CE7453: Photogrammetric Computer Vision

Lecture 1

Introduction

Acknowledgements: part of the materials of the all the lecture notes are from Cyrill Stachniss, Ping Tan, Marc Pollefey, Wolfgang Foerstner, Bernhard Wrobel, James Hays, A. Dermanis, Armin Gruen, Alper Yilmaz.

Introduction – Photogrammetry

“Photogram” --- photograph

“metry” --- Geometry

Mensuration with light!

Early user - Surveyors

Photogrammetry – Brief History

Albrecht Dürer, in 1525,
Perspective Drawing

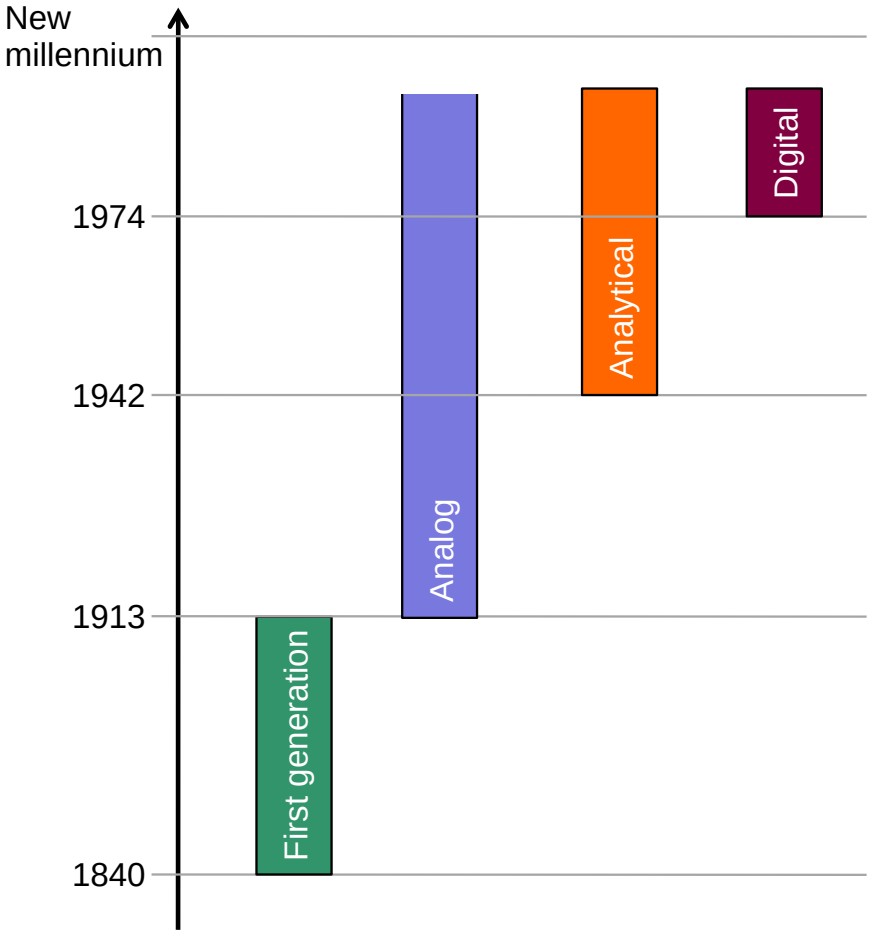
1840 - Dominique François Jean Arago, daguerreotype

1855 - Nadar(Gaspard Felix Tournachon) Air balloon, first aerial photograph

1882 – photograph with kites E. D. Archibald

1909 – First aerial photograph Wrights

Photogrammetry – Brief History



LIDAR, X-Ray, electro-magnetic imaging !

