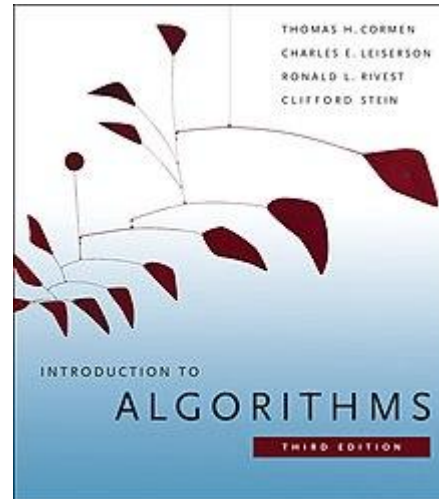


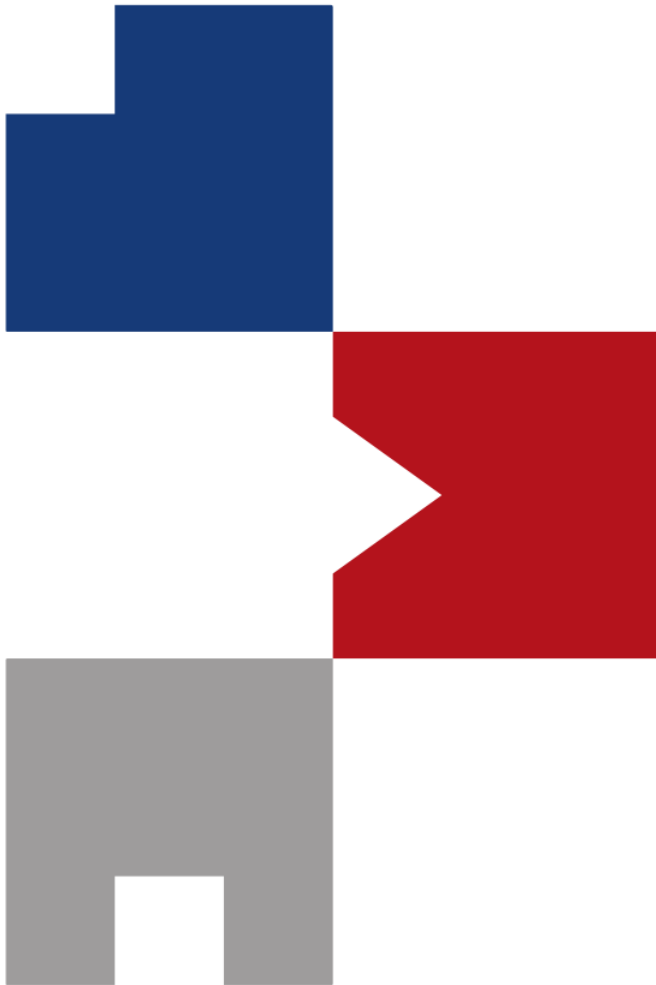
Introduction to 3D Vision



1312 pages

Sunglok Choi, Assistant Professor, Ph.D.
Dept. of Computer Science and Engineering, SEOULTECH
sunglok@seoultech.ac.kr | <https://mint-lab.github.io/>

An Invitation ~~**Introduction**~~ to 3D Vision **: A Tutorial for Everyone**



Sunglok Choi, Assistant Professor, Ph.D.
Computer Science and Engineering Department, SEOULTECH
sunglok@seoultech.ac.kr | <https://mint-lab.github.io/>

What is Computer Vision?

- **Computer vision is an interdisciplinary field that deals with how computers can be made to gain high-level understanding from digital images or videos.**
- From the perspective of engineering, it seeks to automate tasks that the human visual system can do.[1][2][3]
- "Computer vision is concerned with the automatic extraction, analysis and understanding of useful information from a single image or a sequence of images.
- It involves the development of a theoretical and algorithmic basis to achieve automatic visual understanding."[9]



What is Computer Vision?

