# Active Stereo Vision

COMP 4102A

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Version 1

# Why active sensors?

- Project our own texture using light (usually laser)
  - This simplifies correspondence problem (much easier)
- Pluses
  - Can handle different ambient lighting conditions
  - Can get 3d data when there is no natural texture (i.e. white wall)
- Minus
  - Need active source and a way to project it (laser dangerous?)
  - Need more complex hardware
- A number of different systems, but two principles
  - Triangulation (same as stereo but the light source replaces second camera) with camera and light source
  - Time of flight (produce a pulsed beam of light, measure distance by time light takes to return)

# Pulsed Time of Flight

Basic idea: send out pulse of light (usually laser), time how long it takes to return

Advantages:

- Large working volume (up to from 20 to 1000 m.)

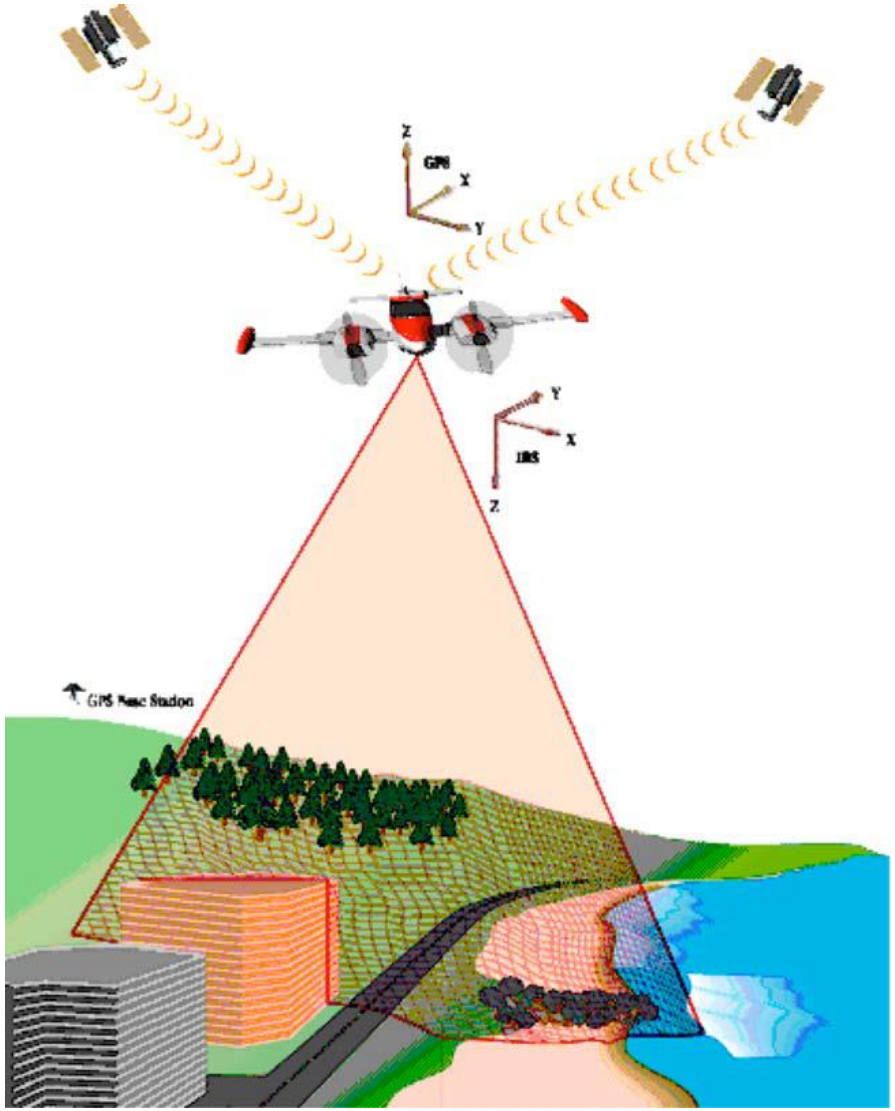
Disadvantages:

- Not-so-great accuracy (at best ~5 mm.)
  - Requires getting timing to ~30 picoseconds

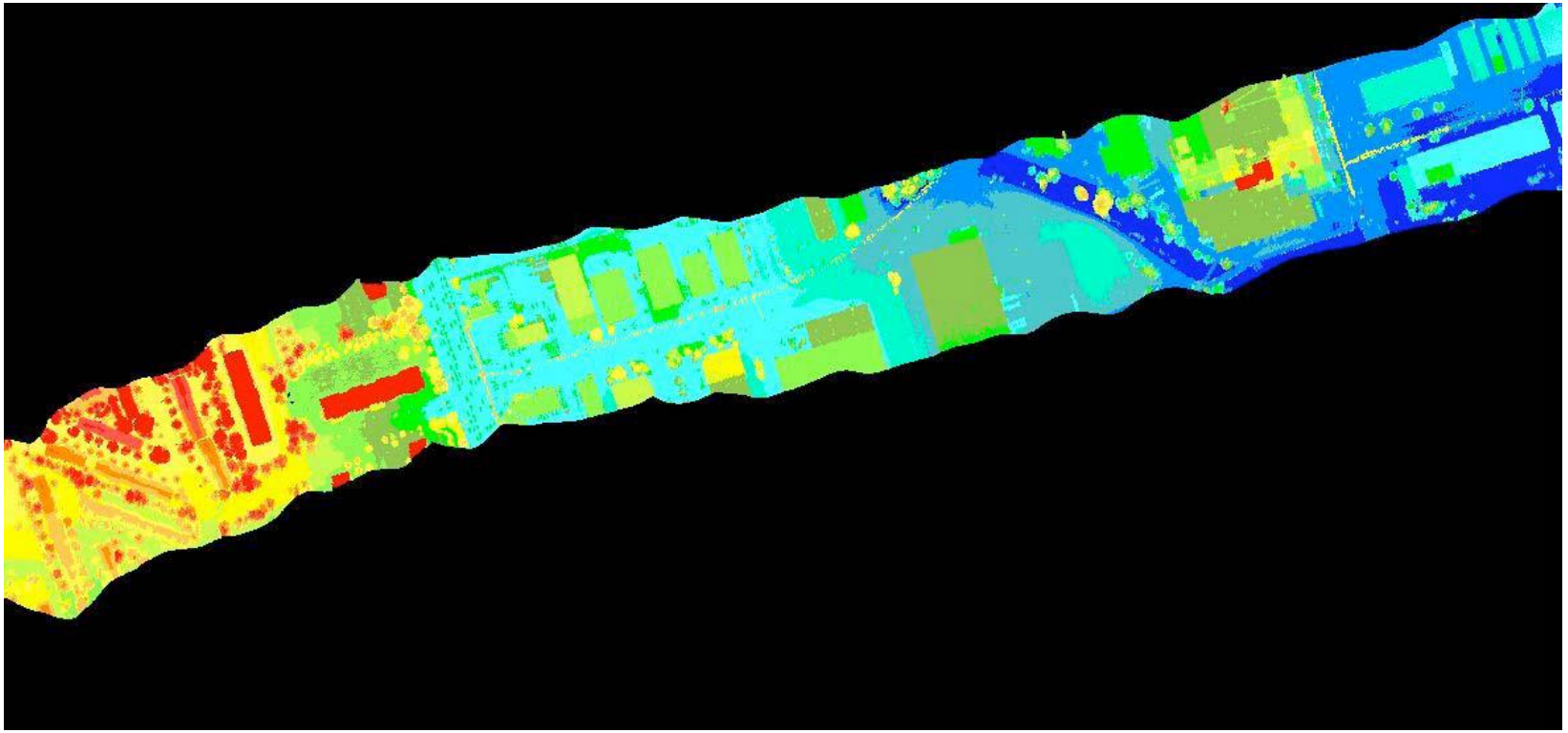
Often used for scanning buildings, rooms, archeological sites, etc.

