3D Computer Vision

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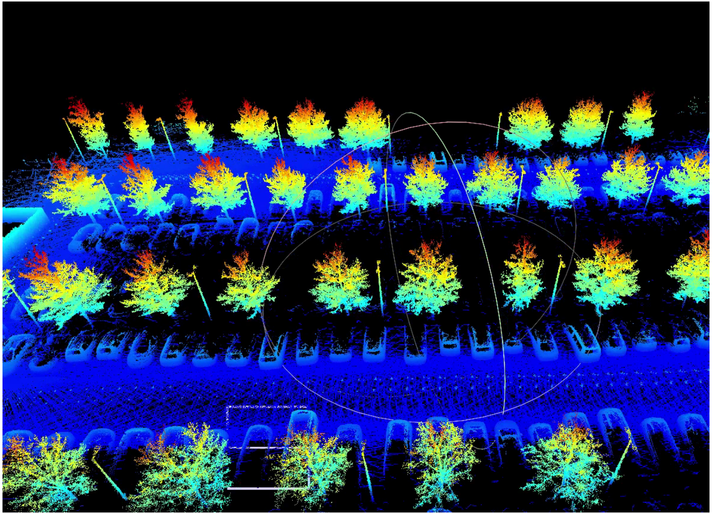
Open Informatics Master's Course

Module I

Course Overview

3D Vision is Not Just about 3D Point Clouds



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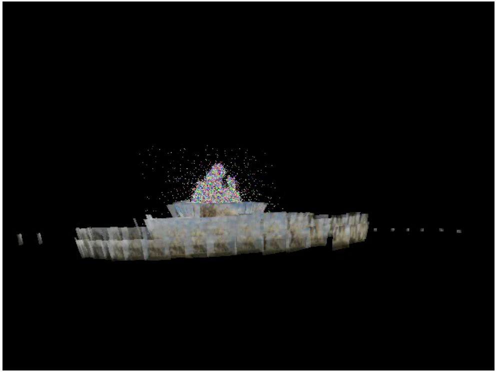
- today, we have laser-based rangefinders (eg. LiDARs) — active sensors
- figure: point cloud obtained from a vehicle with 4 LiDARs on its roof — color = height
- **this course focuses on obtaining such results (and more) by means of passive sensors**

This Course: Structure from Motion & Dense Point Clouds

images + some knowledge about cameras $\rightarrow$ cameras in 3D + sparse 3D points

36 of 237 images of a memorial



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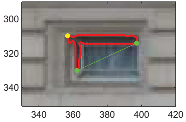
all camera poses, closest 2m, farthest 40m away

Typical phases of a processing pipeline:

1. finding sparse image matches (Matching)
2. determining correspondences and camera poses (Structure from Motion)
3. finding dense correspondences $\rightarrow$ 3D point clouds (Stereovision)
4. (optional: occupancy mapping or surface reconstruction)

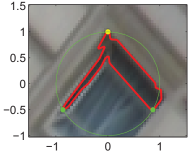
Phase 1: Sparse Image Matches

image features, their descriptors, matches and correspondences



bitangent + distant pt

$\longrightarrow$



normalized feature

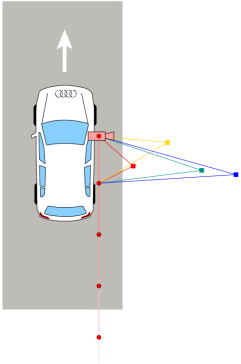
- matches ∼ visually similar
- correspondences ∼ visually similar and geometrically consistent (yellow)
- finding matches must cope with ambiguity
- 5 correspondences determine the relative angular orientation and translation direction between calibrated cameras
  calibrated = we know their internal parameters like the focal length etc

Phase 2: From Matches To Correspondences ("Structure from Motion")

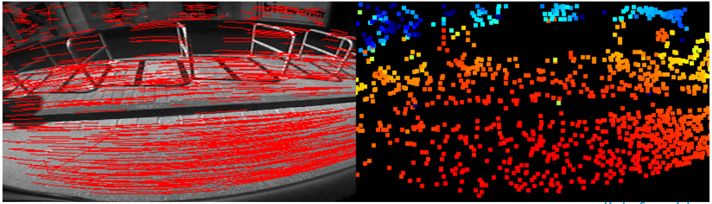
- **Example:** Sensing depth from a single moving camera, 30 fps data stream

  standard automotive wide-angle sensor – reversing camera
- moving videocamera $\sim$ time constraint on image match evolution $\sim$ 'optical flow'

moving camera



'optical flow' in right-mirror camera   estimated depth



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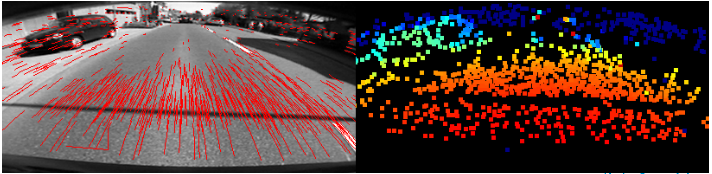
'optical flow' in reversing camera   estimated depth



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- standard term: SfM (Structure from Motion should rather be Structure and Motion)
- single camera: problems with moving objects (wrong depth)

Phase 2: Recovering Camera Poses (= "Motion")

- reversing camera on a car, 30fps; error against RT 3000 GPS system (red)

no fusion with GPS!

