3D Computer Vision

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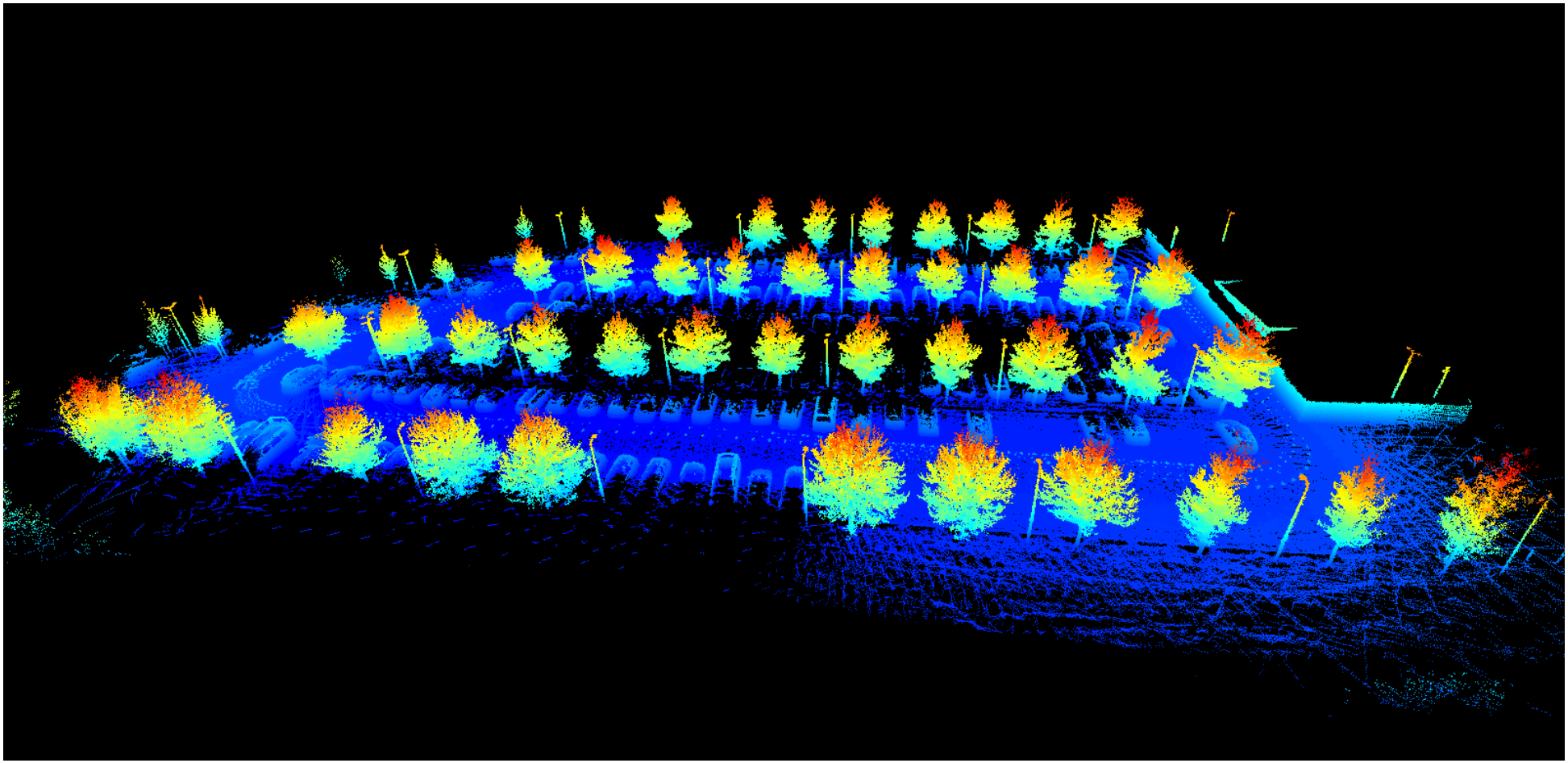
Open Informatics Master's Course

