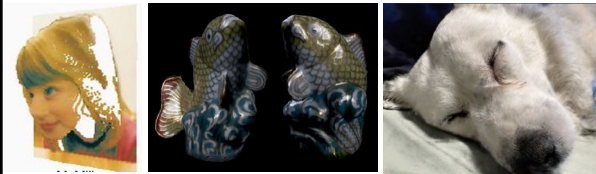


Image-Based Rendering

CSE 274, Lecture 6: Photo Tourism (and Façade)

Ravi Ramamoorthi

<http://www.cs.ucsd.edu/~ravir>



1

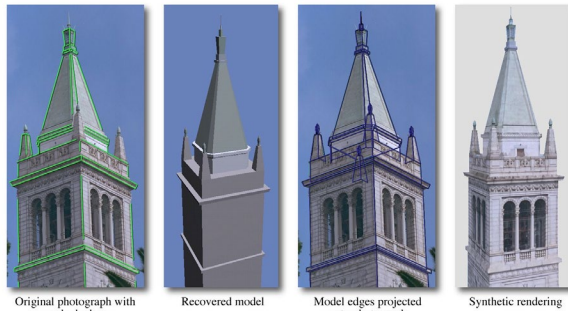
Motivation

- Today IBR models whole urban world (think of Streetview with 3D modeling, NeRFs)
- Remains important topic for sparse views
 - Actively working on WRIVA project
- Briefly trace two key developments
 - Façade system (Debevec et al. 96)
 - [Not covered:] Teller ~00: Automated Model Capture in Extended Urban Environments
 - **Photo Tourism (Snavely et al. 06)**

2

Modeling and Rendering Architecture from Photographs

Debevec, Taylor, and Malik 1996



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3

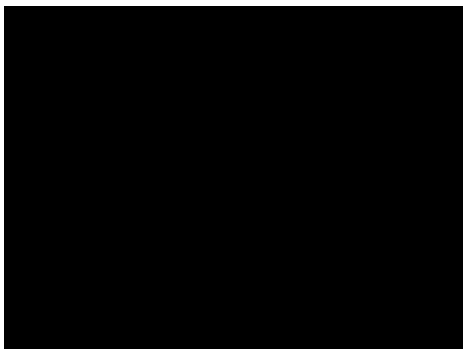
FACADE

- Photogrammetric Modeling
 - Interactively recover 3D models and camera positions from photographs for simple structures
- View-Dependent Texture Mapping (3D model and set of photos into renderings)
- Model-Based Stereo refines geometric model
- Video: <https://youtu.be/F-L5qnTZEfg>

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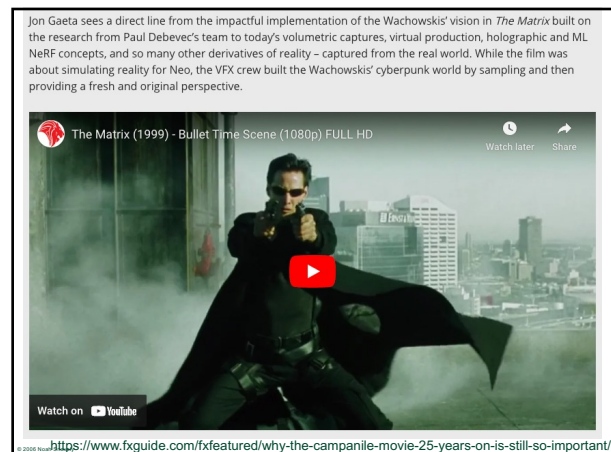
Campanile Movie (SIGGRAPH 97 ET)



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For audio, play off debevec-campanile.mov

