计算摄影学

章国锋、周晓巍

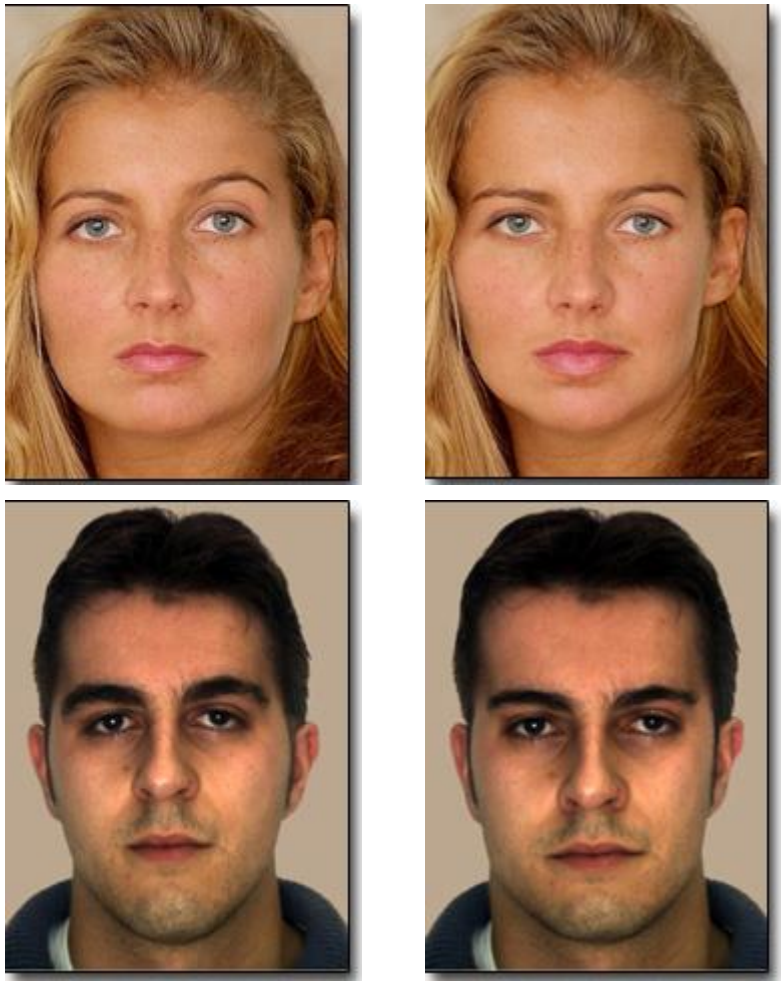
拍摄的苦恼

- 如何拍出完美的照片，俘获心仪女生的欢心？

拍摄的苦恼

- 如何拍出完美的照片，俘获心仪女生的欢心？

美化照片

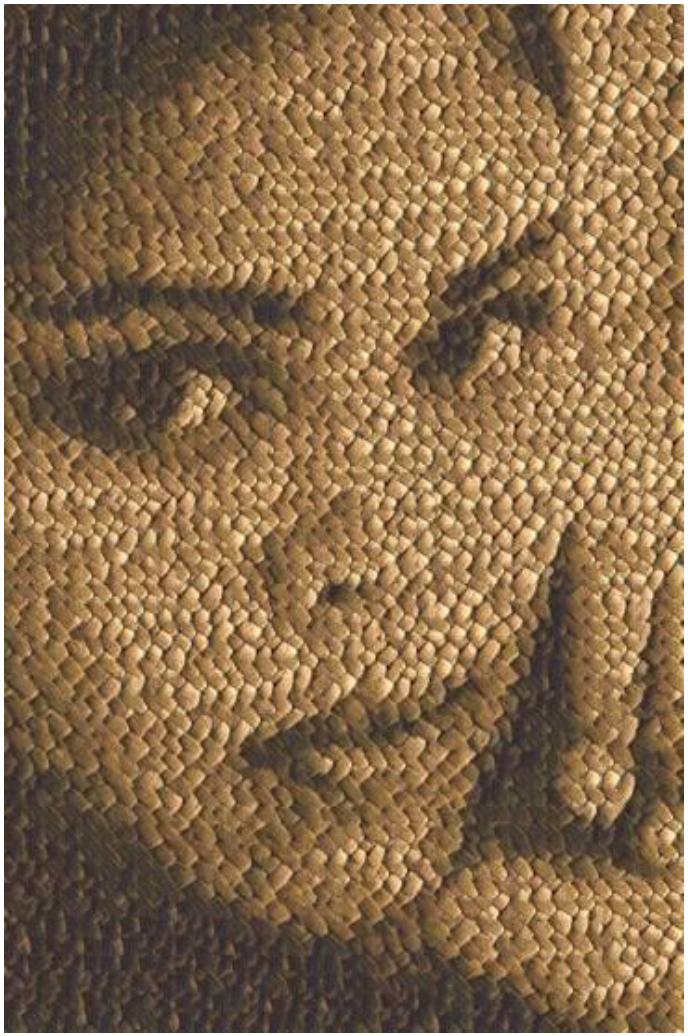


人脸组合

人脸组合

For Fun

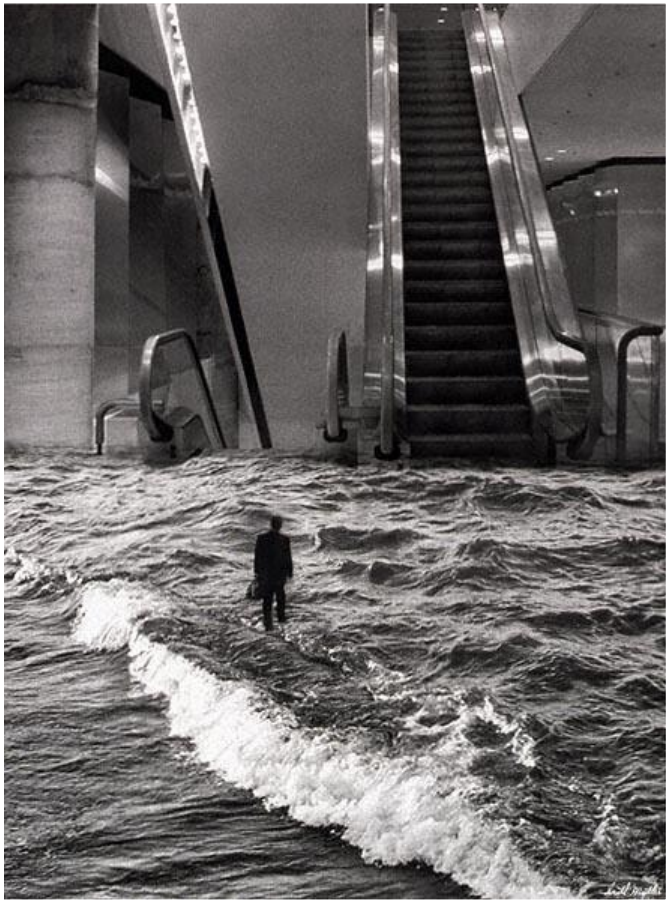
Creating Stylized Images



Creating unlikely juxtapositions

Creating unlikely juxtapositions

Jeff Wall, *Flooded Grave*



Scott Mutter, *Escalator*

Today

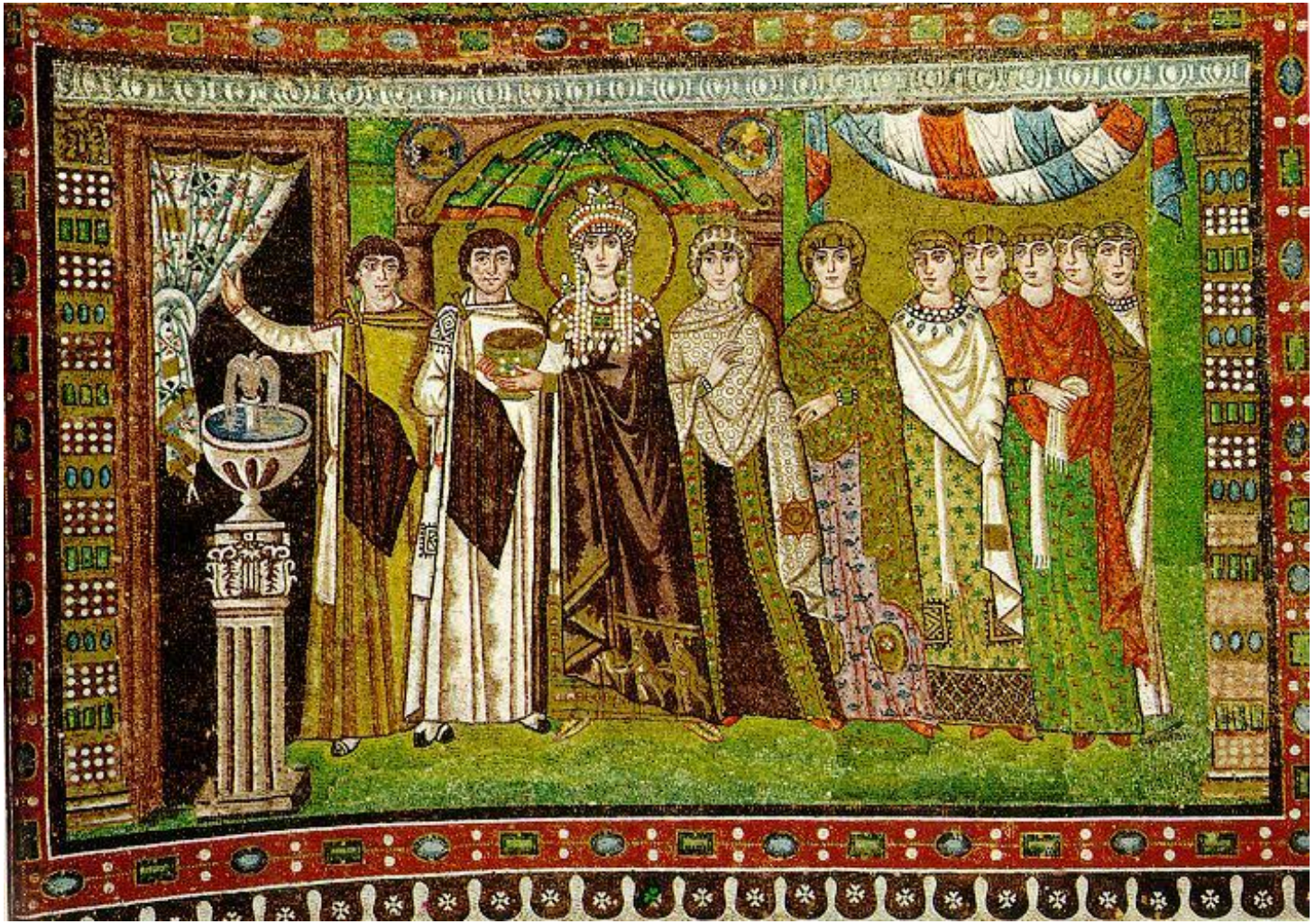
- 1) History of Photography
- 2) What is Computational Photography?
- 3) Course Objectives
- 4) Course Overview
- 5) Projects

A Brief History of Visual Media

Depicting Our World: The Beginning

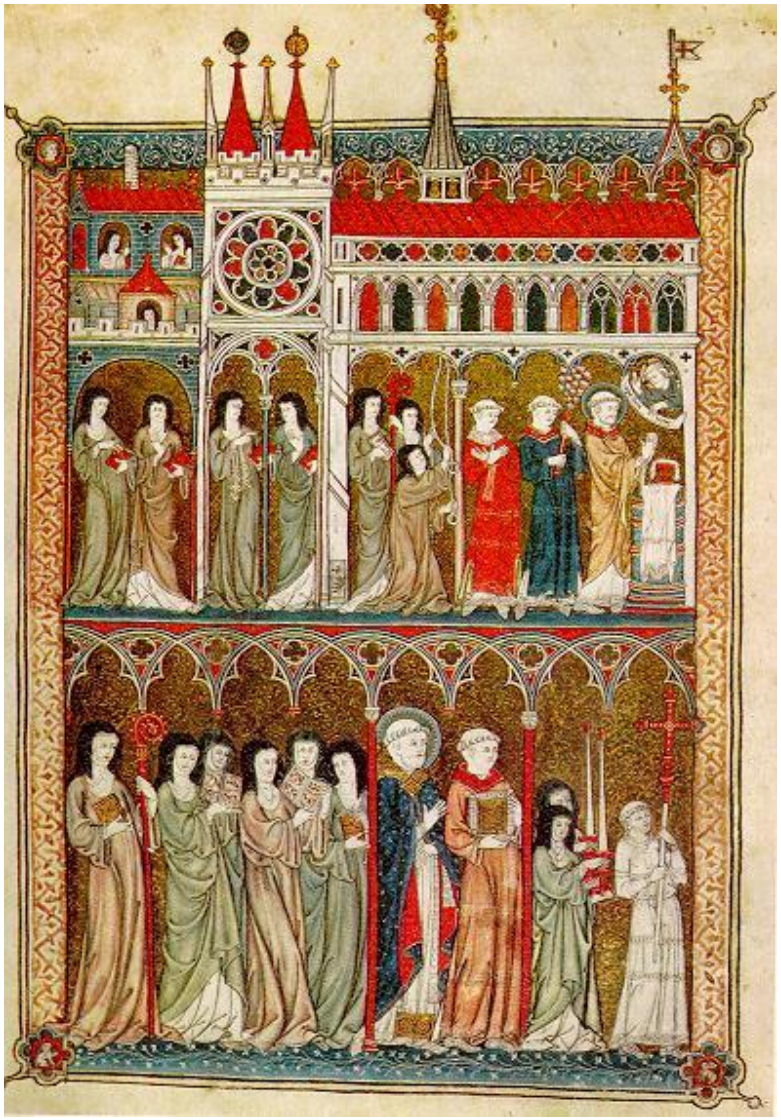
Prehistoric Painting, Lascaux Cave, France
~ 13,000 -- 15,000 B.C.

Depicting Our World: Middle Ages



The Empress Theodora with her court.
Ravenna, St. Vitale 6th c.

Depicting Our World: Middle Ages



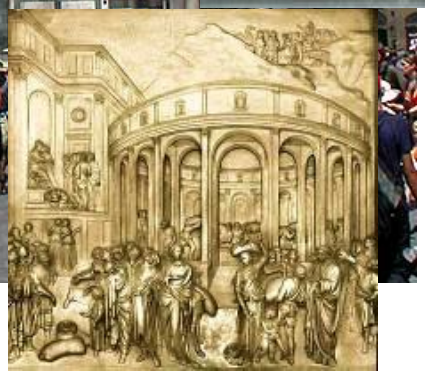
Nuns in Procession. French ms. ca. 1300.

