

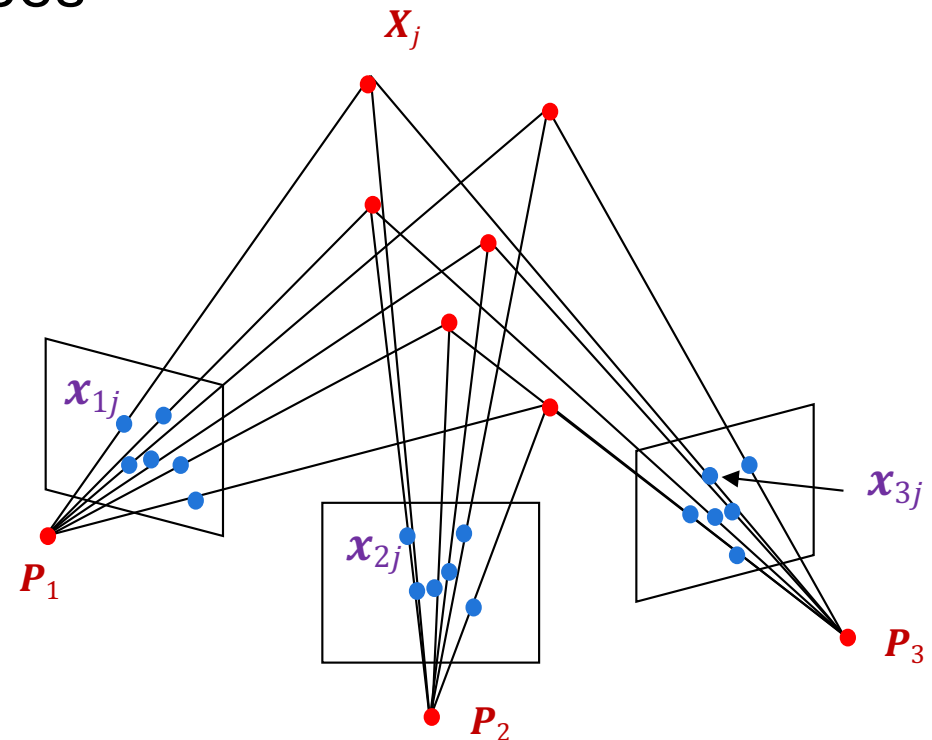
# Structure and motion: some ifs ands and buts

D.A. Forsyth

University of Illinois at Urbana-Champaign

# Structure from motion (SFM)

- Given:
  - $m$  images of  $n$  fixed 3D points
    - $\mathbf{x}_{ij} \cong \mathbf{P}_i \mathbf{X}_j, \quad i = 1, \dots, m, \quad j = 1, \dots, n$
  - note known correspondences
- Estimate:
  - $m$  projection matrices  $\mathbf{P}_i$
  - $n$  3D points  $\mathbf{X}_j$



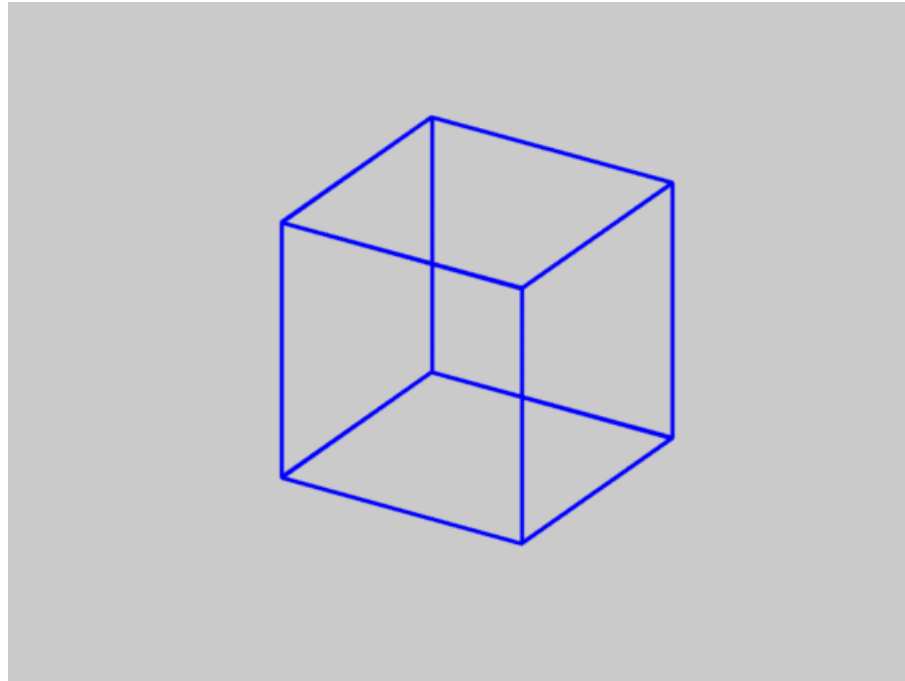
# Cases:

- Offline
  - work with all images
  - **structure from motion**
    - underlying Q:
      - how to make best use of all information
    - roughly familiar structure
      - set up huge optimization problem by constructing start point
      - efficiency is now a serious issue
- Online
  - build best estimate available up to time  $t$
  - **SLAM**
    - simultaneous localization and mapping
    - build a map at the same time as determining where you are
    - new Q:
      - how do you make best use of all information up to now
      - efficiency often crucial
- Hybrids are quite usual, and important

# Difficulties

- Degenerate configurations
- Dealing with repetitions and symmetries
  - which cause matching errors
- Reducing error accumulation and closing loops
- Making the whole thing efficient!
  - See, e.g., [Towards Linear-Time Incremental Structure from Motion](#)

# Is SFM always uniquely solvable?

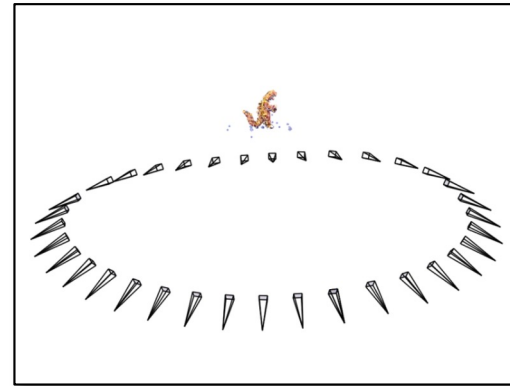
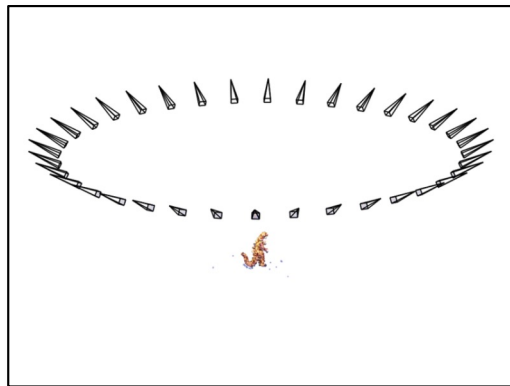


- Necker cube

Source: N. Snavely

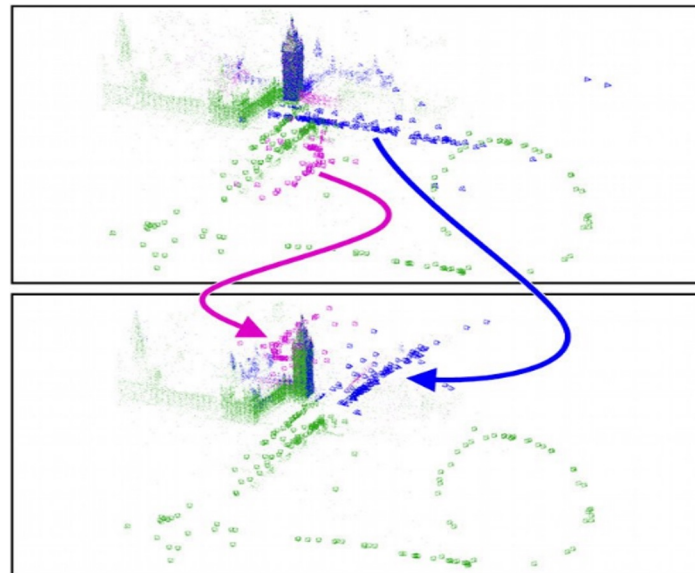
# Is SFM always uniquely solvable?