5



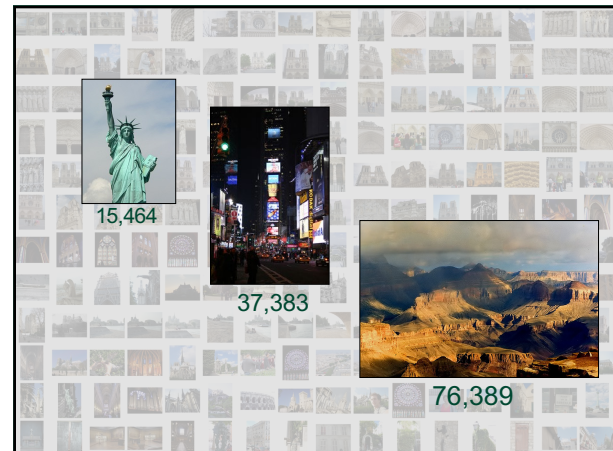
6

Photo Tourism: Exploring Photo Collections in 3D

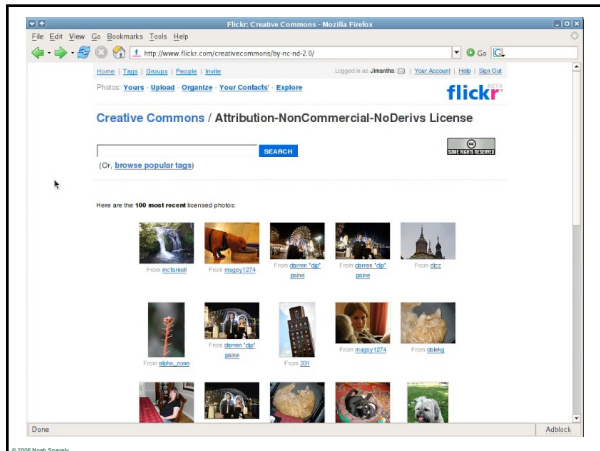
Noah Snavely
Steven M. Seitz
University of Washington
Richard Szeliski
Microsoft Research

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7



8



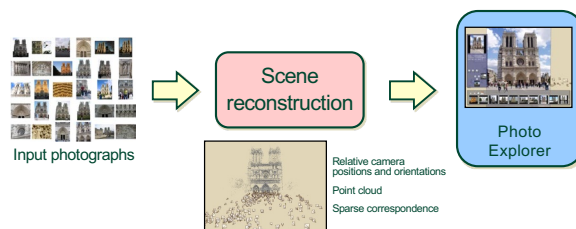
9

Photo Tourism



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Photo Tourism overview



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Related work

Image-based modeling



Debevec, *et al.*
SIGGRAPH 1996



Schaffalitzky and Zisserman
ECCV 2002



Brown and Lowe
3DIM 2005

Image-based rendering



Aspen Movie Map
Lippman, *et al.*, 1978

Photorealistic IBR:
Levoy and Hanrahan, SIGGRAPH 1996
Gortler, *et al.*, SIGGRAPH 1996
Seitz and Dyer, SIGGRAPH 1996
Aliaga, *et al.*, SIGGRAPH 2001
and many others

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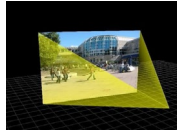
12

Related work

- Image browsing



Toyama, *et al*,
Int. Conf. Multimedia, 2003



McCurdy and Griswold
Mobisys 2003



Sivic and Zisserman
ICCV 2003

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Photo Tourism overview

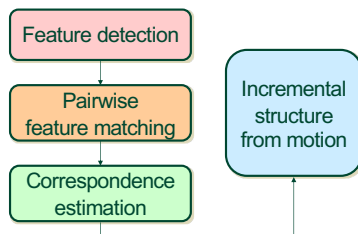


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Scene reconstruction

- Automatically estimate
 - position, orientation, and focal length of cameras
 - 3D positions of feature points



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Feature detection

Detect features using SIFT [Lowe, IJCV 2004]

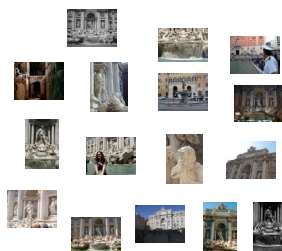


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Feature detection

Detect features using SIFT [Lowe, IJCV 2004]