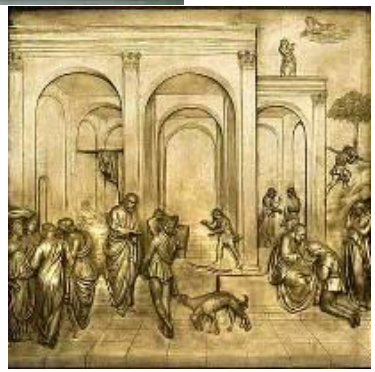
Depicting Our World: Renaissance

North Doors (1424)

Lorenzo Ghiberti (1378-1455)

East Doors (1452)





Depicting Our World: Renaissance

Paolo Uccello,
***Miracle of the Profaned Host* (c.1467-9)**

Depicting Our World: Toward Perfection

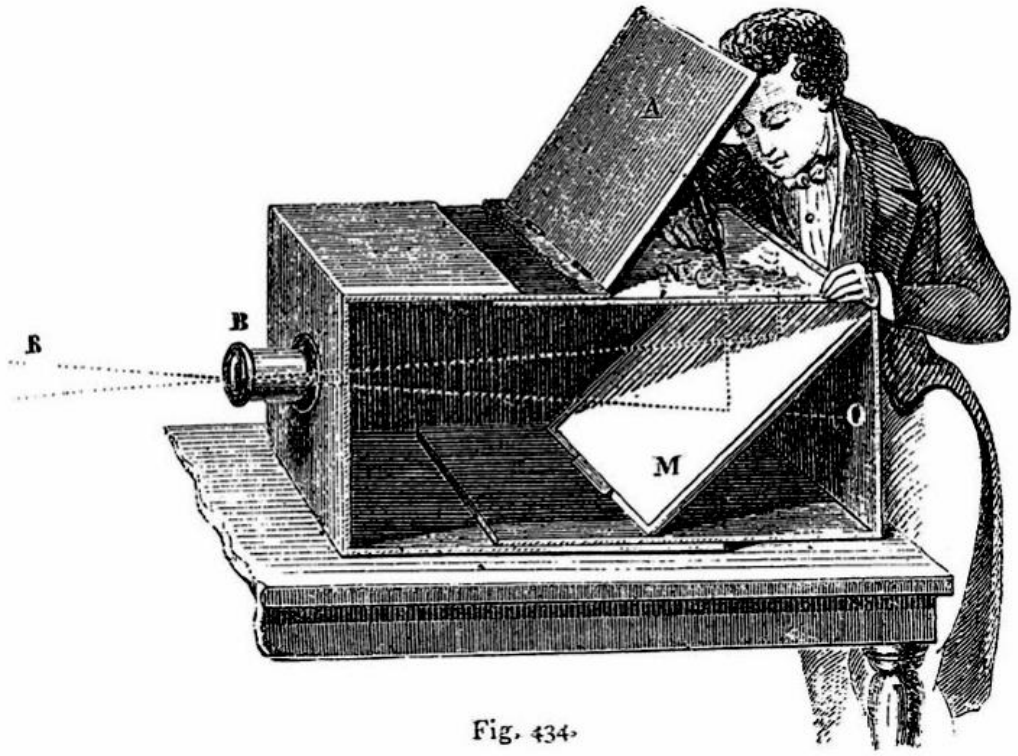


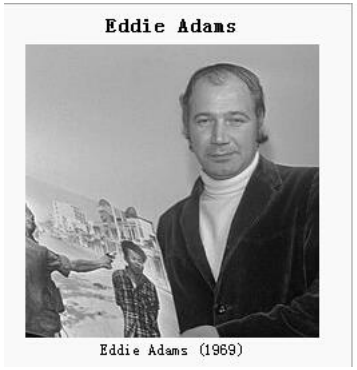
Fig. 434.

Lens Based Camera Obscura, 1568

Depicting Our World: Perfection!

Still Life, Louis Daguerre, 1837

- ‘Still photographs are the most powerful weapon in the world.”
- Eddie Adams, Pulitzer Prize winning photographer.



What is Computational Photography? ---from a hardware's perspective

From a hardware's perspective

- **Digital photography**
  - Simply replaces traditional sensors and recording by digital technology
  - Involves only simple image processing
- **Computational photography**
  - Camera design that takes computation into account
  - More elaborate image manipulation and computation

Examples

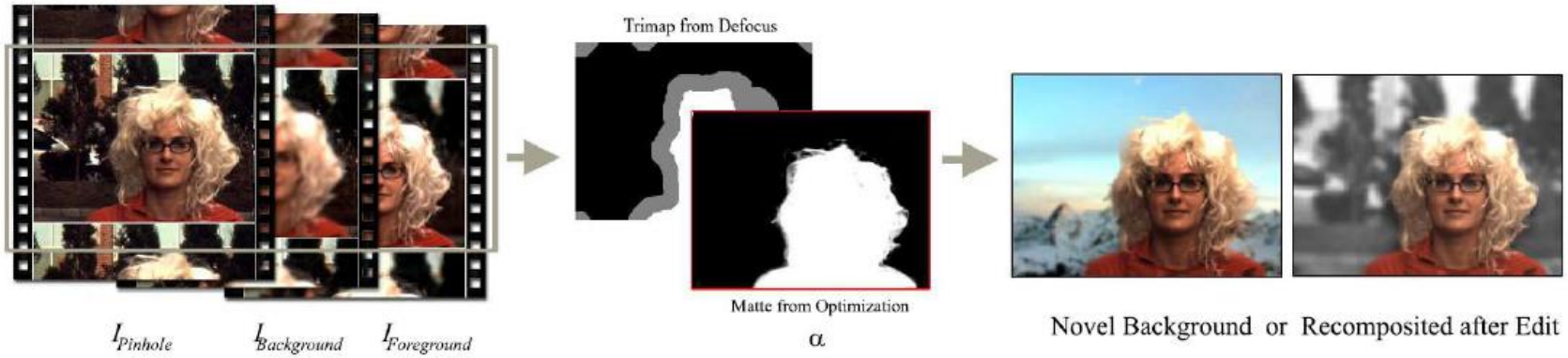
- **Tone mapping**
- **Defocus Matting**
- **Multi-Modal Imaging**

Tone mapping

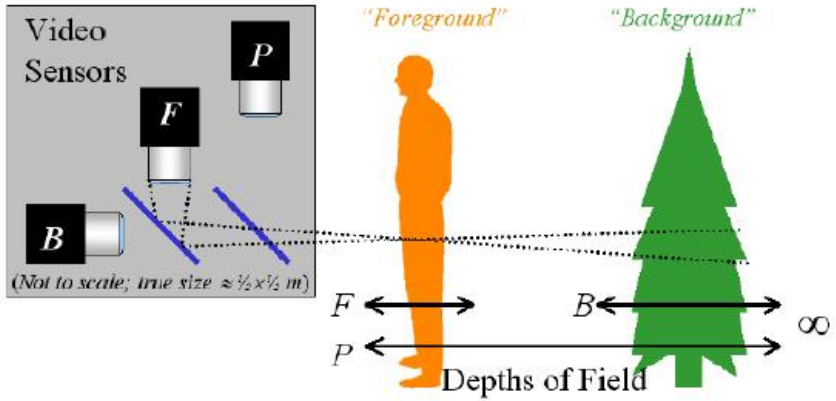
Suitable for HDR images

Defocus Matting

- **What can be achieved**



- **Design: use 3 streams with different focus**

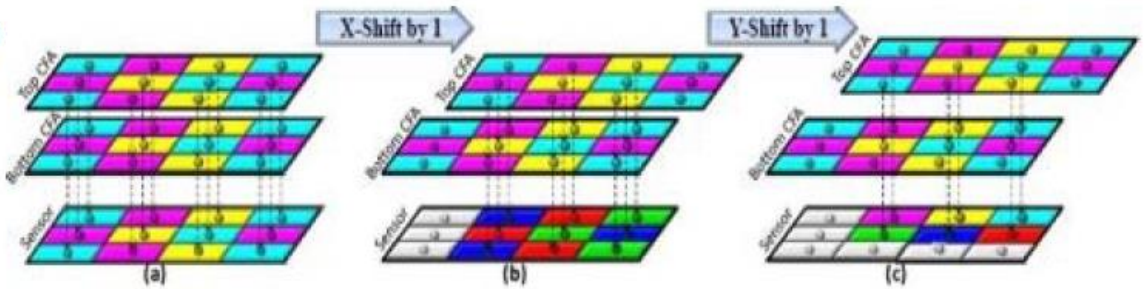


http://people.csail.mit.edu/wojciech/DefocusVideo/index.html

Multi-Modal Cameras

- **What can be achieved**

- **How it works?**



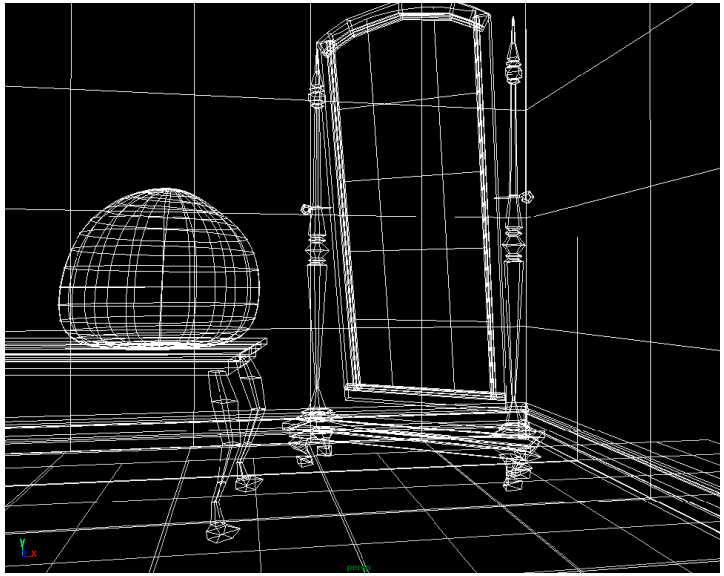
http://www.ics.uci.edu/~bsajadi/SwitchableCam.html

What is Computational Photography? ---from a software's perspective

From a software's perspective

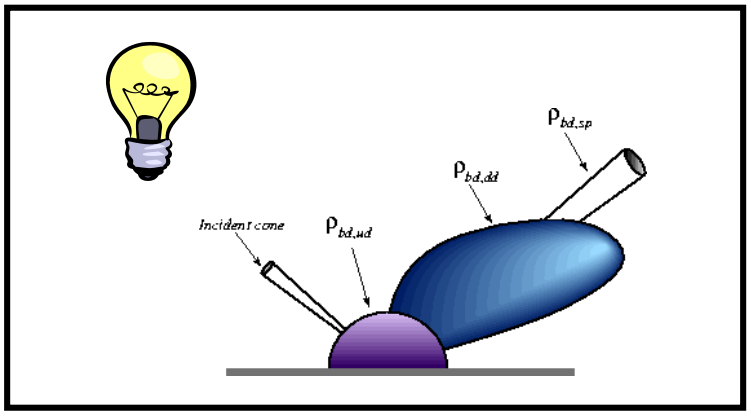
- Definition 1: the use of photographic imagery to create **graphics content**

Traditional Computer Graphics



3D geometry

projection



physics

Simulation

State of the Art (10 years ago)

- Amazingly real
- But so sterile, lifeless, *futuristic (why?)*

The richness of our everyday world

Photo by Svetlana Lazebnik

What are hard to model in Computer Graphics?

1. People

From “Final Fantasy”

On the Tube, London

2. Faces / Hair

From “Final Fantasy”

Photo by Joaquin Rosales Gomez

3. Urban Scenes

Virtual LA (SGI)

Photo of l LA

Slide credit: A. Efros

4. Nature

River Cherwell, Oxford

Slide credit: A. Efros

Creating Realistic Imagery

Computer Graphics

- + great creative possibilities
- + easy to manipulate objects/viewpoint
- -Tremendous expertise and work for realism

Computational Photography

Realism
Manipulation
Ease of capture

Photography

- + instantly realistic
- + easy to aquire
- - very hard to manipulate objects/viewpoint

From a software's perspective

- Definition 1: the use of photographic imagery to create **graphics content**

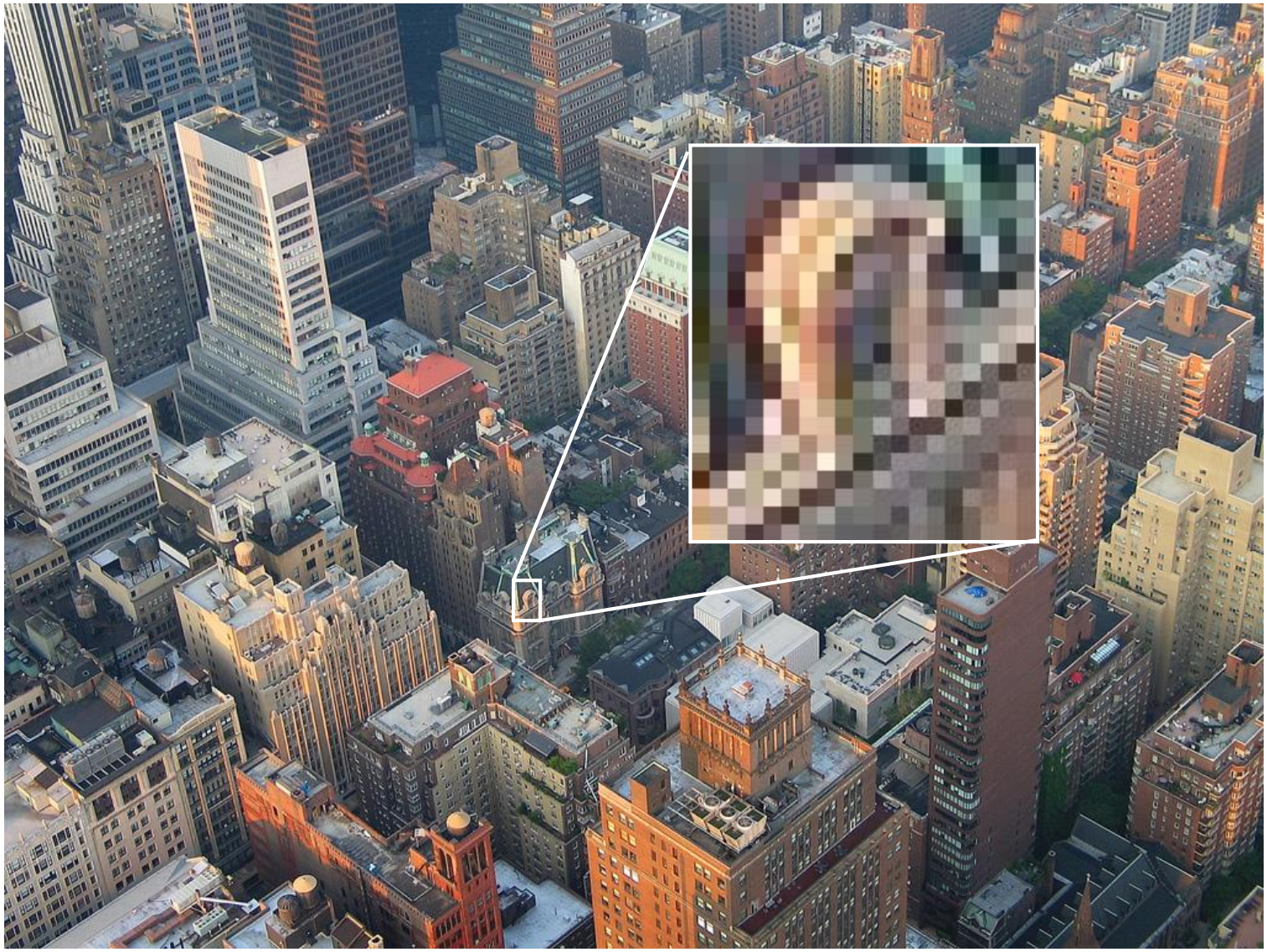
- Definition 2: The use of computational techniques to **overcome limitations of conventional photography**

