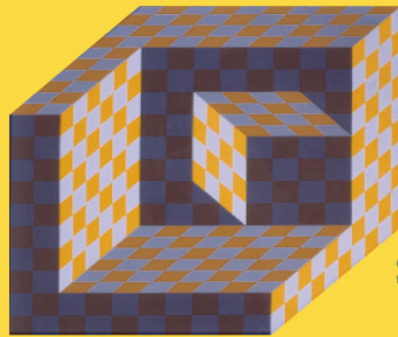


INTERDISCIPLINARY APPLIED MATHEMATICS

IMAGING, VISION, AND GRAPHICS

An Invitation to 3-D Vision

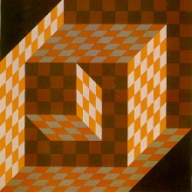
From Images to Geometric Models



Yi Ma
Stefano Soatto
Jana Kosecka
Shankar S. Sastry

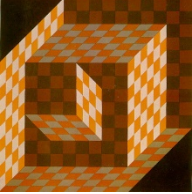


Springer



Lecture 1

Overview and Introduction

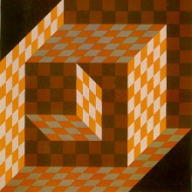


Reconstruction from images – The Fundamental Problem

Input: Corresponding “features” in multiple perspective images.

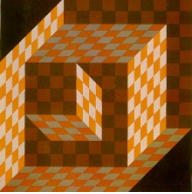
Output: Camera pose, calibration, scene structure representation.





Reconstruction from images – The Fundamental Problem

“Rome wasn’t built in a day.”



APPLICATIONS – Autonomous Highway Vehicles (1990-)

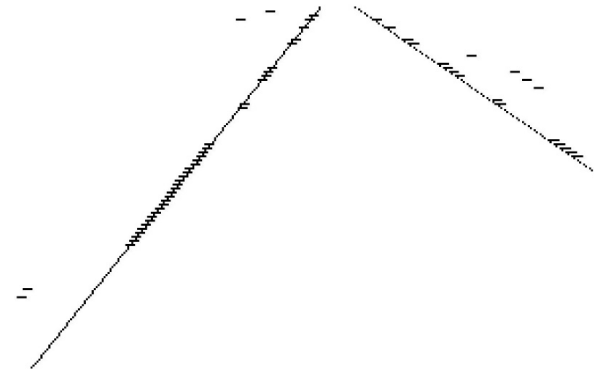
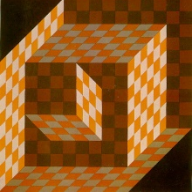


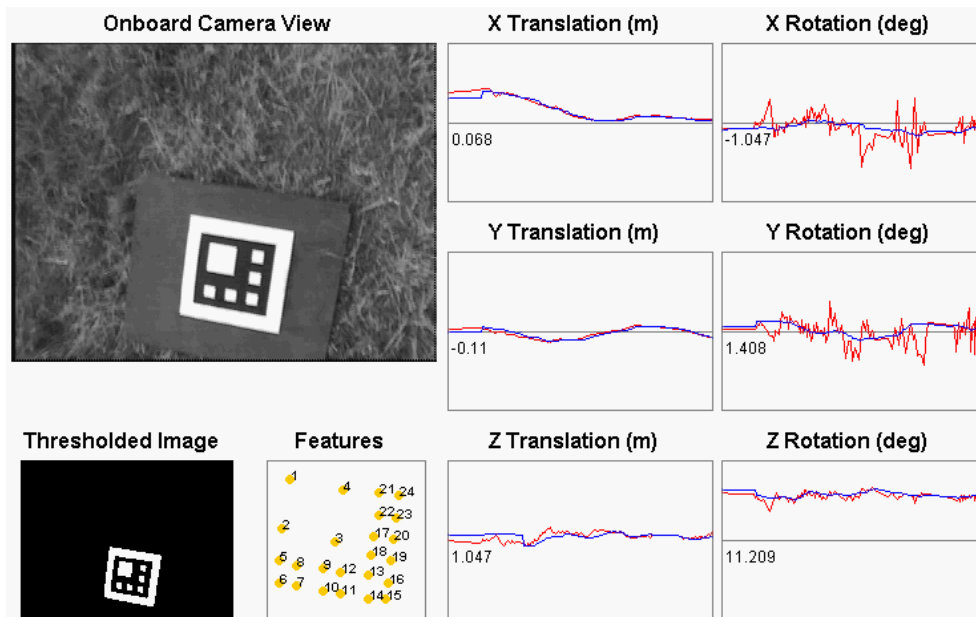
Image courtesy of California PATH



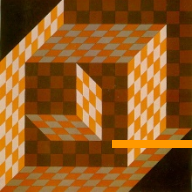
APPLICATIONS – Today **Autonomous Vehicles**



APPLICATIONS – Unmanned Aerial Vehicles (UAVs, 1998)

