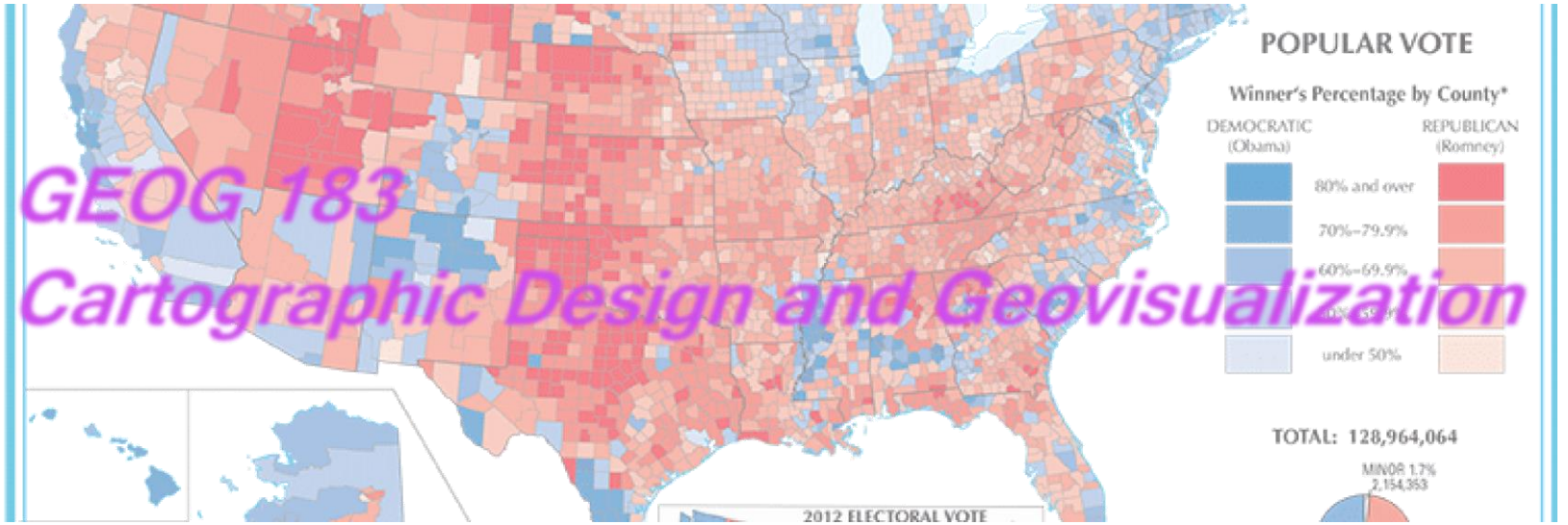
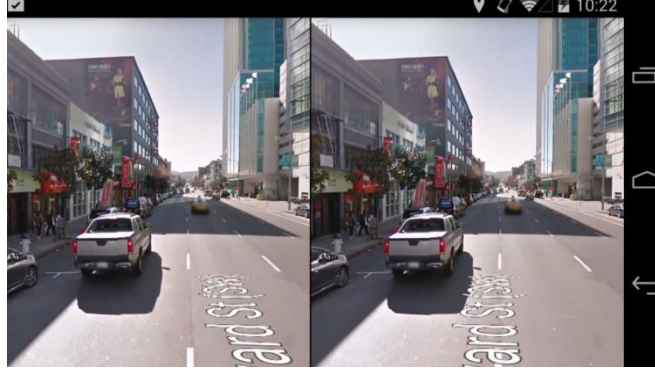


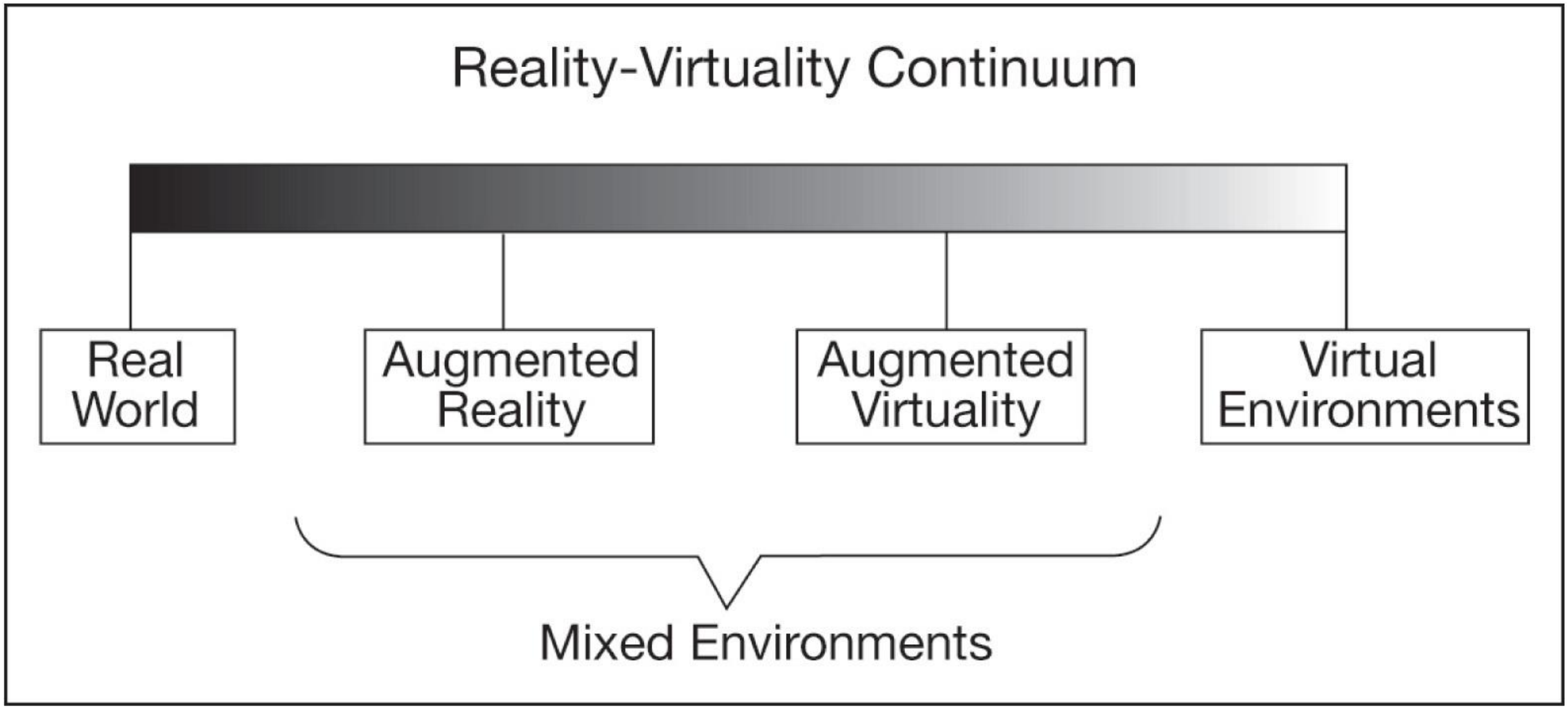
Geog183: Cartographic Design and Geovisualization Spring Quarter 2020

Lecture 17: Cartography in virtual environments

Virtual reality: A spectrum



- ***Virtual reality:*** computer-simulated environment that can simulate physical presence in places in the real world or imagined worlds. Virtual reality can recreate sensory experiences, which include virtual taste, sight, smell, sound, and touch.
  - Immersive multimedia
  - Virtual environment
- ***Mixed reality***: merging of real and virtual worlds to produce new environments and visualizations where physical and digital objects co-exist and interact in real time.
- ***Augmented reality***: a live direct or indirect view of a physical, real-world environment whose elements are augmented (or supplemented) by computer-generated sensory input such as sound, video, graphics or GPS data



Some history

- Mid 1950s, visionary cinematographer Morton H. Eilig built a single user console called Sensorama
  - stereoscopic display
  - fan scent emitters
  - stereo speakers
  - moving chair
- 1961, Philco Corporation developed the first HMD the “Headsight.”
  - helmet had a video screen and tracking system.
  - linked to a closed circuit camera system
  - used for helicopter pilots
- In 1965, Ivan Sutherland envisioned what he called the “Ultimate Display.”
  - “After using this display a person imagines the virtual world very similar to the real world.”
  - During 1966, Sutherland built a tethered VR system

Sensorama and Headsight

Sutherland (1965) Flight Simulator

A HEAD-MOUNTED THREE-DIMENSIONAL DISPLAY*

Ivan E. Sutherland

* The work reported in this paper was performed at Harvard University, supported in part by the Advanced Research Projects Agency (ARPA) of the Department of Defense under contract SD 265, in part by the Office of Naval Research under contract ONR 1866 (16), and in part by a long standing agreement between Bell Telephone Laboratories and the Harvard Computation Laboratory. The early work at the NUT Lincoln Laboratory was also supported by ARPA.

Introduction

The fundamental idea behind the three-dimensional display is to present the user with a perspective image which changes as he moves. The retinal image of the real objects which we see is, after all, only two-dimensional. Thus if we can place suitable two-dimensional images on the observer's retinas, we can create the illusion that he is seeing a three-dimensional object. Although stereo presentation is important to the three-dimensional illusion, it is less important than the change that takes place in the image when the observer moves his head. The image presented by the three-dimensional display must change in exactly the way that the image of a real object would change for similar motions of the user's head. Psychologists have long known that moving perspective images appear strikingly three-dimensional even without stereo presentation; the three-dimensional display described in this paper depends heavily on this "kinetic depth effect". (1)

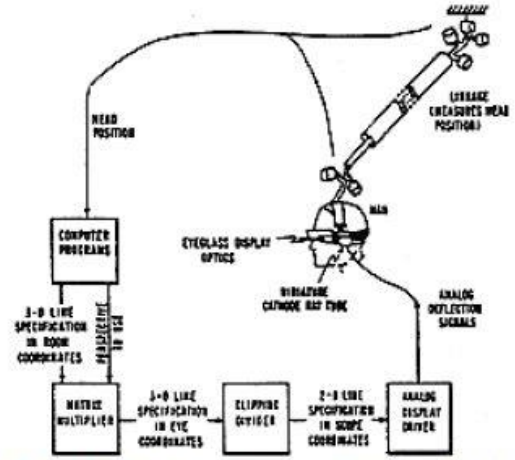
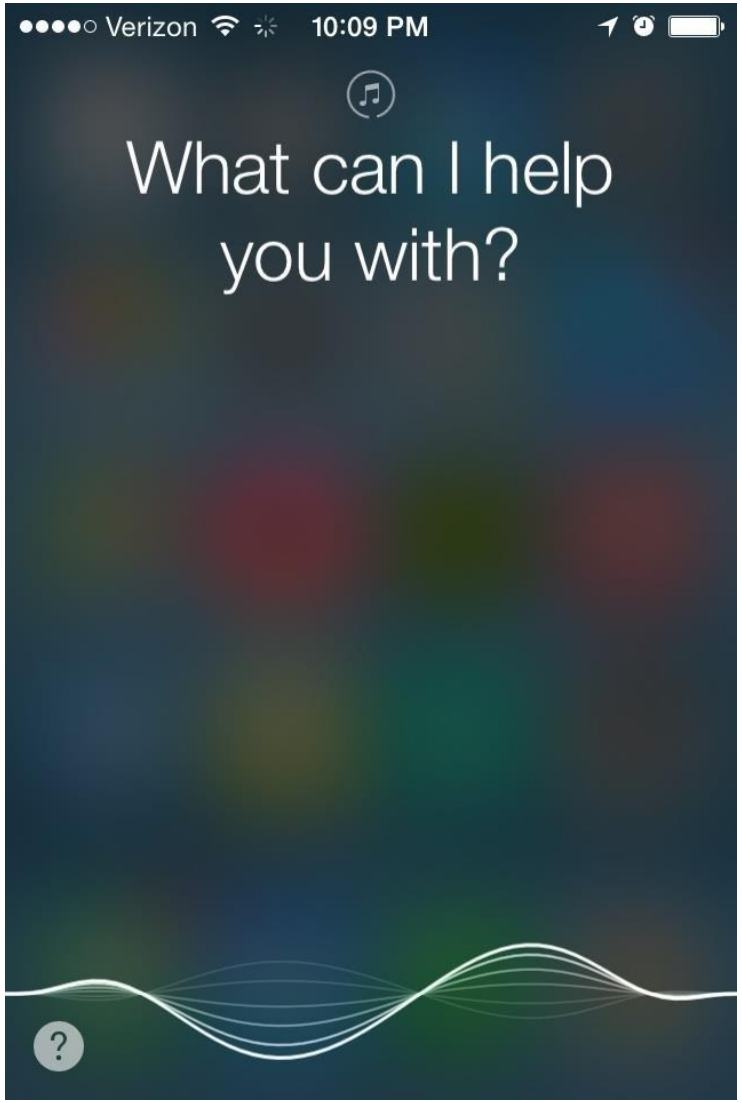


Figure 1: The parts of the three-dimensional display system

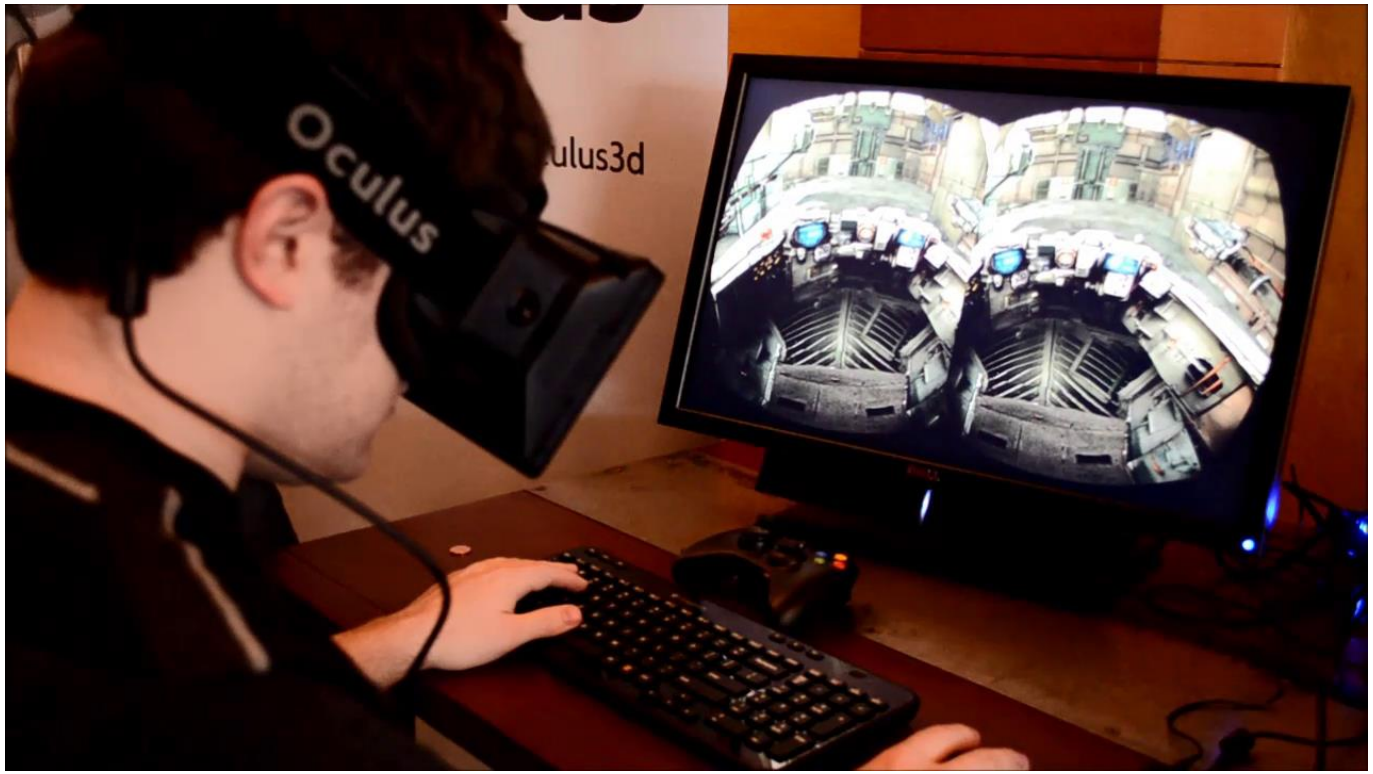
True VR: Immersive, interactive, multi-sense

Types of interaction

- Voice recognition
- Navigation
- Zoom: “Drill down”: Progression
- See through
- Search
- 3-D visualization and movement
- Time-line
- Multimedia : web links and portals

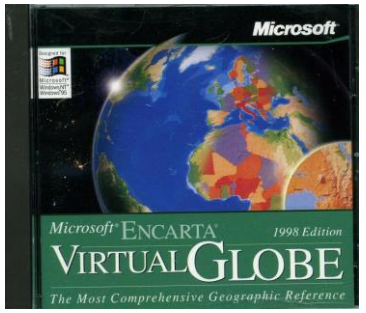


How does it work?



