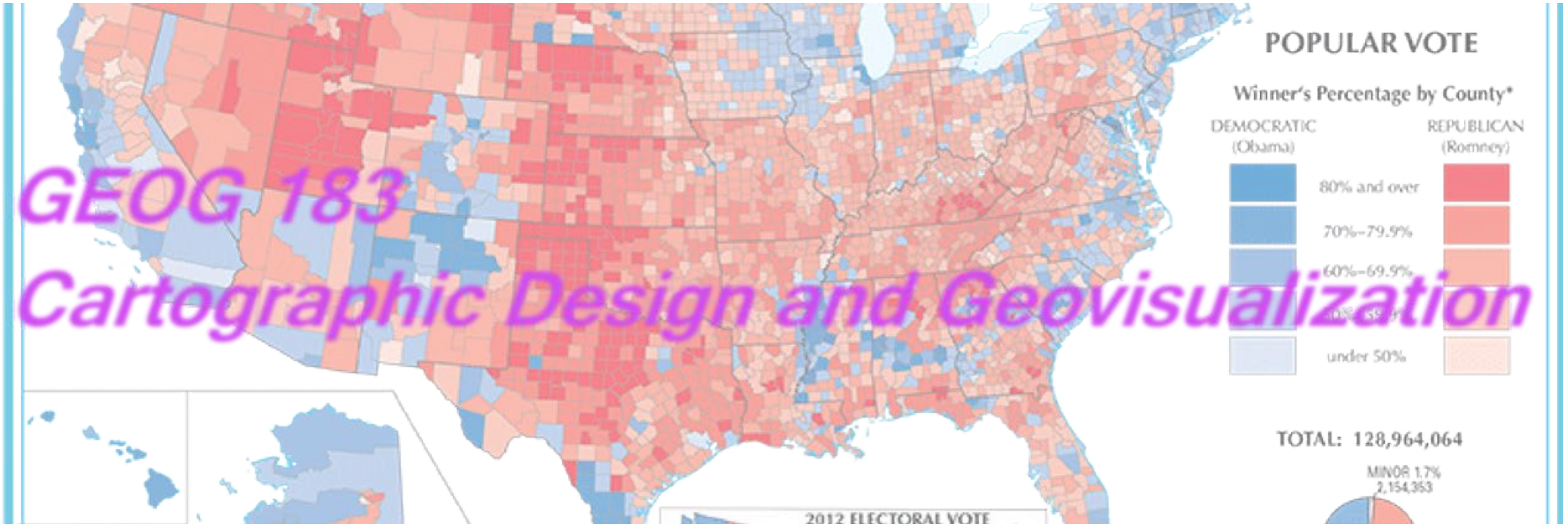
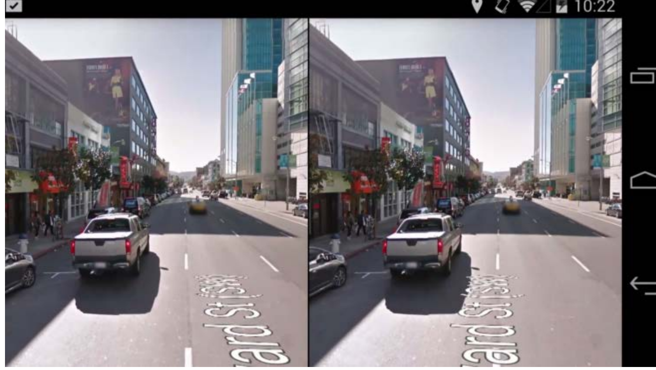


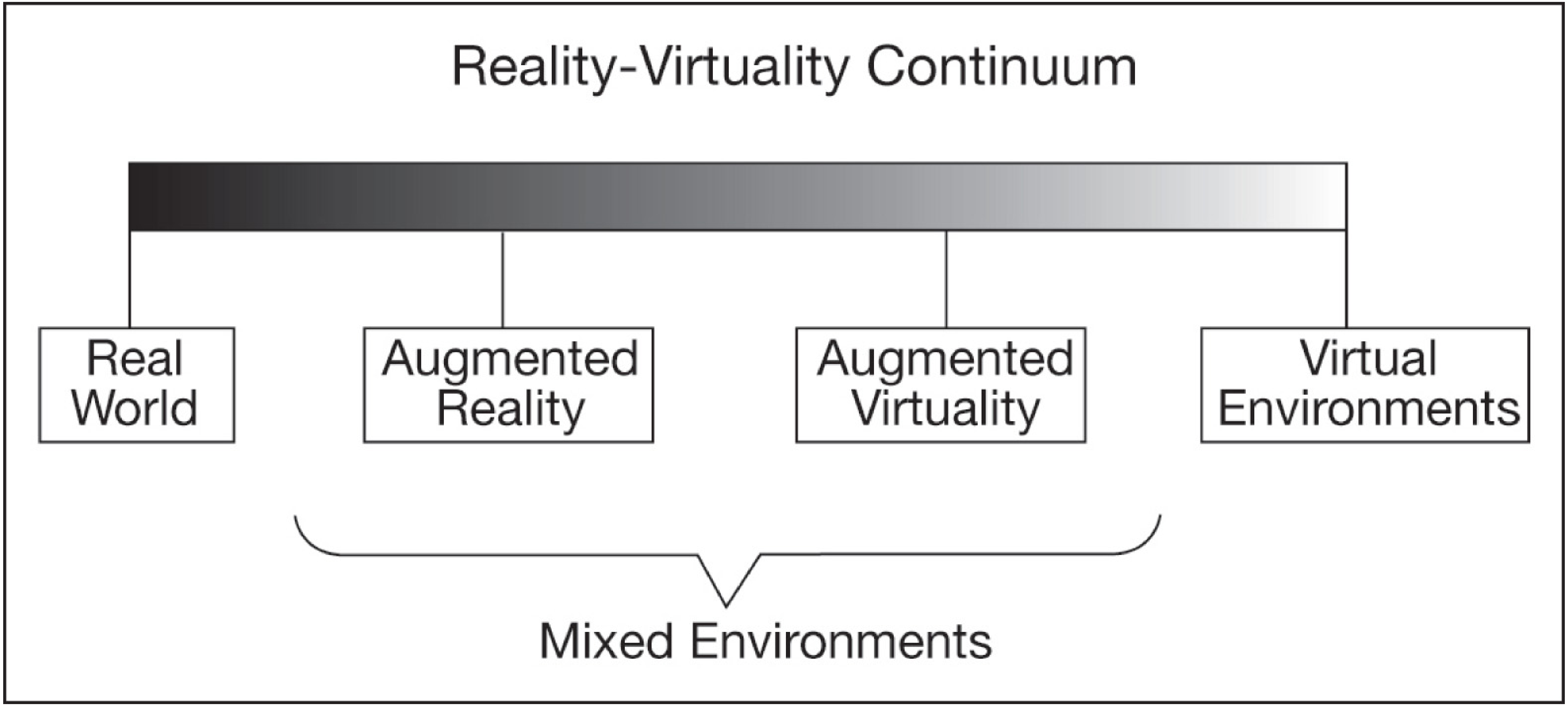
Geog183: Cartographic Design and Geovisualization Spring Quarter 2016

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


Reality-Virtuality Continuum
Real World
Augmented Reality
Augmented Virtuality
Virtual Environments
Mixed Environments

Some history

- Mid 1950s, visionary cinematographer Morton H. Eilig built a single user console called Sensorama
  - stereoscopic display
  - Fan 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)

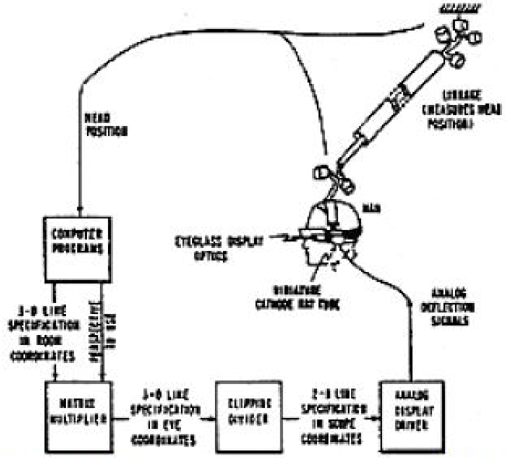
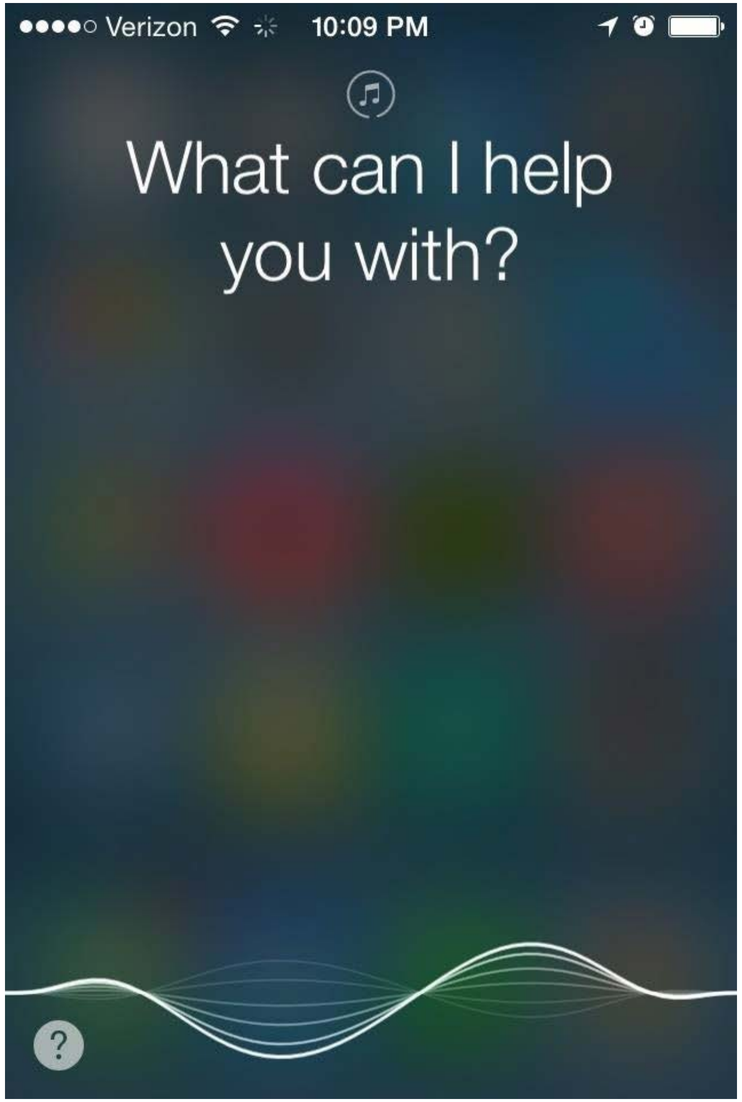


Figure 1: The parts of the three-dimensional display system

True VR: Immersive, interactive, multi-sense

Types of interaction

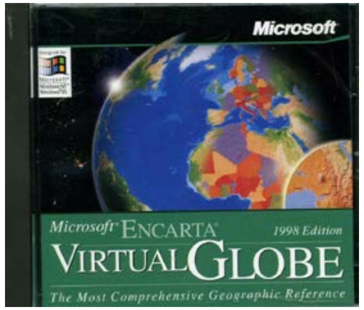
- Voice recognition
- Navigation
- Zoom: “Drill down”: Progression
- See through
- Search
- 3-D visualization and movement
- Time-line
- Multimedia : web links and portals



How does it work?

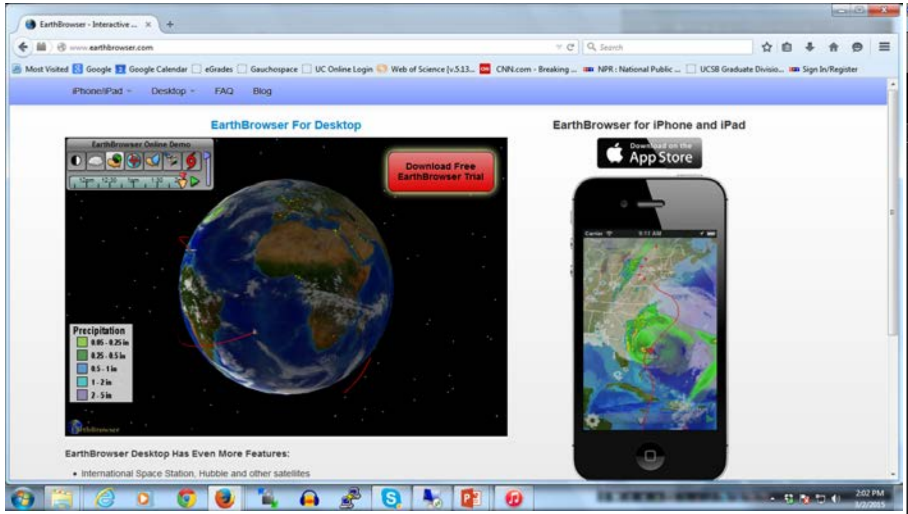
- Synchronized sound and video
- Stereo separation by isolated lenses
- Head movement sensing
- Reduced frame and interaction lag

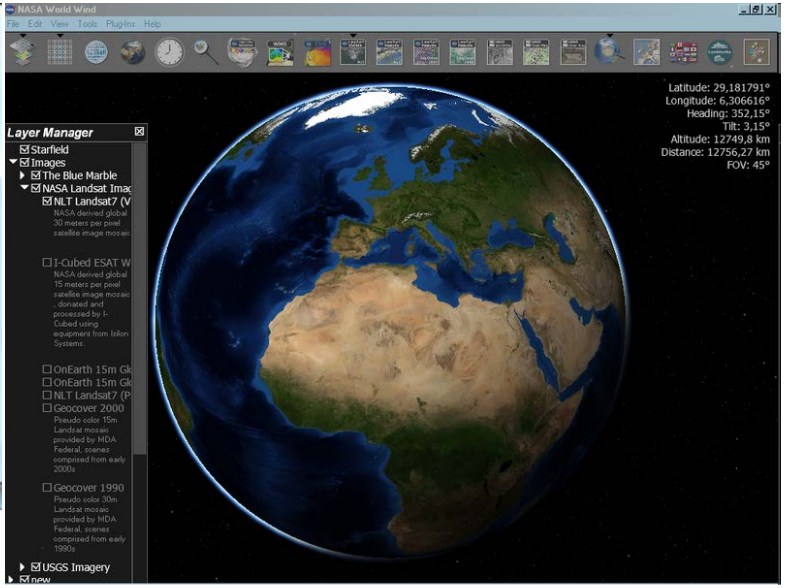
Virtual Globes



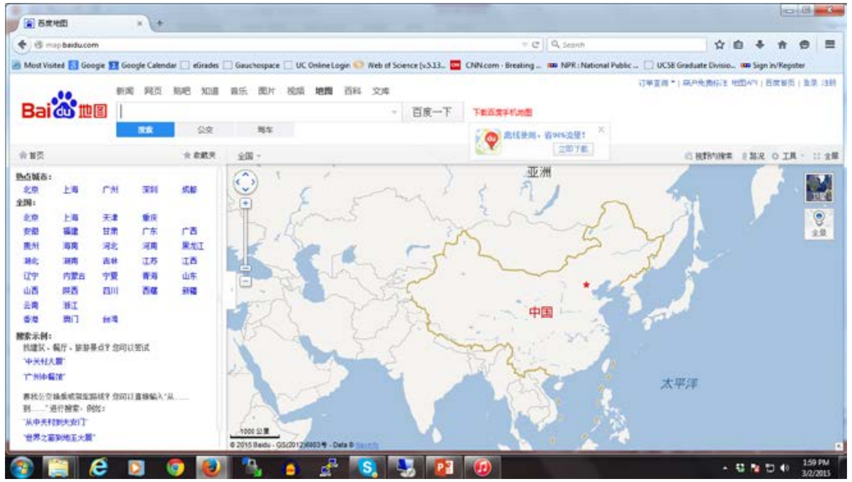
- A **virtual globe** is a 3D software model or representation of the Earth or another world
  - provides the user with the ability to freely move around in the virtual environment by changing the viewing angle and position.
  - have the additional capability of representing many different views on the 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