Limitations of traditional photography

- Blur, camera shake, noise, damage

Limitations of traditional photography

- Limited resolution

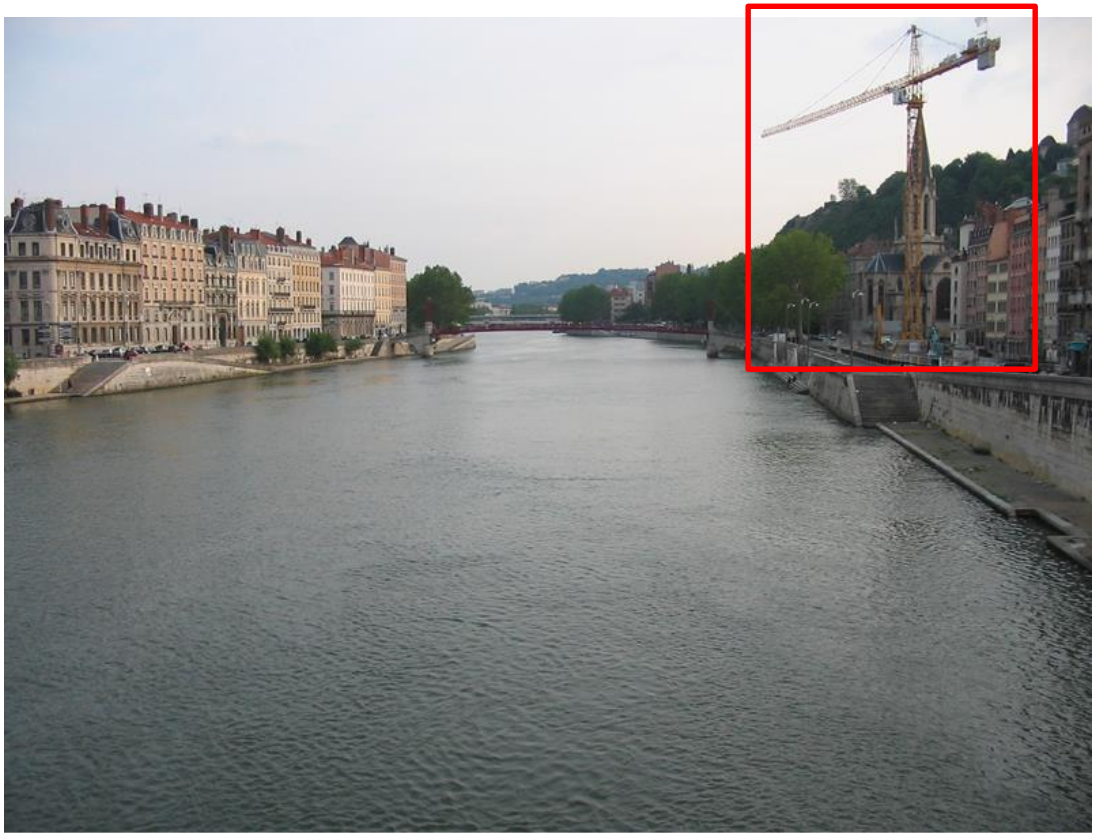


Limitations of traditional photography

- Bad color / no color

Limitations of traditional photography

- Unwanted objects



Limitations of traditional photography

- Unfortunate expressions

Limitations of traditional photography

- Limited dynamic range

Limitations of traditional photography

- Single viewpoint, static 2D picture

Limitations of traditional photography

- Single depth of focus

Comp Photo and Related Fields

- Computer Graphics: Models to Images
- Comp. Photography: Images to Images
- Computer Vision: Images to Models

Course objectives

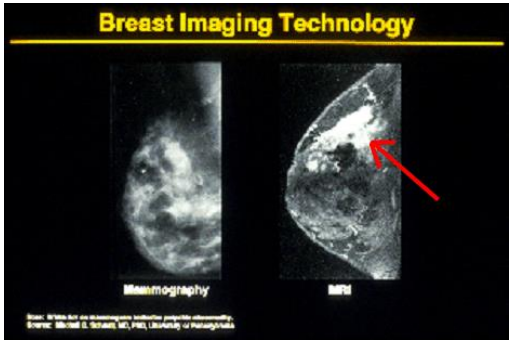
1. You will have new abilities for visual creation.

Graphic by James Hays

Course objectives

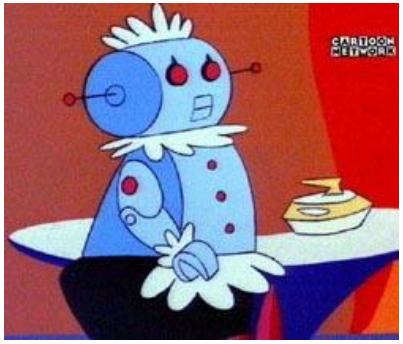
2. You will get a foundation in computer vision.

Safety



Health

Security



Comfort

Fun

Access

Course objectives

3. You'll better appreciate your own visual ability.

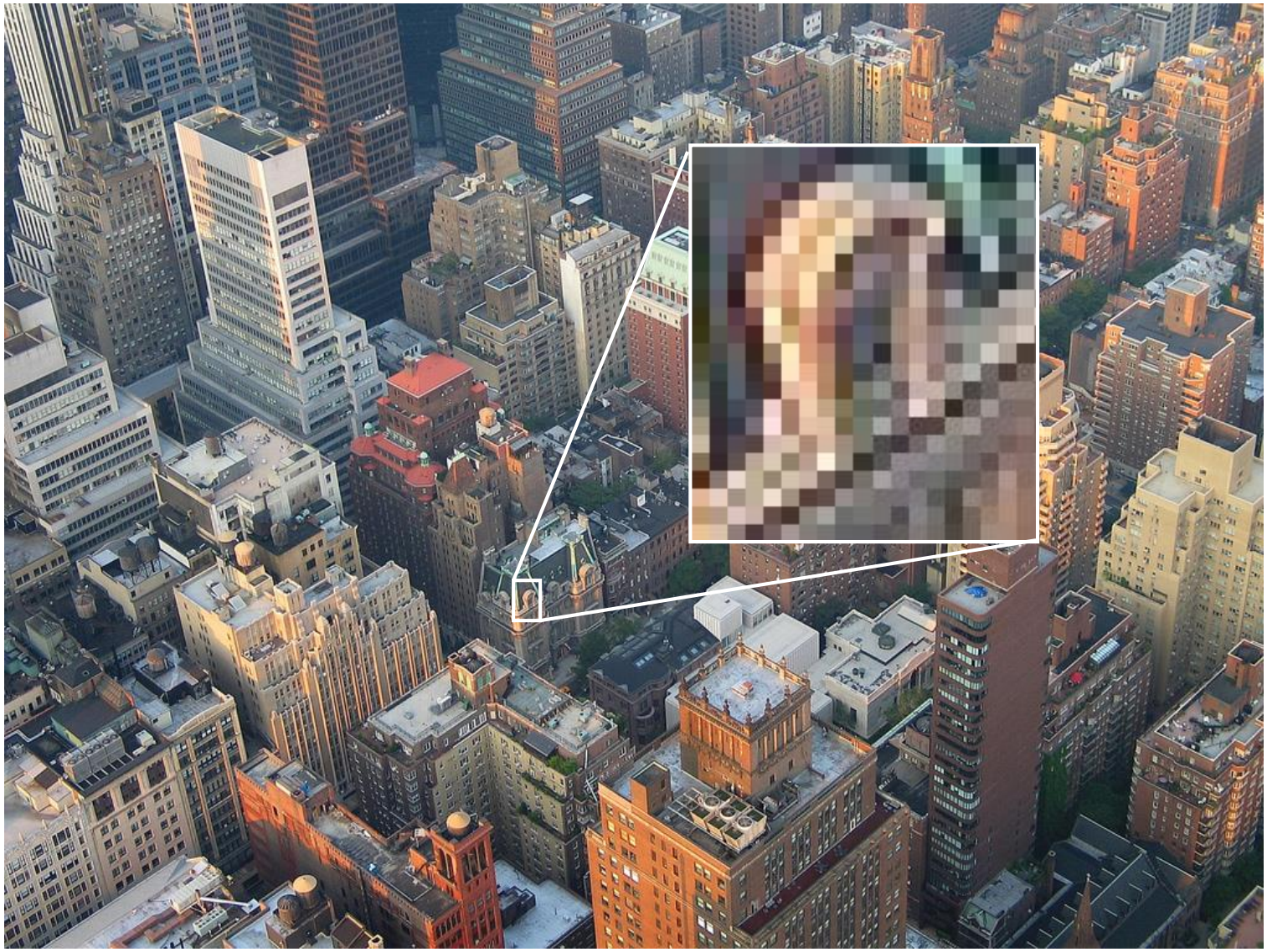
Course objectives

4. You'll have fun doing cool stuff!

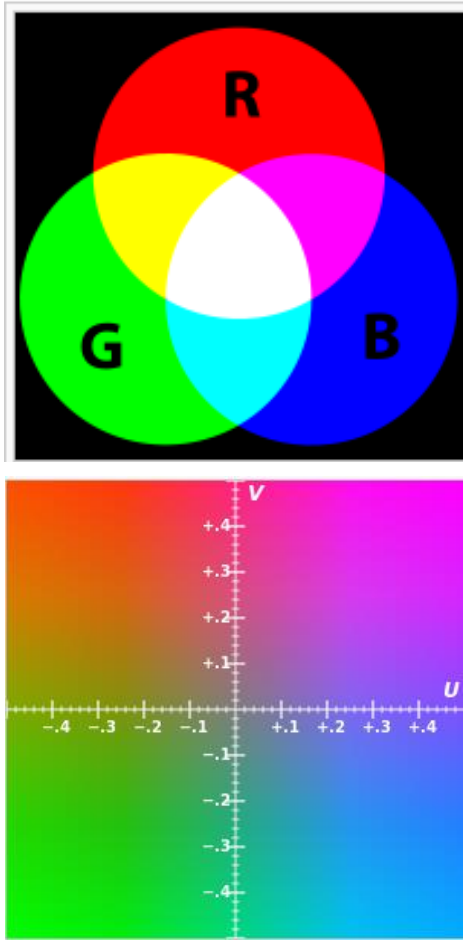
Courses Overview

1. 计算摄影学概览
2. 图像的数字化、颜色空间、滤波与频域变换
3. 泊松图像编辑与交互式数字蒙太奇
4. 深度学习
5. 上色与重上色
6. 图像去模糊与非线性数值优化方法
7. 图像补全
8. 纹理合成与图像缩放
9. 交互式图像分割与抠像
10. 特征匹配与光流
11. 全景图拼接
12. 相机模型与运动推断结构
13. 实时摄像机跟踪
14. 单视图与多视图三维重建
15. 课程讨论与项目答辩

