Computer Vision Project

Exercise 1: Box Detection using RANSAC and Image Processing

Friedrich-Alexander-Universität
Technische Fakultät

Pattern Recognition Lab

FAU

Objective

Detect and estimate the size of a box from distance images and point cloud data.

Steps Involved

1. **Data Handling**
   - Load and visualize amplitude, distance, and point cloud data
2. **Plane Detection(RANSAC)**
   - Identify floor and box-top planes
3. **Morphological Analysis**
   - Use morphological operations and connected component to isolate the box
4. **Measurement**
   - Calculate the box's length, width, and height from geometric analysis

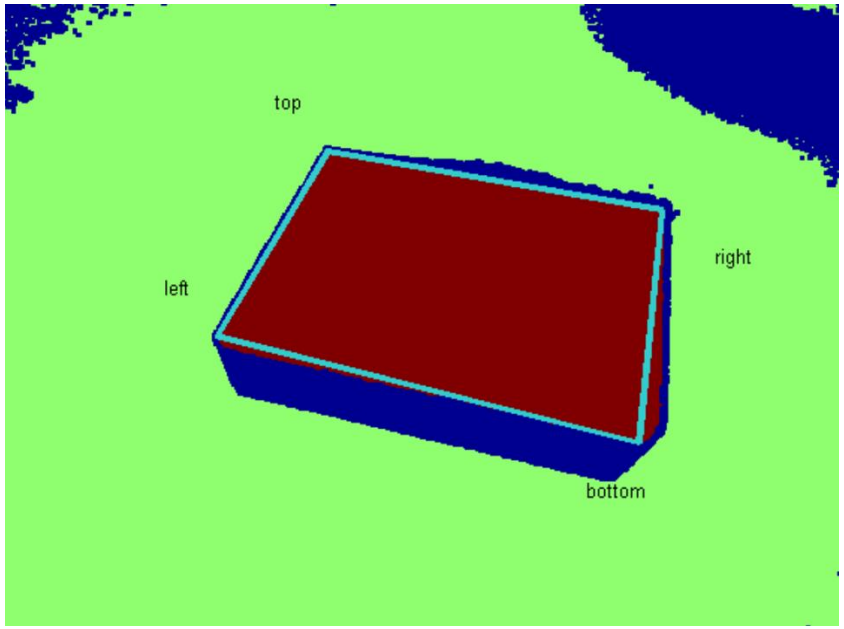


Figure 1:Visualization of floor, box and box corners

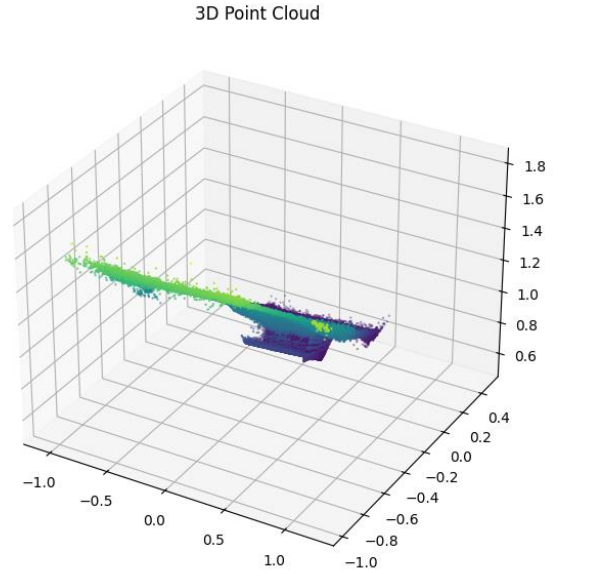
Data Overview

Provided Data Types

1. Amplitude Images
2. Distance Images
3. Point Cloud Data

Data in structured “.mat” files.