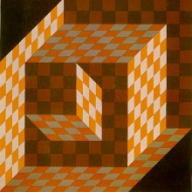


Rate: 10Hz; Accuracy: 5cm, 4°

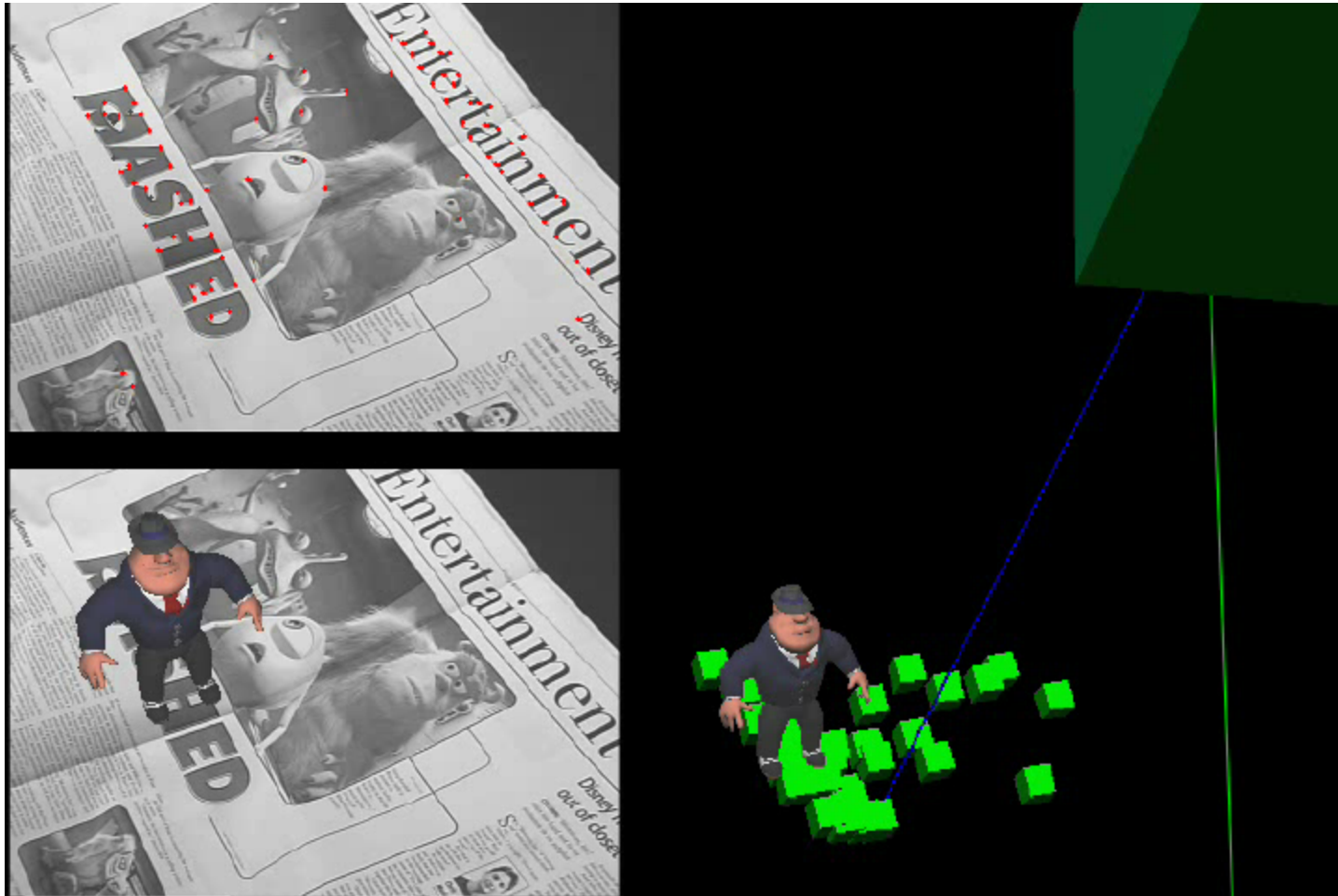


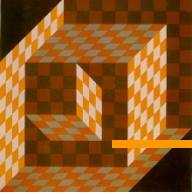
APPLICATIONS – Today Unmanned Aerial Vehicles (UAVs)





