SE 422
Advanced Photogrammetry

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Outlines

- **Definitions**
  - Photogrammetry
  - Analog, Analytic and Digital Photogrammetry
  - Photographic VS Electronic Recording
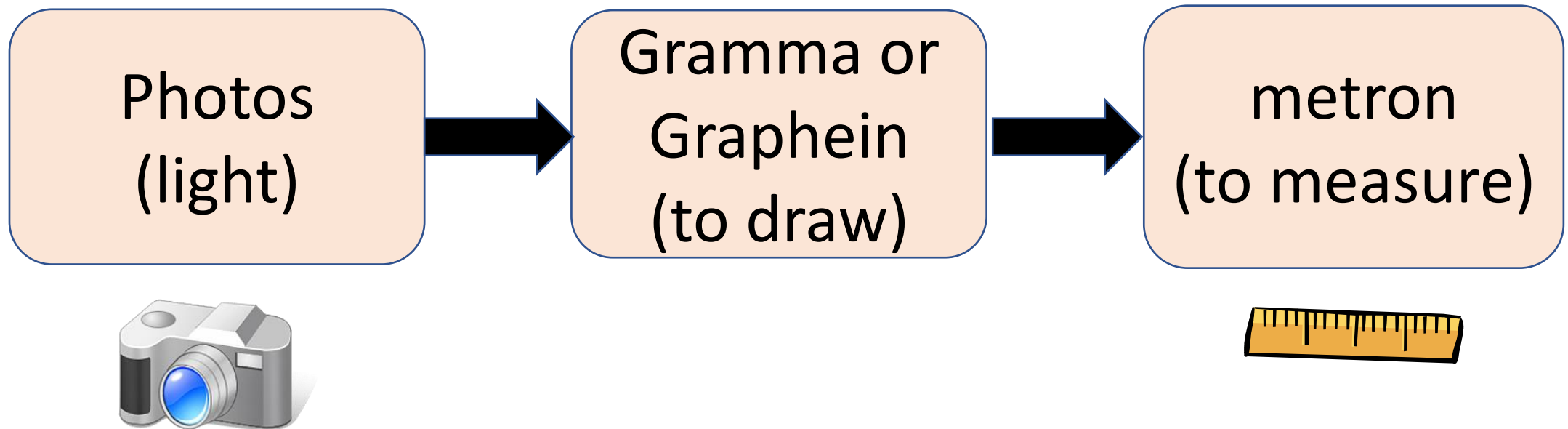 - Photograph VS Image

- **The History of Photogrammetry**
  - 1827 to present
  - Early Aerial Camera Platforms; Balloons, Rockets, Kites and Birds
  - Advantages of Photogrammetry

- **Applications**

Introduction

- **Photogrammetry Term Origin:**


[Courtesy: Cyrill Stachniss]

Introduction

- **Definition**: Photogrammetry is defined as the science of obtaining geometric information (3D coordinates) of objects from images or observations from similar sensors. Manual of Photogrammetry, 5th edition (2006)

"Process of deriving metric information about an object through measurements made on photographs of the object" Mikhail *et al. (2001)*

What are "similar sensors"?

- **Objectives:** 3D data of ground points can be determined, stored as digital information (DEM), or produced as digital or line maps.

[Courtesy: Cyrill Stachniss]
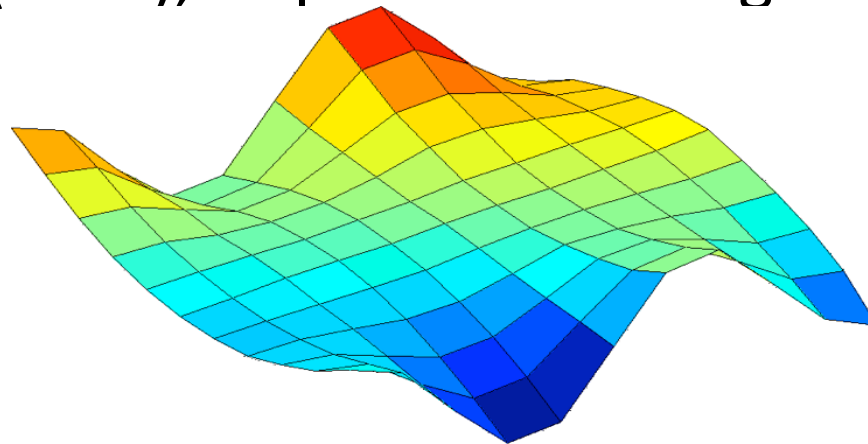
Introduction: definitions

- **Analog Photogrammetry**

Using optical, mechanical and electronical components, and where the images are hardcopies. Re-creates a 3D model for measurements in 3D space.

- **Analytical Photogrammetry**

The 3D modelling is mathematical (not re-created) and measurements are made in the 2D images.

- **Digital Photogrammetry**

Analytical solutions applied in digital images. Can also incorporate computer vision and digital image processing techniques.

- or **Softcopy Photogrammetry**

"Softcopy" refers to the display of a digital image, as opposed to a "hardcopy" (a physical, tangible photo).