Part I

Course Overview

3D Vision is Not Just about 3D Point Clouds

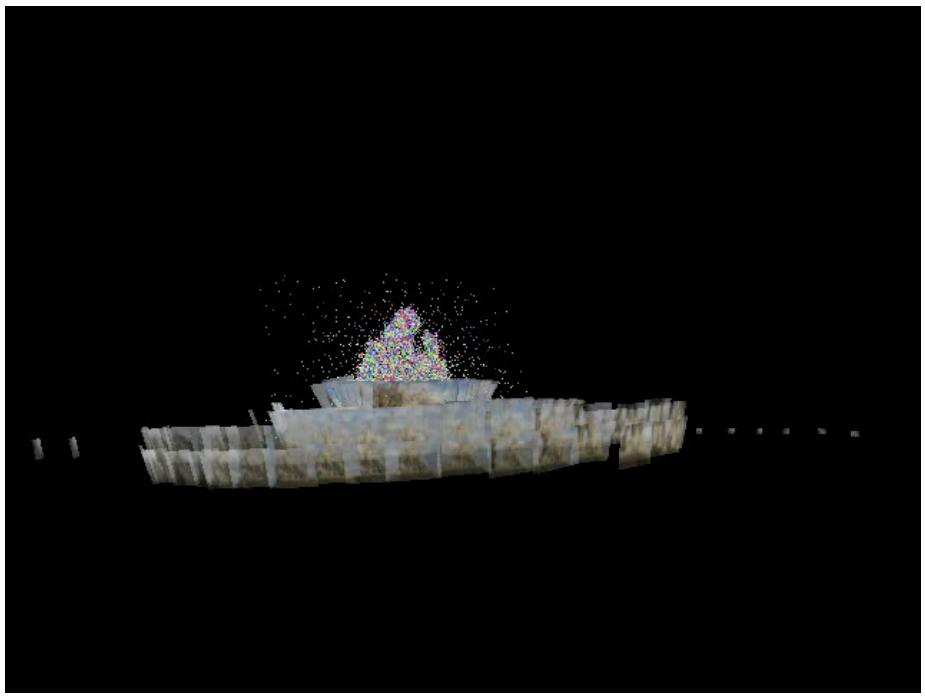


- today, we have laser-based rangefinders (eg. LiDARs) active sensors
- figure: point cloud obtained from a vehicle with 4 LiDARs on its roof color = height
- this course focuses on obtaining such results (and more) by means of passive sensors

This Course: Structure from Motion & Surface Reconstruction

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

36 of 237 images of a memorial



video

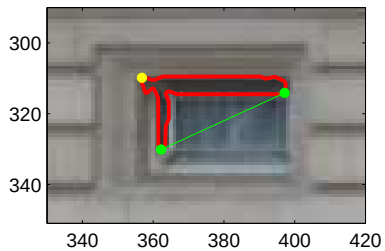
all camera poses, closest 2m, farthest 40m away

Typical phases of a processing pipeline:

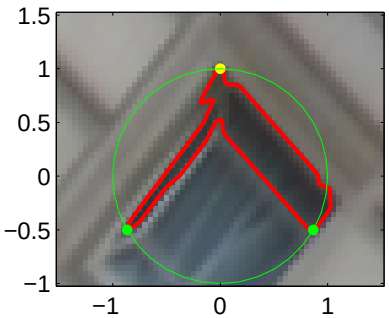
1. finding sparse image correspondences
2. recovering camera poses
3. finding dense correspondences $\rightarrow$ 3D point clouds
4. surface reconstruction