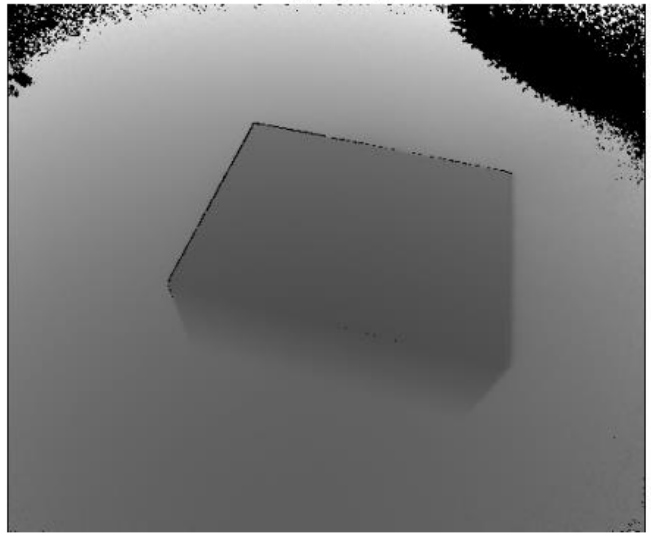
Visual Examples



Amplitude Image

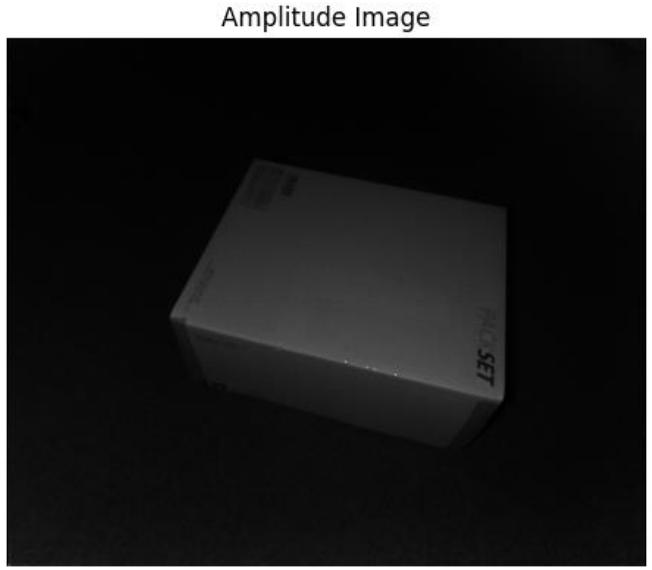
Distance Image

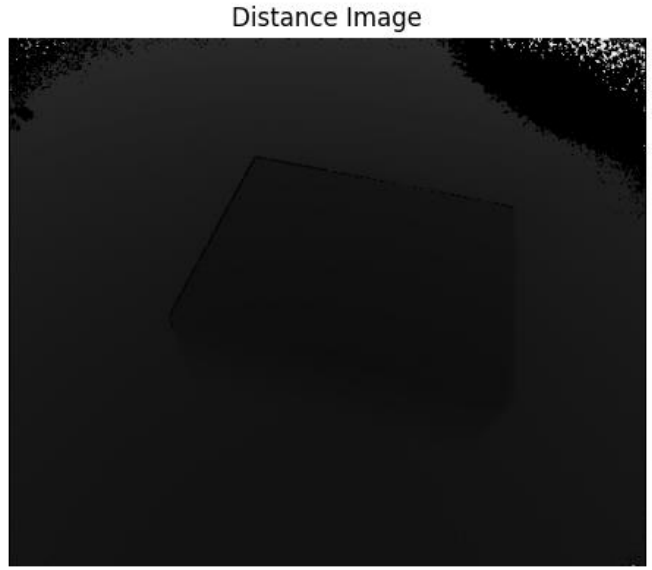
Distance Image (Clipped to 2m)

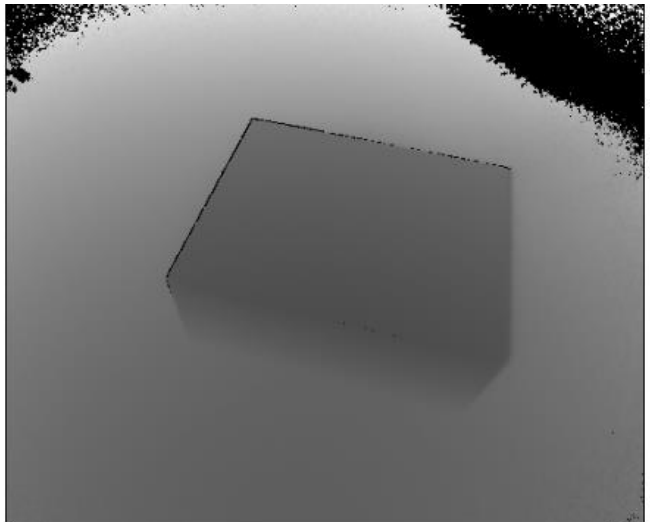


Methodology – Data Loading & Visualization

1. Load .mat files using scipy.io
2. Extract Amplitude, Distance, & Point Cloud
3. Filter valid 3d points (z ≠ 0)
4. Visualize:
   - Amplitude Image (grayscale)
   - Raw Distance Image
   - Clipped Distance Image (Better visibility)