Progress of Photogrammetric Techniques (History)
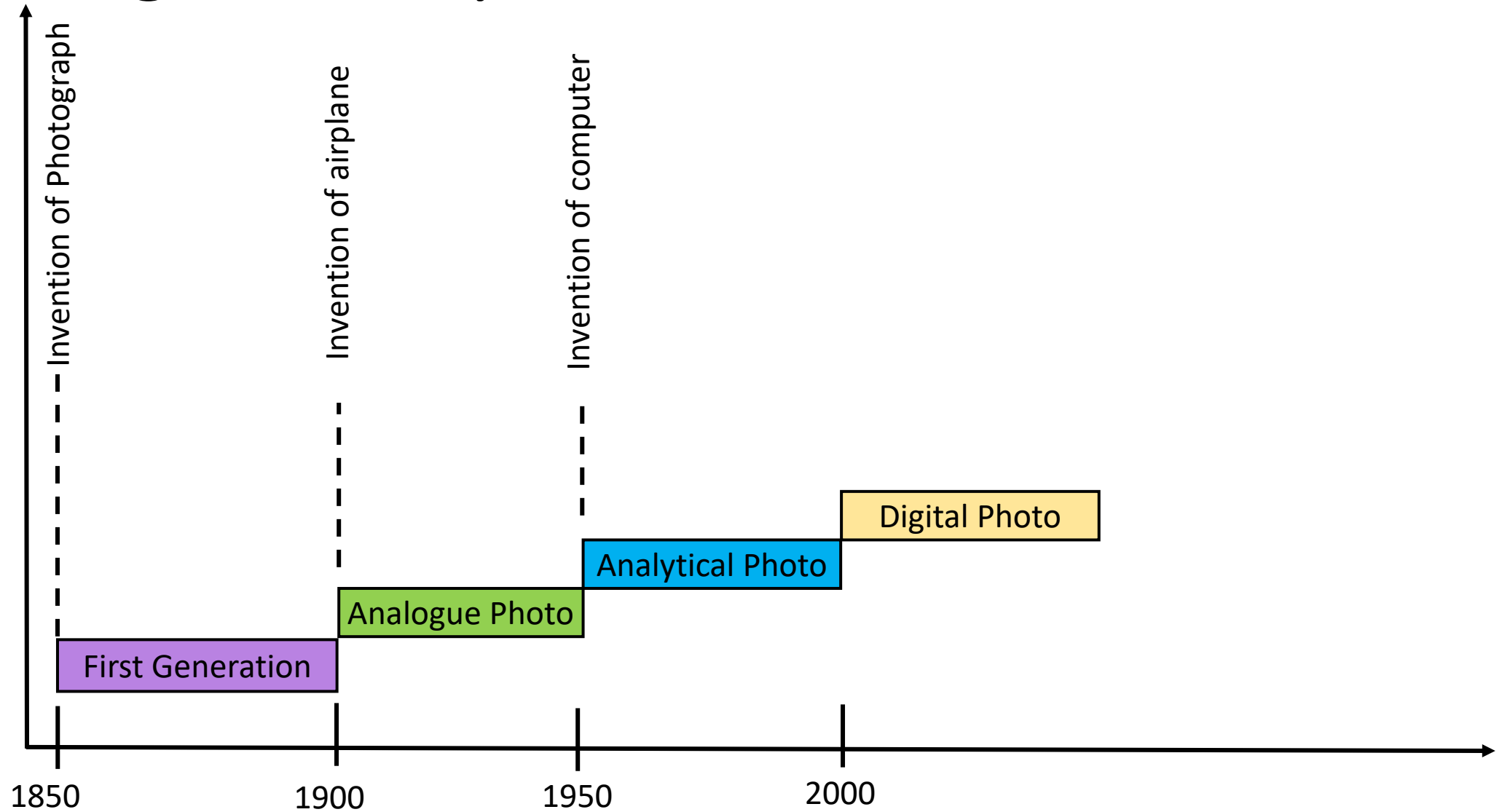

1960-1980

Analogue Photogrammetry

1980-1990

Analytical Photogrammetry

2000- to date

Digital Photogrammetry

Photogrammetry: Generations

Photogrammetry: Generations

(1) Analogue Photogrammetry: Using analogue imagery (obtained by metric cameras with films) and implementing stereo-viewing using optical or mechanical devices. The output of this process is **analogue**.
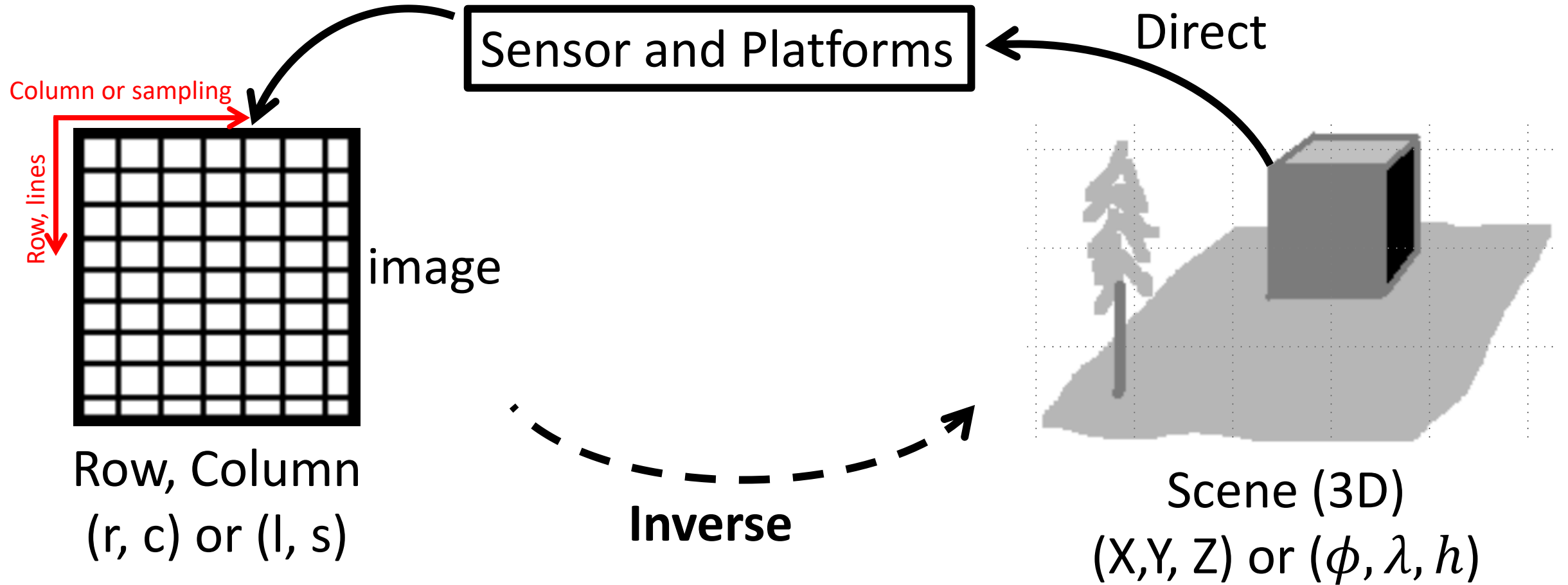
(2) Analytical Photogrammetry: Using analogue imagery and implementing stereo-viewing using computers. The output of this process is **digital**.