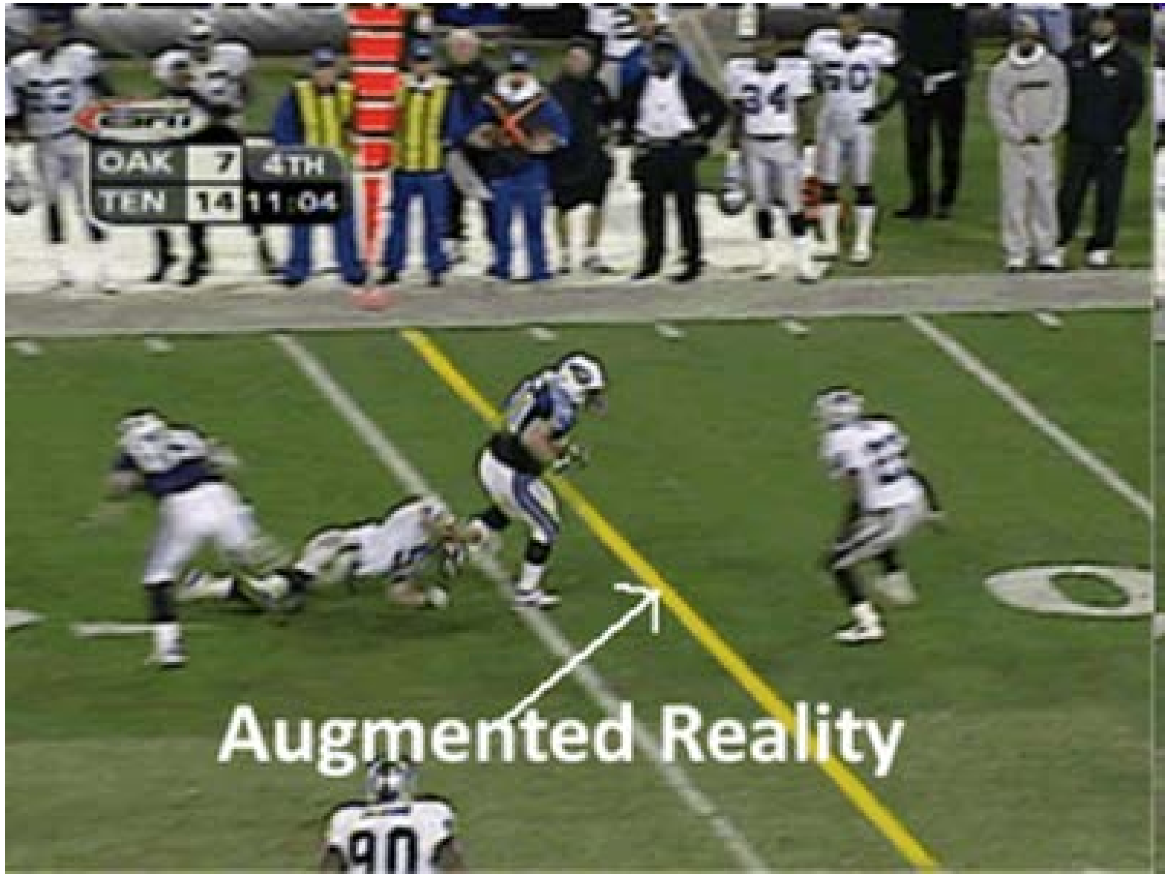




- NASA World Wind
- CitySurf Globe
- Bing Maps
- SkylineGlobe
- Google Earth
- Marble, part of the K Desktop Environment, with OpenStreetMap
- ArcGIS Explorer
- EarthBrowser
- Software MacKiev's 3D Weather Globe & Atlas
- Earth3D
- WorldView
- Bhuvan
- Baidu Map
- National Geographic Atlas



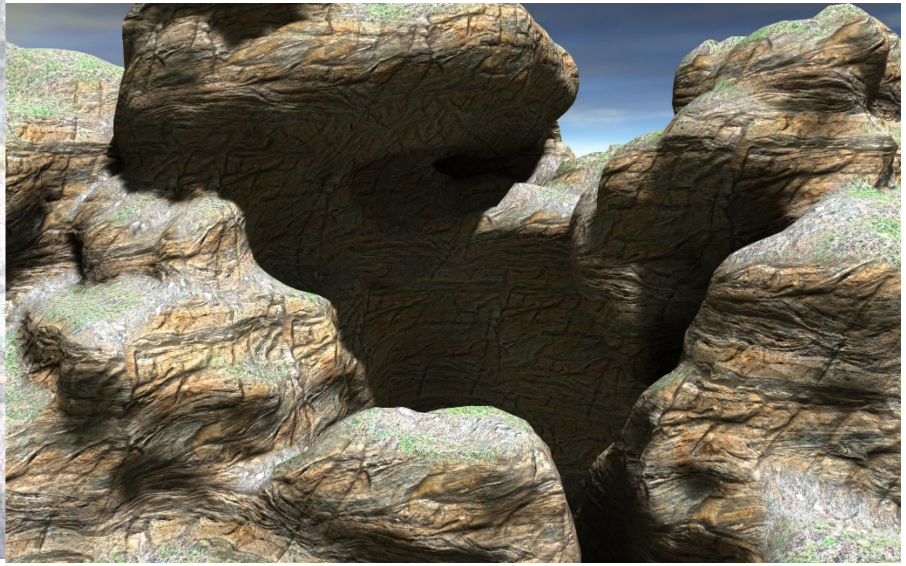
Augmented reality



Some issues

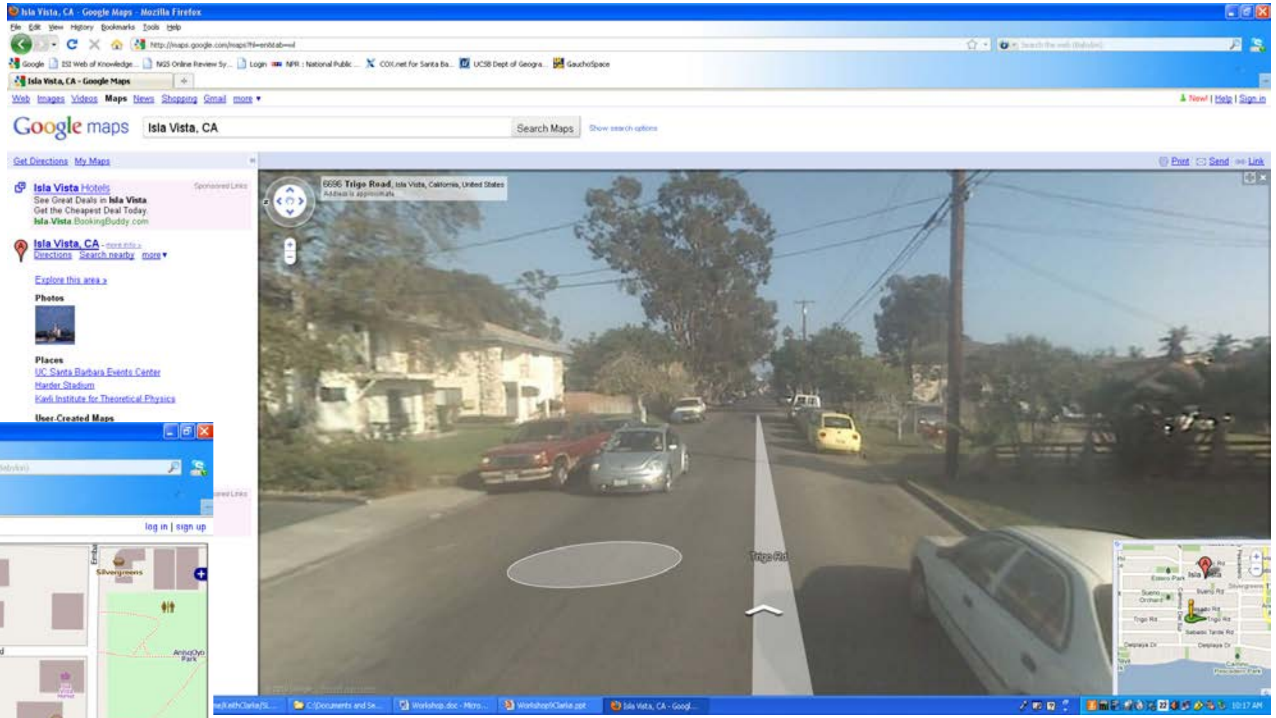
- How do you collect 3D data for photorealism?
- How much realism is necessary?
- How does interaction change the experience?
- What about permanent and temporary objects?
- How do you deal with underground and overlapping spaces?
- Cognitive disturbance: Foveation and peripheral vision altered
- Image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

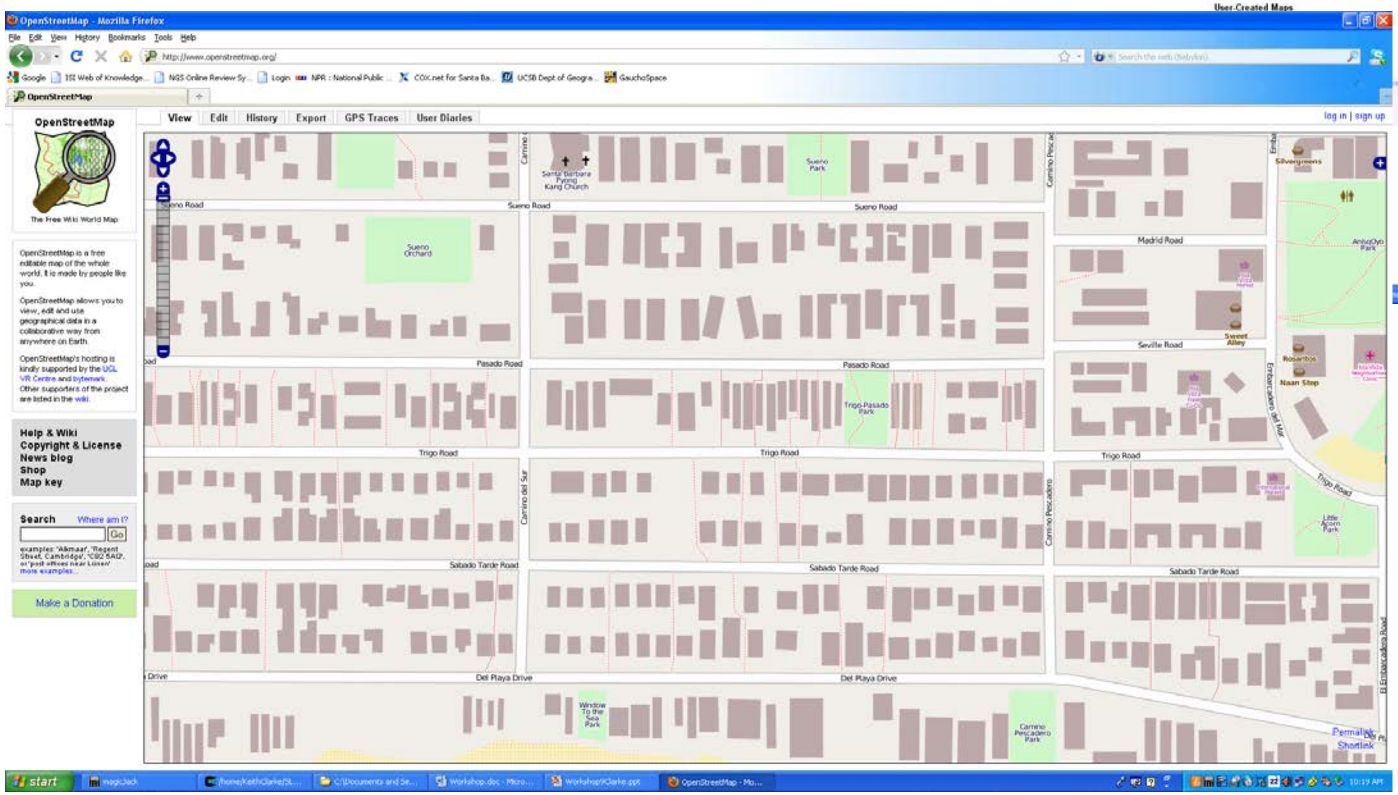
The issue: Can you sense reality?




Google Earth
File Edit View Tools Add Help
Search
Fly To
Find Businesses
Directions
ucsb
ucsb (1 - 1)
UCSB
Places
My Places
Untitled Image Overlay
Layers
Earth Gallery
Primary Database
Borders and Labels
Places
Panoramio Photos
Roads
3D Buildings
Photorealistic
Gray
Ocean
Street View
Weather
Gallery
Global Awareness
More
©2010 Google
start

