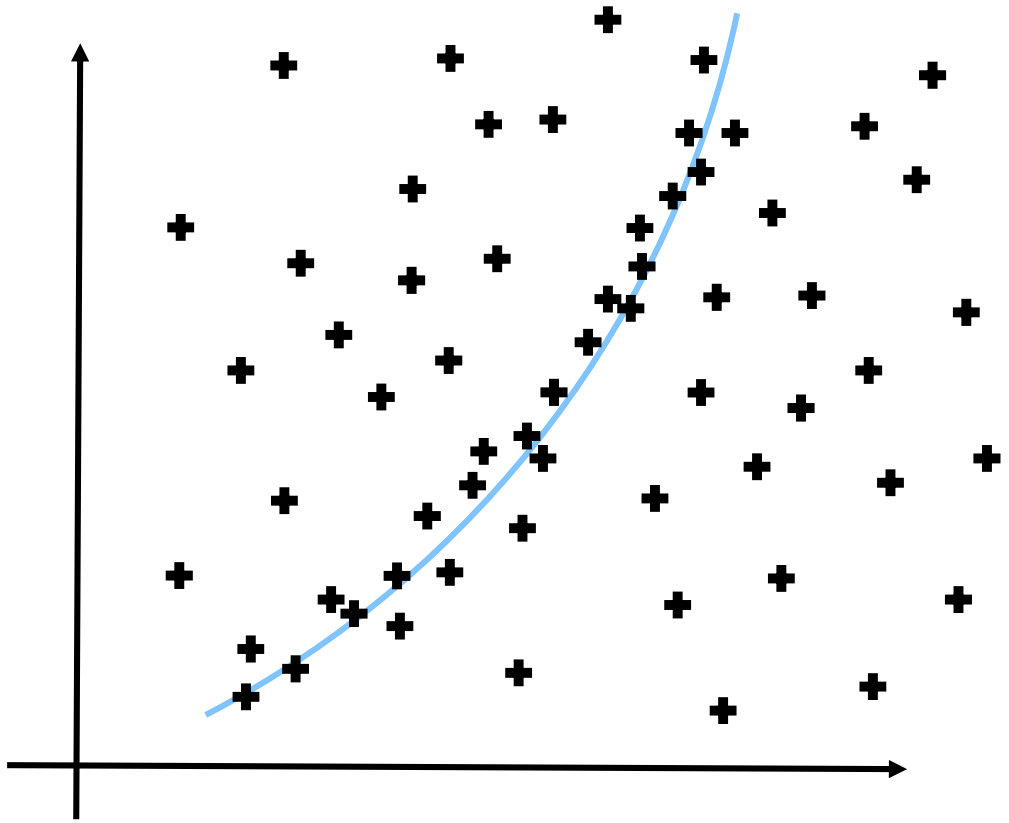
Geometric algorithms

$$x'^T F x = 0 \quad \textit{... Epipolar constraint}$$

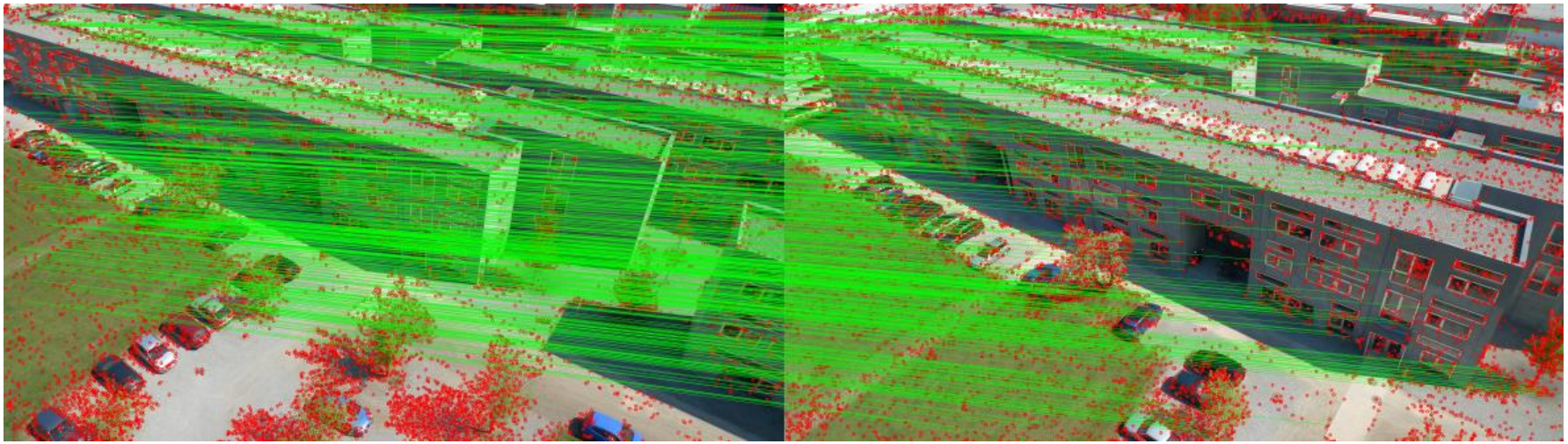


Robust estimation

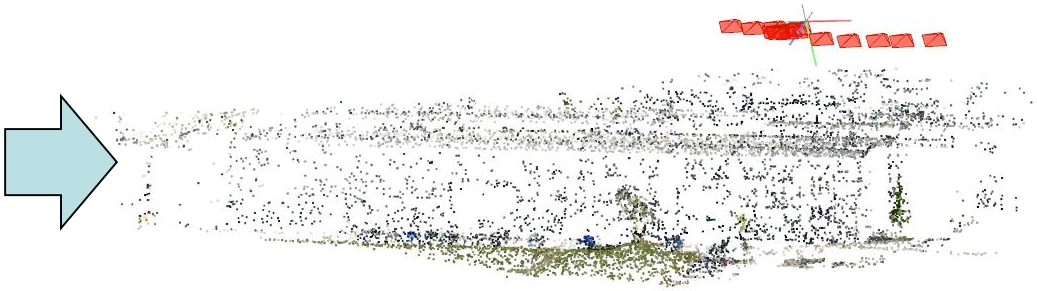