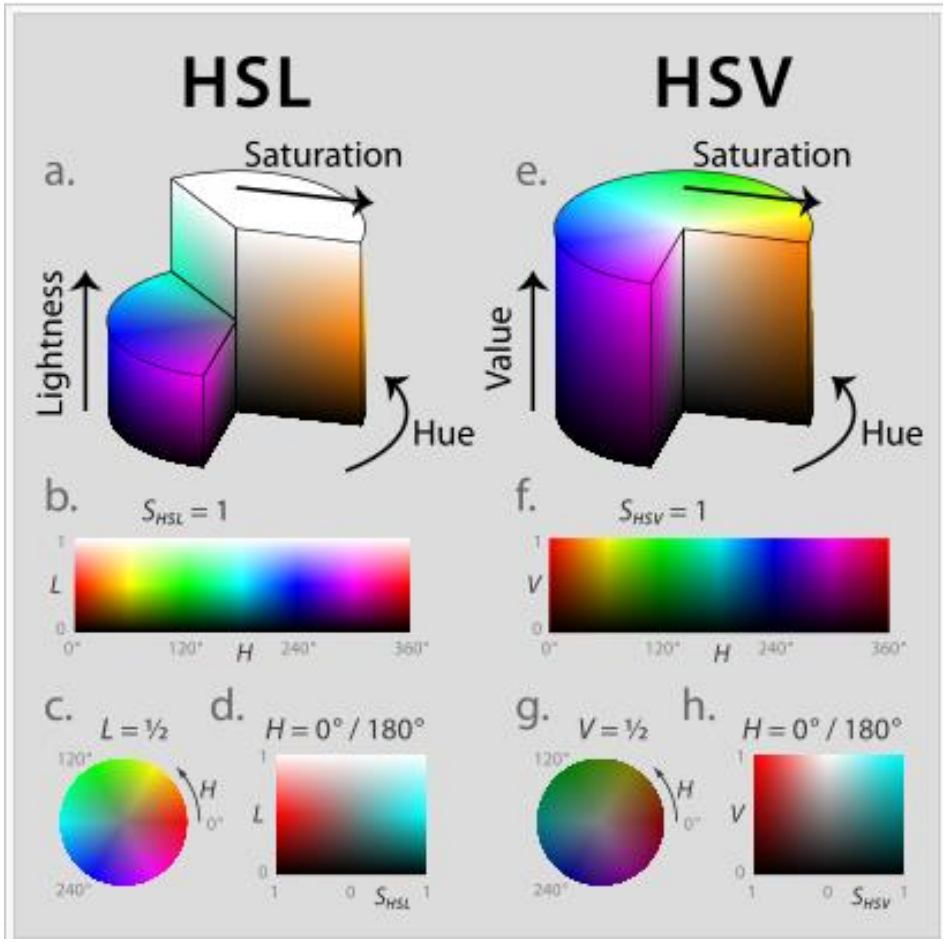
2. Digital Image



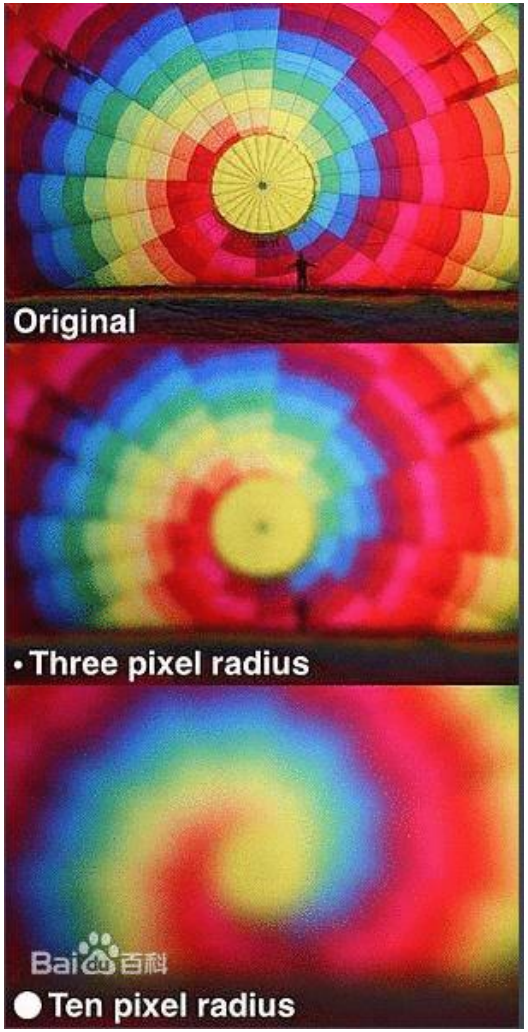
2. Color Space



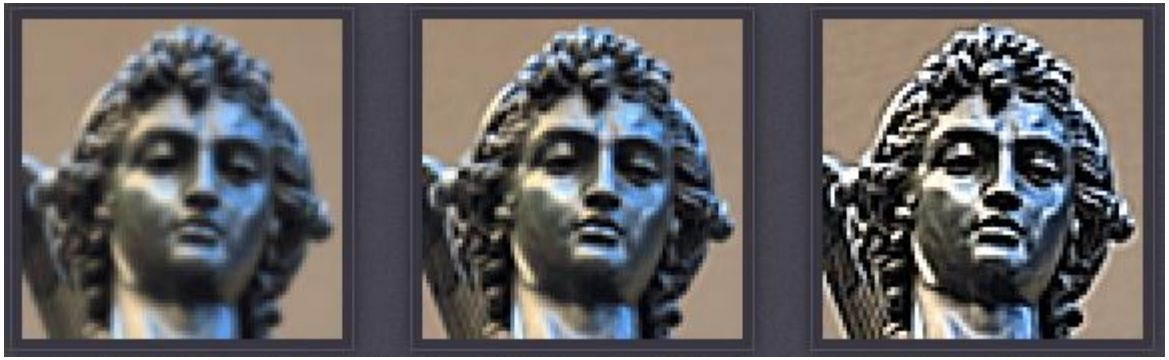
YUV



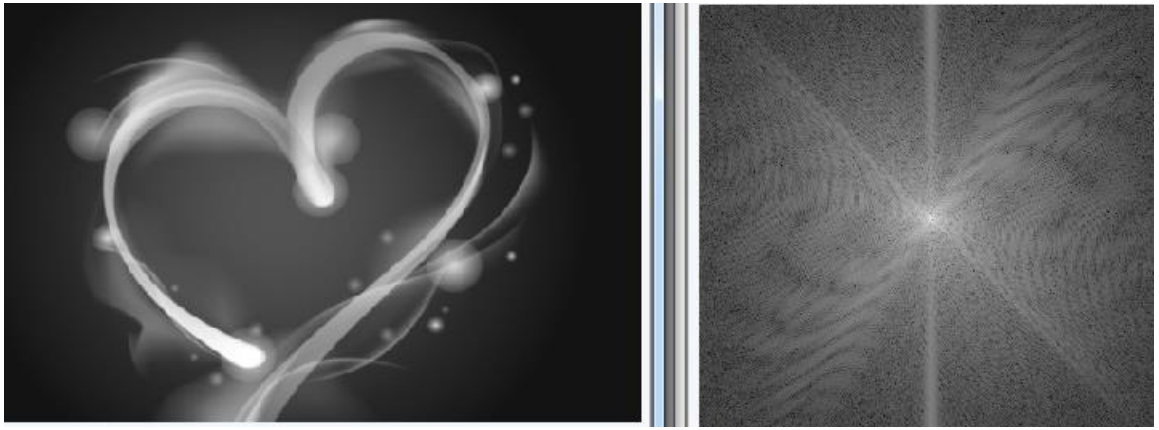
2. Filtering and Fourier Transform



Blur

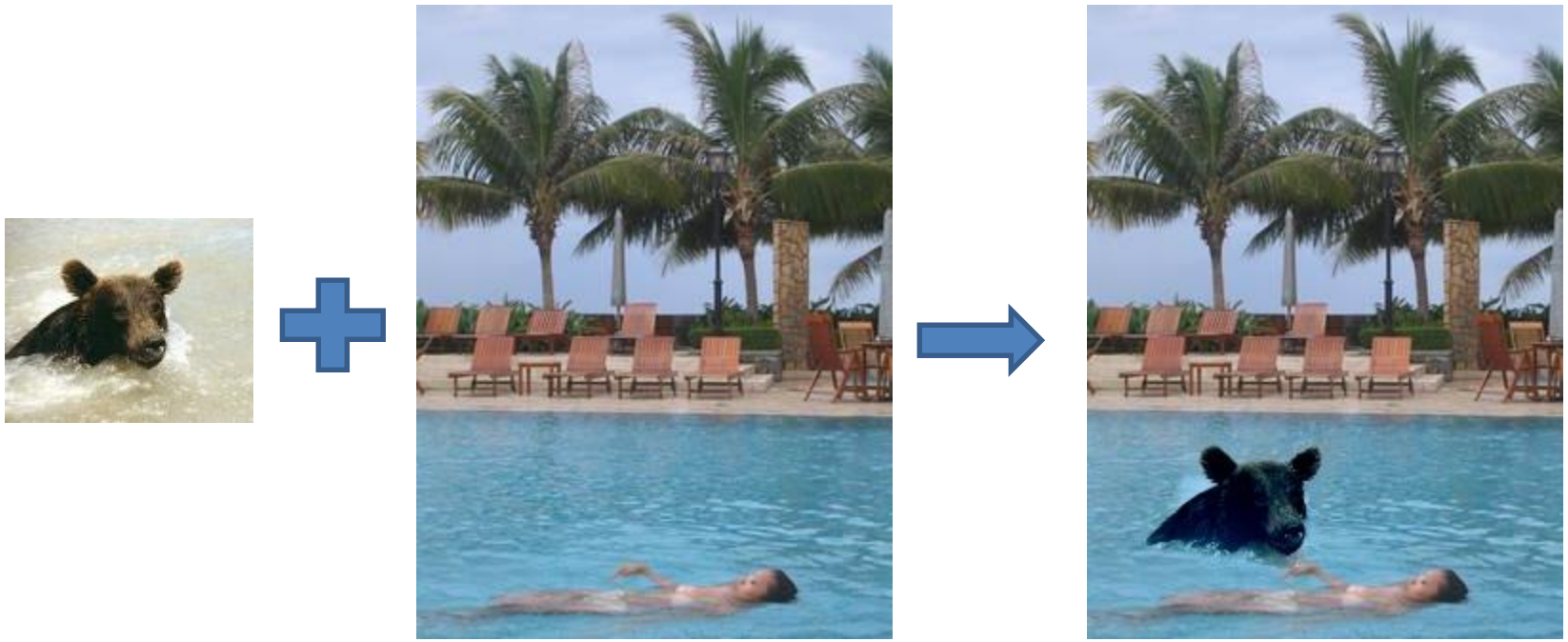


Sharpening



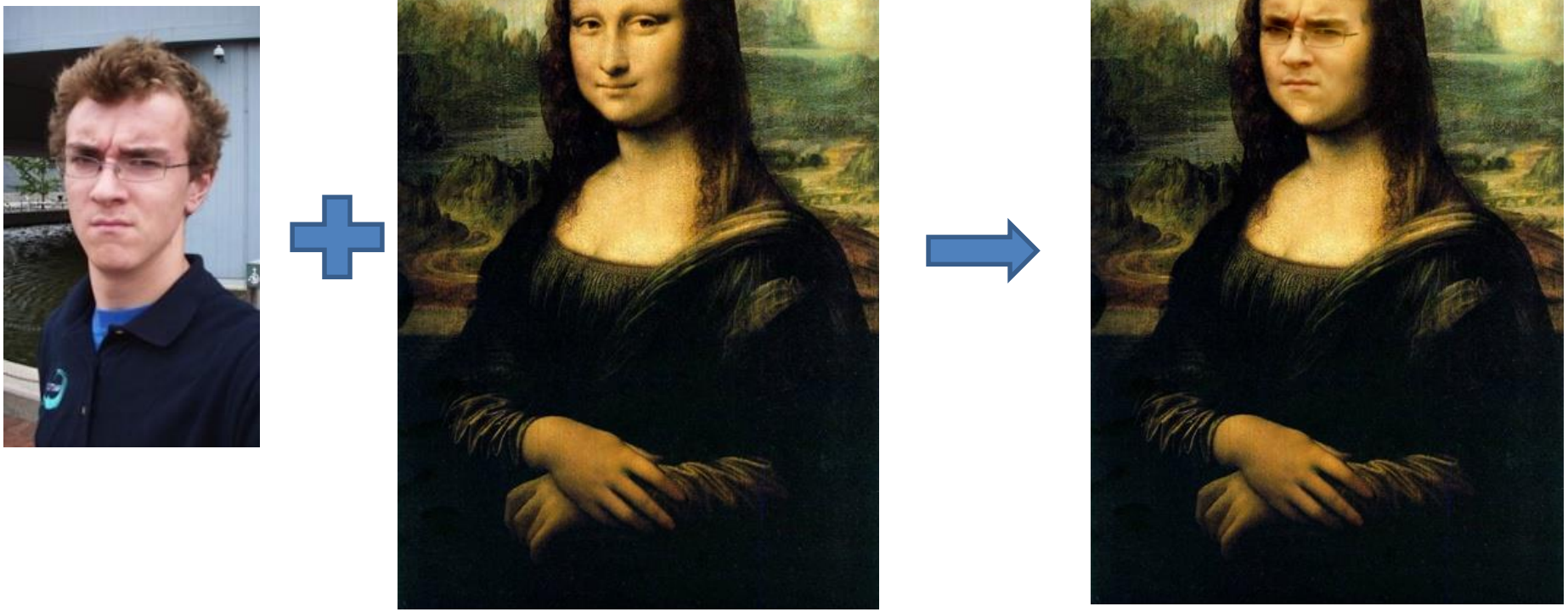
Fourier Transformation

3. Poisson Image Editing



Photos from James Hays

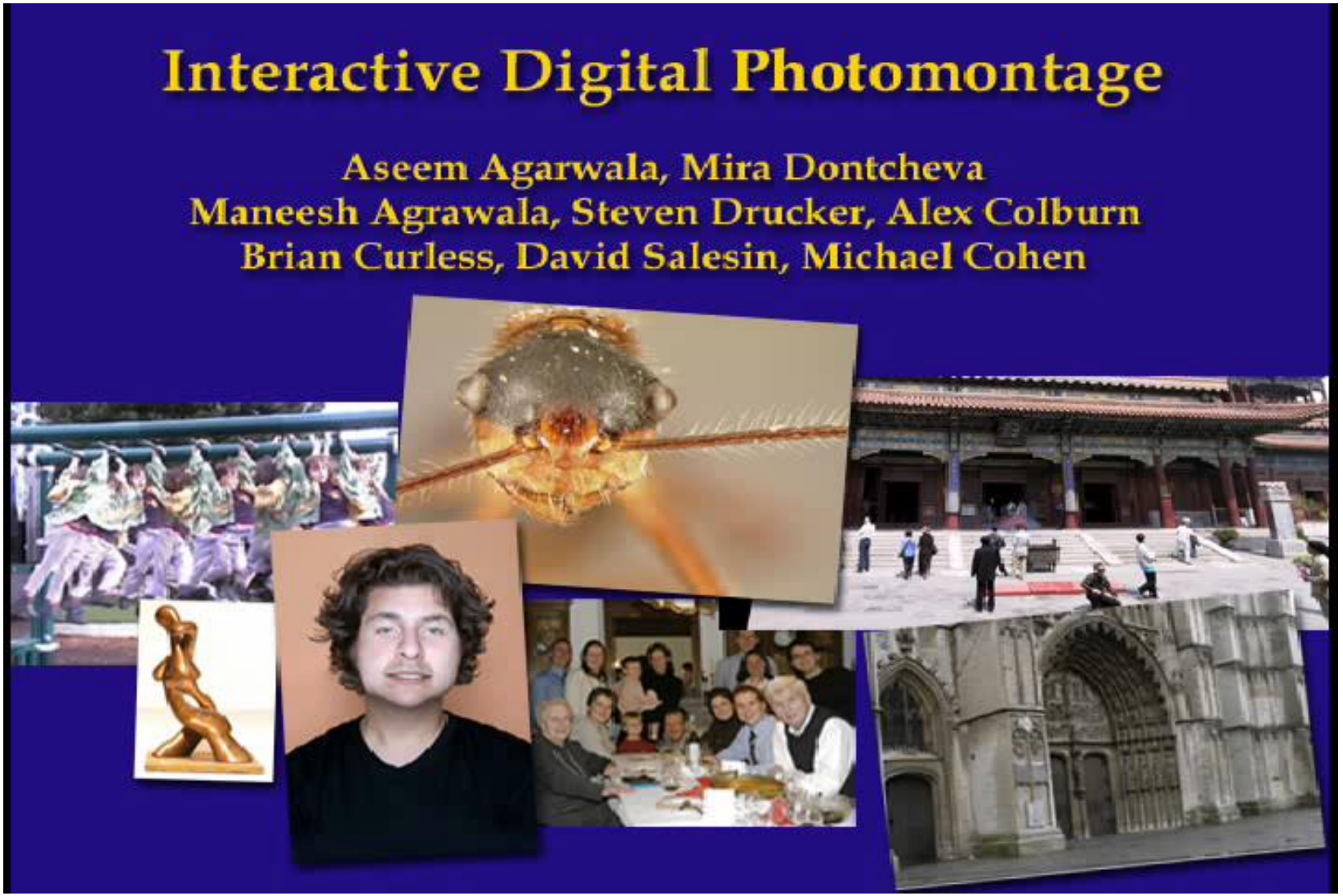
3. Poisson Image Editing



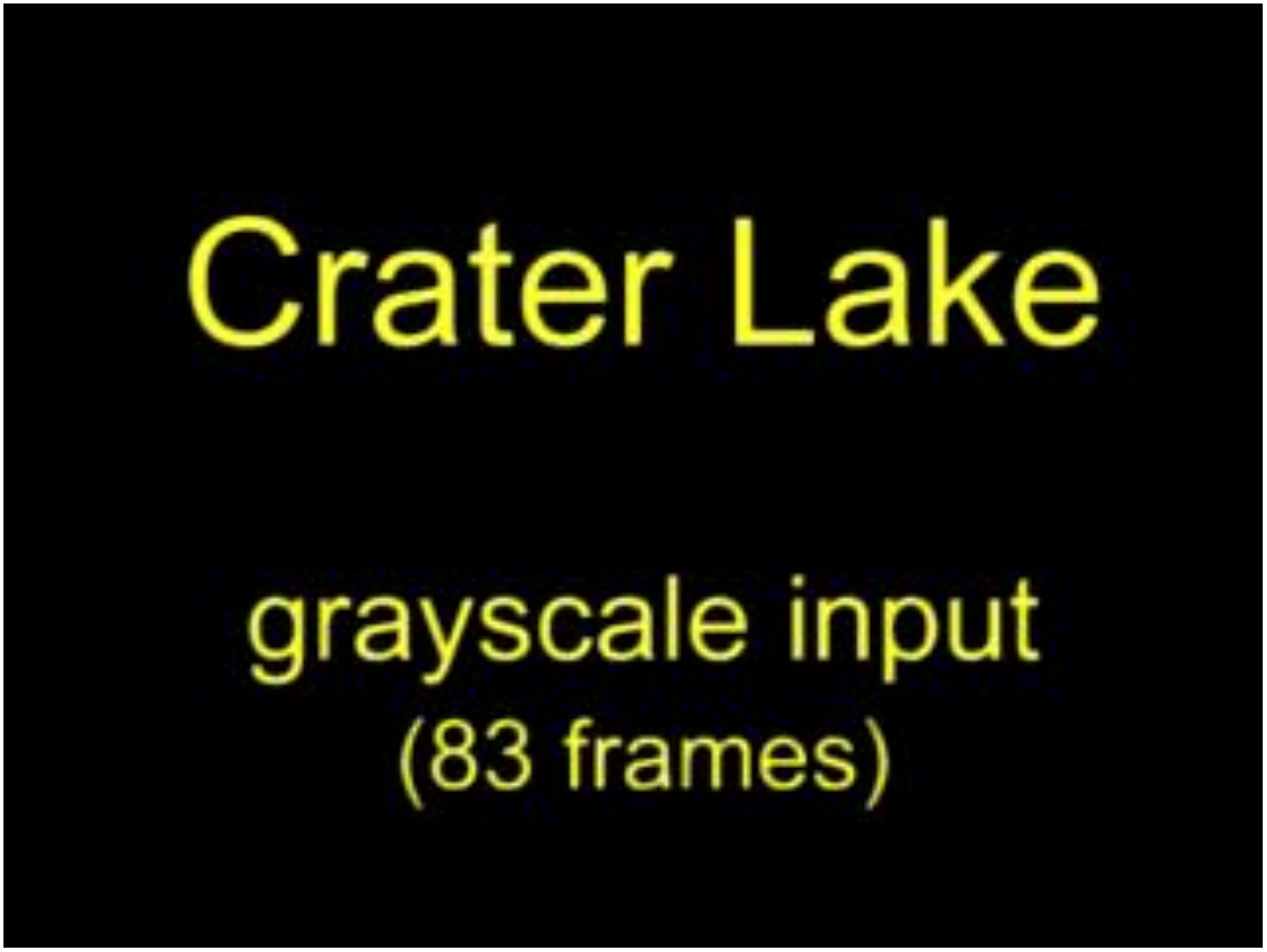
Photos from Evan Wallace

3. Interactive Photomontage

3. Interactive Photomontage



4. Image Colorization & Recolorization


Crater Lake