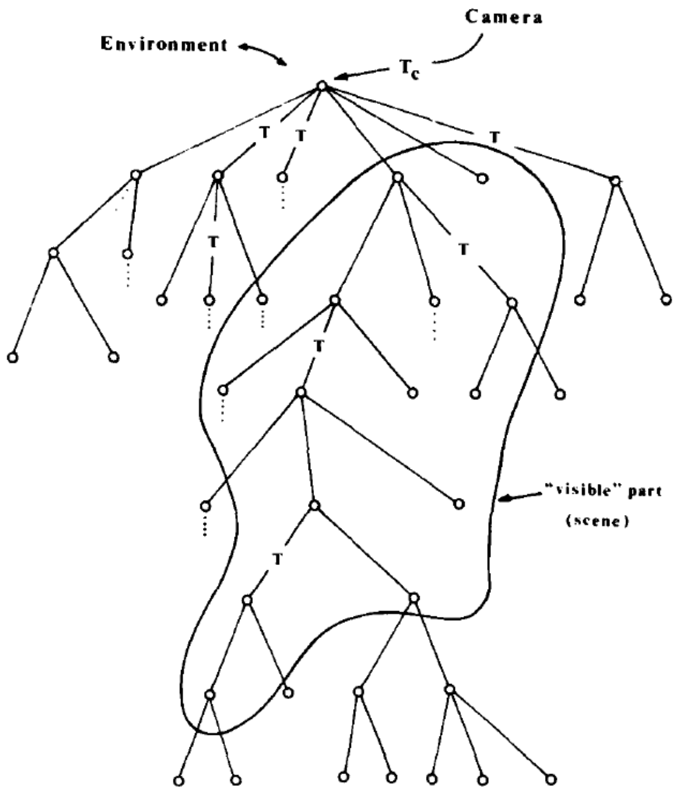
Streetview vs. Openstreetmap

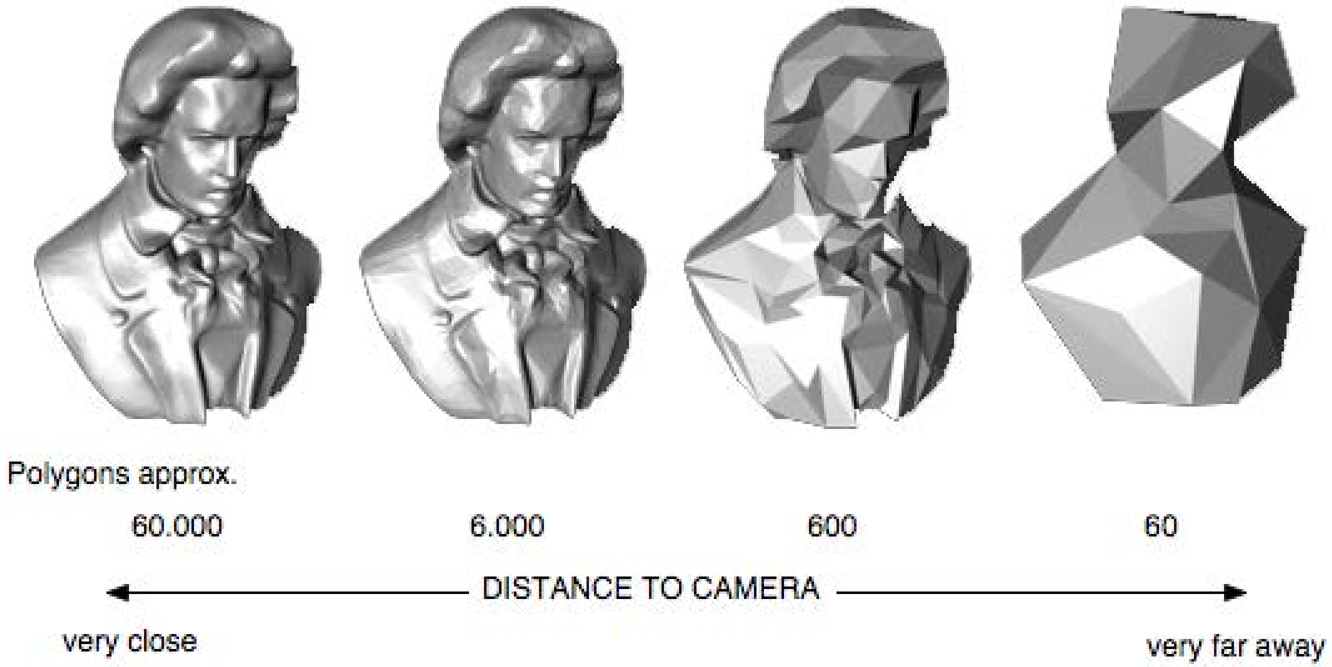




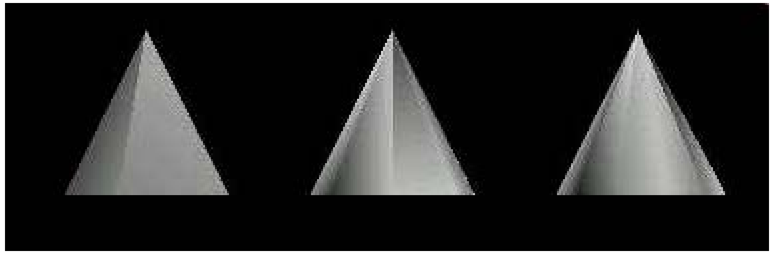
Generalization in Computer Graphics: Level of Detail

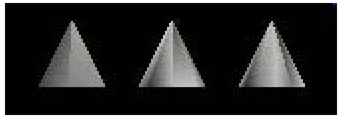
- James H. Clark (1976) *Hierarchical Geometric Models for Visible Surface Algorithms*. Communications of the ACM, October 1976,19, 10. pp 547-554.