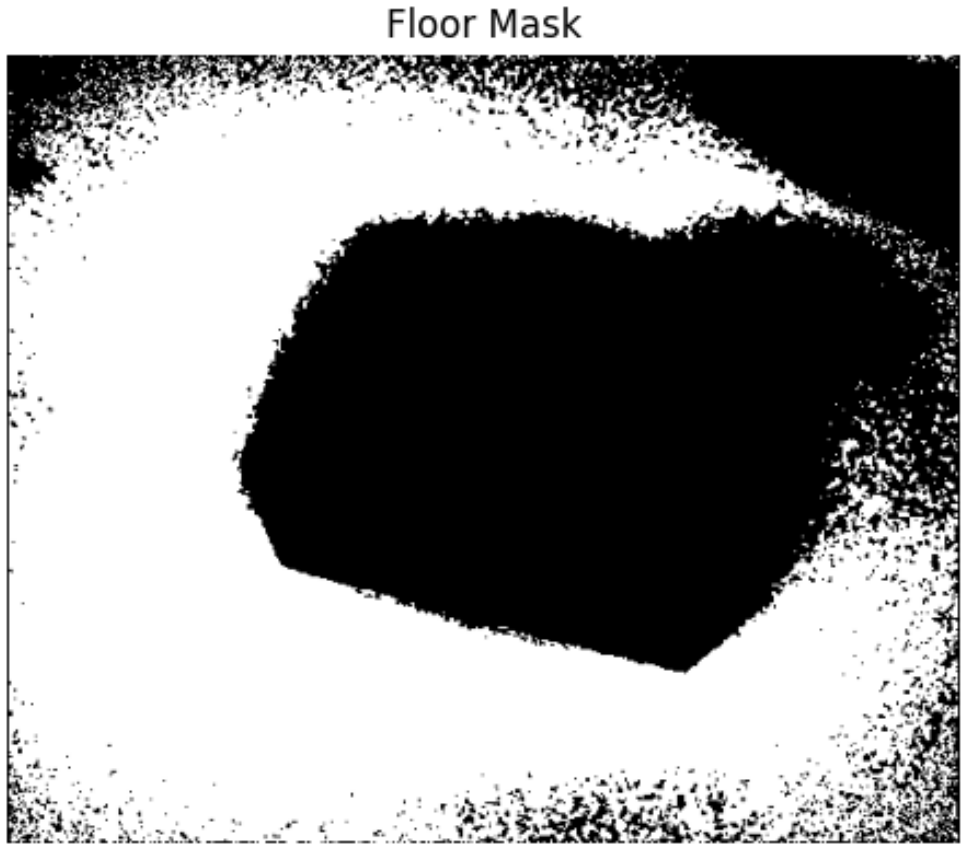






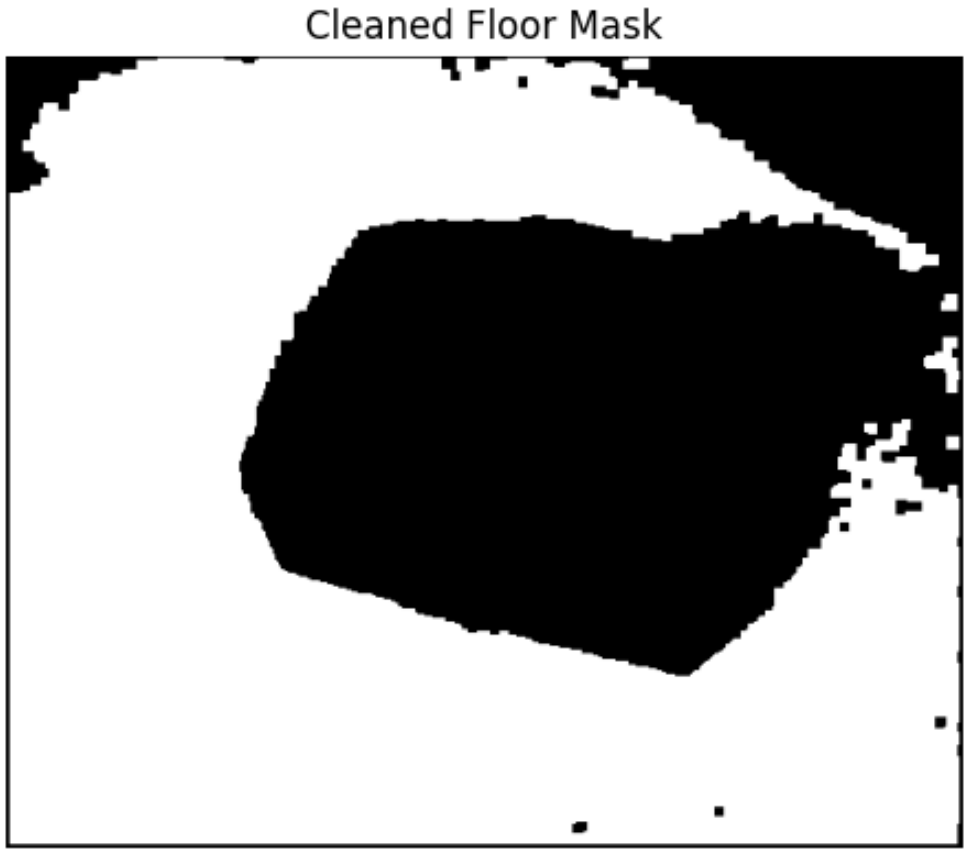
RANSAC – Floor Plane Detection

- Fit a plane to the floor using custom RANSAC
- Random 3-point sampling to estimate plane
- Distance-based inlier counting
- Select model with most inliers
- Output: normal vector, offset, and floor mask



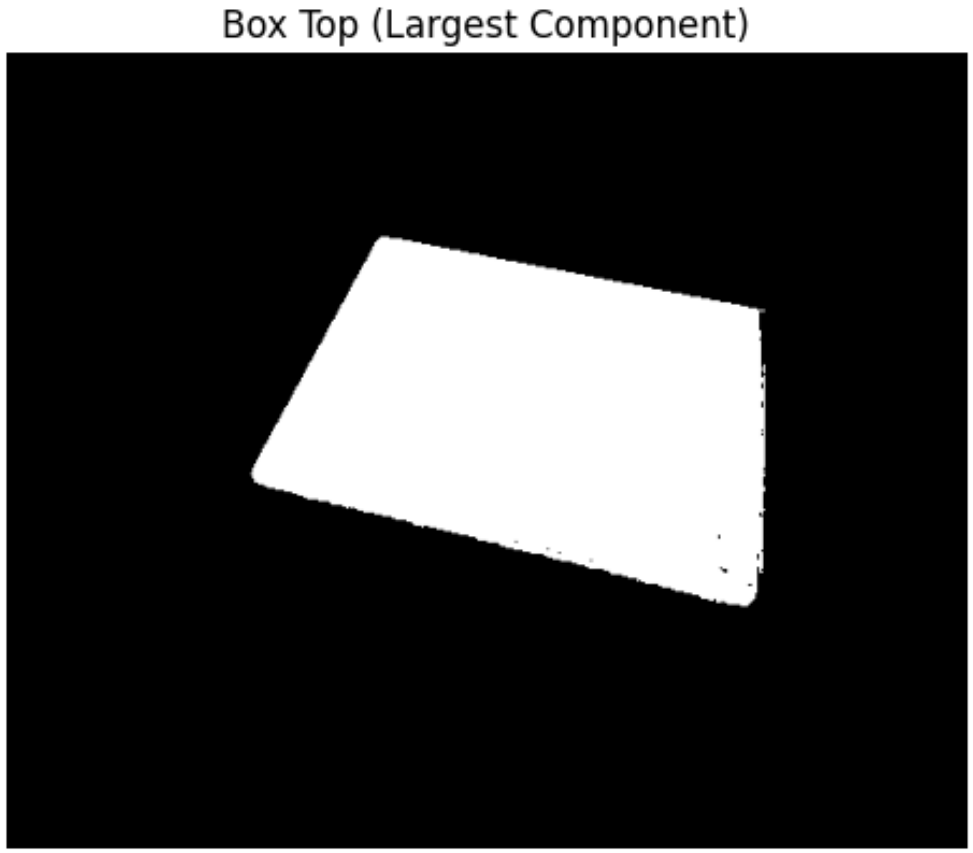
Morphological Filtering of Floor Mask

1. Applied morphological operations to clean the initial floor mask
   - binary_closing() was used to fill small gaps or holes
   - binary_opening() removed small noisy regions
2. Used a 5x5 structuring element in both operations
3. Resulted in a cleaner floor mask for more accurate exclusion of ground points
4. Displayed intermediate results using matplotlib



