

# Computational Photography

- \* Study the basics of computation and its impact on the entire workflow of photography, from capturing, manipulating and collaborating on, and sharing photographs.

# Photo-synth and other Panorama Systems

- \* Exploring space with Photographs
- \* Photosynth, Photomaps, etc .



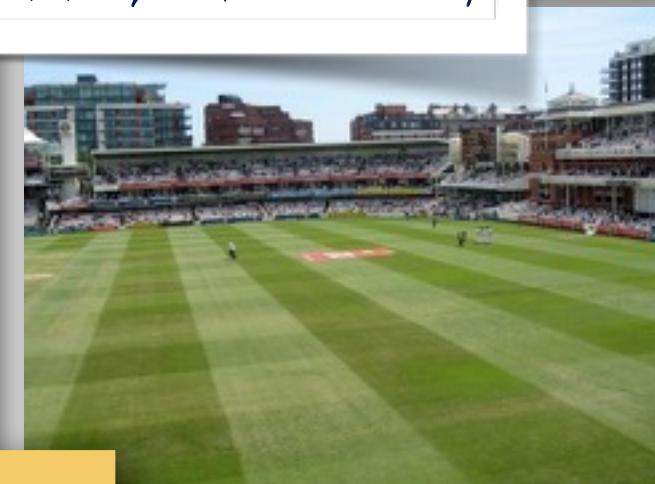
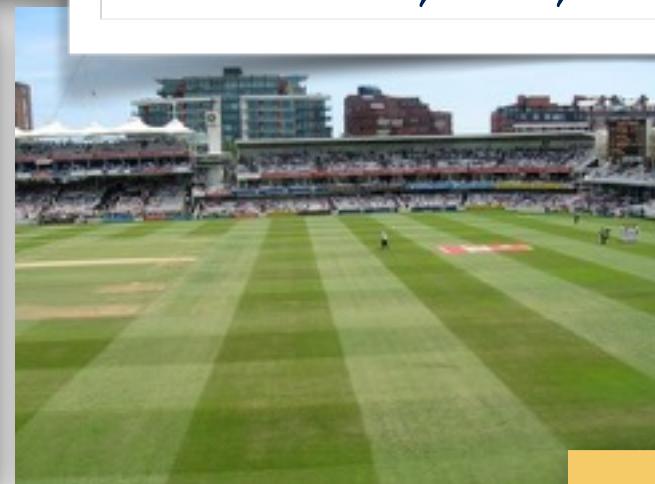
## Lesson Objectives

1. Going beyond  
Panoramas
2. Photo Tourism
3. Photo maps, Street  
Views, etc.

# Recall: Panoramas



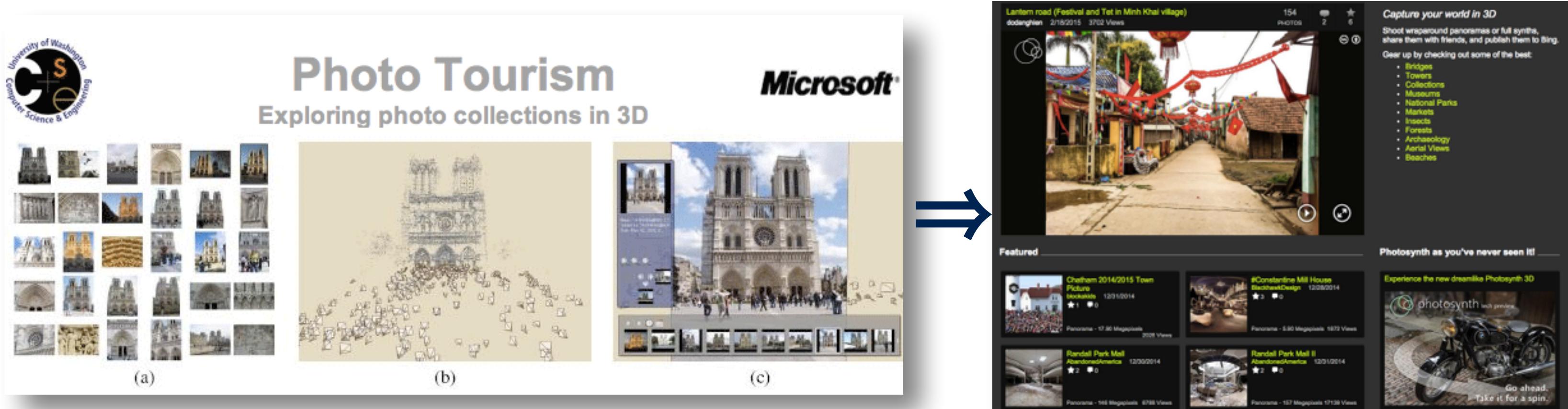
7 Pictures, /  $3,072 \times 2,304$  (7MP)



Recall:  
Planar,  
Spherical,  
Cylindrical  
Panoramas



# Photo Tourism $\Rightarrow$ Photo Synth



- \* Snavely, Seitz, Szeliski, 'Photo tourism: Exploring photo collections in 3D,' > ACM SIGGRAPH, 2006
- \* photosynth.net Technology Preview (2008 - 2013)

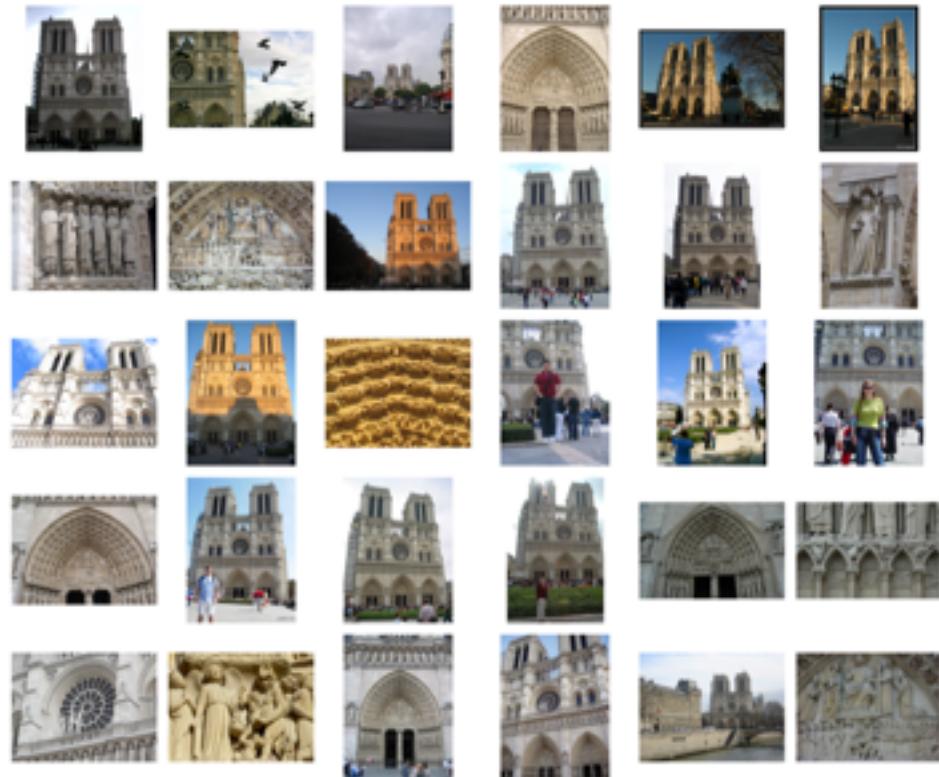
# Photo Tourism

## Exploring photo collections in 3D

Noah Snavely   Steven M. Seitz   Richard Szeliski  
*University of Washington*                    *Microsoft Research*

SIGGRAPH 2006

# Photo Tourism overview



Input photographs

Scene  
reconstruction



Relative camera positions and orientations

Point cloud

Sparse correspondence

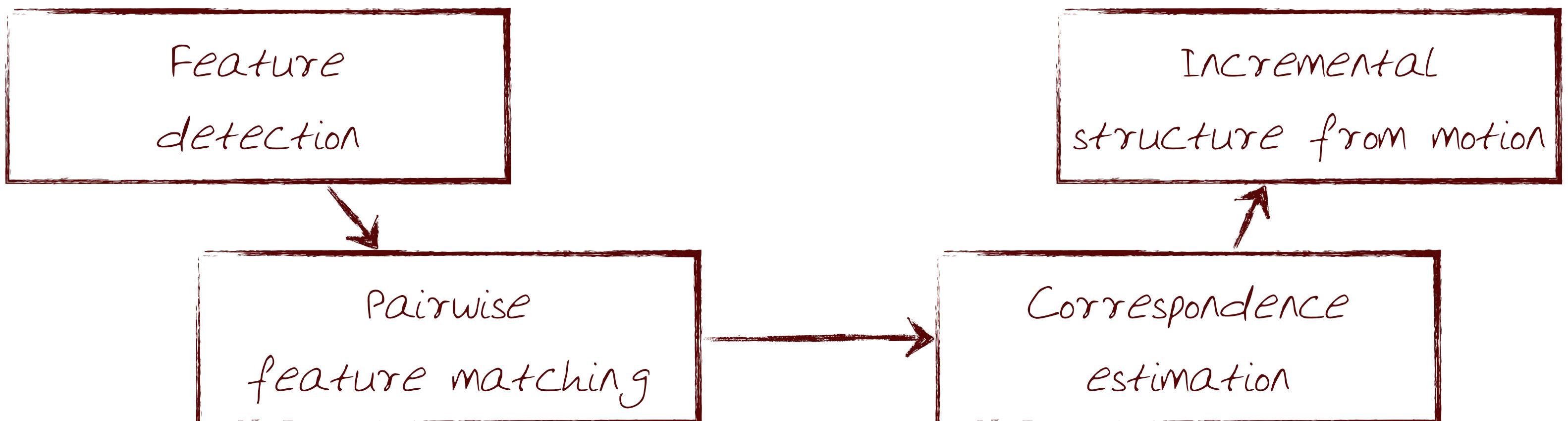


Photo Explorer

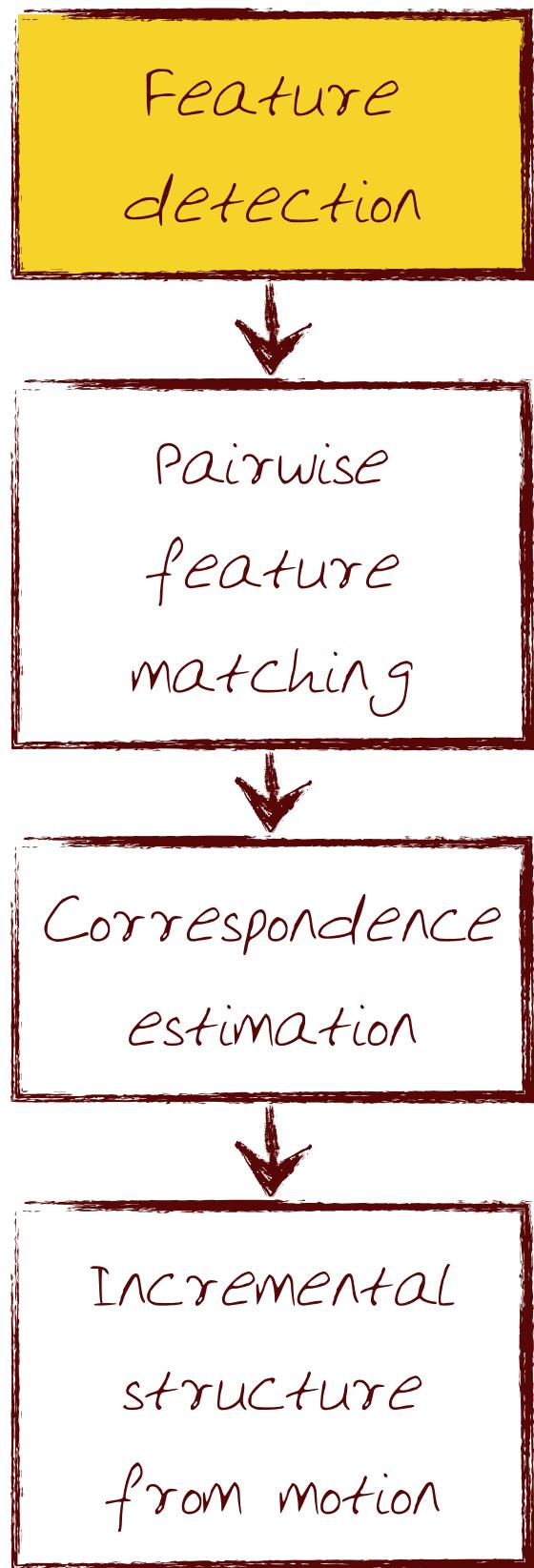
# Scene reconstruction

Automatically estimate

- \* position, orientation, and focal length of cameras
- \* 3D positions of feature points