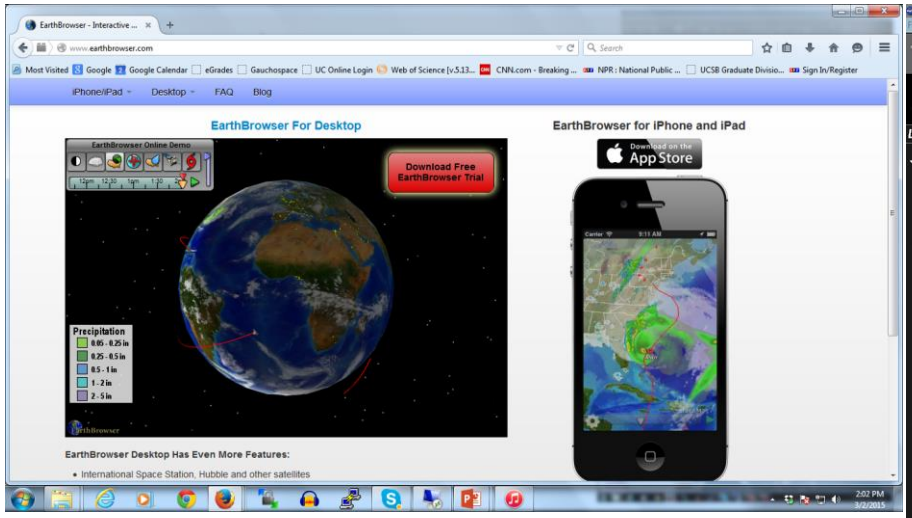
- Synchronized sound and video
- Stereo separation by isolated lenses
- Head movement sensing
- Reduced frame and interaction lag

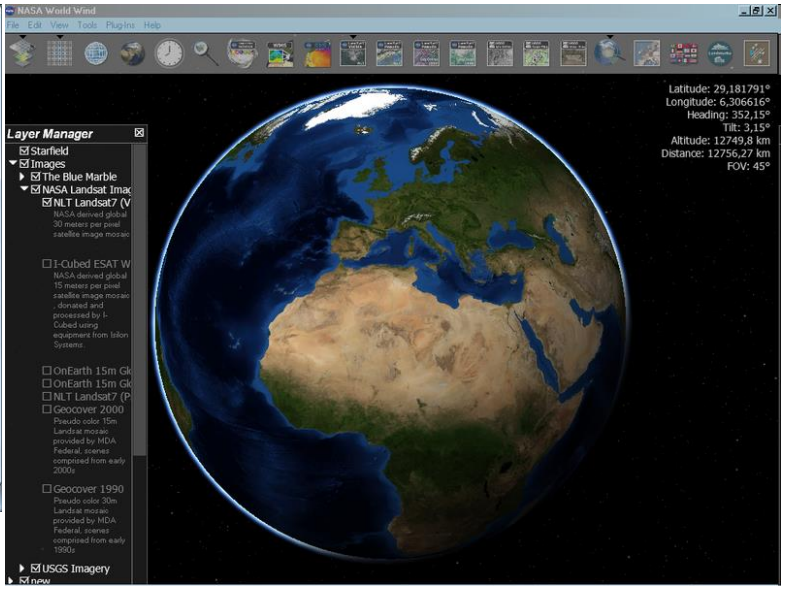
Virtual Globes



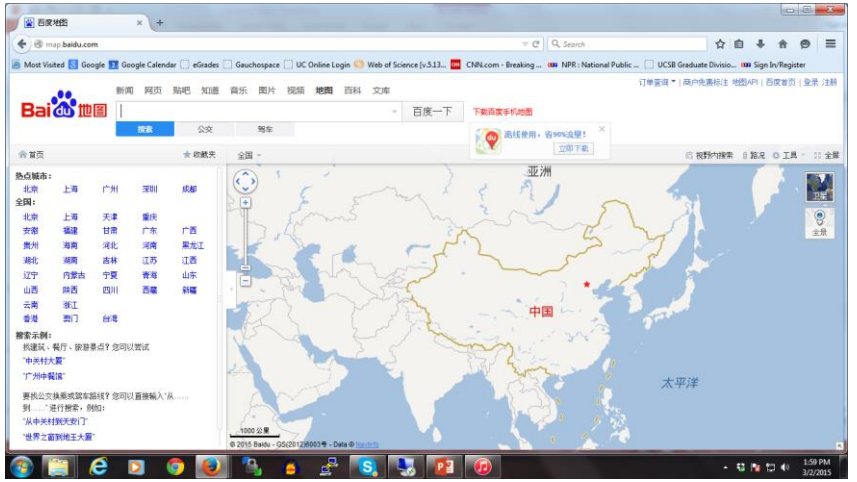
- A **virtual globe** is a 3D software model or representation of the Earth or another world
  - provides the user with the ability to freely move around in the virtual environment by changing the viewing angle and position.
  - have the additional capability of representing many different views on the surface of the Earth
  - geographical features, man-made features such as roads and buildings, or abstract representations of demographic quantities such as population
- In 1998, Microsoft released a popular *offline* virtual globe in the form of *Encarta Virtual Globe 98*.
- The first widely publicized *online* virtual globes were NASA World Wind (released in mid-2004) and Google Earth (mid-2005)
- Many virtual globes exist today

Examples

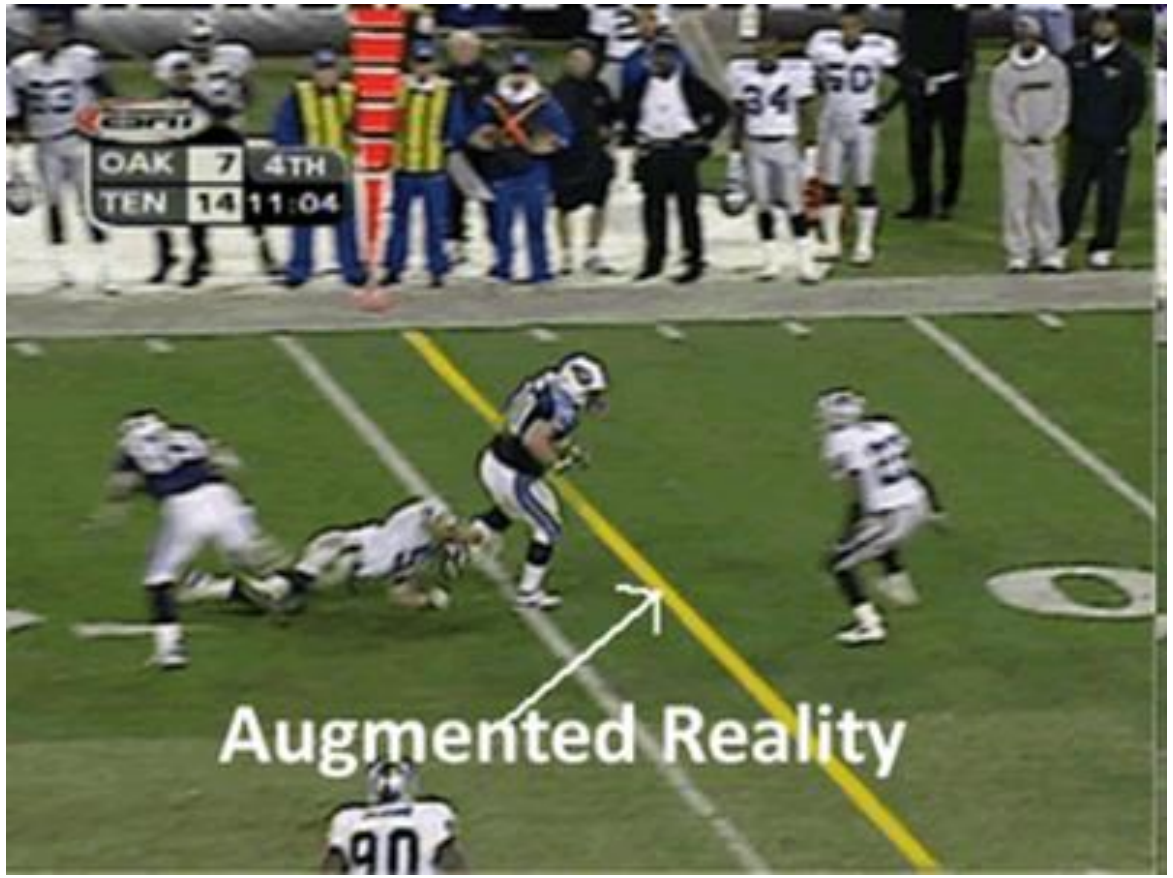




- NASA World Wind
- CitySurf Globe
- Bing Maps
- SkylineGlobe
- Google Earth
- Marble, part of the K Desktop Environment, with OpenStreetMap
- ArcGIS Explorer
- EarthBrowser
- Software MacKiev's 3D Weather Globe & Atlas
- Earth3D
- WorldView
- Bhuvan
- Baidu Map
- National Geographic Atlas



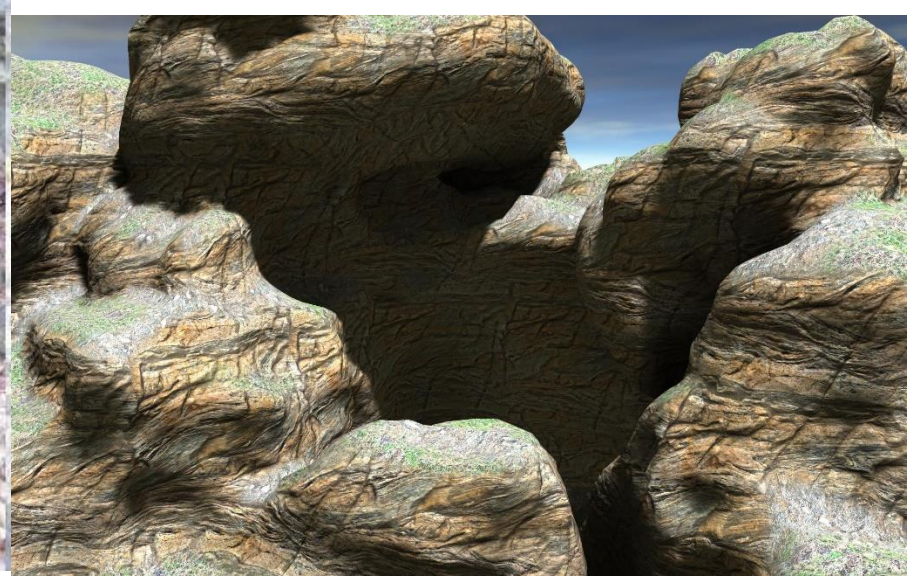
Augmented reality



Some issues

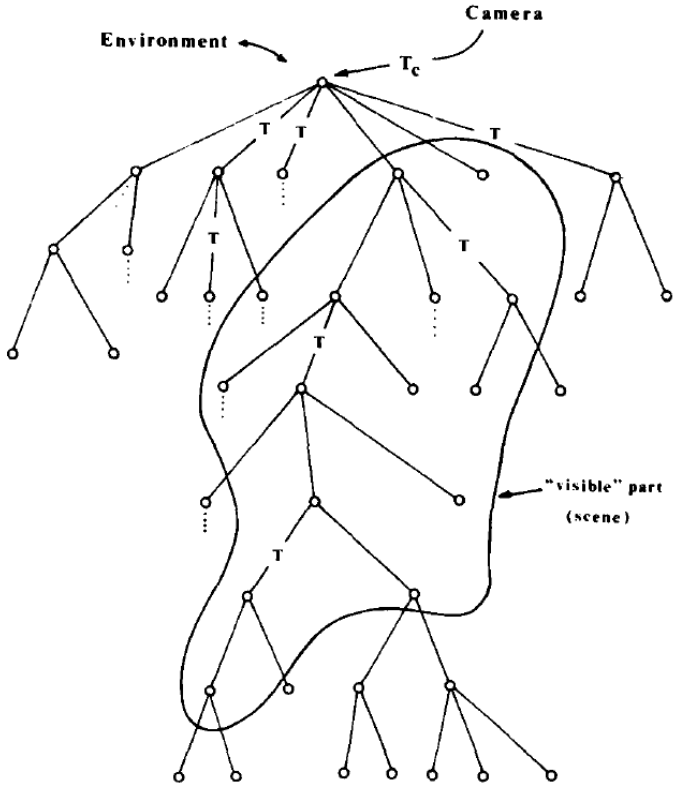
- How do you collect 3D data for photorealism?
- How much realism is necessary?
- How does interaction change the experience?
- What about permanent and temporary objects?
- How do you deal with underground and overlapping spaces?
- Cognitive disturbance: Foveation and peripheral vision altered
- Image lag and motion sickness

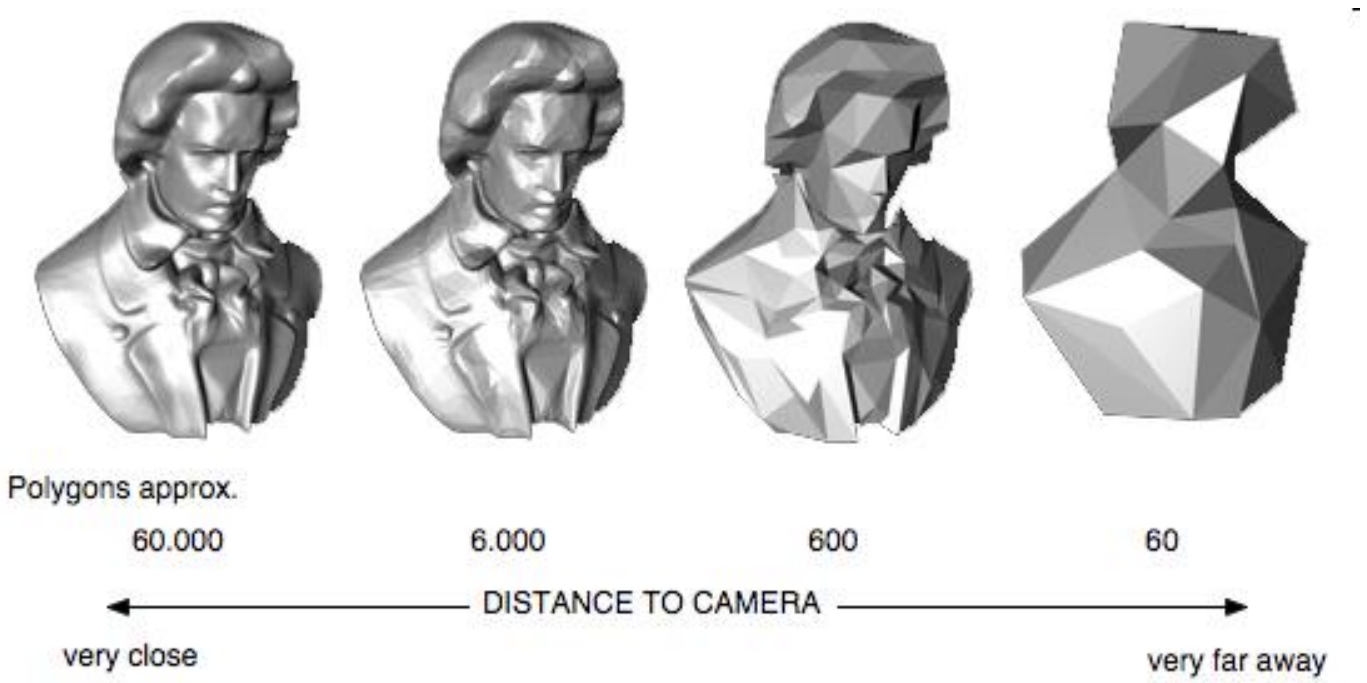
The issue: Can you sense reality?



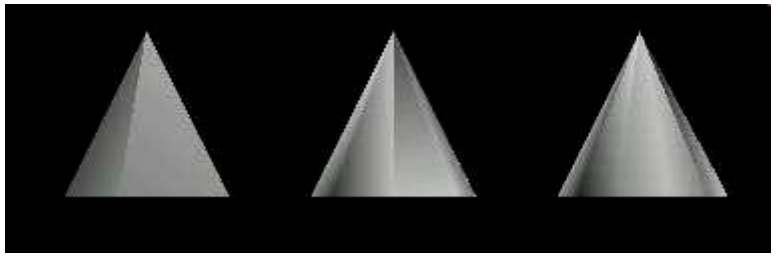
Generalization in Computer Graphics: Level of Detail

- James H. Clark (1976) *Hierarchical Geometric Models for Visible Surface Algorithms*. Communications of the ACM, October 1976,19, 10. pp 547-554.



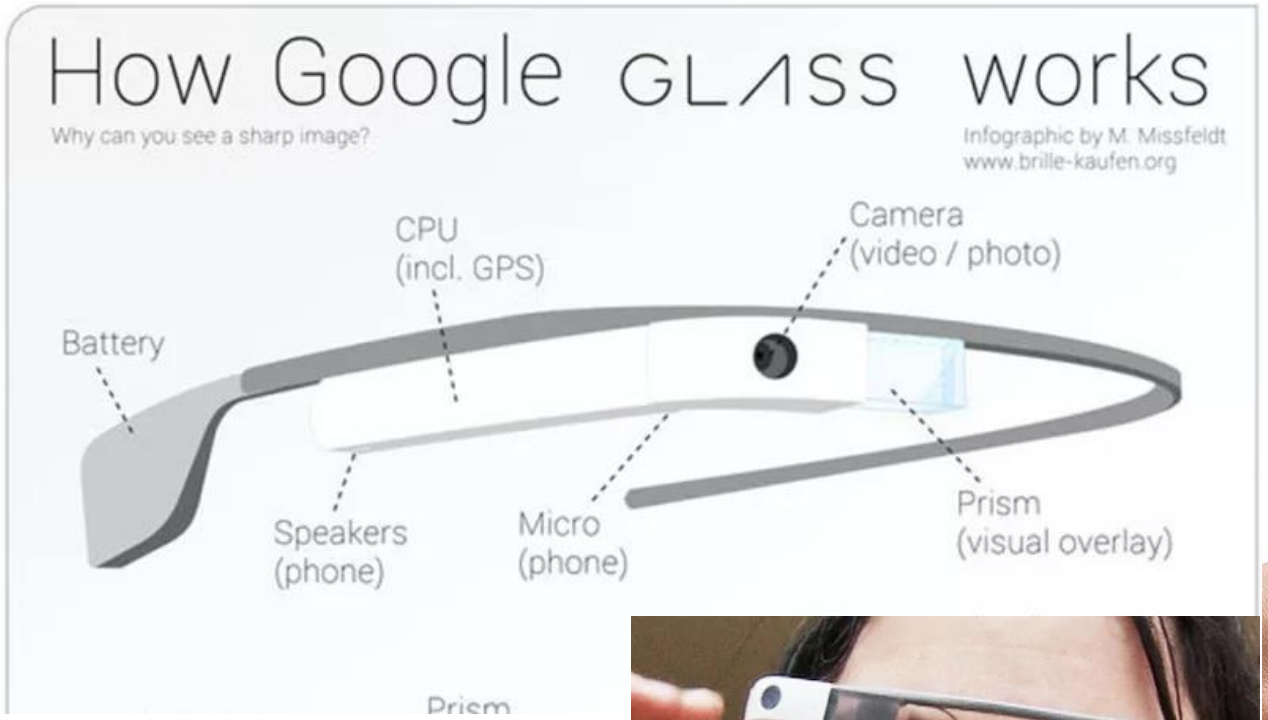


VRML 2.0 LOD Example



```
#VRML V2.0 utf8
LOD { range [20,40] level [
#full detail 16 sided cone
Shape{ appearance Appearance { material Material { diffuseColor 1.0 1.0 1.0 }
geometry Extrusion{ crossSection [ -1 0, 0 0, -1 -2 -1 0]
spine [1 0 0 , 0.866 0 0.5, 0.5 0 0.866, 0 0 1 , -0.5 0 0.866, -0.866 0 0.5, -1 0 0, -0.866 0 -0.5,
   -0.5 0 -0.866, 0 0 -1 , 0.5 0 -0.866, 0.866 0 -0.5, 1 0 0 ] } }
#intermediate detail 8 sided cone
Shape{ appearance Appearance { material Material { diffuseColor 1.0 1.0 1.0 } }
geometry Extrusion{ crossSection [ -1 0, 0 0, -1 -2 -1 0]
spine [1 0 0 , 0.707 0 0.707 , 0 0 1 , -0.707 0 0.707, -1 0 0,-0.707 0 -0.707, 0 0 -1 , 0.707 0 -
   0.707, 1 0 0 ] } }
#low detail 4 sided cone
Shape{ appearance Appearance { material Material { diffuseColor 1.0 1.0 1.0 } }
geometry Extrusion{ crossSection [ -1 0, 0 0, -1 -2 -1 0]
spine [1 0 0 , 0 0 1, -1 0 0, 0 0 -1 , 1 0 0 ] } }
]
}
```