Phase 1: Sparse Image Correspondences

image features, their descriptors, matches and correspondences



bitangent + distant pt



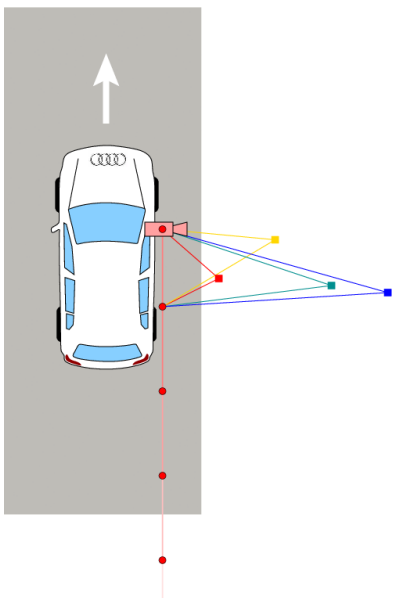
normalized feature

- matches ∼ visually similar
- correspondences ∼ visually similar and geometrically consistent (yellow)
- finding correspondences must cope with ambiguity
- 5 correspondences determine the relative orientation and translation direction between the ('calibrated') cameras

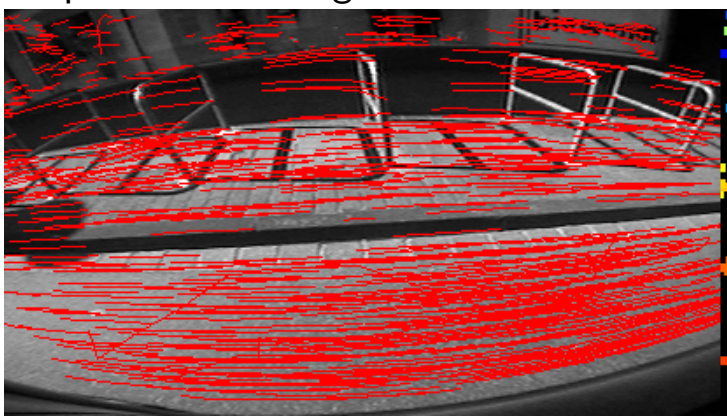
Phase 2: Semi-Dense Correspondences and 3D points (= "Structure")

- sensing depth from a single moving camera, 30 fps data stream

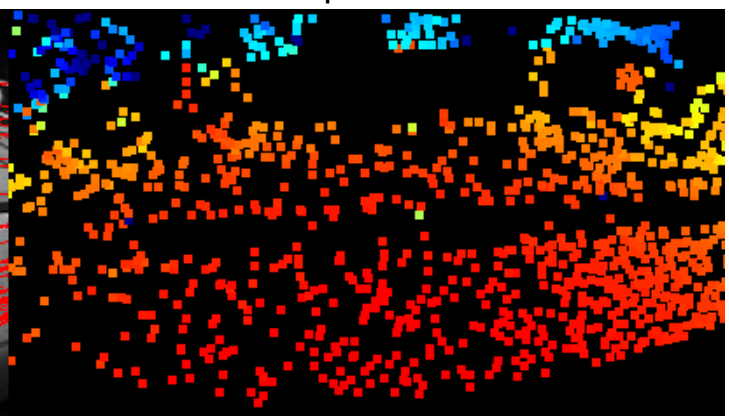
  standard automotive wide-angle sensor – reversing camera
- moving videocamera $\sim$ time constraint on image match evolution $\sim$ 'optical flow'



