Name(s)

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Project Number

S0829

Project Title

Real-Time Freespace Segmentation Using Deep Learning on Autonomous Robots for Detection of Negative Obstacles

Abstract

Objectives

Many small unmanned ground robots are being developed to perform tasks such as delivery, surveillance, household tasks, and many other formerly-human tasks. It is essential to these robots' core functionality that they are able to navigate difficult terrain, requiring advanced perception capabilities. Although a significant amount of work has been done on the detection of standing obstacles (solid obstructions), almost no work has been done on the detection of negative obstacles such dropoffs, ledges, downward stairs. Detecting these negative obstacles using reliable, cost-effective sensors is crucial for the success of autonomous robots.

Methods

Small autonomous robot running Robot Operating System and an embedded GPU which was used to run the neural network, along with a desktop GPU used to train the network.

Results

This research developed a method of terrain safety segmentation using deep convolutional neural networks. The custom semantic segmentation architecture uses a single camera as input and creates a freespace map distinguishing safe terrain and obstacles. The network was trained using heavy data augmentation, enabling the network to generalize well, even when using very small hand-labeled datasets. The results showed that the system generalizes well, achieving around 94.9% mIOU accuracy on the validation dataset.

Conclusions

The neural network is deployed to an embedded GPU on an indoor robot. Because of its computationally-efficient design, the network is able to run at 55 fps and create a freespace map that can be used to create a costmap for navigation and obstacle avoidance. Experimentation with the neural network combined with pathfinding algorithms proved the robot's ability to reliably detect and navigate around both standing and negative obstacles in real-time, using only an RGB camera and the neural network developed in this research.

Summary Statement

I developed a novel method of terrain safety segmentation on autonomous robots using deep neural networks.

Help Received

None. I developed and trained my neural network, and tested it on the robot, completely by myself.