Adapted from Noah Snavely

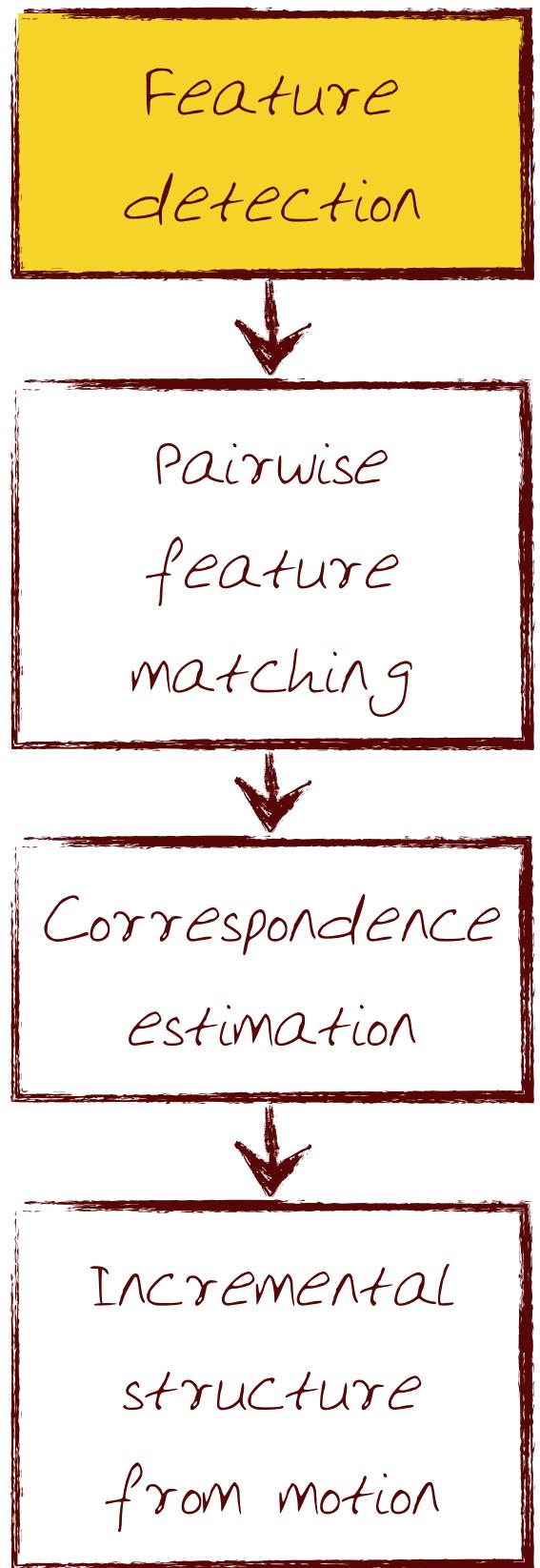


# Feature Detection



Detect features  
using SIFT  
[Lowe, 2004]

Adapted from Noah Snavely

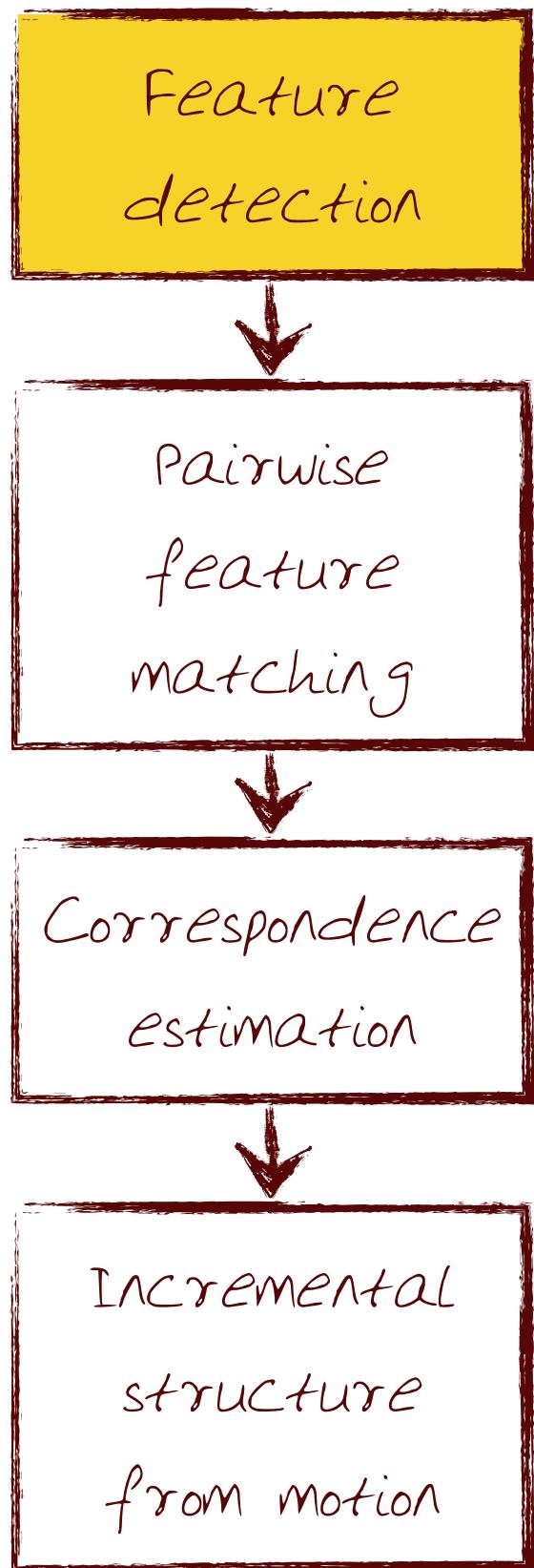


# Feature Detection

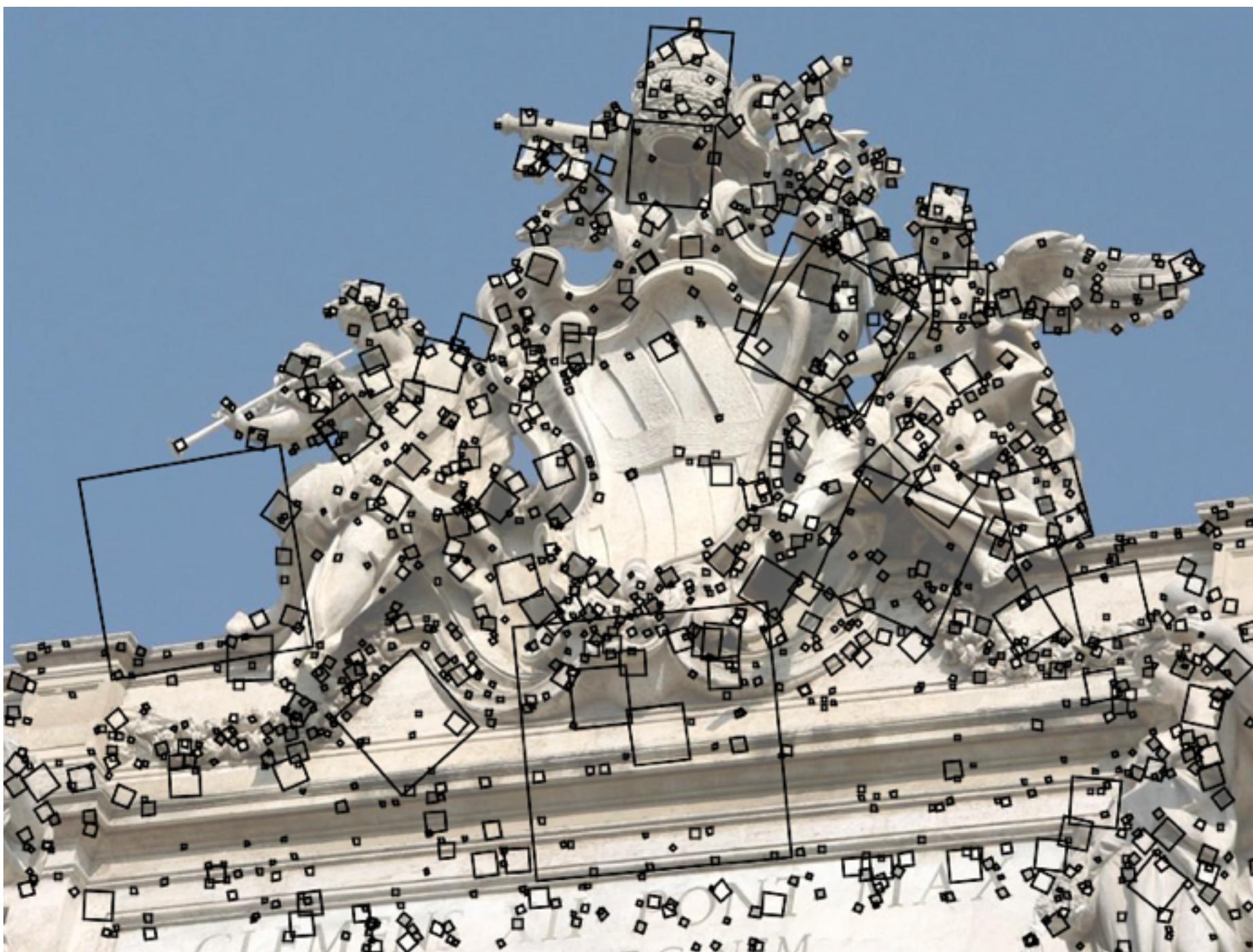


Detect features  
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Adapted from Noah Snavely