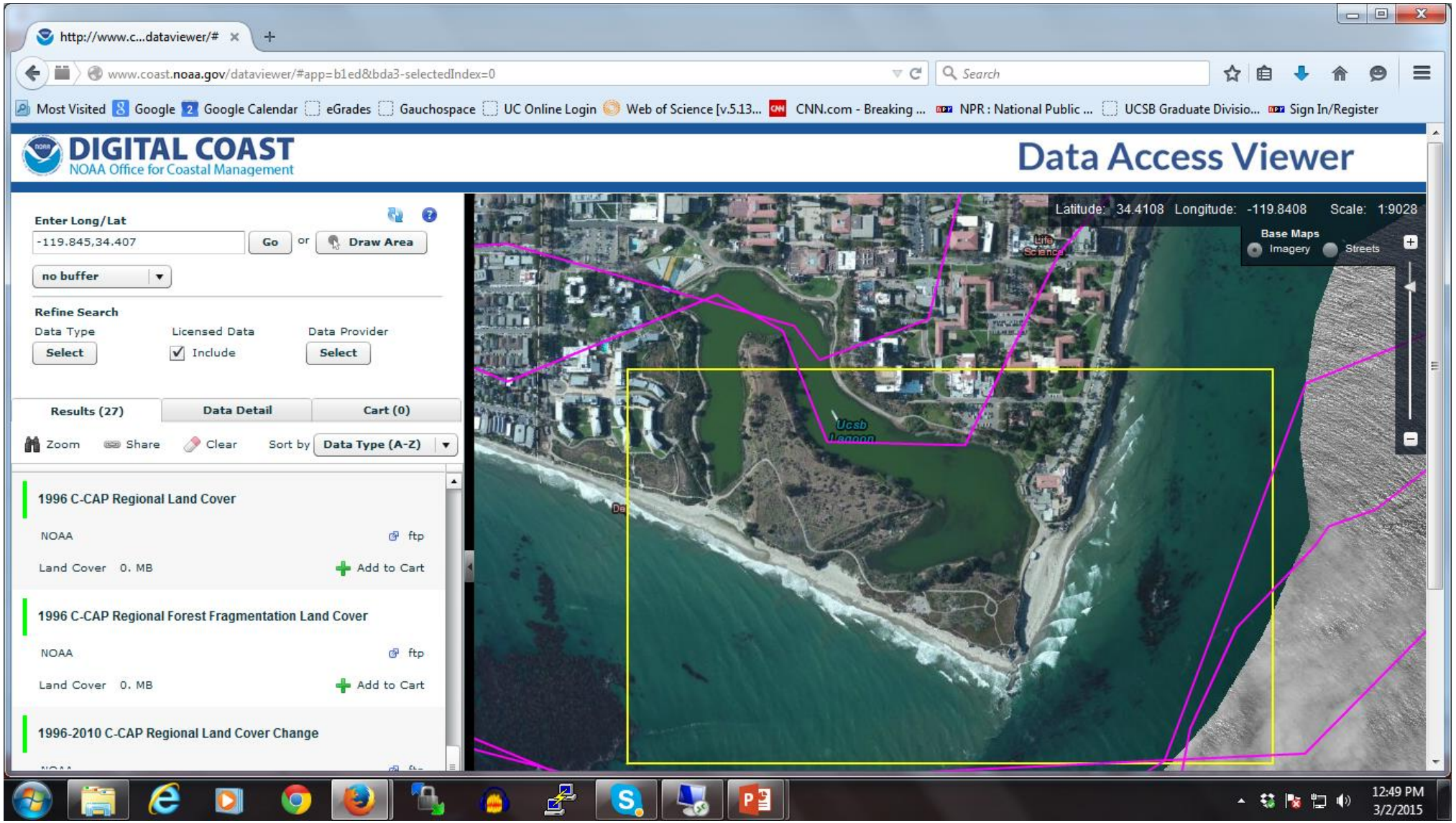
Google Glass, Google cardboard



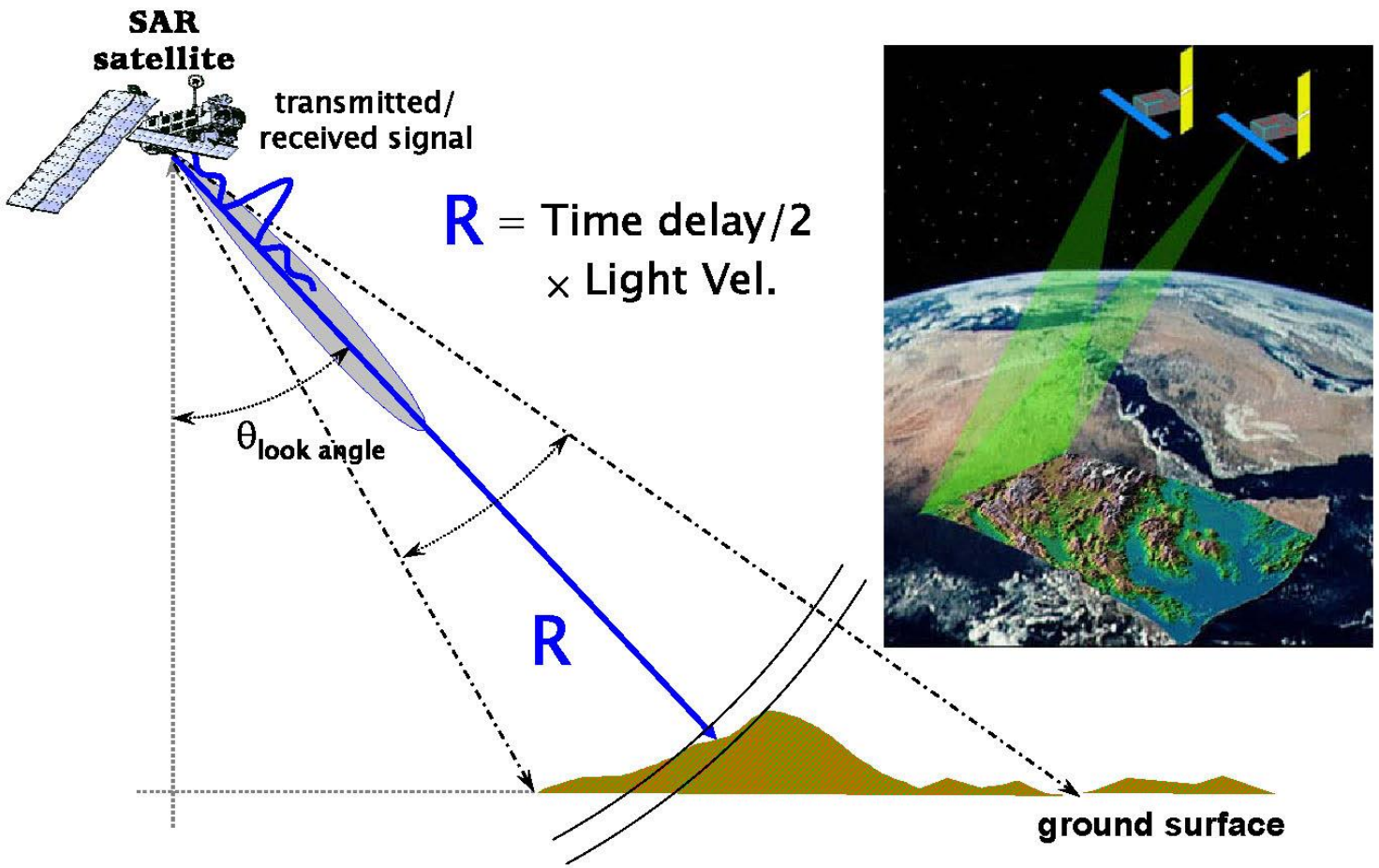
3D measurement systems: remote sensing of objects

- First generation DEMs, photogrammetry and contour conversion
- Second generation based on SAR and IFSAR
- SRTM near global coverage, 30m/90m
- GDEM global based on ASTER imagery
- NED completed at 30m, then 15m and less
- LIDAR has now taking over
- New photogrammetric methods showing promise

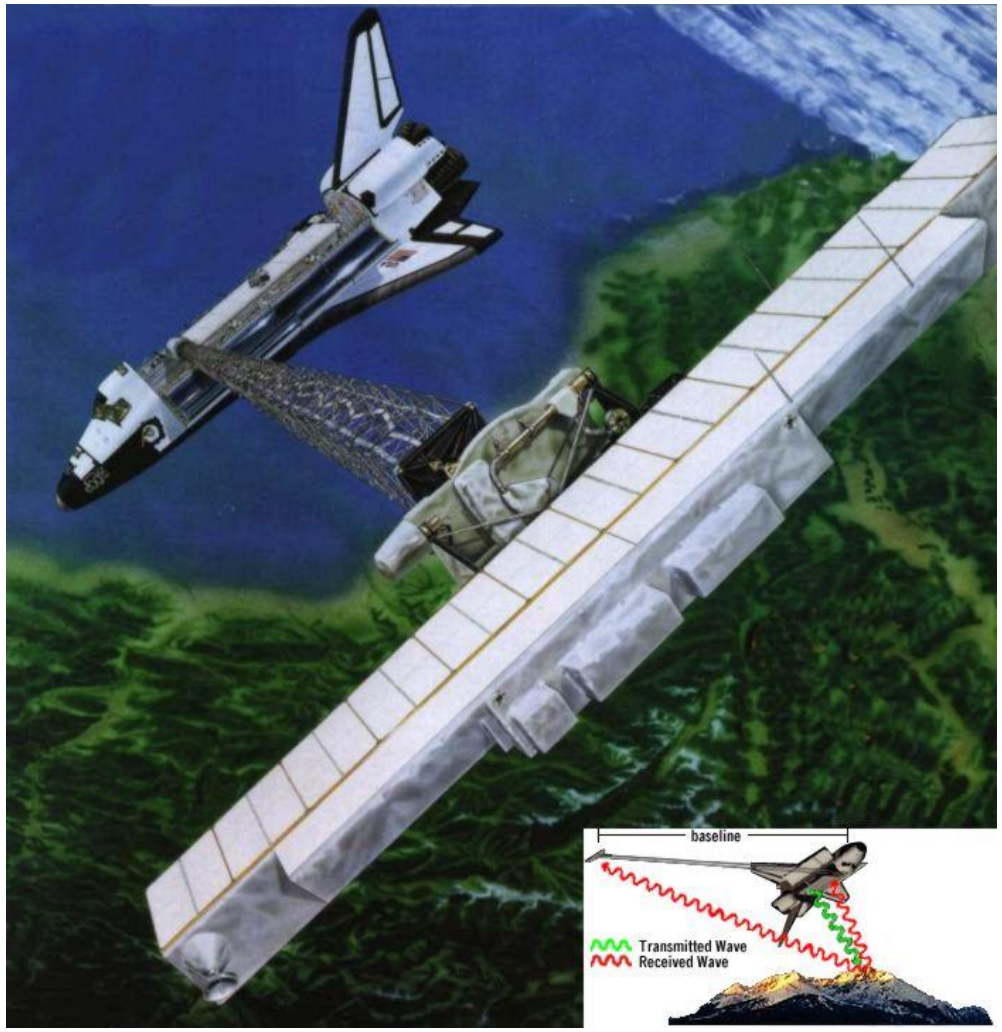
IFSAR DEM

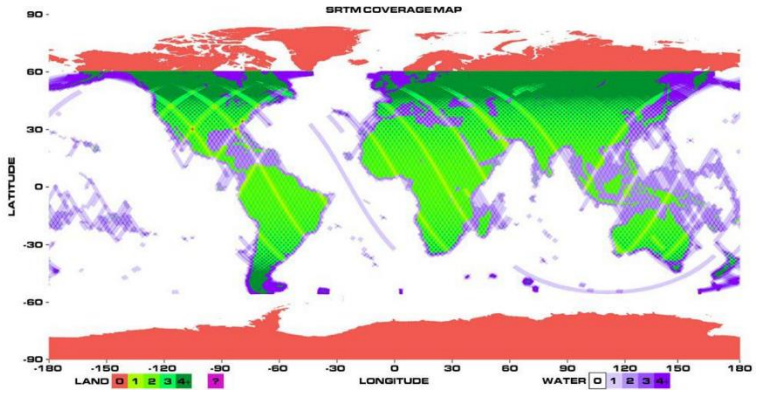

http://www.c...dataviewer/#
www.coast.noaa.gov/dataviewer/#app=b1ed&bda3-selectedIndex=0
Search
Most Visited
Google
Google Calendar
eGrades
Gauchospace
UC Online Login
Web of Science [v.5.13...
CNN.com - Breaking ...
NPR : National Public ...
UCSB Graduate Divisio...
Sign In/Register
DIGITAL COAST
NOAA Office for Coastal Management
Data Access Viewer
Enter Long/Lat
-119.845,34.407
Go
or
Draw Area
no buffer
Refine Search
Data Type
Select
Licensed Data
Include
Data Provider
Select
Results (27)
Data Detail
Cart (0)
Zoom
Share
Clear
Sort by
Data Type (A-Z)
1996 C-CAP Regional Land Cover
NOAA
ftp
Land Cover 0. MB
Add to Cart
1996 C-CAP Regional Forest Fragmentation Land Cover
NOAA
ftp
Land Cover 0. MB
Add to Cart
1996-2010 C-CAP Regional Land Cover Change
Latitude: 34.4108 Longitude: -119.8408 Scale: 1:9028
Base Maps
Imagery
Streets
Life Science
Ucsb Lagoon
12:49 PM
3/2/2015

