Sources of Range Data

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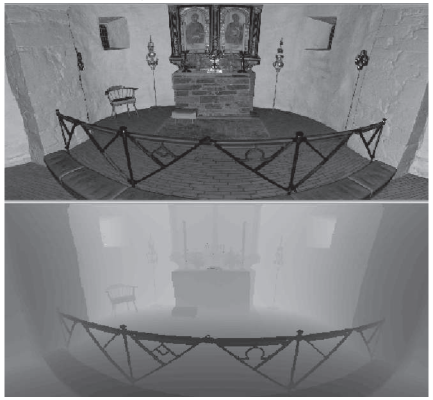
Range Data

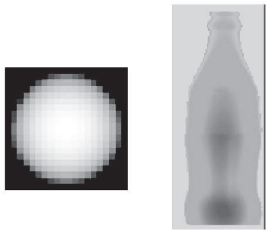
Intensity image: observed_brightness(r,c)

Range image: distance_from_sensor(r,c) or $\{(x_i, y_i, z_i)\}$

top: intensity bottom: range

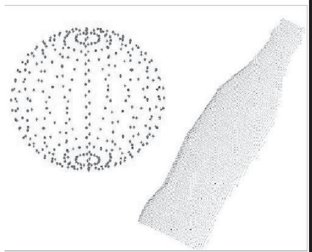


Range Data Representations



Range image:

- (r,c) pixel location
- pixel encodes depth, not colour



Point cloud: $\{(x, y, z)\}$

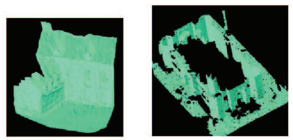
Active 3D Sensing - Motivations

Parts/Objects:

- Analysis/manufacture
- Reverse engineering

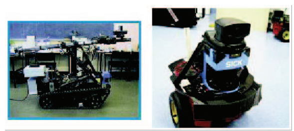
Buildings:

- Use in 3D VR
- Change analysis



Robotic navigation:

on-board laser scanner



Why Range Data

Advantages

Direct, accurate 3D scene information

Unambiguous measurement (unlike brightness)

©Kinect is cheap and reliable

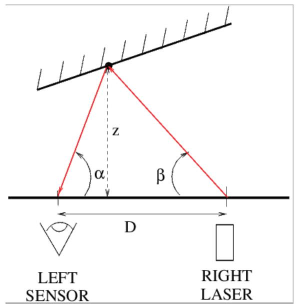
Disadvantages

More complex/expensive sensor

Dark/shiny objects a problem

Generally indirect capture (eg. computed, scanned)

Triangulation range sensors



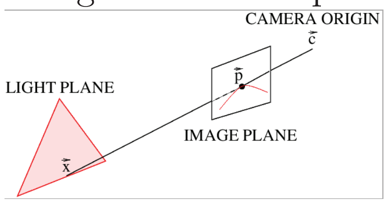
$z = f(\alpha, \beta, D)$

Light beam usually a laser ("laser range scanning"):

Bright
Single frequency (eg 633 nm)
Matching optical filter can eliminate other scene light

Triangulation range calculation

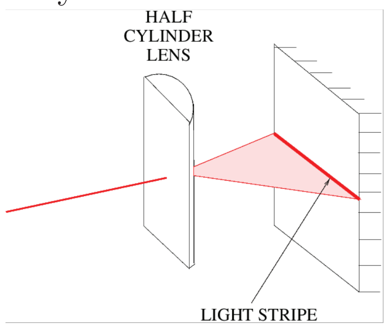
Find pixel $\vec{p}$ on laser stripe in image ($\vec{p}$ is in 3D coordinates, known from camera parameters). Laser stripe plane: unit surface normal $\vec{n}$ and offset from orgin d. Image point $\vec{p}$ defines a ray from camera origin $\vec{c}$ to scene point $\vec{x}$.



Ray equation: $\vec{x} = \vec{c} + \lambda(\vec{p} - \vec{c})$
Light plane equation: $\vec{x} \cdot \vec{n} = d$
Find intersection, solve for λ,
substitute to get $\vec{x}$ (3D coords of point)

Getting a full range image

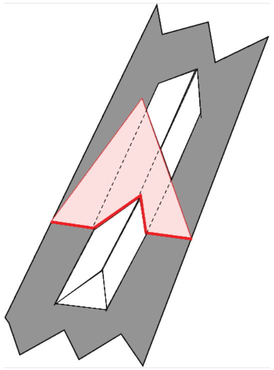
Laser gives a spot, not full image
Use half-cylindrical lens



This gives a stripe on the observed target
For full range image, need to cover all of target

Covering the whole scene

1) Can sweep light plane with rotating mirror
2) Can move sensor (eg sensor in lab)
3) Move parts underneath stripe, eg on a conveyor belt

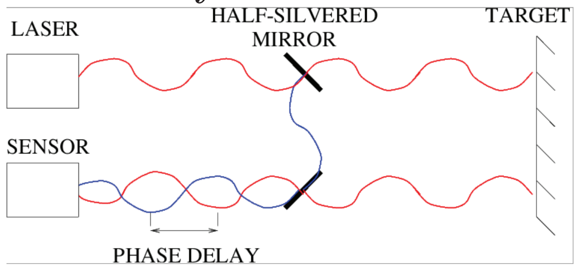


Builds up image column by column as part moves

Range sensor technologies

Time of flight: $d = ct$

Phase delay:



Both need:
1) sophisticated optics/timing electronics, but are common
2) a way to sweep the beam

What We Have Learned

- Some basic triangulation range sensor technology
- Concepts of other forms of range sensor