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Feature detection

Detect features using SIFT [Lowe, IJCV 2004]

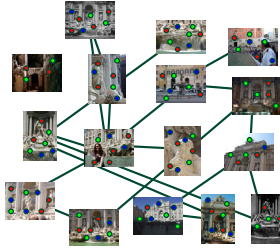


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Feature matching

Match features between each pair of images

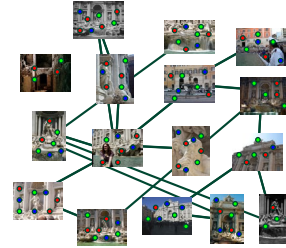


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Feature matching

Refine matching using RANSAC [Fischler & Bolles 1987] to estimate fundamental matrices between pairs

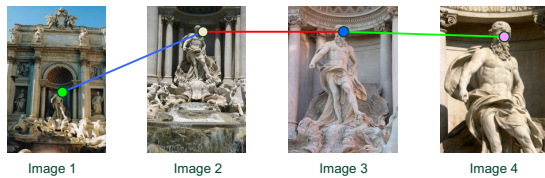


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Correspondence estimation

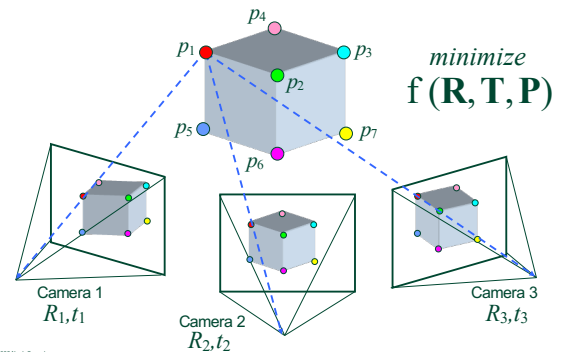
- Link up pairwise matches to form connected components of matches across several images



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Structure from motion



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Incremental structure from motion



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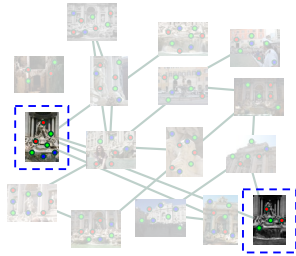
Incremental structure from motion



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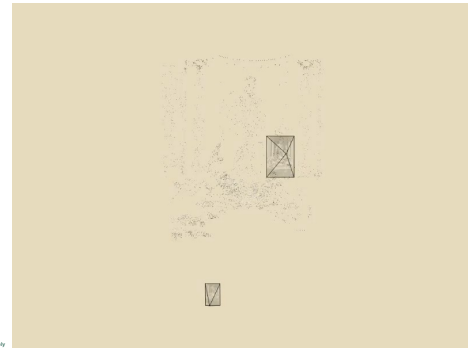
Incremental structure from motion



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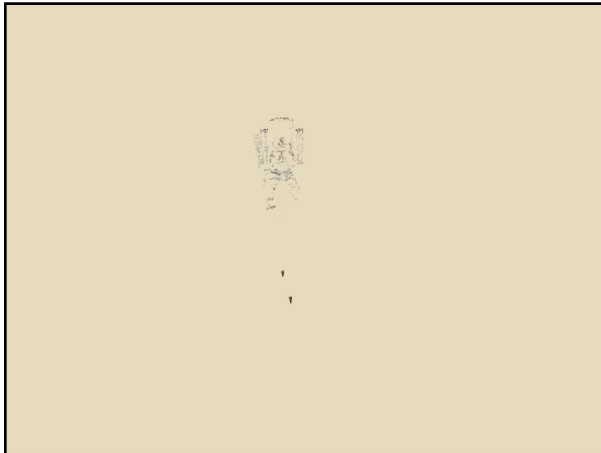
26