(3) Digital Photogrammetry: Using digital imagery (obtained by digital cameras or scanned photos) and implementing stereo-viewing using computers. The output of this process is **digital with more options**.
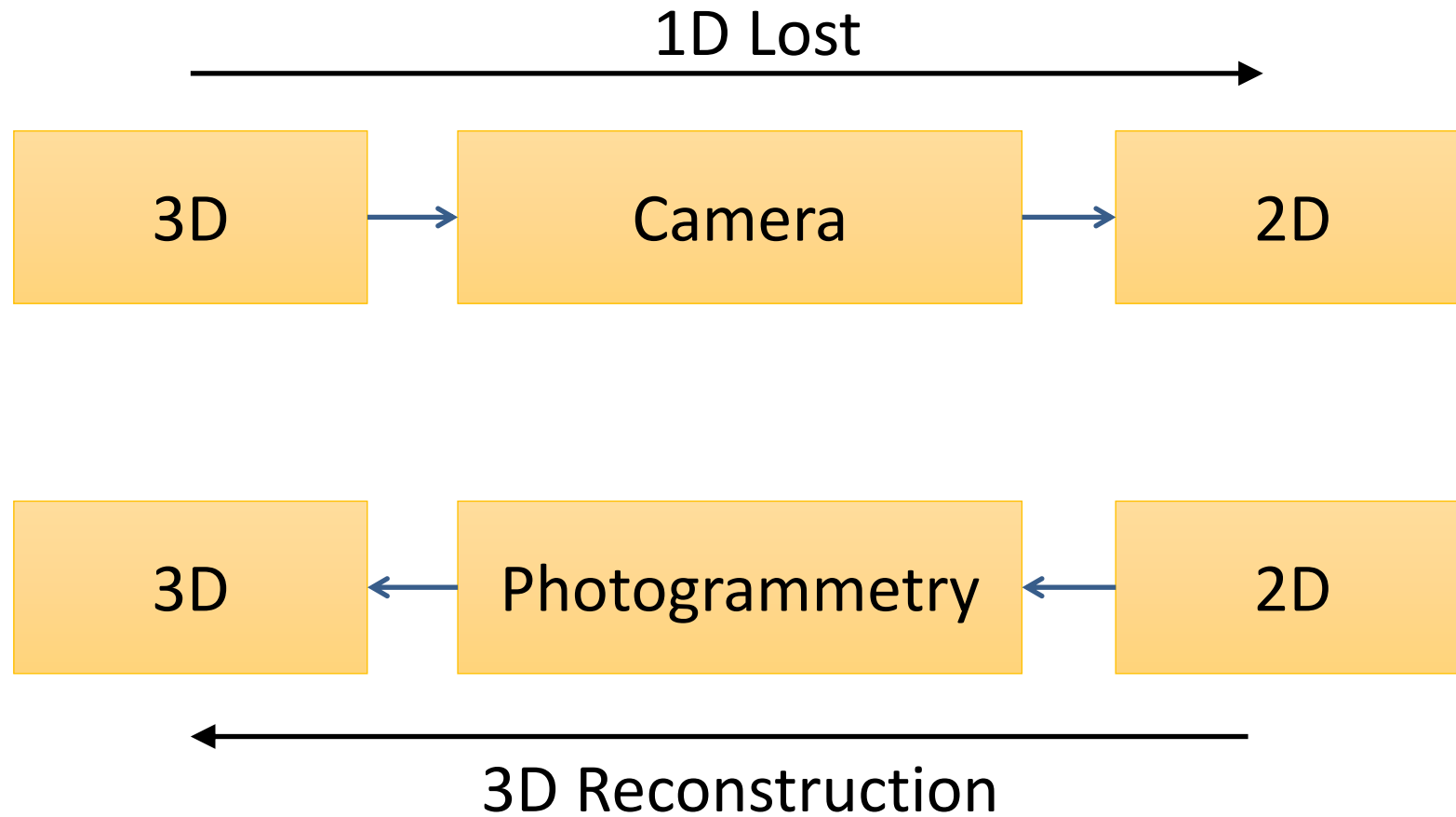
Early Photogrammetry Platforms:

- Balloons
- Model Rockets
- Kites
- Pigeons
- …
- …
- Airplane
- …
- Drone (Unmanned Aerial Vehicle: UAV)

Concept of Photogrammetry:

Column or sampling

Row, lines

Sensor and Platforms

image

Direct

Row, Column
(r, c) or (l, s)

Inverse

Scene (3D)
(X,Y, Z) or (ϕ, λ, h)

Concept of Photogrammetry:

Objectives of Photogrammetry

- Invert the process of photography

- Reconstruct the object space from imagery

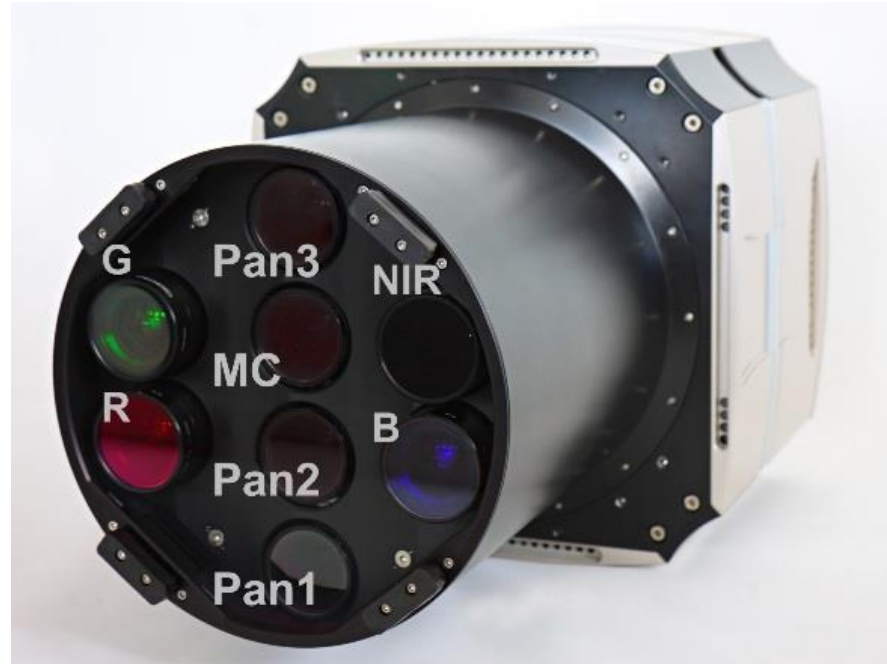- Derive 3D information (3D coordinates) from 2D imagery

Components of Photogrammetry

- Sensors (e.g., camera)

- Imagery/ Data

- Platforms (e.g., unmanned, airplane, satellite, … etc)

- Processing Techniques

- Applications/ Consumers

Importance of Surveying Engineering (Geomatics)

- Survey is the first step in execution of any civil engineering project because availability of detailed and accurate maps and plans is the first thing required to move on.