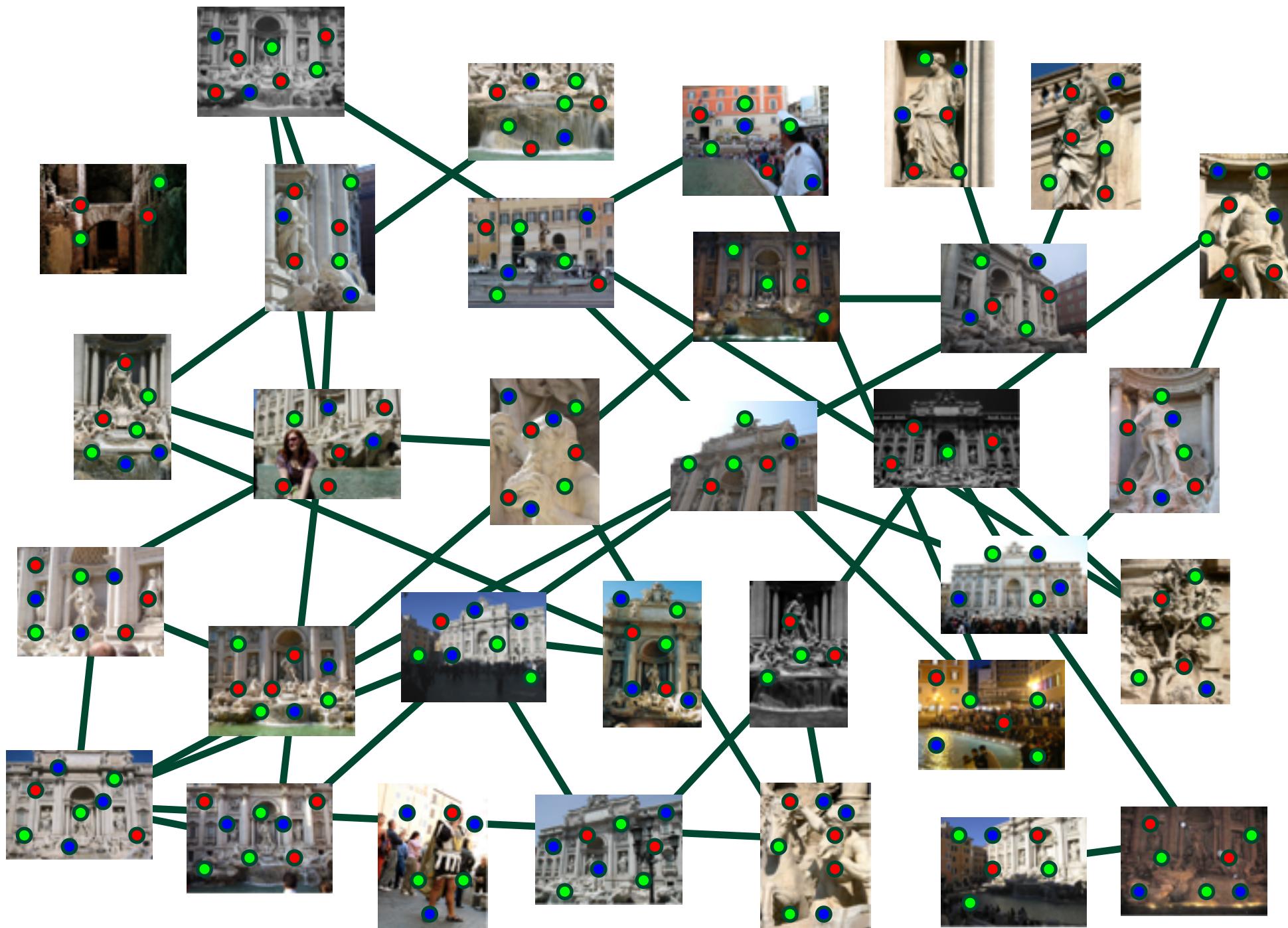
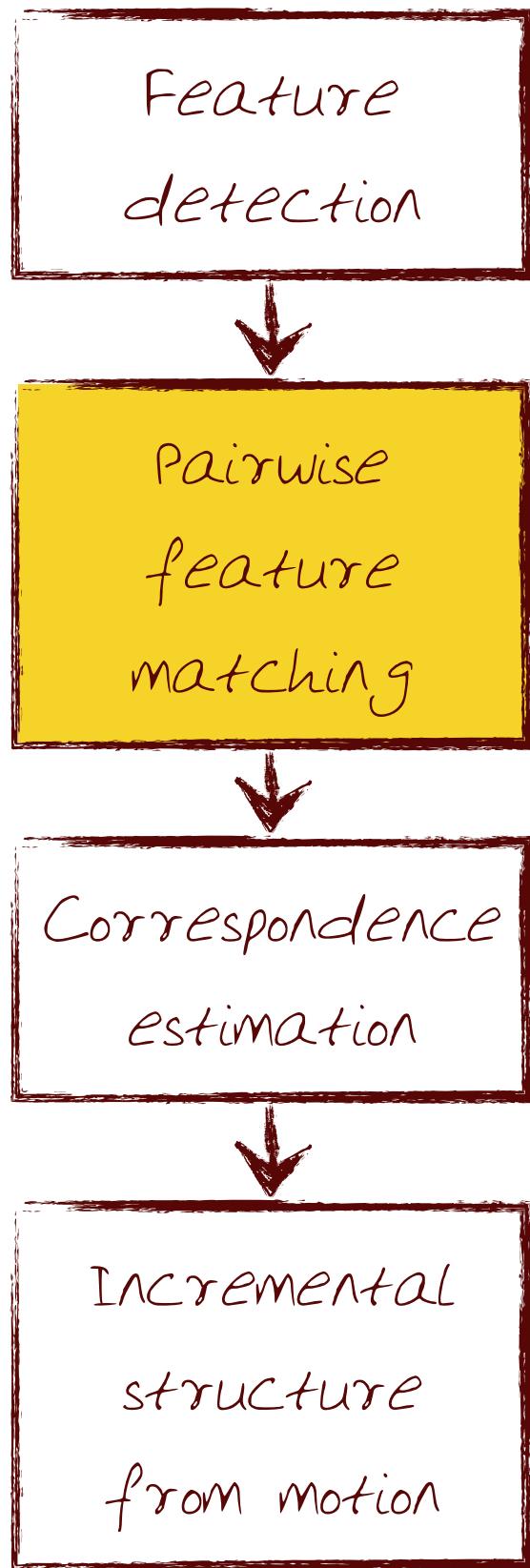
# Feature Detection



Detect  
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[Lowe, 2004]

Adapted from Noah Snavely

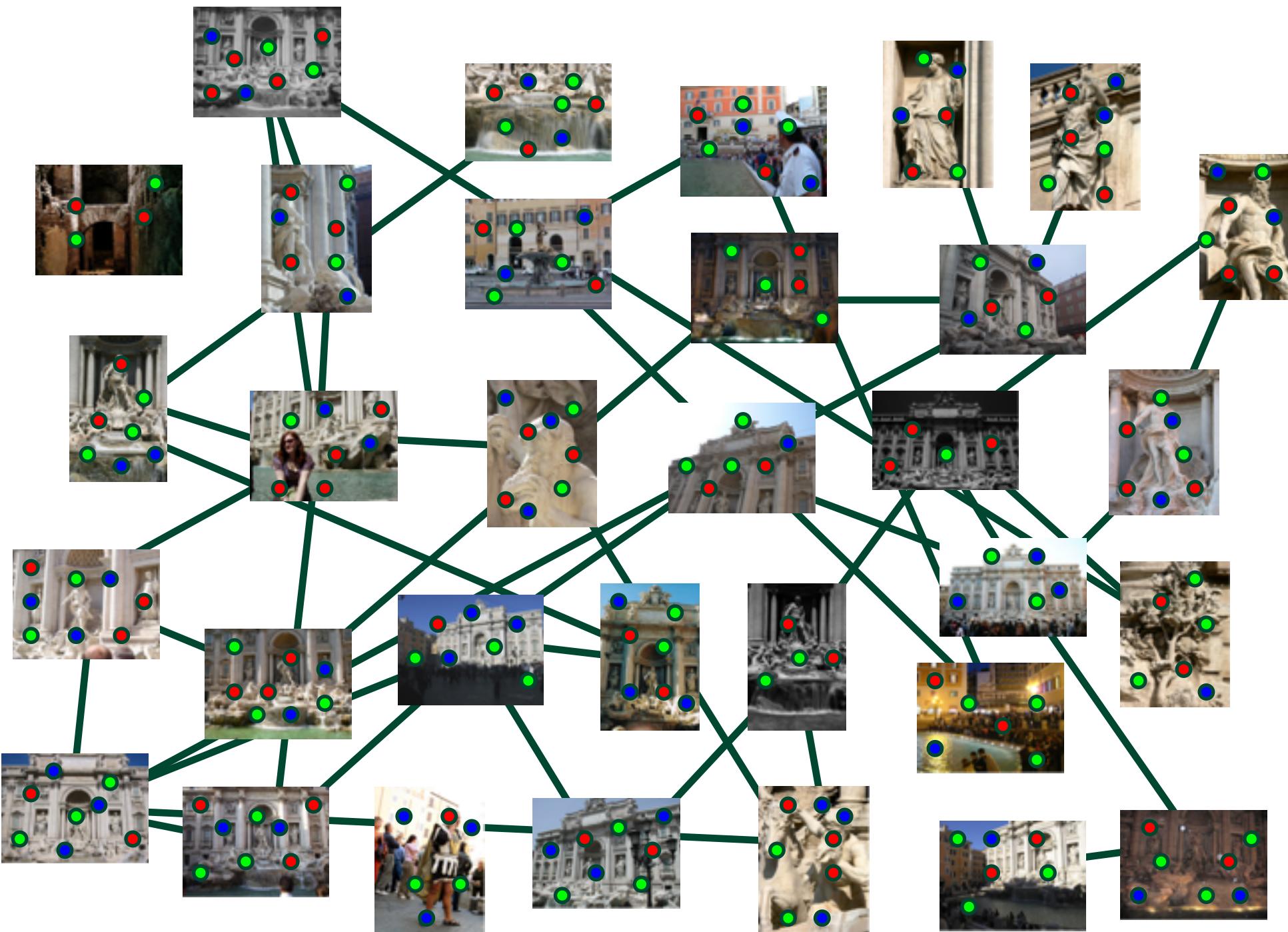
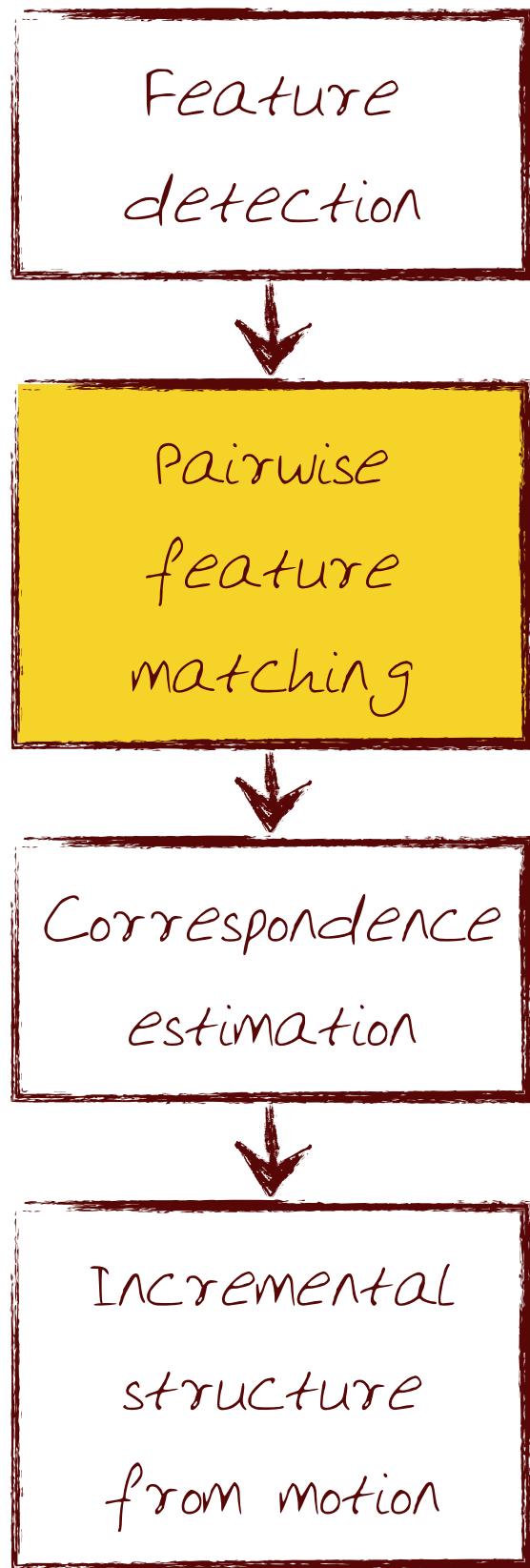
# Pairwise feature matching