APPLICATIONS – Real-Time Virtual Object Insertion





APPLICATIONS – Real-Time Sports Coverage

First-down line and virtual advertising

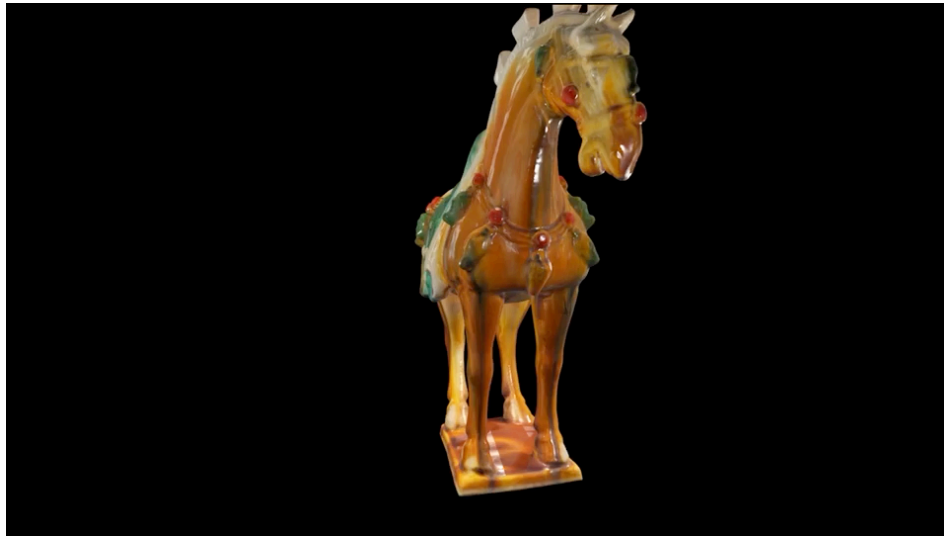


Virtual Museum on Your Phone

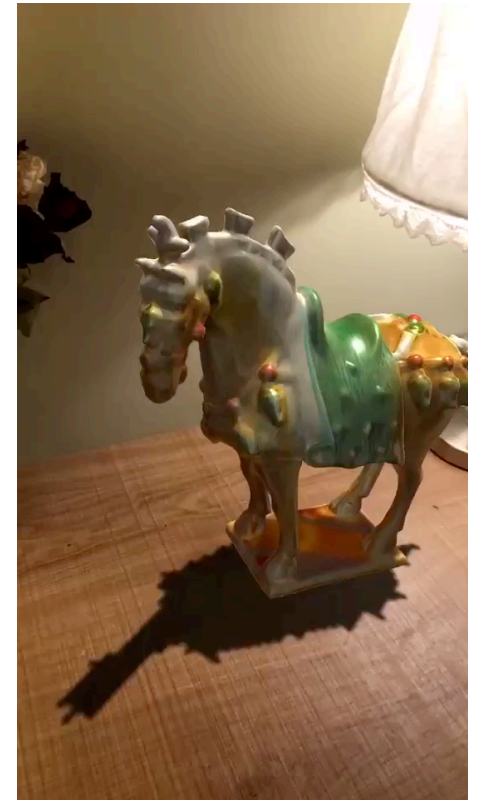
Multi-camera
Light stage

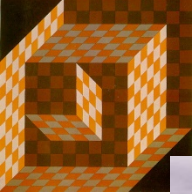


Shanghai Museum Items

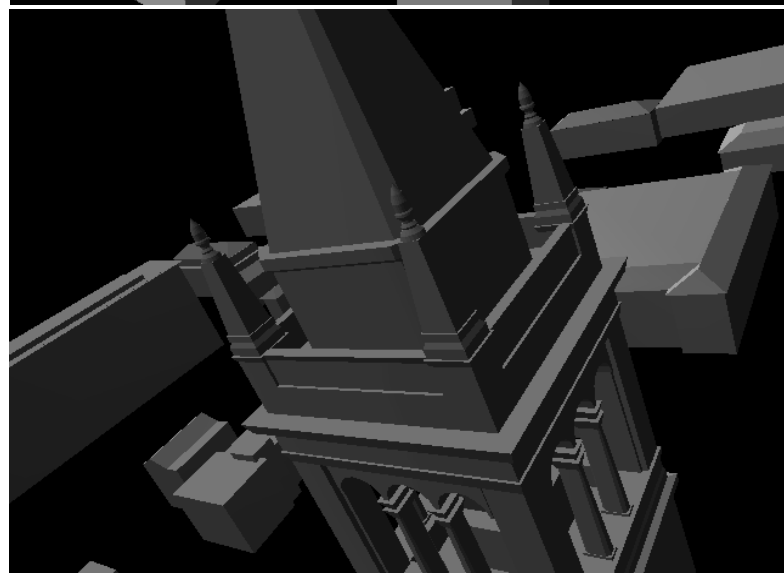
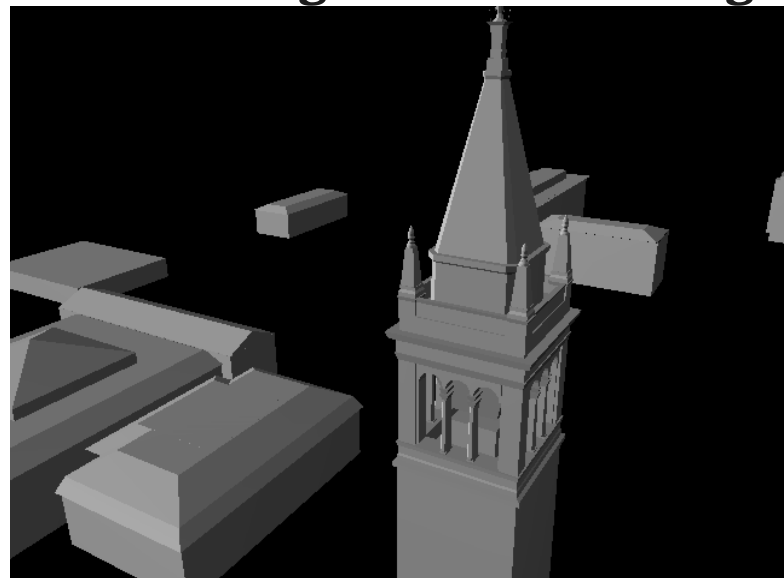


