# 3D Vision with Kinect and Other Similar Depth Sensors

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## Introduction

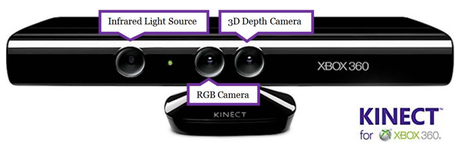
- Depth sensing is a useful tool to estimate object pose
- We tested three depth sensors:
  - Kinect 1
  - Kinect 2
  - Structure.io Sensor
- While these sensors are similar, small differences can have a significant impact on object pose estimation

From the left to the right Kinect 1, Structure.io Sensor and Kinect 2

- This project's goal was to figure out which of these three sensors is the most accurate, and how robust it is to different materials and viewing angles

## Sensor Components

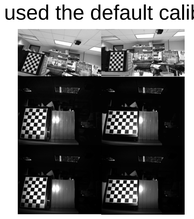
- Kinect 1 consists of a RGB camera , an infra-red camera and an infra-red projector
- Kinect 2 consist of a RGB camera and an infra-red camera;
- Structure.io Sensor has an Infra-red camera and an infra-red projector;




Kinect 1 and its components.

## Calibration

- To calibrate the Kinect 1 and the Kinect 2 (intrinsic and extrinsic parameters) we used a checkerboard since it is easy for sensors to recognize its pattern.
- For the Structure.io we used the default calibration since it is good enough for our goal.



Calibration images from Kinect 2

## Using a Linear Stage to Run Tests

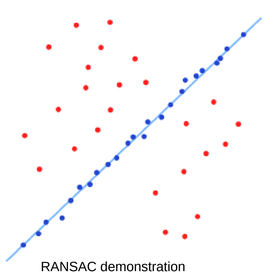
- To get data we used a plane made of different materials (metal, wood, plastic and paper) attached to a linear stage linear stage and moved it to three different distances
- We also created some angles between the camera and the plane to verify the angle range of each sensor.

Linear stage and some materials used to get data

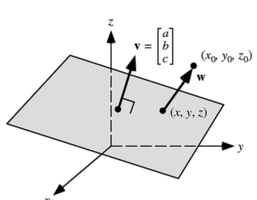
## Using RANSAC to Compare the Data

- To compare the data we used the Random Sample Consensus to fit a plane from the point clouds;
- After fitting a plane we calculated the centroid of the second point cloud then calculated the distance between plane and point.


Point Cloud Plotted in MATLAB



RANSAC demonstration




Distance between a Plane and a Point

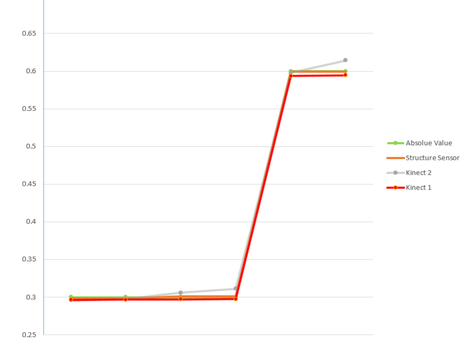
## Results

| Metal | Kinect 1 | Kinect 2 | Structure io |
|---|---|---|---|
| Parallel | 2.1 mm – 5.8 mm | 3.6 mm – 7.3 mm | 1.6 mm – 4.8 mm |
| 30 Degrees | 1.4 mm – 4.3 mm | 2.7 mm – 3.8 mm | 0.2 mm – 4.9 mm |
| 45 Degrees | 3.1 mm – 6.6 mm | 1.3 mm – 6.4 mm | 1.1 mm – 4.5 mm |
| 60 Degrees | 1.9 mm – 6.3 mm | 2.9 mm – 21.9 mm | 0.1 mm – 0.6 mm |

| Wood | Kinect 1 | Kinect 2 | Structure io |
|---|---|---|---|
| Parallel | 3.9 mm – 7.5 mm | 4.1 mm – 9.9 mm | 1.9 mm – 4.9 mm |
| 30 Degrees | 0.4 mm – 3.0 mm | 1.3 mm – 3.3 mm | 2.0 mm – 5.8 mm |
| 45 Degrees | 1.6 mm – 4.2 mm | 1.1 mm – 3.3 mm | 0.8 mm – 2.5 mm |
| 60 Degrees | 1.8 mm – 4.6 mm | 0.8 mm – 4.0 mm | 0.7 mm – 2.8 mm |

Comparison tables

- Based on the graph and on the tables one can assume that Structure.io Sensor is the best choice since it is stable and has good accuracy;
- Kinect 2 is more unstable than the others two sensors;
- Kinect 1 also is stable but its accuracy is worse than the structure sensor.




Comparison Graph between depth sensor

## Future Work

- Improving calibration using the method presented in the paper "Joint Depth and Color Camera Calibration with Distortion Correction." by Herrera, Kannala and Heikkila.

## References

- [1] J. Smisek, M. Jancosek and T. Pajdla. 3D with Kinect. CMP, Dept. of Cybernetics, FEE, Czech Techical University in Prague, 2011.
- [2] P. Kovesi. Ransac Code. School of Computer Science and Software Engineering, The University of Western Australia, 2003 – 2005.