The only practical long range measuring technology (triangulation fails over 20 meters)

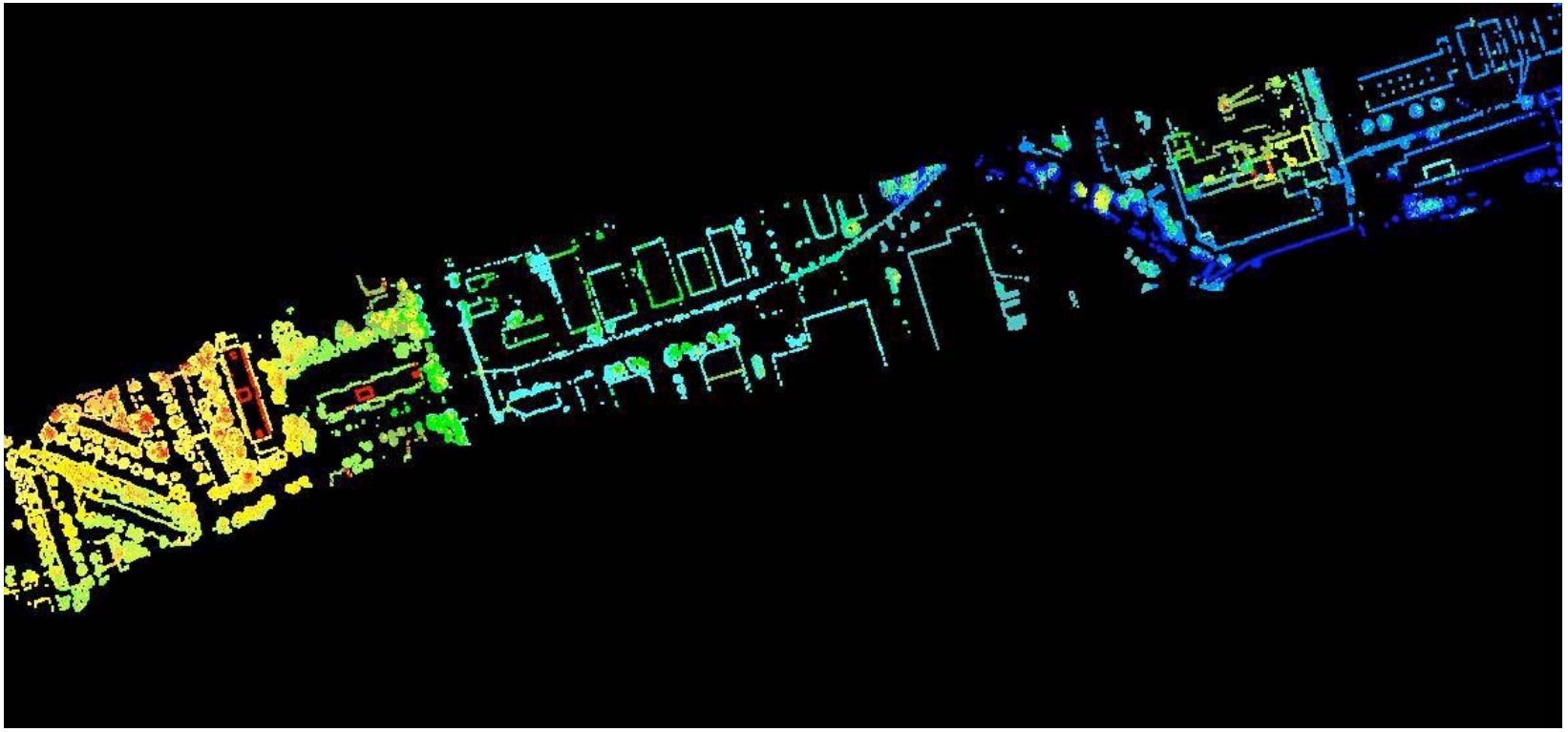
# Optech – Airborne Laser Mapping



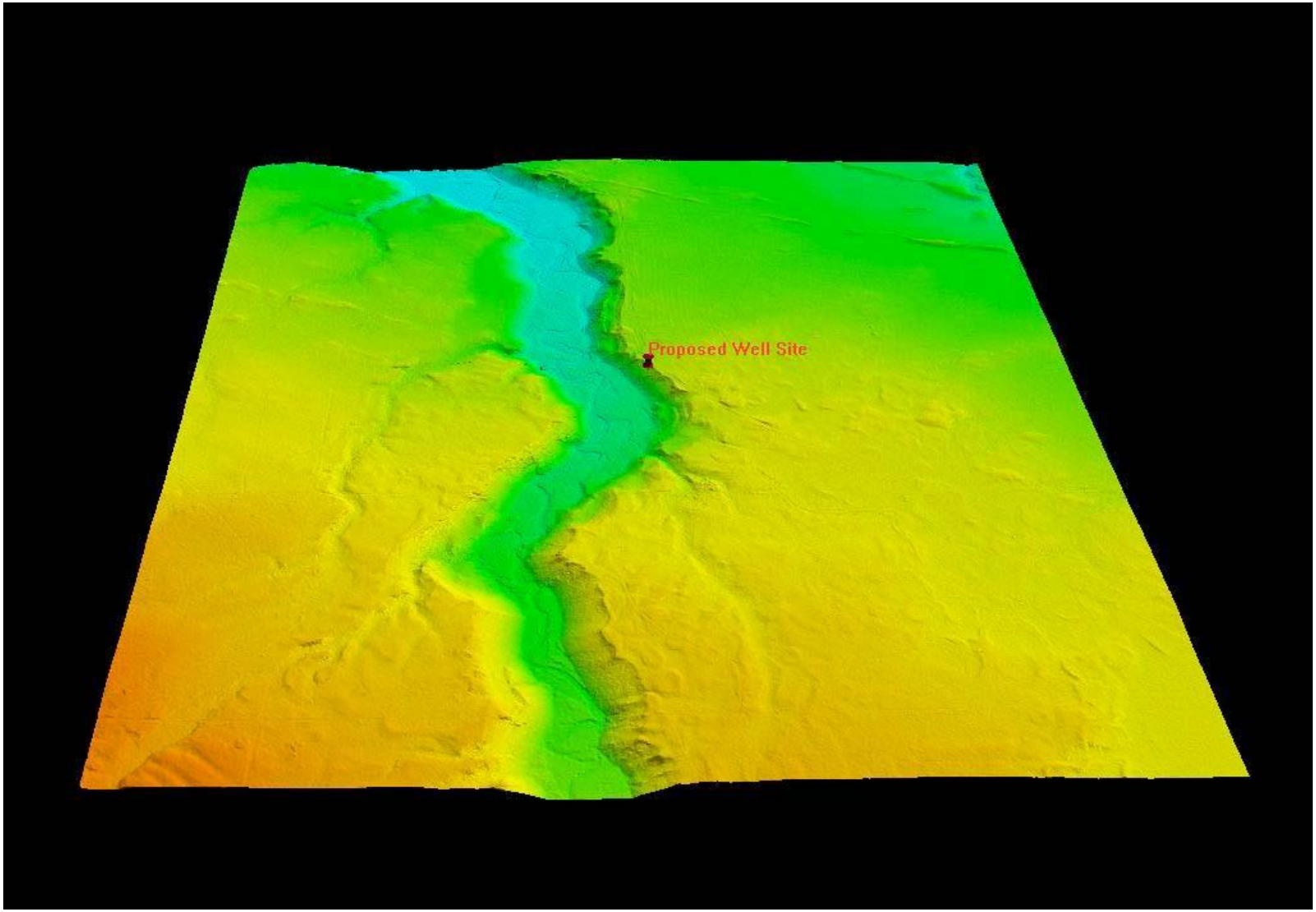
# Raw Image – depth is colour coded



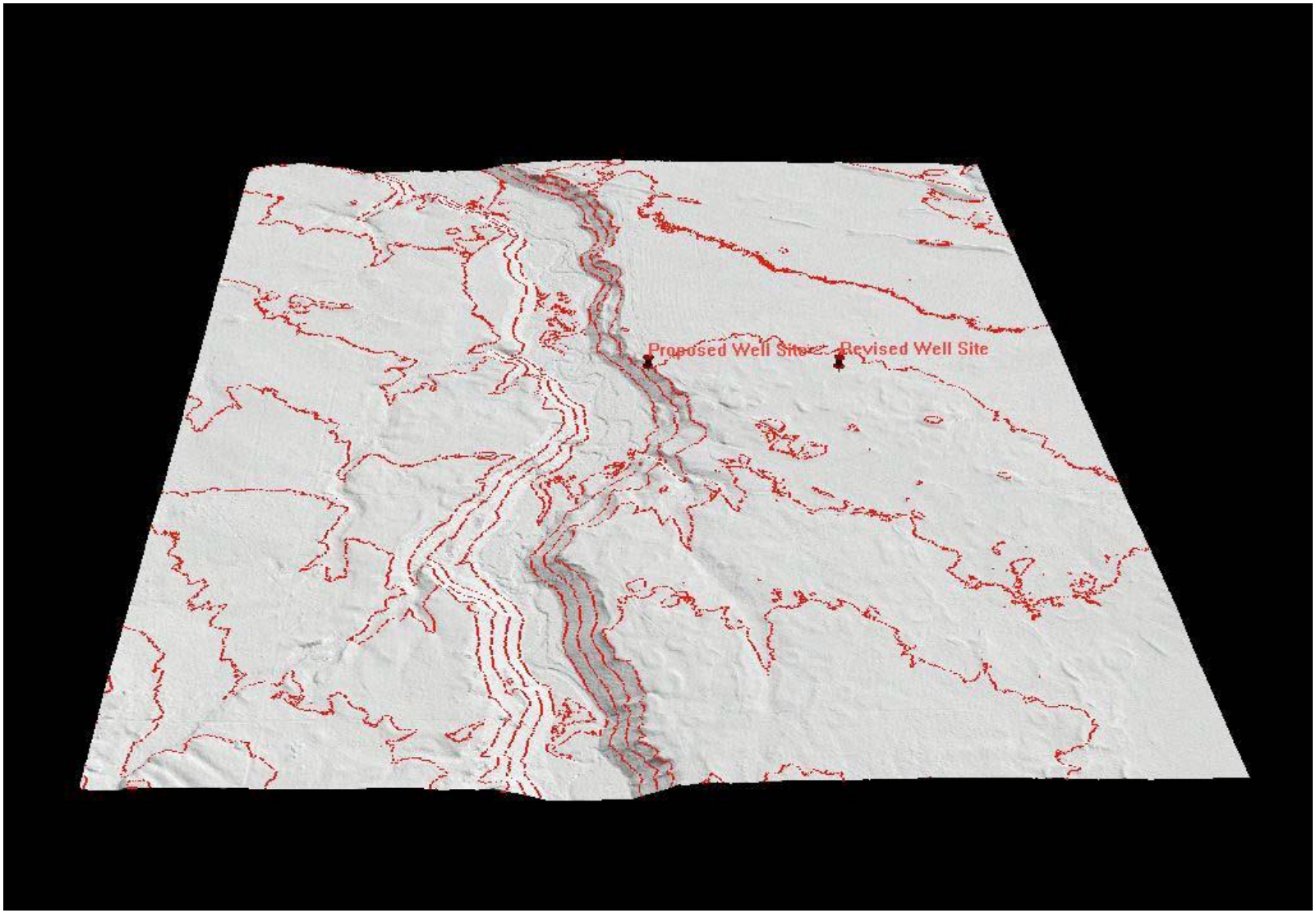