Match  
features  
between  
each pair of  
images

Adapted from Noah Snavely

# Pairwise feature matching



Refine  
matching  
using RANSAC  
between pairs

Adapted from Noah Snavely

# Correspondence Estimation

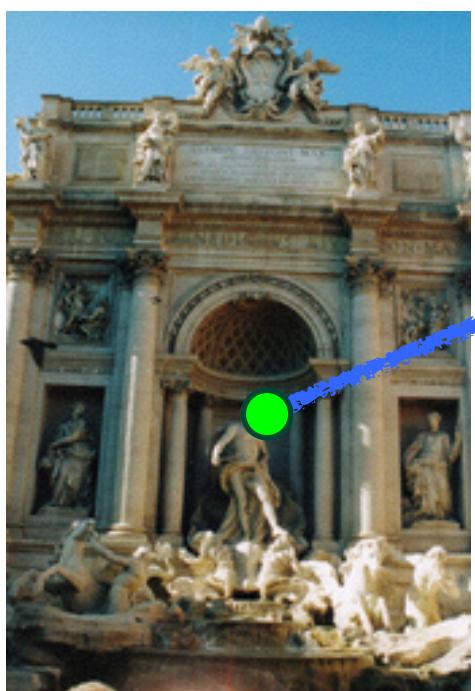
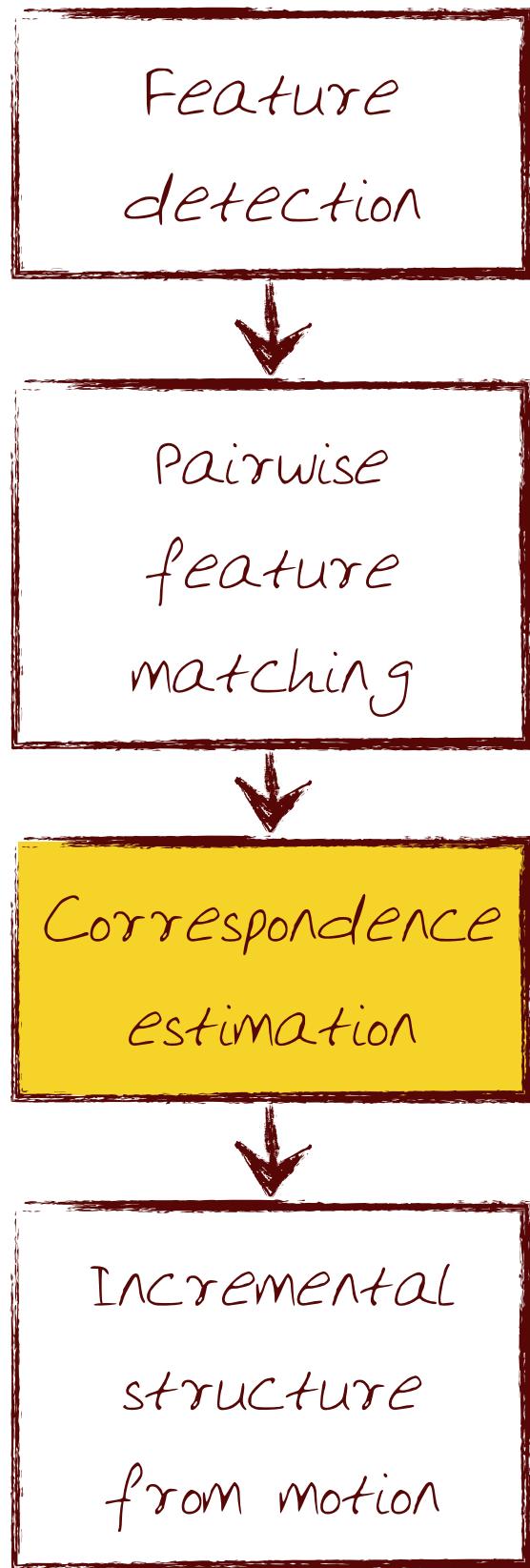


Image 1

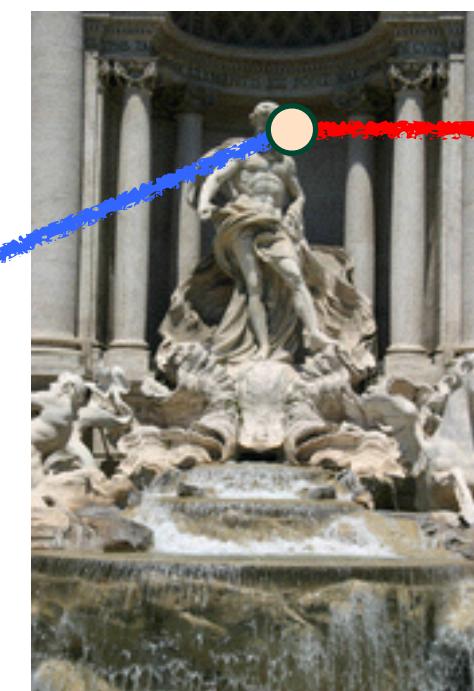


Image 2

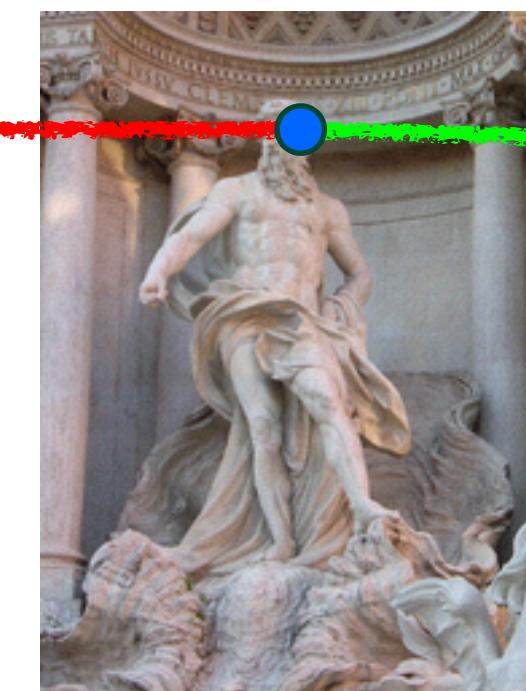


Image 3

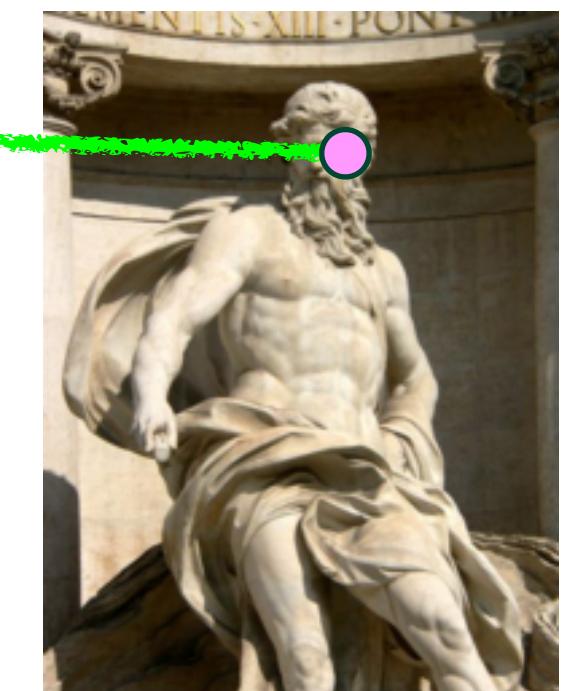
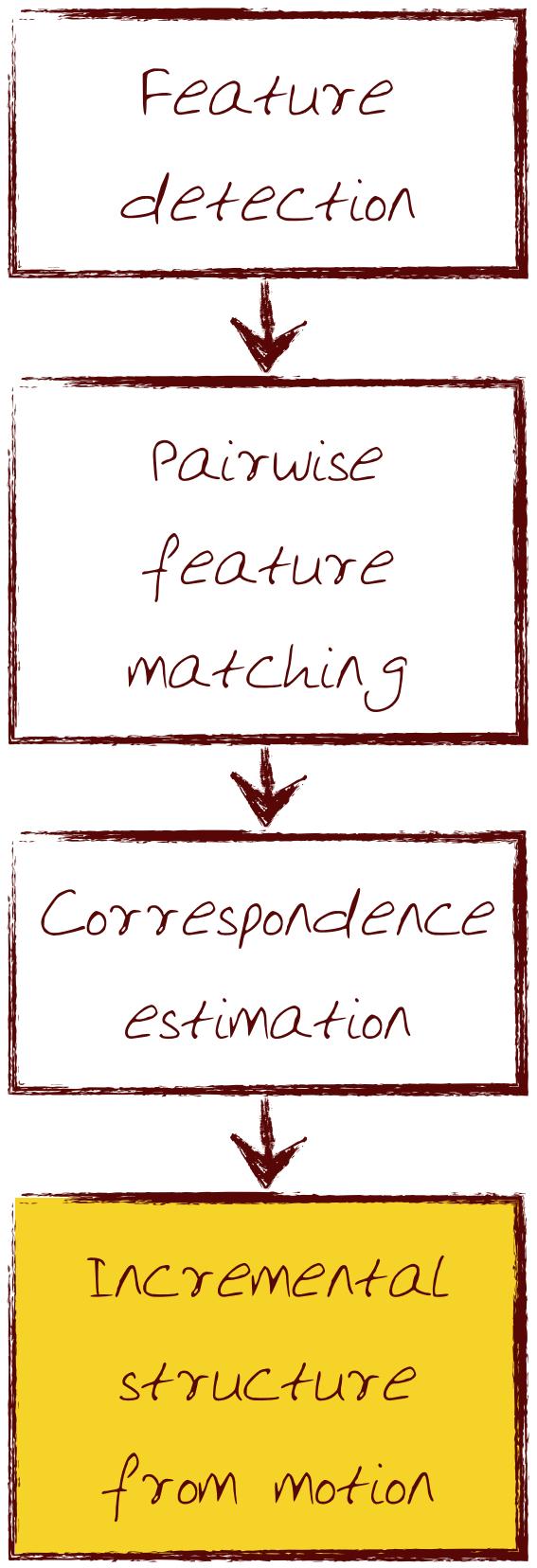


