Evaluation of 3D Model Accuracy for Automated Unloading of Containers

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Activities in logistics' material flow include transport, storage and handling processes for a wide variety of goods. Especially the handling of mass goods during container unloading is done manually as containers are often packed chaotically and the working space within containers is restricted. Because manual handling of goods is a strenuous task it poses health risks making automated solutions highly desirable. Developing autonomous systems for unloading in a general, largely unconstrained environment is, however, very challenging due to industrial requirements (robustness, safety, real-time operation) and large variations in goods and environmental conditions. Existing systems for automated unloading are restricted to specific scenarios and still have drawbacks in their flexibility, adaptability and robustness. Hence, researchers in the EU funded project RobLog develop appropriate methods and technologies meeting the requirements to automate logistics processes.

A key challenge addressed in the RobLog system is 3D perception, which is the base for autonomous decisions about the next object to grasp, computation of collision-free trajectories in the restricted working space, obstacle avoidance during motion execution, including grasping and the transfer to a conveyer belt. The whole process of one full gripping cycle – including data acquisition, data fusion, outlier removal, integration into a dynamic 3D semantic map, simulation of the effects of potential actions and selection of the next action – has to be completed in less than 8 s (time span with which economically competitive applications are possible). The performance of the RobLog system depends crucially on the 3D perception quality. A first step is therefore to evaluate the model quality that can be obtained with different 3D sensor and compare them to the requirements of the application. This contribution presents a method to evaluate the model quality for generic scenes and first results for different TOF cameras.

The criteria considered for the requirements analysis are given by operational constraints for a system for autonomous unloading of containers, the required information, the environmental conditions, and restrictions due to the installation of sensors. The criteria are discussed together with the corresponding requirements on the sensors' properties.

Similar to [1], the basic idea behind the evaluation method is to derive a probabilistic representation of a 3D scan using the 3D-NDT method [2]. Considering this 3D-NDT model as an approximation to ground truth, measurements from alternative sensors are compared in terms of their log-likelihood. This concept was applied to compare 3D sensors and could also be used to compare up-sampling approaches in RGB-D sensors.

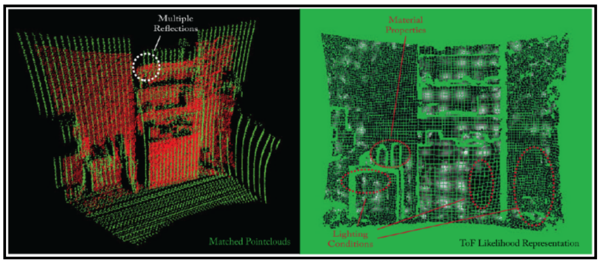

Figure 1 - Comparison between 3D scans obtained with an actuated laser range finder (aLRF, Sick LMS 200) and a TOF camera (Swiss Ranger SR4000). The left panel shows a direct comparison of the range data (laser range finder in red, TOF camera in green). The right panel shows the likelihood distribution of the ToF scan with respect to the NDT-model of the LRF scan.

We will present results that compare different TOF-cameras and the Kinect sensor based on a 3D-NDT model obtained with an actuated laser range scanner (SICK LMS 200). An example is shown in Fig. 1.

References

[1] T. Stoyanov, M. Magnusson, H. Almqvist and A. J. Lilienthal, "On the Accuracy of the 3D Normal Distributions Transform as a Tool for Spatial Representation". Proc. ICRA, 2011, to appear.

[2] M. Magnusson, T. Duckett, and A. J. Lilienthal, "3d scan registration for autonomous mining vehicles". Journal of Field Robotics, vol. 24, pp. 803–827, Oct 24 2007.