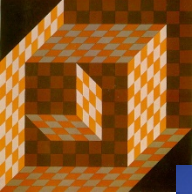
On iPhone VR kit





APPLICATIONS – Image Based Modeling and Rendering





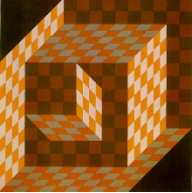
APPLICATIONS – Image Alignment, Mosaicing, and Morphing



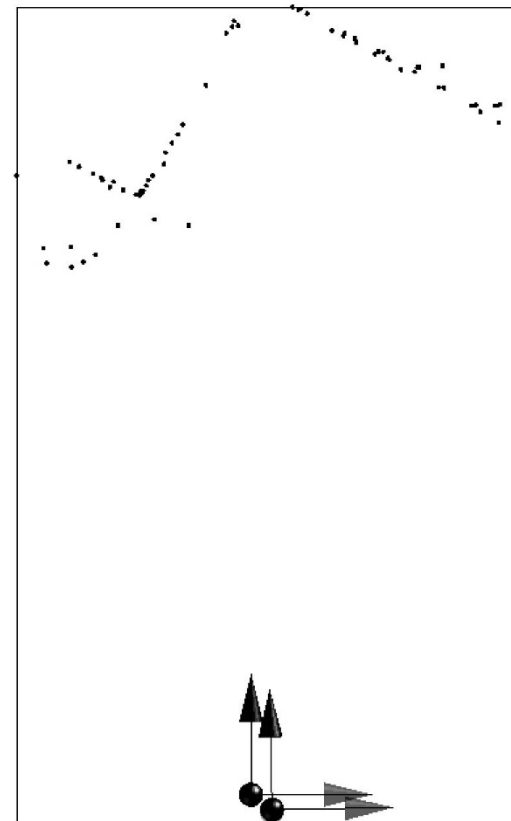
GENERAL STEPS – Feature Selection and Correspondence



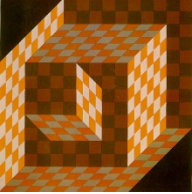
1. Small baselines versus large baselines
2. Point features versus line features



GENERAL STEPS – Structure and Motion Recovery

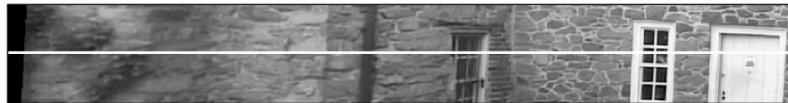
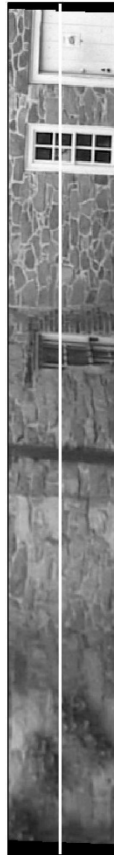


1. Two views versus multiple views
2. Discrete versus continuous motion
3. General versus planar scene
4. Calibrated versus uncalibrated camera
5. One motion versus multiple motions

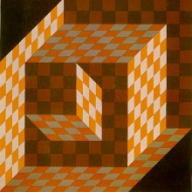


GENERAL STEPS – Image Stratification and Dense Matching

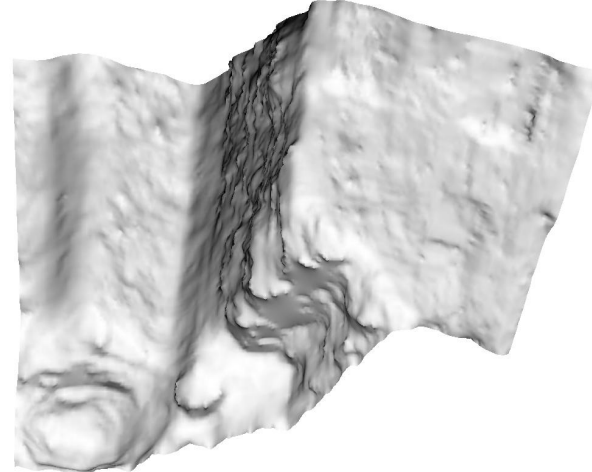
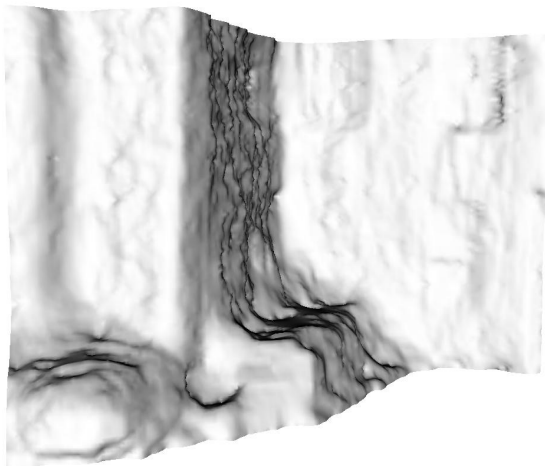
Left