- Example, laying of roads, railways, pipelines and electric supply lines, dams construction,….

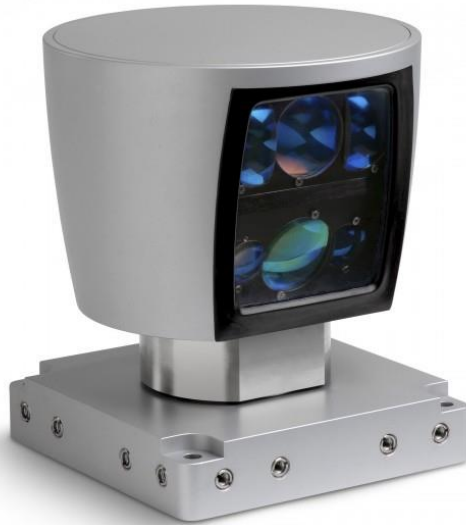# Typical Sensors:

- Microsoft Ultracam (Bing Maps)

[Courtesy: Microsoft]

Typical Sensors:

- Industrial Cameras

Stingray
F-125

[Courtesy: Stingray, ImagingSource, UniQ]

Typical Sensors:

- Consumer Cameras

Typical Sensors:

• Laser Range

[Courtesy: Velodyne, Sick, Faro]

Processing Techniques in Photogrammetry (1)

- Point measurement

- Space Resection, space intersection

- Bundle-block adjustment (BBA)

- Rectification, registration

- Terrain and feature extraction

- Segmentation

- Multispectral / hyperspectral classification

Processing Techniques in Photogrammetry (2)

- Manual, automated, semi-automated

- Analog, digital

- Optical flow analysis

- Change detection

- Automated target recognition

- Stereo viewing, interpretation and 3D data capture

Processing Techniques in Photogrammetry (3)

- Visualization, image based rendering

- Image restoration, enhancement, super-resolution

- Data fusion

- Mosaics

- Matching and correspondence

- Compression

- Data hiding, digital watermarking

Applications

- Topographic mapping, cartography, large scale, small scale

- Land development, roadway design, earthwork computation

- Data for GIS, transportation, urban features, land use

- Reconaissance, surveillance

- Targeting

- Creation of 3D CAD models

- Image based rendering, virtual scene generation, replacement of actual camera operation
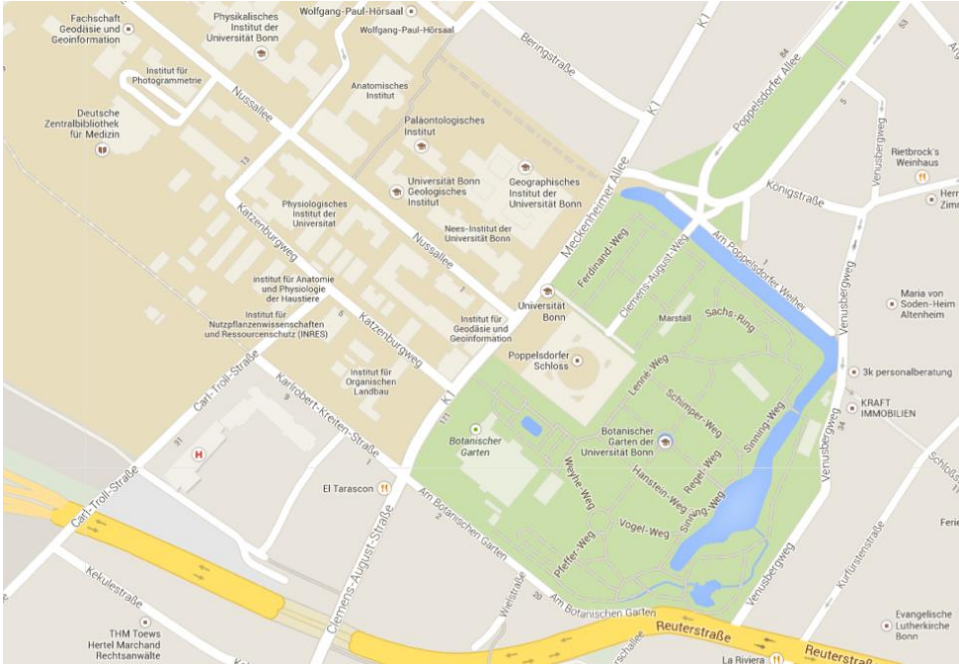
Applications

- Visualization, simulation

- Close-range: industrial, architectural, medical

- Resource management, forests, agriculture, wildlife, urbanization, environmental assessment