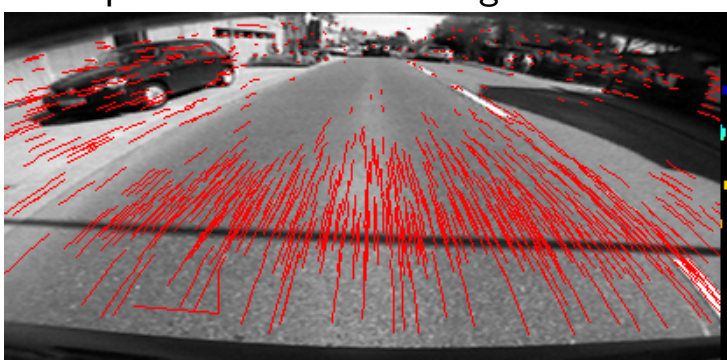
'optical flow' in right-mirror camera



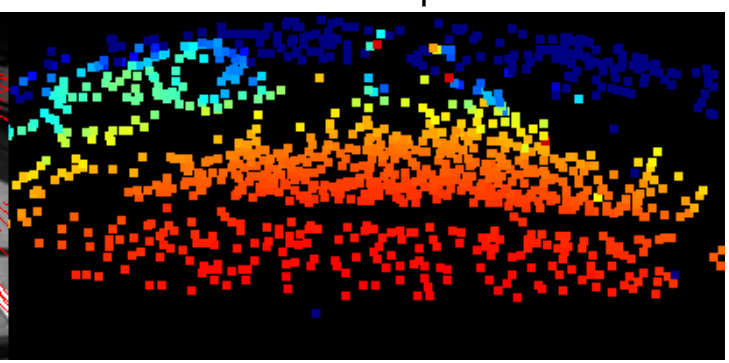
estimated depth



'optical flow' in reversing camera



estimated depth

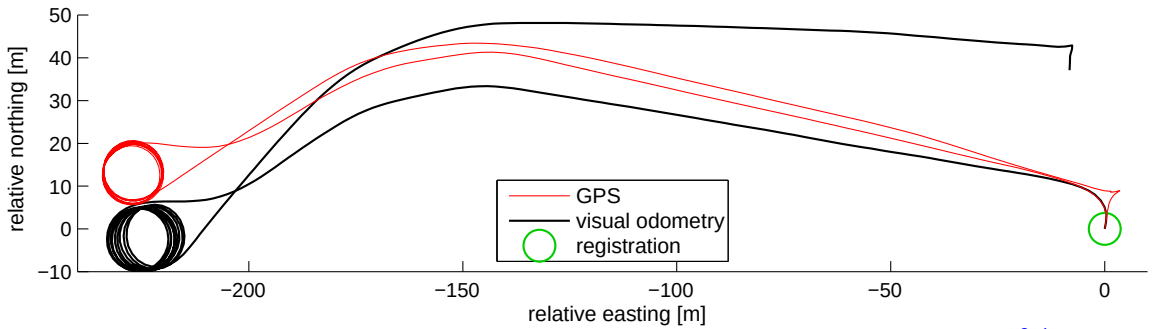


- standard term: SfM (Structure from Motion)
- problems with moving objects (wrong depth)

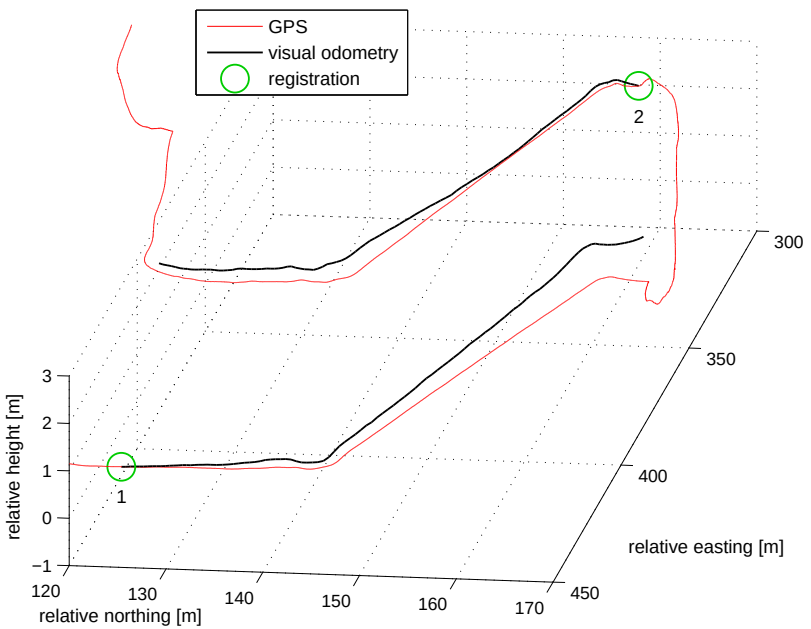
Phase 2: Recovering Camera Poses (= "Motion")

- reversing camera on a car, 30fps; error against RT 3000 GPS system (red) no fusion with GPS!