SAR from Space

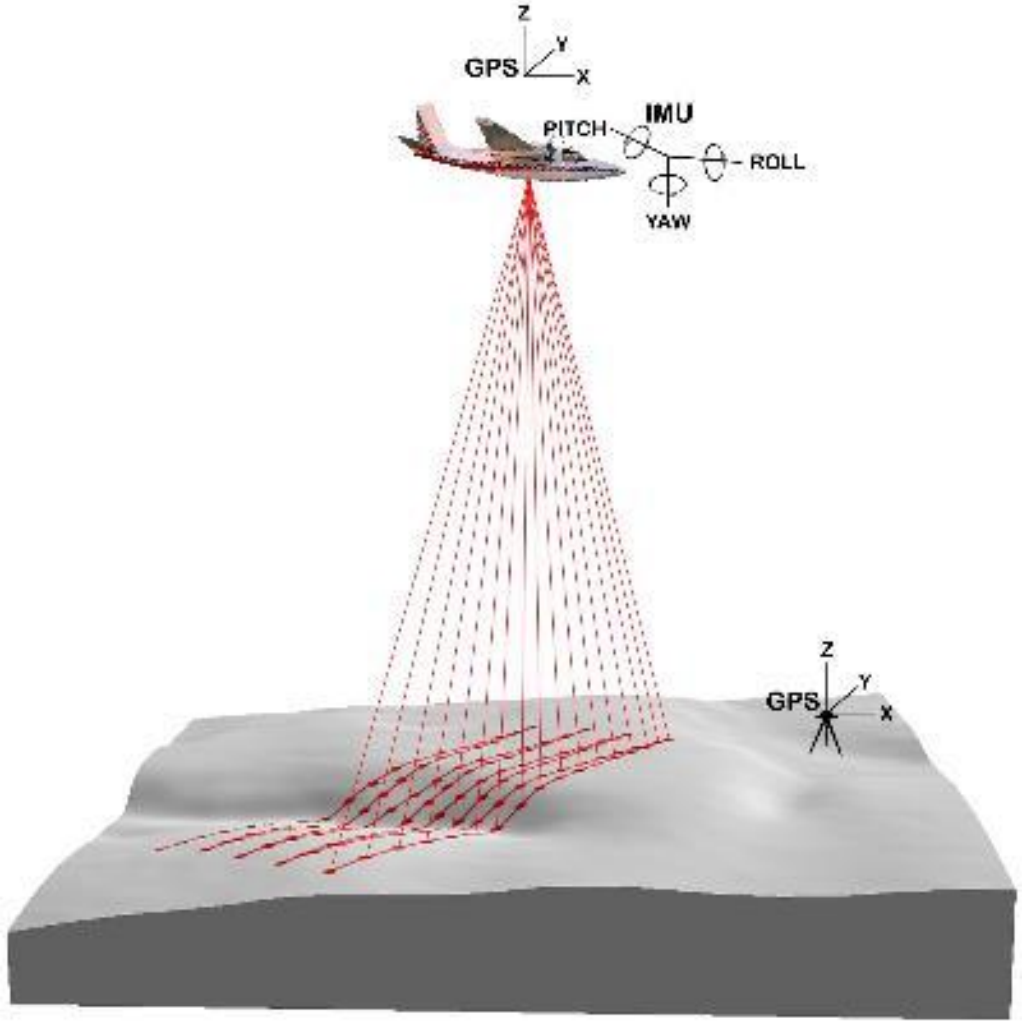


SRTM: Global topo map

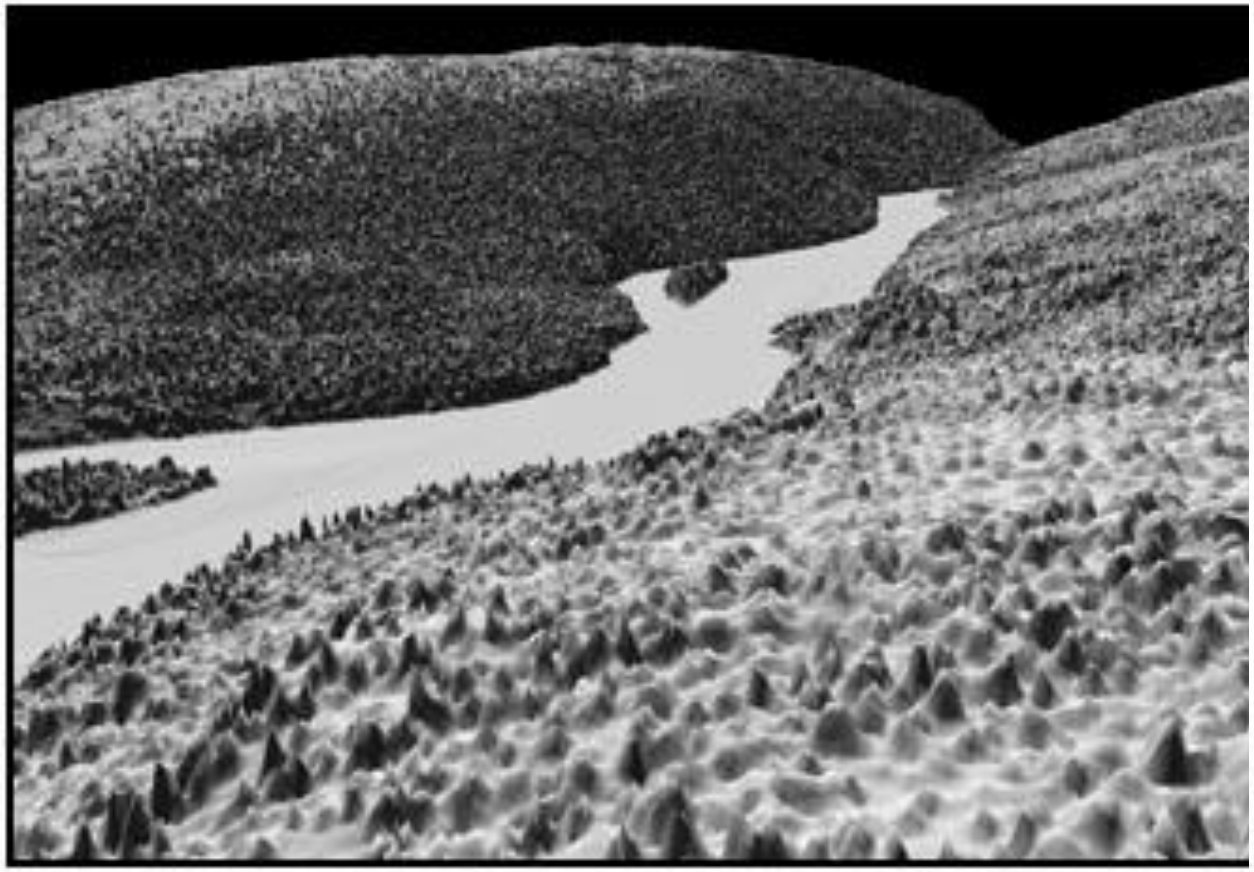


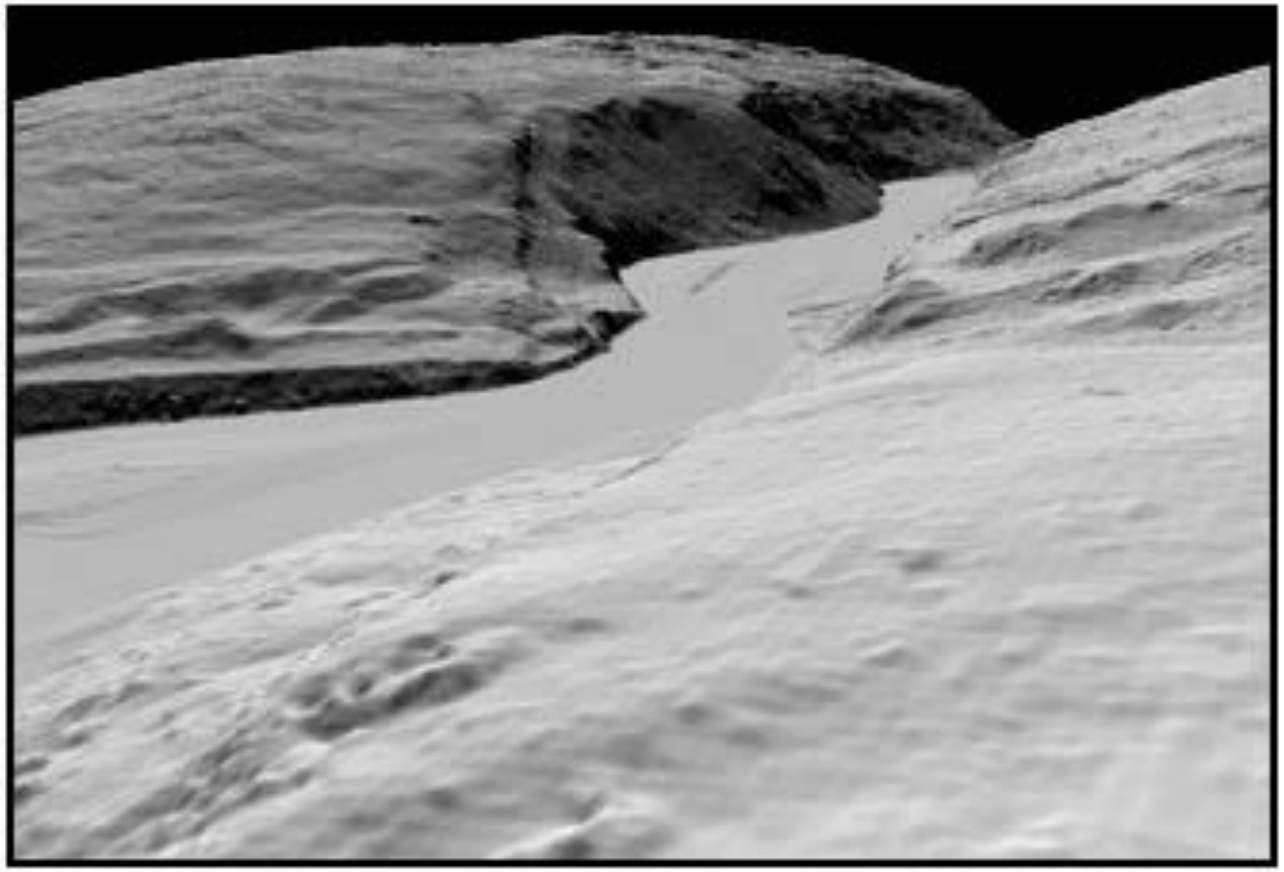


How Lidar works

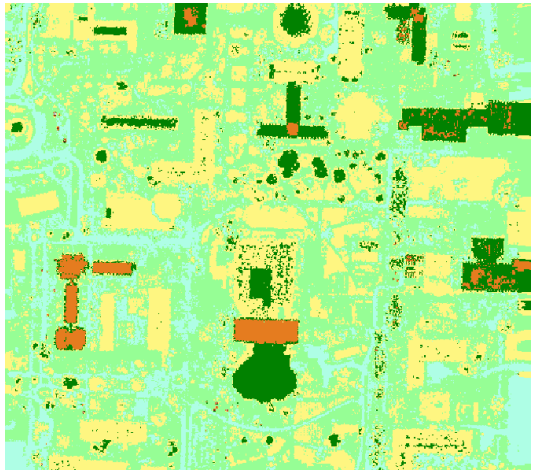


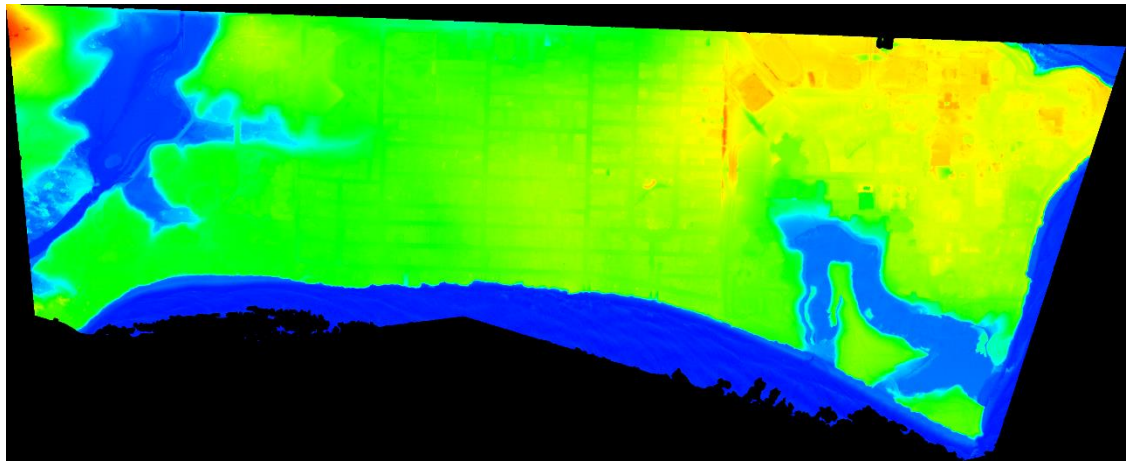
LIDAR first and last pulse

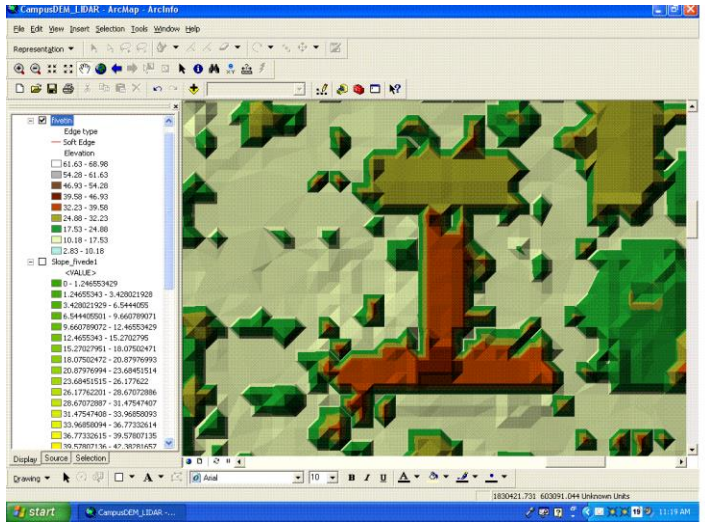


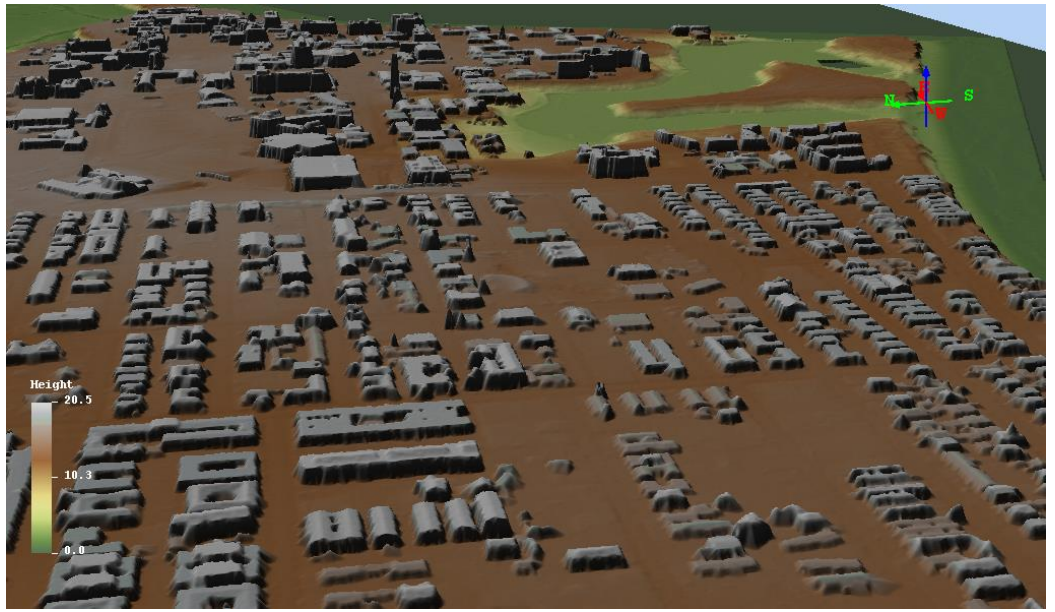


3D Models LiDAR

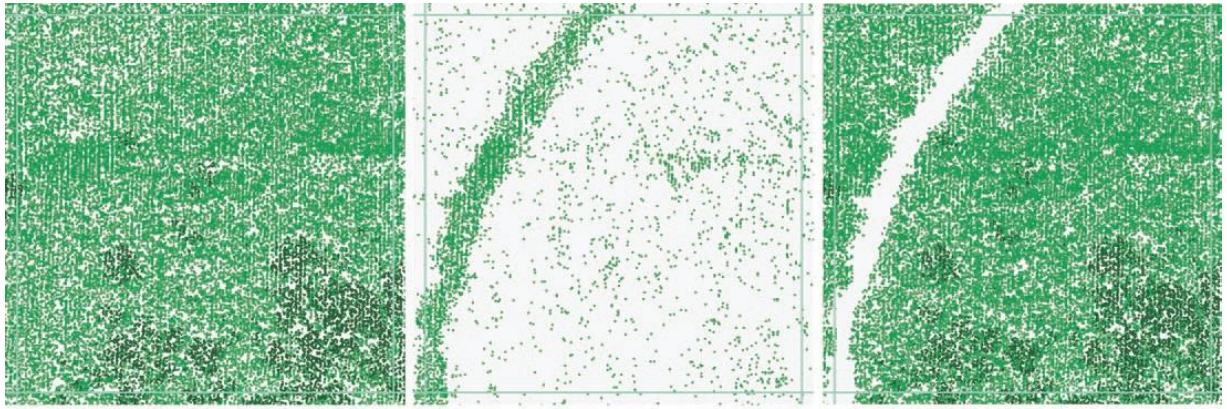


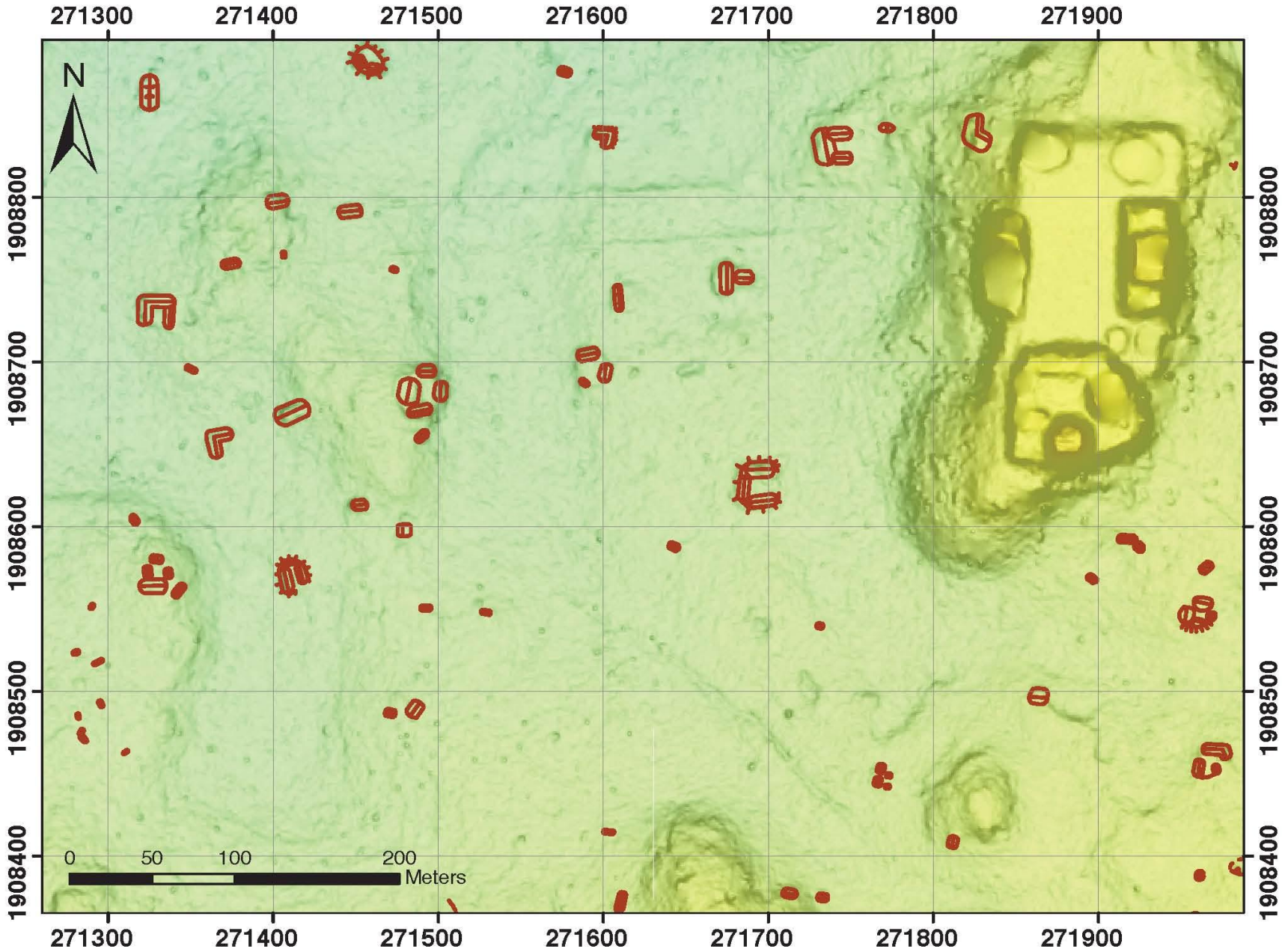






LiDAR at El Pilar

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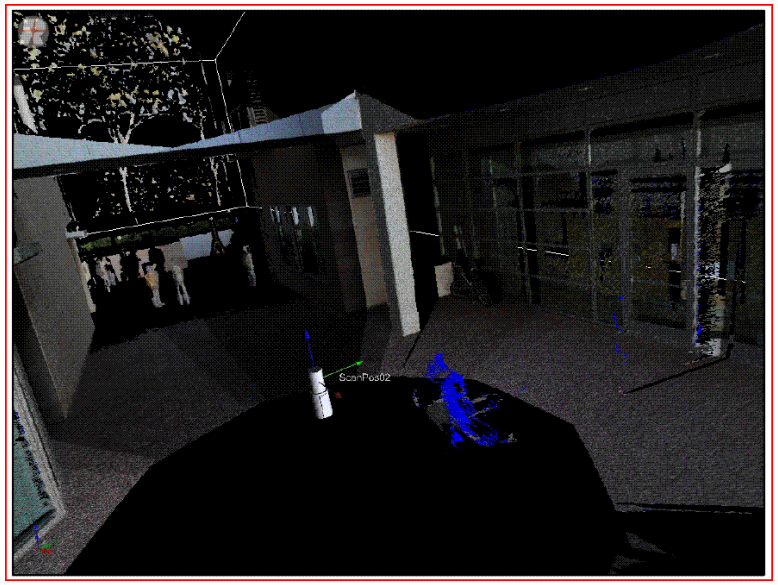
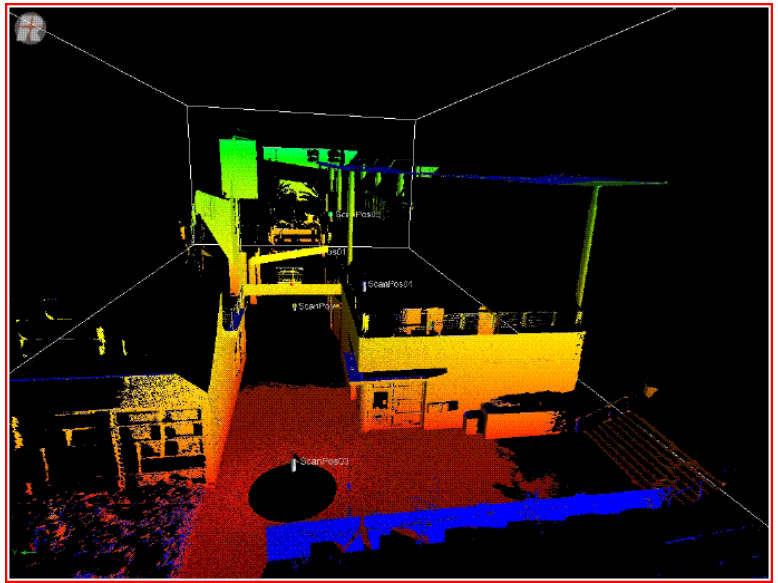
Meters