Invention of CCD cameras

Invention of computer

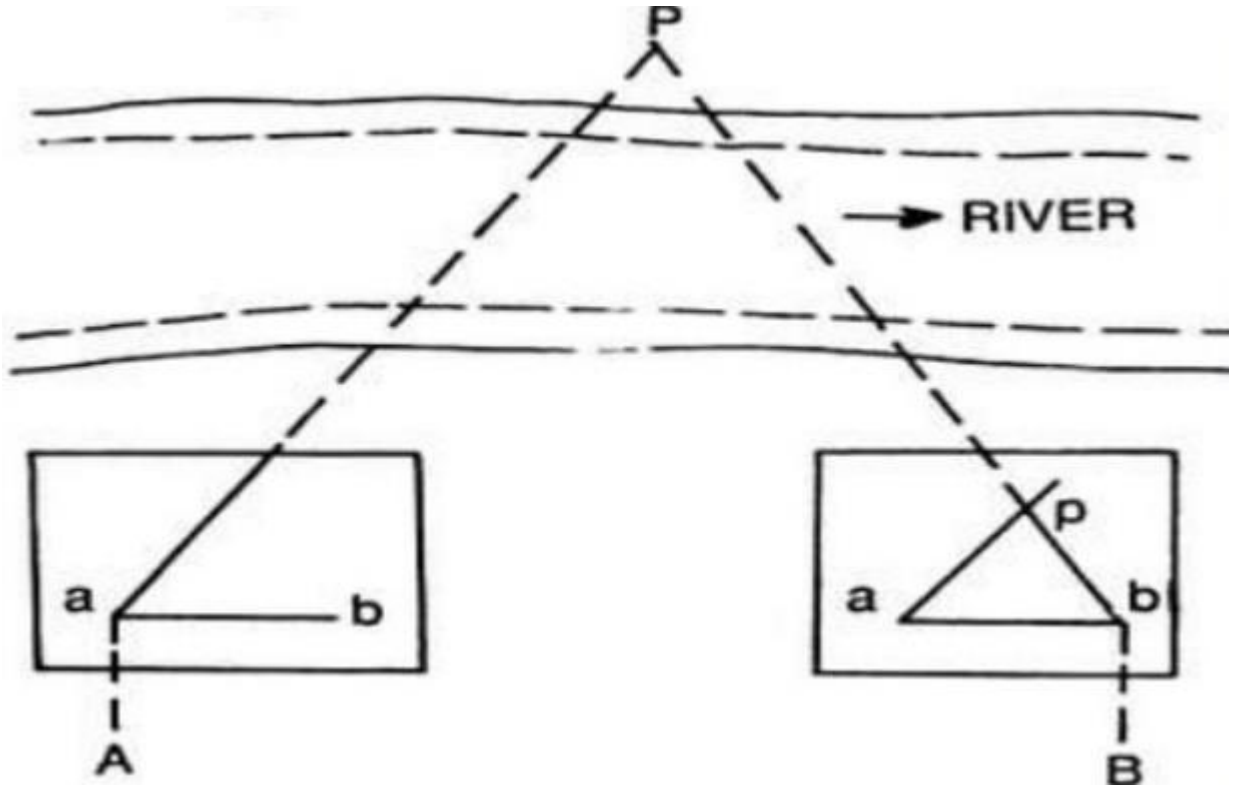
Invention of plane

Invention of photography

Plane Table Photogrammetry

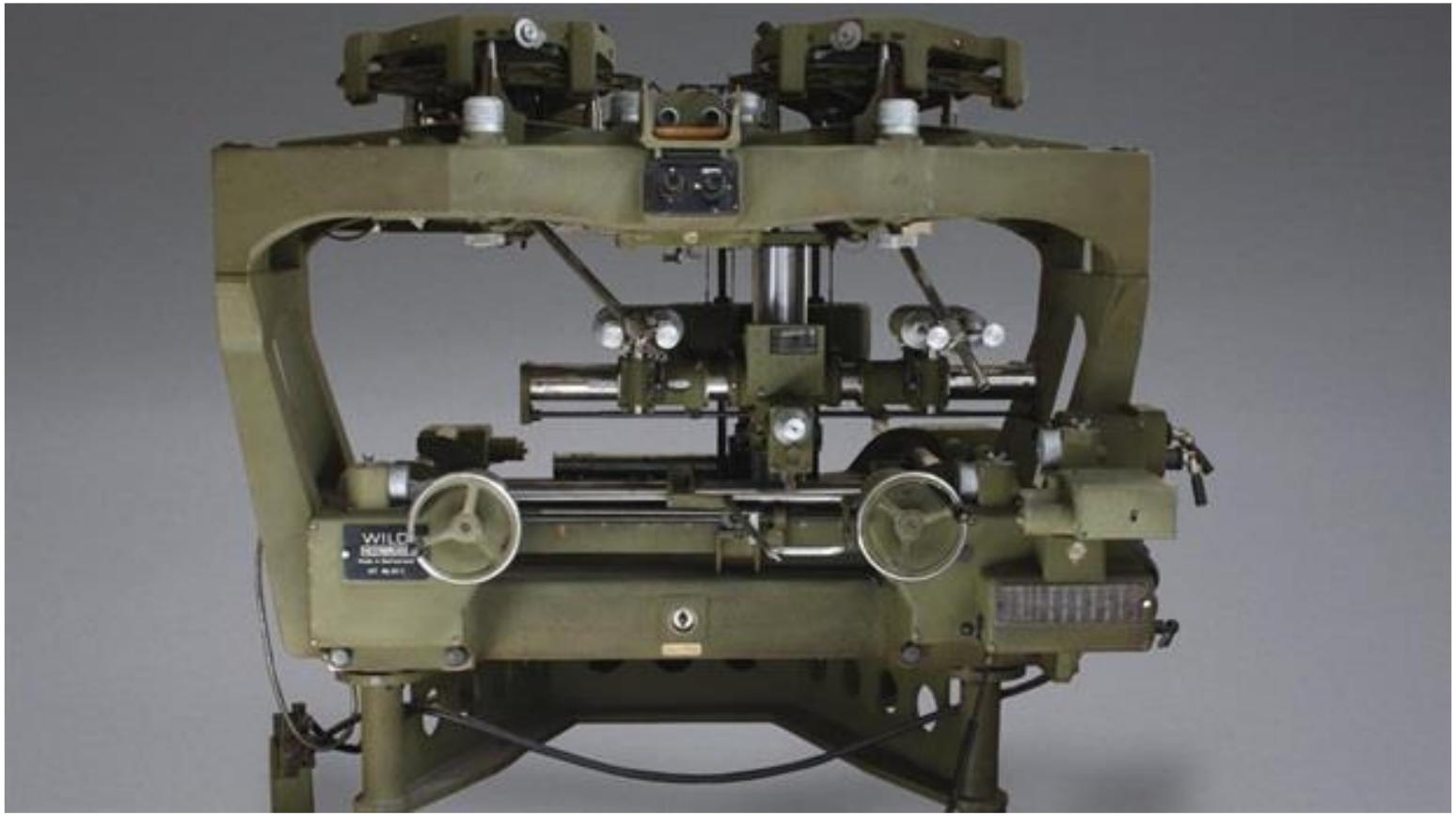
Plane Table Photogrammetry

- 1850 – 1900



Analog Photogrammetry

- 1900-1960



Orientation being mechanical movement

Analytical Photogrammetry

- 1960-2010

Orientation being computed by computers, as well as the intersection of rays

Digital Photogrammetry

- 1993 - now

Imag courtesy: http://www.gpsi-corp.com

All replaced by digital devices

Automated topography generation

Digital Photogrammetry

- Fully Automated Digital Surface Model Generation

Google Earth

Computer Vision

- A science-driven discipline that interpret the physical environment from images, and simulating human vision systems and intelligence

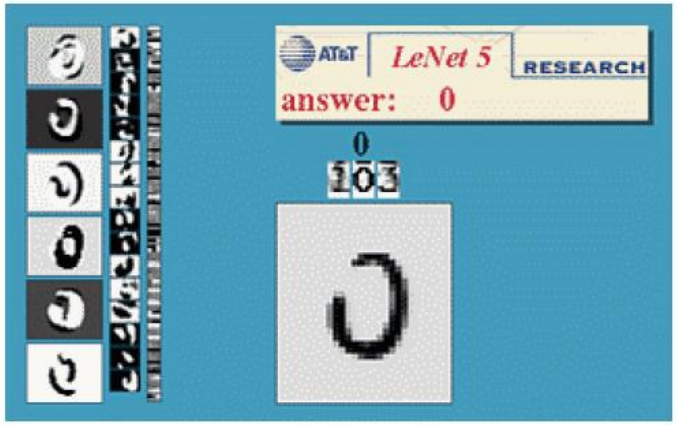
- Does not focus on particular applications

Computer Vision – Examples of Topic

Optical character recognition (OCR)