- Mineral, petroleum exploration

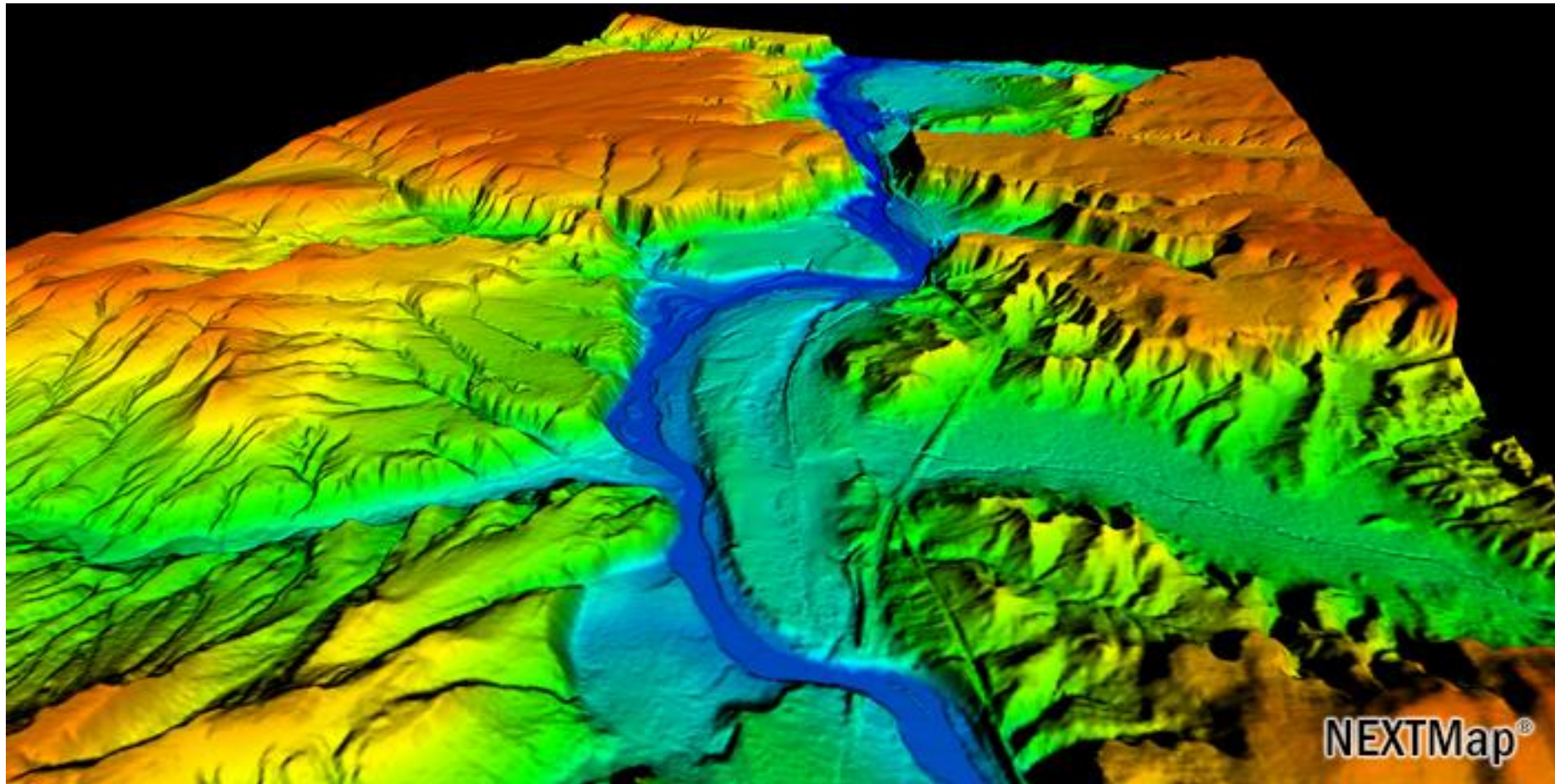# Photogrammetric Applications

- Archaeology

- Medicine

- Digital Elevation Models

- 3D City Modelling

- Crime Scene Investigation

- Biometrics

- Machine Vision

- Optical Character Recognition (OCR)
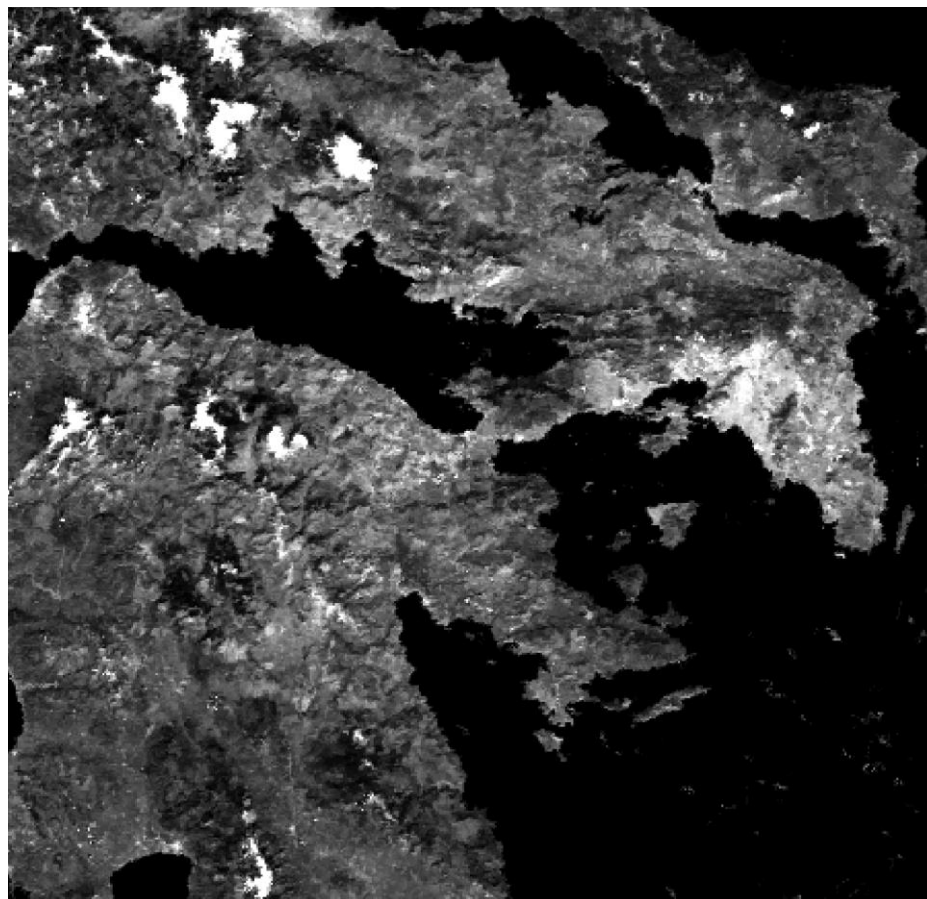
Applications of Geomatics: Maps