grayscale input
(83 frames)

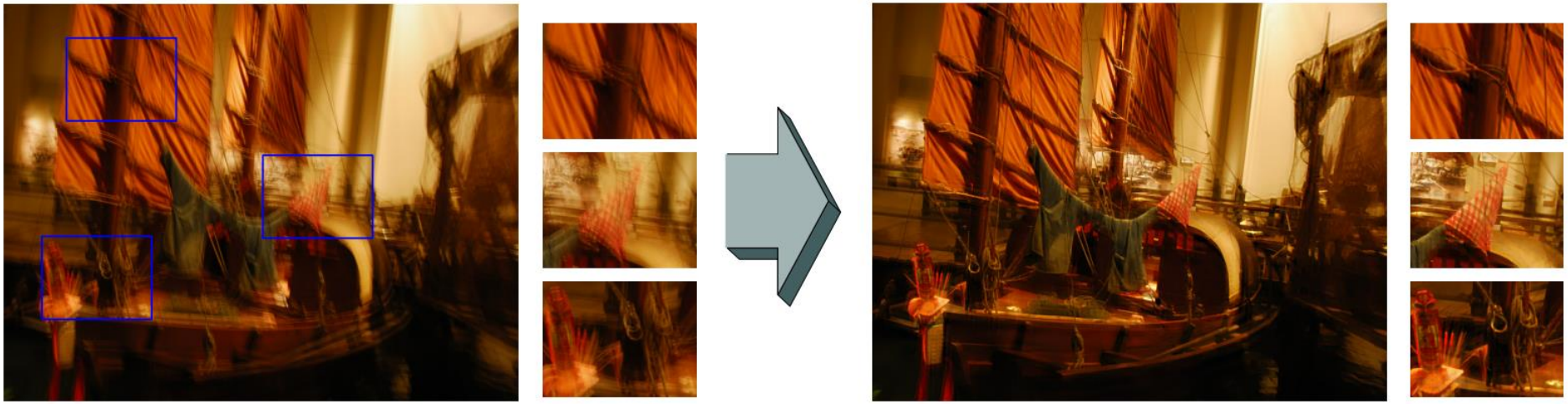
4. Image Colorization & Recolorization

5. Image Deblurring

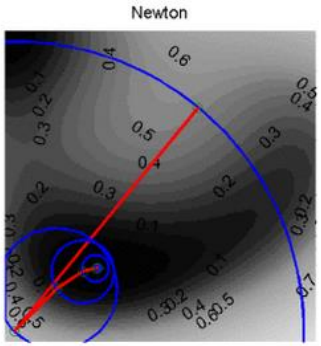
Real Image Input

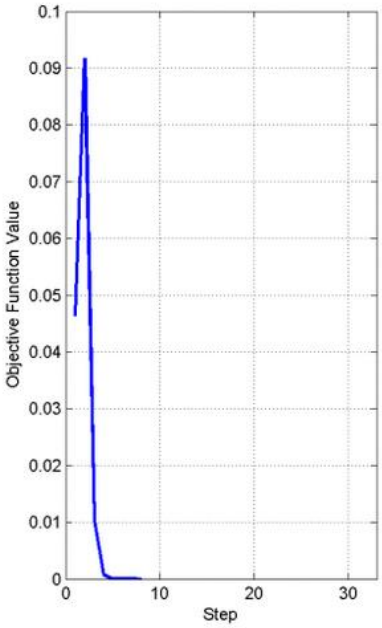
Deblurring Result

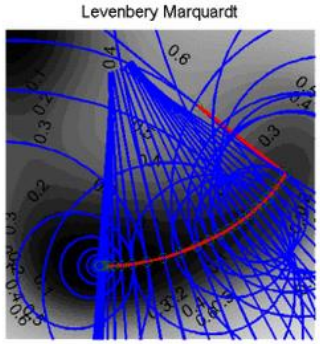
5. Image Deblurring

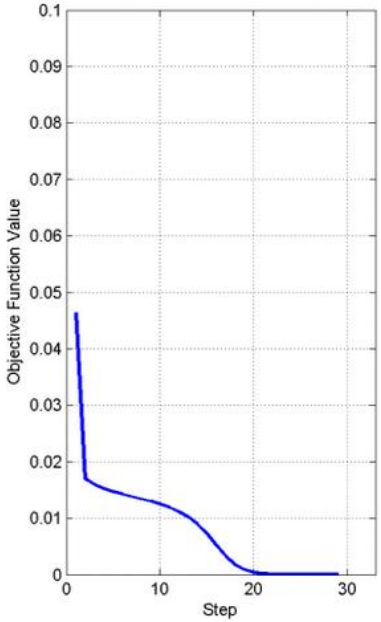


5. Non-Linear Optimization









6. Image Completion

Original Image | Input | Scene Matches | Output

6. Image Completion

a

b

Statistics of Patch Offsets for Image Completion

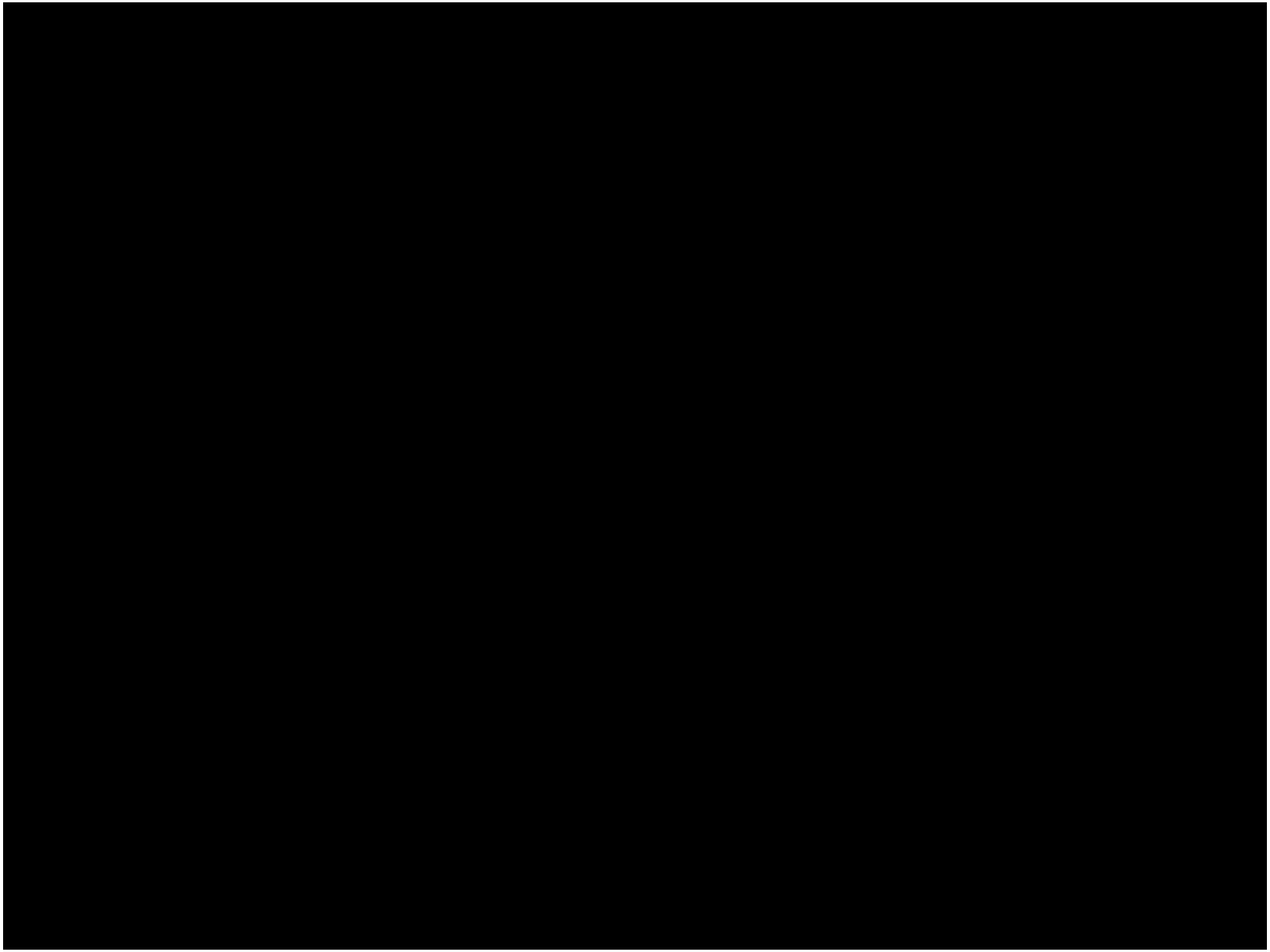
Demo

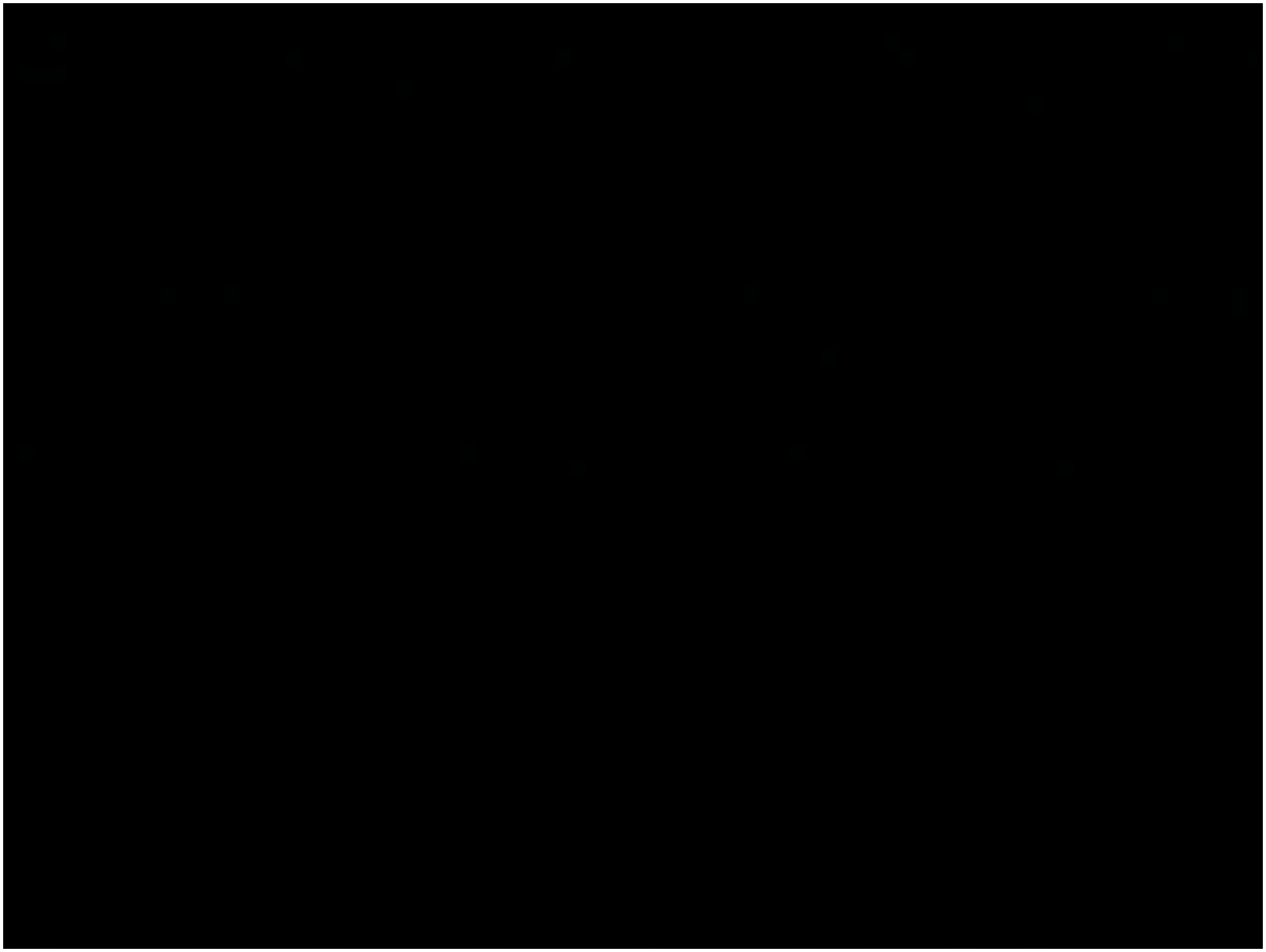
Kaiming He and Jian Sun
Microsoft Research Asia