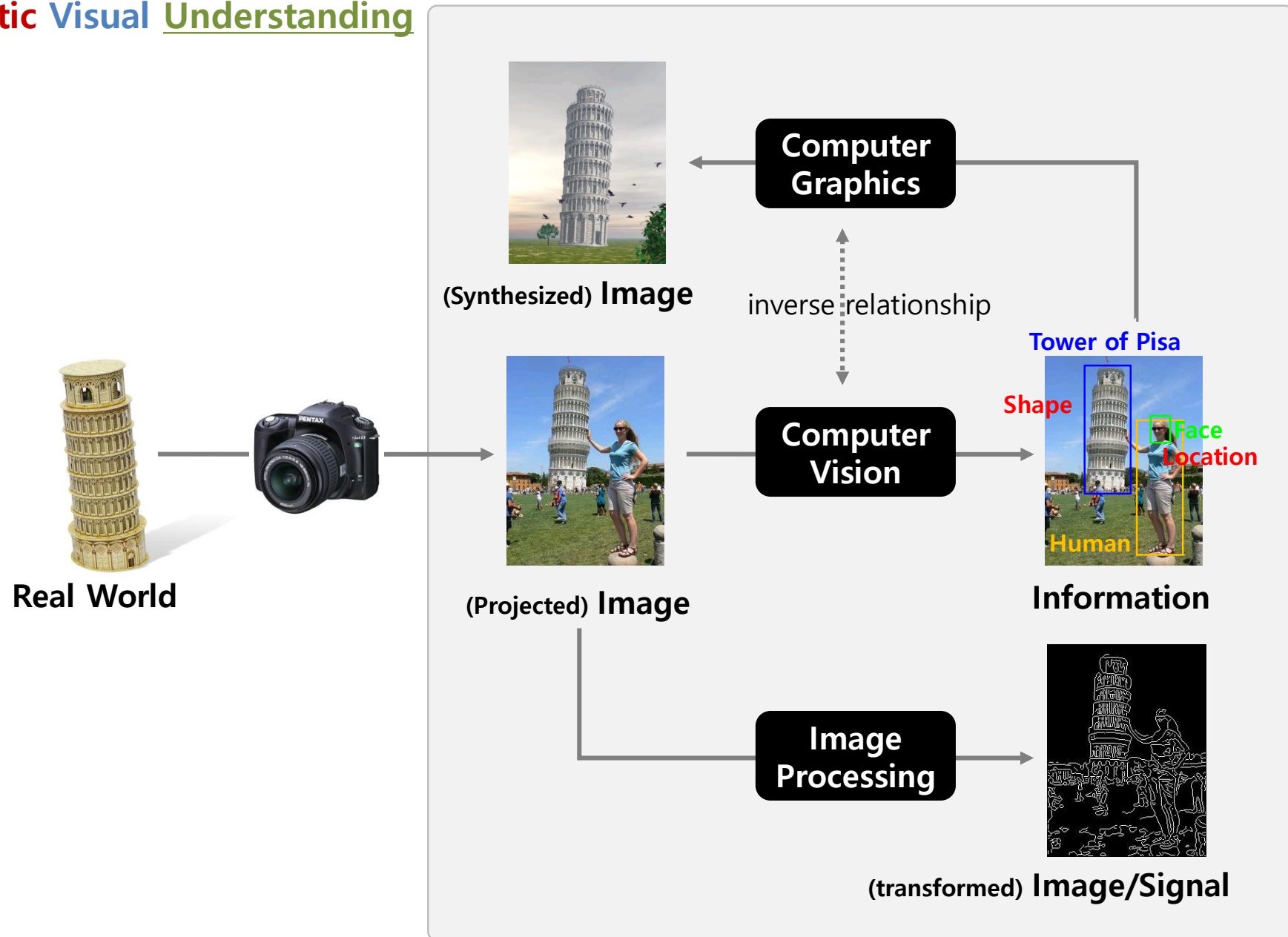
- Computer vision is an interdisciplinary field that deals with how **computers** can be made to gain high-level understanding from digital images or videos.
- From the perspective of engineering, it seeks to **automate** tasks that the human visual system can do.^{[1][2][3]}
- "Computer vision is concerned with the **automatic** extraction, analysis and understanding of useful information from a single image or a sequence of images.
- It involves the development of a theoretical and algorithmic basis to achieve **automatic visual understanding**."^[9]



What is Computer Vision?

Automatic Visual Understanding


Computer Vision



What is Computer Vision?

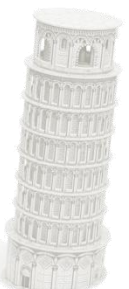
Computer Vision

What is it?

- Label (e.g. Tower of Pisa)
- Shape (e.g. )



Where am I?