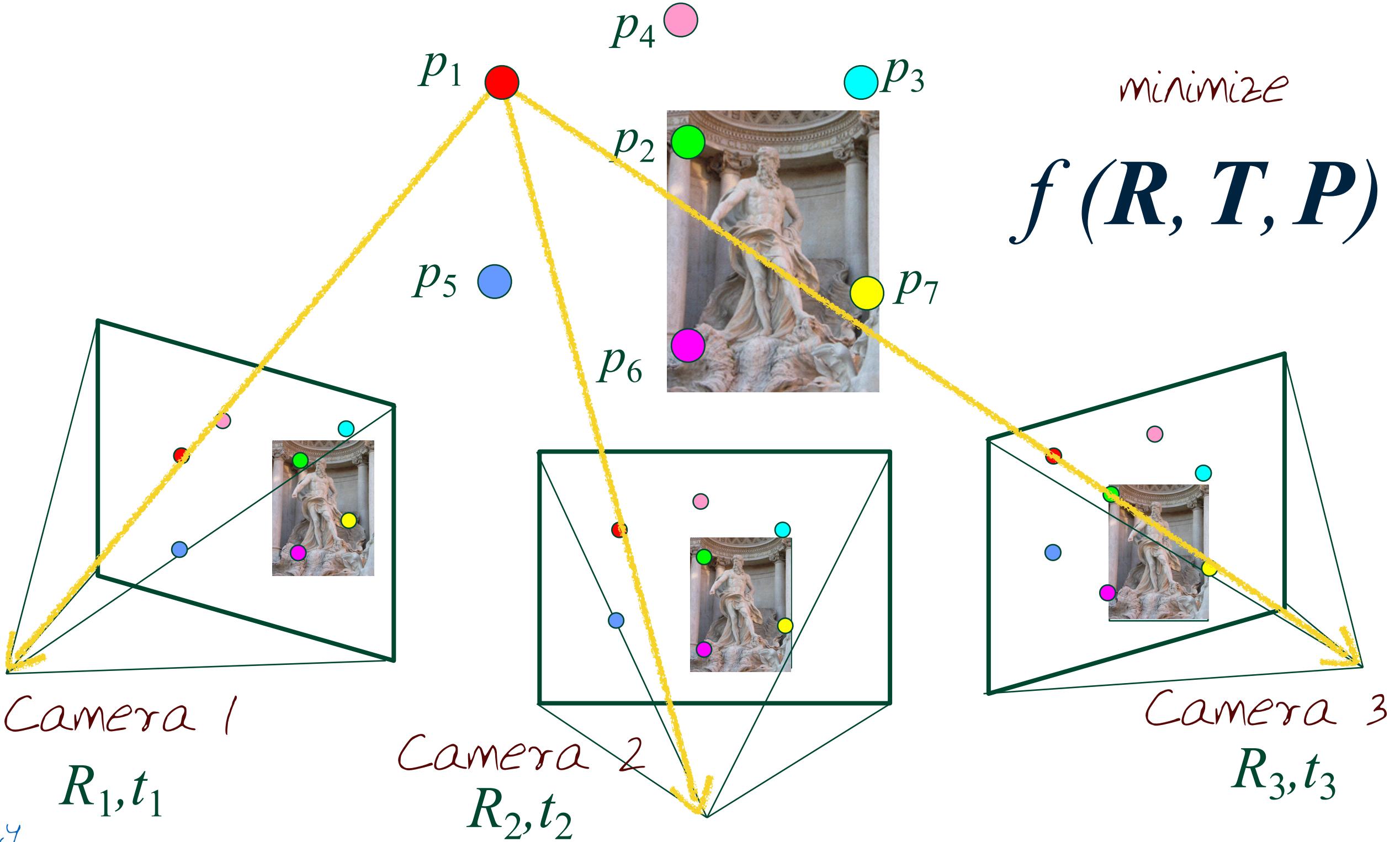
Image 4

Link up pairwise matches to form connected components of matches across several images

Adapted from Noah Snavely

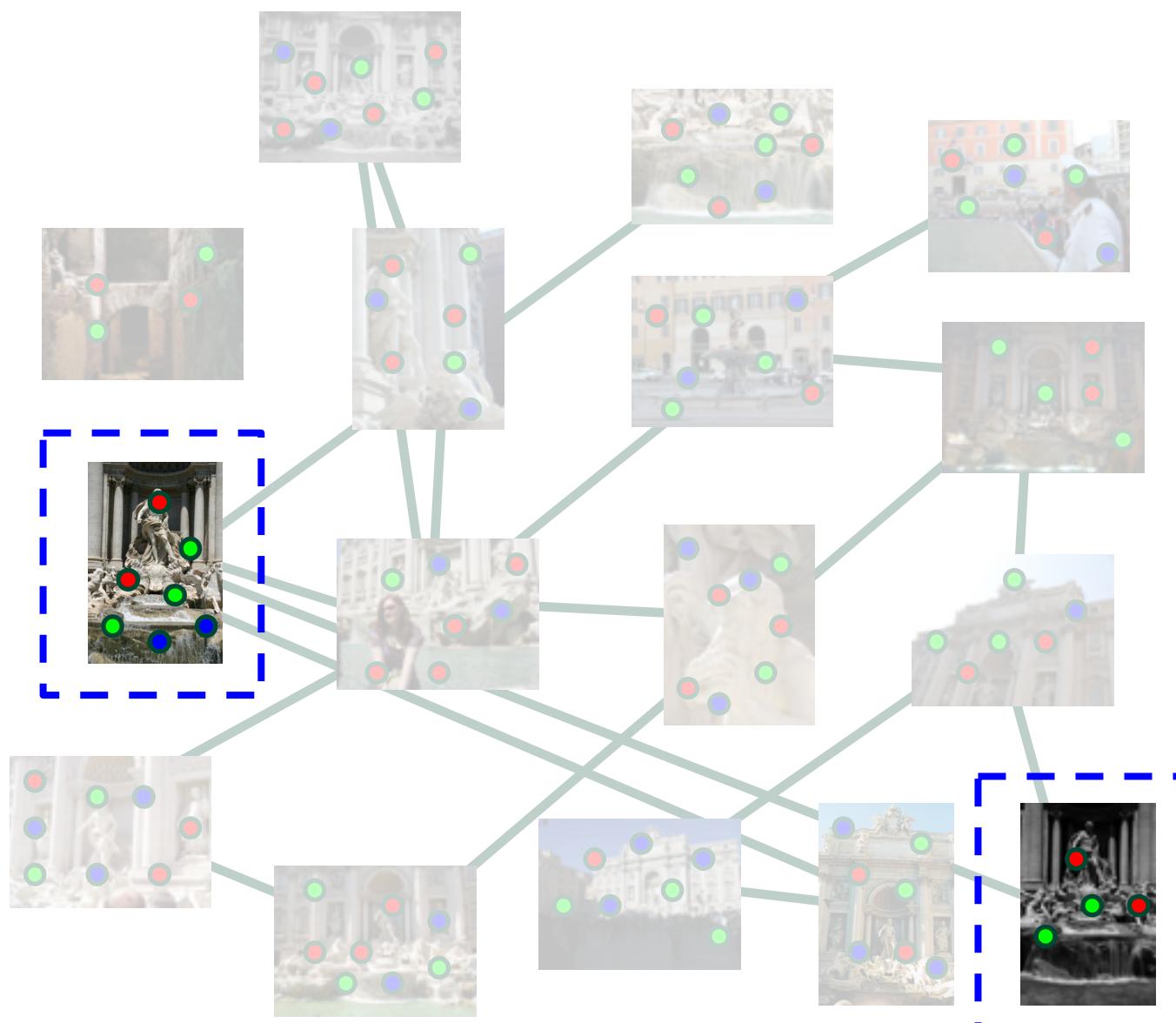
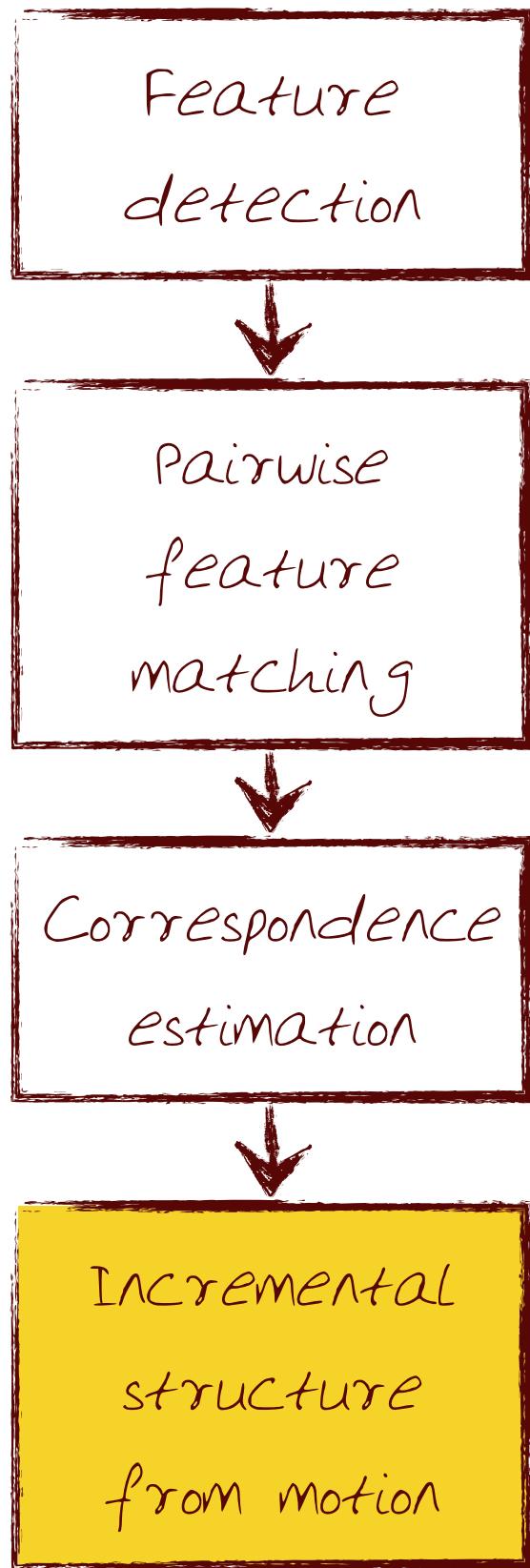