# Building, outlines, trees and wires



# Bare Earth Model

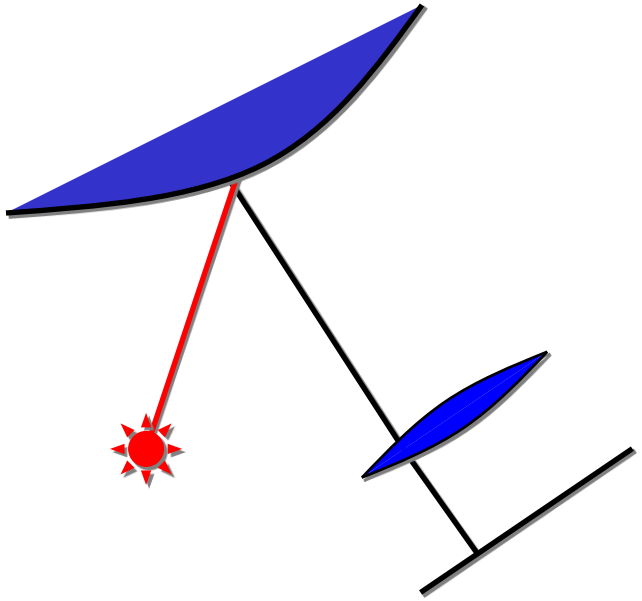


# Removing the trees



# Triangulation

- One or two cameras and a light source
- Many possible light sources and variations
- Still use triangulation to find the depth