Right



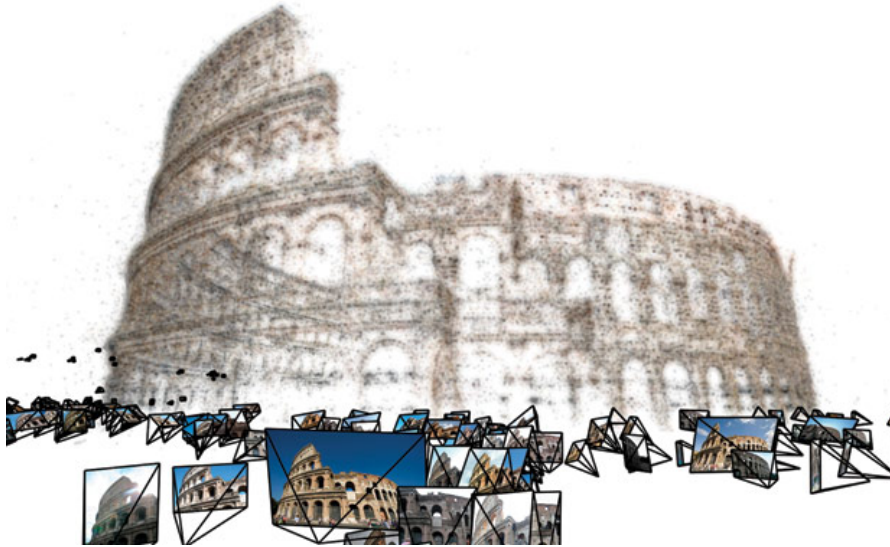
GENERAL STEPS – 3-D Surface Model and Rendering



