EE 146 Project:
RGB-D based Object Detection and Distance Estimation

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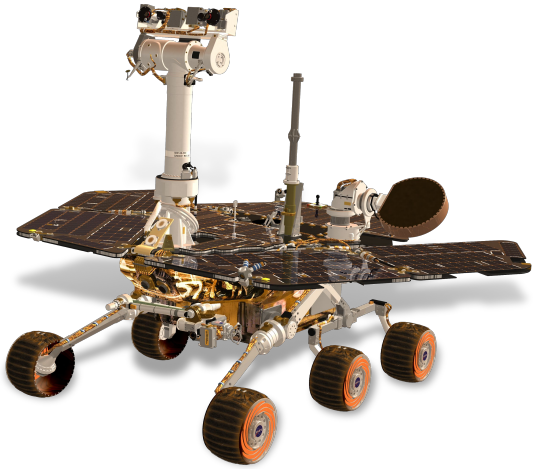
Presented on 3/14/19

Problem Statement & Significance



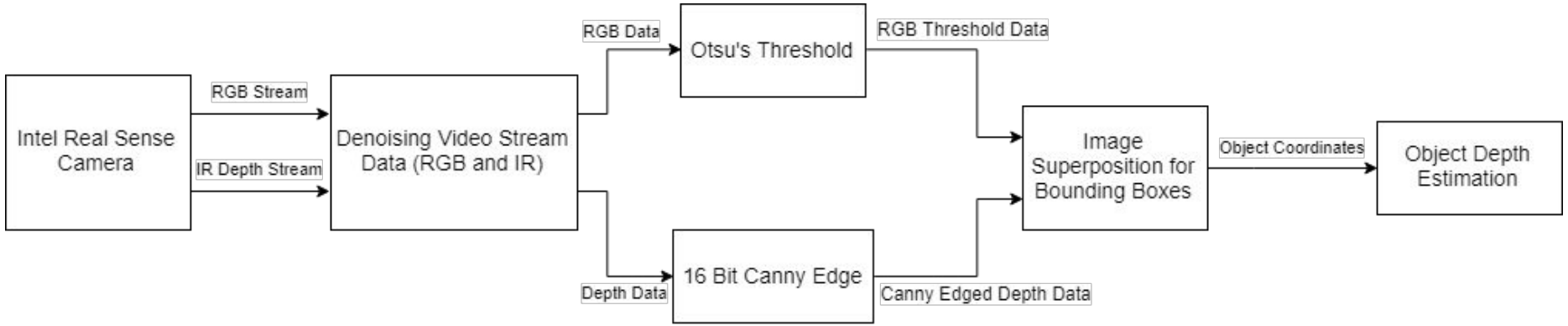
Object detection and distance estimation for robotic applications.

Commonly use Machine Learning (Neural Networks) to find objects.

Develop a general object detection algorithm to locate obstacles in front of a vehicle using using the basic techniques taught in class RGB and depth images from an Intel Realsense camera

Author/s:	Content	Comments:
Hsieh-Chang Huang , Ching-Tang Hsieh, Cheng-Hsiang Yeh	An Indoor Obstacle Detection System Using Depth Information and Region Growth. Uses canny edge detection of depth, thresholding, and RANSAC plane fitting for ground detection.	Heavily inspired our project. RANSAC too slow in our implementation because we suck at programming.
Bir Bhanu, Sungkee Lee, Chih-Cheng Ho, Tom Henderson	Analysis of different algorithms for a robust detection of edges using infrared or depth stream data.	Very detailed report on multiple approaches for detecting edges on a depth image. Provided groundwork for analyzing depth image.
Xyza Vada Maree L. Rivera, Ruel Mark D. Cadubla, Jaymark M. Alemania	Depth map characterization of RGB-D sensor for obstacle detection system. Show characterization of the Kinect system and show how reliable depth image data is at certain distances.	We had a lot of trouble getting reliable depth data and this helped us understand the problems we were running into. Sadly this paper gives results for the Kinect.
Wei Liu, Xiaogang Chen, Qiang Wu, Jie Yang	Fast robust detection of edges in noisy depth images. Uses some simple techniques like morphologies and histogram equalization to get better edges.	We have issues detecting edges. This helped us understand why and helped fixed our issue in detecting edges by using histogram equalization.
Surapol Vorapatratorn, Atiwong Suchato, Proadpran Punyabukkana	Real-time obstacle detection in outdoor environment for visually impaired using RGB-D and disparity map. Obstacle detection in intense light and reflective environments.	Another paper on how reflection and light effects depth images and offers another ground deletion algorithm using RANSAC with disparity image.
Our implementation	Real Time object detection and depth estimation using RGB-D video streaming.	Object detection combining RGB and Depth information using canny edge detection and