[Courtesy: Google Maps]
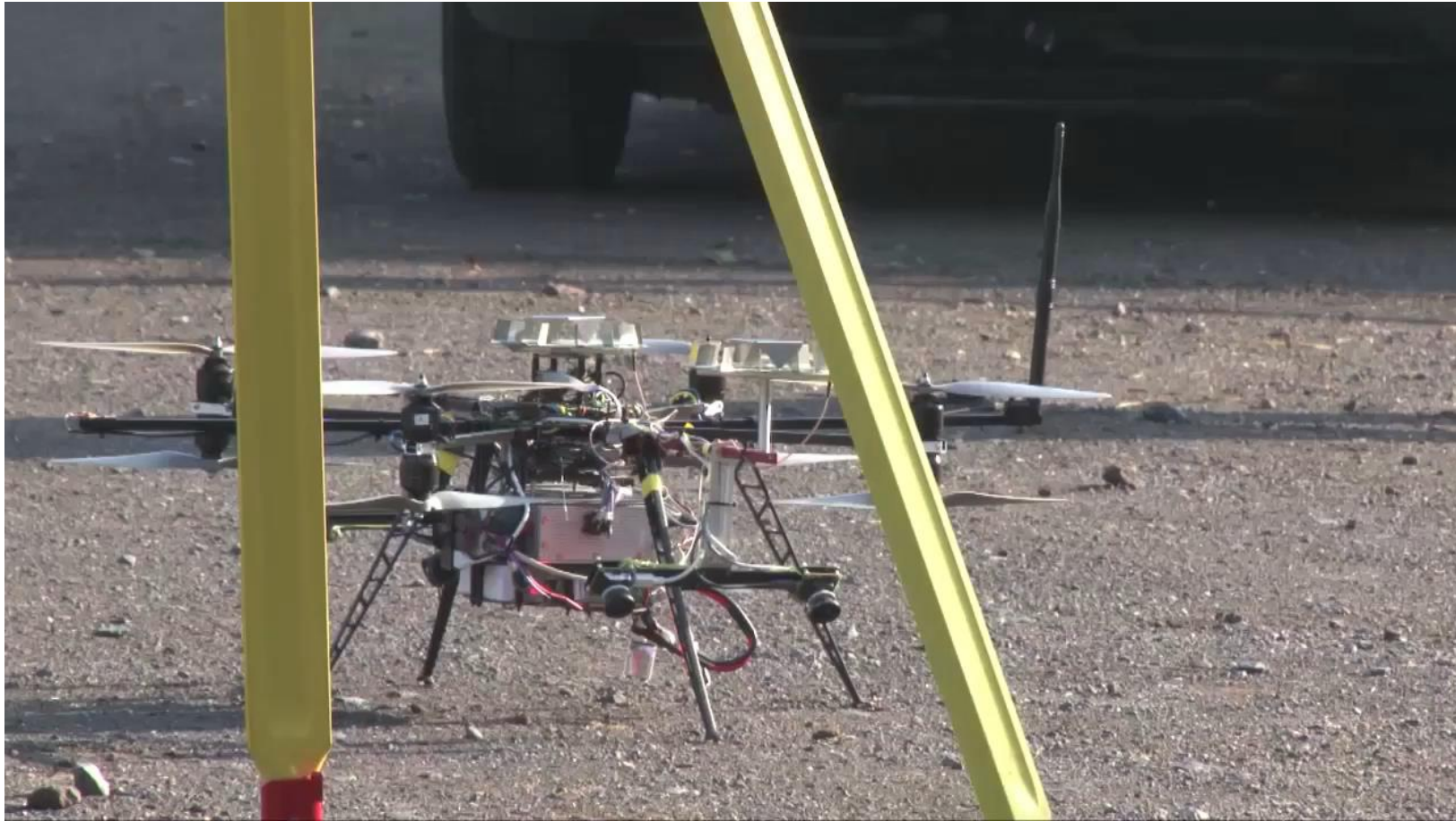
Application: Terrains Models

[Courtesy: NEXTMap]

Application: Environmental Monitoring

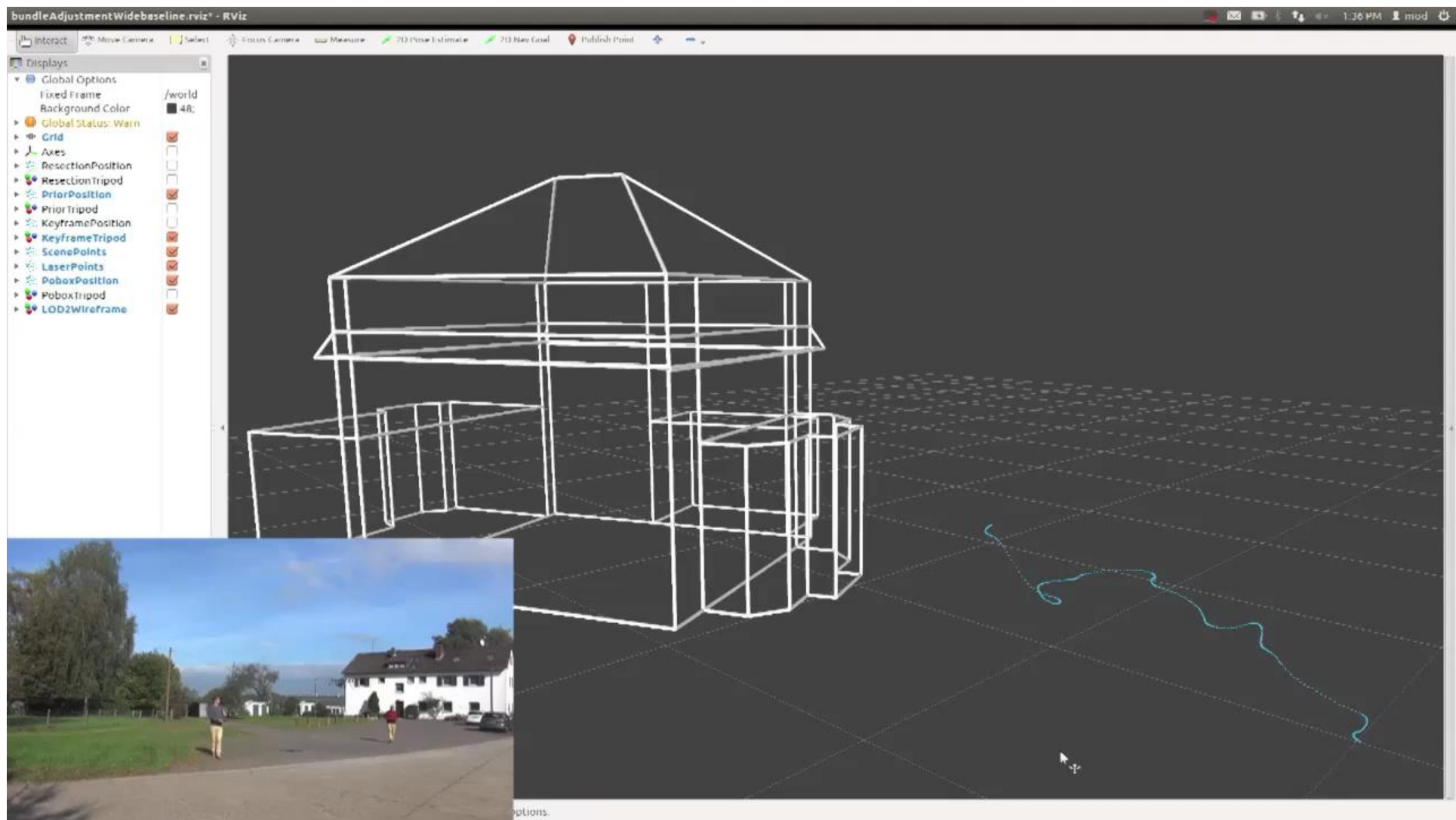[Courtesy: DLR]