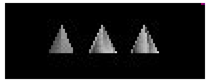




VRML 2.0 LOD Example





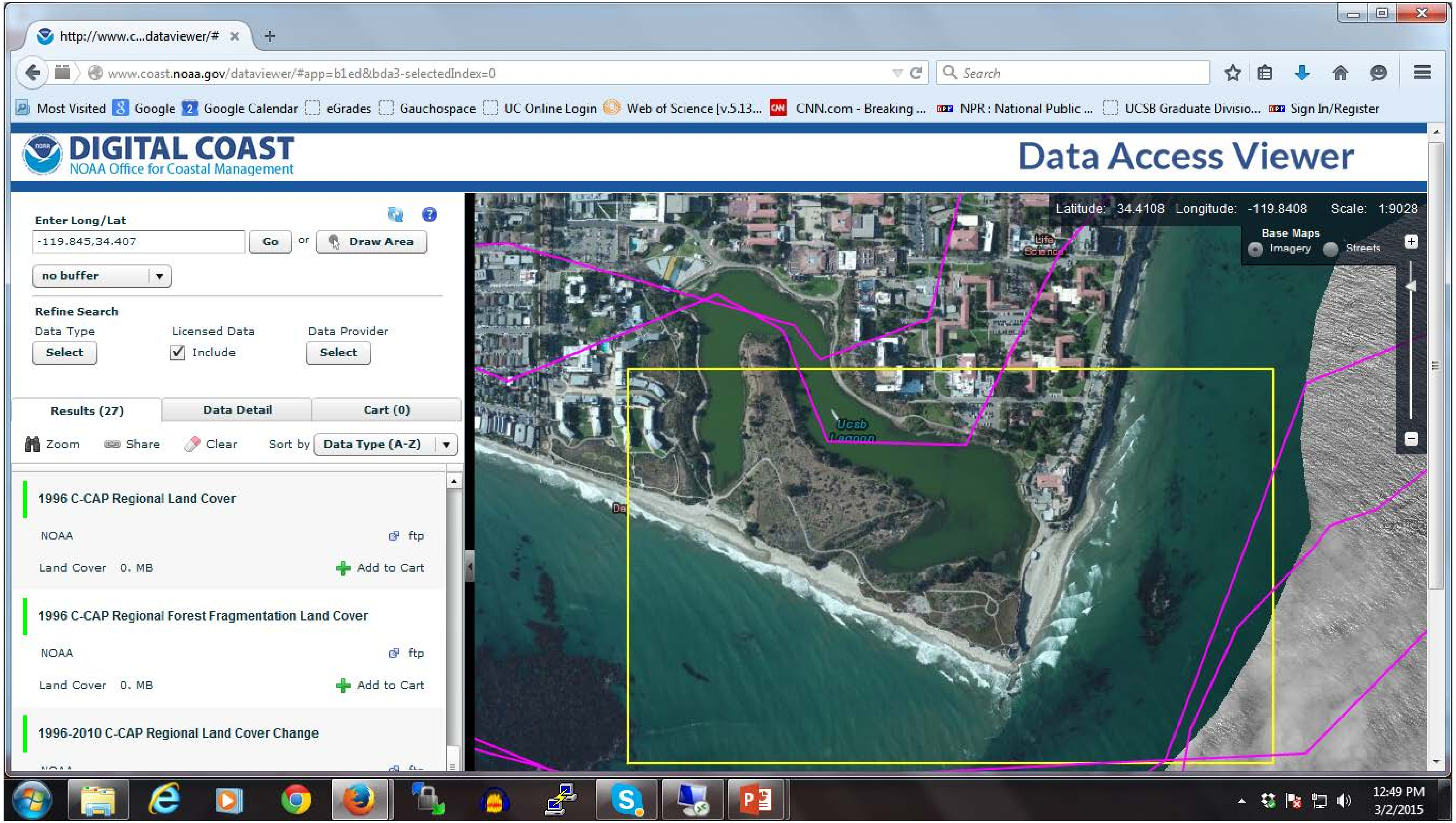


```
#VRML V2.0 utf8
LOD { range [20,40] level [
#full detail 16 sided cone
Shape{ appearance Appearance { material Material { diffuseColor 1.0 1.0 1.0 }
geometry Extrusion{ crossSection [ -1 0, 0 0, -1 -2 -1 0]
spine [1 0 0 , 0.866 0 0.5, 0.5 0 0.866, 0 0 1 , -0.5 0 0.866, -0.866 0 0.5, -1 0 0, -0.866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

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
- NED completed at 30m, then 15m and less
- LIDAR has now taking over
- New photogrammetric methods showing promise

IFSAR DEM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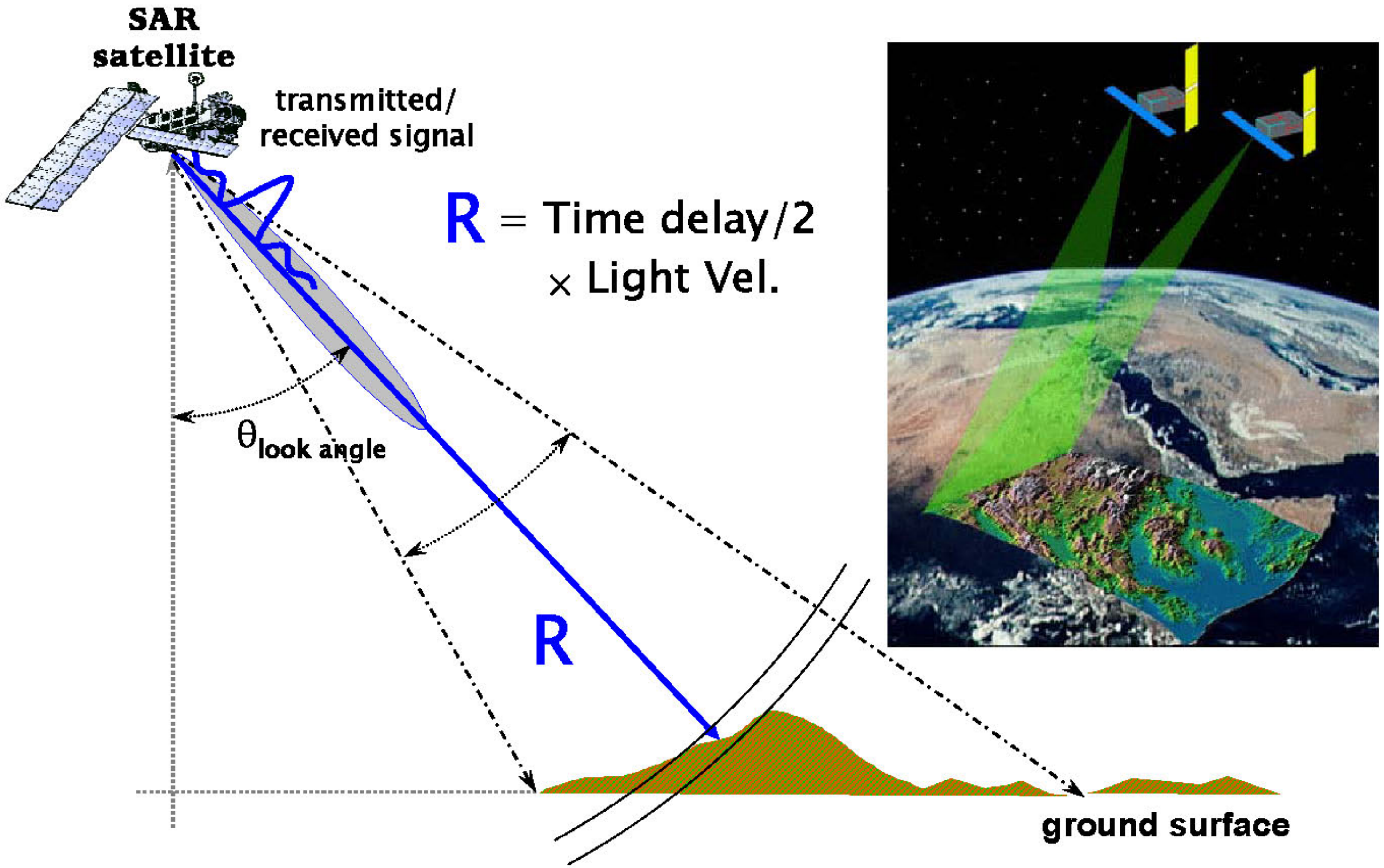
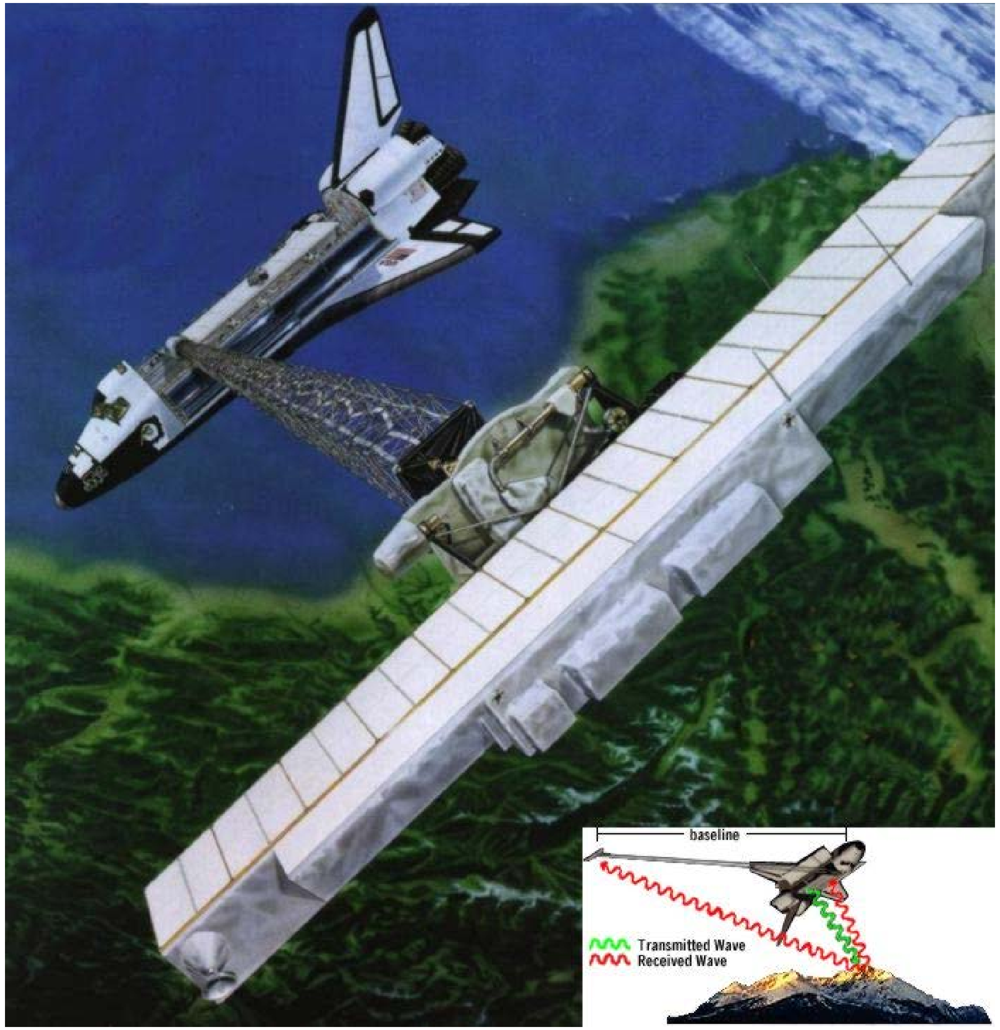
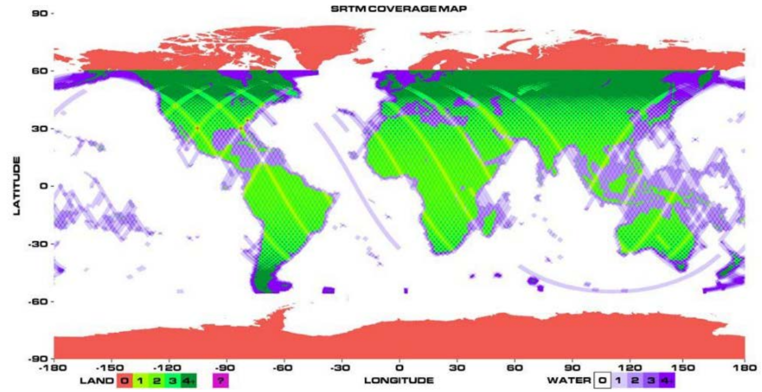
www.coast.noaa.gov/dataviewer/#app=b1ed&bda3-selectedIndex=0
Most Visited
Google
Google Calendar
eGrades
Gauchospace
UC Online Login
Web of Science [v.5.13...
CNN.com - Breaking ...
NPR : National Public ...
UCSB Graduate Divisio...
Sign In/Register
DIGITAL COAST