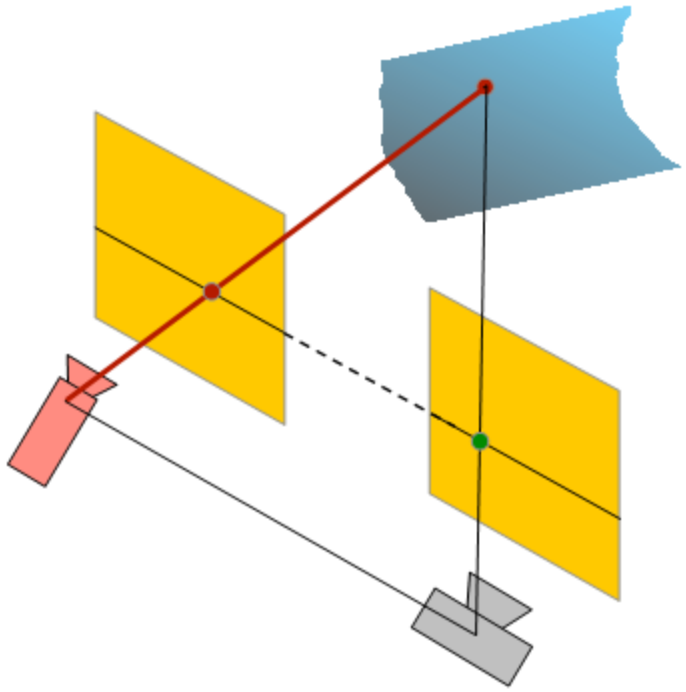


# Simplest possible triangulation system?

- Take two calibrated stereo cameras
- Use a laser pointer to shine light on where we want the depth
- Find that laser spot in both images, this feature must correspond, so you get 3d
- This is easy because the laser spot is very bright compared to the rest of the world
- This works, but getting data is very slow since you must move around the laser spot
- Very easy to build, and to make it work!

# Triangulation system with one camera?

- What if you have a single laser pointer and also a single camera looking at the spot?



# Triangulation with one camera?

- Assume laser moved by a calibrated motor
  - Then you know direction in space of the laser beam
- Camera calibrated and you know baseline, so can find laser spot location in image
- Then you can still triangulate to find depth!
  - Even though you only have one camera
- Need a very accurate and high speed motor to move the laser spot around the scene
- This is complex hardware but is exactly what was done at NRC over about 30 years!

# Triangulation can be very accurate

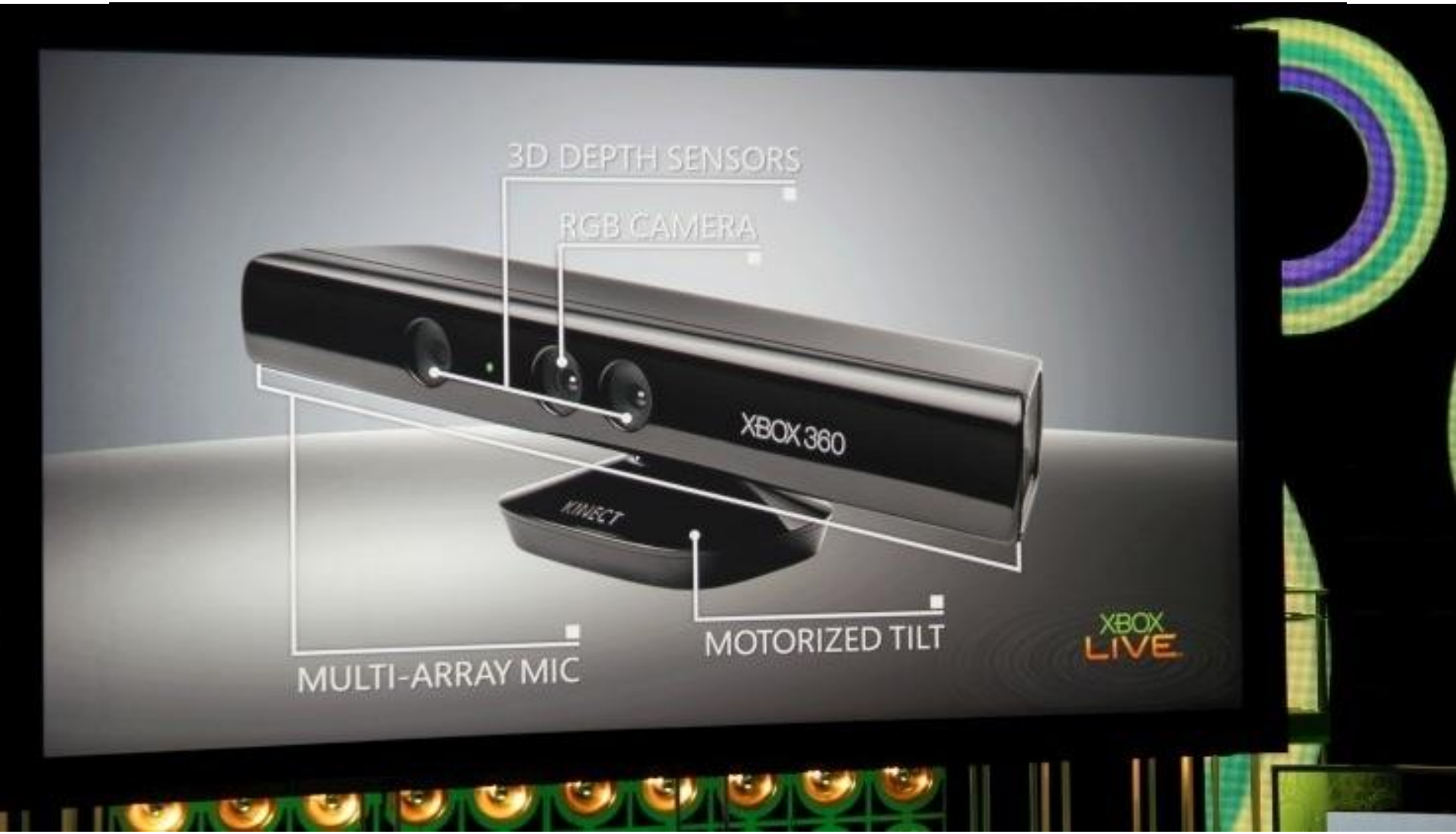
Can get accuracy down to 20 microns

(1/50$^{th}$ of a millimeter!)