RANSAC – Top Plane Detection

- Ran RANSAC again on remaining points (non-floor)
- Identified second dominant plane as box top
- Created mask from top-plane inliers
- Used scipy.ndimage.label() to find connected components
- Selected the largest component as box top



Dimension Estimation

Height:

Distance between floor plane and box-top plane using plane equations

$$Height = \frac{|\Delta d|}{||\vec{n}||}$$

$$\Delta d = d_{top} - d_{floor}$$

- $\vec{n}$ is the **normal vector** to both planes

Length & Width:

Determined from 3D coordinates of bounding corners in the largest component

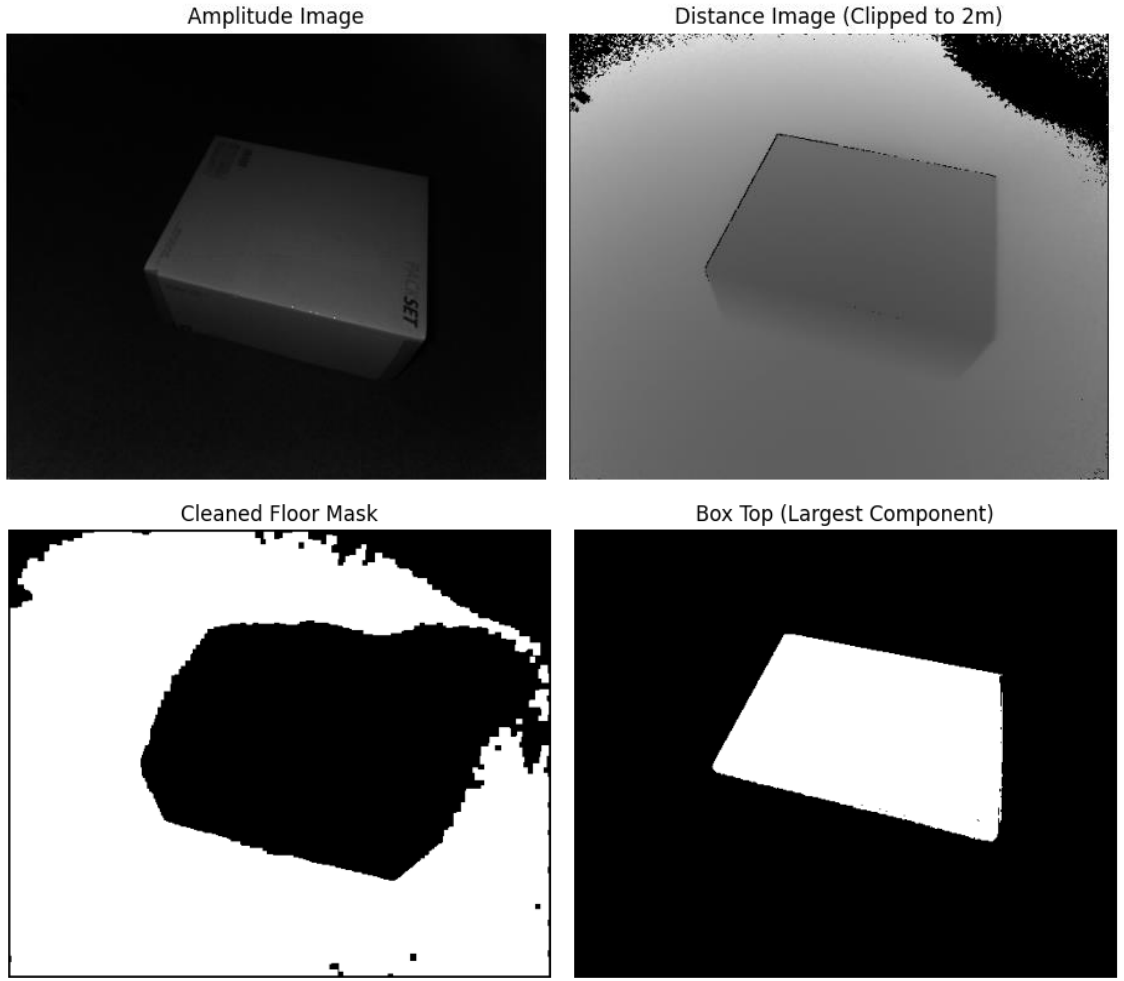
Output example:

Height: 0.184 m
Length (XY-diagonal): 0.649 m
Width (X/Y span): 0.530 m

Results Overview

Example 1:

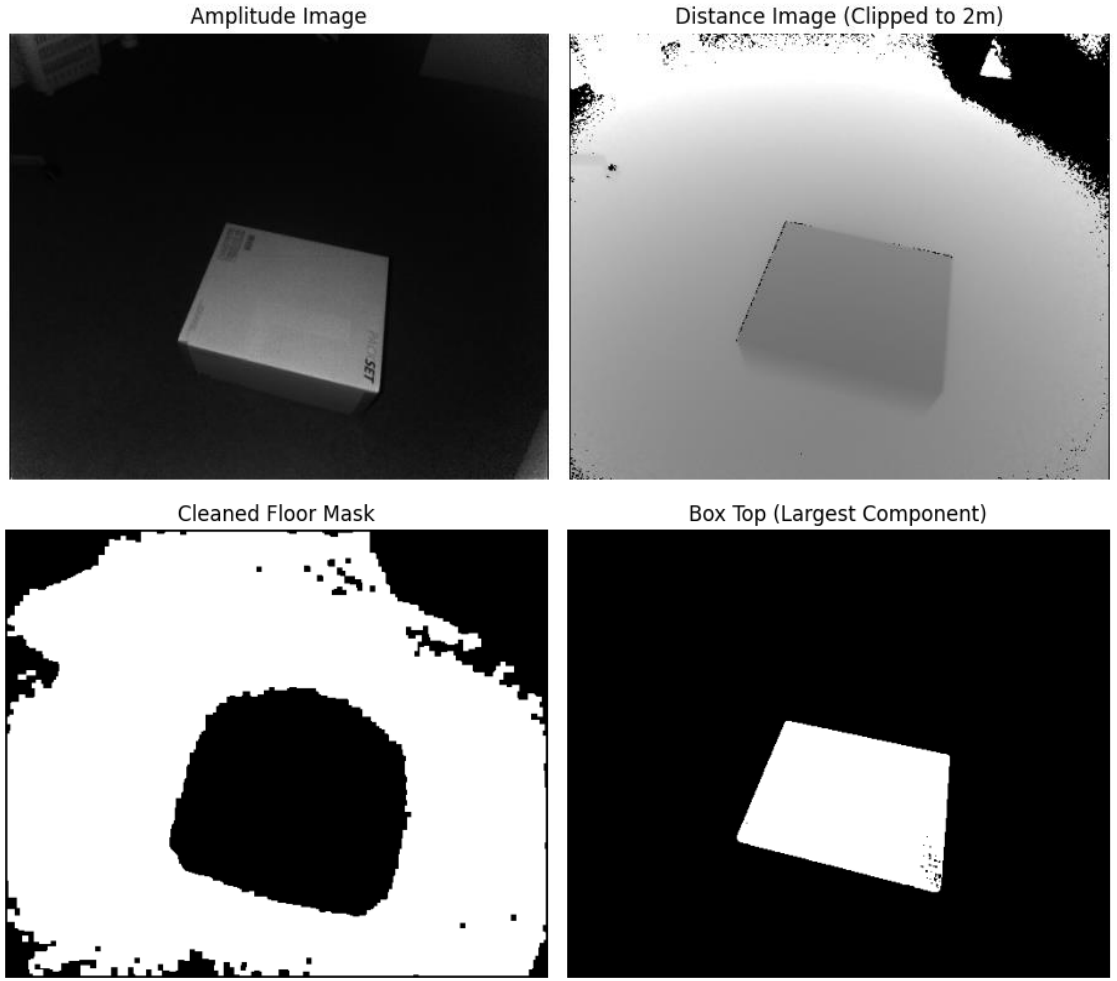
Estimated Box Dimensions:
Height: 0.184 m
Length (XY-diagonal): 0.649 m
Width (X/Y span): 0.530 m