7. Texture Synthesis

input images

quilting results



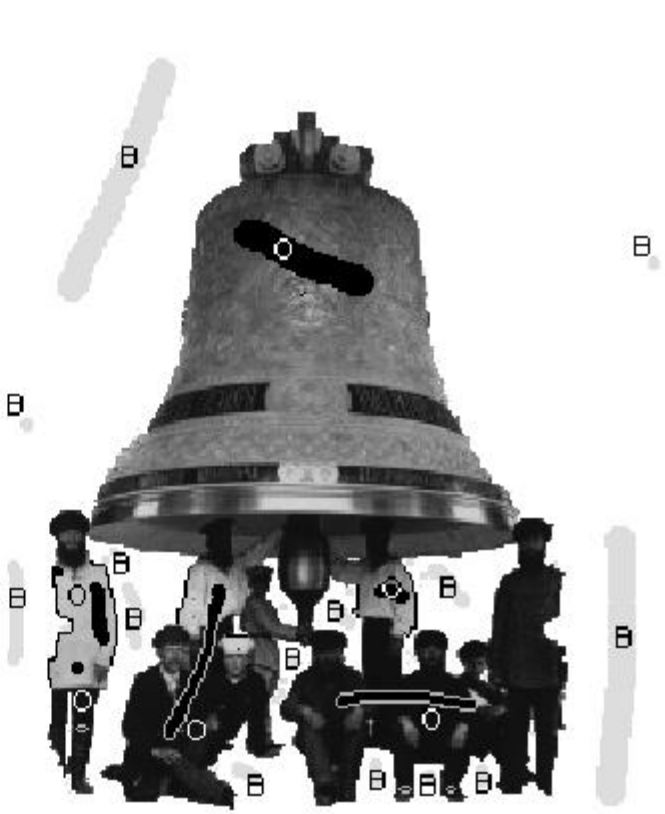


7. Image Resizing

8. Interactive Image Segmentation

- Graph Cut

(a) Original B&W photo



(b) Segmentation results

8. Interactive Image Segmentation

- Grab Cut

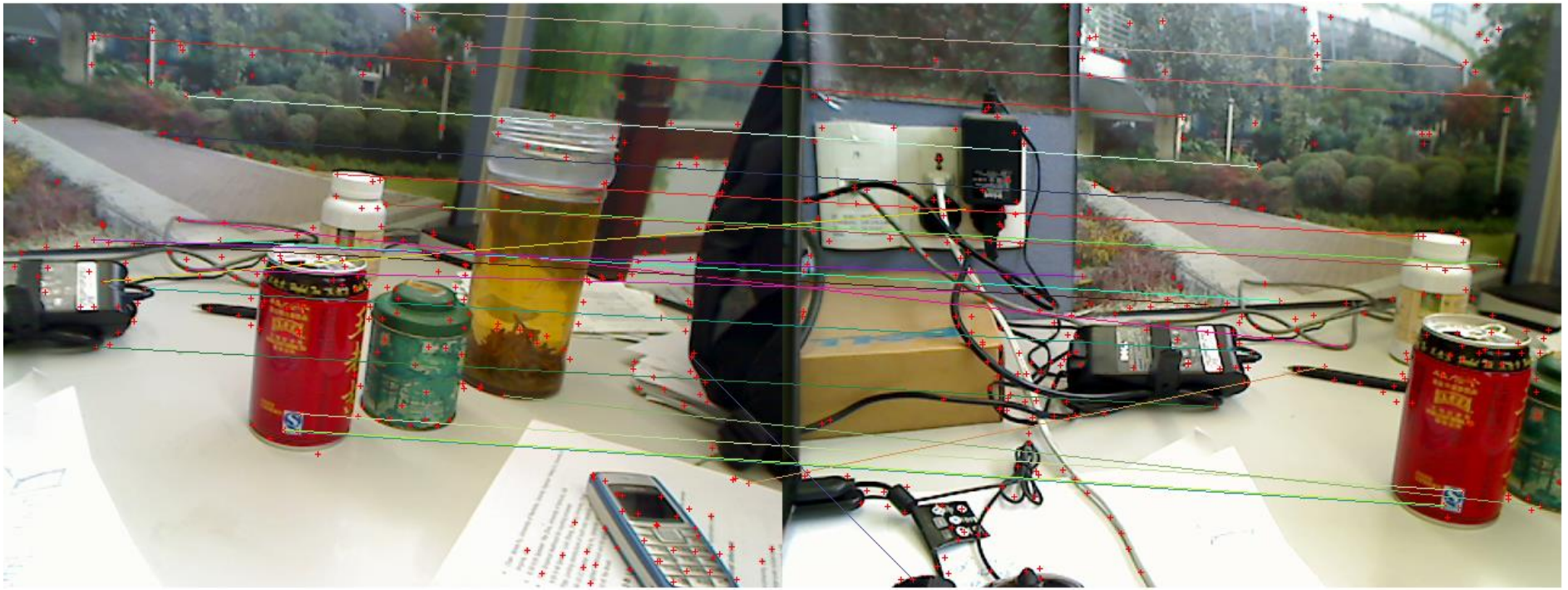
GrabCut

Interactive Foreground Extraction using Iterated Graph Cuts

Carsten Rother
Vladimir Kolmogorov
Andrew Blake

Microsoft Research Cambridge

9 . Feature Matching

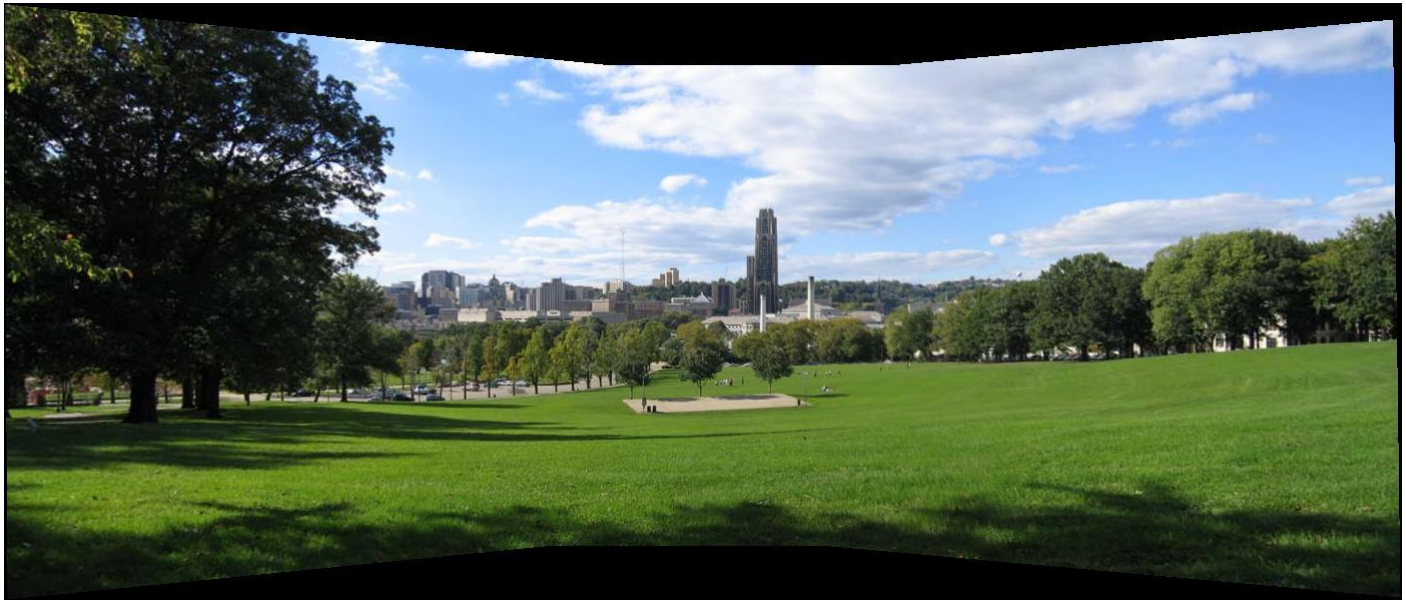


9. Optical Flow

Photos from Ce Liu

10. Recognising Panoramas



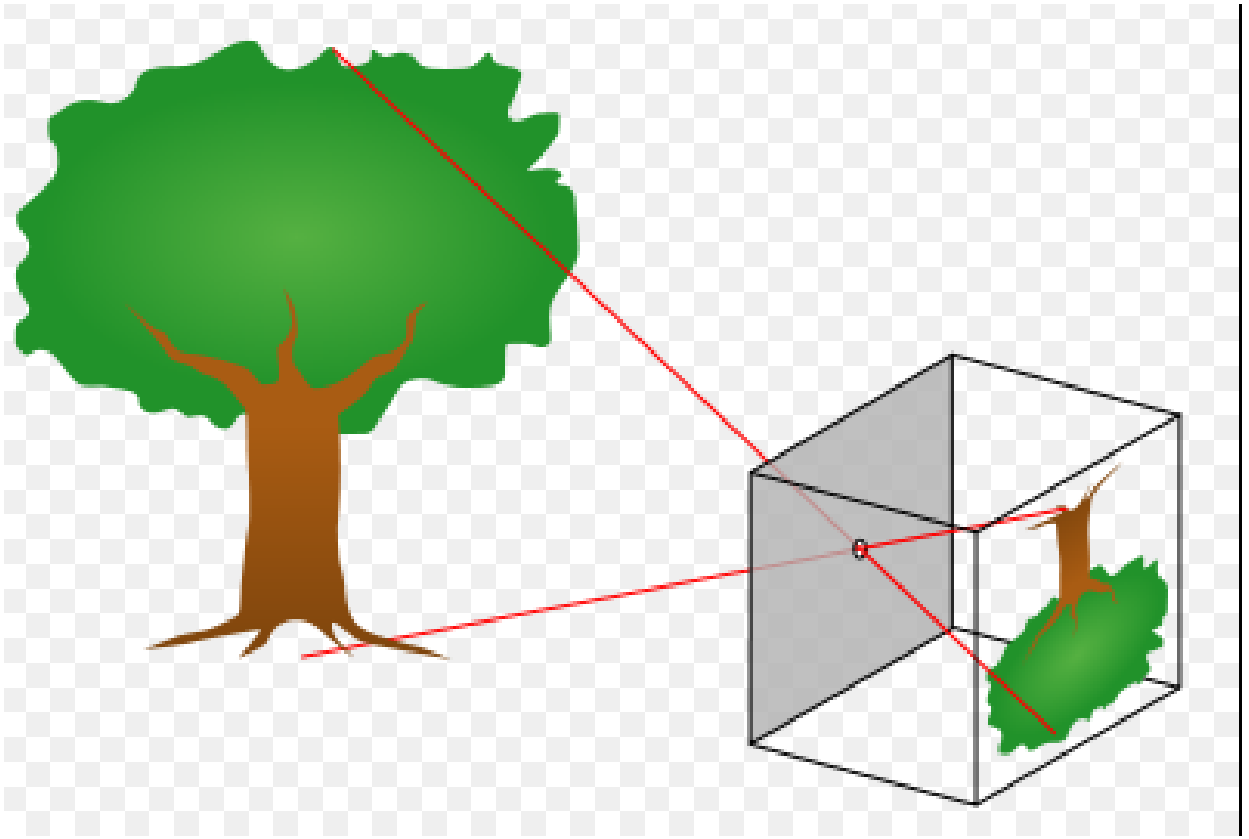
Photos from Derek Hoiem

10. Multiview Panorama Stitching


优酷
Street Slide