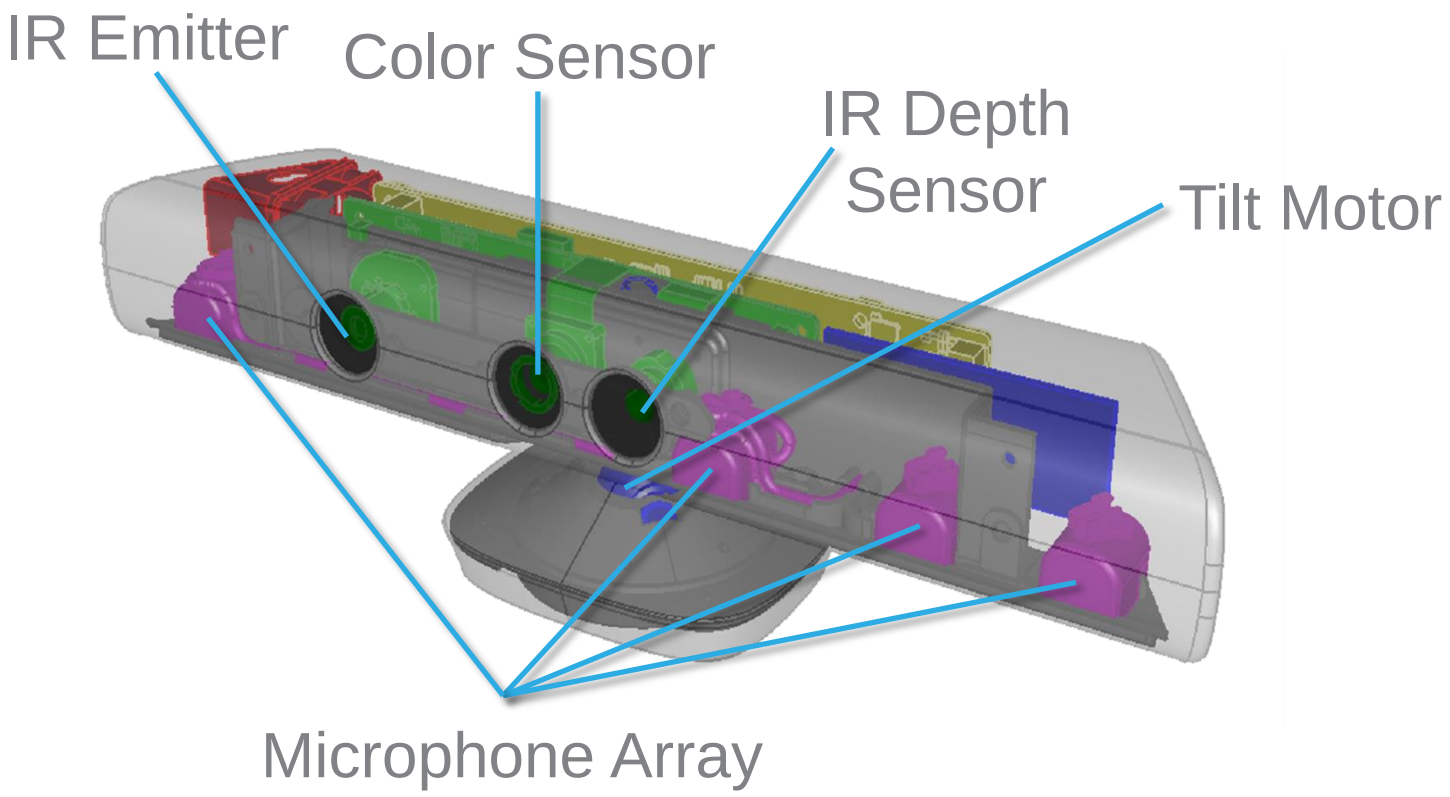
# Microsoft Kinect

- Triangulation based system for finding depth
- Designed to interpret motions, not to build accurate 3d models or measure objects
- Frequency of infrared projector similar to sun
- So can not be used close to a window or be taken outdoors
- Still, for Human Computer Interaction, Kinect is a big breakthrough
- The first inexpensive and mass produced active sensor for consumers and researchers