- Place (e.g. Piazza del Duomo, Pisa, Italy)
- Location (e.g. )

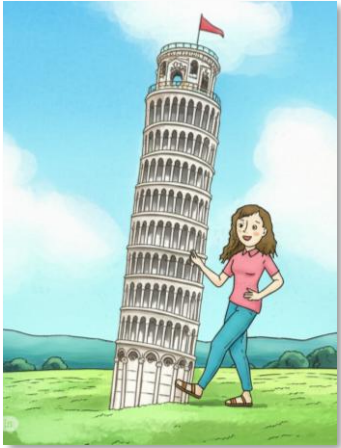
(84, 10, 18) [m]



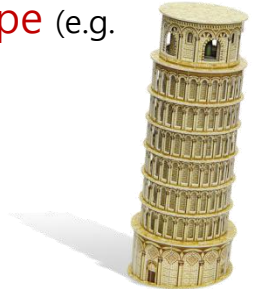
What is 3D Vision?

Automatic 3D Visual Perception

Computer Vision

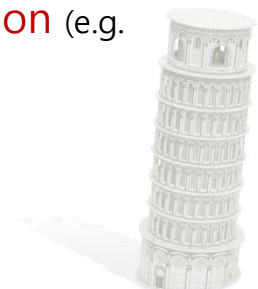


What is it?

- **Label** (e.g. Tower of Pisa)
- **Shape** (e.g. )



Where am I?

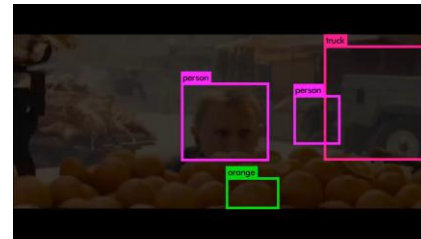
- **Place** (e.g. Piazza del Duomo, Pisa, Italy)
- **Location** (e.g. )

(84, 10, 18) [m]



Generation Problems

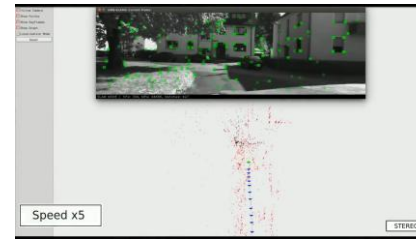
Recognition Problems vs. Reconstruction Problems



YOLO v2 (2016)

Stanford CS231n:

[Deep Learning for Computer Vision](#)



ORB-SLAM2 (2016)

Stanford CS231A:

[Computer Vision,
From 3D Perception to 3D Reconstruction and beyond](#)

What is 3D Vision?

Visual Geometry

Multiple View Geometry

Geometric Vision

Photogrammetry



image



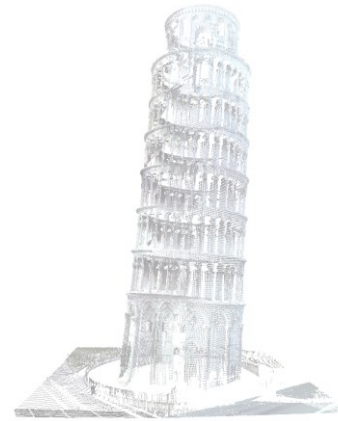
Perspective Camera



Omni-directional Camera

3D Vision

vs.



depth image, range data, point cloud, polygon mesh, ...