Technical Approach - Block Diagram

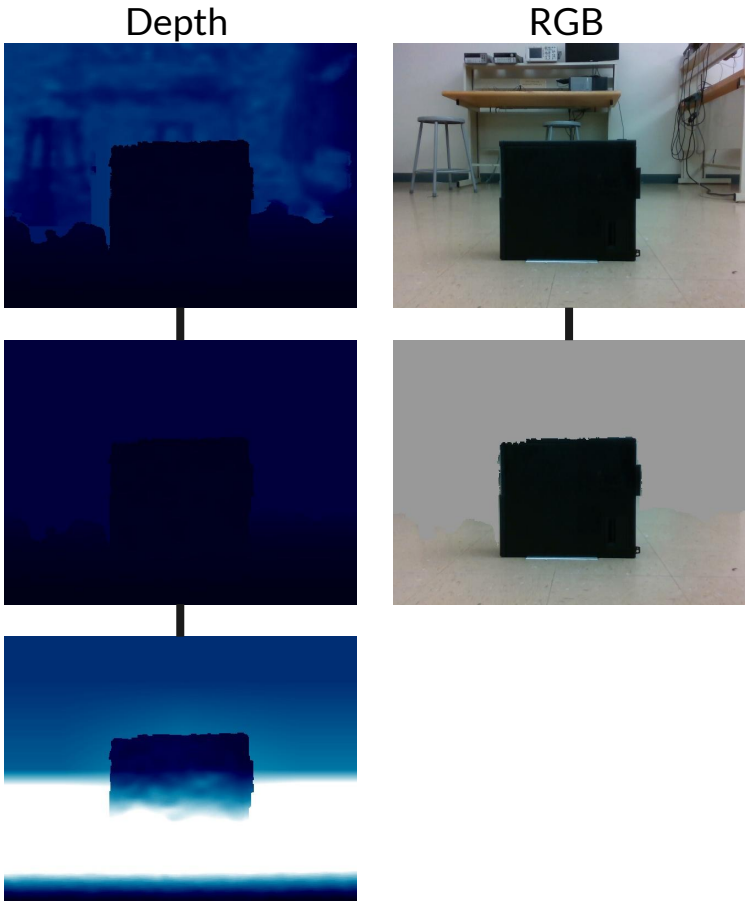


Cleaning Noisy Data

How did we make the data usable?

Depth:
Hole filling
Background deletion
Histogram equalization
Open and close morphological operators on depth image

RGB:
Background deletion



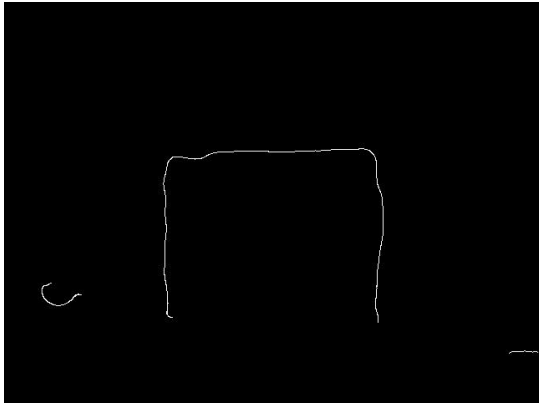
Canny Edge on Depth / Thresholding RGB

Next we extract the object from the depth and RGB image

Depth:
16 bit Canny Edge Detection

RGB:
Convert to grayscale.
Blur
Otsu's Threshold
Open and close morpho to remove unwanted noise

Canny of Depth

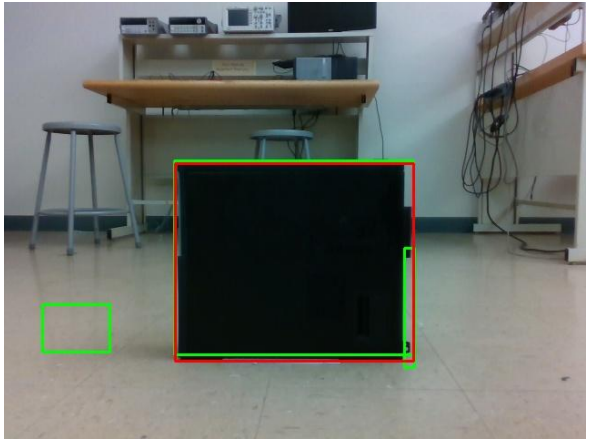


Otsu of RGB

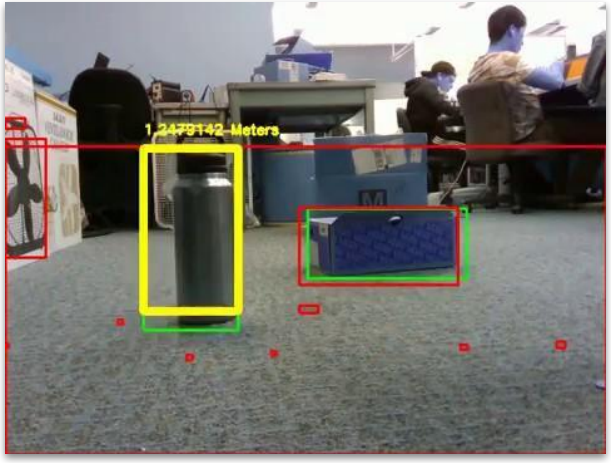
Bounding Box Estimation and Distance Estimation