1. Point clouds versus surfaces (level sets)
 2. Random shapes versus regular structures
-

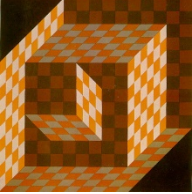
GENERAL STEPS – Image-Based 3D Modeling

Building Rome in One Day



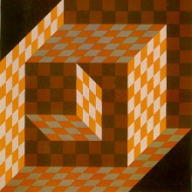
The Colosseum, 2,106 images



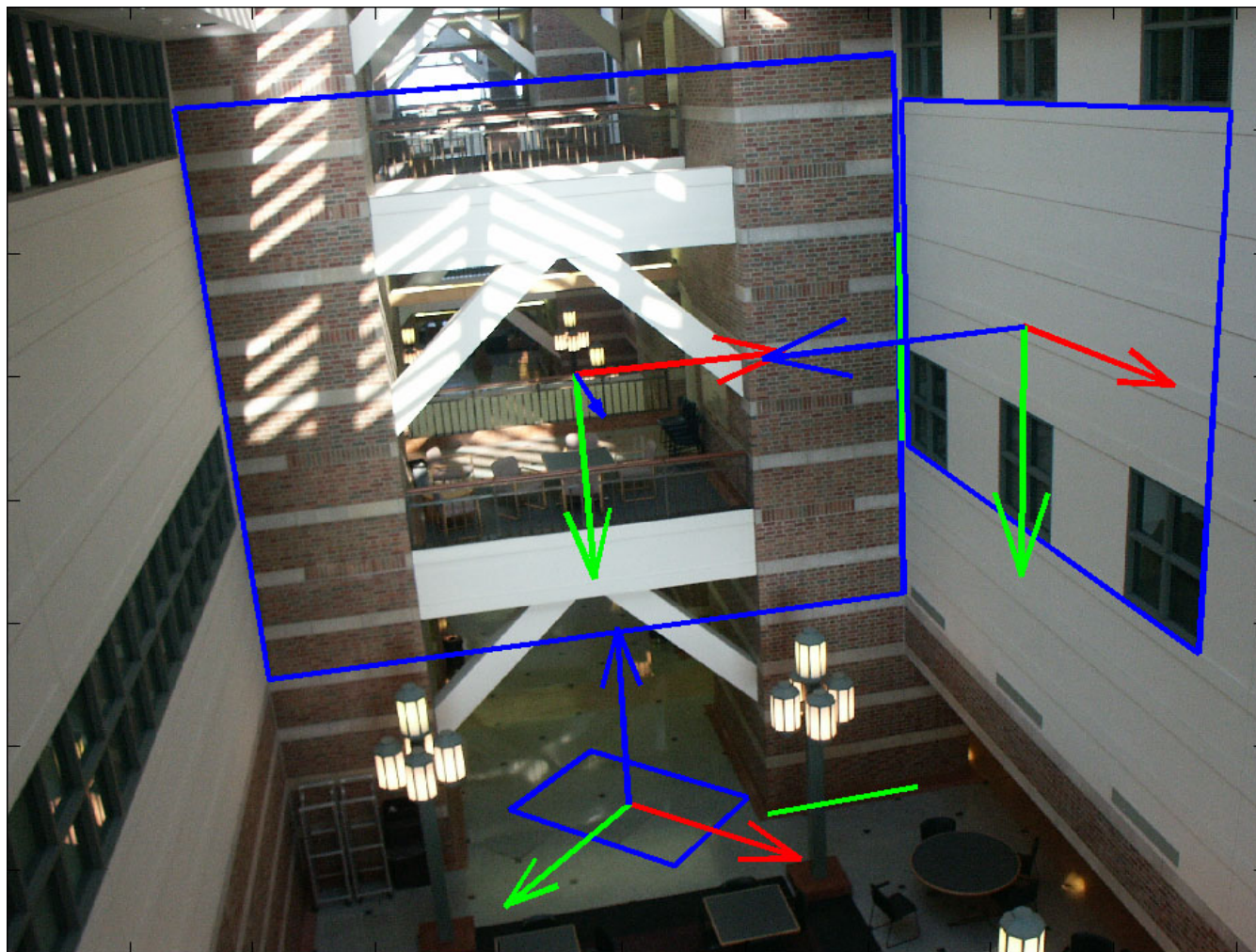


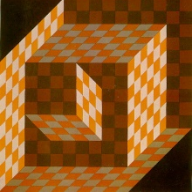
Symmetry based Modeling & Reconstruction





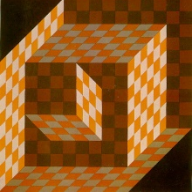
Symmetry based Modeling & Reconstruction



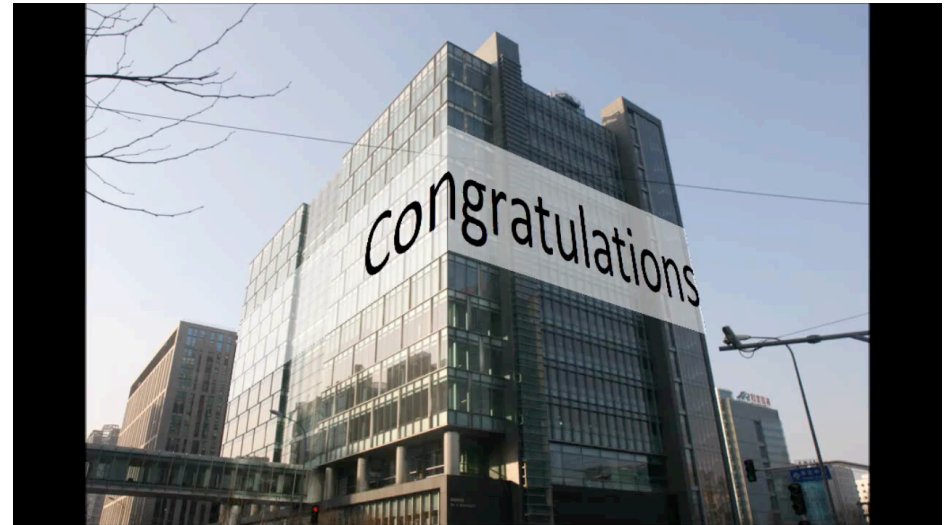
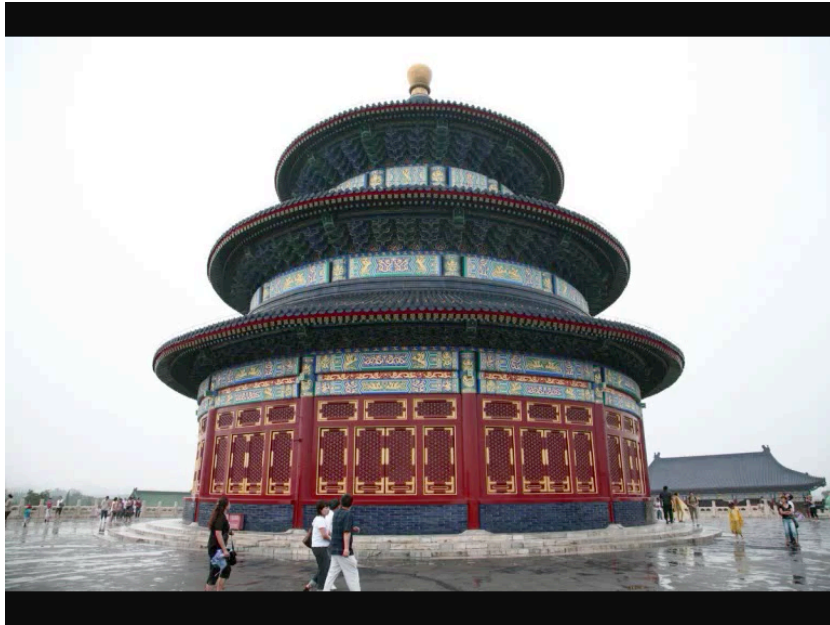


