Improving a Simulator with Computer Vision

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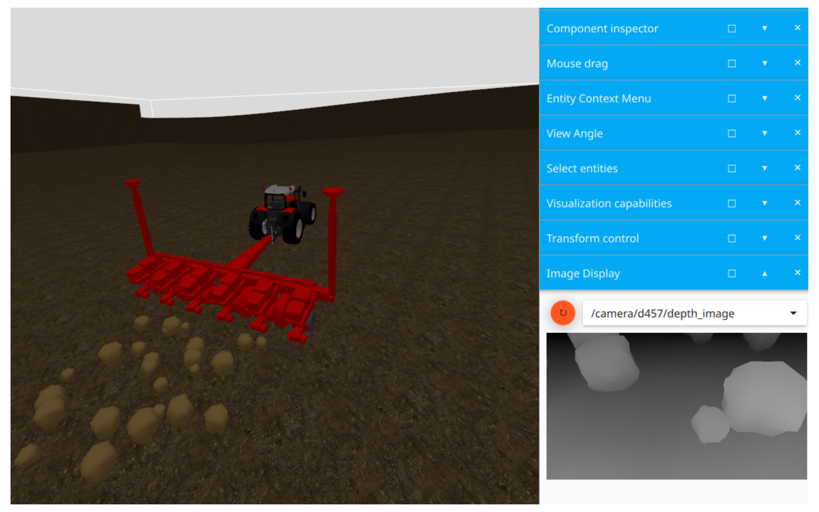
Background

Väderstad AB manufactures farming equipment for tillage and seed planting. The current development toward smarter implements and autonomous tractors requires more sensors and data processing. For tillage operations, it is particularly interesting to assess soil surface roughness and the size distribution of soil clods left after the implement. Väderstad currently has an early simulator built on ROS2 and Gazebo that simulates a tractor with an implement.

Problem Formulation

This project aims to improve the existing simulator by simulating soil clods according to some chosen distribution and then trying to determine this distribution using simulated sensors and computer vision.

