College of Engineering
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ENVIRONMENTALLY FRIENDLY ROBOT: PROTECTING NATURAL RESERVES AGAINST RANDOM LITTERING

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Abstract

With large increases in tourism, it is difficult to maintain parks and preserves in their natural state due to random littering. The purpose of this research project is to develop an automated robot that is capable of maneuvering in a dynamic and unstructured wilderness environment to collect data about the **form and distribution of litter**. The robot is intended to provide critical information about the commonly contaminated areas and to help tourist sites develop a more efficient method of collecting trash. The distribution patterns will allow for cleaning crews to quickly find trash in **common areas**, thus reducing laboring costs and helping preserve the natural beauty of the park.

Our robot, equipped with Laser Scanner (top) and Kinect RGBD sensor (front)

Hybrid 2D and RGBD Simultaneous Localization and Mapping

Simultaneous Localization and Mapping (SLAM), is a technique that allows robots to update a map of its surrounding and localize it while navigating in unknown environment. For path planning, action planning and probabilistic reasoning, it provides one fundamental basis. The key idea of mapping is to constantly match and align the current sensory data to the previous observations; by aligning the new sensory data to the existing map, the robot will also be able to determine its current position and orientation.

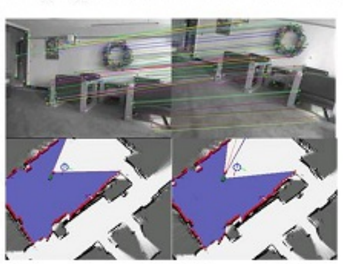
The proposed RGB-D based matching method, extracts and matches image features between subsequent observations, along with the *proposed bad correspondences rejection* method, performs frame-to-frame alignment.

Example: Multiple RGBD Images Registration, Result visualized from different angles

The final proposed solution incorporates a feedback system that uses both RGBD and 2D matching methods to take advantage of both measures. The proposed method also fuses all sensory information into 2D global map for long term planning; local sensory data will be for more accurate, short term path planning.

Three major features include:
- Combine both measures and use each when it works best
- Give best estimate of the surroundings by learning from multiple observations
- Balance and maintain the consistency of the pose estimations based on the two versions of sensory observation

Example: The mapping process, all information fused into a 2D global map



Example: Upon significant tilt and roll, RGBD based matching routine is called, robot pose(green) estimation keeps consistent as before

Image Segmentation and Object Classification

In order to understand the distribution of litter, the robot must extract interesting objects from unknown scenes and distinguish trash and garbage from other natural objects.

a. Segmentation with Texture Learning

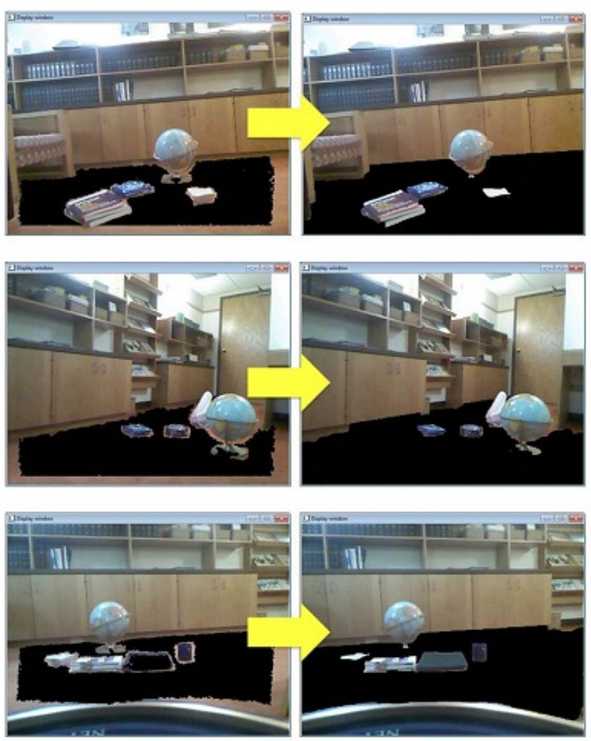
Assuming most garbage is sitting on the ground, extracting and subtracting the ground component will be helpful for clustering and extracting other interesting objects.

The proposed segmentation methods involve
- Computation on color and geometric features
- Generalization and analysis of texture
- Energy minimization for optimal solution

It learns about the texture of new environment for the purpose of refinement and more intelligent segmentation among subsequent RGBD images.

Step 1. This clustering method is based on the similarities of geometric features

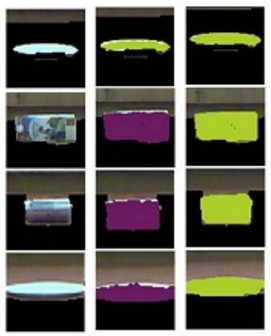
Step 2. This clustering method is based on the similarities of the shape, colors and spatial distance between neighboring pixels.



Step 2. The 'ground' from the first pass

Step 3. After one iteration of refinement

a. Segmentation with Texture Learning



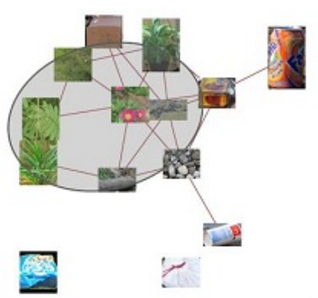
Another Example: After subtracting the ground component, Plate, Milk box, Can were extracted and refined by texture analysis

b. Object Classification (*In Progress*)

What is garbage? What is non-garbage? In the context of natural reserves, we consider garbage as a class of various kinds of objects such as cans, plates, plastic bags that are disposed in the environment. Is there any common features among garbage that can be useful for robot to distinguish garbage among the other objects in the reserves? From a human's perspective, detecting garbage from a natural environment is often easy—intuitively we can say "the garbage looks odd".

This research investigates in
- generalized texture patterns
- shape descriptors
- energy minimization
- probabilistic and learning models

While training is currently in progress, the current clustering patterns sheds lights on the classification and shows it may not just be a problem of *"garbage vs. non-garbage"*, but also *"natural vs. non-natural"*.
Below is an example showing the texture clustering pattern (small sample size)



Example: Texture Clustering Pattern, Natural vs. Garbage *(not final)*

Acknowledgement

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