3D Data Processing



RGB-D Camera

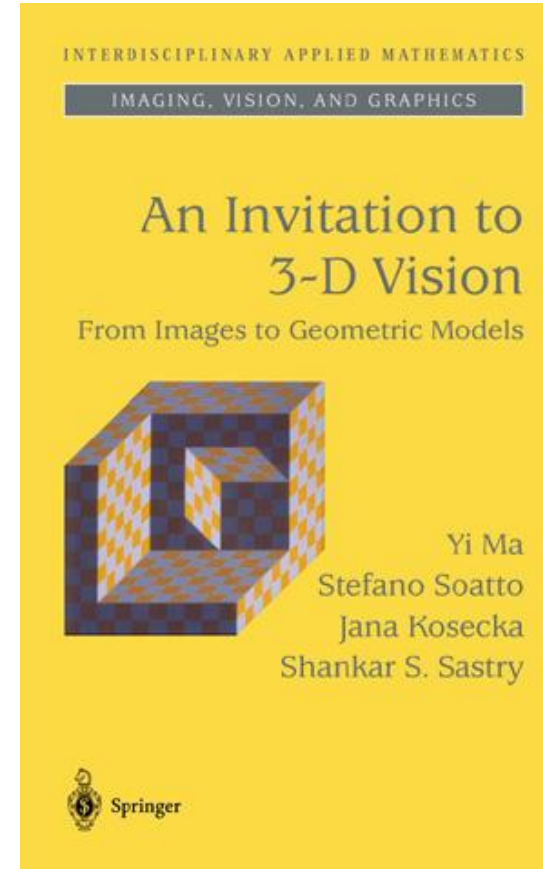
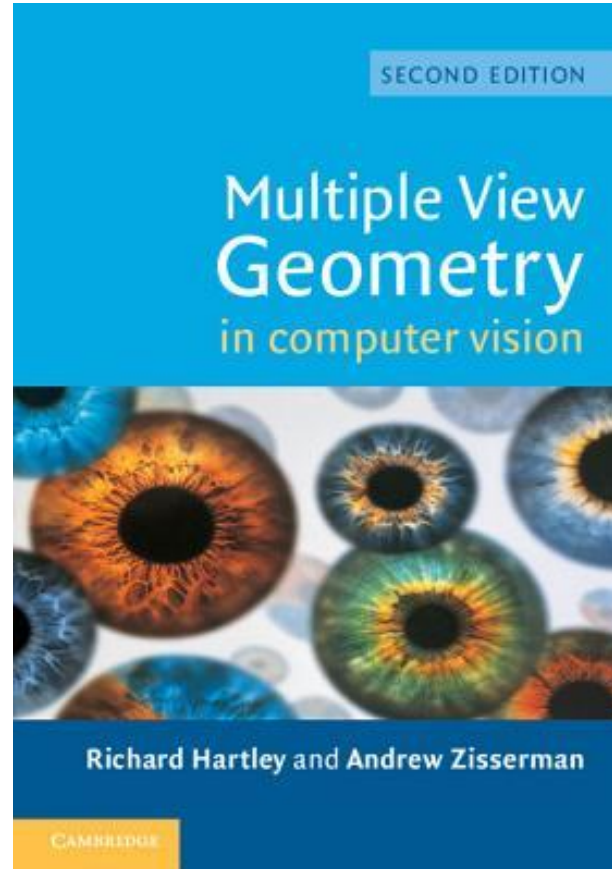
(Stereo, Structured Light, ToF, Light Field)



Range Sensor
(LiDAR, RADAR)

What is 3D Vision?

- Reference books



What is 3D Vision?

- All example codes are available at https://github.com/mint-lab/3dv_tutorial.
 - All example codes are mostly **less than 100 lines** and based on recent **OpenCV (> 3.0.0)**.
 - Note) OpenCV (Open Source Computer Vision)

OpenCV v4.8.0 main modules:

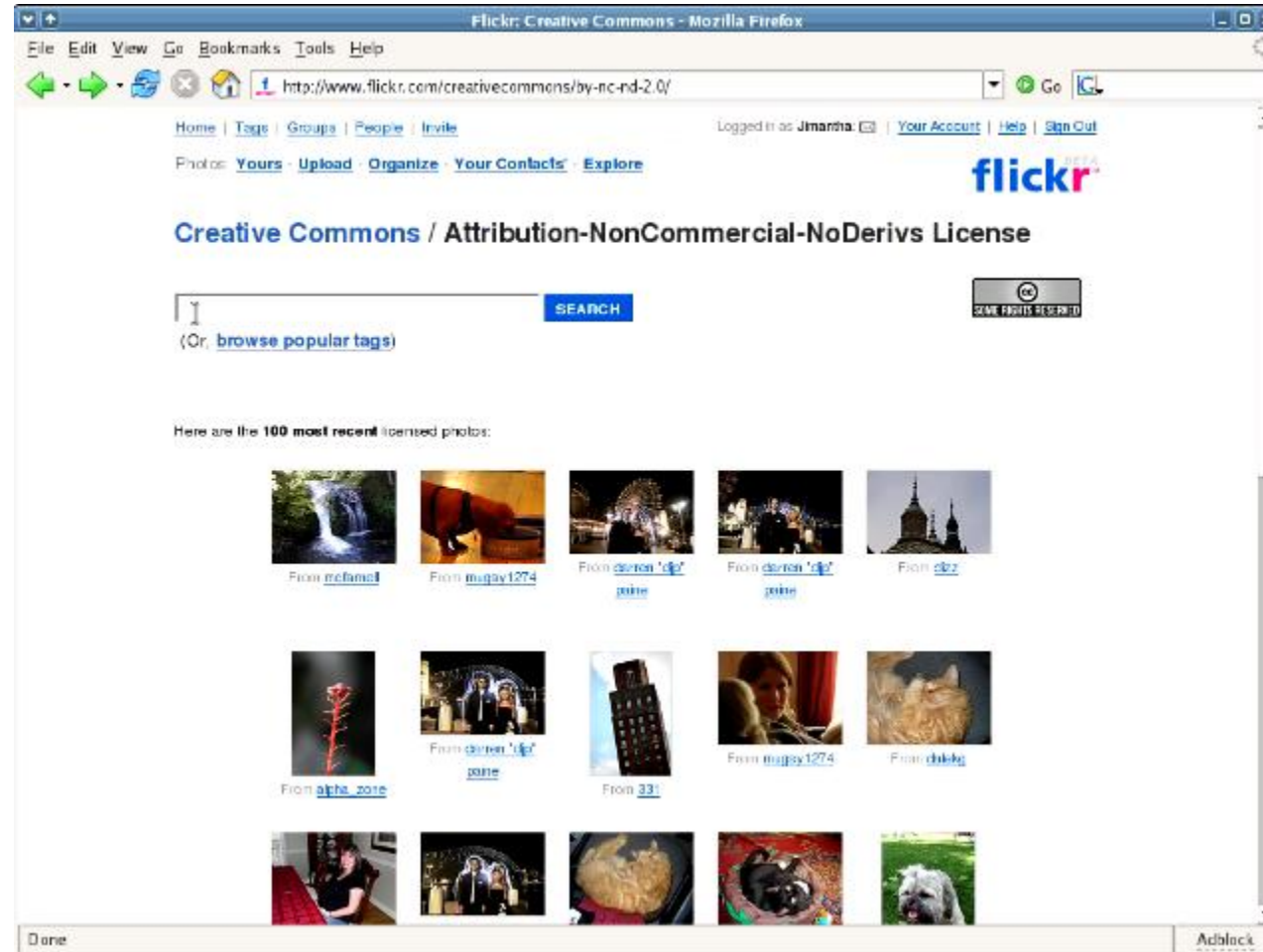
- core. [Core functionality](#)
- imgproc. [Image Processing](#)
- imgcodecs. [Image file reading and writing](#)
- videoio. [Video I/O](#)
- highgui. [High-level GUI](#)
- video. [Video Analysis](#)
- calib3d. [Camera Calibration and 3D Reconstruction](#)
- features2d. [2D Features Framework](#)
- objdetect. [Object Detection](#)
- dnn. [Deep Neural Network module](#)
- ml. [Machine Learning](#)
- flann. [Clustering and Search in Multi-Dimensional Spaces](#)
- photo. [Computational Photography](#)
- stitching. [Images stitching](#)
- gapi. [Graph API](#)

OpenCV v5.0.0-pre main modules:

- core. [Core functionality](#)
- imgproc. [Image Processing](#)
- imgcodecs. [Image file reading and writing](#)
- videoio. [Video I/O](#)
- highgui. [High-level GUI](#)
- video. [Video Analysis](#)
- 3d. [3d](#)
- stereo. [Stereo Correspondence](#)
- features2d. [2D Features Framework](#)
- calib. [Camera Calibration](#)
- objdetect. [Object Detection](#)
- dnn. [Deep Neural Network module](#)
- ml. [Machine Learning](#)
- flann. [Clustering and Search in Multi-Dimensional Spaces](#)
- photo. [Computational Photography](#)
- stitching. [Images stitching](#)
- gapi. [Graph API](#)

Applications) Photo Browsing

- [Photo Tourism](#) (2006)



Applications) 3D Reconstruction

- [Building Rome in a Day](#) (2009)



photo by [Ceci And Brandon](#)

2106 images, 819242 points

[click here to see more views](#)