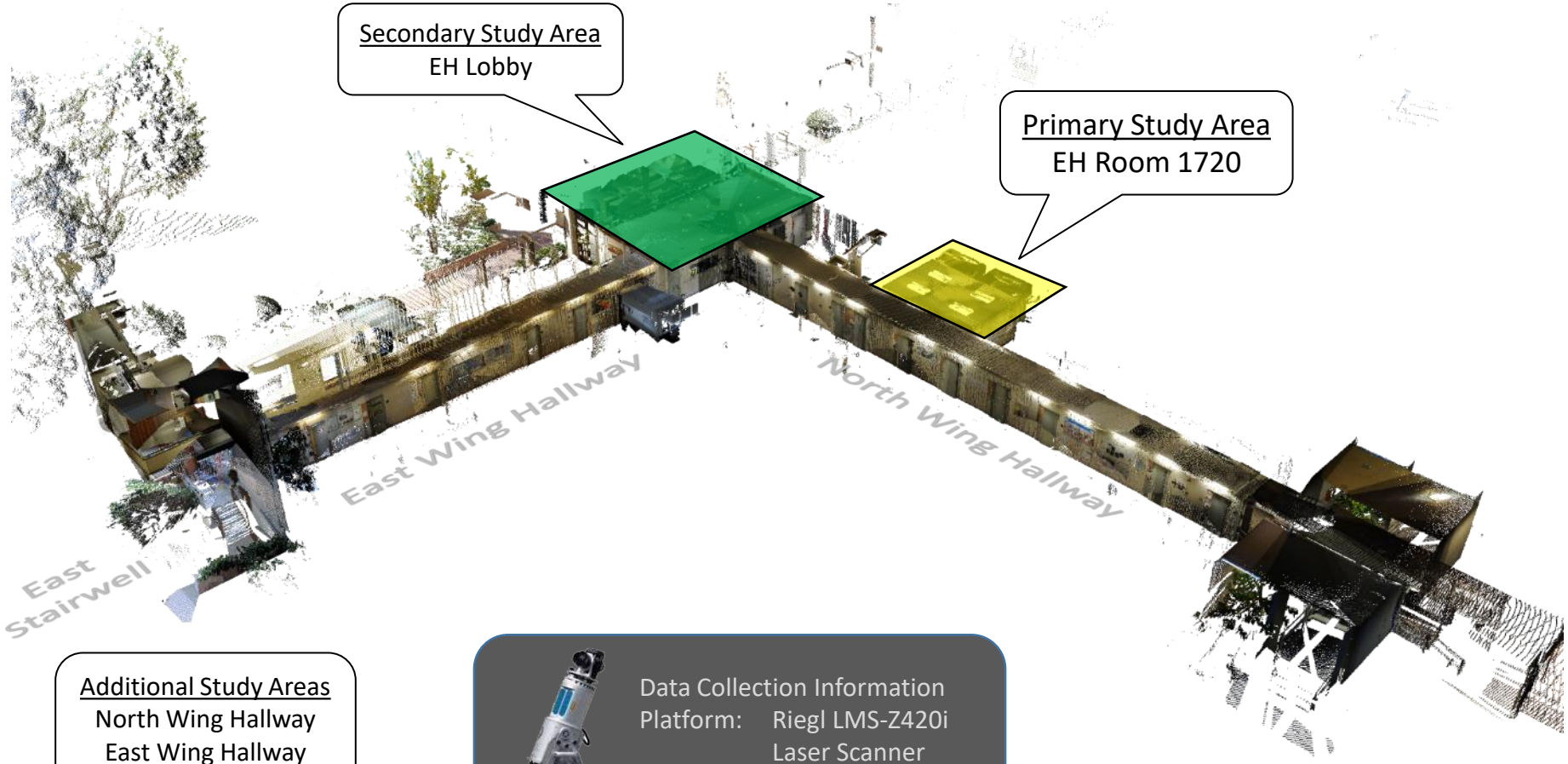
Terrestrial Scanning LiDAR





Lidar Point Cloud Data

UCSB Ellison Hall, 1st Floor

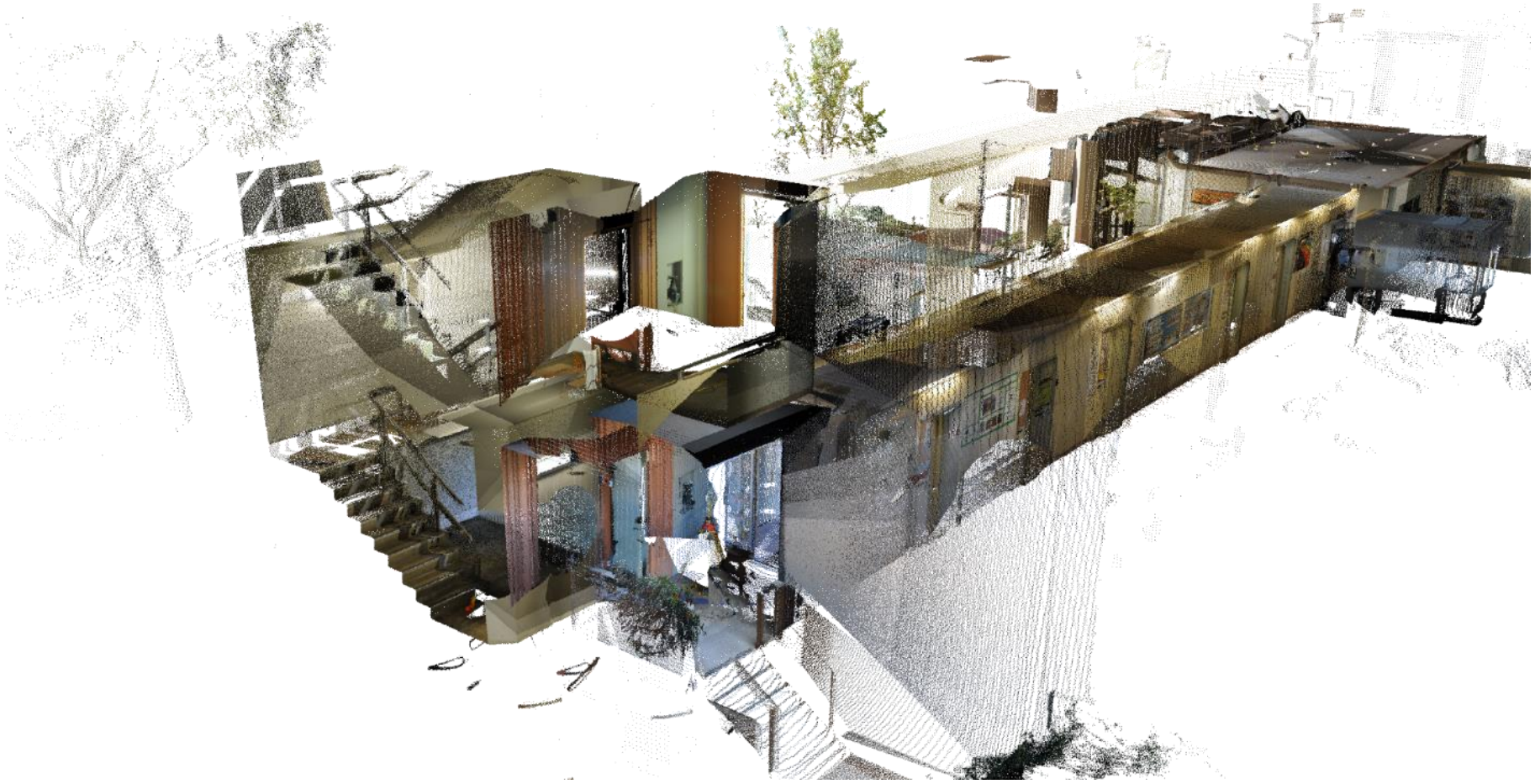


Additional Study Areas
North Wing Hallway
East Wing Hallway
East Stairwell

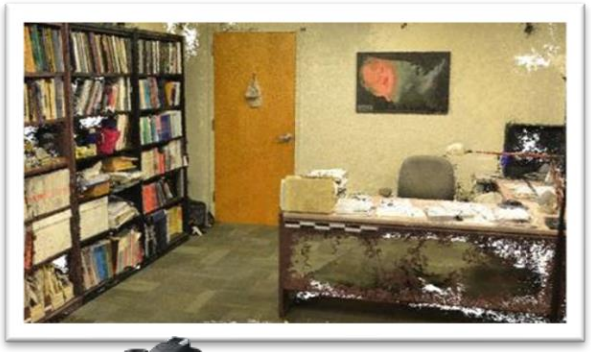
Data Collection Information
Platform: Riegl LMS-Z420i Laser Scanner
Points: 35 million

Lidar Point Cloud Data

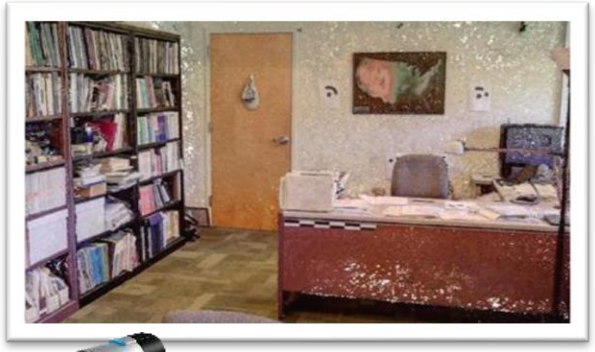
EH East Stairwell, 1st/2nd Floors



Platforms Tested To Date (EH Room 1720 Only)



Nikon D3100
(14.2 MP)



Microsoft LifeCam Studio
(2.1 MP)

Logitech QuickCam Deluxe
(0.3 MP)

Sony DSC-TX10
(16.2 MP)

Panasonic DMC-FZ28
(10.1 MP)

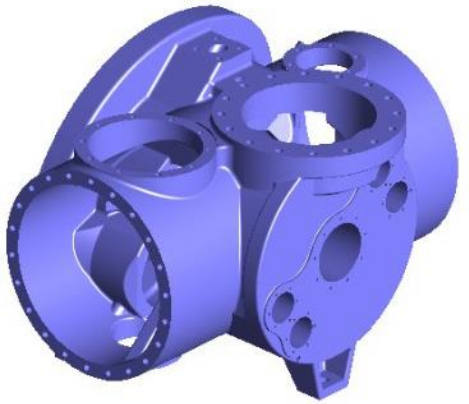
Riegl LMS-Z420i Laser Scanner
(Baseline Measurements)

Animated Point Cloud (LifeCam Studio)

3D modeling and data structures

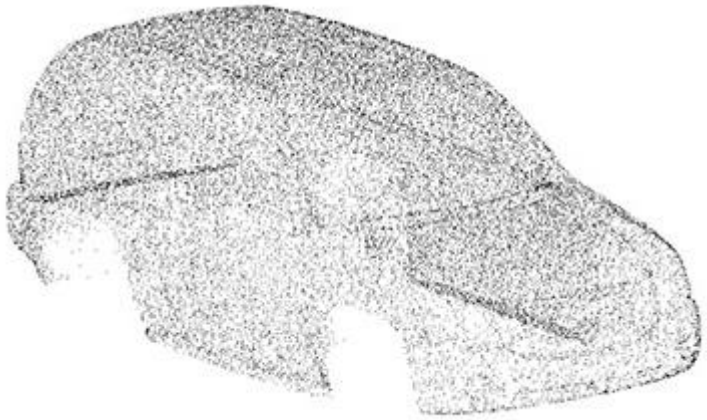
- Longley et. al. 6 models: gridded points, irregular points, cells, irregular polygons, TIN and contours
- Prior dominance of DEM
- Extensive use of TIN and surface patches
- Computer graphics and games favor Voxels
- LIDAR and photogrammetry return a POINT CLOUD
- Has led to use of term Digital Surface Model

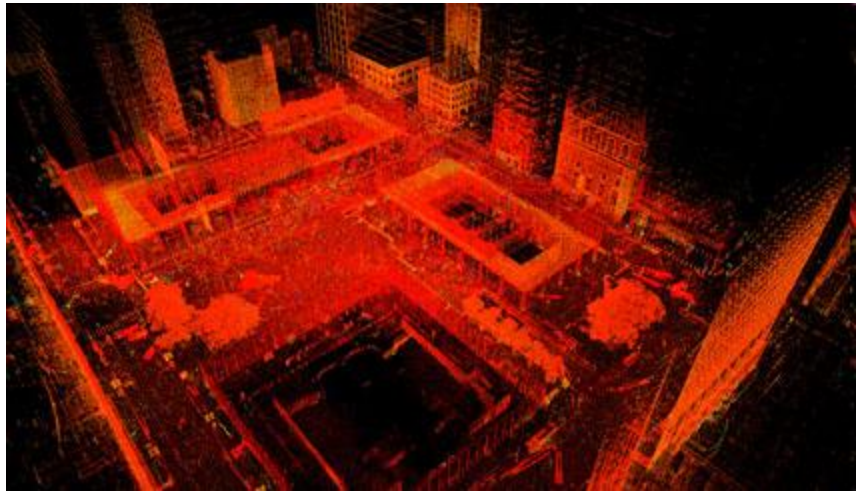
Measurement vs. Modeling

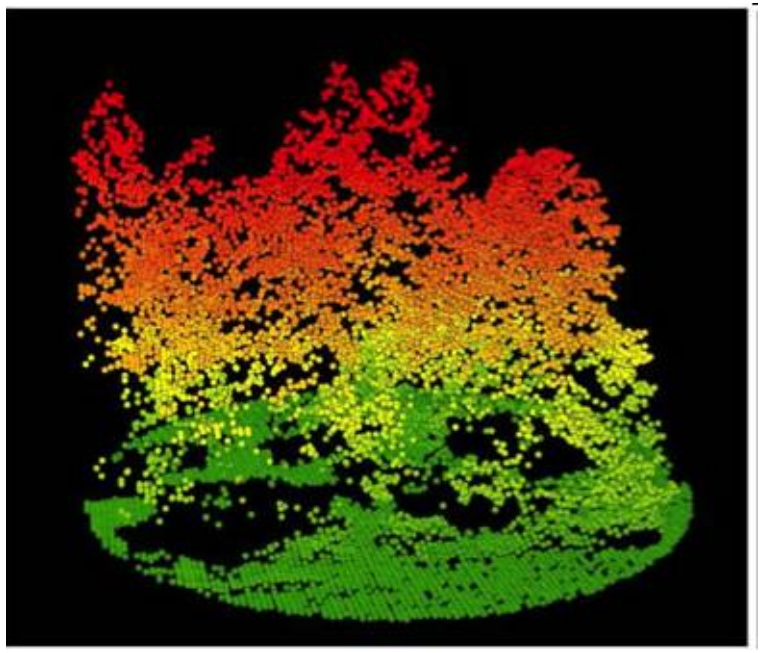


- Select key surface points, edges
- Generalize remaining surfaces
- Solids modeling
- Feature extraction; Buildings, trees (e.g. Lidar analyst, Feature analyst, Quick Terrain modeler, TerraSolid (Microstation)
- Geometric vs. natural objects
- Realism vs. Size e.g. Google Object Warehouse