Incremental structure from motion



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Reconstruction performance

- For photo sets from the Internet, 20% to 75% of the photos were registered
- Most unregistered photos belonged to different connected components



- Running time: < 1 hour for 80 photos
> 1 week for 2600 photo

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Photo Tourism overview



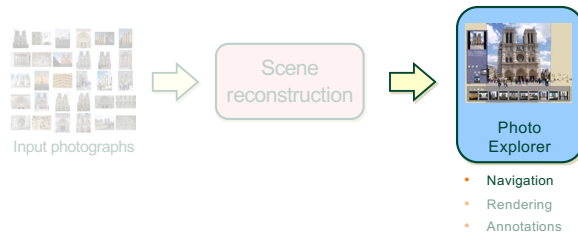
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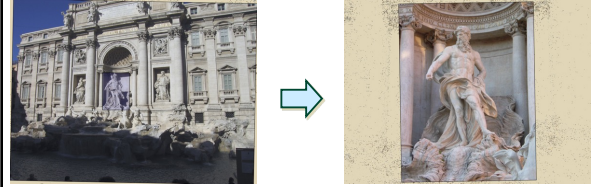
32

Photo Tourism overview



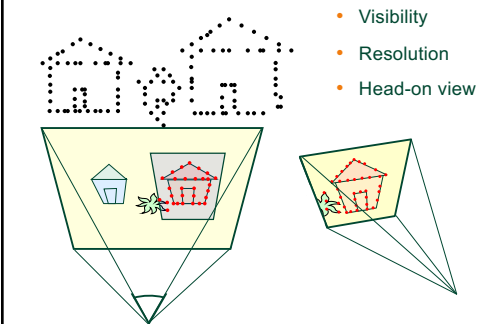
34

Object-based browsing



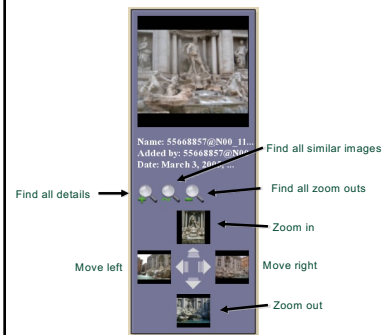
36

Object-based browsing



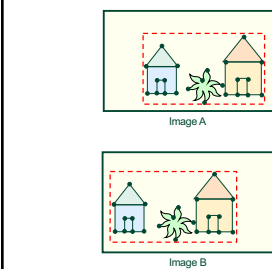
37

Relation-based browsing



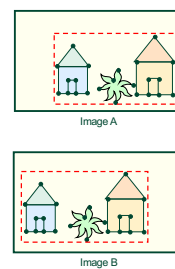
38

Relation-based browsing



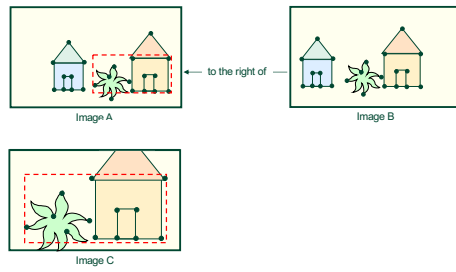
41

Relation-based browsing



42

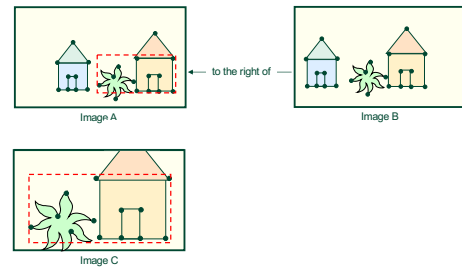
Relation-based browsing



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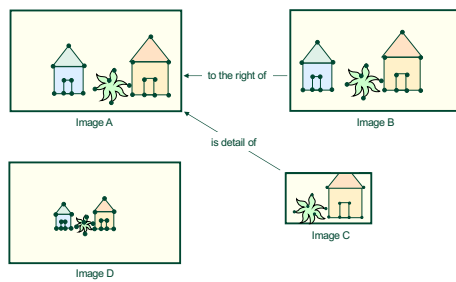
Relation-based browsing