NOAA Office for Coastal Management
Data 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
Ucsb Lagoon
12:49 PM
3/2/2015

SAR from Space

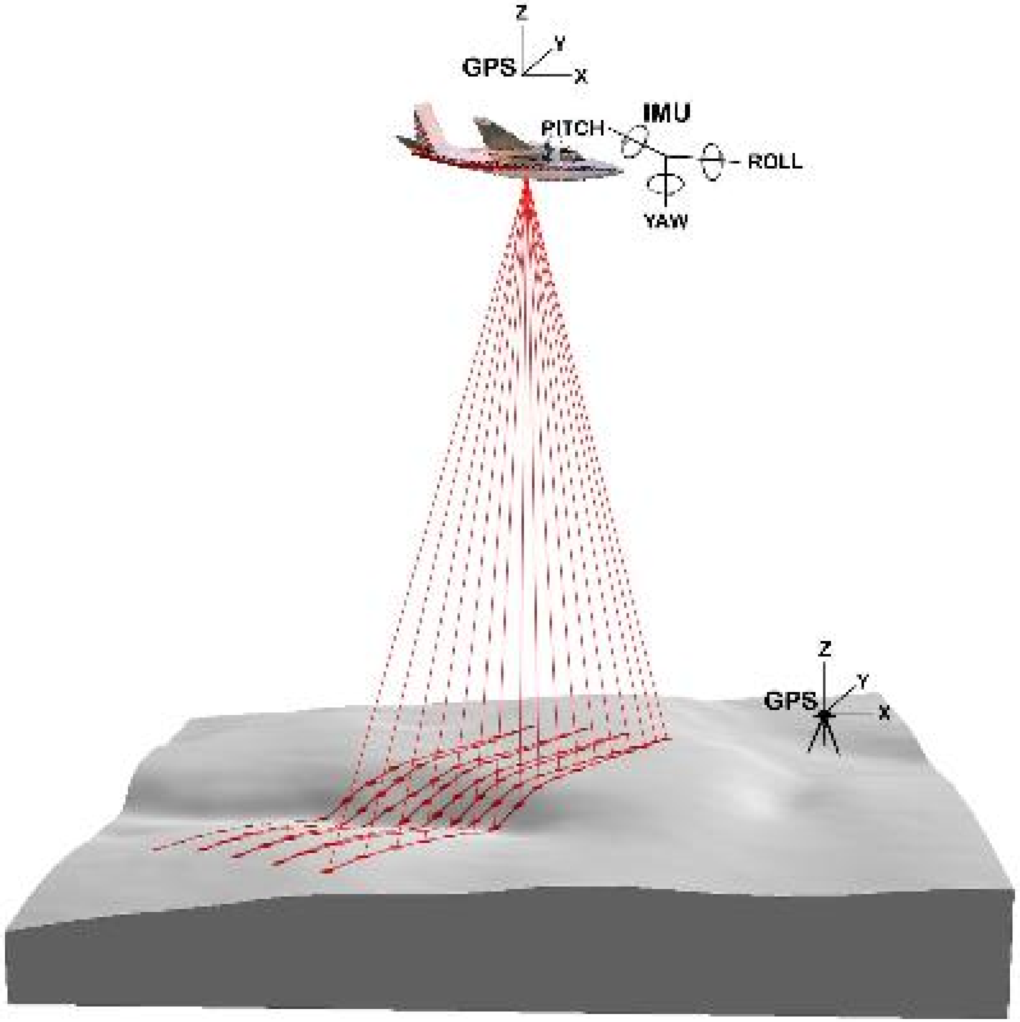


SRTM: Global topo map

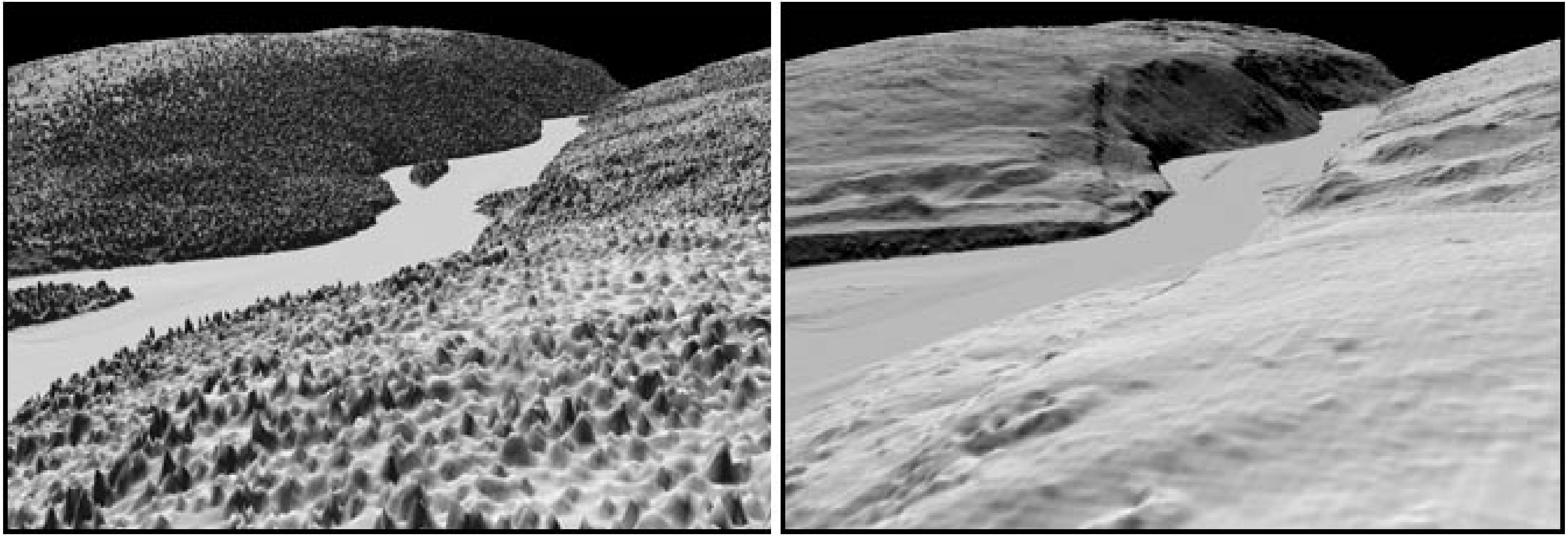




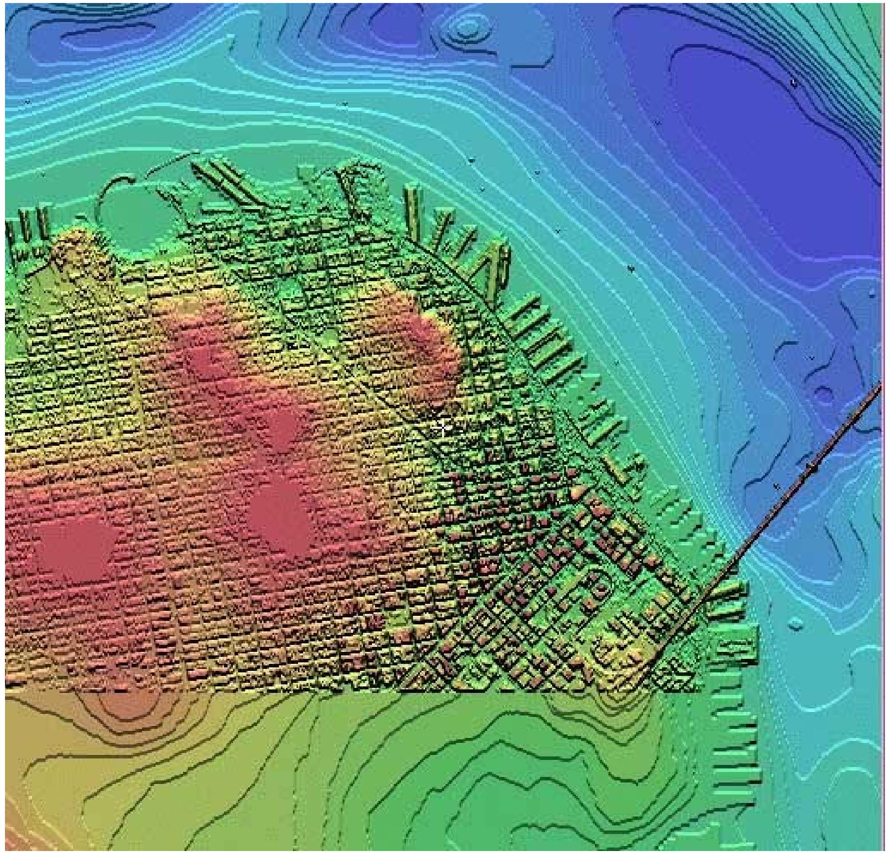
How Lidar works

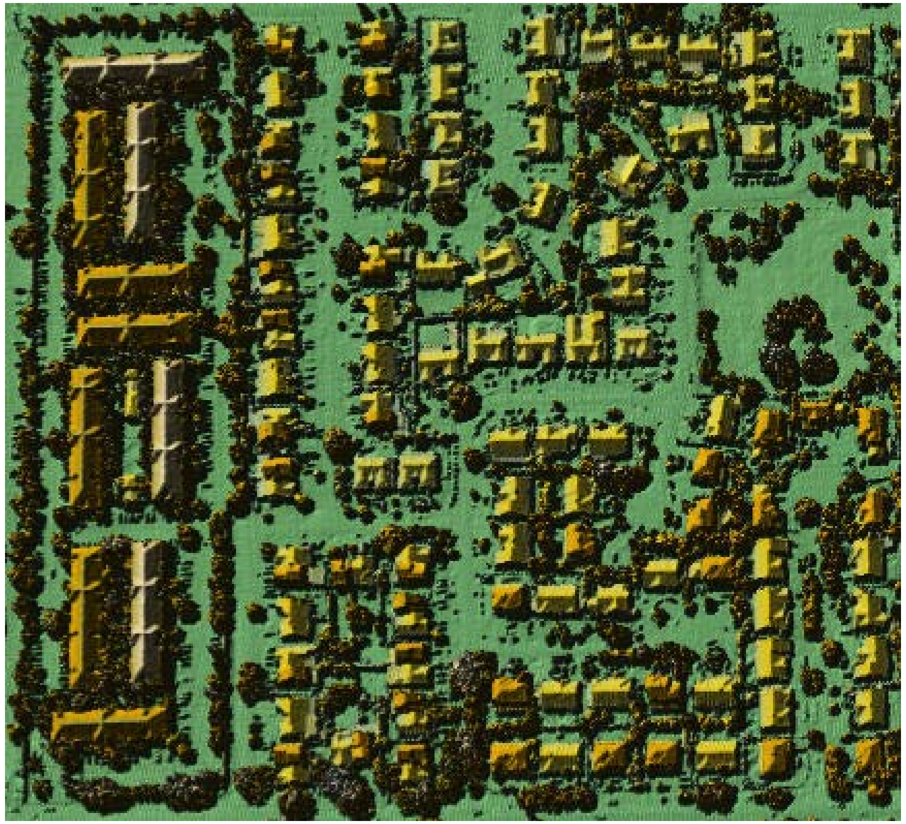


LIDAR first and last pulse

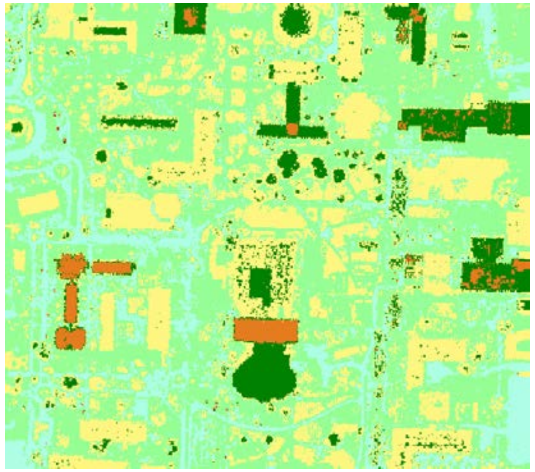


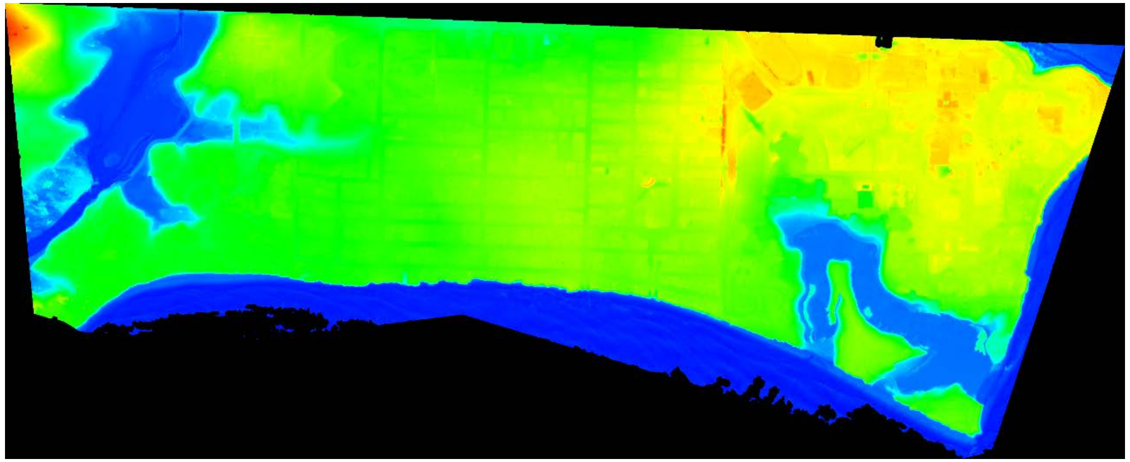
LIDAR terrain detail

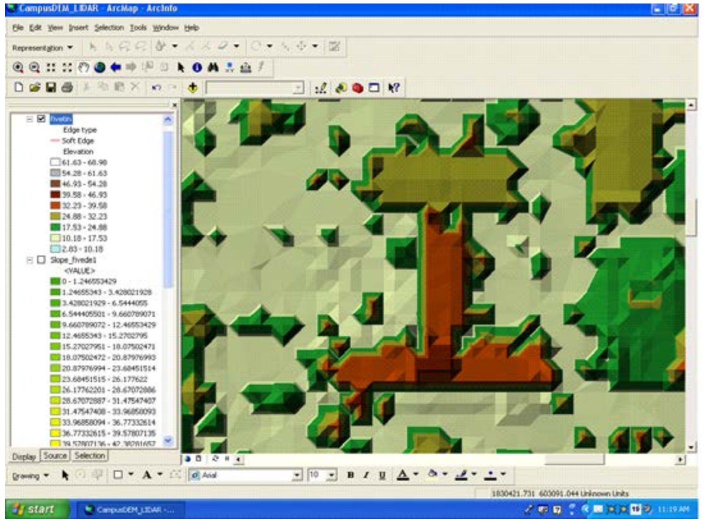


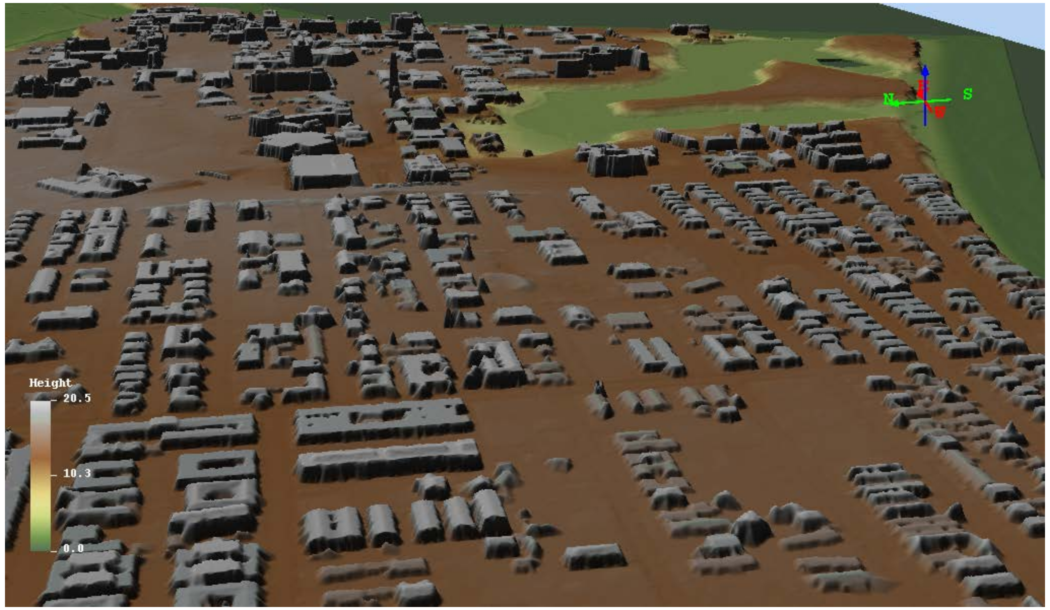


3D Models LiDAR

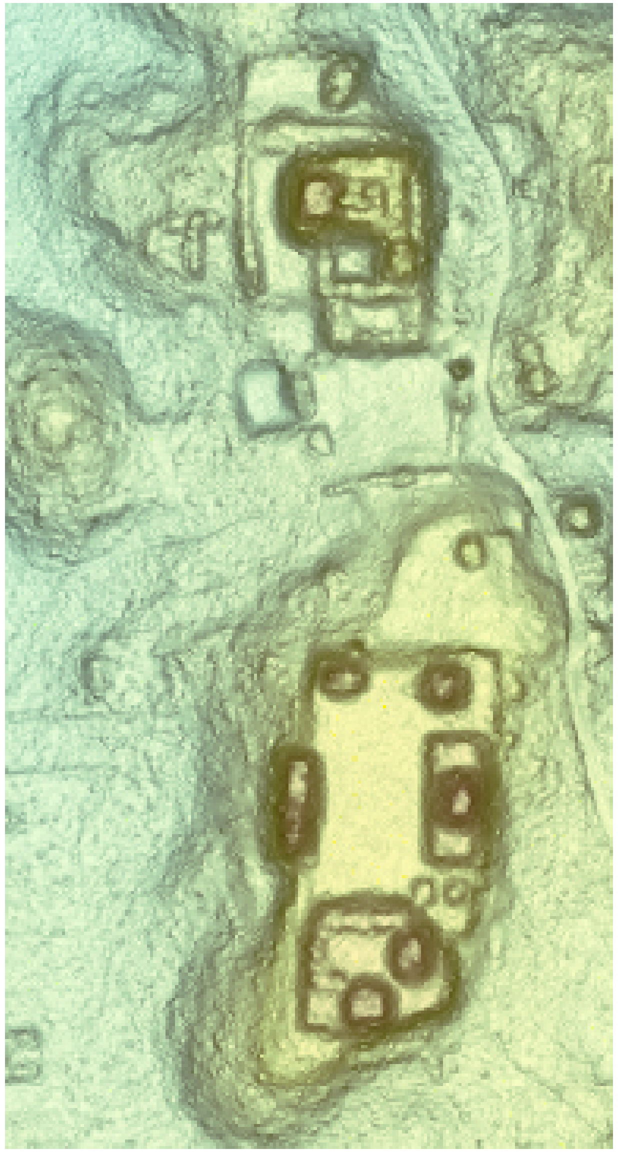


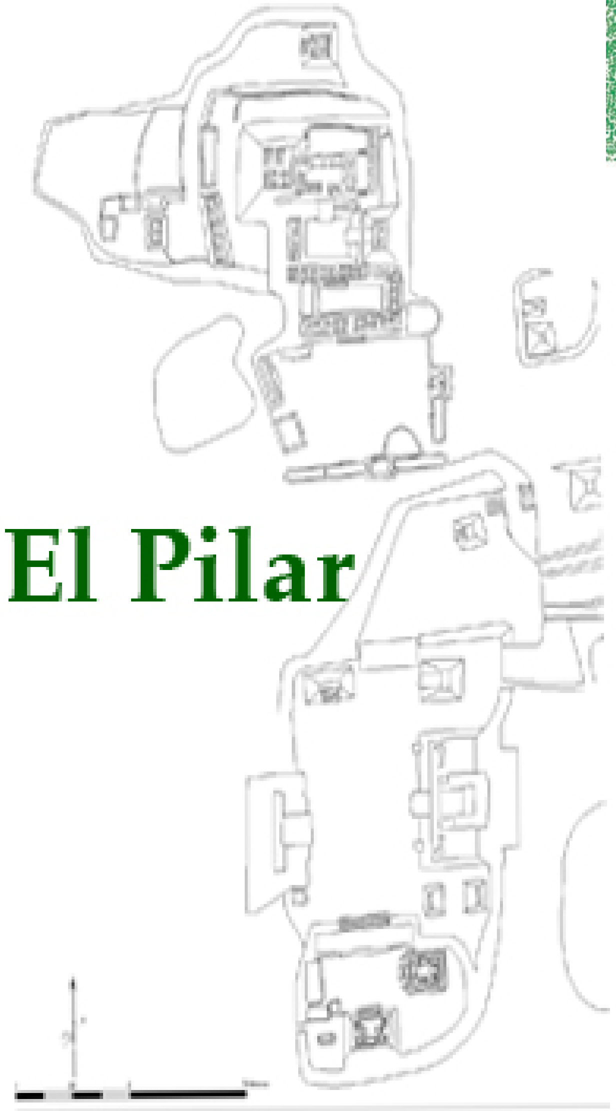


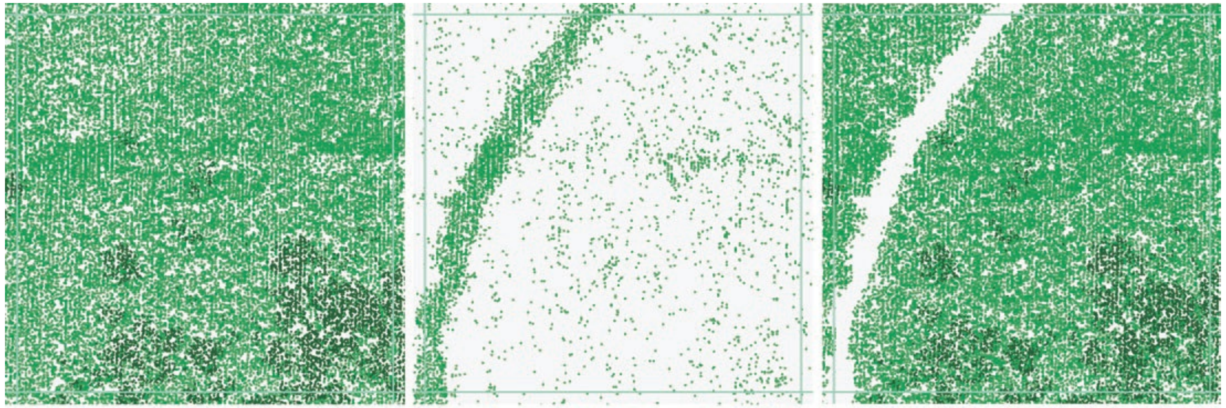


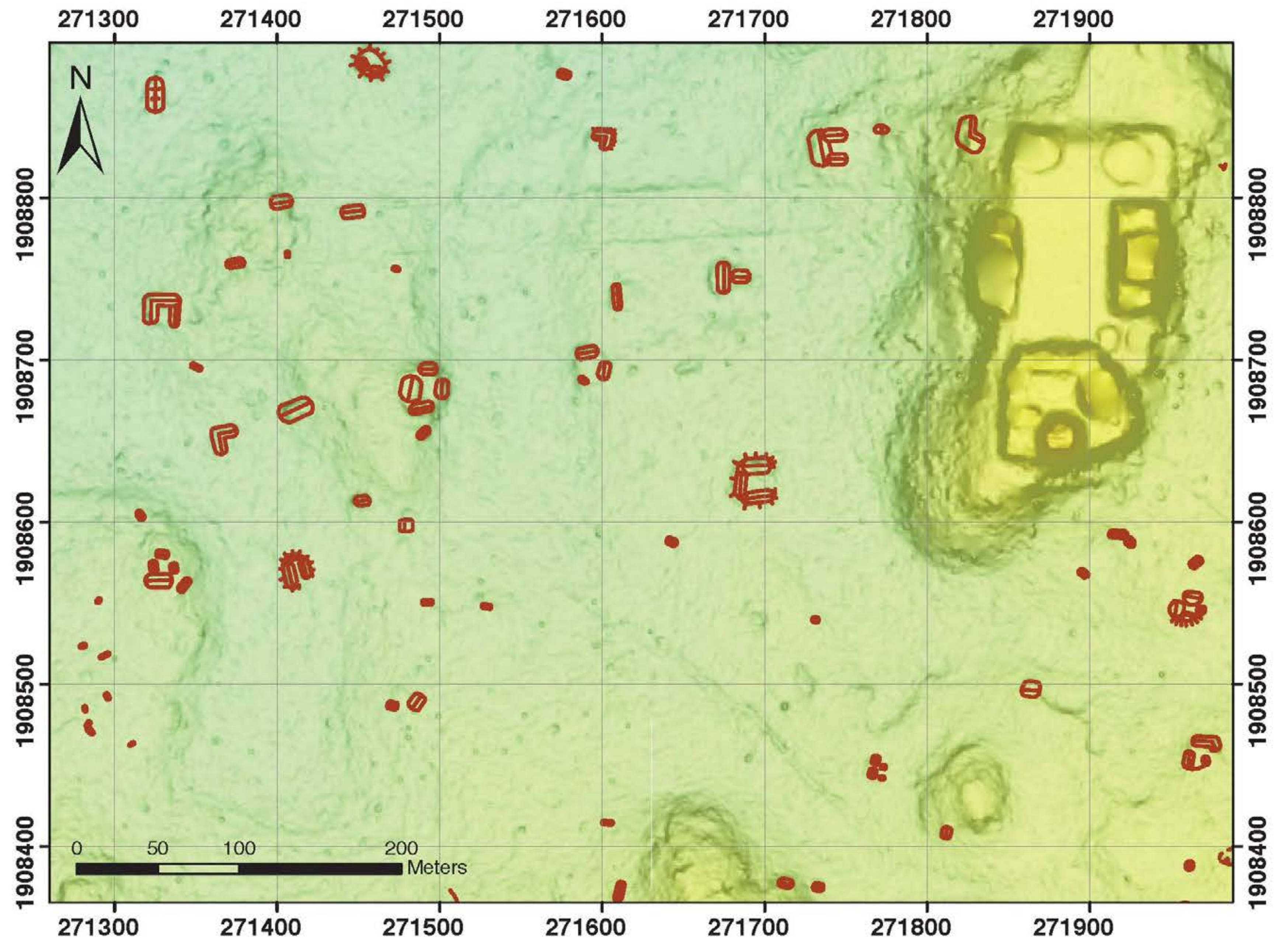


LiDAR at El Pilar





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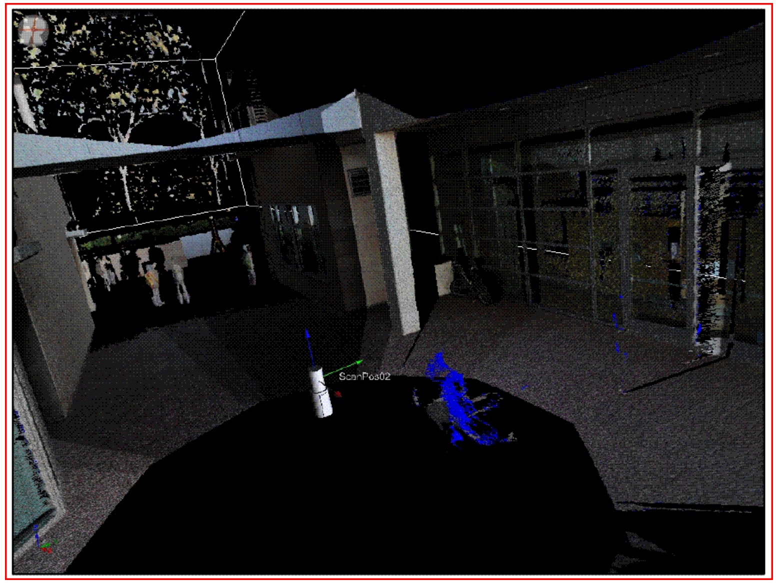
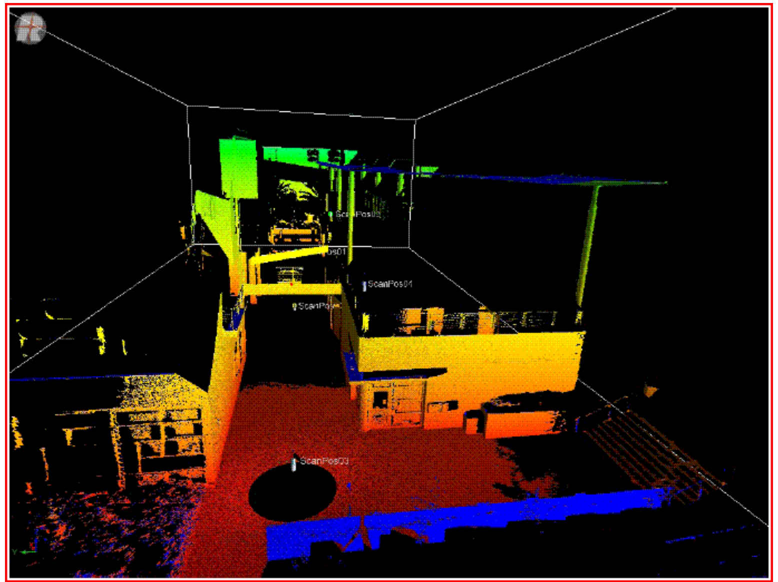
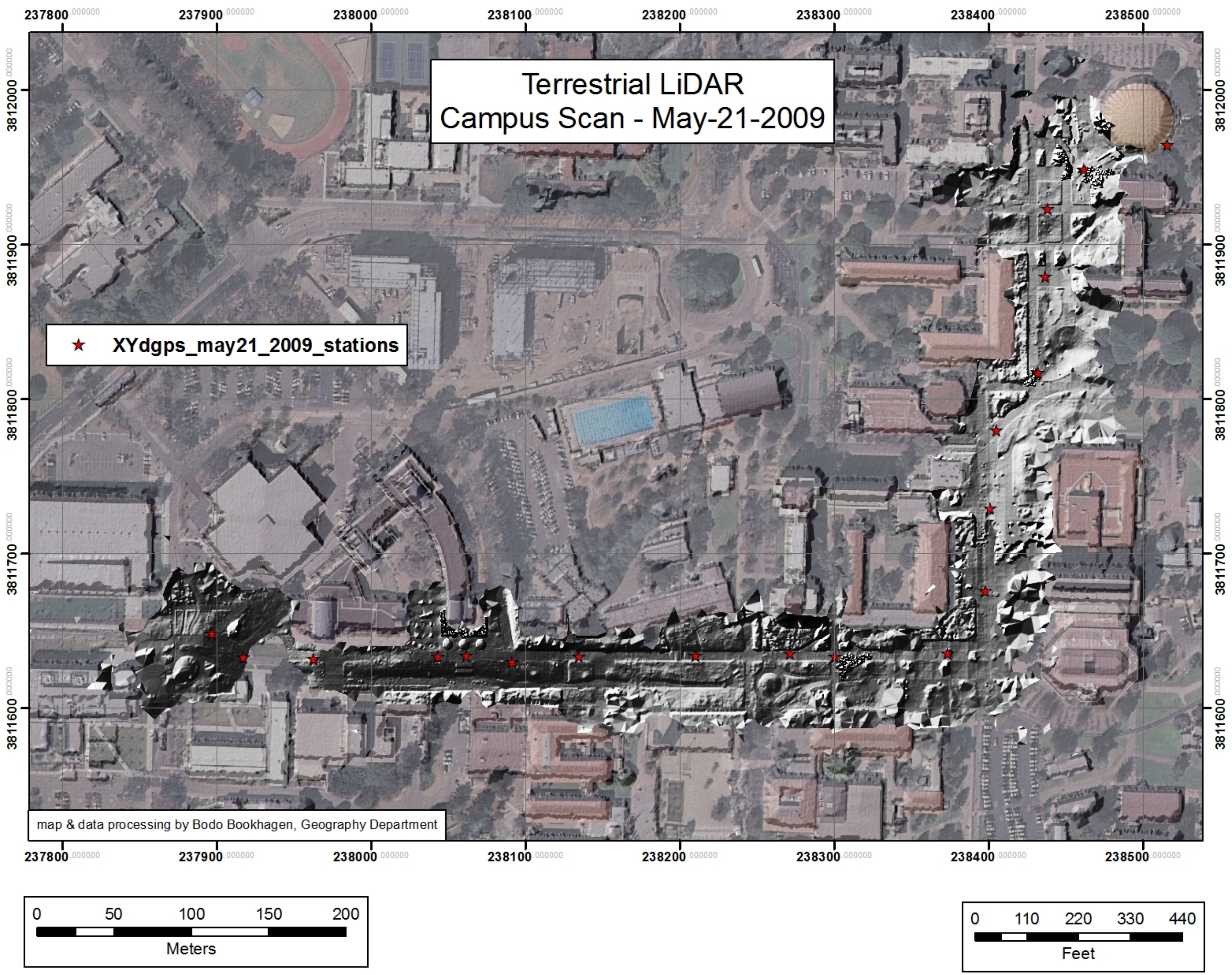
200
Meters

Terrestrial Scanning LiDAR





Campus scans

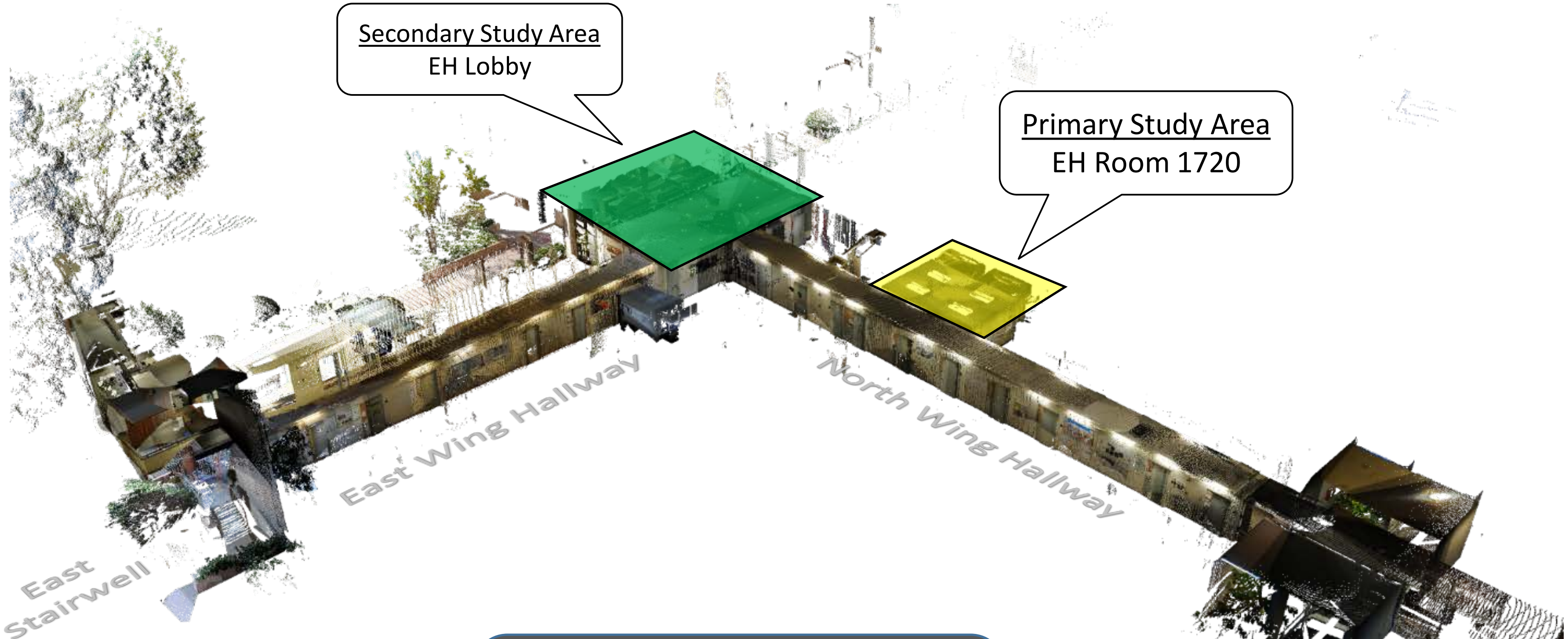


Lidar Point Cloud Data