- Ransac – Random sample consensus



Feature detection and matching

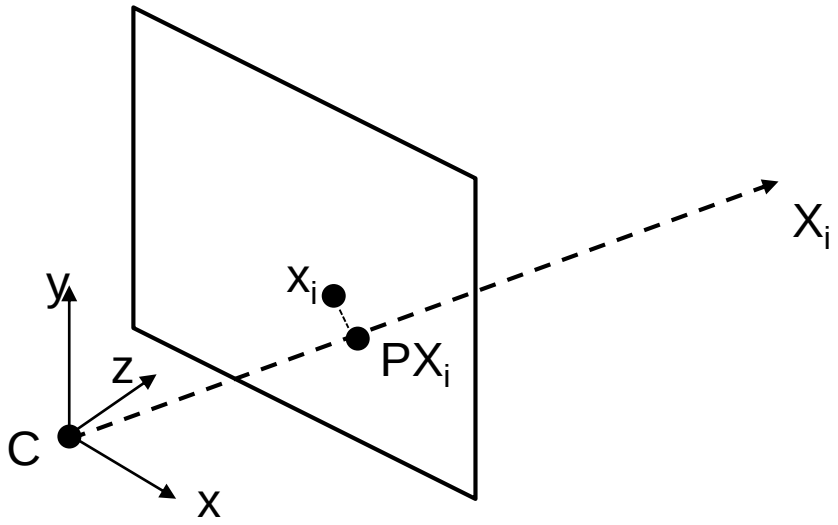


Structure-from-Motion (SfM) concept



Bundle adjustment

$$\min_{P_j, X_i} \left(\sum_i \sum_j \left\| x_{i,j} - P_j X_i \right\| \right)$$