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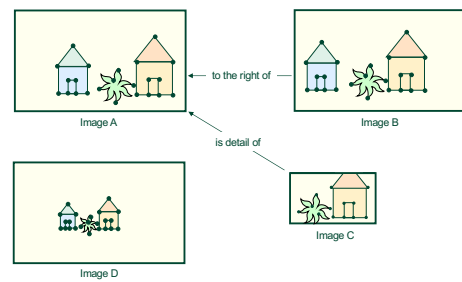
Relation-based browsing



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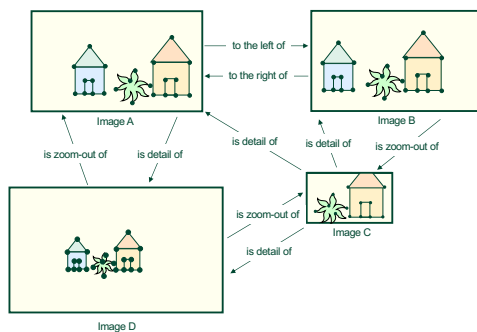
Relation-based browsing



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Relation-based browsing



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Overhead map



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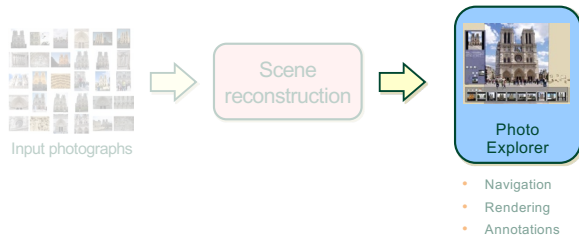
49

Prague Old Town Square



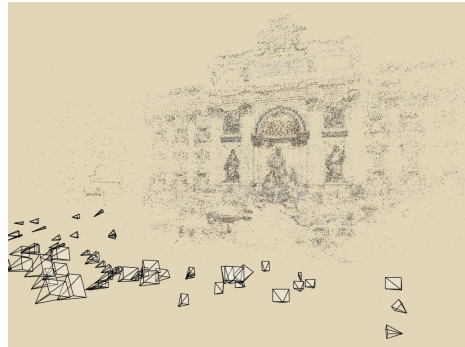
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Photo Tourism overview



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Rendering



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Rendering



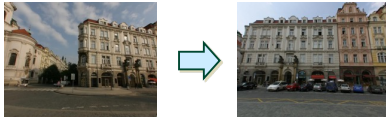
53

Rendering



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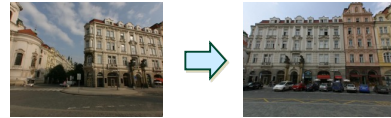
Rendering transitions



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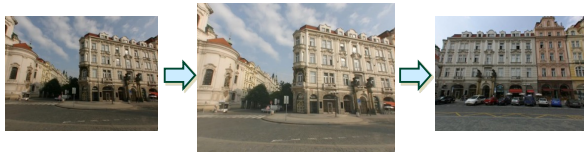
Rendering transitions



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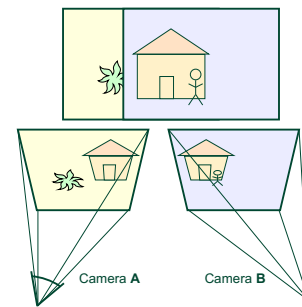
Rendering transitions



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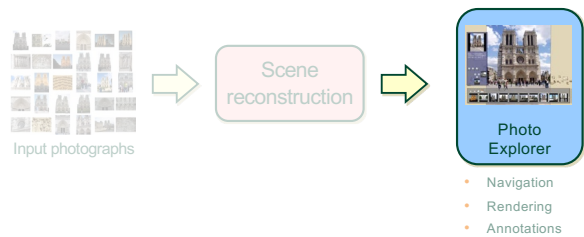
Rendering transitions