Technology to convert scanned docs to text

- If you have a scanner, it probably came with OCR software



Digit recognition, AT&T labs
http://www.research.att.com/~yann/

License plate readers
http://en.wikipedia.org/wiki/Automatic_number_plate_recognition

Computer Vision – Examples of Topic

Face detection

- Many new digital cameras now detect faces
  - Canon, Sony, Fuji, …

Computer Vision – Examples of Topic

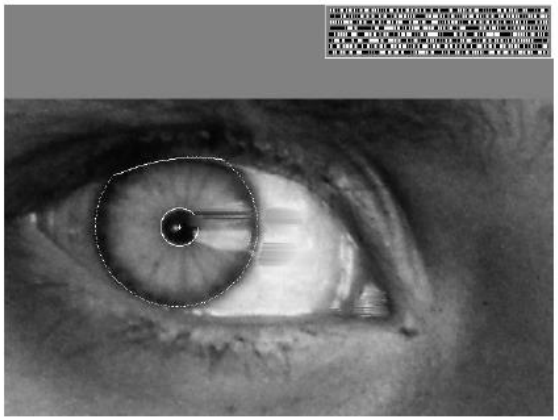
3D from thousands of images

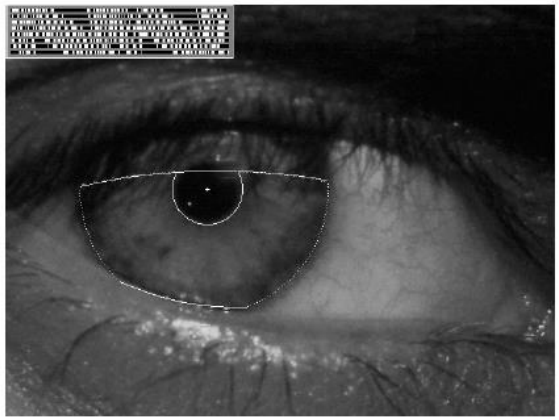
Building Rome in a Day: Agarwal et al. 2009

Computer Vision – Examples of Topic

Vision-based biometrics

"*How the Afghan Girl was Identified by Her Iris Patterns*" Read the story wikipedia





Computer Vision – Examples of Topic

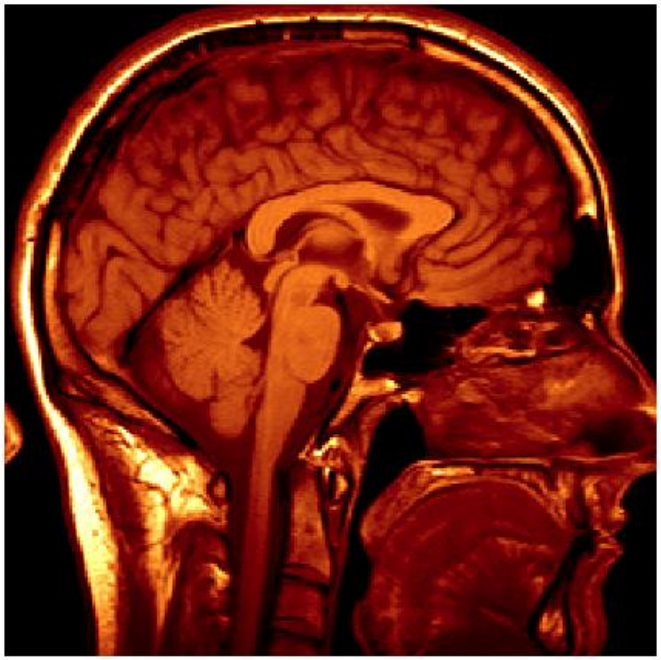
Object recognition (in mobile phones)

Point & Find, Nokia

Google Goggles

Computer Vision – Examples of Topic

Medical imaging



3D imaging
MRI, CT

Image guided surgery
Grimson et al., MIT

Computer Vision – Remarks

T. S. Huang

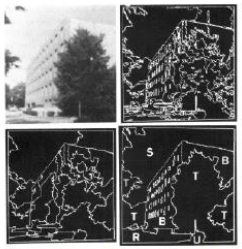
Practically successful computer Vision algorithm may :

1) Allow Human Interaction

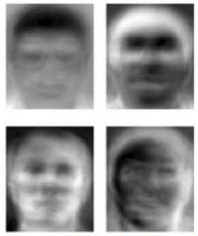
2) Forgiving

Computer Vision – A Brief Intro

- 1960s, Larry Roberts Recover 3D from synthetic 2D views (MIT)
- Extract primal sketches of real-world images, David Marr, 1978 (MIT). Tasks such as segmentation, edge detection, low-level vision
- 1980s, Artificial Neural networks. 3D recovery from 2D images, mathematical model development. Low-level vision
- 1990s, face recognition, object recognition, tracking of moving objects, high-level vision
- 2000s, large annotated datasets, video data processing, structure from motion.
- 2012s, deep convolutional neural network, applied to both low-level and high-level vision problem



Ohta Kanade '78



Turk and Pentland '91

Snavely 06,07

Russakovsky et al 2015

Photogrammetric Computer Vision

- We aim to merge the mensuration nature of photogrammetry methods and intelligent image understanding techniques with a major focus on perceiving, understanding and measuring the Physical environment

Synergy and Difference

Photogrammetry	Computer Vision
Mensuration, Topographic Mapping	Achieving human vision capability
Mature, developed with the need of surveying industry	Not particularly developed
Application mainly cover large scale, e.g. aerial surveillance, earthquake, flood, GIS, manufacturing	Application mainly cover intelligent systems, drivel-less car, speech recognition, human face detection, movie, robotic navigation. Rarely deal with top-view data
Engineering driven	Largely science-driven
All kinds: expensive metric camera, satellite camera, mobile. Including laser scanning	dealing with consumer grade cameras
3D vision and photogrammetry share very similar theoretical basis, though formulation might be different	
Mapping requires intelligence and computer vision demand for accuracy	