Browsing Street Level Imagery

11. Camera Model

- Pinhole Camera



11. Structure From Motion

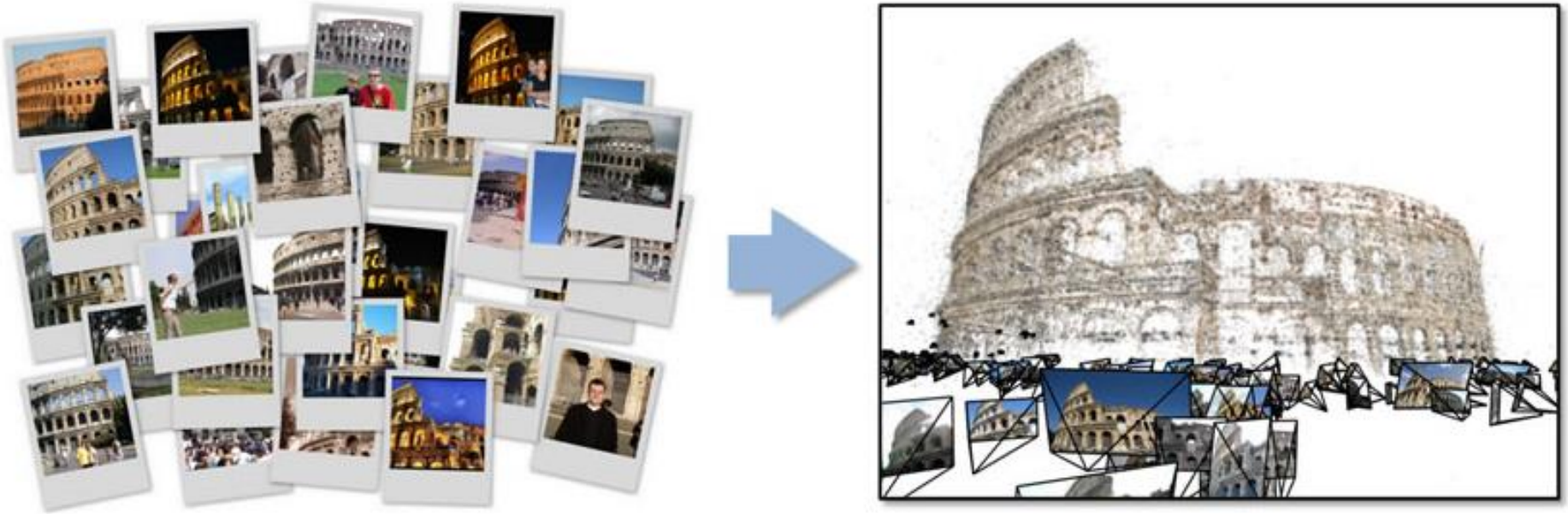


Photo Tourism

Exploring photo collections in 3D

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

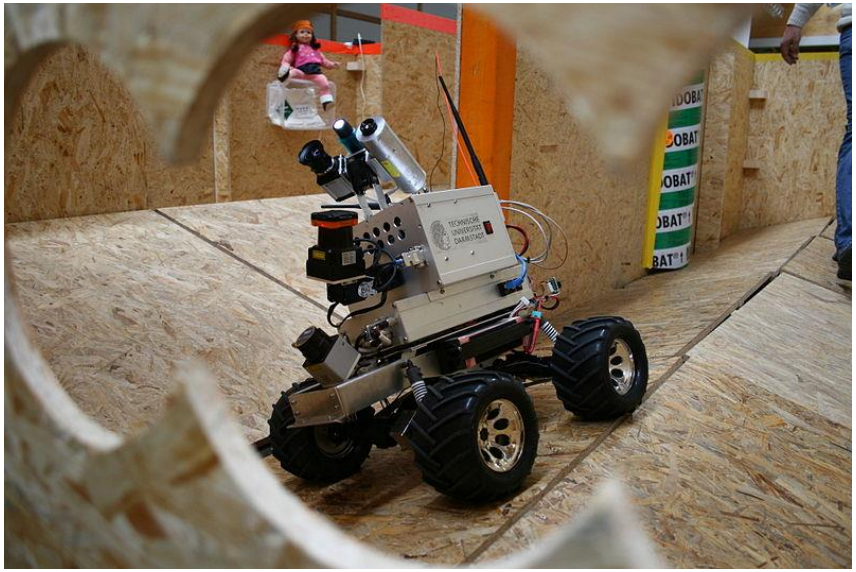
SIGGRAPH 2006

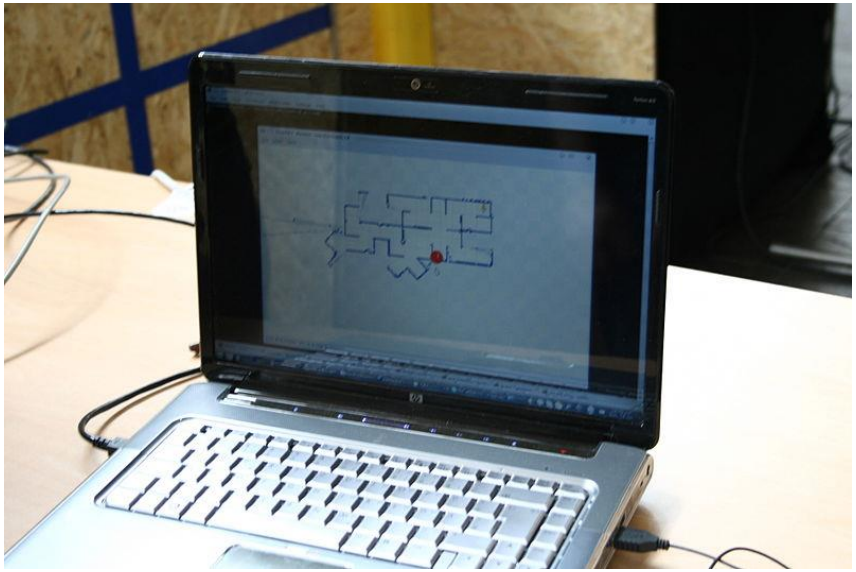
Input Sequences

Speed: ×2

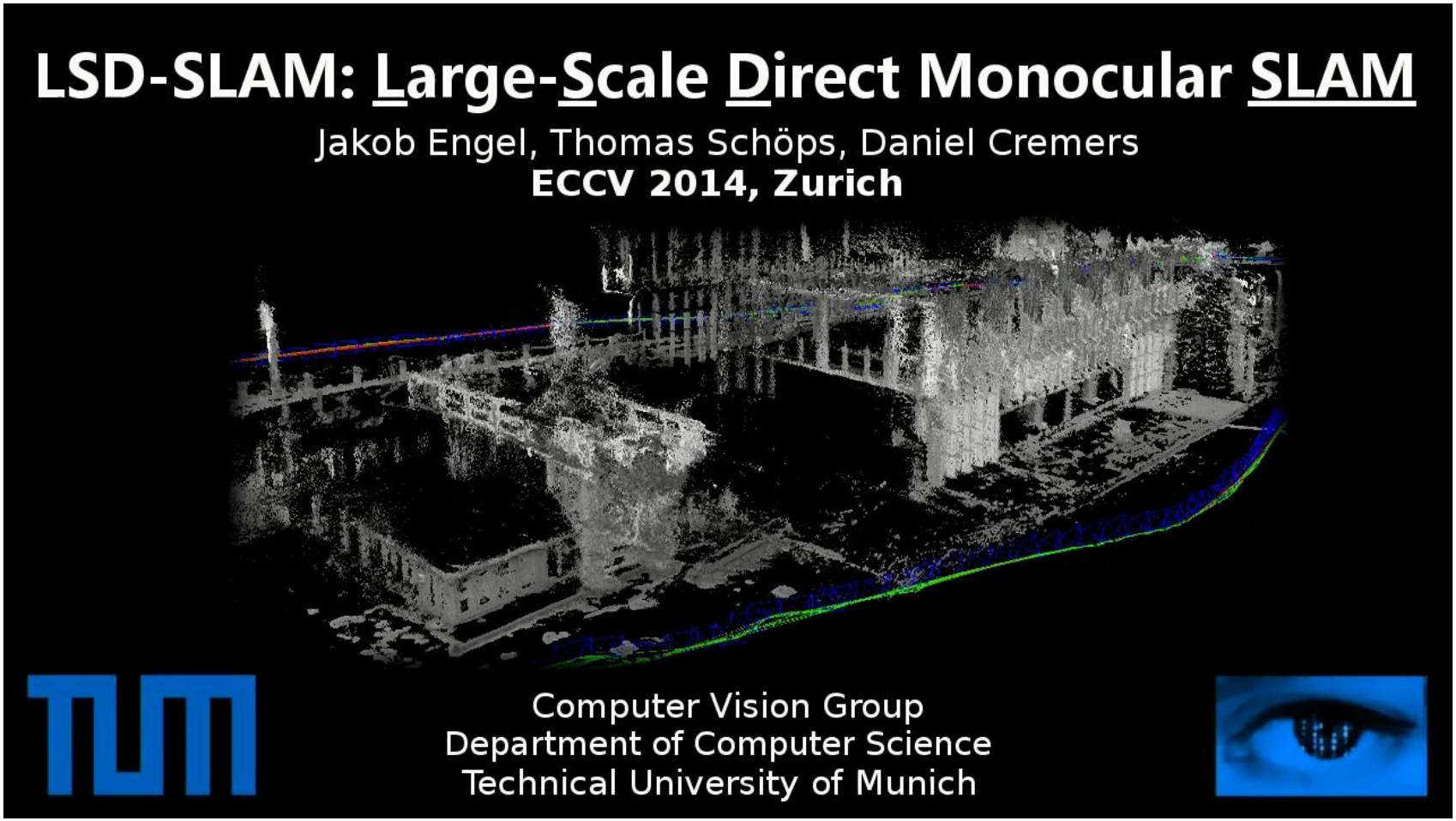
...

12. SLAM & AR



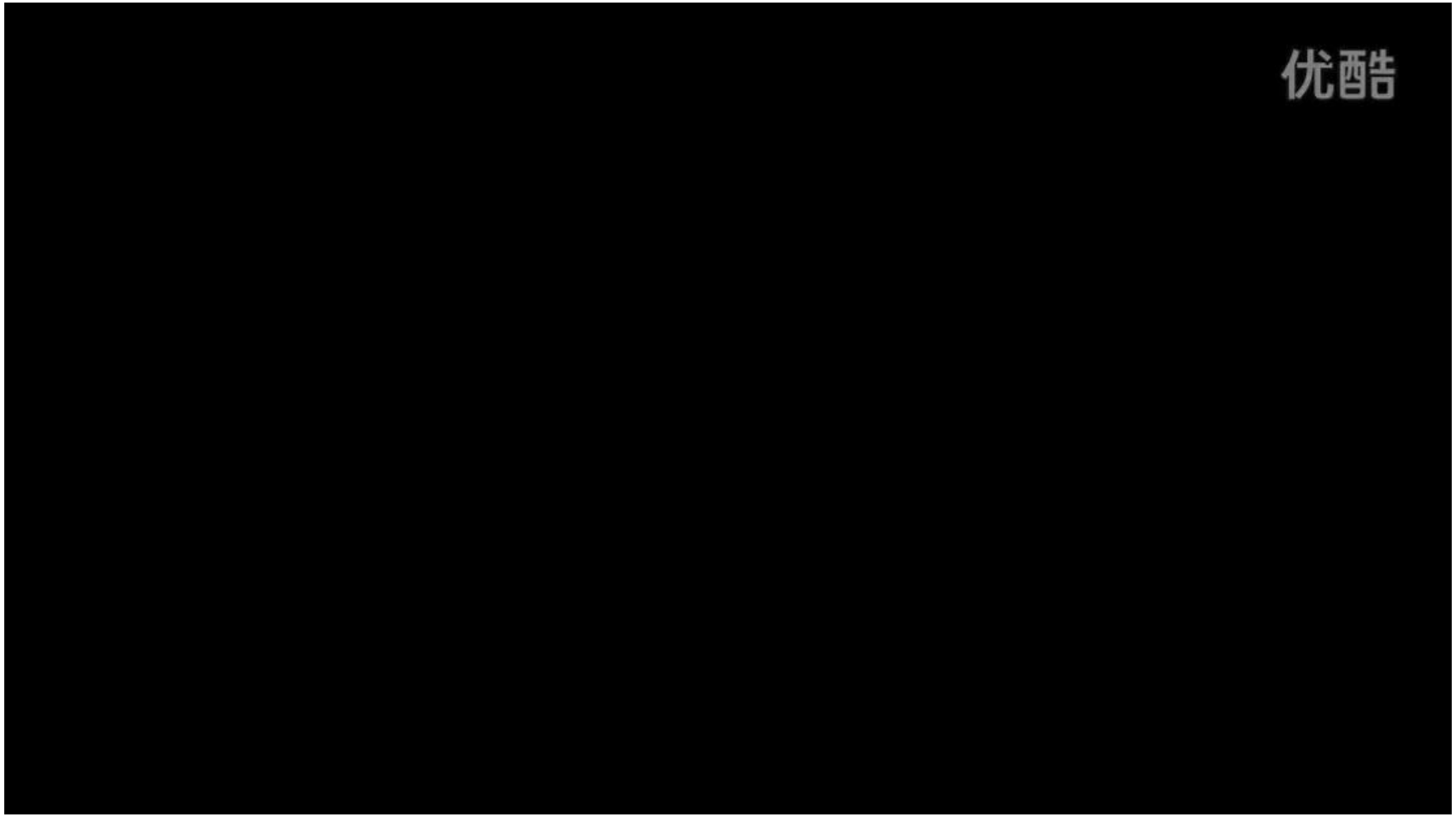


LSD-SLAM

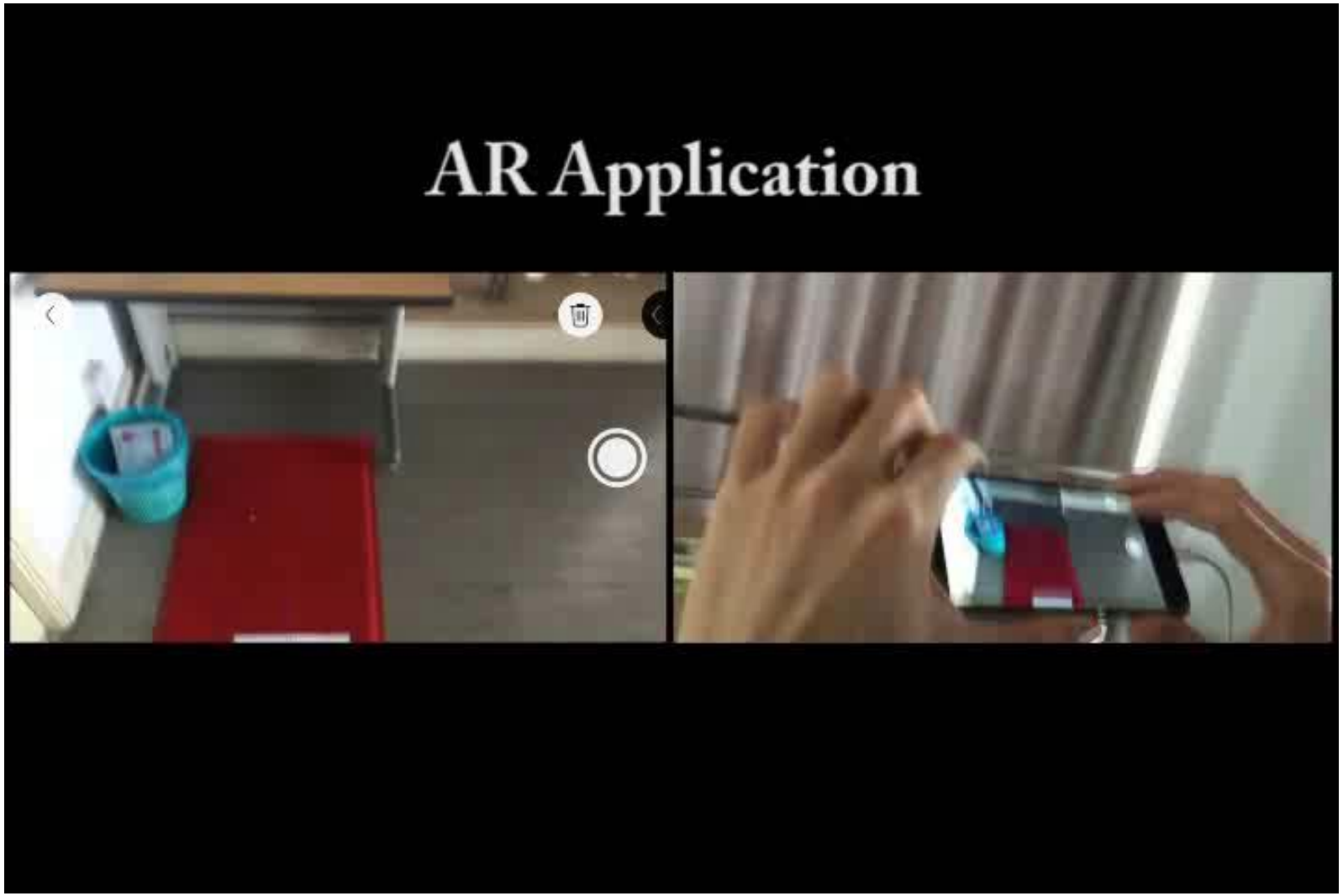

LSD-SLAM: Large-Scale Direct Monocular SLAM
Jakob Engel, Thomas Schöps, Daniel Cremers
ECCV 2014, Zurich
Computer Vision Group
Department of Computer Science
Technical University of Munich