Symmetry based Modeling & Reconstruction



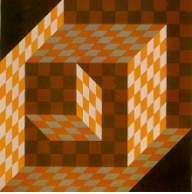


Regular Structure Based Modeling & Reconstruction



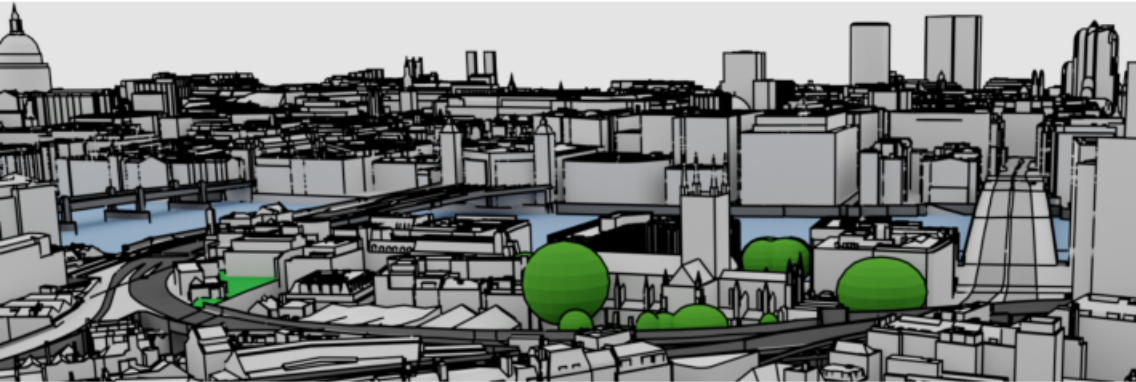
360°



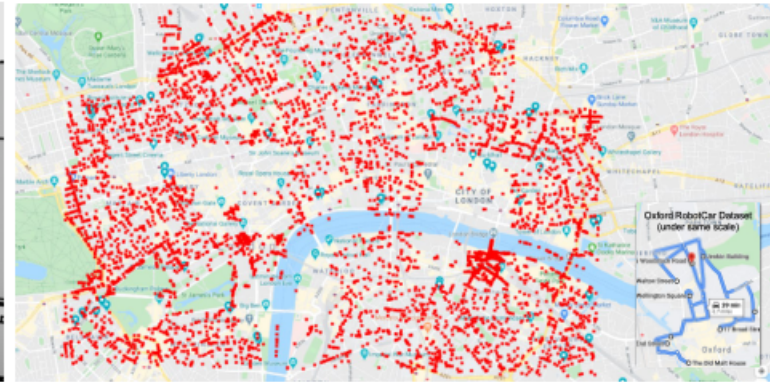


From Images to 3D CAD Models

Holicity: 20 km² of downtown London



(a) Bird's-eye view of the HoliCity CAD model



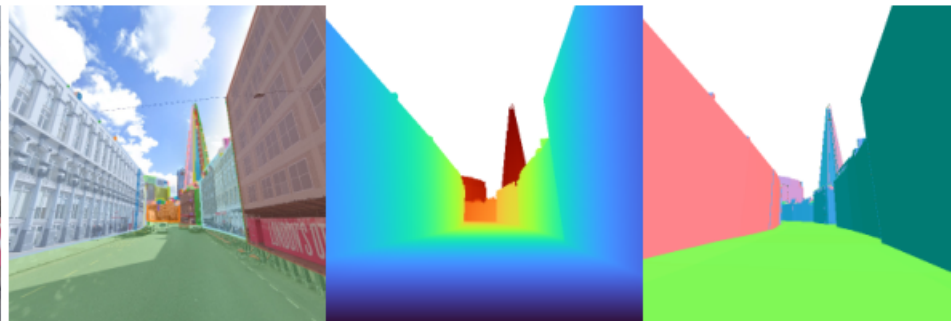
(b) Viewpoint coverage



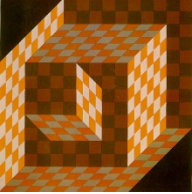
(c) Panorama



(d) RGB



(e) Renderings (surface segments, depth, normal)

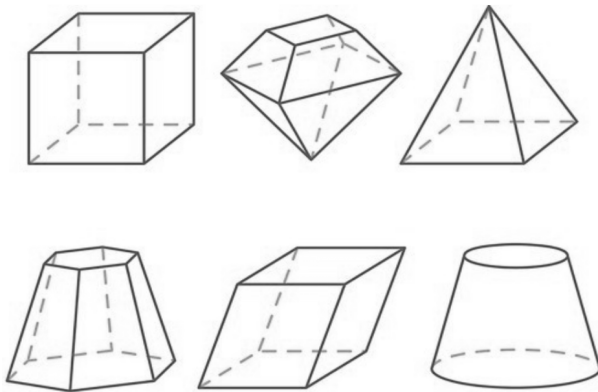


Combine Geometry and Learning (for Structures)