Connections

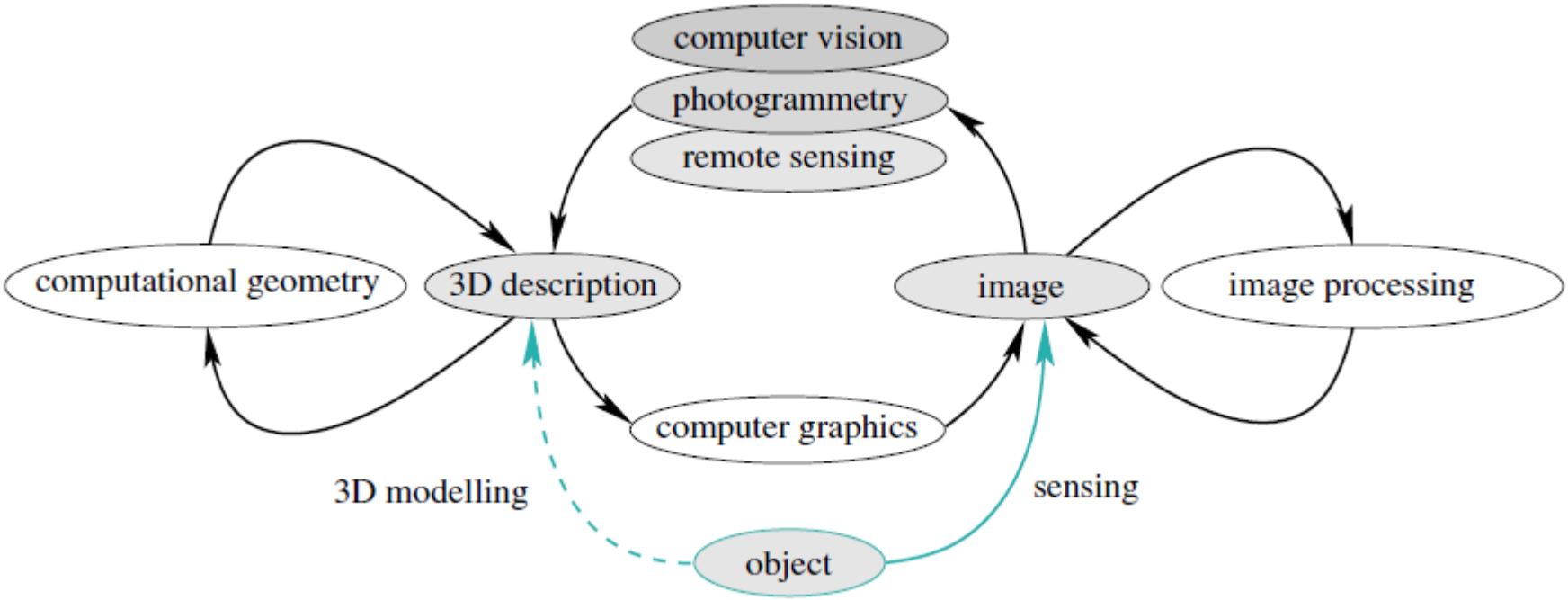


Image courtesy: Foerstner and Wrobel

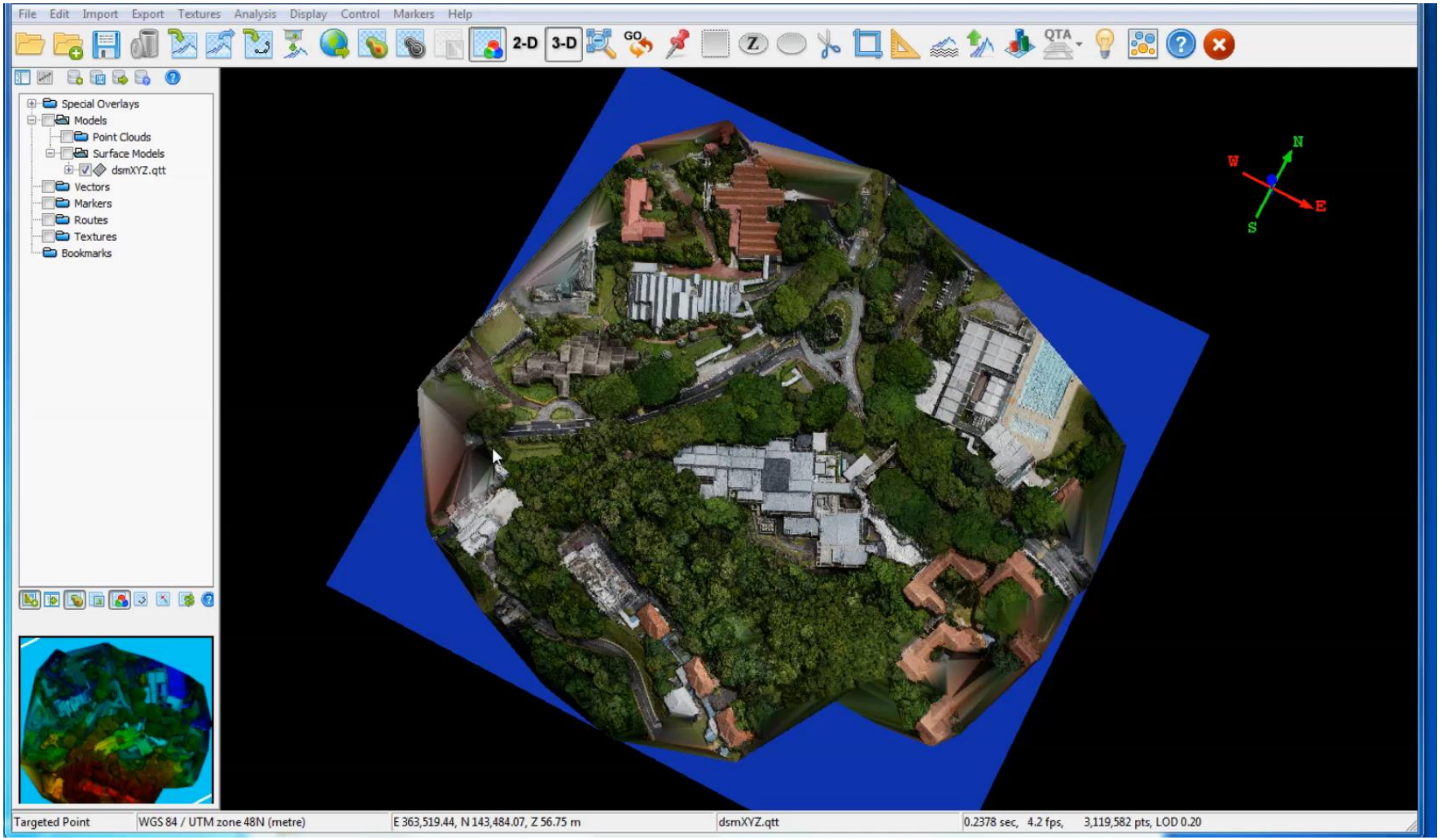
Common Applications in PCV

- Large-scale semantic 3D reconstruction of the earth object.
- Precision navigation using images and multi-sensory data
- Simultaneous localization and mapping
- 3D object tracking
- Virtual / Augmented Reality