Simulation in Gazebo

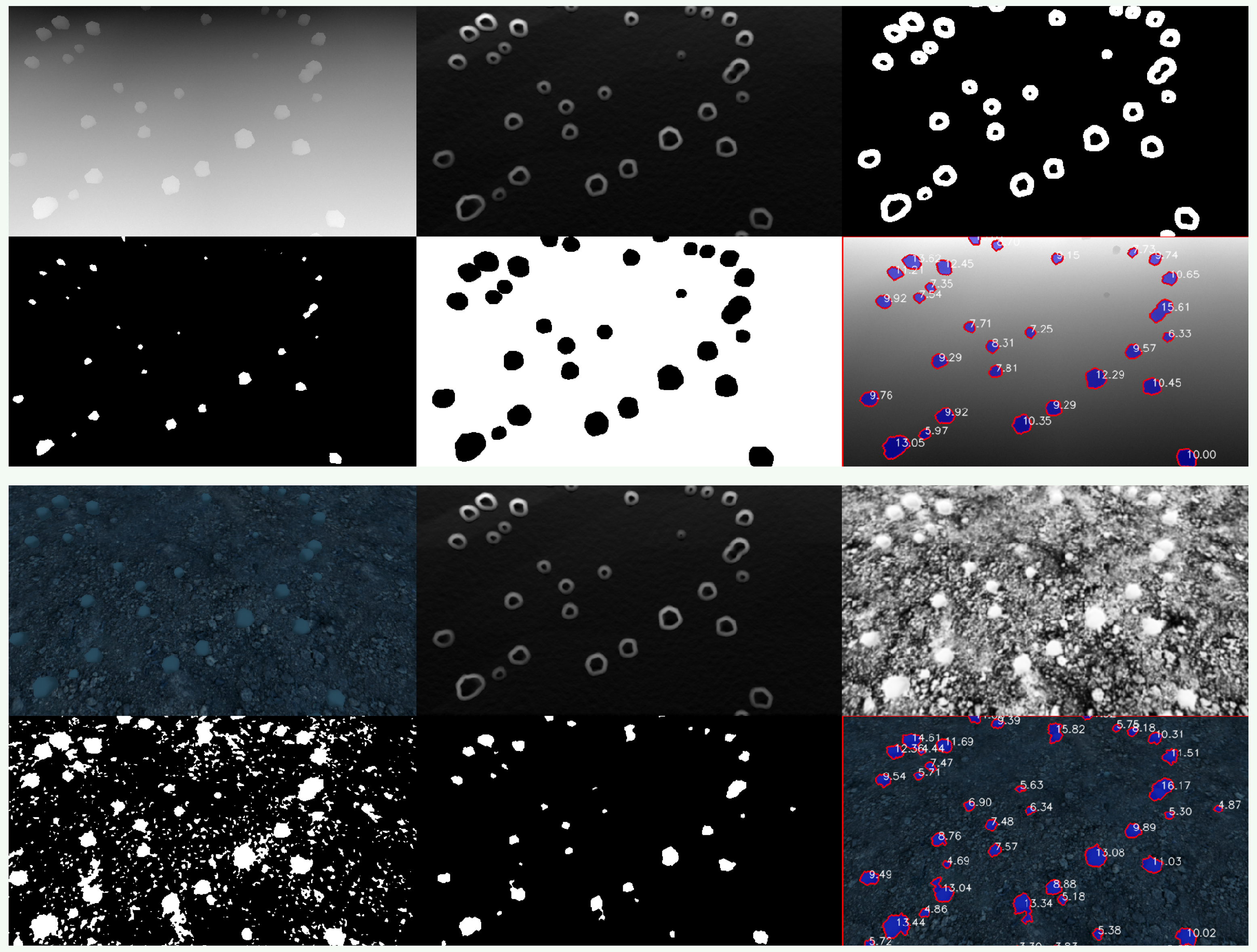


The current simulator uses ROS2 Jazzy and Gazebo Harmonic to simulate the tractor and implement, which also includes simulated sensors. We have created a Gazebo plugin that generates particles (soil clods) according to a selected distribution whenever the tractor moves forward. In addition, we also have a script that automatically starts a simulation, drives the tractor forward for a certain duration, and records the image feeds from the simulated camera. We are using a depth camera which gives one normal RGB feed and one with depth data.

Image segmentation

We have tested several different methods both using RGB images, depth data, and a combination of the two. We have gotten good results using depth discontinuity to find approximate particle edges and then using the watershed algorithm to get exact contours and segments. In order to get a size from each segmented particle, we fit an ellipse to the contour and translate the size to meters using the depth at that specific particle along with the focal length of the camera.

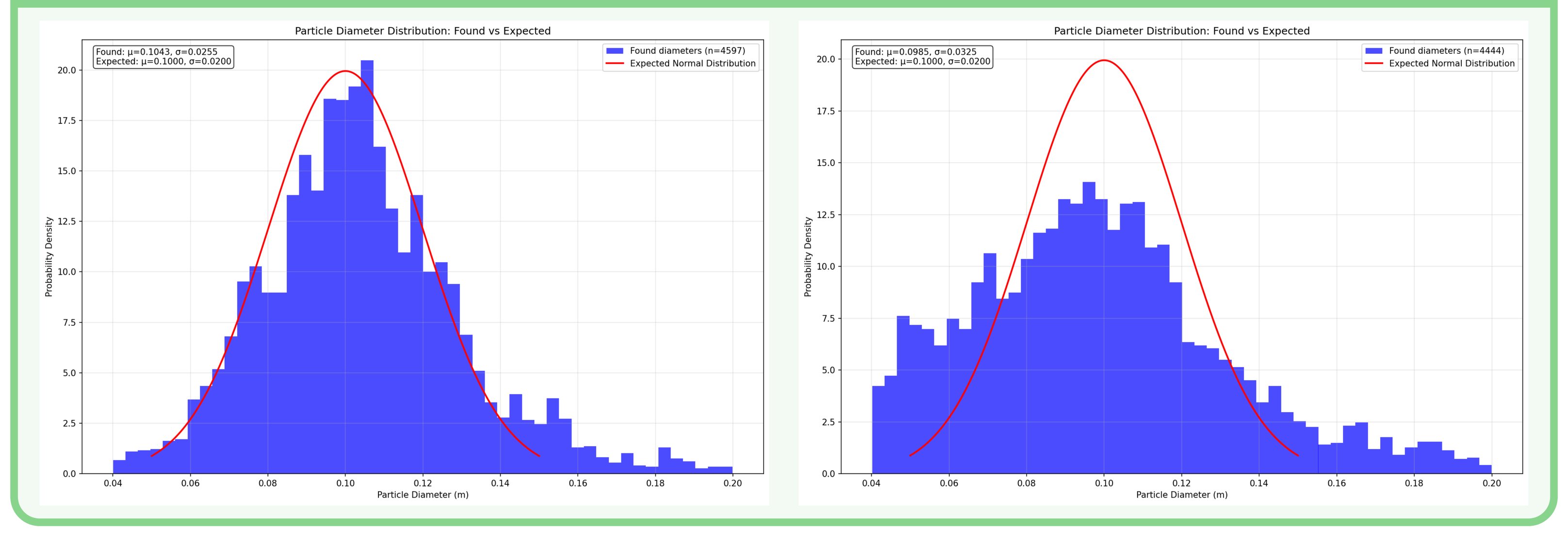
Segmentation



One limitation with the simulation is that the depth images are not that realistic, since the particles lay on top of a mostly flat surface. On the other hand, using the RGB images will inevitably give false particles from the background, which means that we can no longer validate with the known particle distribution.

We also tried with Meta's AI model Segment Anything Model, which gives good results, but is a lot slower than classic computer vision algorithms. In this project we did not evaluate any more lightweight Convolutional Neural Network (CNN).

Results



Further Work

In this project, we would have liked to train our own AI model to try to achieve better results while still being fast enough that the code could be run on an embedded system or a single-board computer. Another area of improvement would be to create more realistic depth data so that the developed methods could be more applicable to a real scenario.

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