- Could actually happen in affine structure from motion:



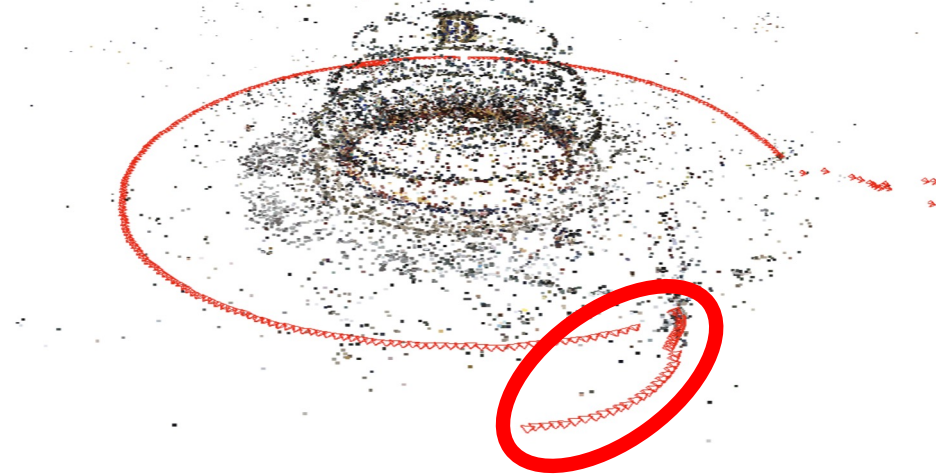
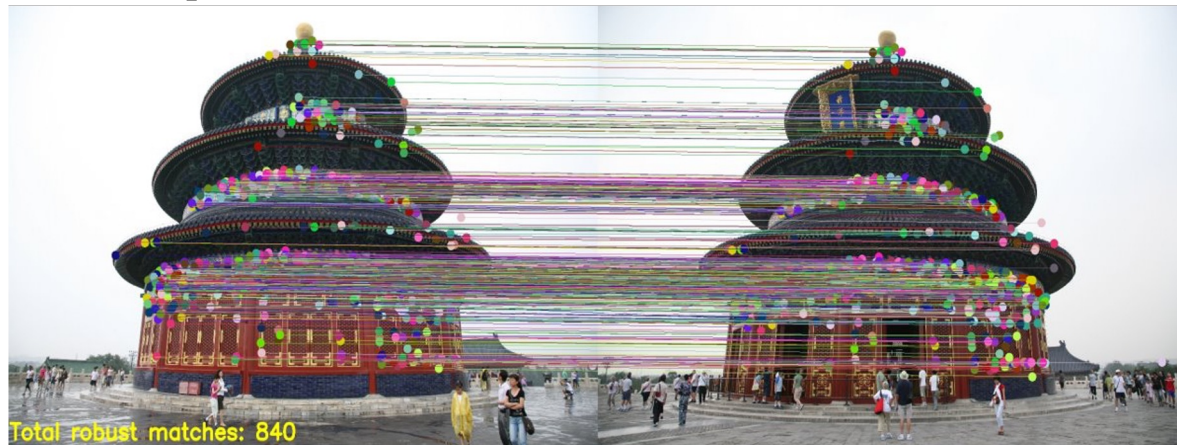
Source: N. Snavely