UCSB Ellison Hall, 1st Floor

Secondary Study Area
EH Lobby

Primary Study Area
EH Room 1720



Additional Study Areas
North Wing Hallway
East Wing Hallway
East Stairwell

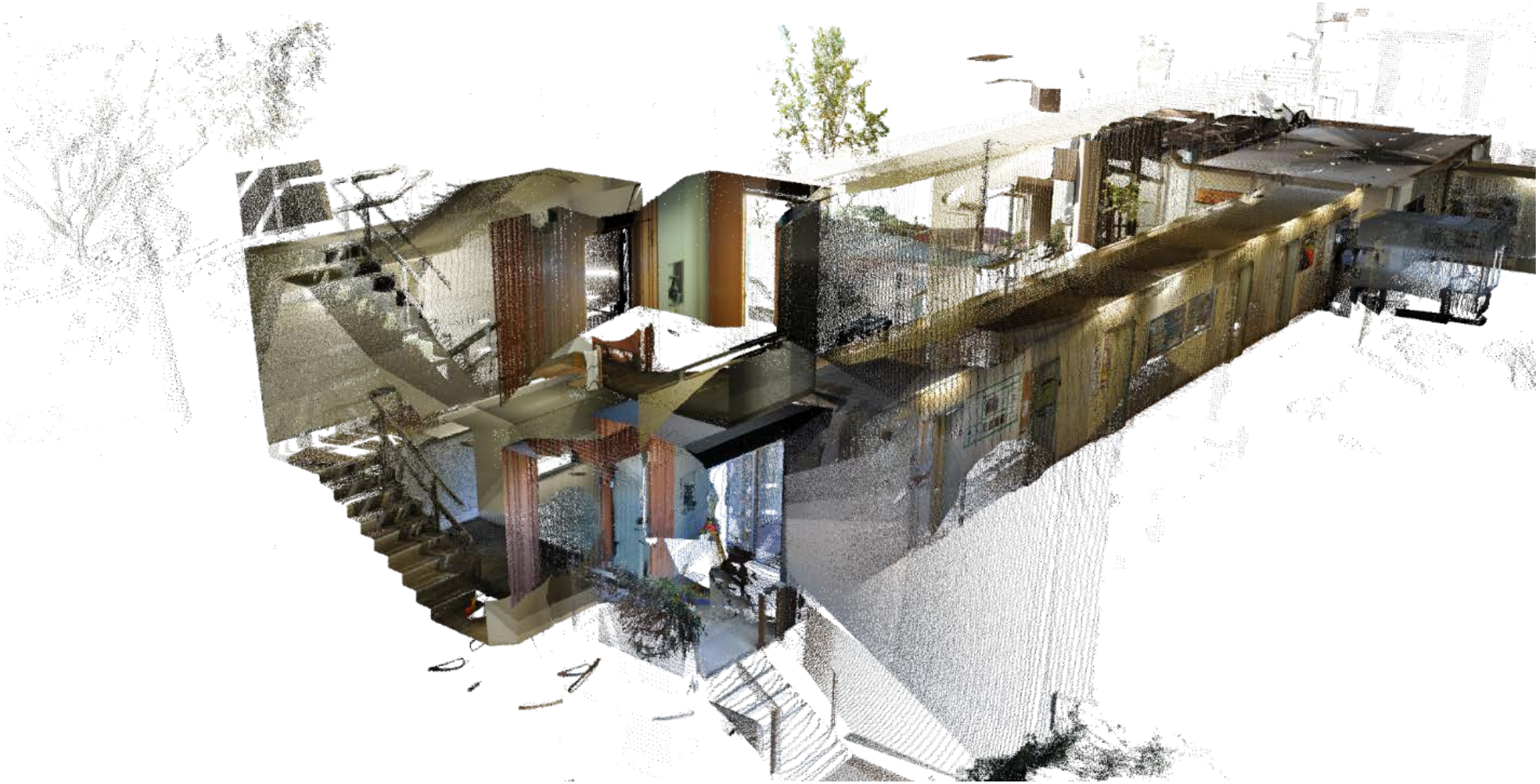
Data Collection Information

Platform: Riegl LMS-Z420i Laser Scanner

Points: 35 million

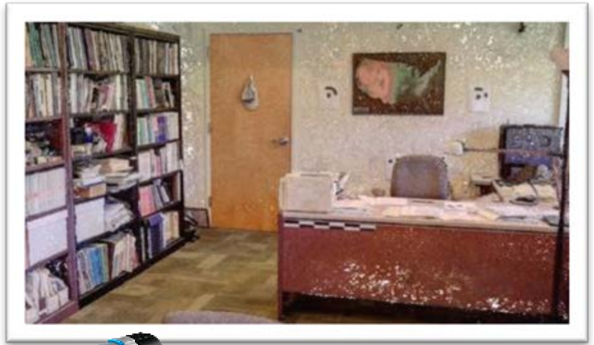
Lidar Point Cloud Data

EH East Stairwell, 1st/2nd Floors

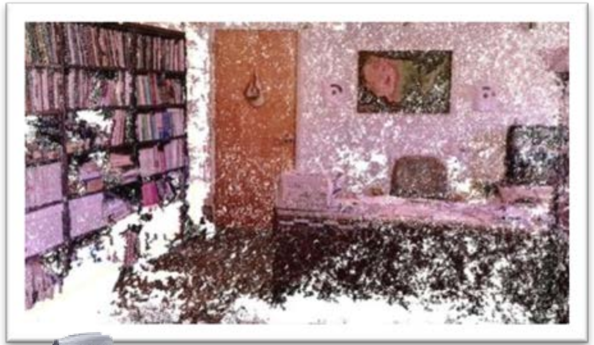


Platforms Tested To Date (EH Room 1720 Only)


Nikon D3100
(14.2 MP)




Microsoft LifeCam Studio
(2.1 MP)



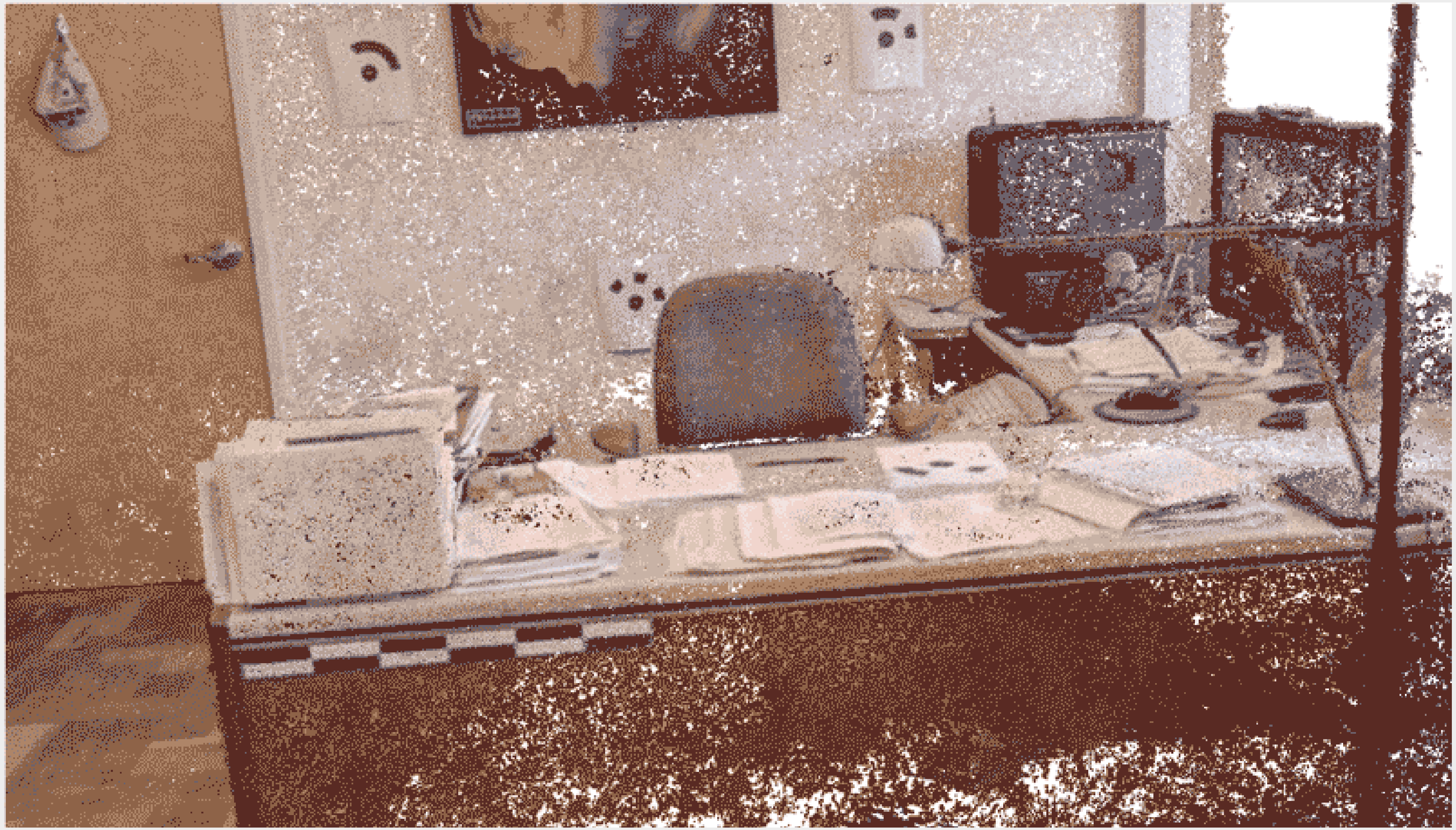

Logitech QuickCam Deluxe
(0.3 MP)


Sony DSC-TX10
(16.2 MP)


Panasonic DMC-FZ28
(10.1 MP)


Riegl LMS-Z420i Laser Scanner
(Baseline Measurements)

Animated Point Cloud (LifeCam Studio)

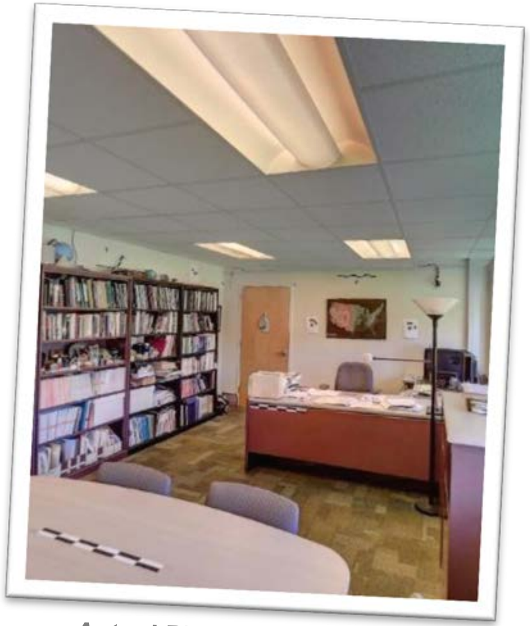


Sample 3D Point Cloud via Webcam

Raw 3D Point Cloud of EH Room 1720

3D Point Cloud Inside Bookshelf

Camera:	Microsoft LifeCam Studio (1920x1080)
# Stations:	48 around room perimeter
# Images:	144 HDR images
# Points:	18.3 million

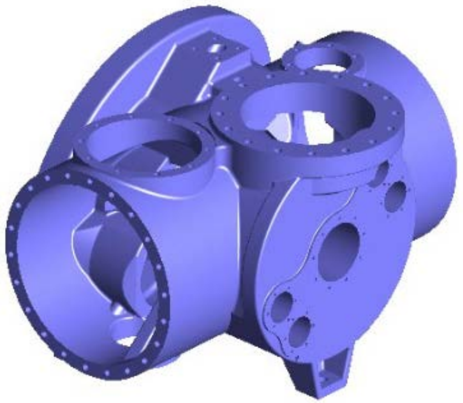