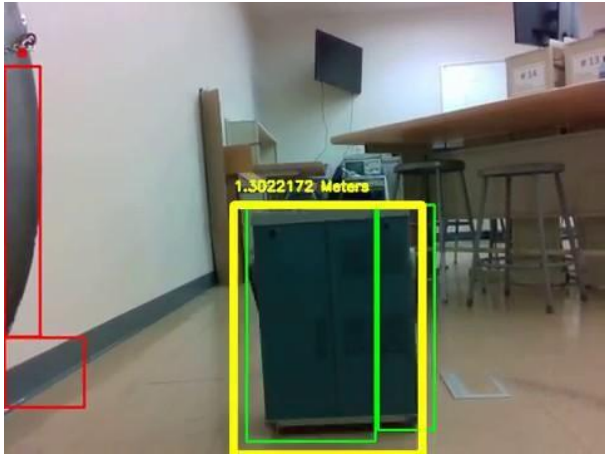
By using both the canny edge image and color threshold image we contour the image and find bounding boxes of any “object” on the image. Using these bounding boxes we find the largest box with the highest percentage overlap between two images and decide that its an object.

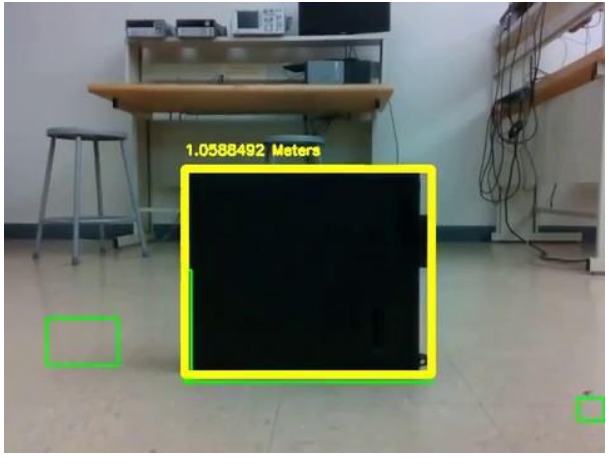
For distance estimation we take the predicted bounding box and took the mean of the depth image elements in the bounding box to obtain a distance estimation.

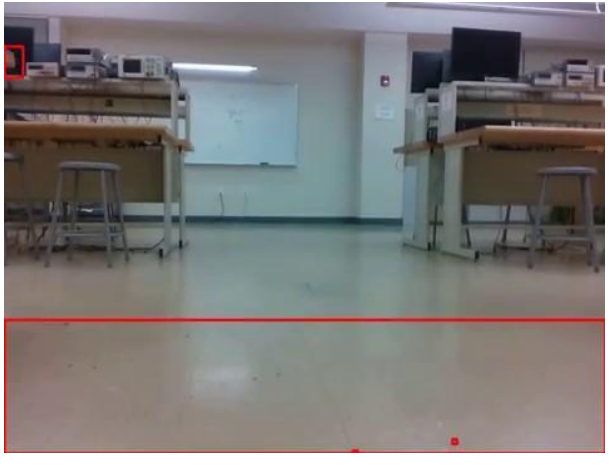


Results

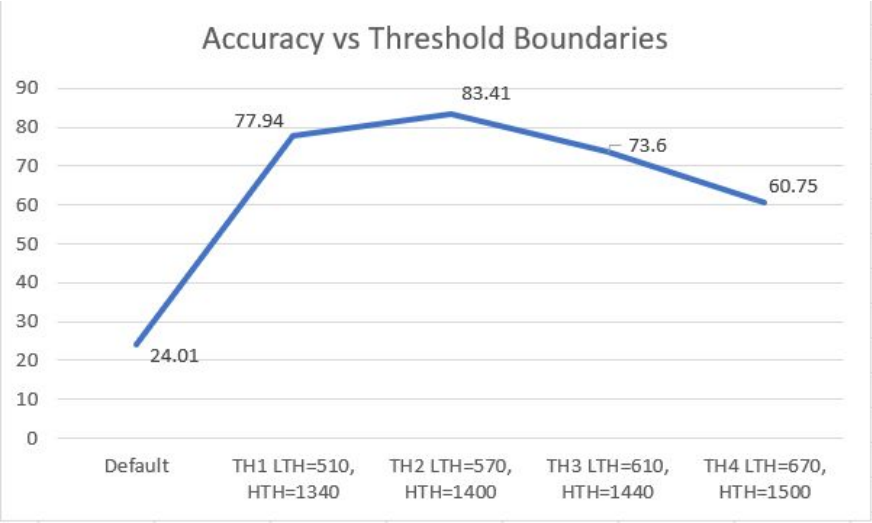








Quantitative Results



Confusion Matrix

(image frames) N = 1020	Pred: Yes	Pred: No	
Actual: Yes	TP= 529	FP=145	674
Actual: No	FN= 133	TN=213	346
	662	358	

Conclusion

Although our implementation works well when there is an object on screen, It does not work well with many objects on reflective floors, or when there is no pronounced objects on screen to detect.

To fix this ground deletion is necessary for isolating objects in depth image although we did not have success implementing it in a real time environment.

The camera height from the ground effects quality of algorithm.

References

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