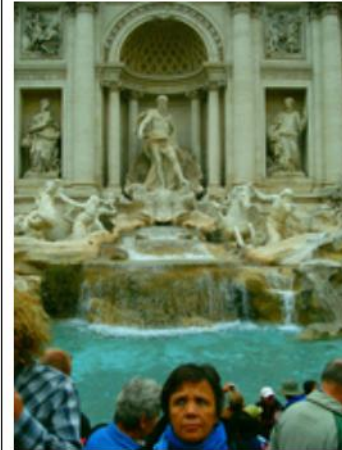


photo by [TORISFERICK](#)

1936 images, 656699 points

[click here to see more views](#)



photo by [act2win](#)

1815 images, 422593 points

[click here to see more views](#)



photo by [angle_in_soul](#)

1381 images, 499044 points

[click here to see more views](#)



Applications) 3D Reconstruction

- [Building Rome in a Day](#) (2009)



The Old City of Dubrovnik
YouTube

Applications) Depth Estimation from Cellular Phones

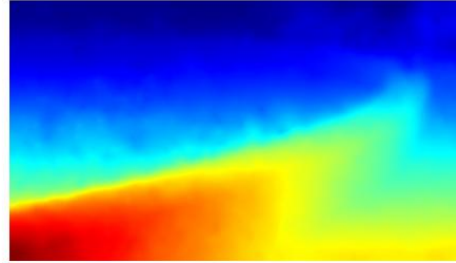
- [Structure from Small Motion](#) (SfSM; 2015)



(a) Reference images



(b) SfSM results



(c) Depth maps

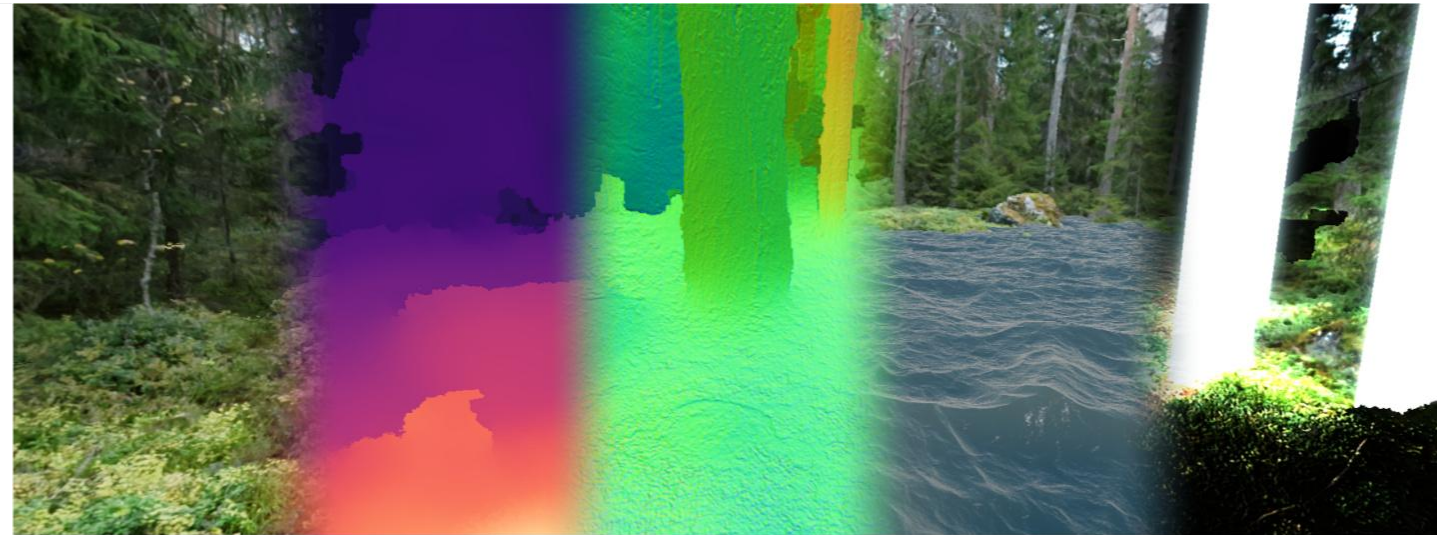


(d) Our 3D meshes

- [Casual 3D Photography](#) (2017)