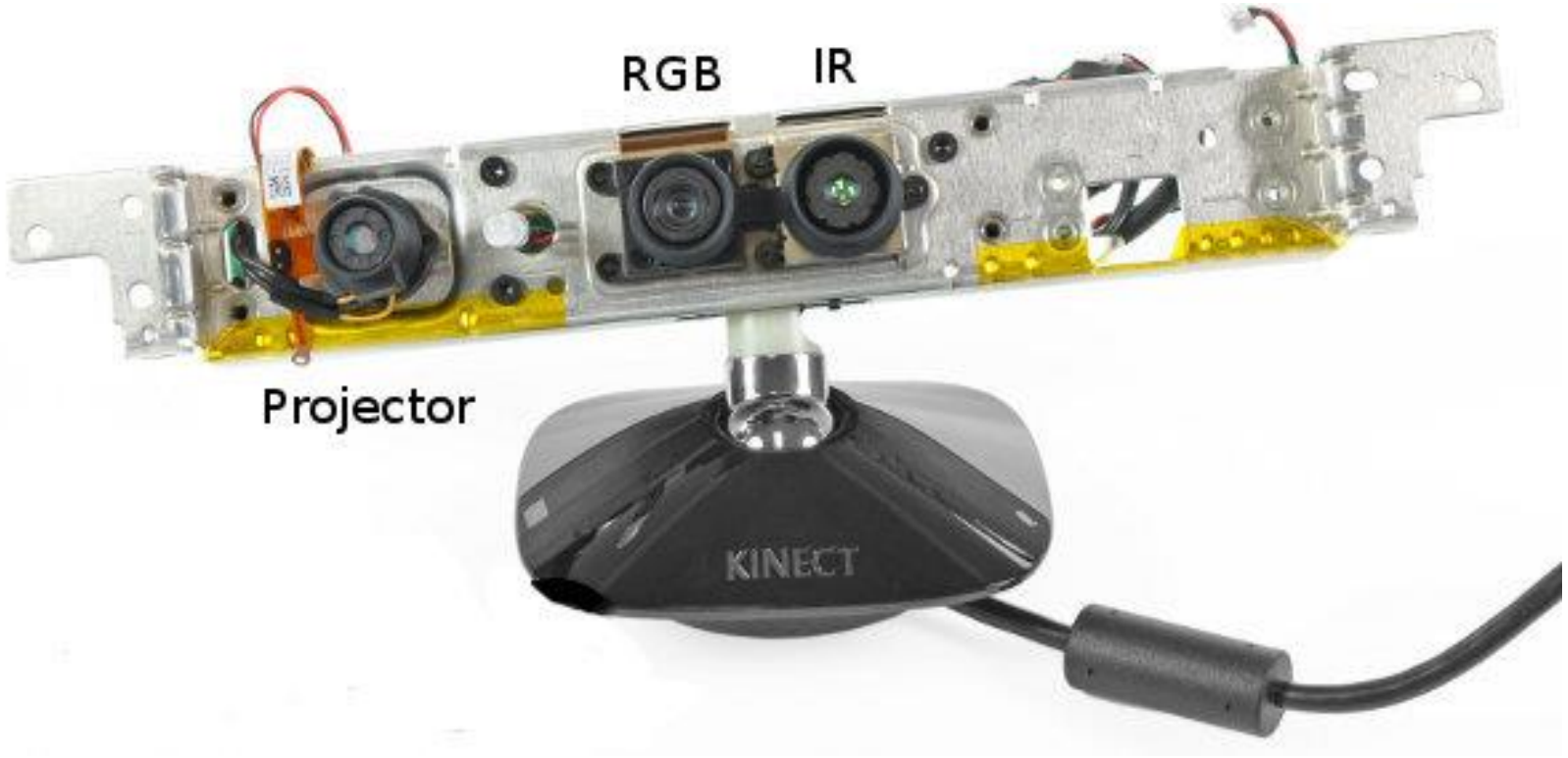
# Kinect Hardware



# Kinect Hardware



# Kinect Hardware



# Sensors/Resolution of Kinect

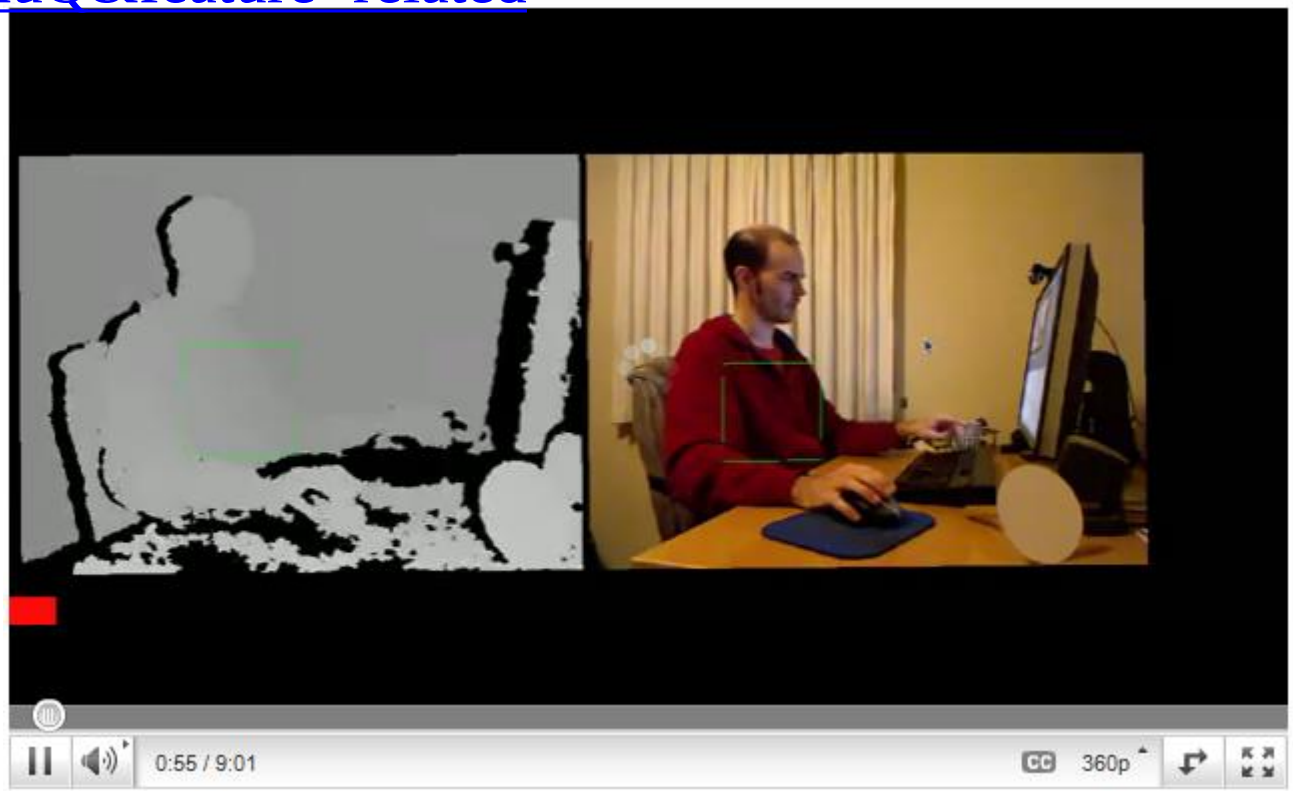
- Separate sensors for depth and colour
- Color
  - 12 FPS: 1280X960 RGB
  - 15 FPS: Raw YUV 640x480
  - 30 FPS: 640x480
- Depth
  - 30 FPS: 80x60, 320x240, 640x480
  - Not that accurate unless extra calibration is done
- Depth and colour registered so you can get the colour for each depth point

# Depth and Intensity Images

- Depth image shown in “depth map” style, with brighter points closer to camera

http://www.youtube.com/watch?v=inim0xWiR0c

http://www.youtube.com/watch?v=7TGF30-5KuQ&feature=related



# How does Kinect get depth

- Project “pseudo-random” dots on world


http://www.youtube.com/watch?v=dTKlNGSH9Po&feature=related

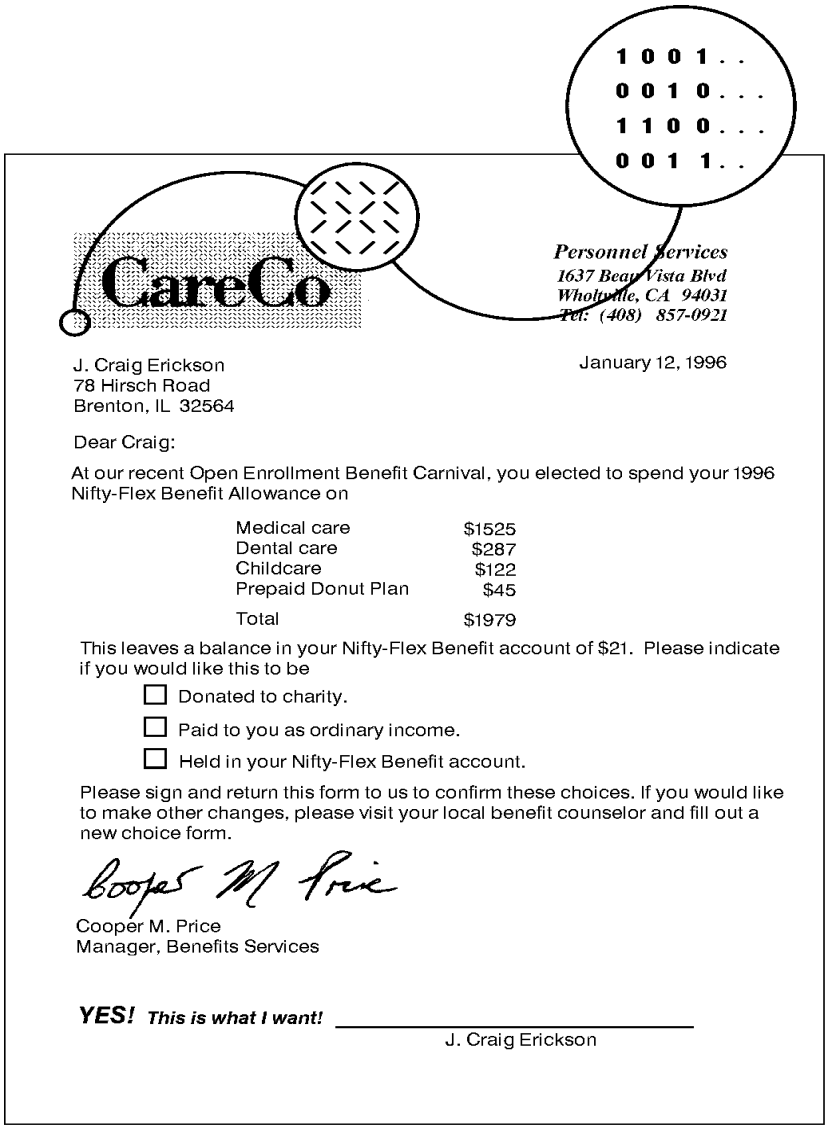
# Local patterns are almost unique

- What is the principle? Uses self identifying patterns of dots (like glyphs)
- What are glyphs?
- A local pattern that identifies itself uniquely