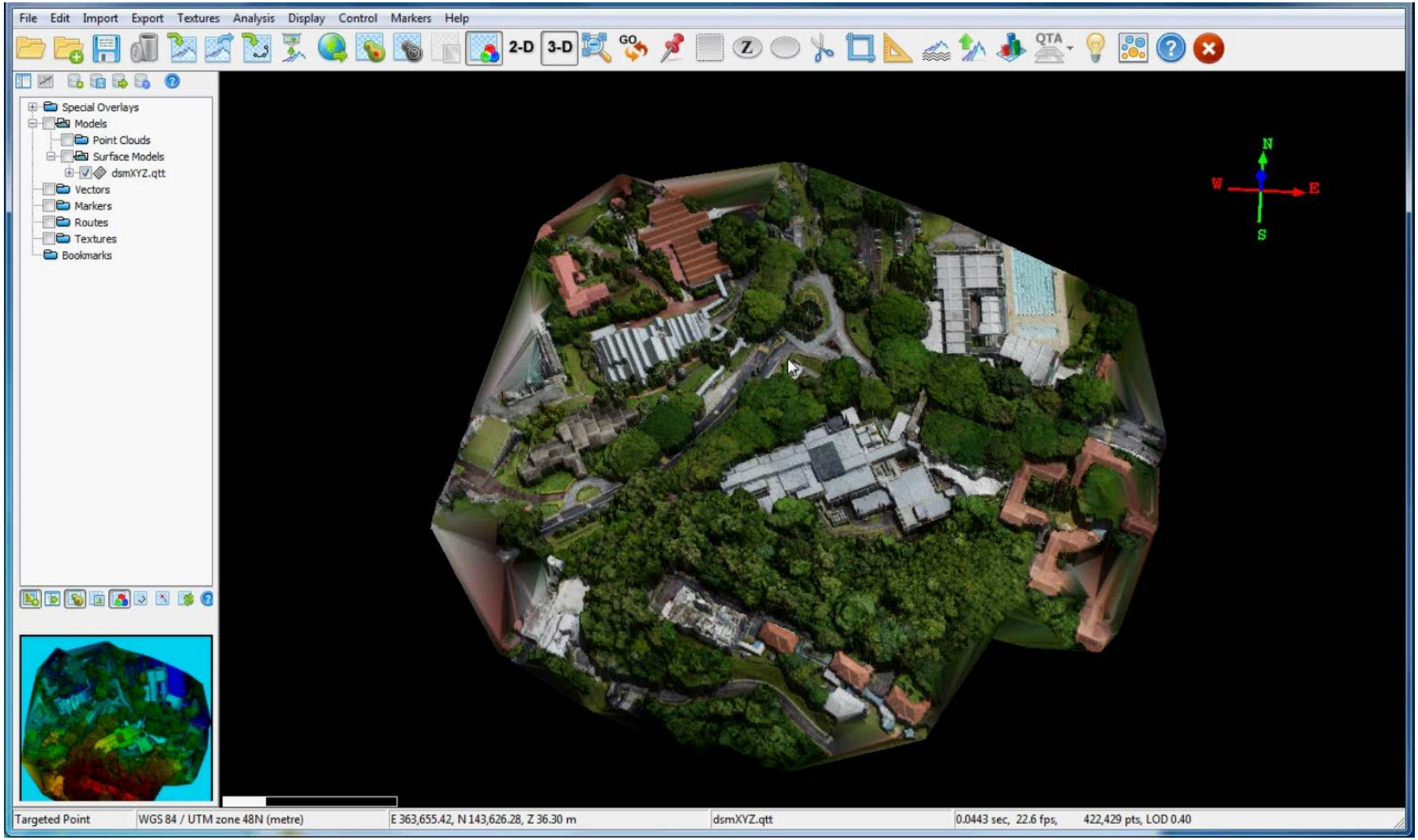
…

Civil Applications

- Disaster Response



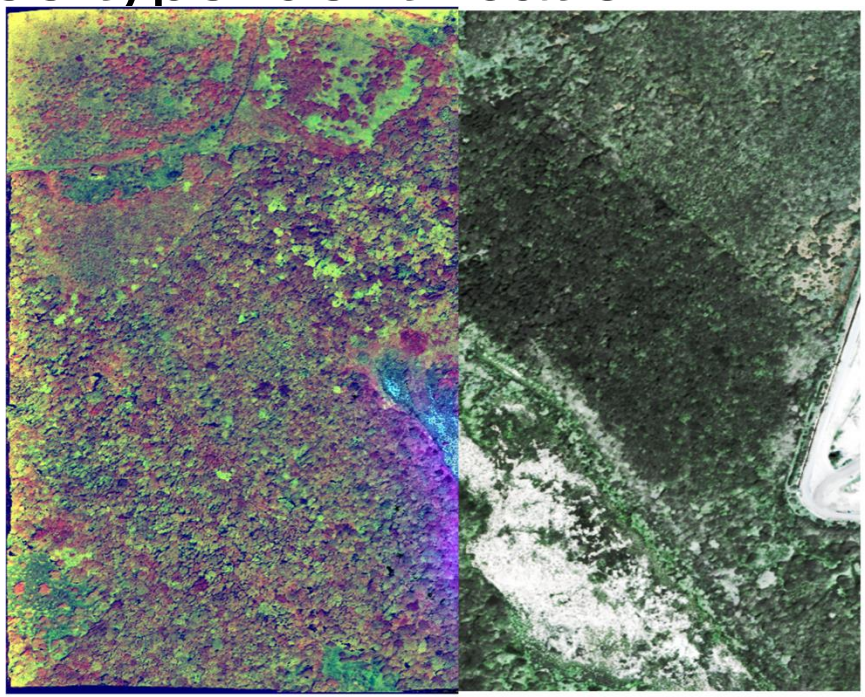
Civil Applications – Flood Simulation

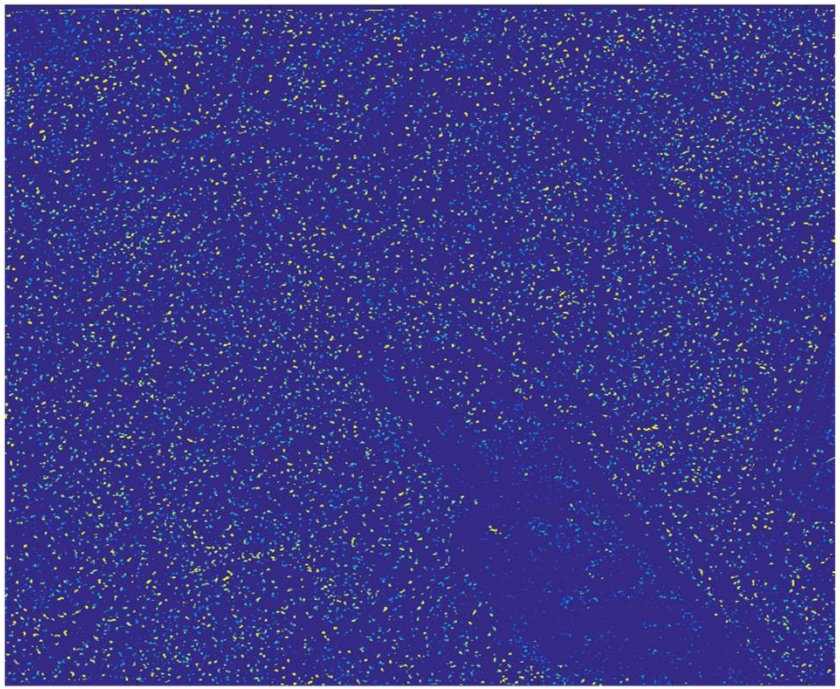


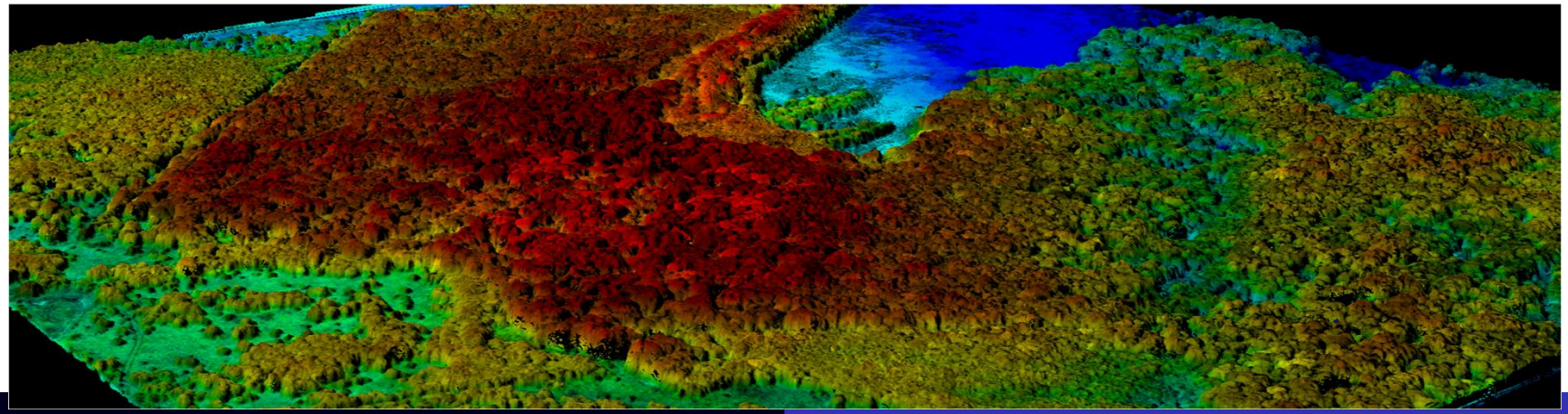
Civil Applications – Car tracking

Environmental Applications

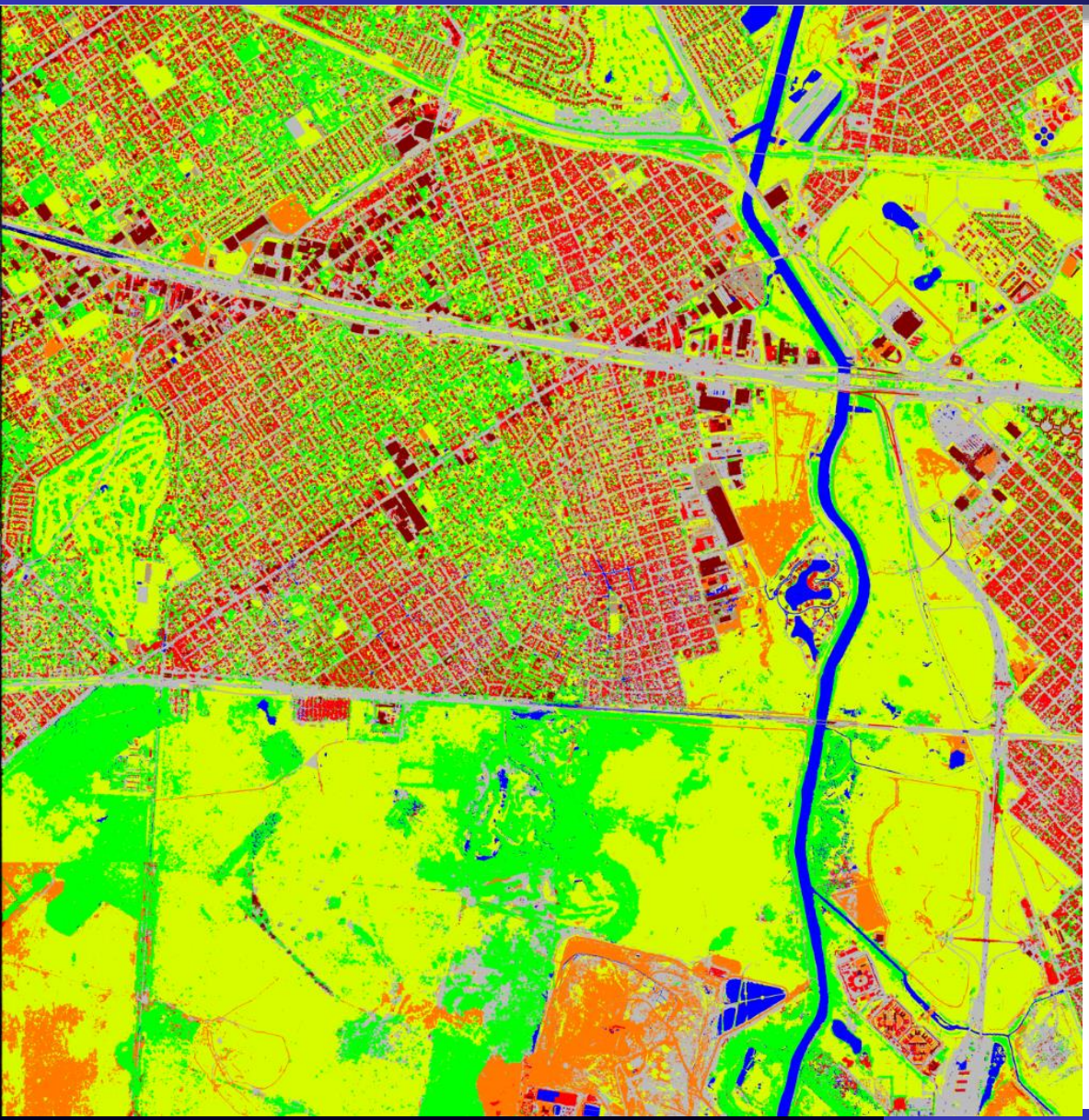
Tree type identification





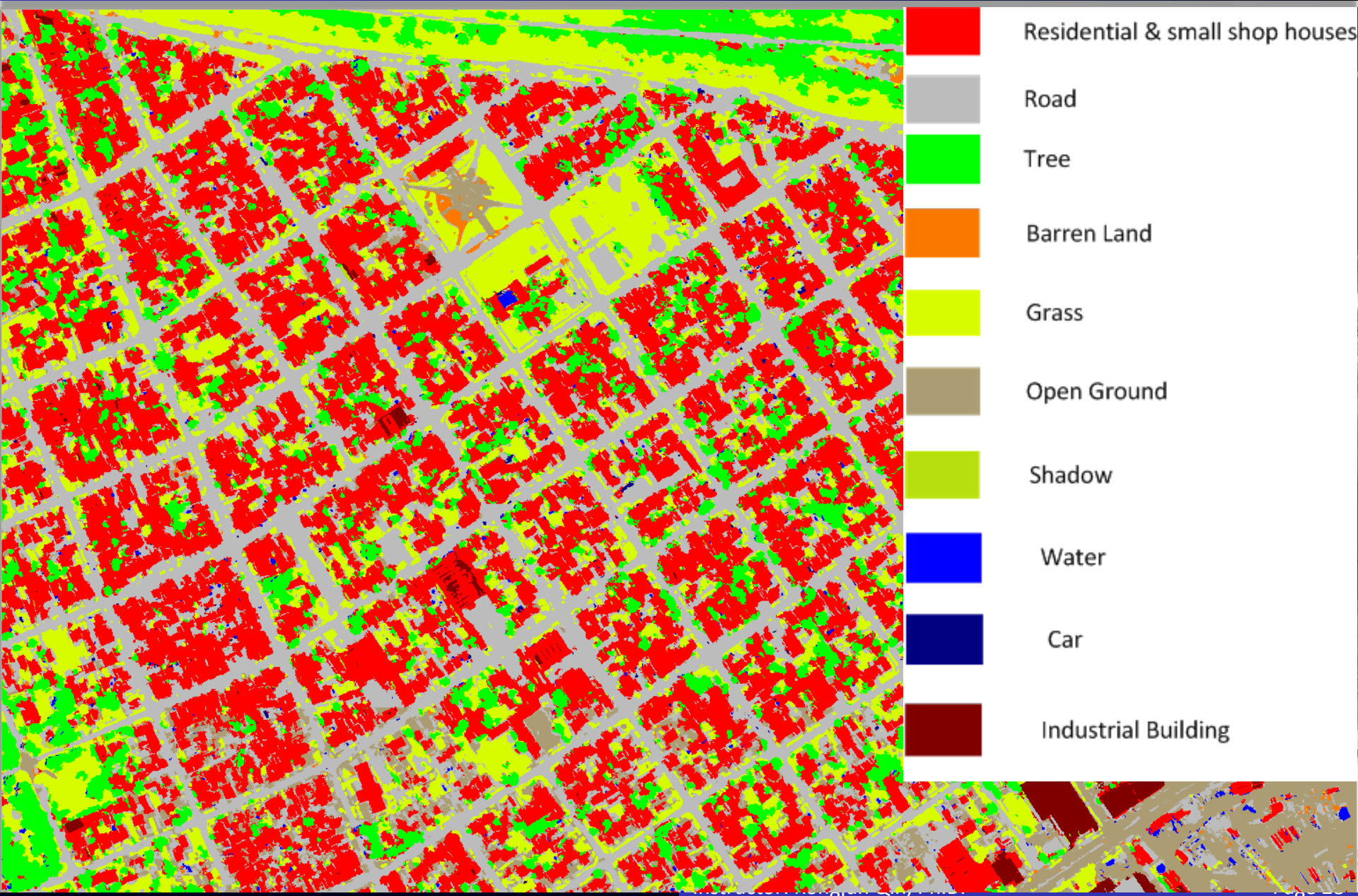


Machine Learning on Satellite Images

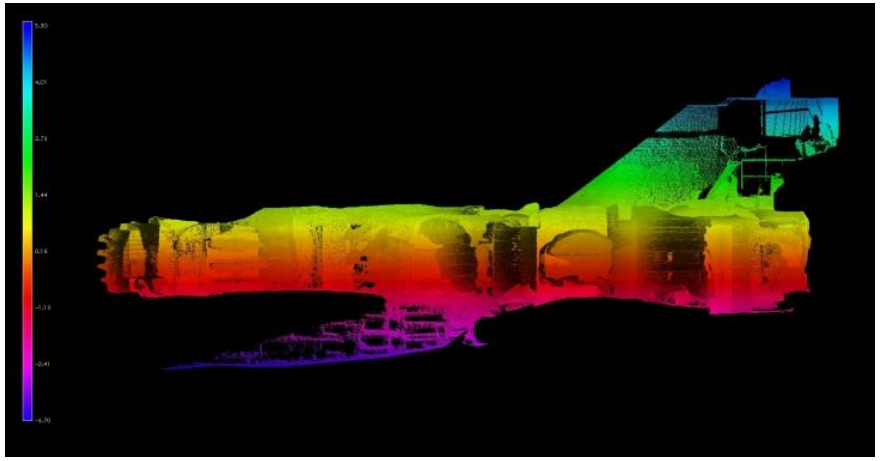