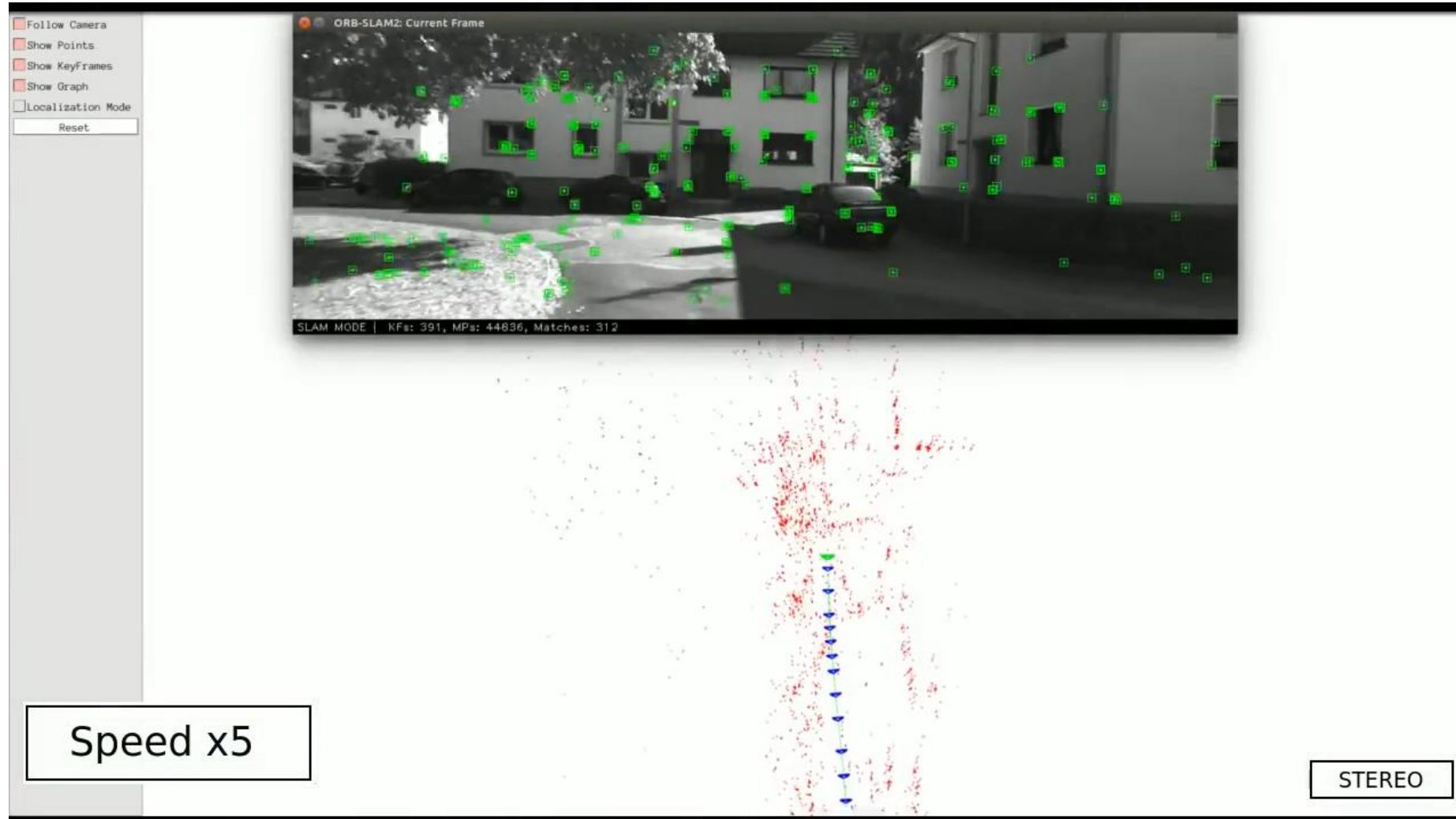
Casual 3D photo capture



Color Depth Normal map Geometry-aware Lighting
Reconstruction Example Effects

Applications) Real-time Visual SLAM

- [ORB-SLAM](#) (2014)



Applications) Augmented Reality

- [PTAM: Parallel Tracking and Mapping](#) (2007)

4. Ewok rampage

Here the camera is used to aim Darth Vader's laser pistol. Movement is controlled with the keyboard.