Actual Photograph of Office

3D modeling and data structures

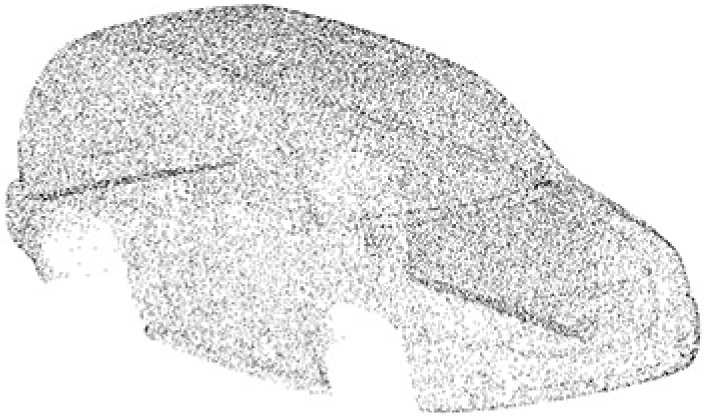
- Longley et. al. 6 models: gridded points, irregular points, cells, irregular polygons, TIN and contours
- Prior dominance of DEM
- Extensive use of TIN and surface patches
- Computer graphics and games favor Voxels
- LIDAR and phtogrammetry return a POINT CLOUD
- Has led to use of term Digital Surface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

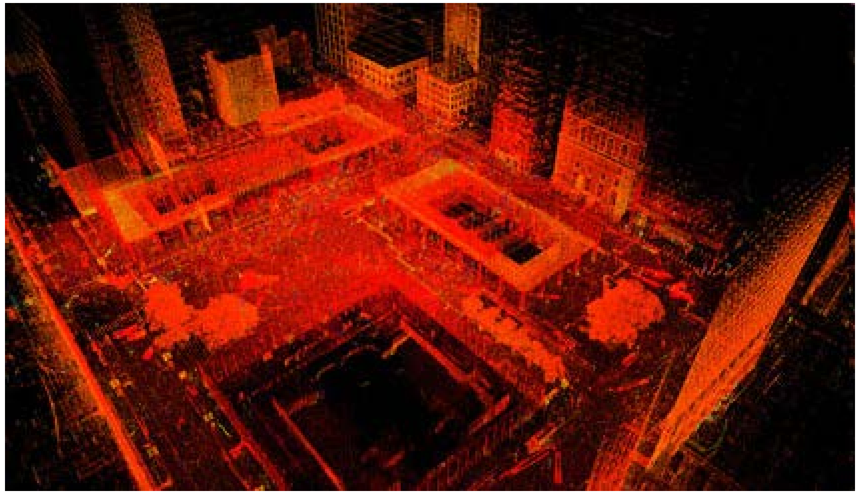
Measurement vs. Modeling

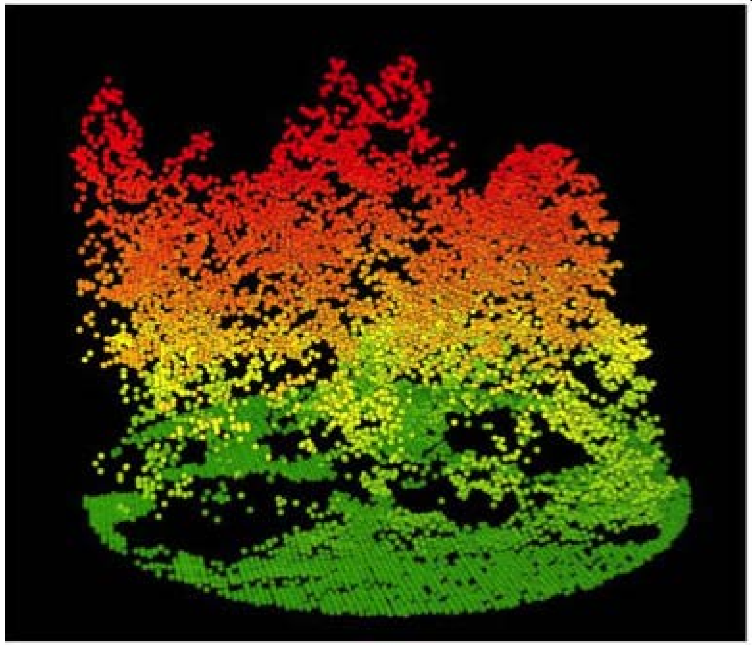


- Select key surface points, edges
- Generalize remaining surfaces
- Solids modeling
- Feature extraction; Buildings, trees (e.g. Lidar analyst, Feature analyst, Quick Terrain modeler, TerraSolid (Microstation)
- Geometric vs. natural objects
- Realism vs. Size e.g. Google Object Warehouse

Point Clouds

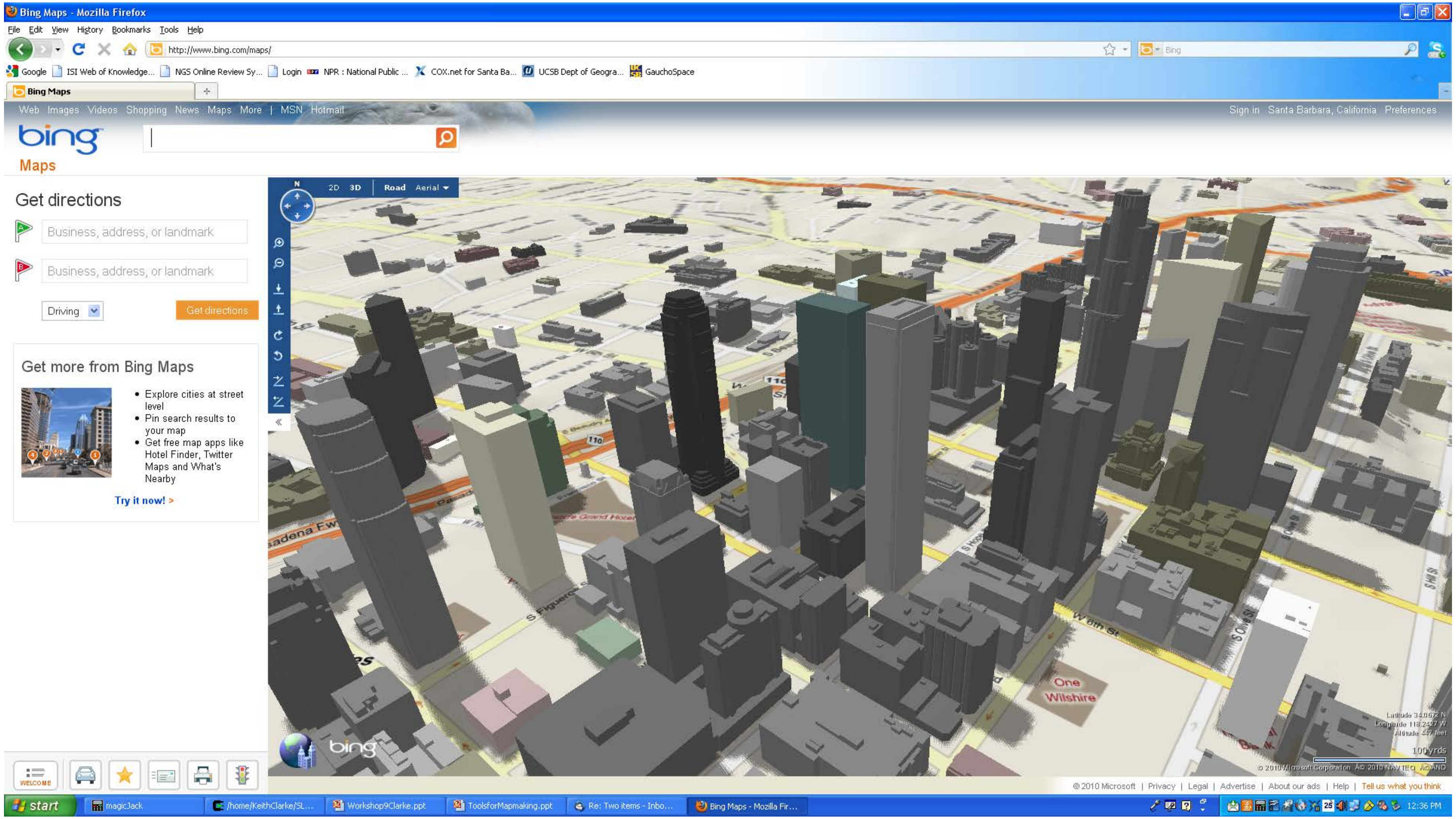




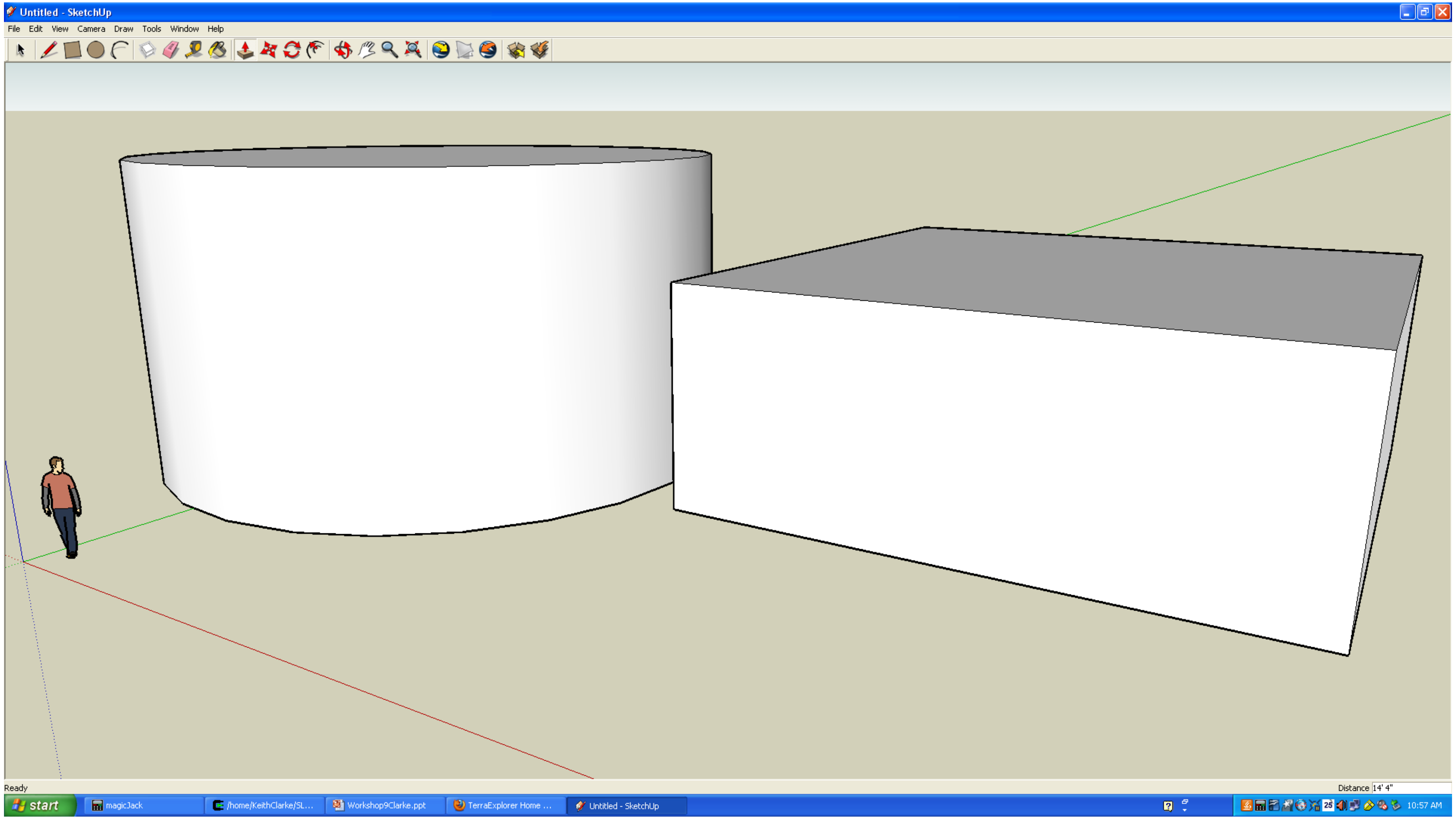


Simple 3D Model built by extrusion

BingMaps 3D Selected Cities (LA)