# Structure from Motion

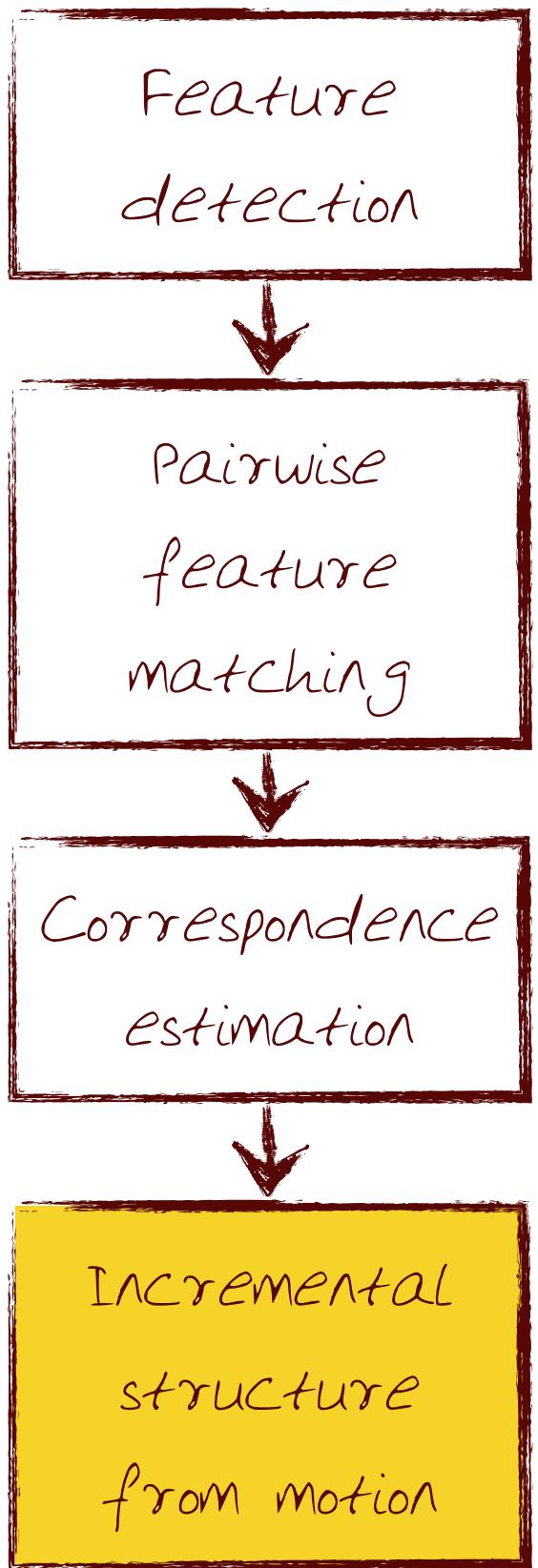


Adapted from Noah Snavely

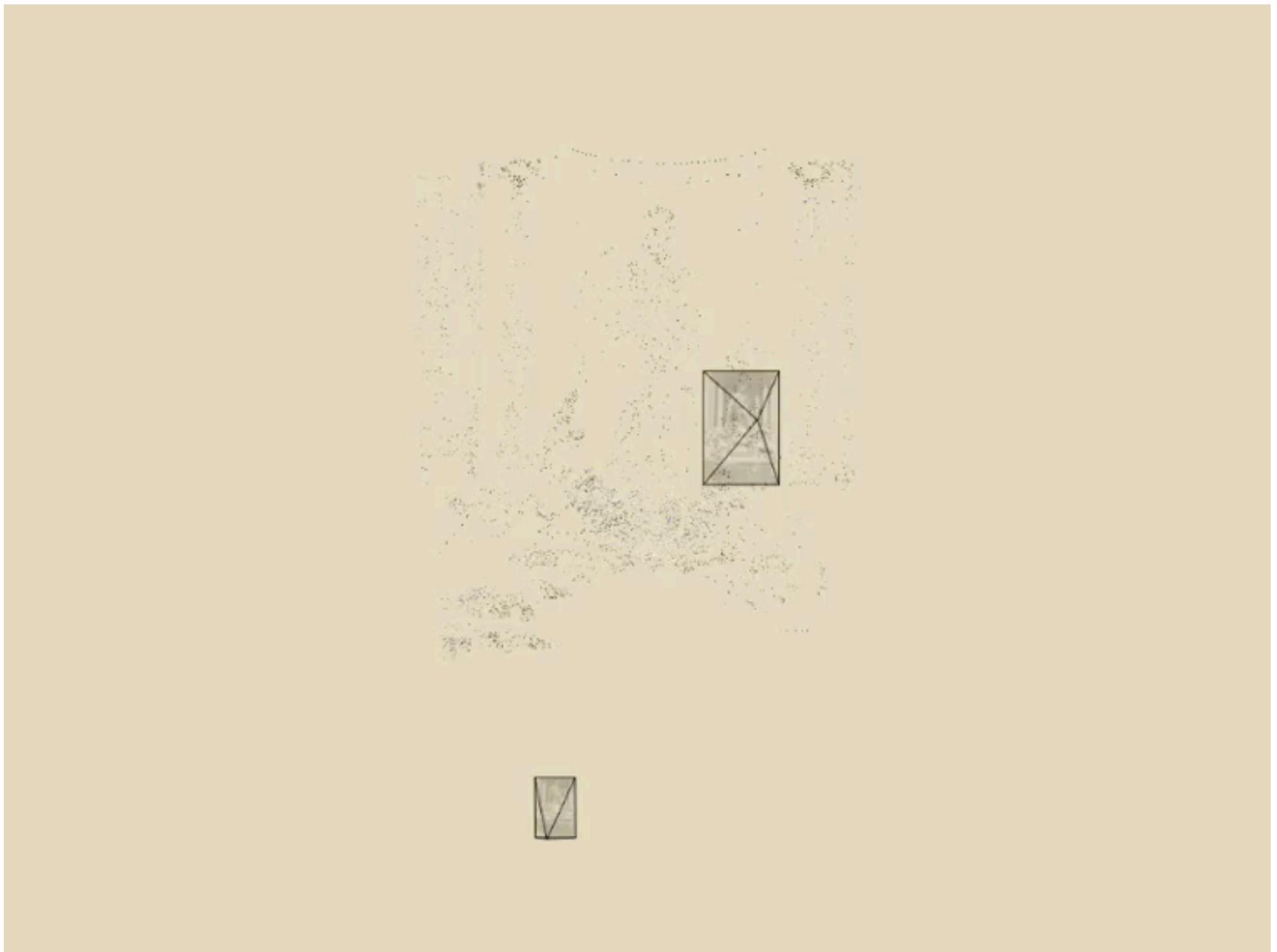
# Incremental Structure from Motion

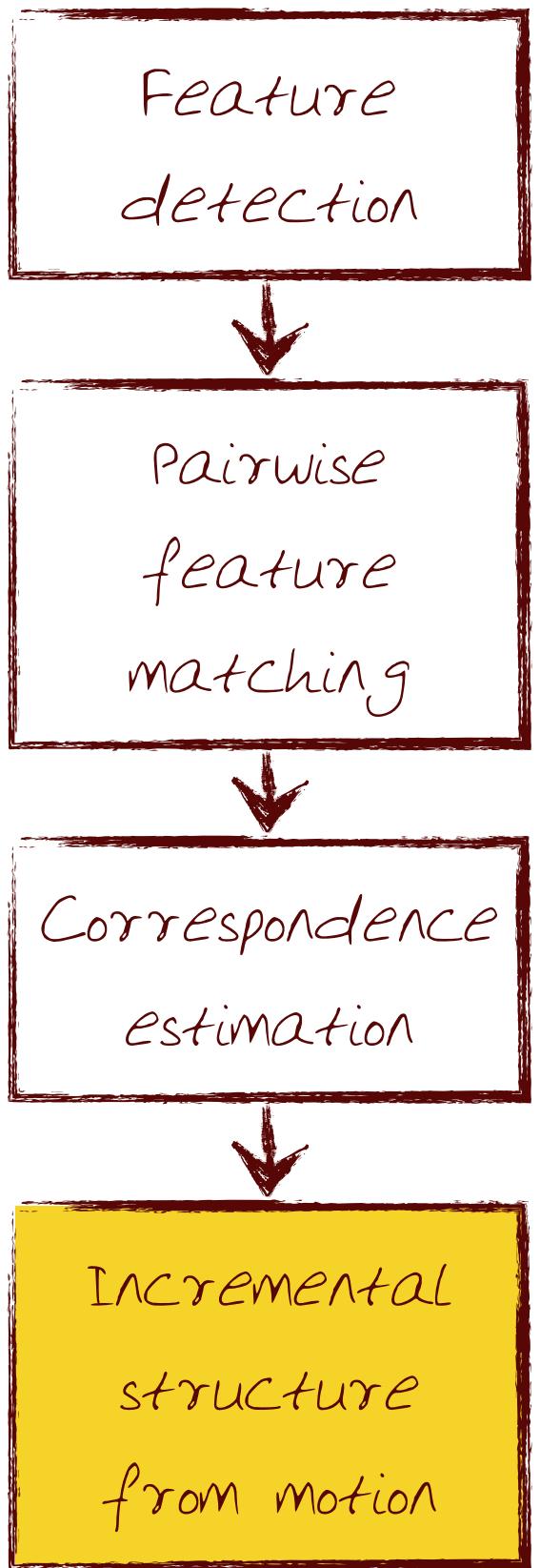


Adapted from Noah Snavely



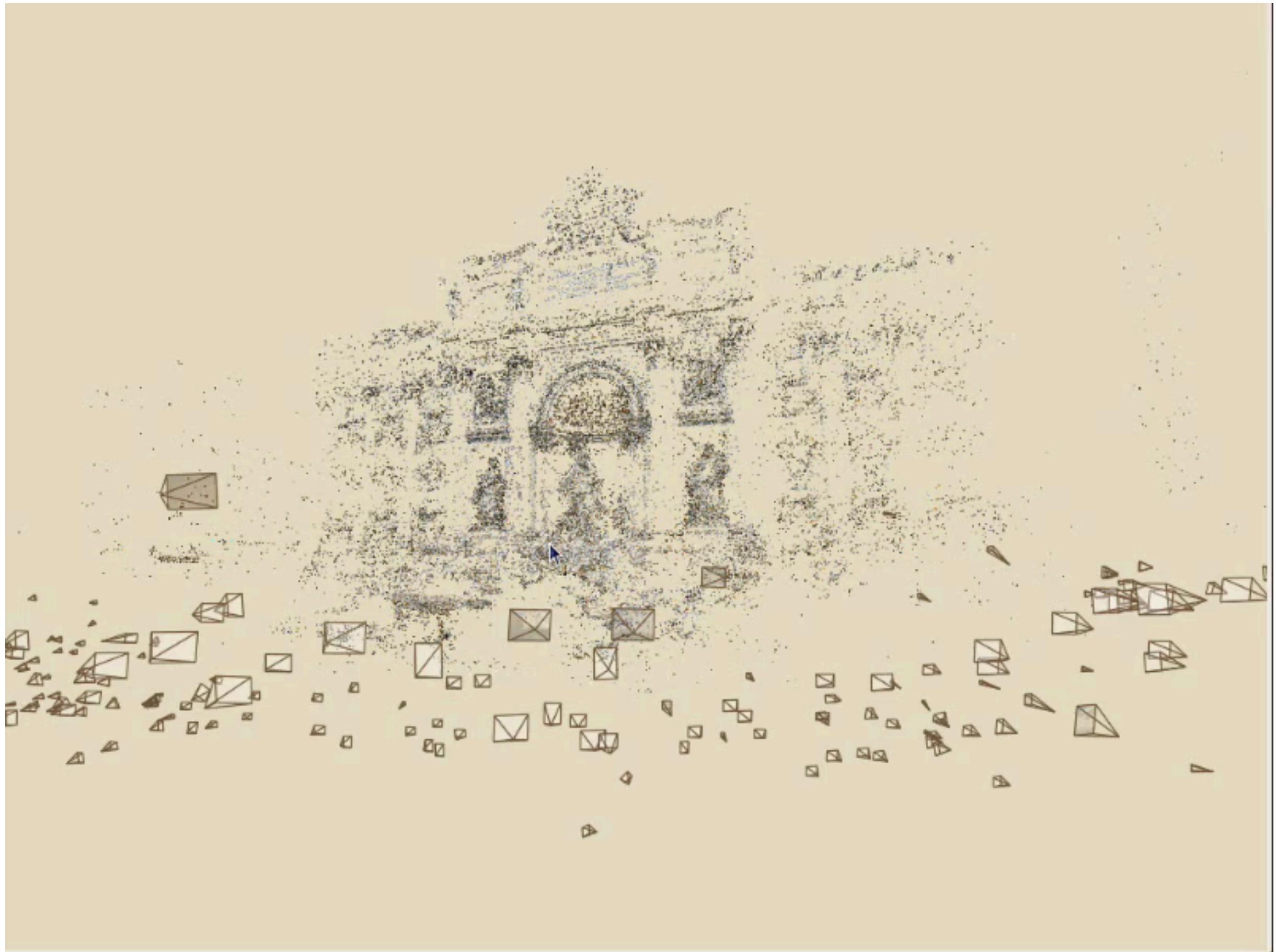
# Incremental Structure from Motion





# Incremental Structure from Motion





# Photosynth.net

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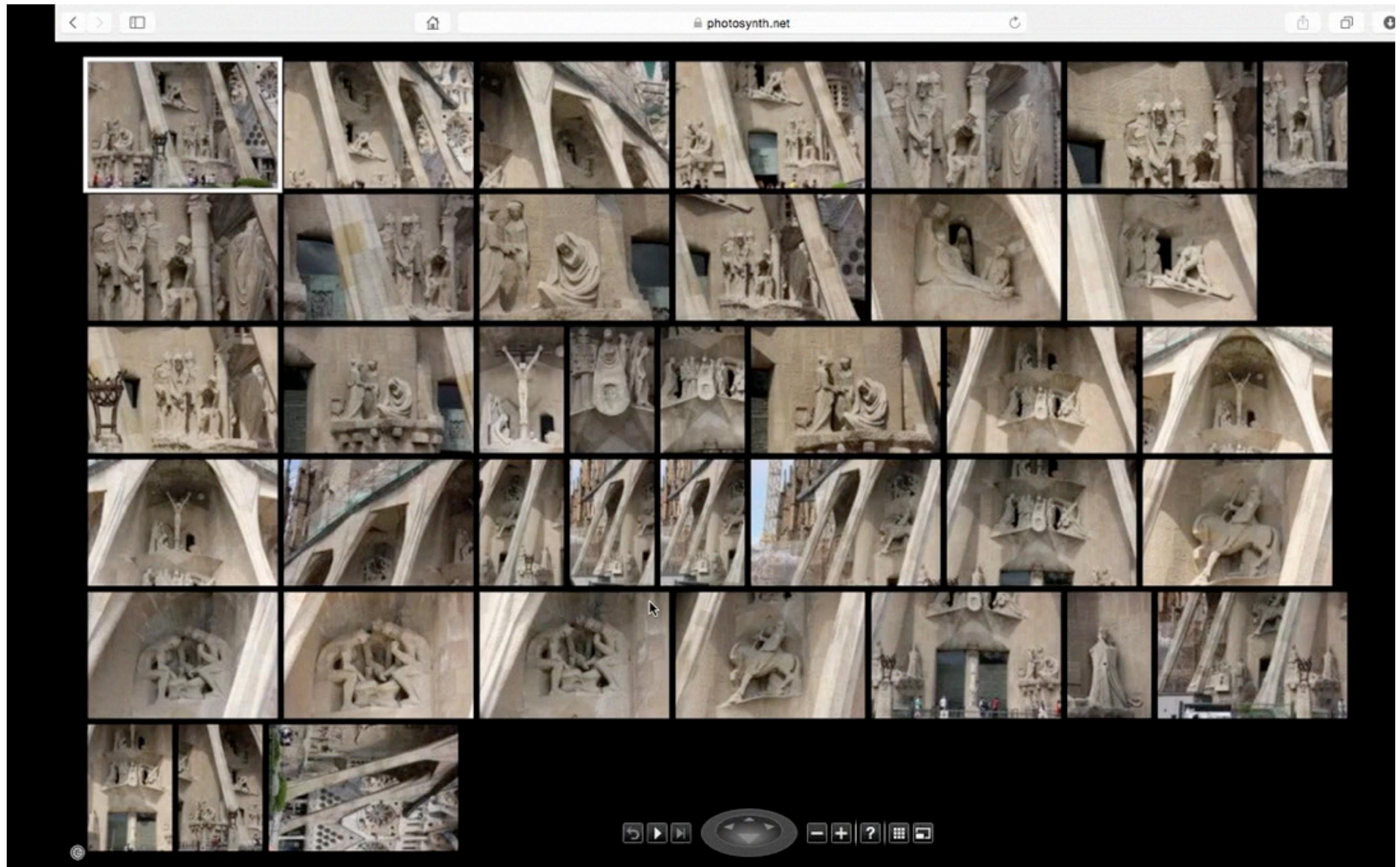
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#Constantine Mill House BlackhawkDesign 12/28/2014 ★ 3 0 Panorama - 5.90 Megapixels 1882 Views

Randall Park Mall AbandonedAmerica 12/30/2014 ★ 2 0 Panorama - 148 Megapixels 6791 Views

Randall Park Mall II AbandonedAmerica 12/31/2014 ★ 2 0 Panorama - 157 Megapixels 17148 Views