Scene I



Scene II



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

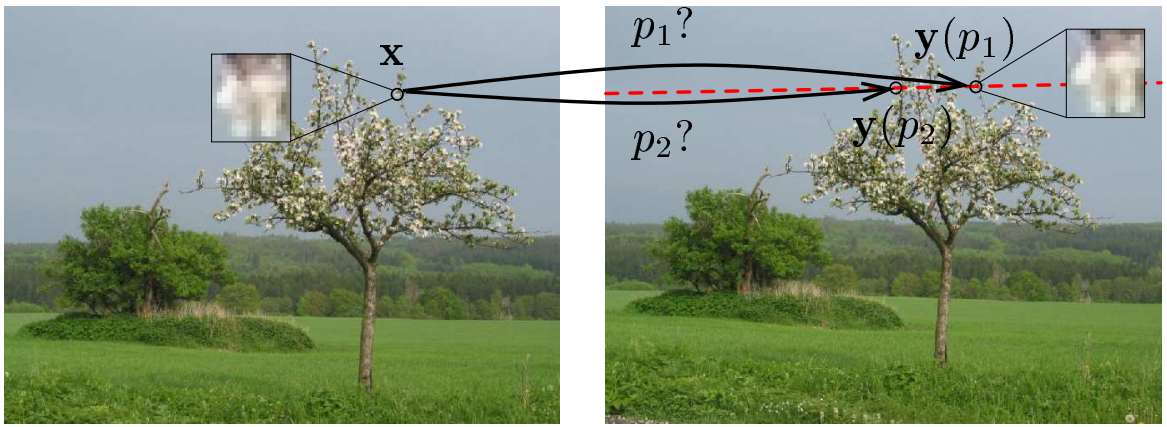
Some applications:

- visual odometry
- SLAM

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

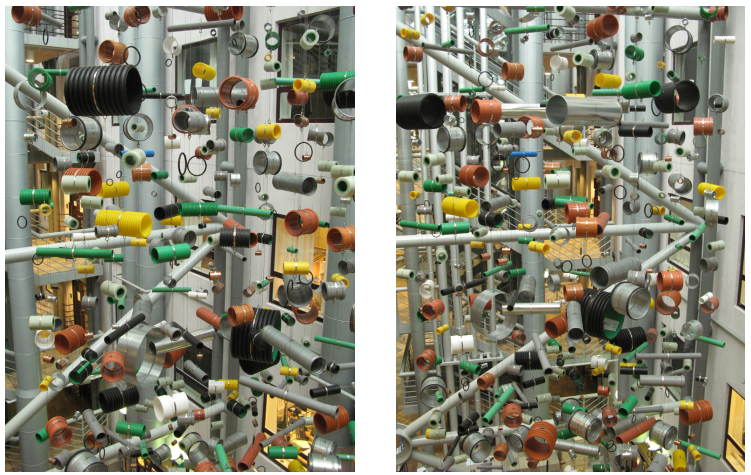
Phase 3: Dense 3D Point Cloud by Stereovision