# Repetitive structures cause catastrophic failures



<https://demuc.de/tutorials/cvpr2017/sparse-modeling.pdf>

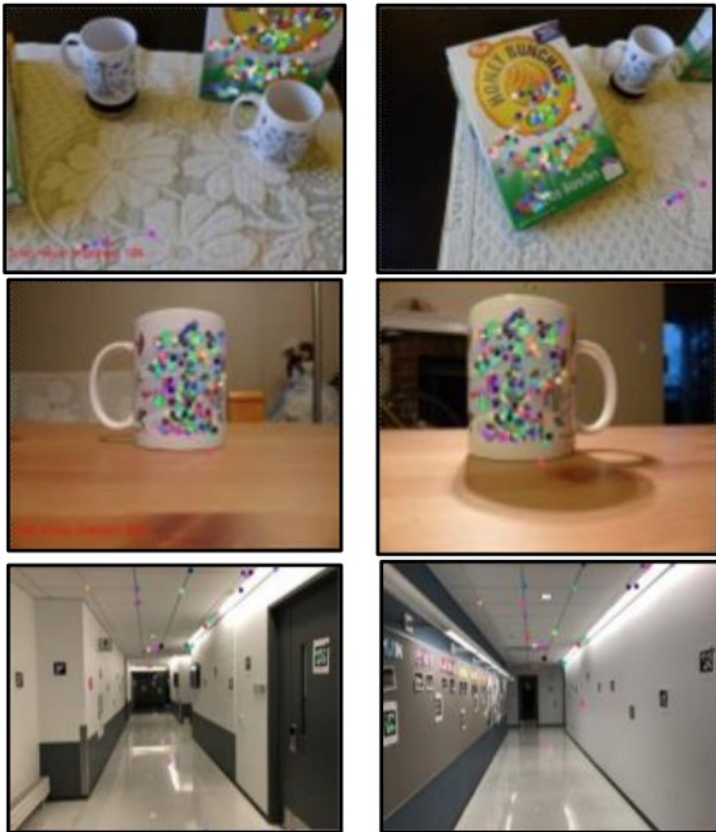
# Repetitive structures cause catastrophic failures