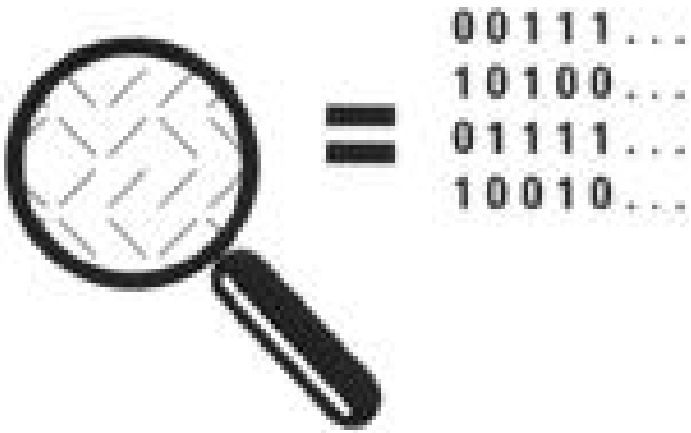
Qrcode

Augmented Reality Tags

# Glyphs printed in paper (Dataglyphs)



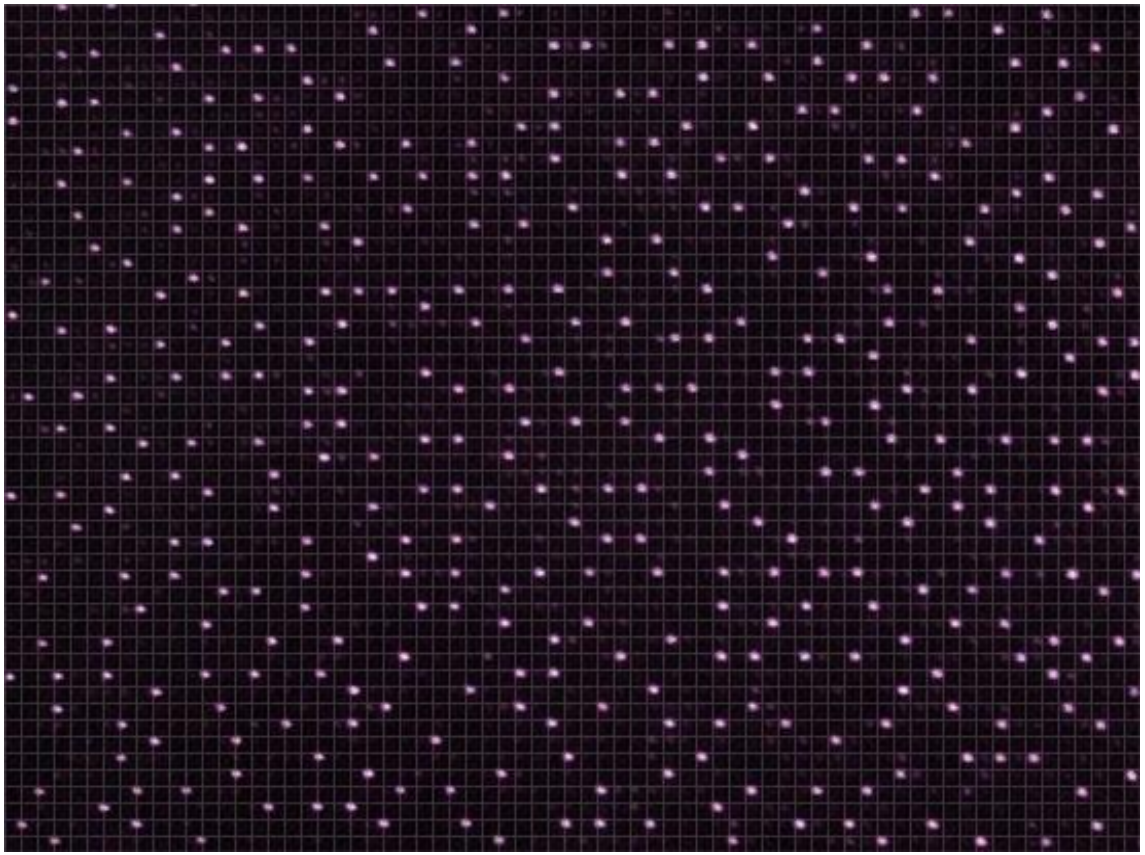

Old Xerox technology
A little pattern that is hard to see but encodes a unique bit string