Scene I

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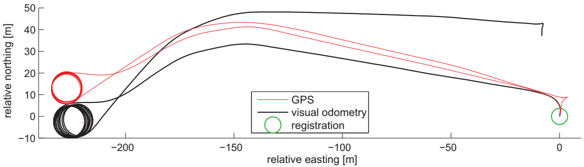
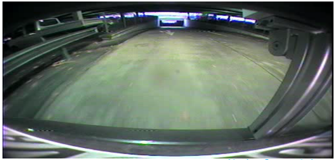


Scene II



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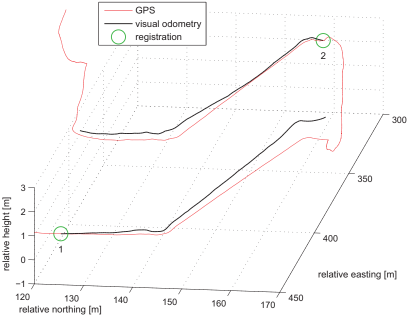


- 1 km, 5% accumulated drift
- measures elevation
- bad lighting conditions
- difficult scene

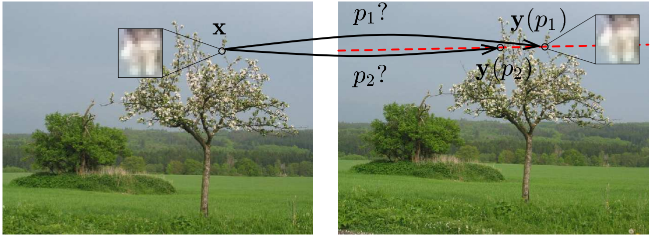
Some applications:

- visual odometry
- SLAM

- the drift is reduced if the correspondences linking camera pairs form a dense graph, not a chain like here

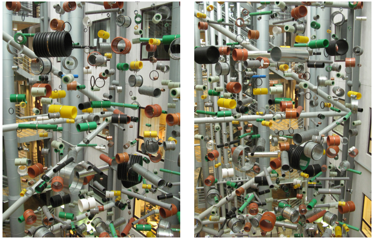
Phase 3: Dense Correspondences by Stereovision

stereo seems easy in familiar scenes



input images

unfamiliar scenes are difficult



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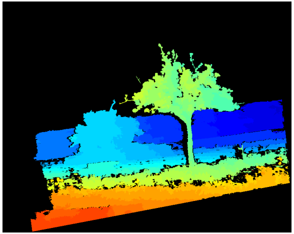

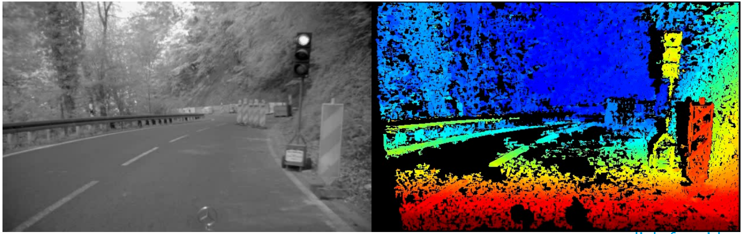

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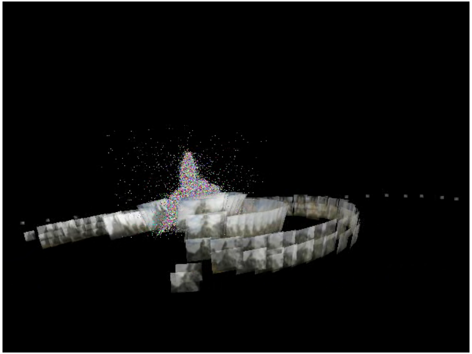
- the result is a dense 3D point cloud (color = range)

typically $10^6 - 10^9$ 3D points

Phase 4: Point Cloud and Surface Reconstruction

cameras + point cloud + images $\longrightarrow$ triangulated surface



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- we will not cover surface reconstruction in this course
- (but you may be able to use one of the popular algorithms)

Thank You