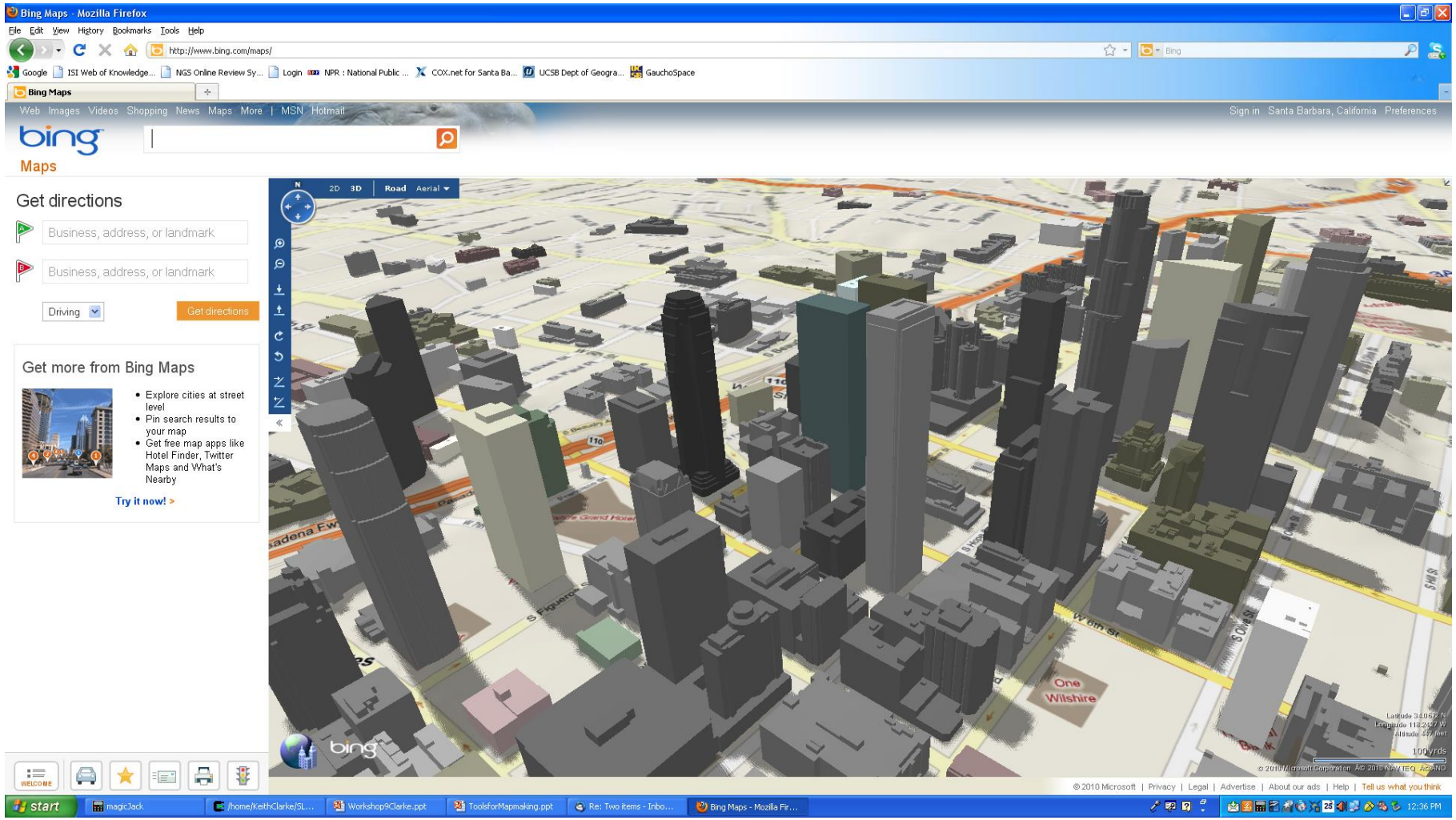
Point Clouds



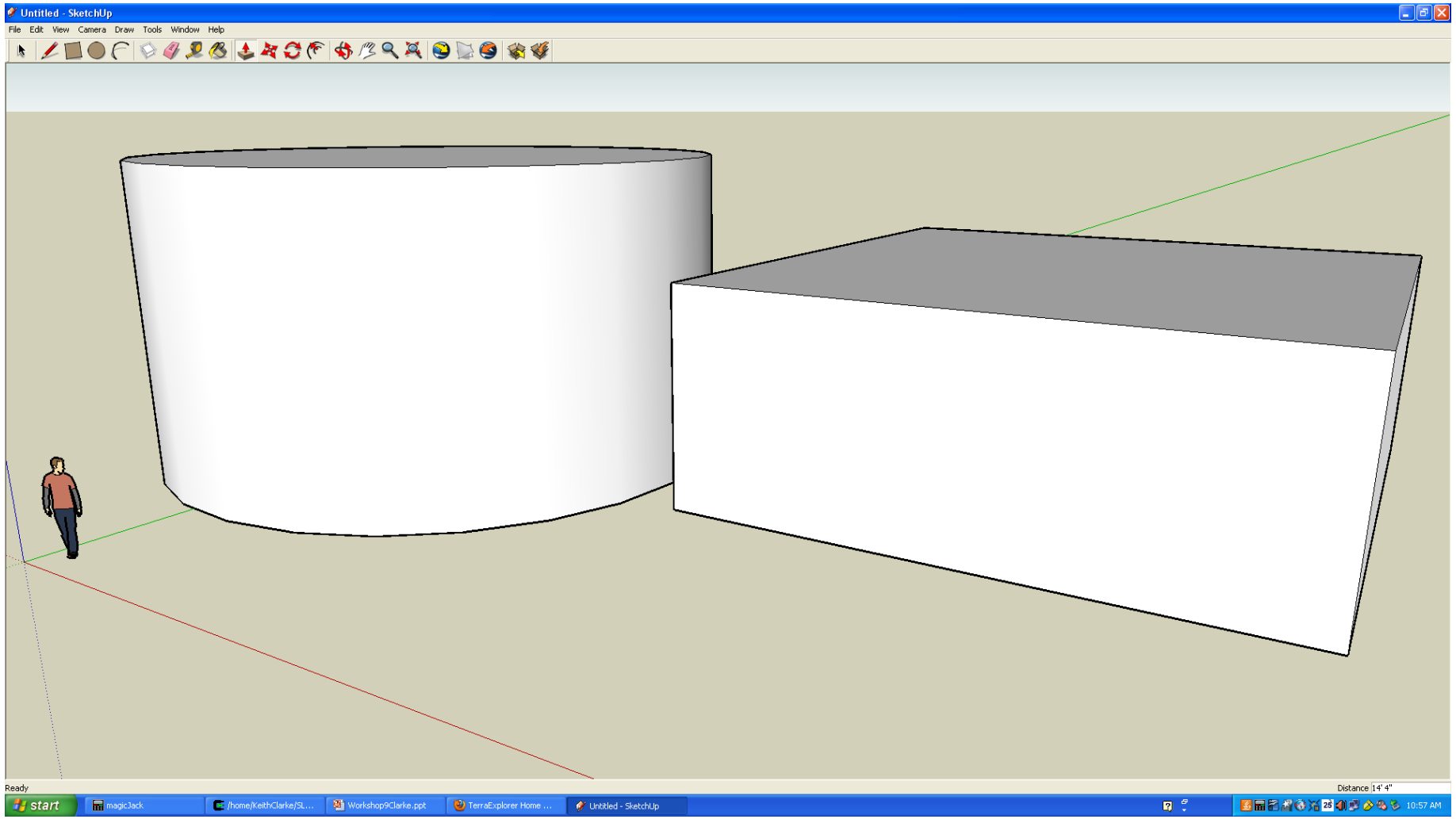




BingMaps 3D Selected Cities (LA)

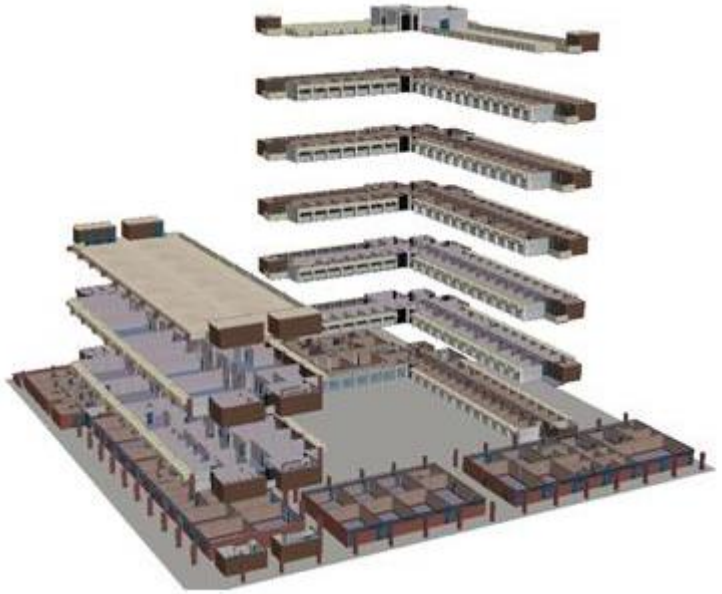


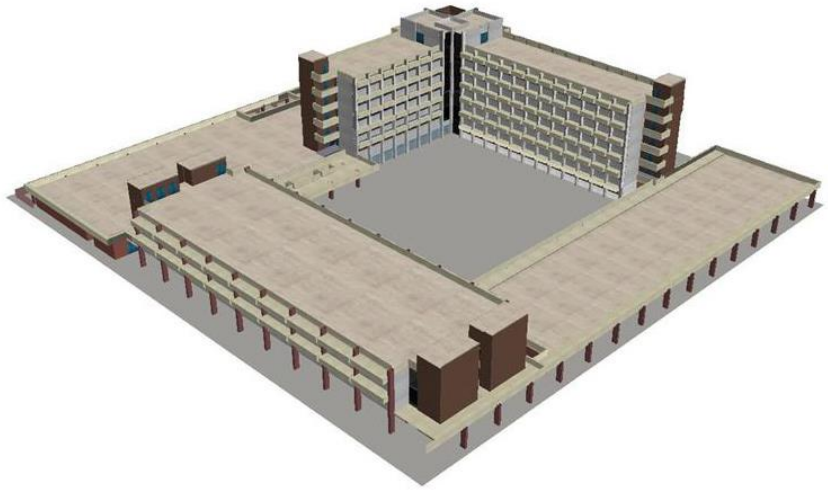
Simplest 3D tool: Sketch-Up (KML)Trimble



3D Buildings/Flat trees

Polygon extrusion (ArcScene)





Software (See: wiki entry)

- 3dsmax
- AC3D
- Ayam
- AOI
- Blender
- Carrara
- Cheetah 3D
- Cinema 4D
- CityEngine
- Cobalt
- Electric Image Animation System
- Form-Z
- Houdini
- Hypershot
- Hypermove
- Lightwave3D
- MASSIVE
- Maya
- Modo
- plugin3D
- POV-Ray
- Pro/Engineer
- Quest 3D creative
- Quest 3D Power
- Quest 3D VR
- Relux Professional
- Rhinocerous 3D
- Silo
- SketchUp/Pro
- Softtimage
- Solid Edge
- solidThinking
- SolidWorks
- Swift3D
- trueSpace
- ViewBuild3D
- VR4MAX
- Vue
- ZBrush

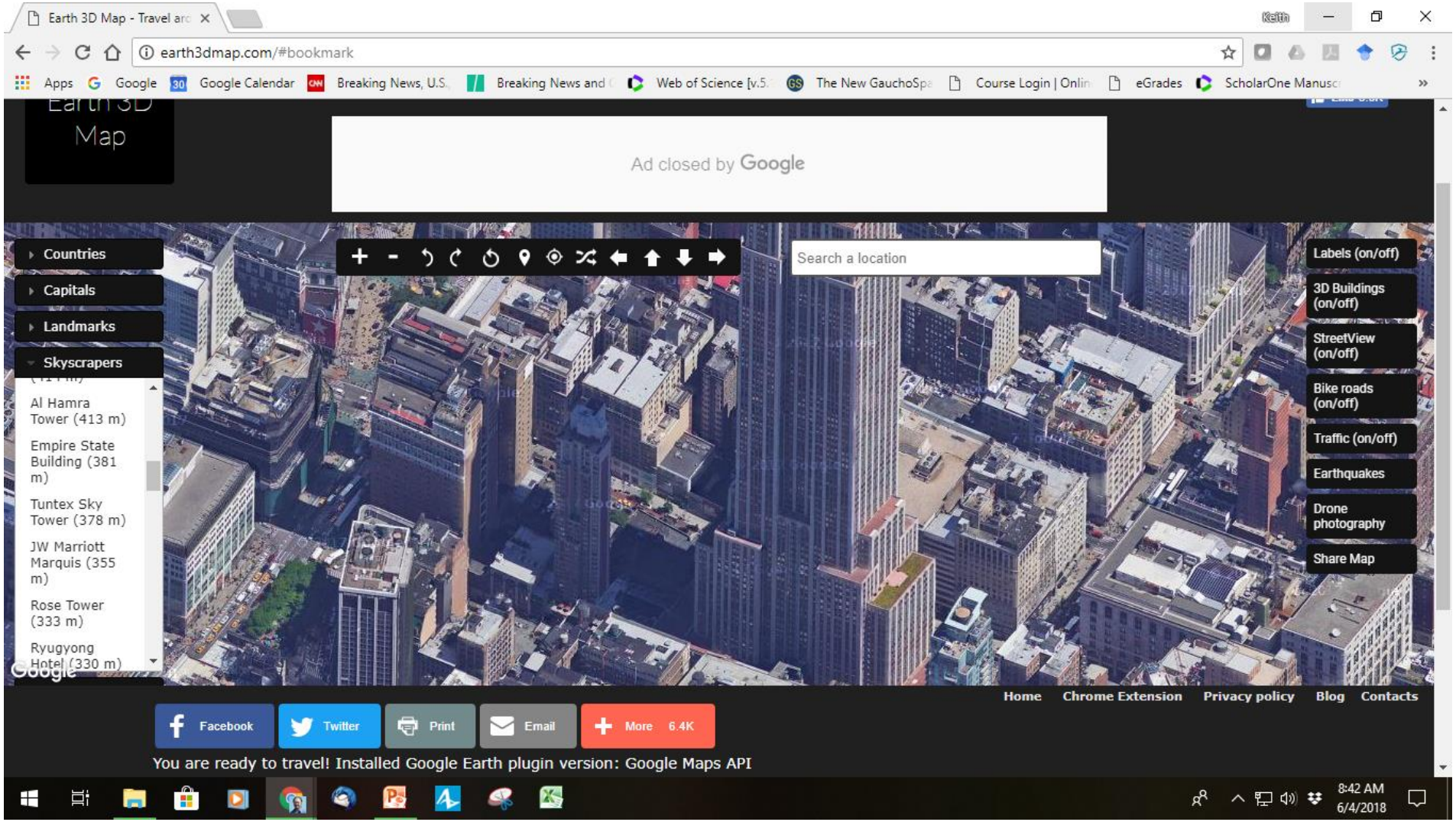
3D standards for Geospatial data

- VRML and GeoVRML
- X3D and OGC, Geospatial component and X3D Earth (e.g. Planet9 London)
- OGC CityGML
- Web3D Service
- LandXML.org
- COLLADA /KML (SONY, Google)
- National 3D-4D-BIM Program (USGSA)
- 3DVIA (Bing Maps)

3D in Geobrowsers

- Picture and panorama inclusion
- Google streetview
- GoogleEarth 3D Buildings
- Bing Maps 3D and oblique views
- Microsoft Photosynth
- Most geobrowsers include topography

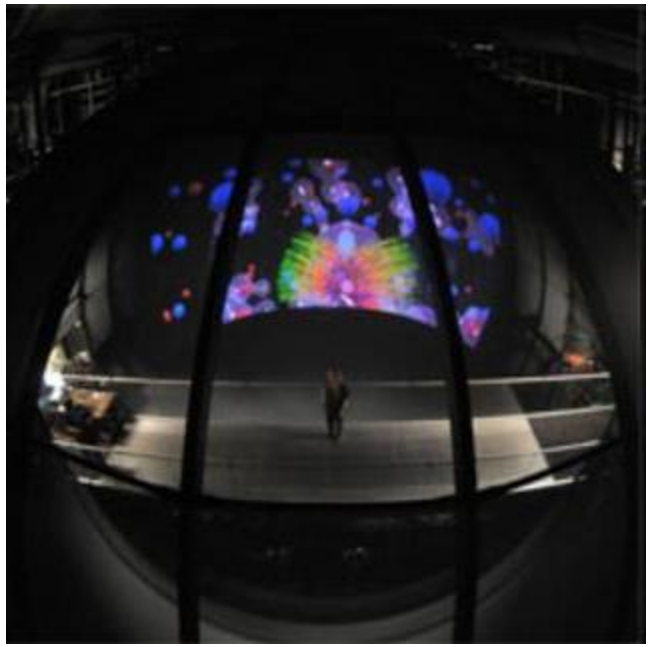
Earth3Dmap

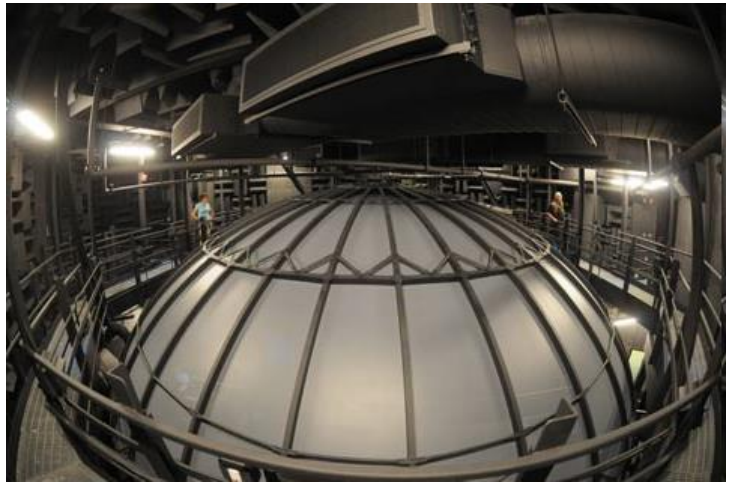

Earth 3D Map - Travel arc
earth3dmap.com/#bookmark
Apps
Google
Google Calendar
Breaking News, U.S.
Breaking News and
Web of Science [v.5
The New GauchoSpa
Course Login | Onlin
eGrades
ScholarOne Manusc
Earth 3D Map
Ad closed by Google
Countries
Capitals
Landmarks
Skyscrapers
Al Hamra Tower (413 m)
Empire State Building (381 m)
Tuntex Sky Tower (378 m)
JW Marriott Marquis (355 m)
Rose Tower (333 m)
Ryugyong Hotel (330 m)
Search a location
Labels (on/off)
3D Buildings (on/off)
StreetView (on/off)
Bike roads (on/off)
Traffic (on/off)
Earthquakes
Drone photography
Share Map
Home
Chrome Extension
Privacy policy
Blog
Contacts
Facebook
Twitter
Print
Email
More 6.4K
You are ready to travel! Installed Google Earth plugin version: Google Maps API
8:42 AM
6/4/2018