sometimes stereo seems easy



input images

sometimes it is difficult



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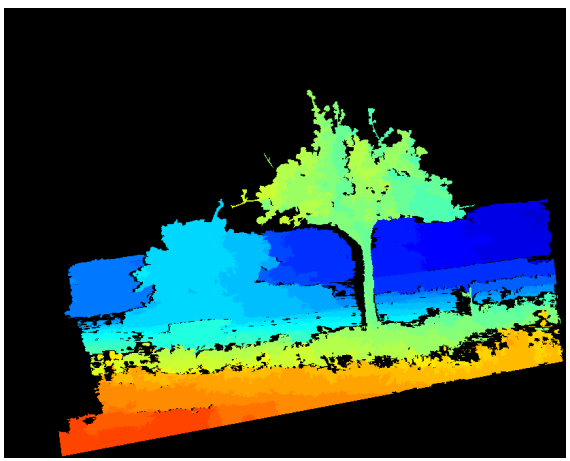
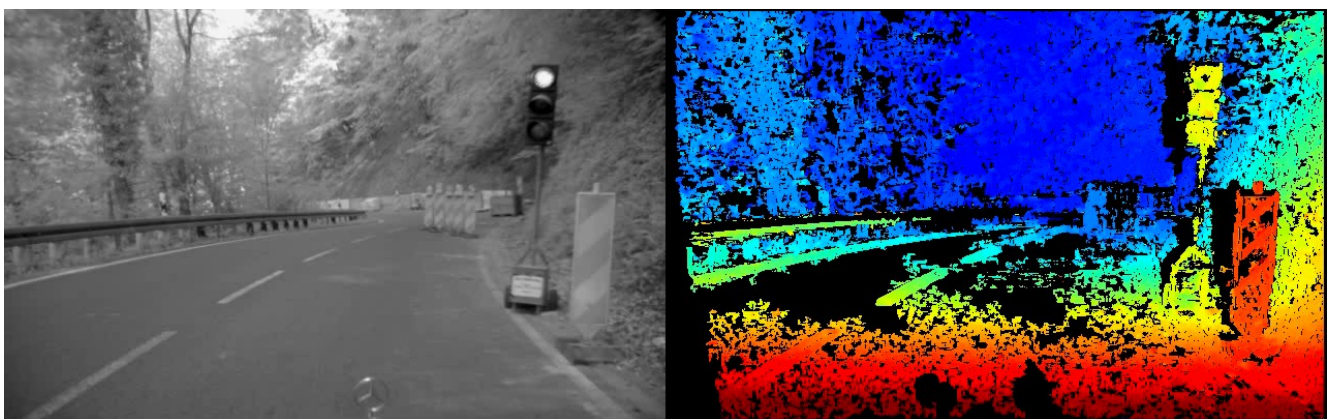




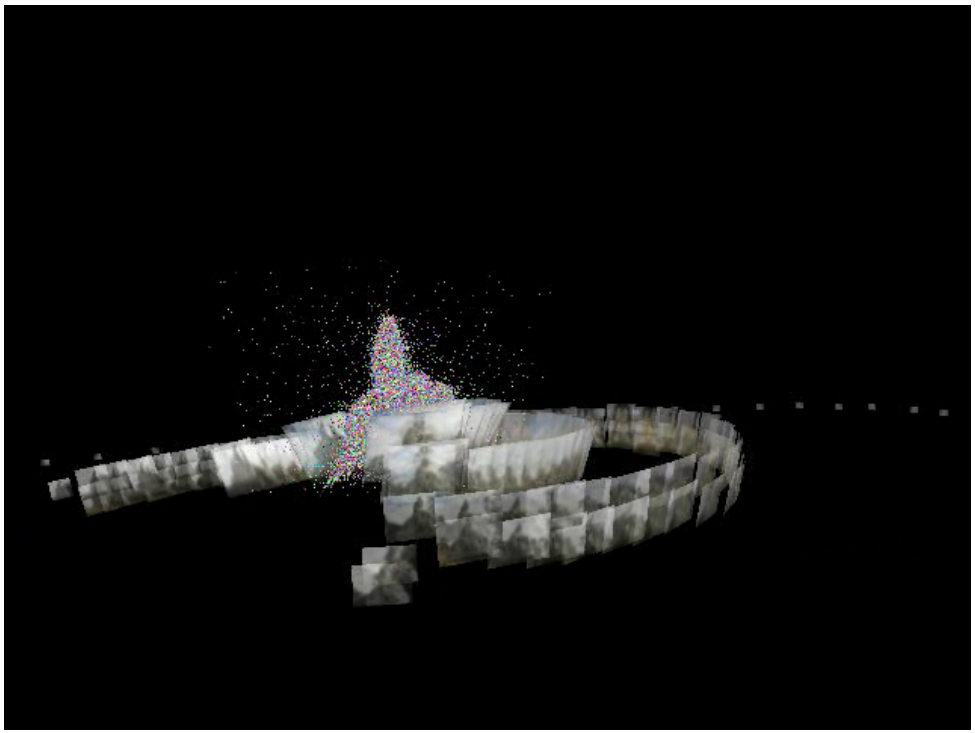
video

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

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

Phase 4: Surface Reconstruction

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



video

video

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

Thank You