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Photo Tourism overview



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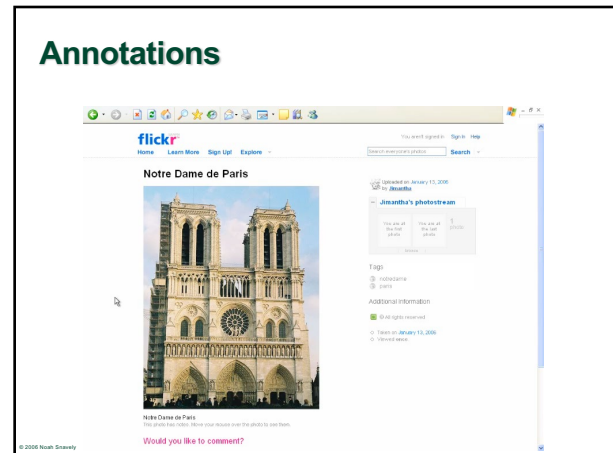
59



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62



63



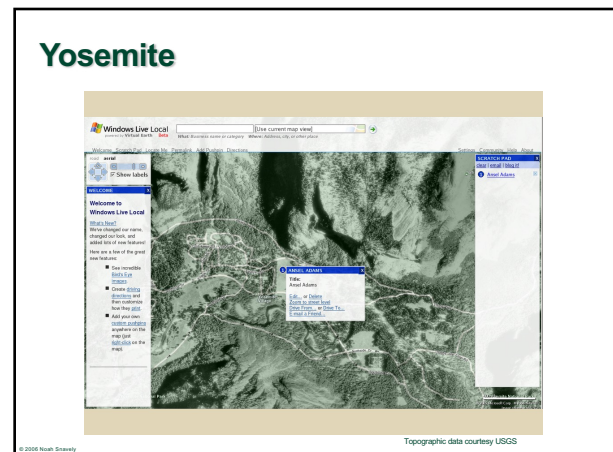
64



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Contributions

- Automated system for registering photo collections in 3D for interactive exploration
- Structure from motion algorithm demonstrated on hundreds of photos from the Internet
- Photo exploration system combining new image-based rendering and photo navigation techniques

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Limitations / Future work

- Not all photos can be reliably matched



- Structure from motion scalability

→ More photos

- Plane-based transitions



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Limitations / Future work



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Limitations / Future work

- Not all photos can be reliably matched
 - Better feature detection / matching
 - Integrating GPS & other localization info.
- Structure from motion scalability
 - More efficient (sparse) algorithms
- Plane-based transitions lack parallax
 - Richer transitions
- Photo explorer scalability...

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Future work

- Photo explorer scalability
 - Design client-server architecture for streaming images and geometry at required resolution
 - Scale to *all* of the world's photos (and videos...)
 - Photosynth project at Microsoft Live Labs (live demo)

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Acknowledgements

- National Science Foundation
- Achievement Rewards for College Scientists (ARCS)
- The many people who allowed use of their photos
- UW GRAIL Lab
- MSR Interactive Visual Media Lab
- Kevin Chiu and Andy Hou for writing the Java applet

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Conclusion

Indexing everyone's photos provides a new way to share and experience our world

To find out more:

- <http://phototour.cs.washington.edu>
- <http://research.microsoft.com/IVM/PhotoTourism>
- <http://labs.live.com/photosynth>
- Exhibition booth #2619



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Today: NeRFs for Landscapes

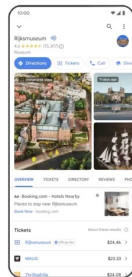


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Instant NeRF (@jonstephens85 on Twitter); slide courtesy Thomas Muller

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NeRFs in StreetView



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