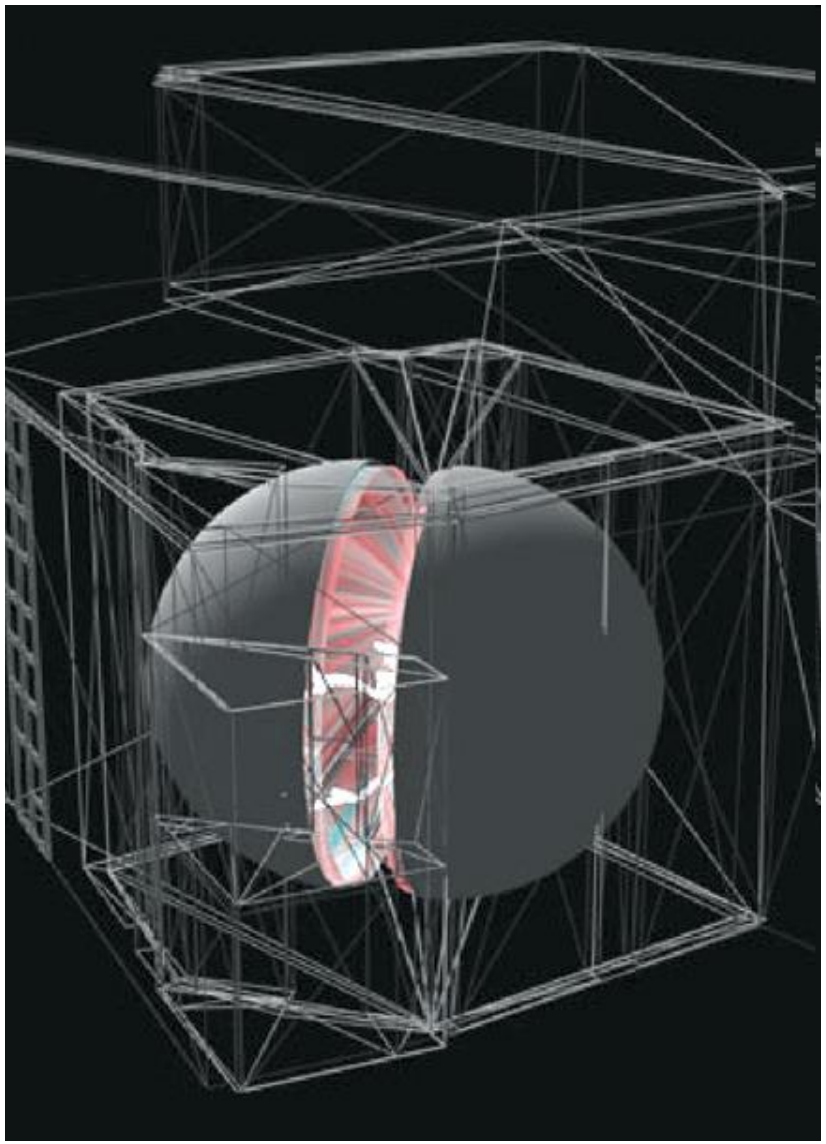
Bundler

- Structure-from-motion system for unordered image collections (for instance, images from the Internet) written in C and C++. Opensource, UWash+Cornell
- Outdoor game: http://photocitygame.com/
- “Our ultimate goal is to reconstruct the entire world, one photo at a time.”

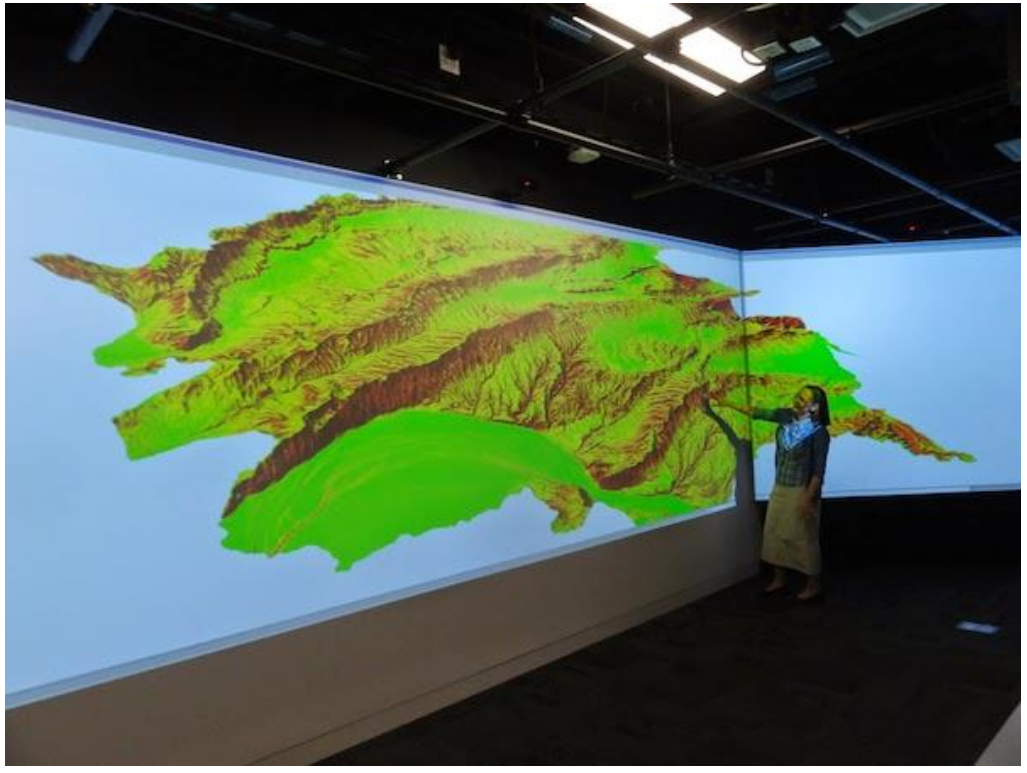
Virtual Reality: The Allosphere

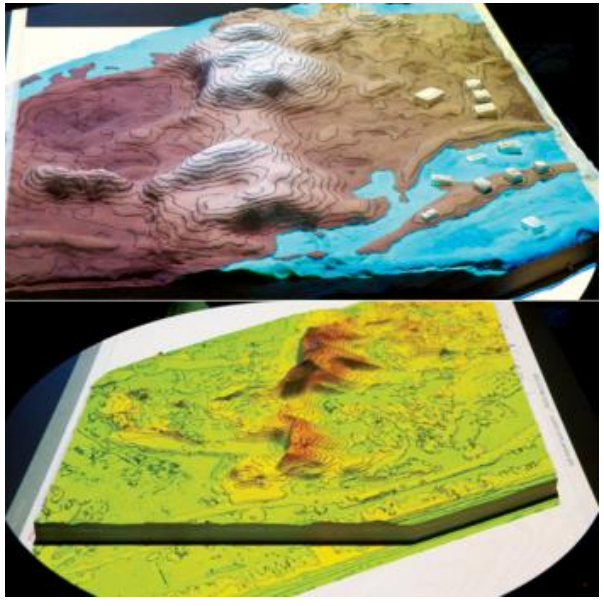




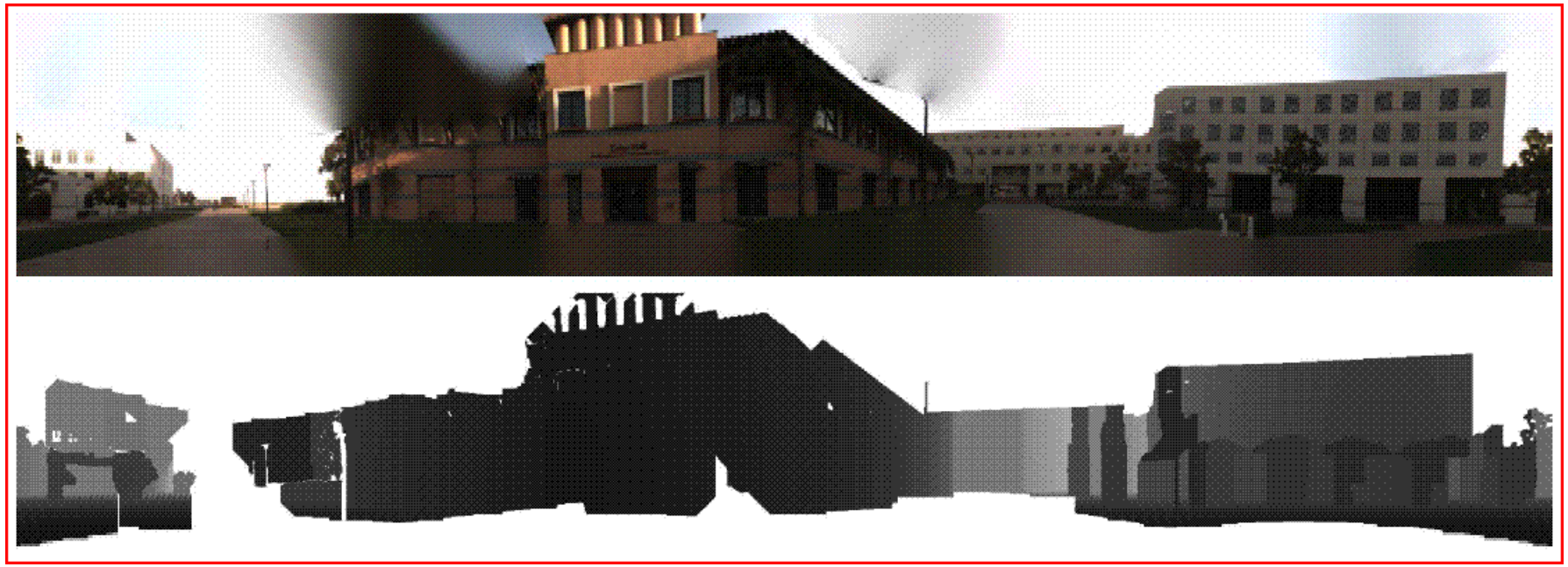


Projected images





Augmented Reality



Kite photogrammetry

Durai Island

Anambas Islands, Indonesia

Reset view

For more information see Mapping with strings attached: Kite aerial photography of Durai Island, Anambas Islands, Indonesia (*Journal of Maps, 2014*).

Installed Plugin Version: **7.1.2.2041**

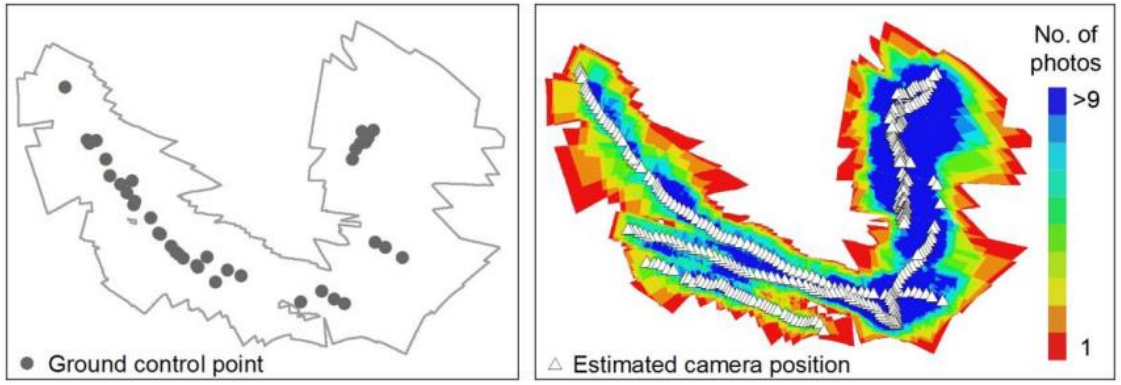
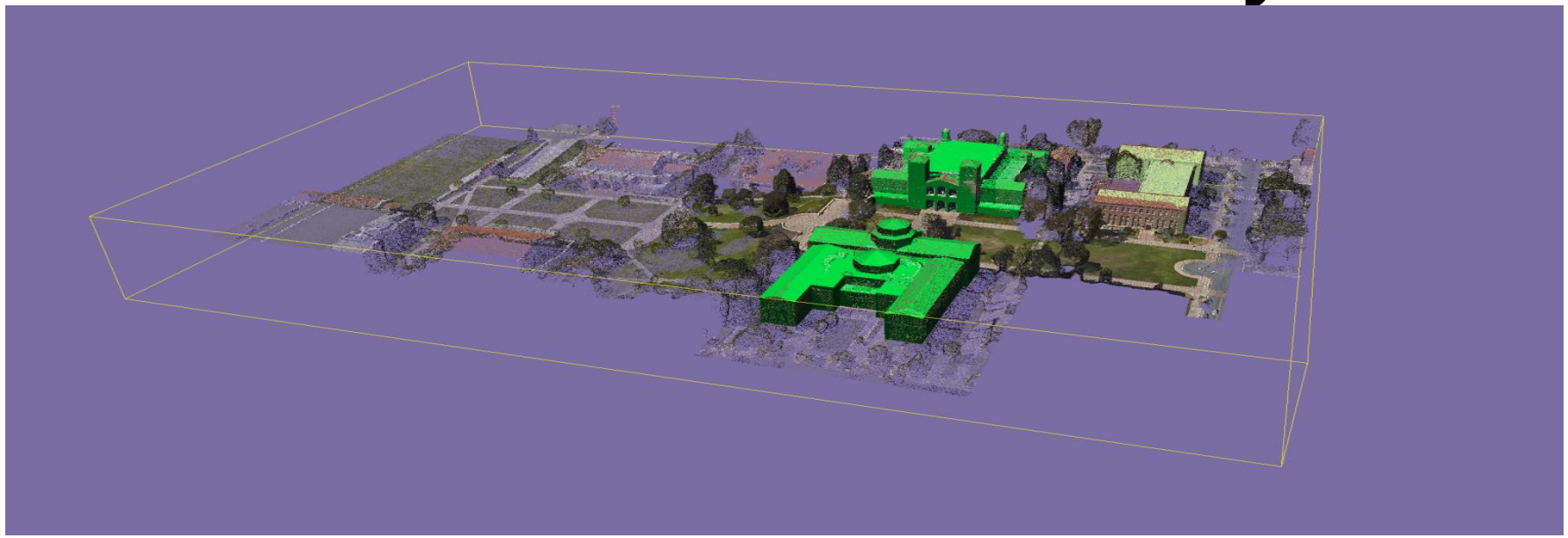


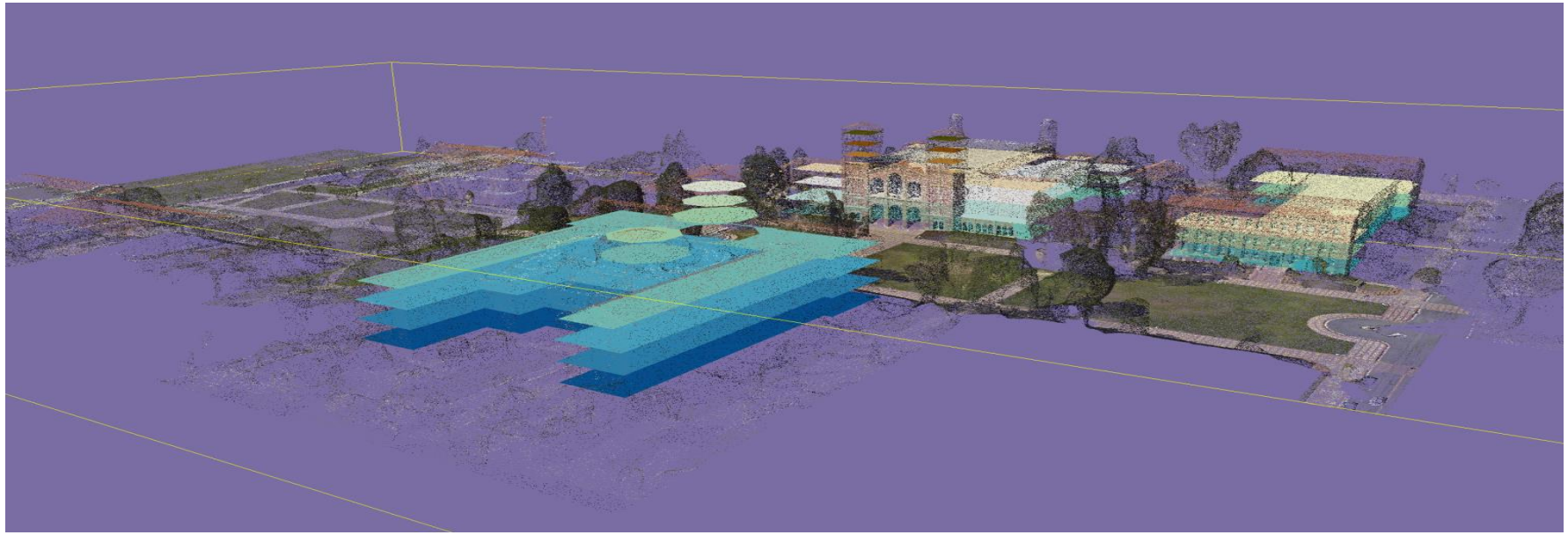
Figure 3. (a) Locations of 38 ground control points relative to mosaic's extent. (b) Estimated camera positions for 357 images, superimposed on a map of image density.