Applicatio: Aerials Mapping (1)

[Courtesy: Cyrill Stachniss]

Source:store.dji.com

Applications: Aerial Mapping (2)

[Courtesy: Cyrill Stachniss]

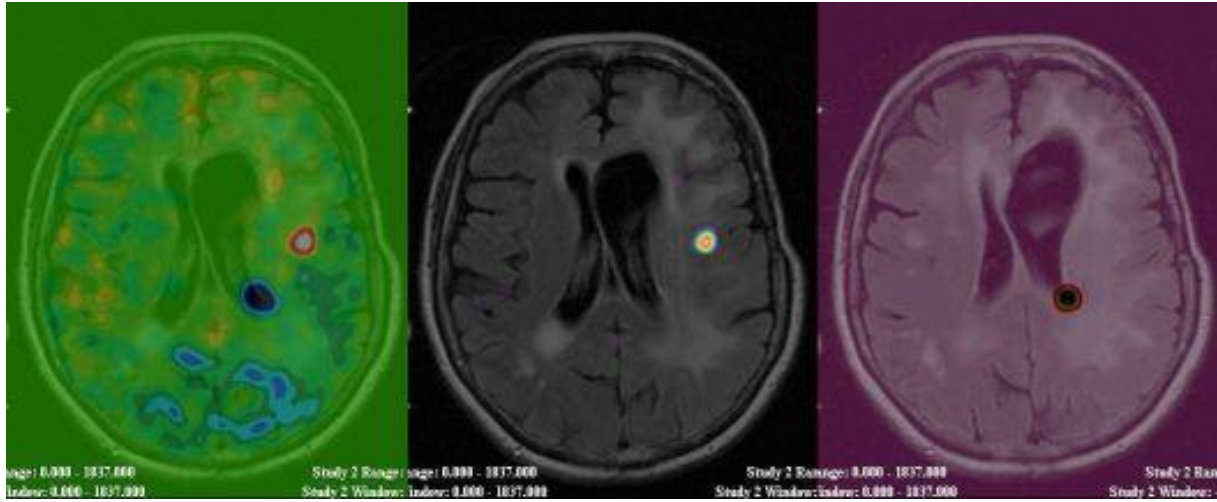# Application: Orthophotos

Application: City Mapping

Application: 3D City Model
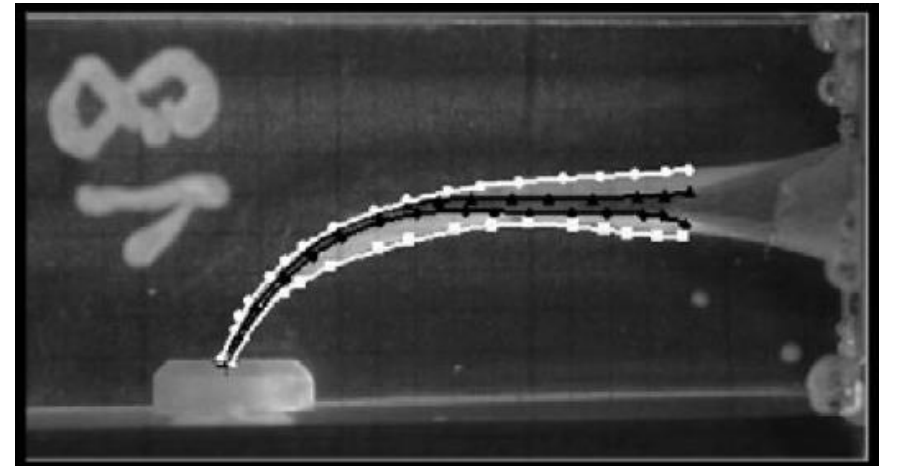
Application: Medical

Alignment of MRI scans over time

Determination of root canal curvatures before and after canal preparation

[Courtesy: Cyrill Stachniss]

Application: Quality Control

I. Elhasan, H. Bilani, M. Alheyf

[Courtesy: Cyrill Stachniss]

