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Abstract. This year the task of the UvA Rescue Team is to break up the monolith architecture of the control architecture. On the one hand this will make the existing modules reusable by other researchers; on the other hand it opens the possibility to incorporate efficient modules from other research groups. A first attempt will be to incorporate 3DTK - The 3D Toolkit which provides methods and algorithms to process 3D point clouds.

Introduction

The RoboCup Rescue competitions provide benchmarks for evaluating robot platforms' usability in disaster mitigation. Research groups should demonstrate their ability to deploy a team of robots that explore a devastated area and locate victims. The Virtual Robots competition, part of the Rescue Simulation League, is a platform to experiment with multi-robot algorithms for robot systems with advanced sensory and mobility capabilities.

The shared interest in the application of machine learning techniques to multi-robot settings has led to a joint effort between the laboratories of the Universities of Oxford and Amsterdam . The result of this four year collaboration has boiled down in a number of shared publications [1–5] and a thesis [6] from Oxford's Exeter College. Oxford University is still active on this subject [7], although their participation for the Iran Open and Brazil 2014 is not yet confirmed. This year's challenge will be to make the world modeling truly 3 dimensional, by using an existing toolkit [8].

To be able to efficiently coordinate a team of robots in a disaster situation many state-of-the-art robotic techniques have to be integrated. Our approach is extensively described in previous Team Description Papers and aggregated in a Technical Report [9]. The later report gives an overview of the publications for the period 2008-2012. Also in 2013 our team had several publications [7, 10, 11, 5, 12–14]. In this paper we will concentrate on this year's innovations.

1 Team Members

UsarCommander was originally developed by Bayu Slamet and all other contributions have been integrated into this framework. Many other team members have contributed to perception and control algorithms inside this framework.

The following contributions have been made and will be made this year:

Arnoud Visser : Planar 3D mapping

2 Planar 3D mapping

One of the main challenges faced in the competition (and for robots in general) concerns building a map of the environment as the robot explores it. The Amsterdam-Oxford team currently has software that enables a virtual robot to build a 2-dimensional map from sensor data. Although useful in a number of situations, this is potentially quite limiting in the real world, as search and rescue operations are unlikely to take place in perfectly flat environments. Therefore, the aim of this project is to extend the mapping capability to 3-dimensonal space. This would give rescue workers a better idea of the layout of the environment, and would help to highlight features and hazards that would not be apparent in a 2D map.

In a previous attempt by Nelson [15] to build a 3-dimensional map inside USARSim, the classical ICP algorithm [16] was implemented efficiently with a Kd-Tree, an approach already advocated by Rusinkiewicz and Levoy [17]. For efficiency reasons, not the full 3D point-cloud was used by Nelson. Instead, only the edge-points of surfaces were used, which gave an efficiency improvement of a factor 100. The ICP algorithm tries to reduce the distance between the 3D-datapoints by finding the optimal translation and rotation vector, which implies a full 6D localization.

Yet, in the nomenclature of Borrmann *et al* [8] this is Planar 3D mapping and not full 6D SLAM, because the 3D point-cloud consists of slices of a rotating 2D laser scanner. When acquiring this data while moving, the quality of the resulting map crucially depends on the pose estimate that is given by inertial sensors. In principle, the probabilistic methods from planar 2D mapping are extendable to 3D mapping with 6D pose estimates. Yet, for 3D point-clouds it is essential to have a good strategy for reducing the computational costs of matching.

In the approach of Nelson [15], the 3D map is build based on *pairwise ICP*, which gives good results for local maps, but on the end registration errors sum up. Borrmann *et al* [8] solve this by adding a loop-detector in the code, which indicates when a place is visited for a second time. At that moment a 6D graph optimization algorithm for global relaxation based on the method of Lu and Milios [18] is employed.

The benefit of using the 3DTK Toolkit is not only that it contains Lu and Milios SLAM algorithm, but in addition that the whole implementation is highly efficient, for instance the datastructure for the nodes is 8 times smaller than the datastructure used in PCL [19].

3 Innovations

The scan matching in the 3DTK Toolkit is based on the classical ICP algorithm. In a previous publication [20] we have demonstrated that we could outperform ICP by reducing the correspondence error with the Weighted Scan Matching algorithm. When implemented inside the 3DTK Toolkit, we could study if the increase in robustness is worth the increase in computational complexity.

4 Conclusion

This paper summarizes the plans for improvement of the algorithms of the UvA Rescue Team, after our team won the Infrastructure award sinceat the RoboCup 2012 in Mexico. Many developments inside our framework are not only valuable inside the Rescue Simulation League, but coulde also be valuable for the Soccer Simulation, the RoboCup@Home and the Standard Platform League [12]. For the Virtual Robot competition, developments in the user interface and full 3D mapping are important.

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