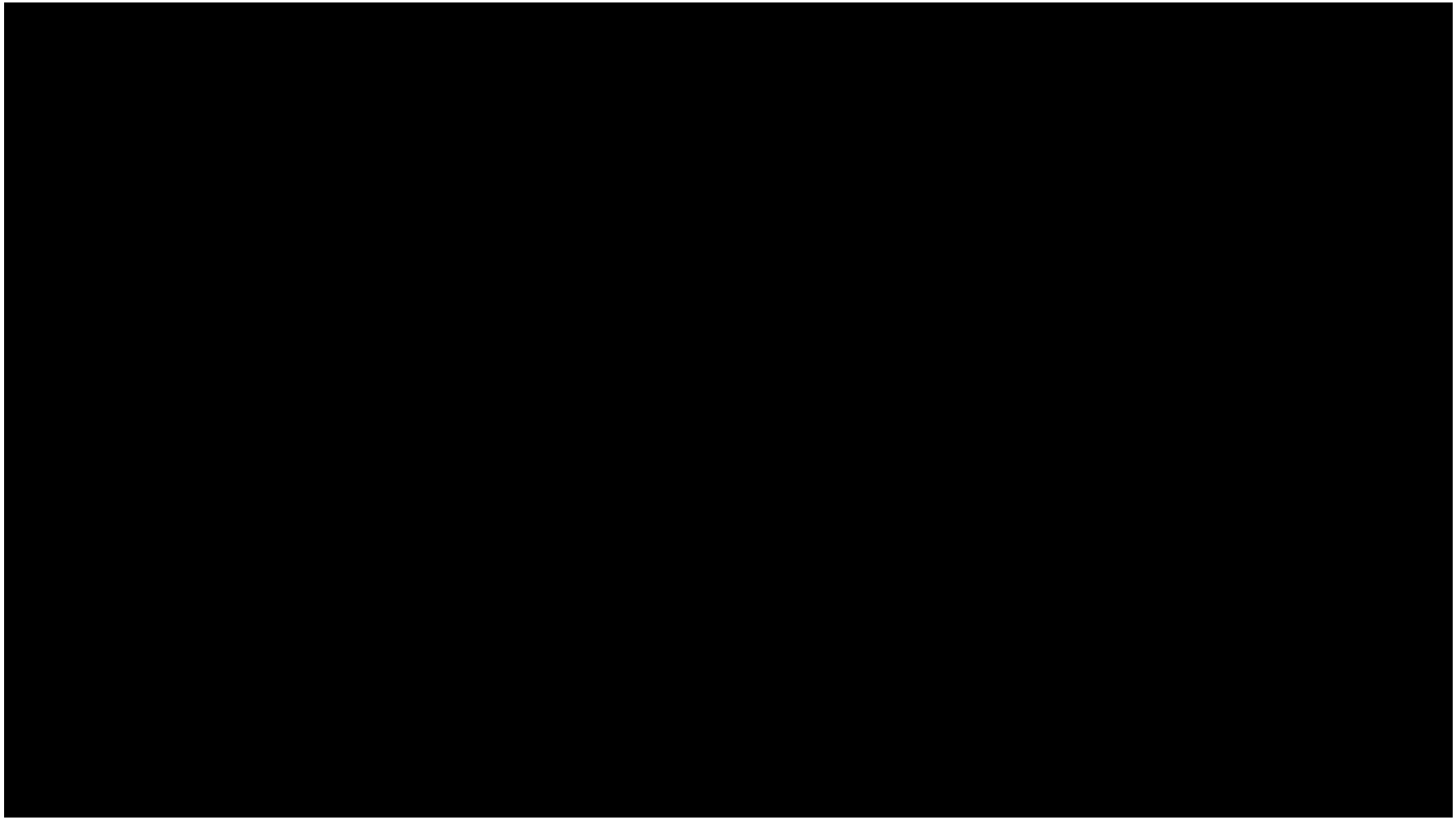
ENFT-SLAM

Sony SmartAR

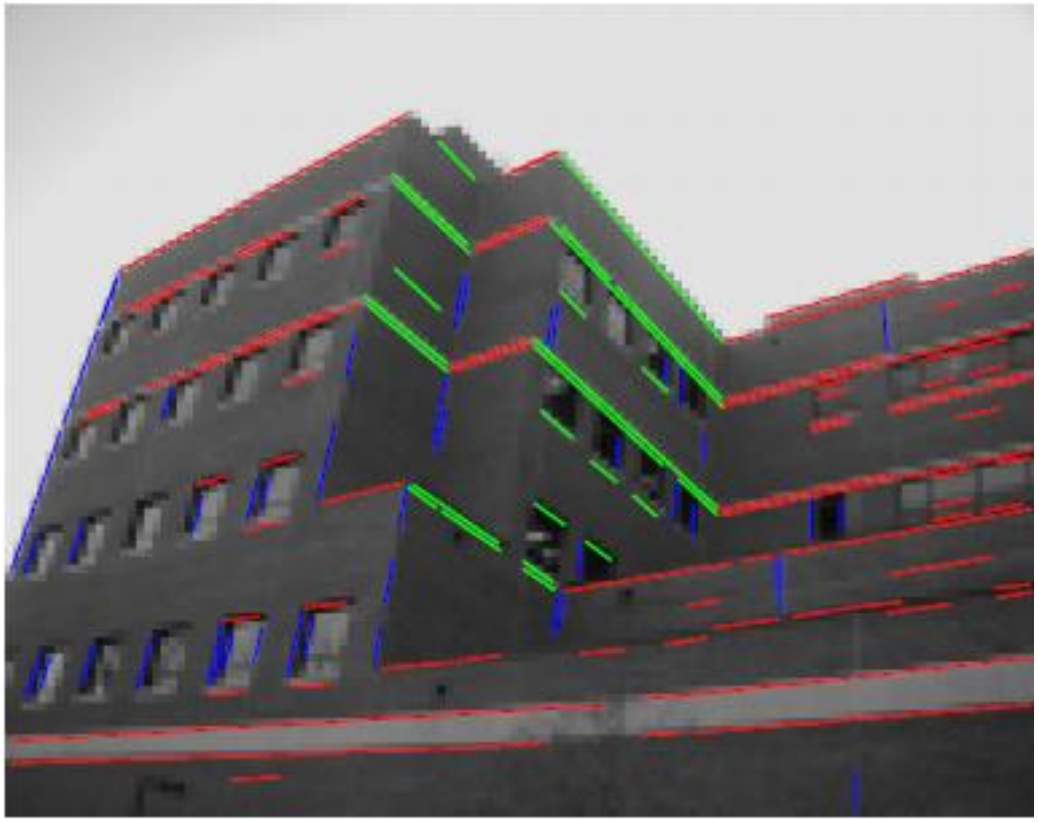


SLAM for AR Applications





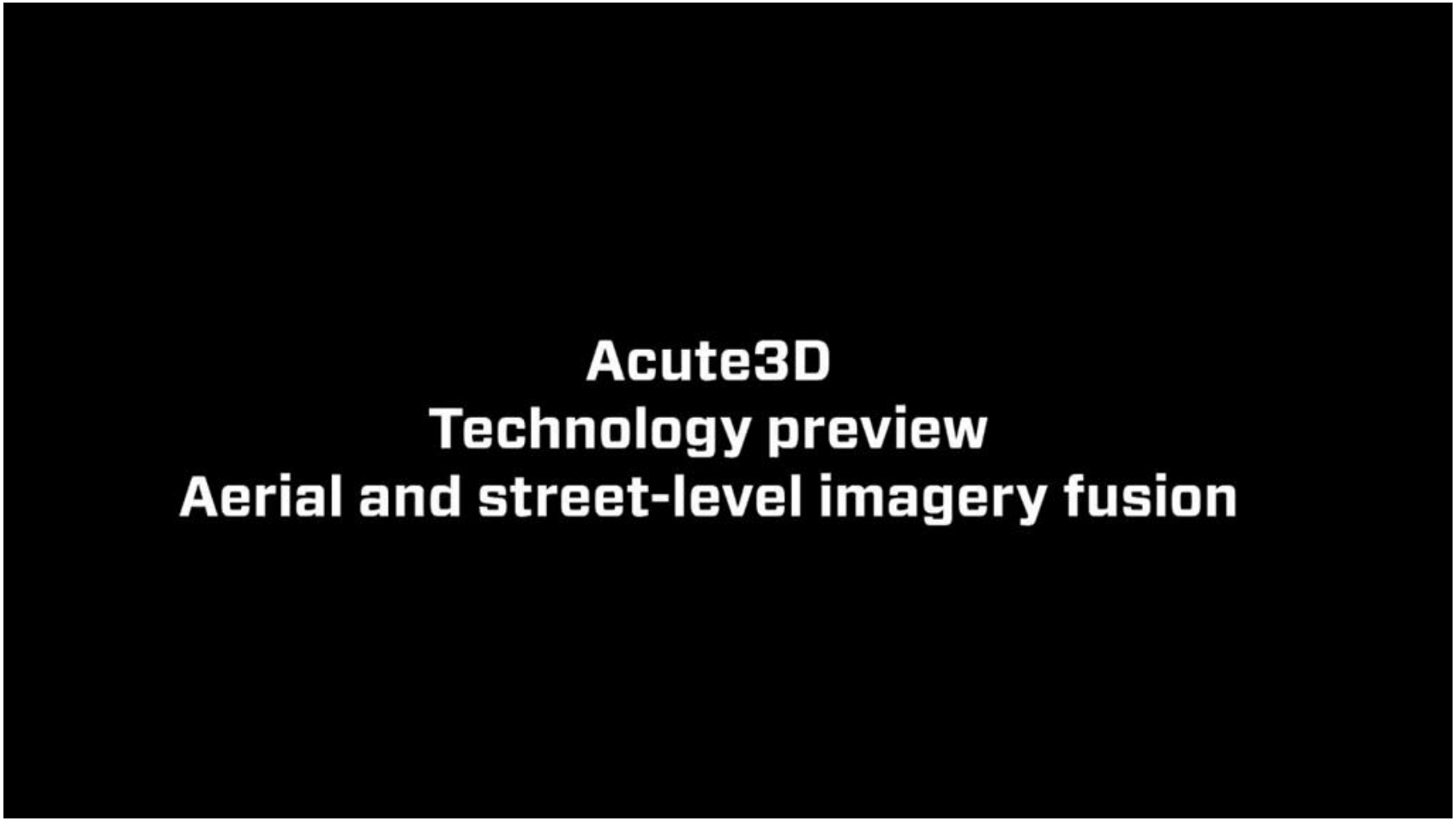
13. Single-View 3D Reconstruction



Automatic Photo Pop-up

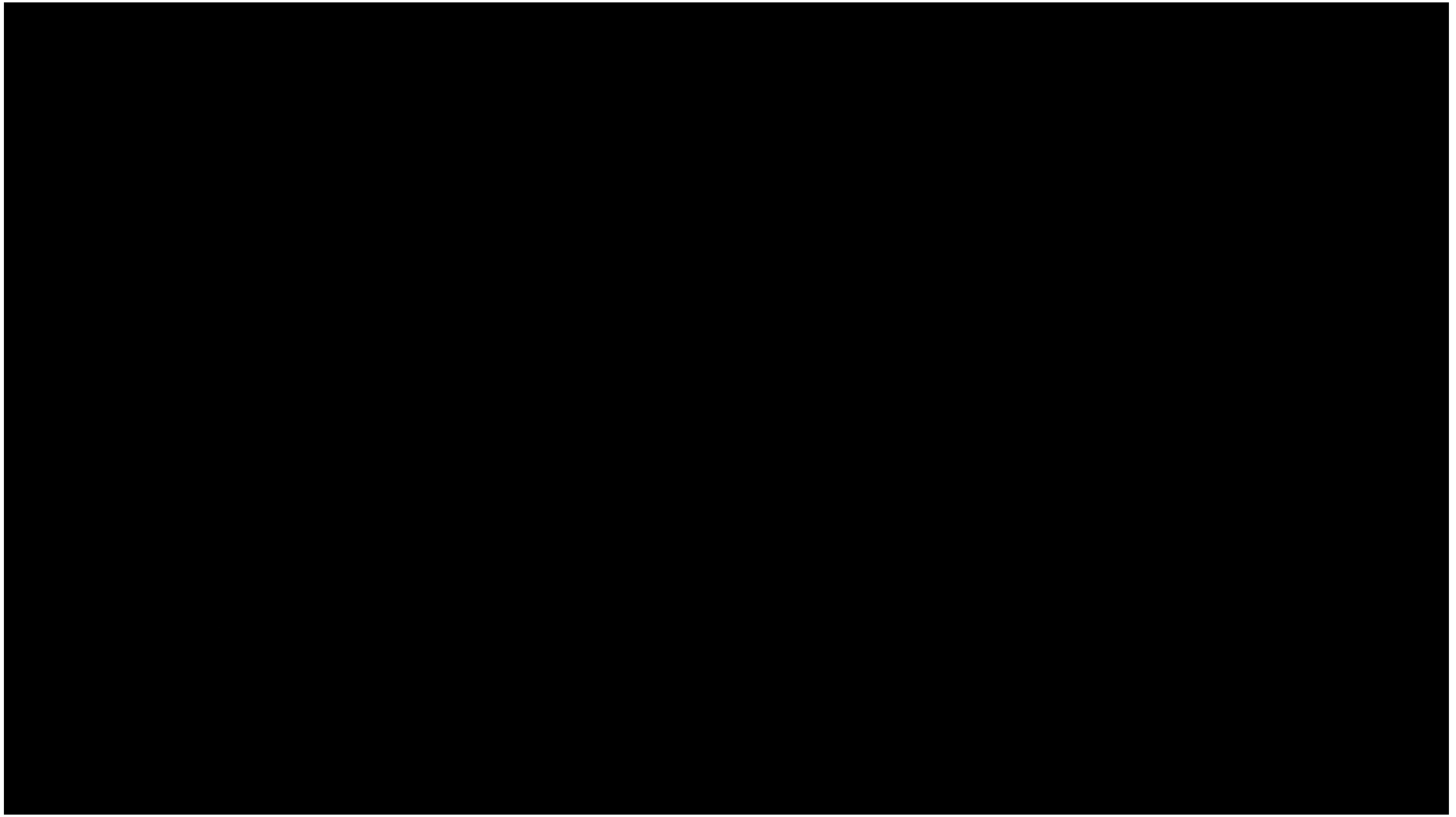
D. Hoiem A.A. Efros M. Hebert
Carnegie Mellon University

13. Multi-View 3D Reconstruction


Acute3D
Technology preview
Aerial and street-level imagery fusion


smart3Dcapture™

Microsoft HoloLens



课程作业

- 课后编程题
  - 有5个课后编程题
  - 考核一些基本知识的掌握程度
  - 可以在上机课里完成

- 软件工具
  - Microsoft Visual Studio, C/C++编程
  - Matlab
  - OpenCV

项目设计与演示

- 编程项目展示
  - 从项目列表中按兴趣自选一个项目
  - 会提供程序框架和测试数据，按要求实现模块和测试结果
  - 独立或分组合作完成（最多3人）
  - 提交完整demo和项目报告
- 课堂项目答辩
  - 每个人报告10分钟，提问5分钟
- 软件开发工具
  - Microsoft Visual Studio, C/C++编程
  - OpenCV

提供设备

KINECT

Structure sensor

佳能100D

GoPro运动相机

Sony HDV

考试方式及要求

- 评分分为3个部分
  - 课程作业：50%
  - 项目设计与演示：40%
  - 项目课堂答辩：10%

- 注意事项
  - 可以相互之间讨论，但不能共享代码
  - 要自己实现，不能借鉴他人
  - 如果遇到问题，可以找我讨论

课件与答疑

- 课程教学网站
  - http://www.cad.zju.edu.cn/home/gfzhang/course/computational-photography/
- 答疑
  - 助教：
    - 叶智超（1721010@zju.edu.cn)
    - 杨镑镑（ybbbbt@zju.edu.cn）
    - 范天行（11821030@zju.edu.cn）
    - 彭思达（pengsida@zju.edu.cn）
  - 时间地点：
    - 每周三下午9-10节（上机课）曹西503

Questions?