Robust Curb and Ramp Detection for Safe Parking Using the Canesta TOF Camera

O. Gallo*, R. Manduchi*, and A. Rafii‡

*{orazio, manduchi}@soe.ucsc.edu, University of California, Santa Cruz.

‡arafii@canesta.com, Canesta, Inc.

Motivation

Over a hundred people die every year, in the US alone, due to vehicles backing up. Time-Of-Flight sensors have the potential to overcome some of the limitations of currently available devices for assisted backup. However, the first step towards reliable obstacle detection is the recognition of the ground plane, a particularly challenging task when curbs and ramps are present.

Standard robust fitting techniques, such as RANSAC, are prone to neglecting the presence of these features, for points from different planes might be too close to be classified as outliers.

We propose a modification of the RANSAC algorithm, CC-RANSAC, to improve the estimation of the dominant plane.

Method

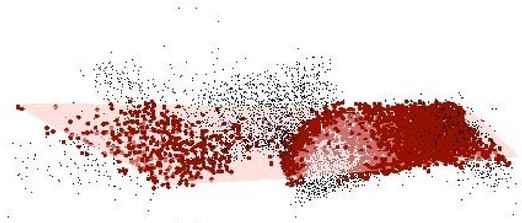
The detection of curbs and ramp, useful per se and needed to find obstacles, requires fitting planes to the 3D points.
At each iteration, RANSAC and CC-RANSAC define the fitness as in:

$$f = |(I(P))| \quad (RANSAC)$$

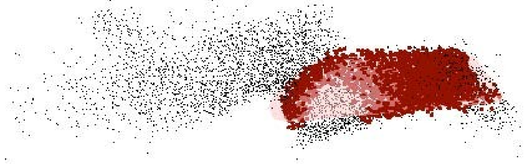
$$f = |(I_{connected}(P))| \quad (CC-RANSAC)$$

To find the connected components among the 3D points, CC-RANSAC uses the 8-neighborhood topology inherited from the camera sensor.

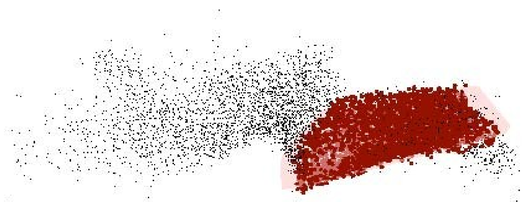
I(P) set of inliers for plane P
$\mathbf{I}_{\mathbf{connected}}$ largest connected component within I(P)
$|\cdot|$ cardinality of the set



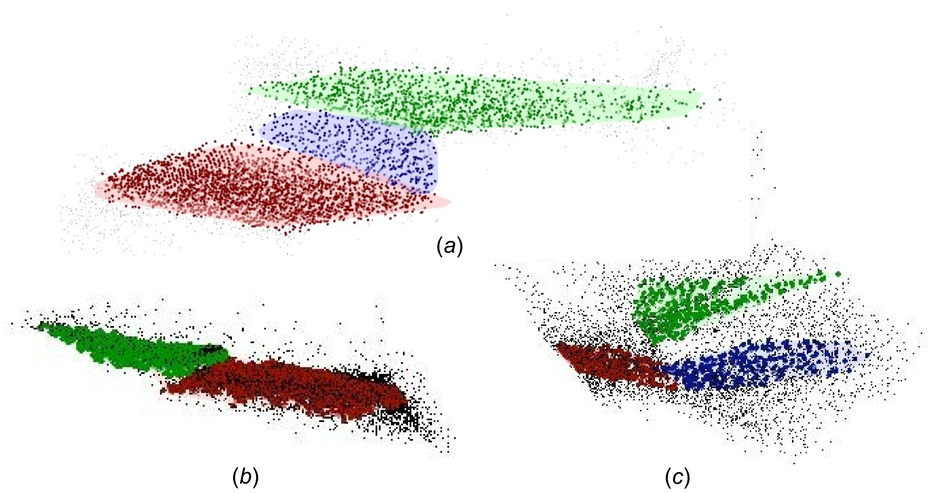
The plane found by RANSAC (shown in faint red) has inliers from different real planes (the red dots)



The same plane as in the figure above has a smaller support using RANSAC-CC



The correct plane, found by RANSAC-CC



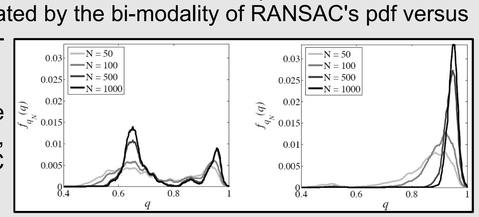
(*a*)

(*b*) (*c*)

Results of the fitting with CC-RANSAC. Different colors correspond to different planar patches and the corresponding inliers. (*a*) and (*b*) are curbs seen from different distances while (*c*) is a more complex structure involving two different ramps separated by a curb.

Results and Future Work

CC-RANSAC provides a more accurate estimation of the dominant plane than RANSAC with a smaller number of iterations, as indicated by the bi-modality of RANSAC's pdf versus the strongly peaked pdf for the case of CC-RANSAC.



Planes are correctly fitted even in the case of small steps such as the one in (*b*), situations in which the standard RANSAC algorithm is prone to failing.

The computational cost of finding the connected components is balanced by the sensibly smaller number of iterations required to reach convergence.

Although successful in all of our examples, the hypothesis that inliers form a connected component needs to be investigated further.