Stereo matching

Left View

I_l

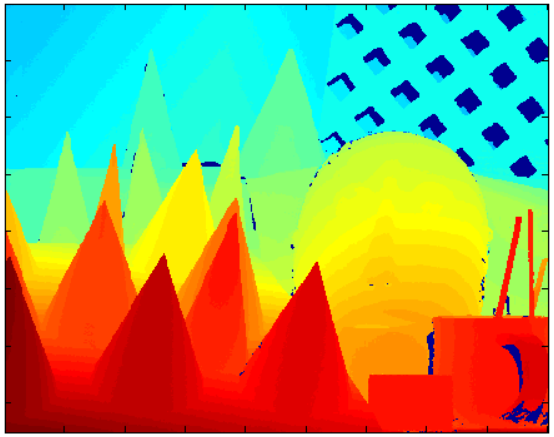
+

Right View

I_r

$*$

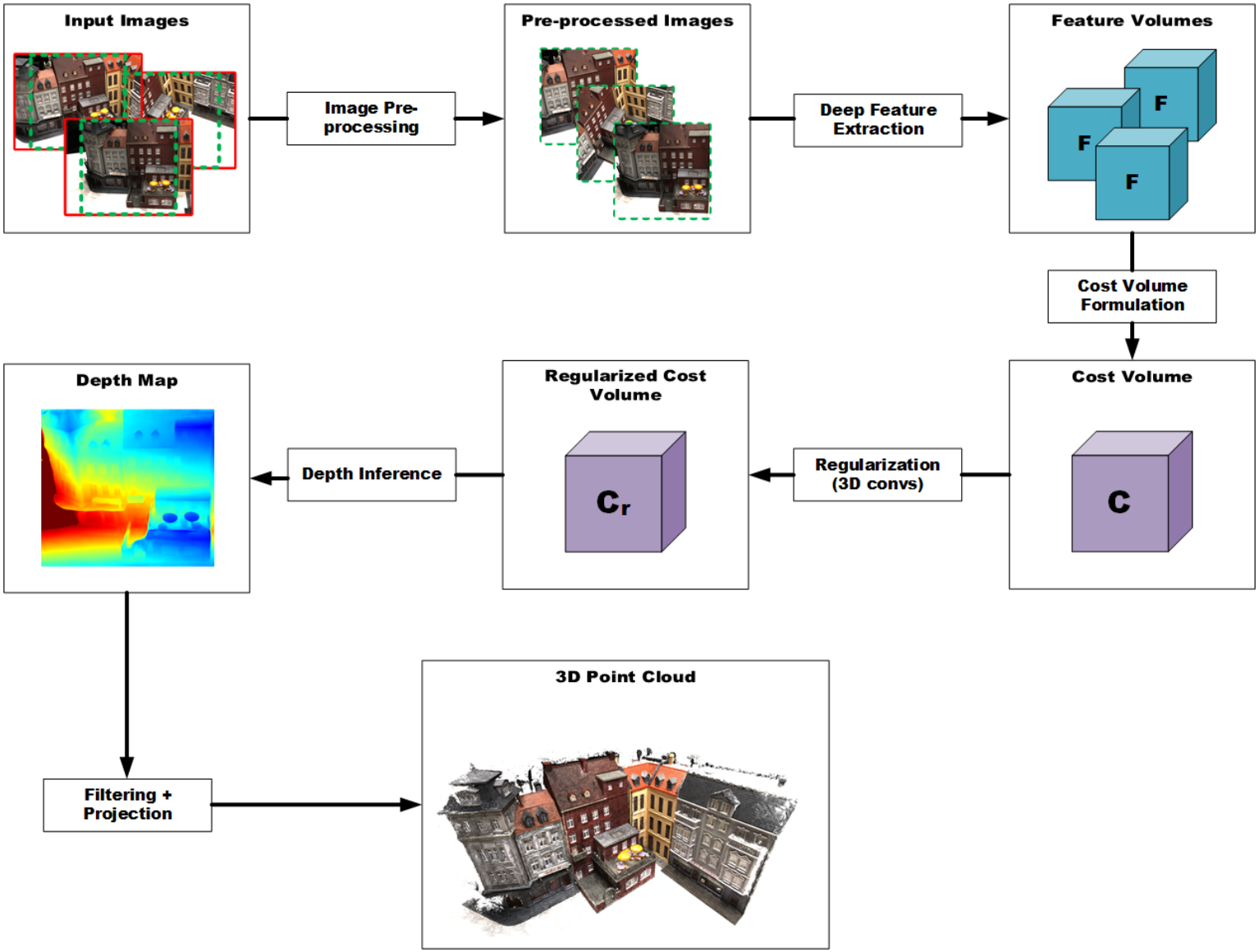
$=$



Disparity image

D

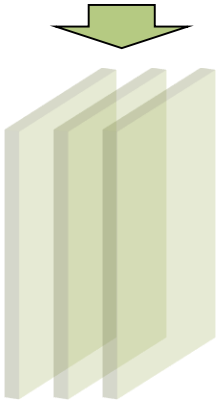
Multi-View Stereo



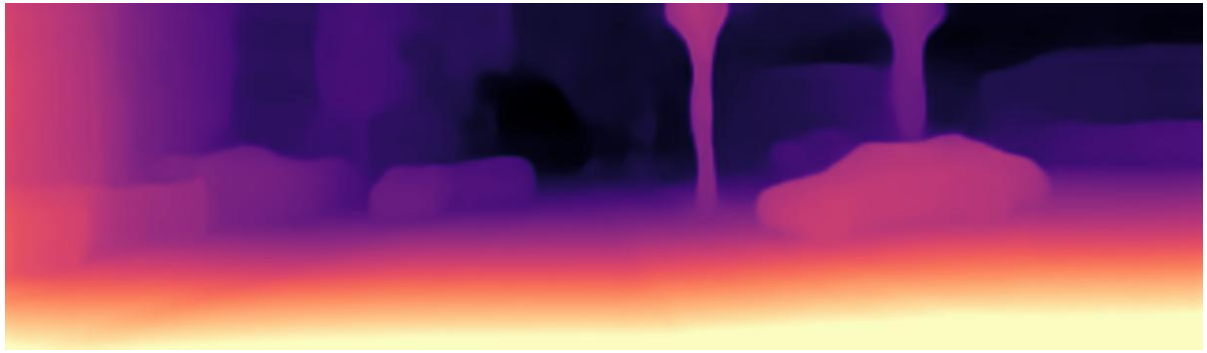
Multi-View Stereo

Deep learning for monocular depth estimation

input image



depth CNN



depth image (output)

Depth Cameras