R. Kataria et al. [Improving Structure from Motion with Reliable Resectioning](#). 3DV 2020

# Repetitive structures cause catastrophic failures

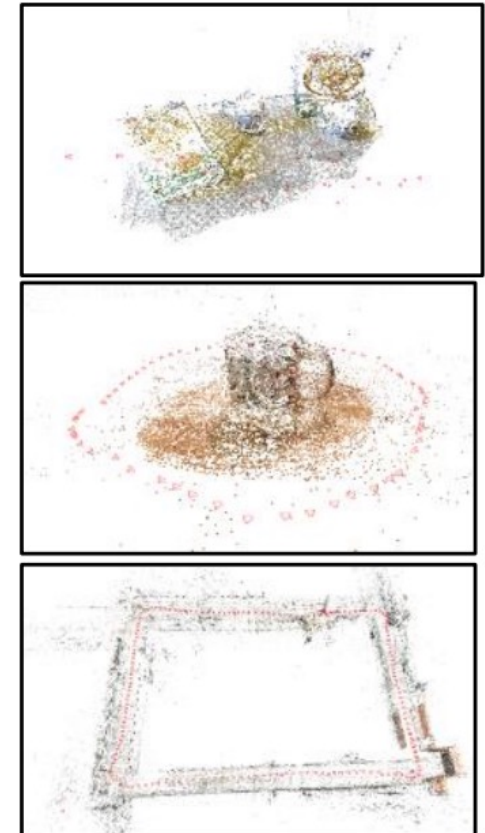
Erroneously Matching Images



Baseline Reconstruction



Our Reconstruction



# Reducing error accumulation and closing loops



seattle1

more\_half

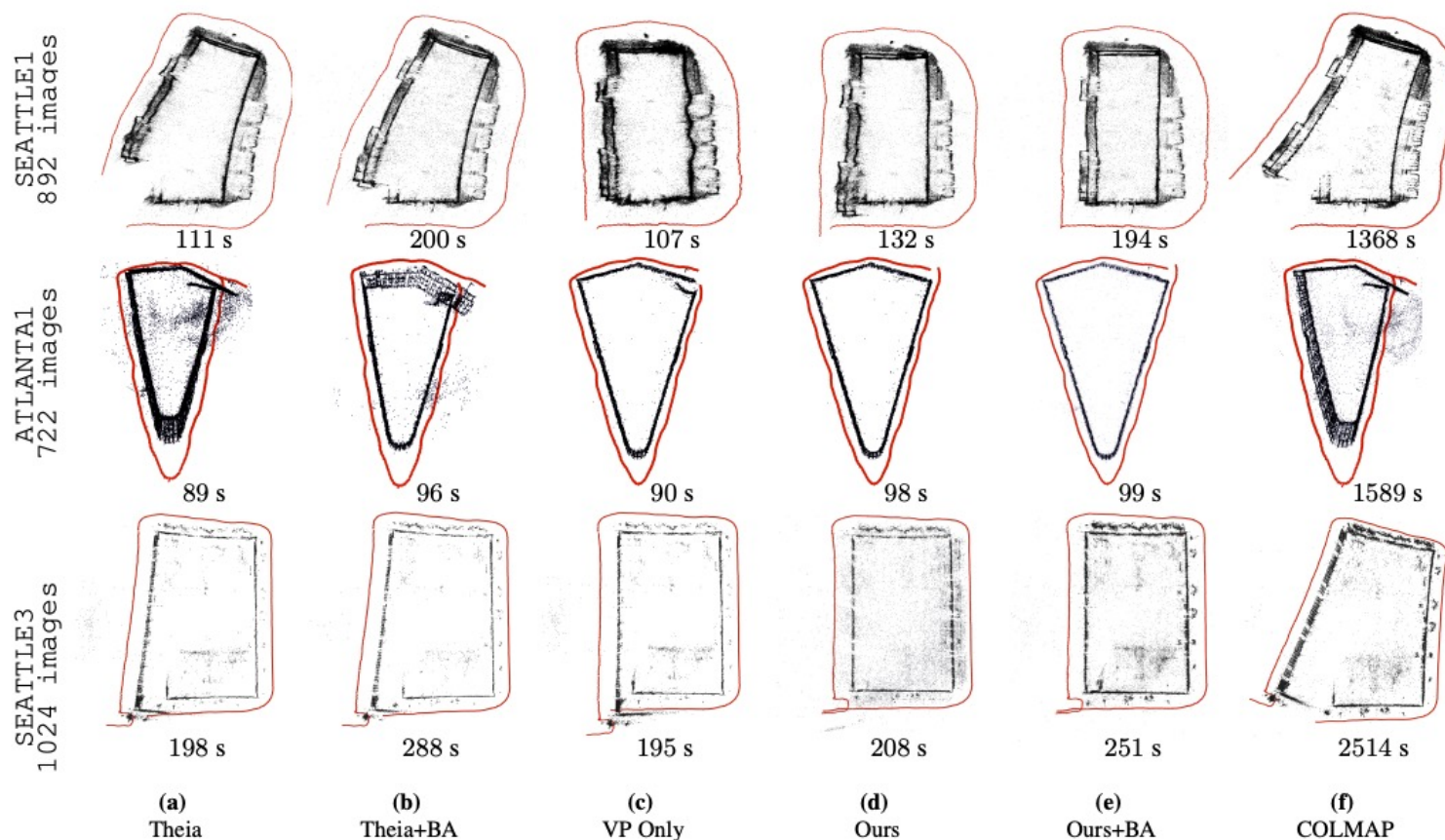
seattle2

atlanta1

seattle3

A. Holynski et al. [Reducing Drift in Structure From Motion Using Extended Features](#). arXiv 2020

# Reducing error accumulation and closing loops



A. Holynski et al. [Reducing Drift in Structure From Motion Using Extended Features](#). arXiv 2020