# Kinect Projects dots which are glyphs

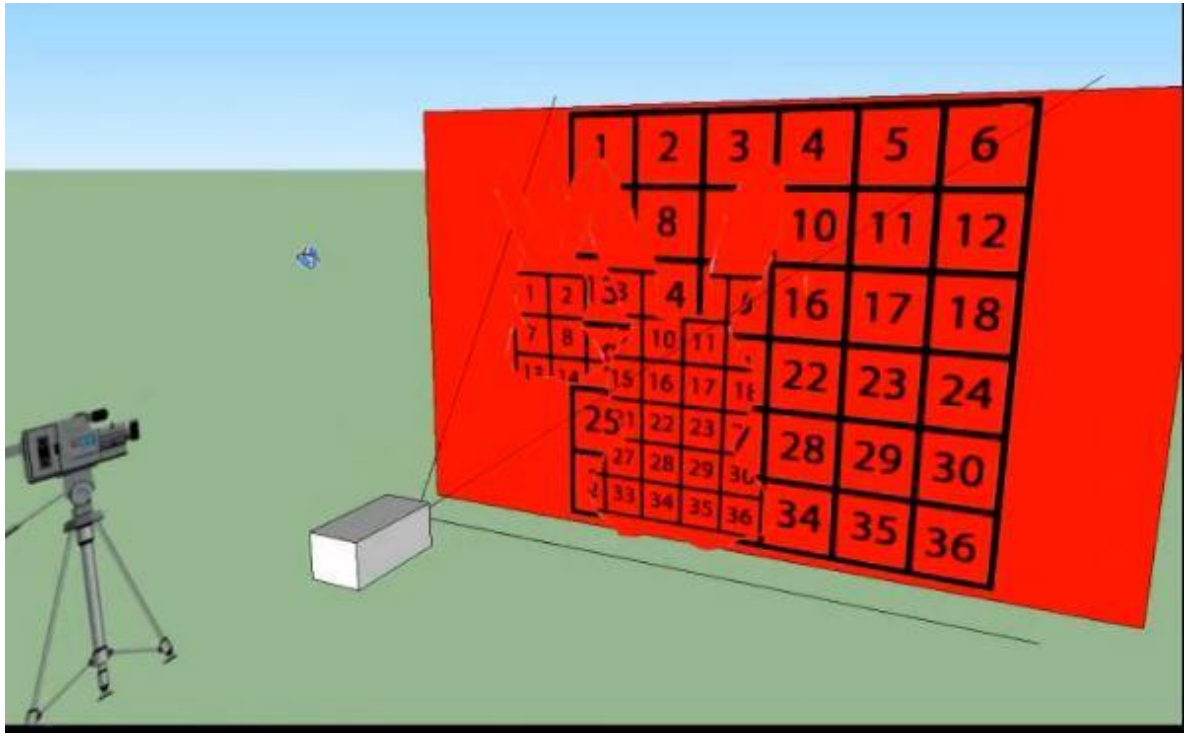
# Kinect Glyphs – almost unique

- Local pattern identifies location of projection
- Find local identifier by looking in a small region around a given point => code



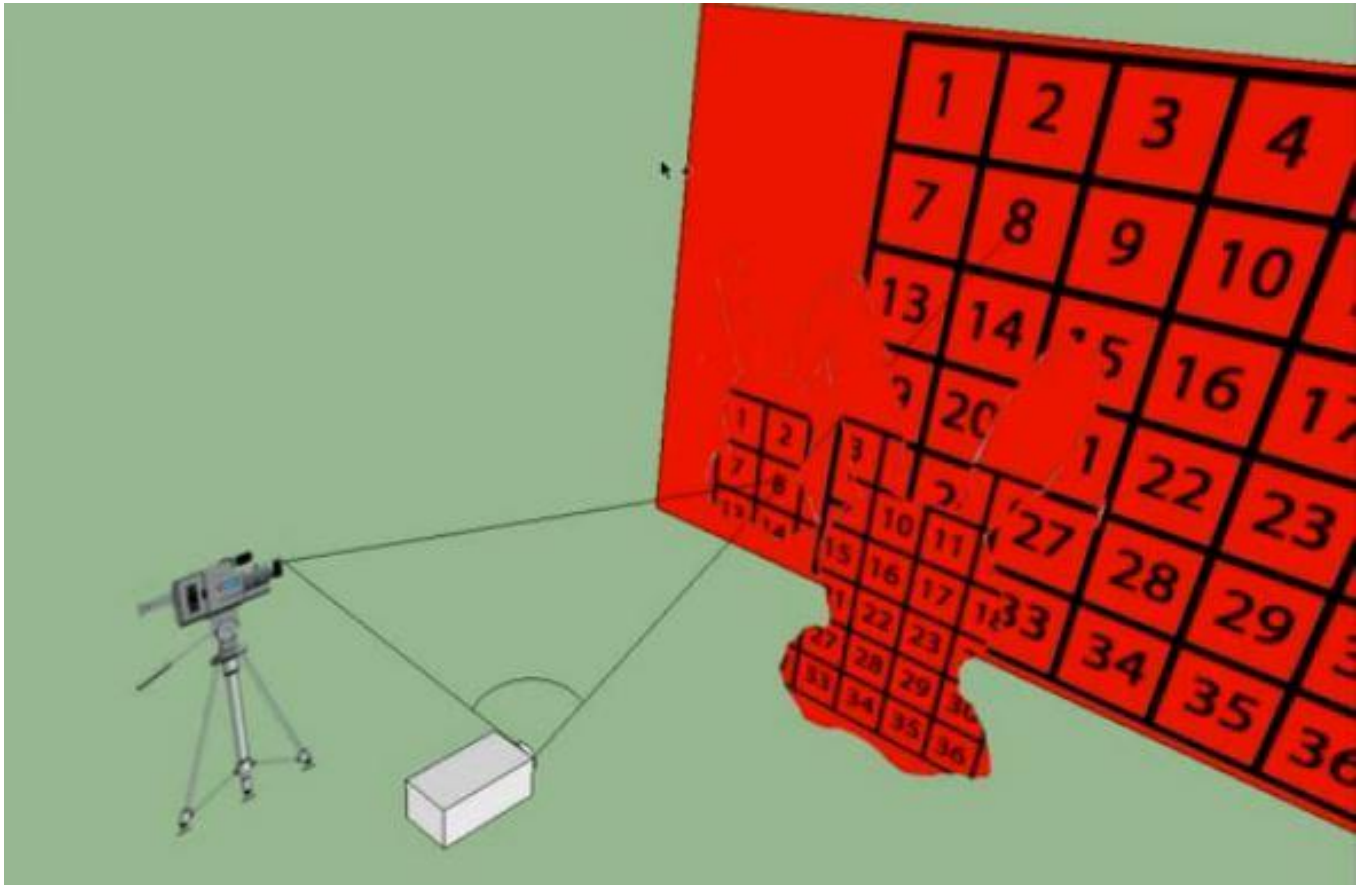
# How do Pseudo-Random dots work?

- One you get the glyph, a prior calibration tells you the angle(s) and therefore the ray for that particular point
- So now you can triangulate to get depth!



# How do Pseudo-Random dots work?

- Repeat this process for each small region in the dot image to get depth at that point



# Kinect Depth Acquisition Summary

- There is a projector for the laser dots and a sensor just for these dots (infrared)
- We can recognize the glyph in the infrared image so can triangulate to find the depth
- This requires a prior calibration process so that we know the rays for the laser dots
- Still just ordinary triangulation process
- There is a another camera that produces a separate and distinct intensity image
- The Kinect returns both a depth map and the overlayed intensity image

# Model Building with a Kinect

- Given a series of depth images (from Kinect) and overlaid intensity what can we do?
- A simple model building algorithm
  - Take overlapping depth images
  - In intensity image find some surf images
  - Each surf feature has range value in depth
  - Each surf feature has range value in depth
  - Align the overlapping depth images
- If you repeat this process enough times you get one big model

# Kinect for model building

- http://www.youtube.com/watch?v=NsrmniEvO4s

# Depth sensor better than intensity?

- Is it easier to use a Kinect (depth sensor) or an ordinary digital camera to make models?
- Using a Kinect is much better because the depth accuracy from the Kinect does not change as you move camera
- Depth accuracy depends on baseline alone
- With an intensity image sequence the quality of any depth reconstruction process depends on the spacing between the images
- Can not rotate the intensity camera and get depth, but can rotate Kinect camera

# Limitations of Kinect

- Not that accurate unless you do more complex calibrations
- It was designed to interpret motions, not to build accurate 3d models or measure objects
- Frequency of infrared projector similar to sun
- So Kinect can not be used close to a window or be taken outdoors in bright sunlight
- Multiple Kinects interfere with each other
- For Human Computer Interaction, Kinect is a big breakthrough; inexpensive and useful