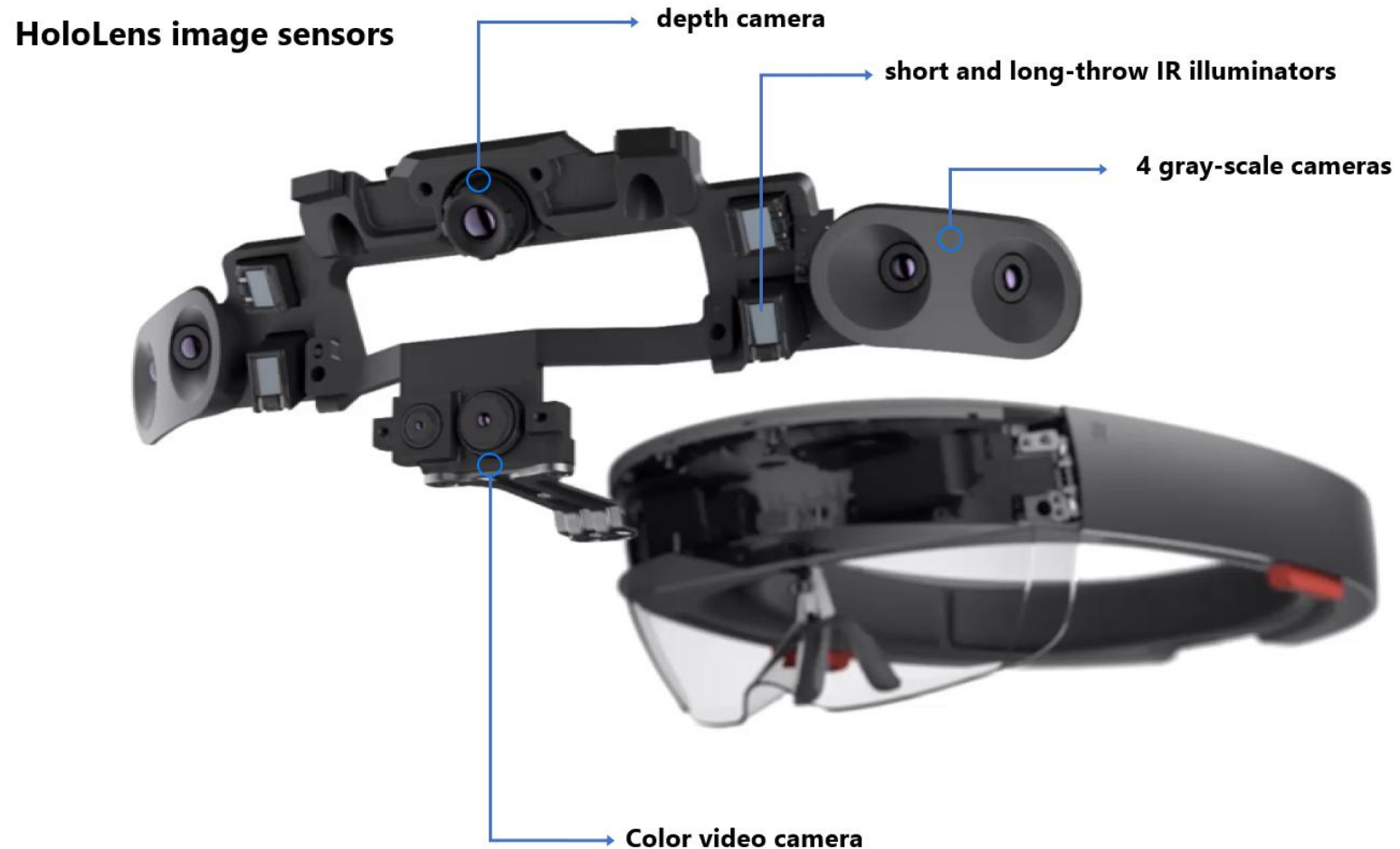
Applications) Virtual Reality

- [Oculus Quest](#) (2019)



Applications) Mixed Reality

- [Microsoft HoloLens 2](#) (2019)
 - Head tracking: 4 x visible light cameras



Summary) Introduction

- What is Computer Vision?
- What is 3D Vision?
 - What? Recognition problem vs. Reconstruction problem
 - Note) Generation problem vs. Reconstruction problem
 - Why? Applications

Next Topics

- **Single-view Geometry**
- **Two-view Geometry**
- Solving Equations
- Finding Correspondences
- **Multi-view Geometry**
- Special Topic) Bayesian Filtering
- Visual SLAM and Odometry
- 3D Representations