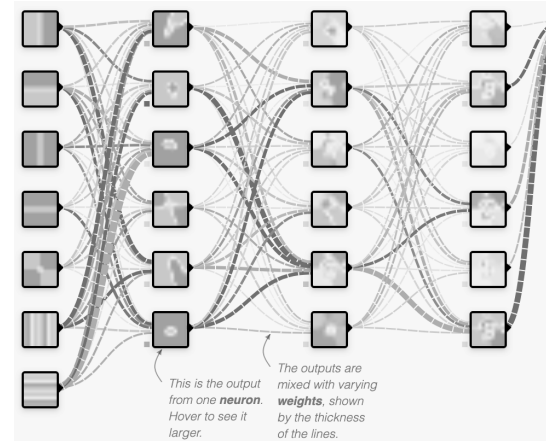
From Images to CAD Model



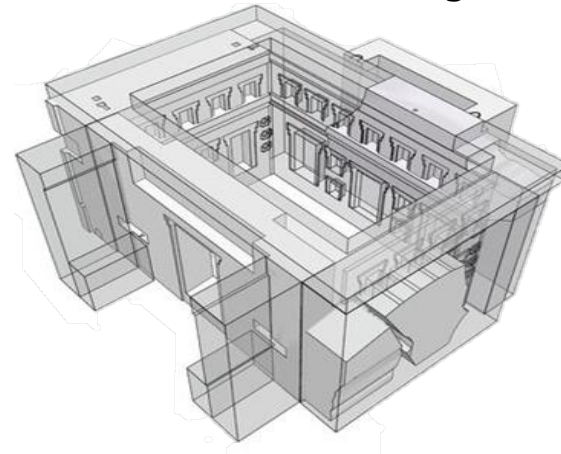
Multi-view Correspondence



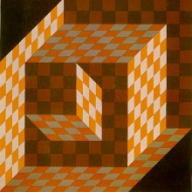
Geometric Structure



End-to-end Learning



Data Representation



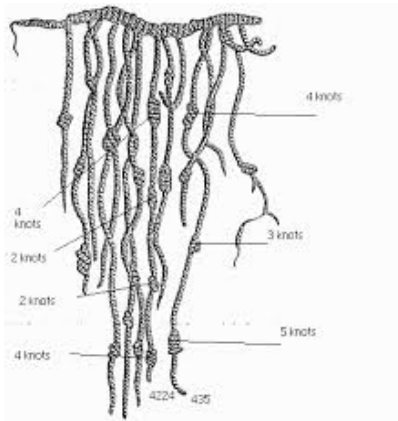
Evolution of Interface and Media

From 1D to 3D, and from physical to virtual...

1D media

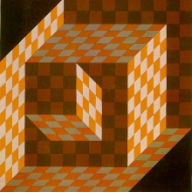
2D media

3D media

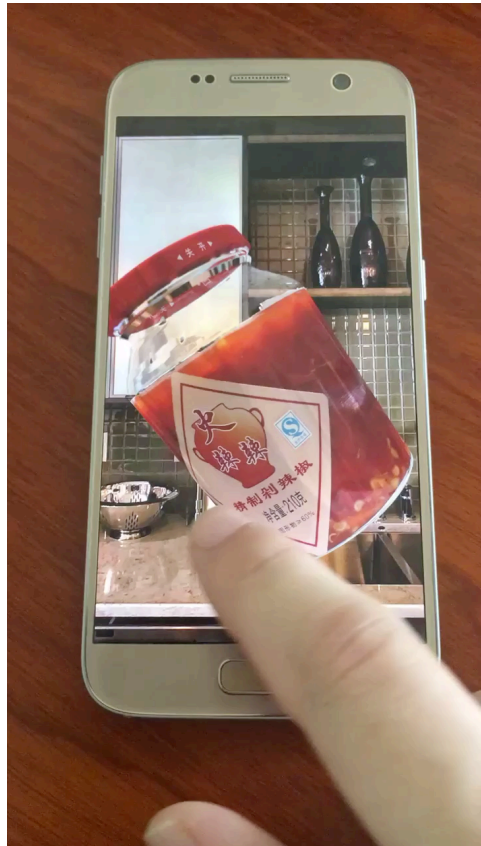


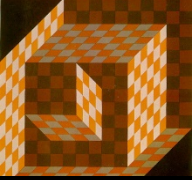
Quipu, Inca people
3rd millennium BCE





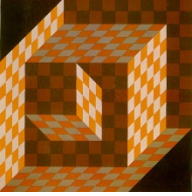
More Applications – Virtual Shopping





More Applications – Virtual Entertainment





Reconstruction from images – The Fundamental Problem

“Rome wasn’t built in a day.”

But a digital Rome may be built in a day!