A Low Cost 3D Laser Distance Scanner

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PROBLEM STATEMENT

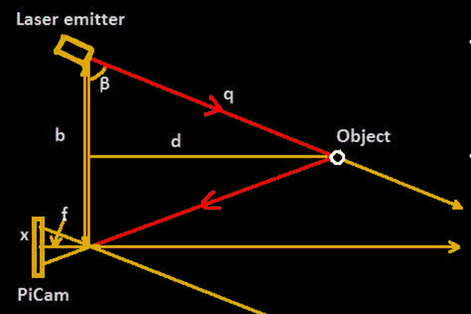
Current LIDAR scanners are bulky and extremely expensive. Most affordable scanners on the market today are 2D planar scanners giving a limited amount of points per second. This greatly hinders the capabilities of autonomous robots as the amount of information available to them about their environment is limited

OBJECTIVE

The project goal is to design a laser distance sensor which satisfies the following criteria:

- Costs under $200
- Provide 3D distance measurements
- Portable with a small form factor
- Range from 10cm - 6 meters
- 95% accuracy at maximum range
- Constructed from off the shelf components
- Easy to setup and use
- Eye safe

THEORY OF OPERATION



. 5mW laser emits light at an object which reflects back onto Pi-cam

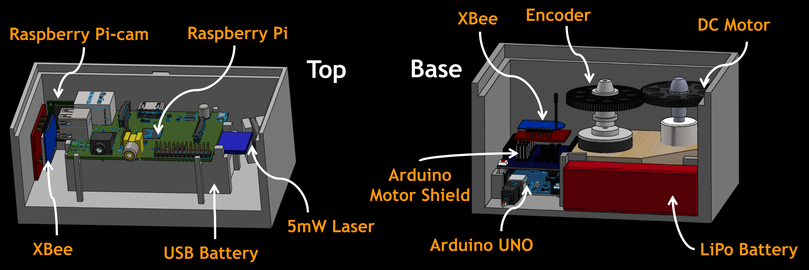
. Given the laser angle β and the physical location on the camera where the reflected laser is detected x, the distance to a single point on the object can be calculated

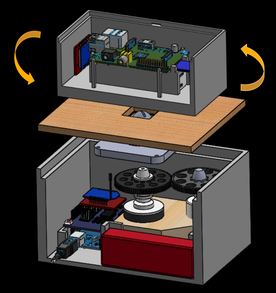
$$d = \frac{fb}{2x}$$

$$d = q\sin(\beta)$$

SENSOR DESIGN

Sensor composed of top and base components





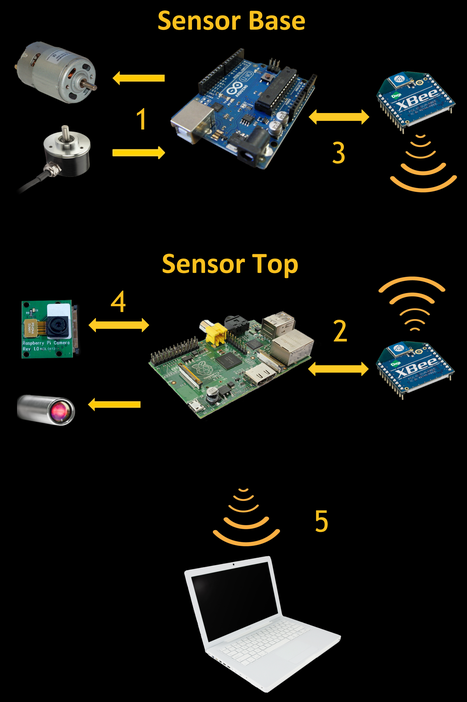
- Setup allows for full 360° scan of environment
- Also allows for 3D laser scans of objects
  - Object placed on rotating base
  - Top module placed a known distance away with laser oriented along center axis of object

DESIGN ALTERNATIVES

Design Choice		Alternative Design	
✓ Pro	✖ Con	✓ Pro	✖ Con
DC Motor		**Servo Motor**	
✓ Continuous rotation	✖ Requires Encoder	✓ Easier to control	✖ Limited Rotation Angle
Visible Laser		**IR Laser**	
✓ Easier to Debug	✖ Difficult to filter	✓ Easier to filter	✖ Invisible. Harder to debug
Raspberry Pi		**Beagleboard Black**	
✓ Larger Community	✖ Lower Hardware Specifications	✓ Better Hardware Specifications	✖ Smaller Community

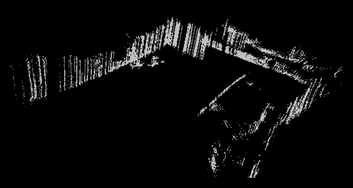
SENSOR OPERATION

1. Arduino reads encoder angle
2. Raspberry Pi requests encoder angle from Arduino
3. Arduino replies with updated angle
4. Raspberry Pi takes picture with Pi-cam and calculates distances
5. Distance data is transmitted to PC via Wi-Fi
6. The entire process is repeated as the top rotates, resulting in a 3D scan of the environment



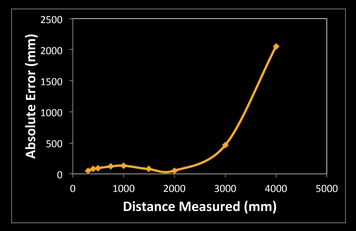
RESULTS

Picture of scanned room



3D scan of room

- Preliminary results show scan range of up to 5 meters
- Range limited in bright daylight due to large laser spread angle (120°)



Error as a function of distance

Mesh created from a point cloud scan of a face

Point Cloud Scan of a Febreze Bottle

Sensor	Cost	Range (m)	Angular Range (degrees)	Angular Resolution (degrees)	Scan Speed (points/ second)
Hokuyo UTM-30LX	$6210	0.1-30	270	0.25	43,000
Hokuyo URG-04LX	$1130	0.02-4	240	0.35	6,600
Velodyne HDL-32E	$30,000+	0.1-100	360	1.33	700,000
Mapomatix	< $200	0.2-5	360	0.09	3,400

Mapomatix Performance vs. Commercially available sensors

FUTURE IMPROVEMENTS

- Select faster camera and board with multiple processors
- Use laser with smaller spread angle
- Adjust for ambient light noise dynamically
- Implement blob detection

REFERENCES

1. Kurt Konolige, Joseph Augenbraum, Nick Donaldson, Charles Fiebig, Pankaj Shah, " A Low-Cost Laser Distance Sensor," International Conference on Robotics and Automation, Pasadena, CA: 2008