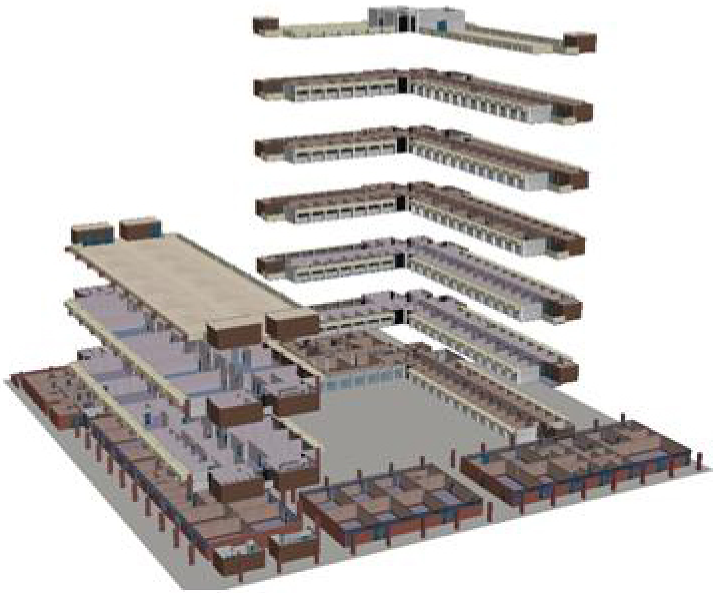


Simplest 3D tool: Sketch-Up (KML)



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)

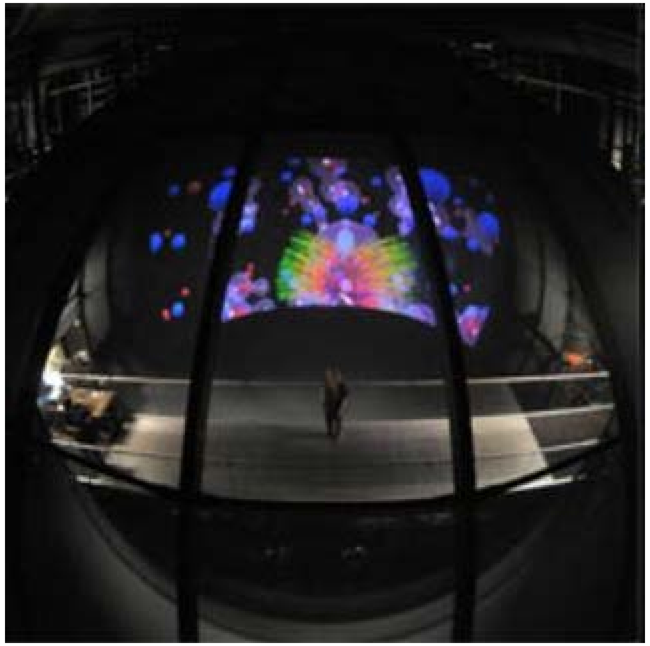
3D in Geobrowsers

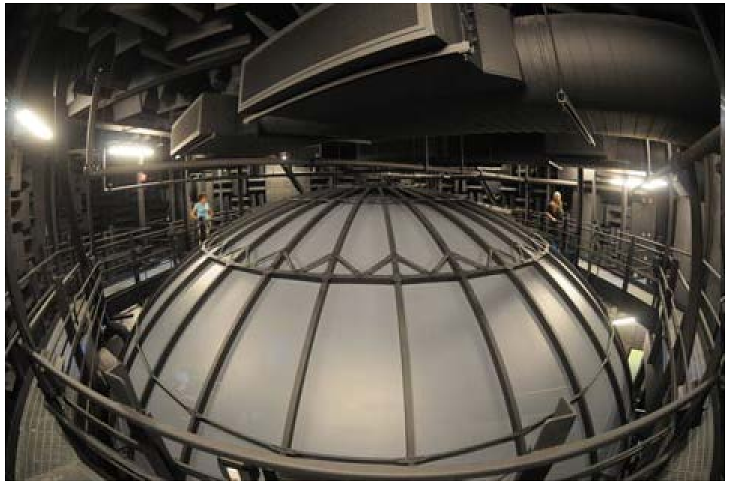
- Picture and panorama inclusion
- Google streetview
- GoogleEarth 3D Buildings
- Bing Maps 3D and oblique views
- Microsoft Photosynth
- Most geobrowsers include topography

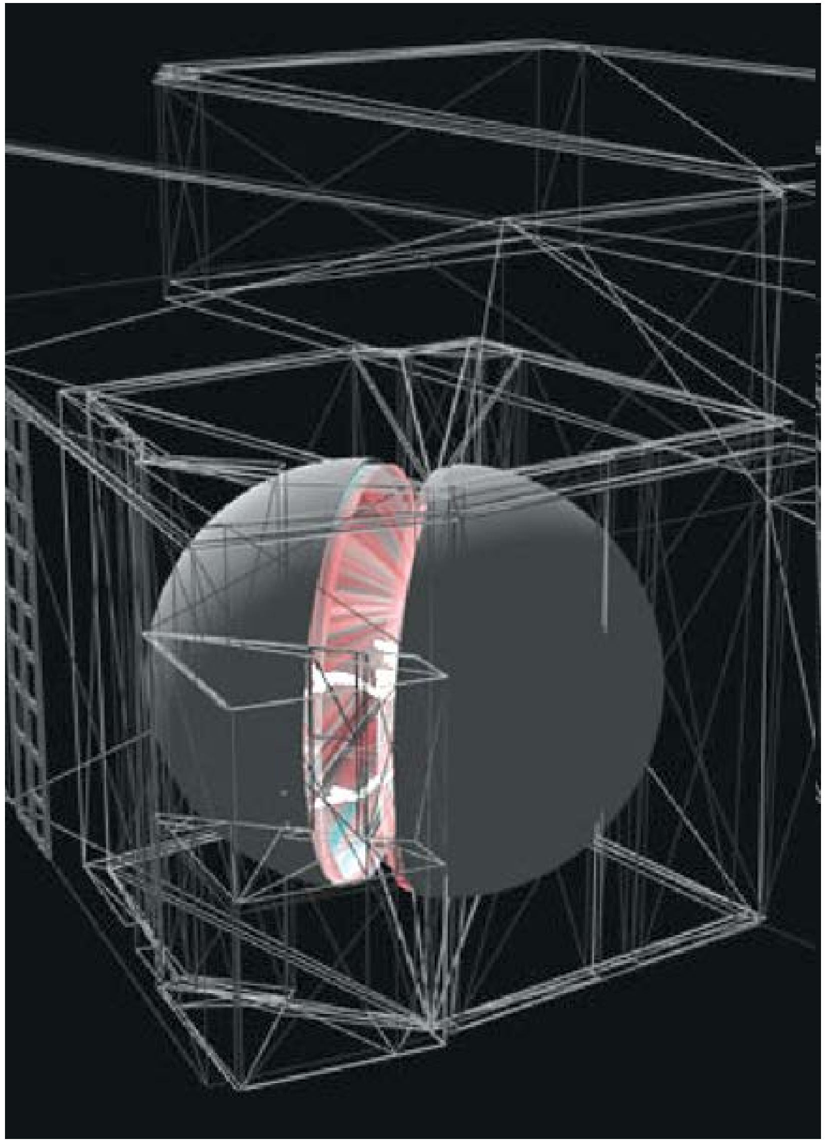
Bundler

- 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."

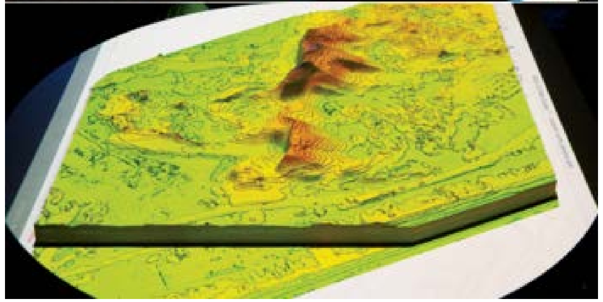
Virtual Reality: The Allosphere



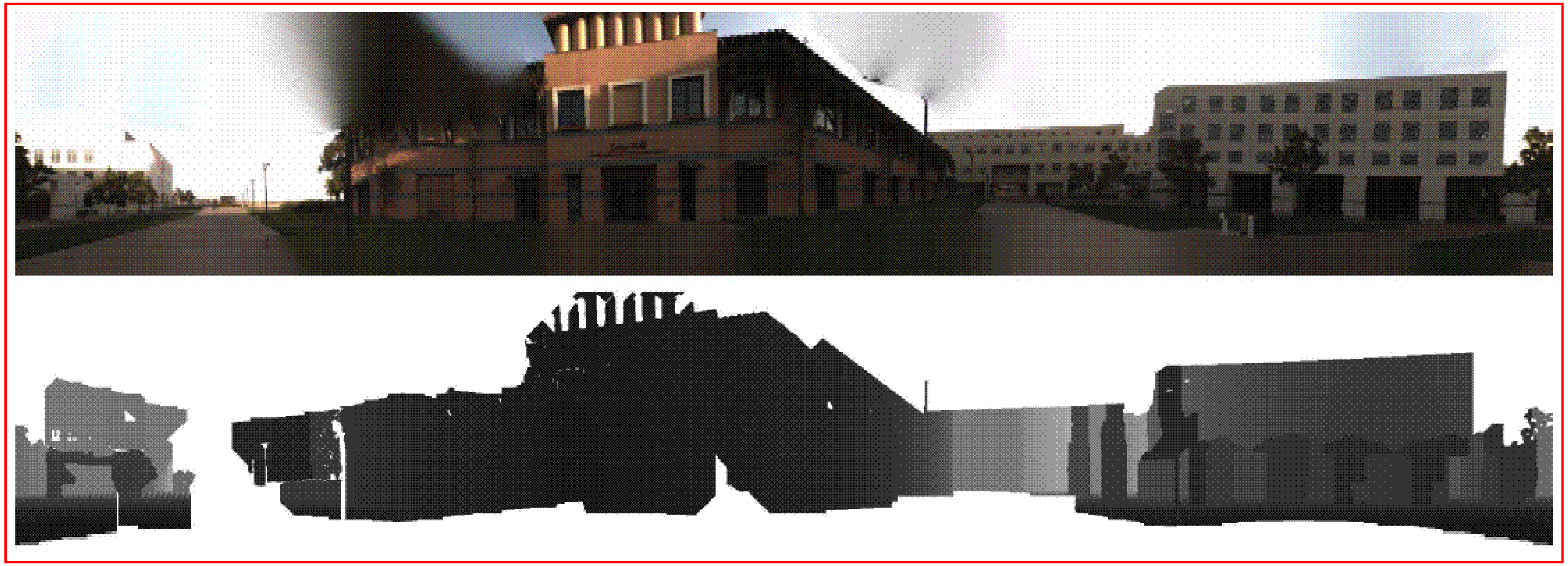




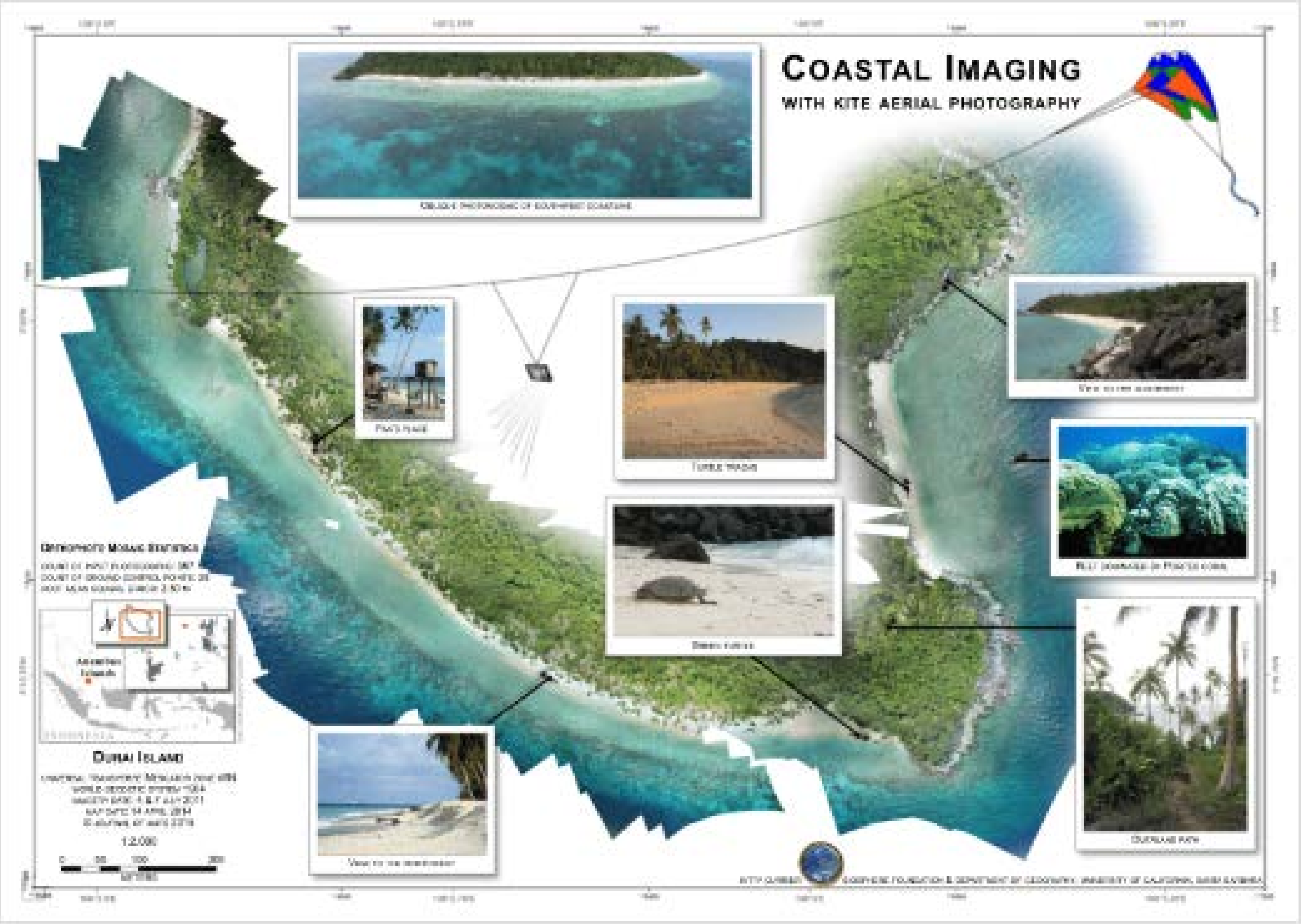
Projected images



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**

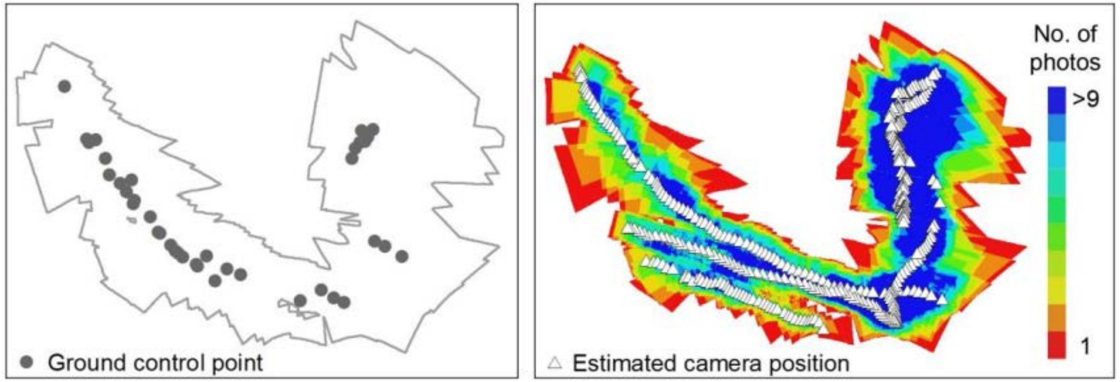


Figure 3. (a) Locations of 38 ground control points relative to mosaic's extent. (b) Estimated camera positions for 357 images, superimposed on a map of image density.

3D Printing

Credit: Kitty Currier

Drone photogrammetry: Agisoft 3D modeling

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!