3D Printing

Credit: Kitty Currier

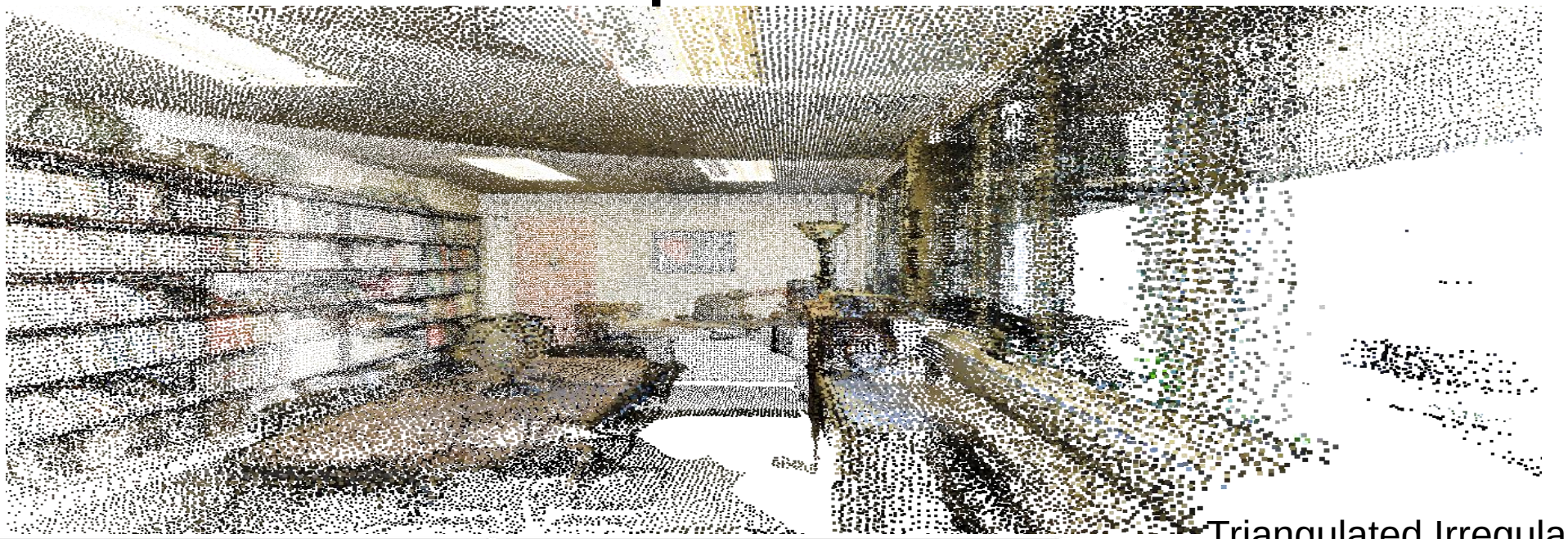
Coordinate systems



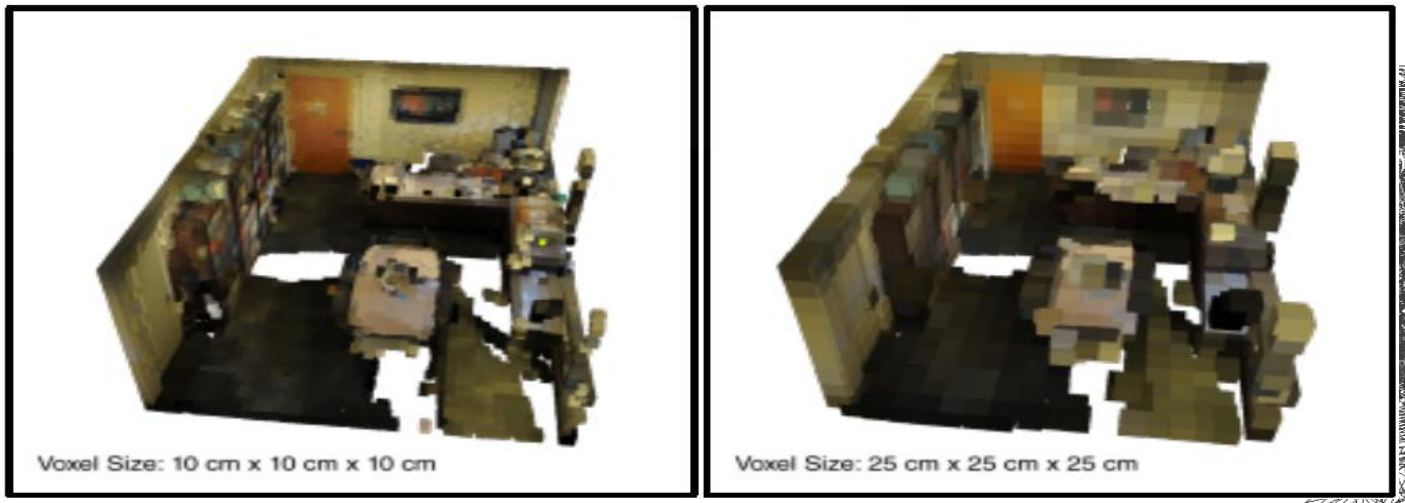


Millimeter based
Uses 3 tie points
False origins with offsets
Can float with object
Implemented forward
and inverse transforms

Space abstraction

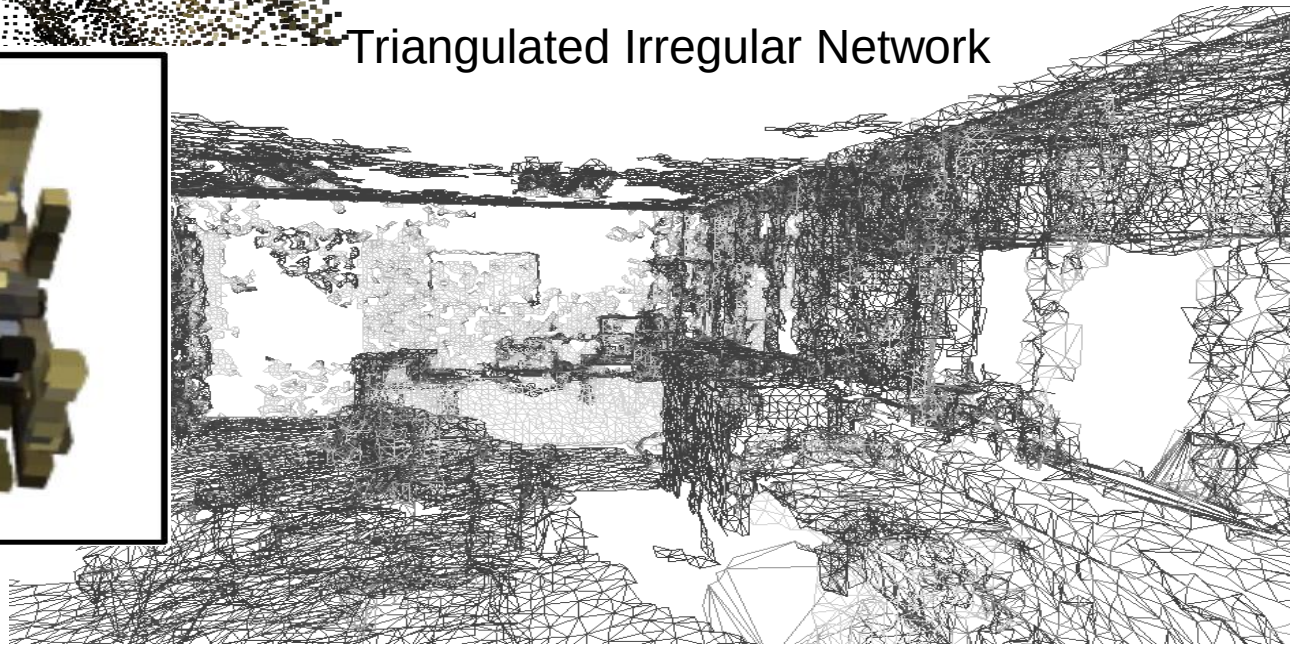


Point Cloud

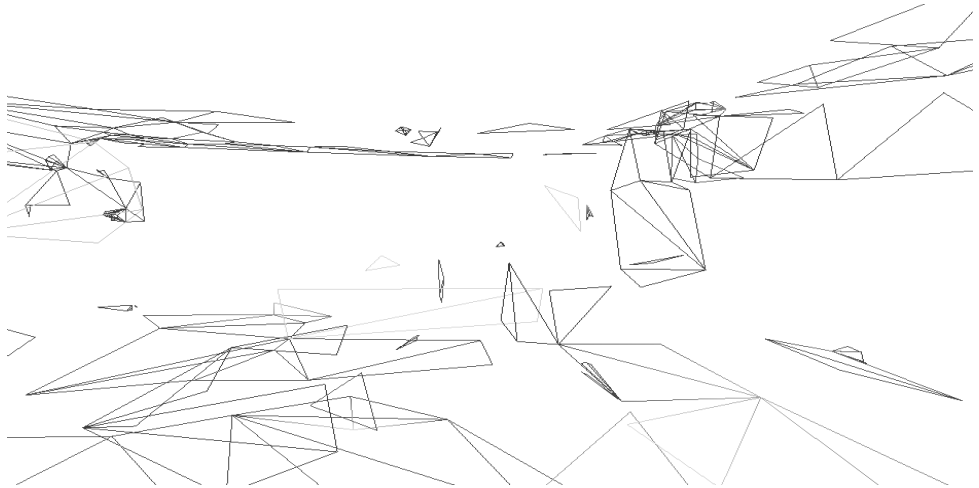


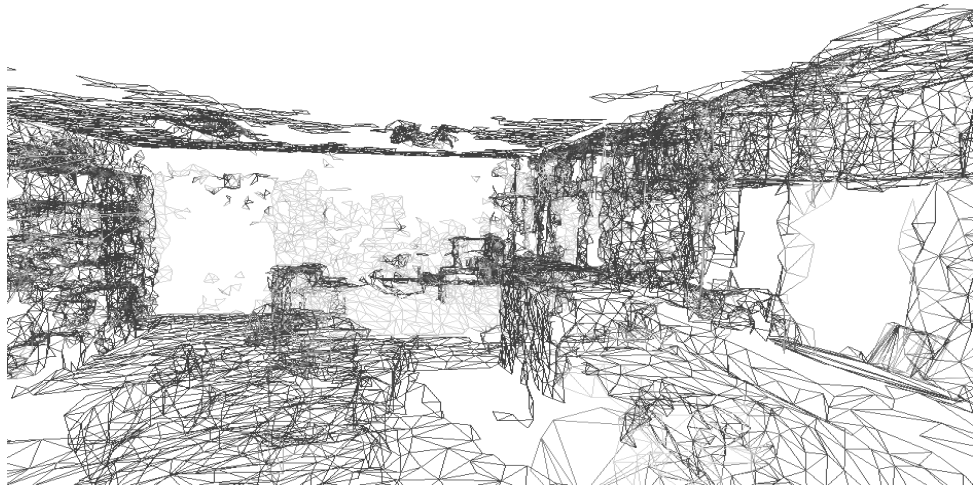
Voxels

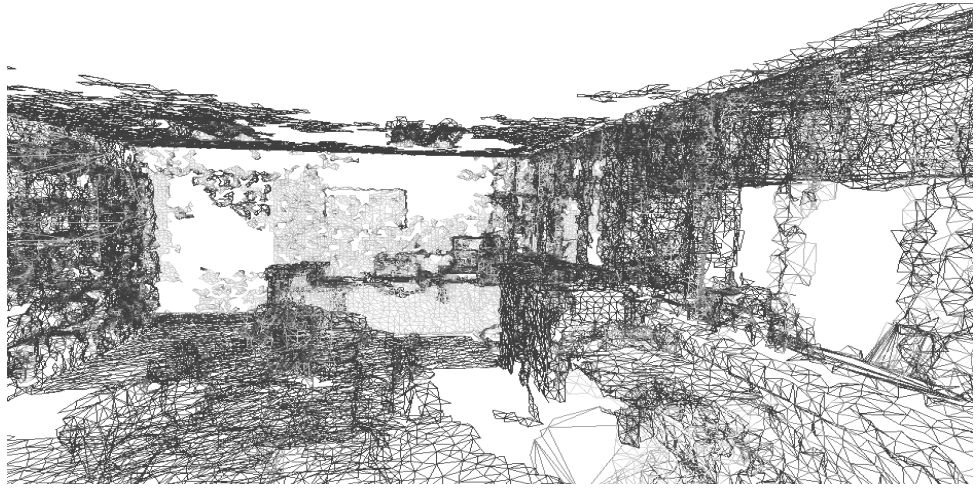
Triangulated Irregular Network



Generalization







How to generate images?

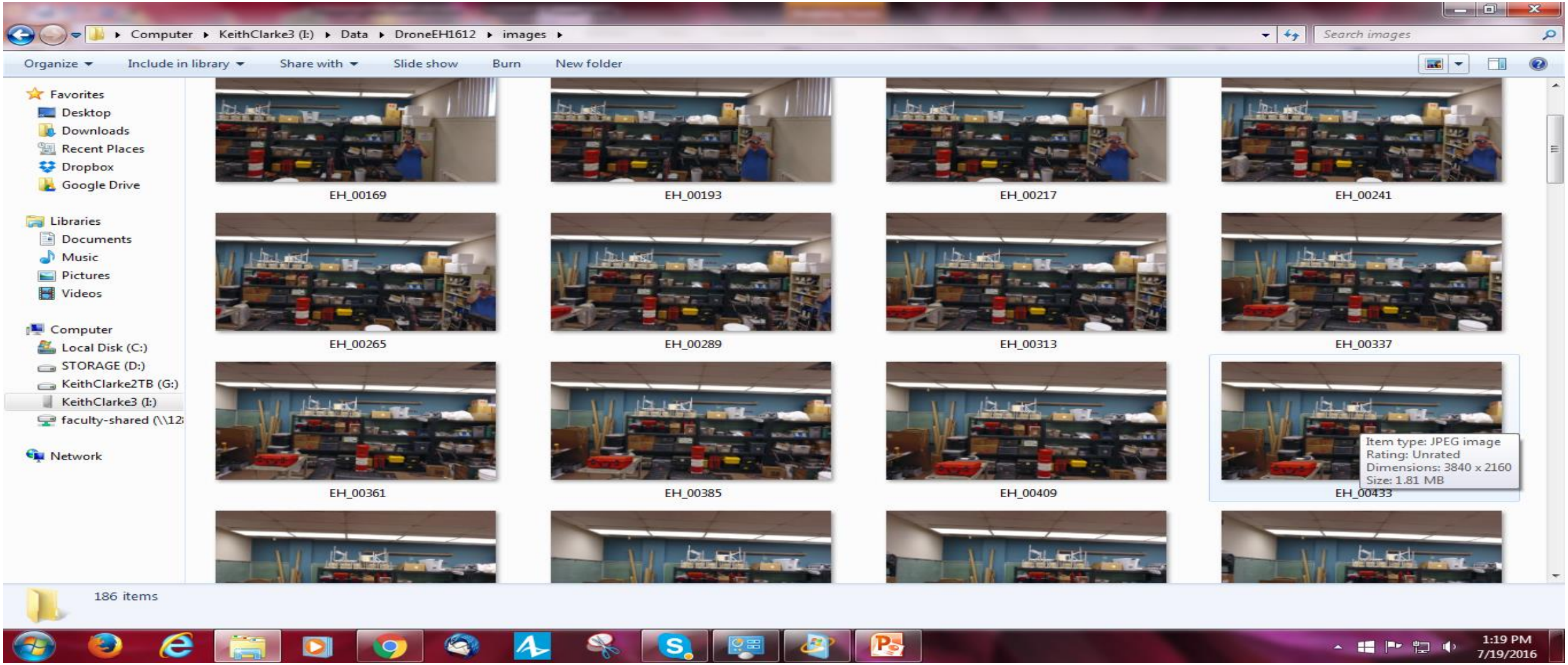
- Need many images from different angles
- Overlap creates stereo model
- Agisoft Photoscan then extracts model and assigns point cloud with color
- Can process with Meshlab, CloudCompare, other software
- Our answer: Drone (Quadcopter)

Phantom 4 with collision avoidance

Scans height by IR sensor
Position using GPS
Fully gimballed camera
Can be programmed to collect
video or interval images
20 minutes of flight with rechargeable batteries
Flight planning software, smartphone or tablet piloting

Mapping Ellison 1612

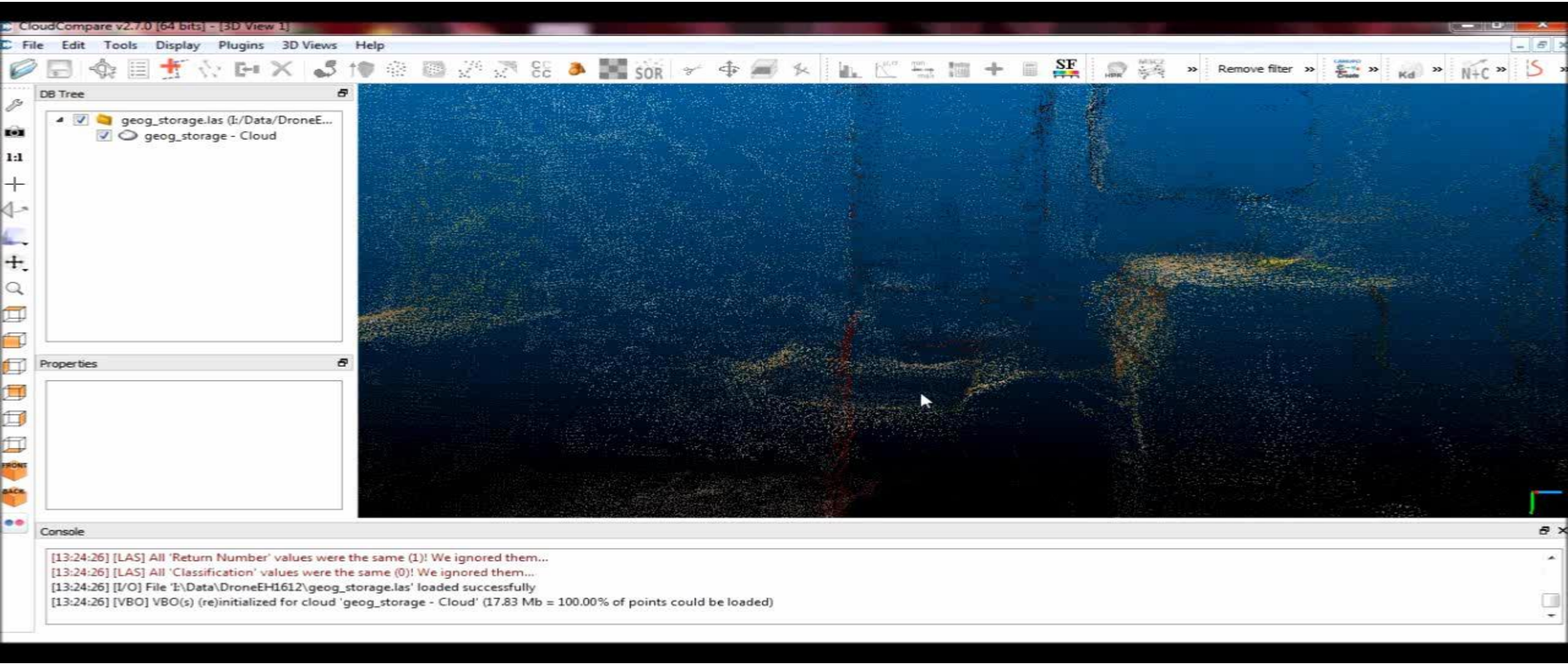
Image capture



Point Cloud

This is not a photograph

A 3D model from scratch



Closer to home

Summary

- Spectrum from augmented to virtual reality
- Term virtual environment useful
- Many cognitive and interaction issues for 3D
- Measurement technologies now ubiquitous
- LiDAR now moving to photogrammetry, DSMs and point clouds
- Applications in mapping and for LBS
- Many software systems and standards
- Expect more!