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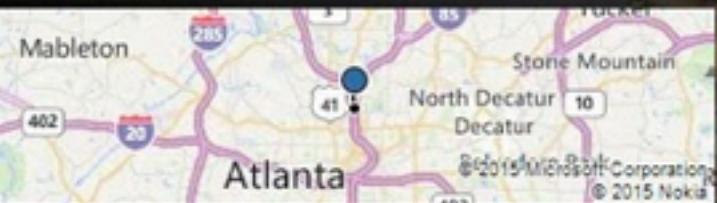
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3 views : panorama : 5 photos

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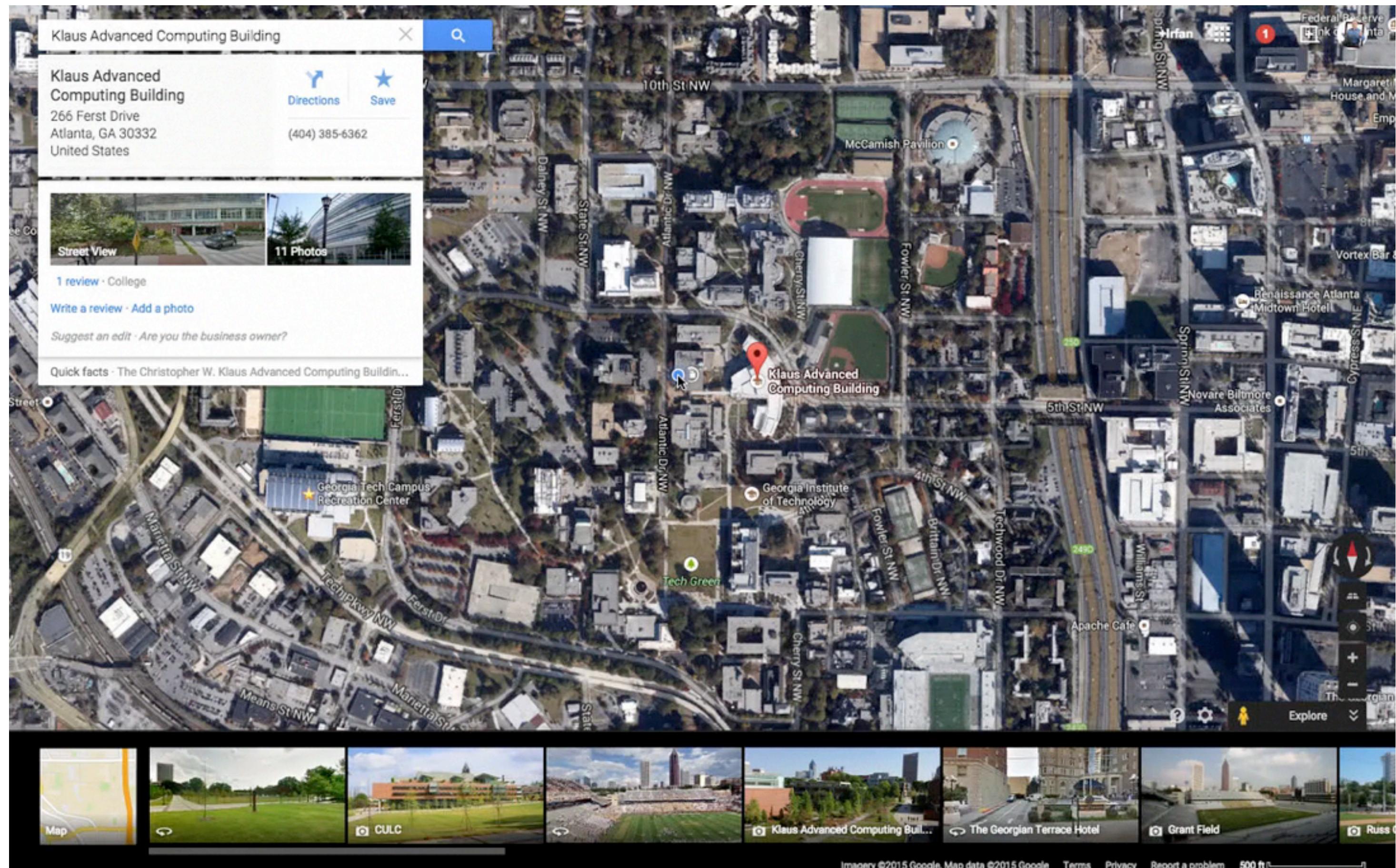
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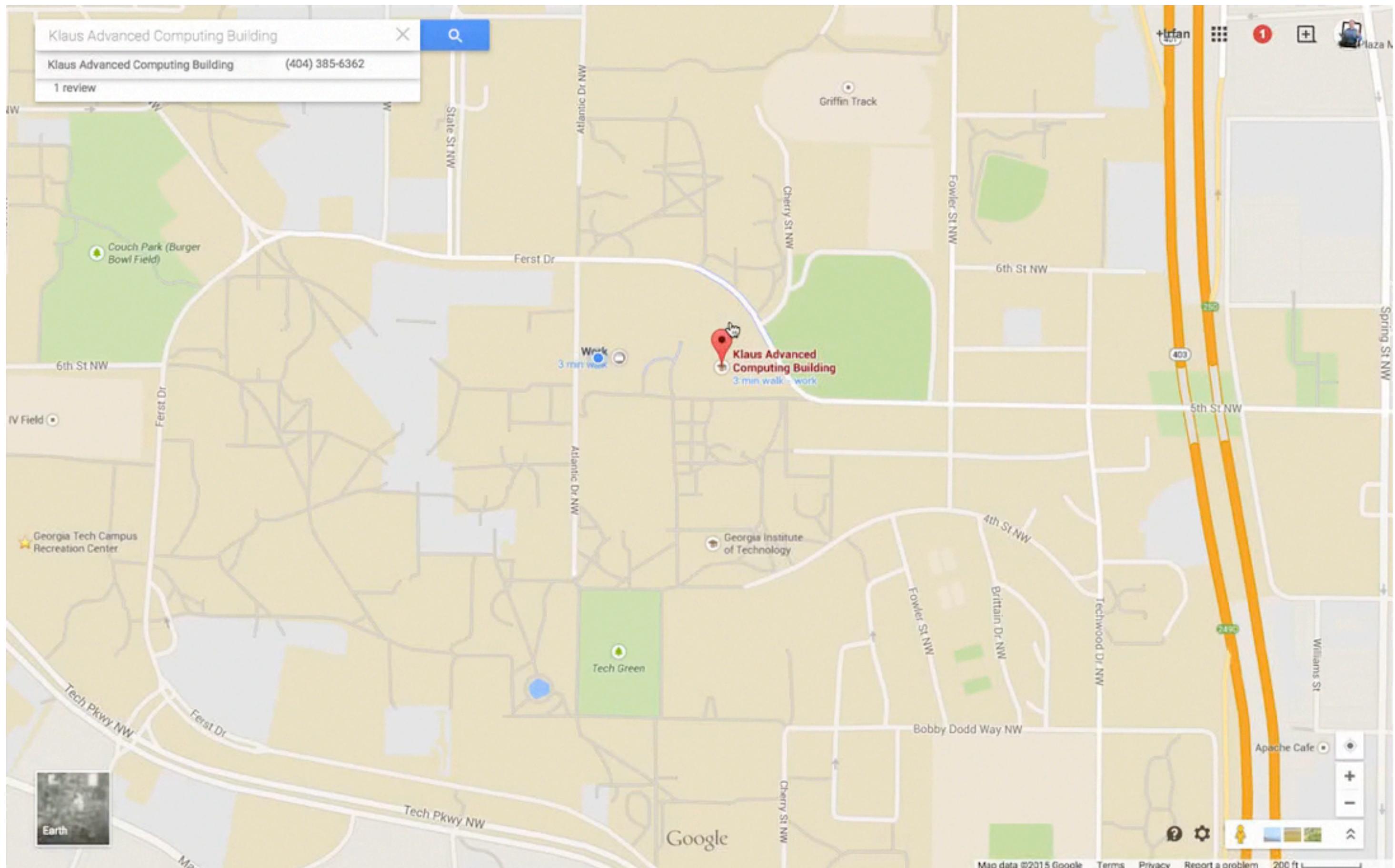
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# Google Streetview





#### [Collecting Imagery >](#)

First off we need to actually drive around and photograph the locations to show in Street View. We pay close attention to many factors, including the weather and the population density of various areas, to determine when and where can collect the best possible imagery.