- Residential & small shop houses
- Road
- Tree
- Barren Land
- Grass
- Open Ground
- Shadow
- Water
- Car
- Industrial Building

Machine Learning on Satellite Images



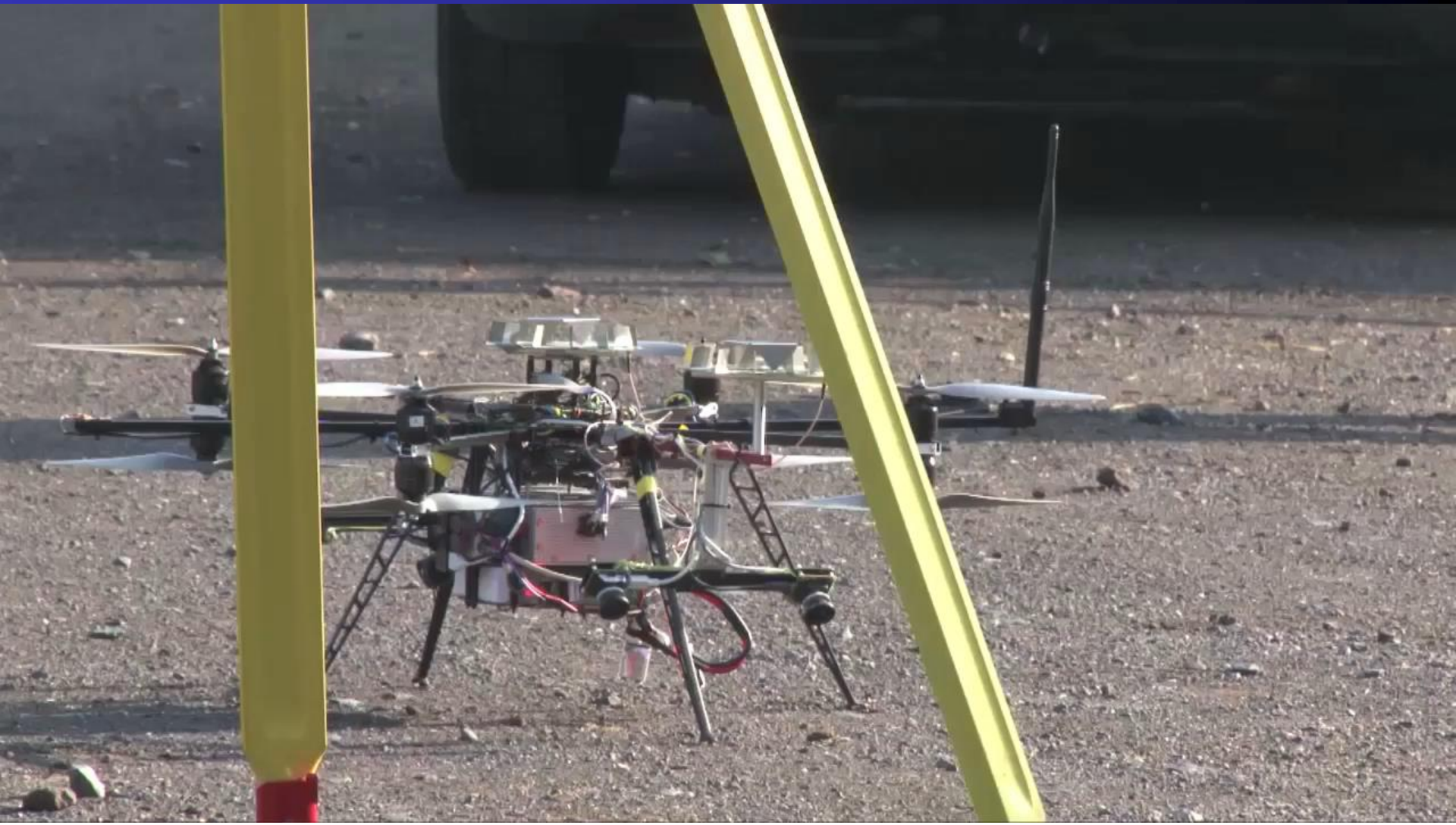
Heritage Preservation



Autonomous Driving

Google Car, Courtesy of Google

Visual Navigation



From Cyrill Stachniss

Autonomous Driving

3D Modeling for Virtual Reality

Course Content

- **Introduction**
- **Radiometry and Features**
- **Perspective Geometry**
- ***Image Orientation***
- ***Surface Reconstruction from Oriented Images***
- ***Simultaneous Localization and Mapping***

Course logistics

- **Text Book: Lecture notes**; **Reference list**; Wolgang Foestner and Bernhard Wrobel, **Photogrammetric Computer Vision**, Springer; Richard Harley and Andrew Zisserman; **Multi-view Geometry in Computer Vision,** Cambridge University Press.

Course logistics

Phone: (614) 292-4356

Office: Bolz Hall 218B

Office Hours/ Availability Outside of Class Time: Tu 2-3:30 pm or by appointment outside these hours.

Class Meeting Times: Tu- Th 09:35 am -10:55 am

Classroom: 183 Caldwell Lab.

GRADING

Homework assignments	70%
Midterm	15%
Final	15%

Assignments

Tri-weekly, including programming assignment and/or reading notes

It should be written in C/C++, MATLAB is discouraged but allowable. Refers to the slide of how to set up OpenCV

Assignment Release Time and Submission Deadlines – refer to syllabus (**Always Thursday**)

Questions?