Application: Robotics

I. Elhasan, H. Bilani, M. Alheyf
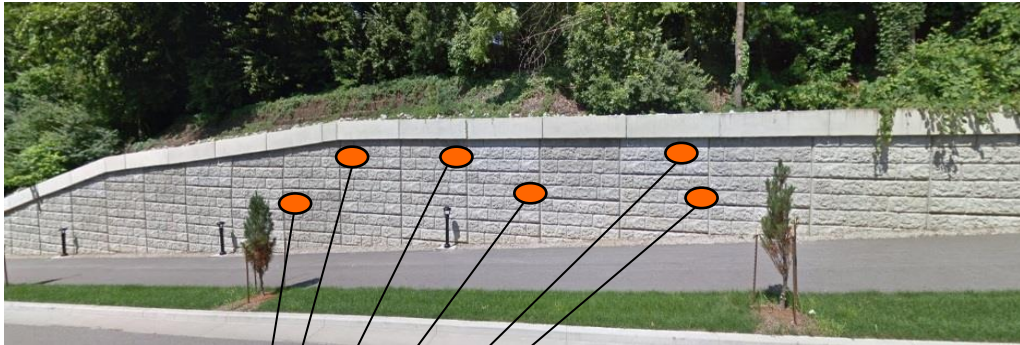
[Courtesy: Cyrill Stachniss]

Application: Monitoring Infrastructure

- Infrastructures such as bridges, retaining wall, tunnels, dams, … etc

Application: Monitoring Infrastructure

Relative movement of concrete panels

Backfill Leakage

I. Elhasan, H. Bilani, M. Alheyf

Application: Monitoring Infrastructure

r^m

Z_m

X_m **Mapping Frame**

Y_m
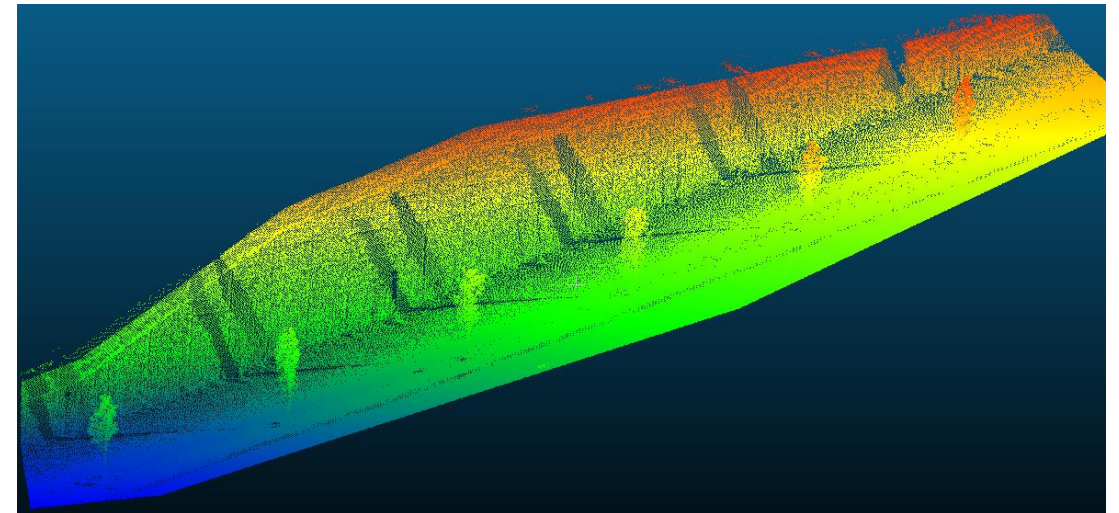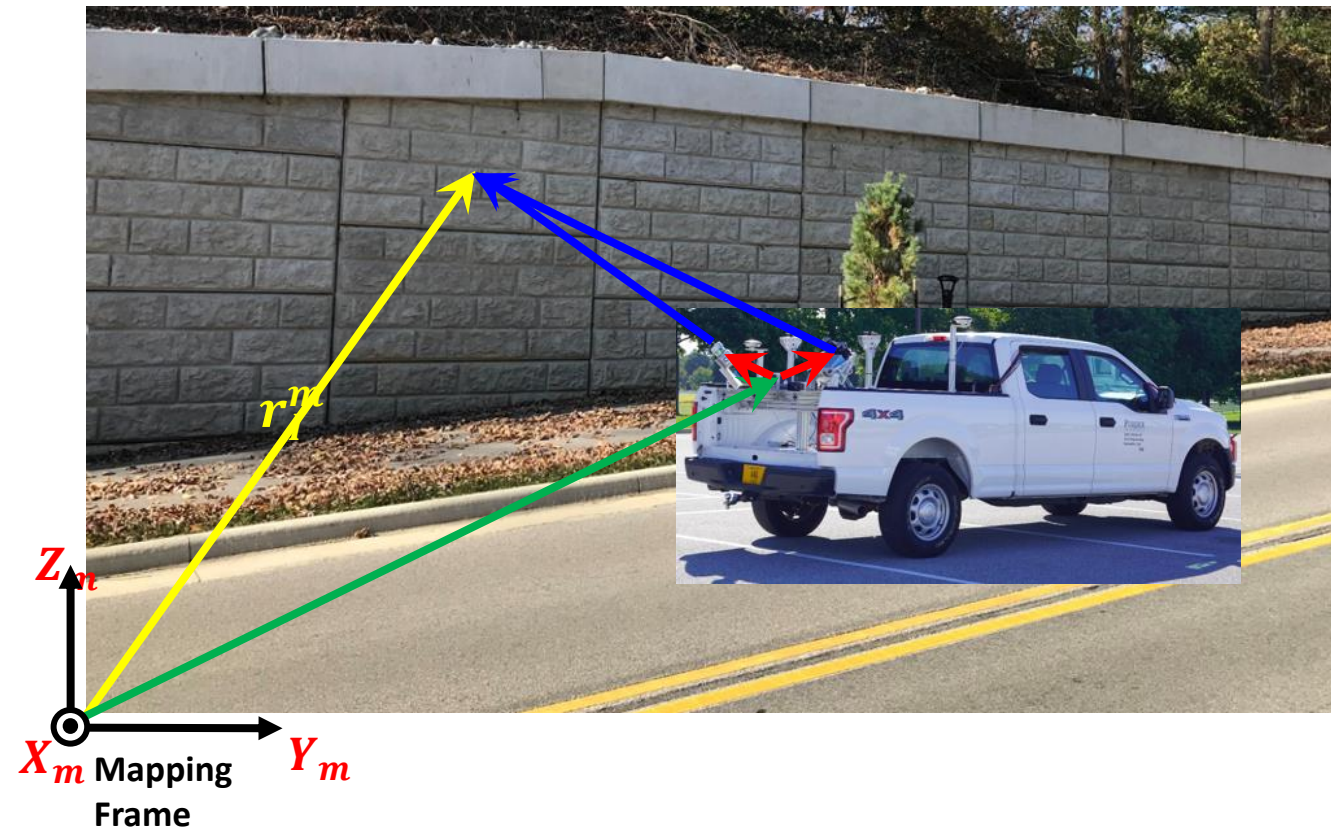
Point Clouds of an object

I. Elhasan, H. Bilani, M. Alheyf

Advantages of Photogrammetry:

- (1) Contact-free sensing

- (2) Dense coverage of comparably large areas

- (3) Flexible range (small but accurate and large but coarse models)

- (4) Ability to record dynamic scenes

Disadvantages of Photogrammetry:

- (1) Light source is needed

- (2) Occlusions and visibility constraints

- (3) One image a projection from the 3D world to a 2D image plane

- (4) Other techniques may achieve a higher measurement accuracy

Types of Photogrammetry according to distance (distance-based):

(1) Terrestrial (Close Range) Photogrammetry

- Precision survey of buildings and engineering objects
- Documentation of historical buildings
- Medical applications
- Personal Identification
- Mapping of roads & nearby objects (mobile mapping systems)

(2) Aerial Photogrammetry

- Reconnaissance & exploration.
- Mapping (topographic, thematic, cadastral, geologic…etc
- Digital Terrain Model (DTM) generation.
- Land use planning & mapping
- Construction and route planning
- Military applications

(3) satellites Photogrammetry

Types of Photogrammetry according to accuracy :

Photogrammetry

- **Metric (geometric)** based on stereo-models
Interior orientation parameters (IOPs) are known
Making precise measurements from photos to
determine the relative locations of points
  - Distances   - Angles
  - Areas   - Volume
  - Elevations   -Sizes
- **Non-metric:** IOPs are not known (i.e., all consumer
  grade cameras)

Interpretative
Based on a single photo