#### [Aligning imagery >](#)

To match each image to its geographic location on the map, we combine signals from sensors on the car that measure GPS, speed and direction. This helps us reconstruct the car's exact route, and even tilt and realign images as needed.

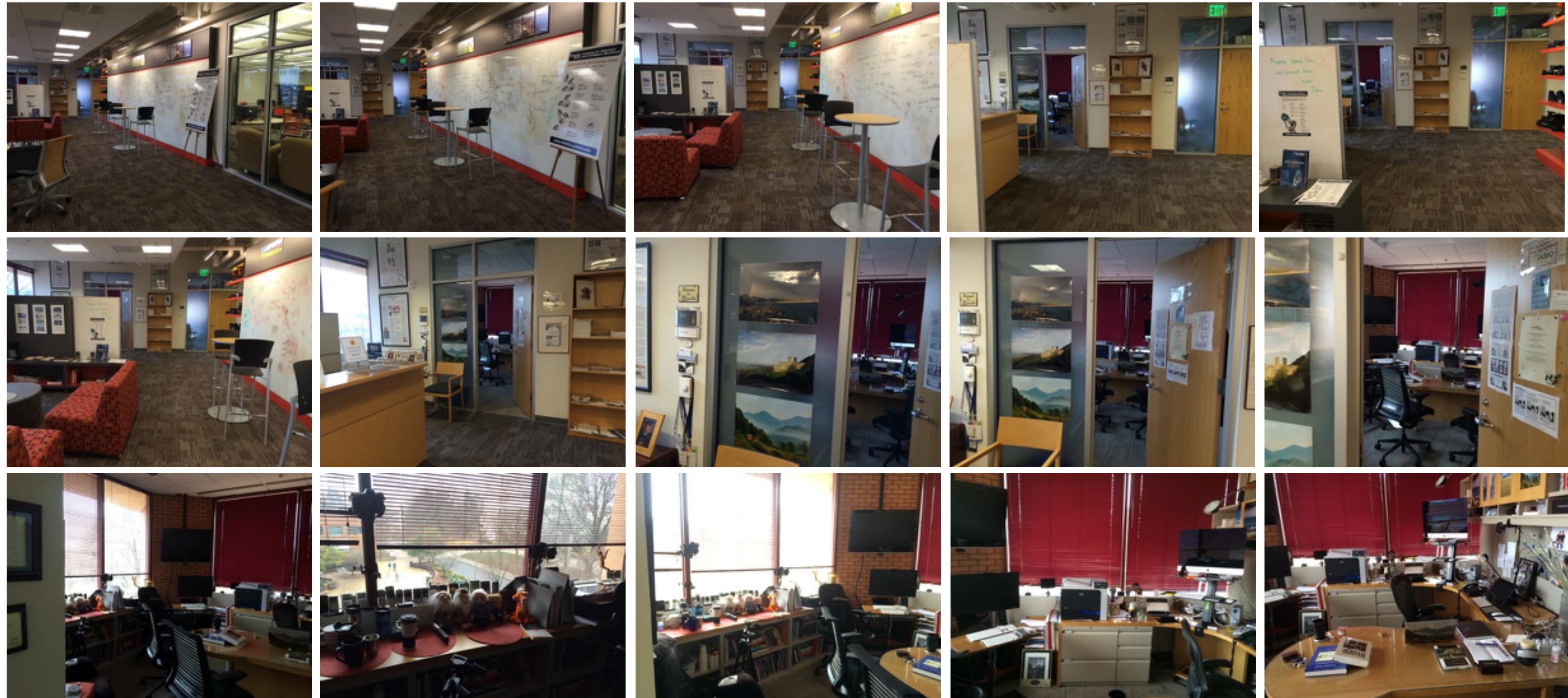
#### [Turning photos into 360-degree panoramas >](#)

To avoid gaps in the panoramas, adjacent cameras take slightly overlapping pictures, and then we "stitch" the photos together into a single 360-degree image. We then apply special image processing algorithms to lessen "seams" and create smooth transitions.

#### [Showing you the right image >](#)

How quickly the car's three lasers reflect off surfaces tells us how far a building or object is, and enables us to construct 3D models. When you move to an area in the distance, the 3D model determines the best panorama to show you for that location.

<http://www.google.com/maps/about/behind-the-scenes/streetview/>



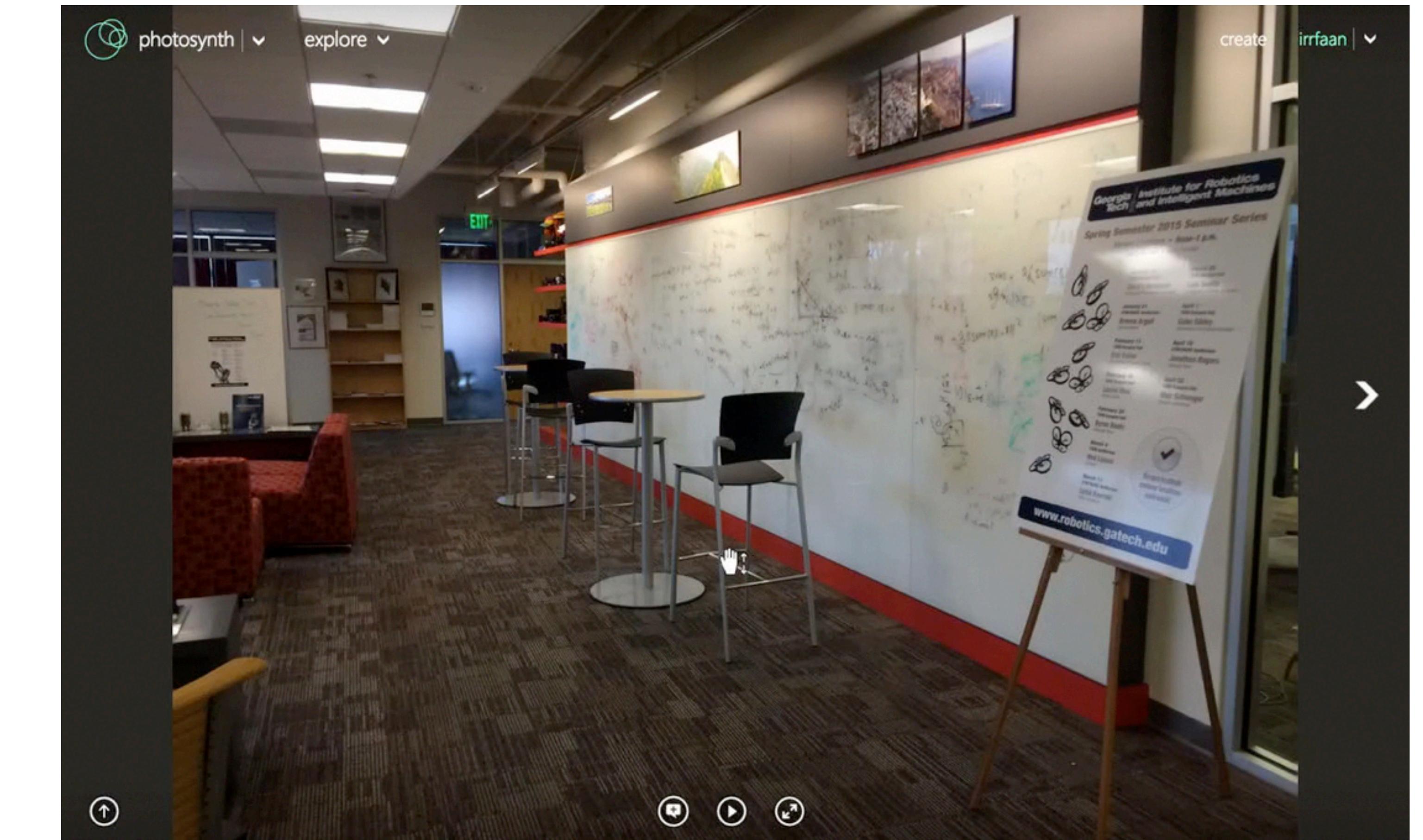


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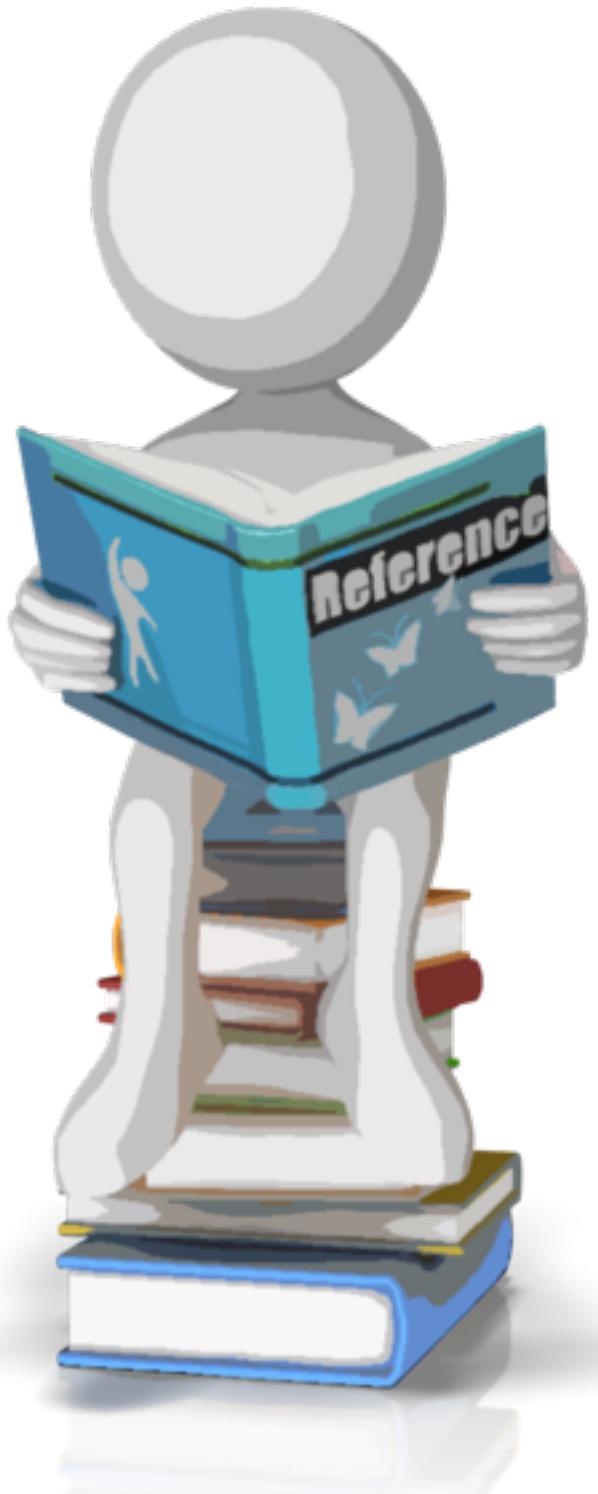


# Summary

- \* Photos to show space / environments
- \* Photo tourism / photosynth / street views



# Further Reading



- \* Snavely, Seitz, Szeliski (2010) ‘Photo tourism.’ Exploring photo collections in 3D, » ACM SIGGRAPH 2006
- \* Kushal, Self, Furukawa, Gallup, Hernandez, Curless, Seitz (2012) “Photo tours” , 3DPTV 2012
- \* Szeliski (2010)

# Credits



- \* For more information, see:
  - \* Richard Szeliski (2010) Computer Vision: Algorithms and Applications, Springer (Chapter 3)
- \* Some concepts in slides motivated by similar slides from Noah Snavely
- \* [www.photosynth.net](http://www.photosynth.net)
- \* [maps.google.com/phototours](http://maps.google.com/phototours)

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- \* Study the basics of computation and its impact on the entire workflow of photography, from capturing, manipulating and collaborating on, and sharing photographs.