Results Overview

Example 2:

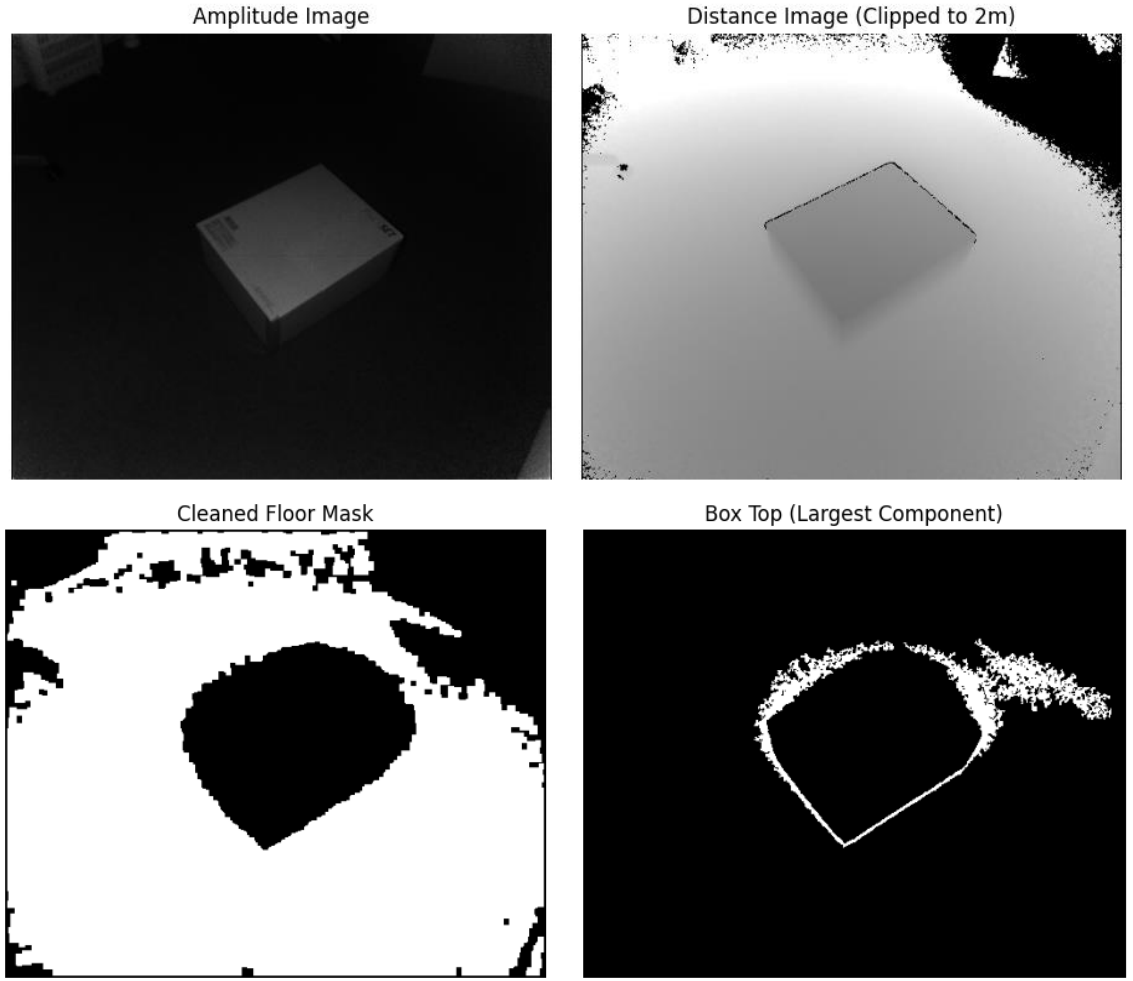
Estimated Box Dimensions:
Height: 0.182 m
Length (XY-diagonal): 0.634 m
Width (X/Y span): 0.515 m



Results Overview

Example 3:

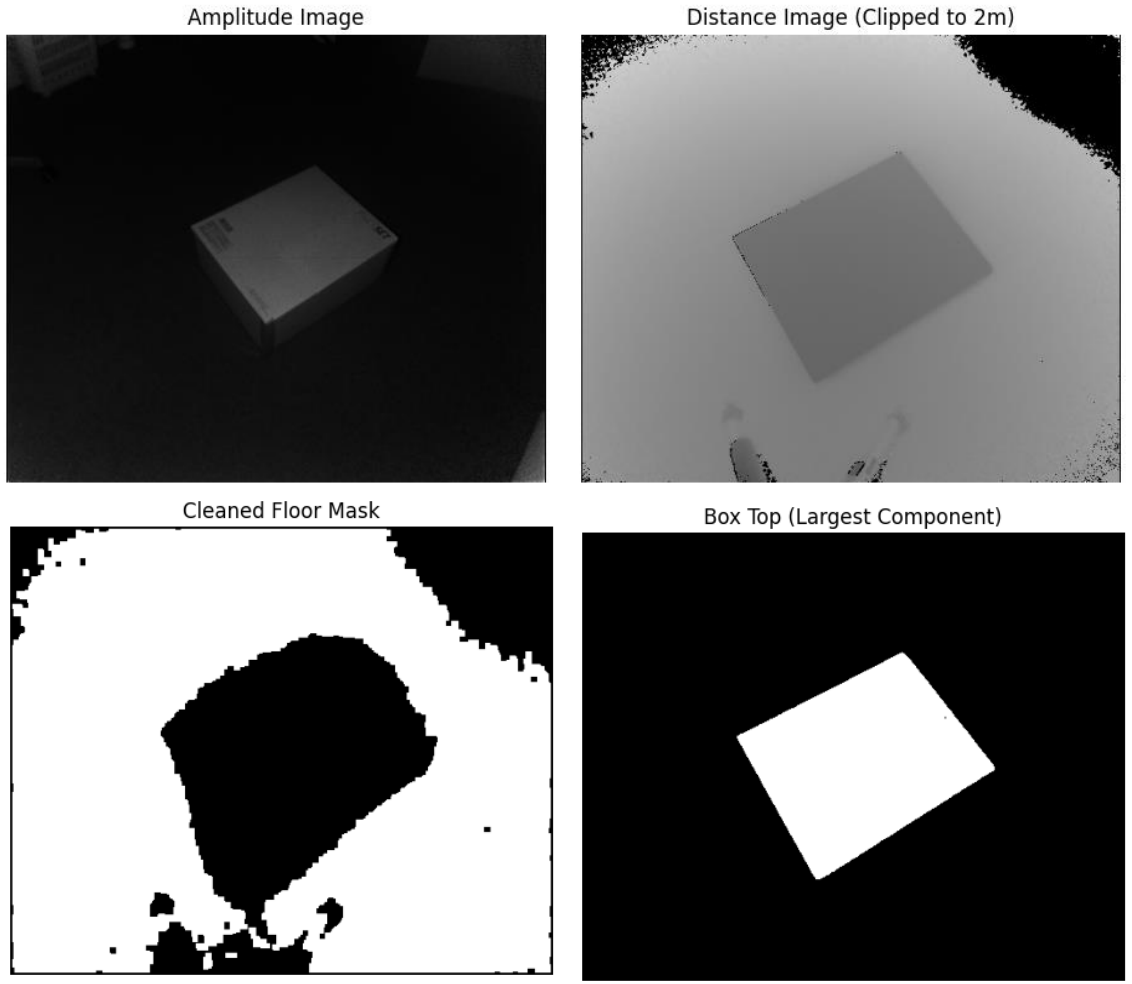
Estimated Box Dimensions:
Height: 0.044 m
Length (XY-diagonal): 1.439 m
Width (X/Y span): 1.260 m



Results Overview

Example 4:

Estimated Box Dimensions:
Height: 0.191 m
Length (XY-diagonal): 0.751 m
Width (X/Y span): 0.569 m



Discussion – Strength & Weaknesses

Strengths:

- Clean custom RANSAC implementation
- Accurate isolation of floor and box via masks
- Effective use of morphological processing

Weaknesses:

- No noise filtering (e.g., median or Gaussian filters)
- Parameter tuning for RANSAC and morphological ops is manual

Suggestions:

- Add filtering for smoother masks
- Improve robustness for noisy or cluttered scenes

Conclusion

- Successfully identified and measured a box using only geometric methods
- Solid use of RANSAC, 3D point processing, and morphological analysis
- Future improvements:
  - Incorporate adaptive thresholding
  - Use filtering to improve mask precision