
Gian
Danuser

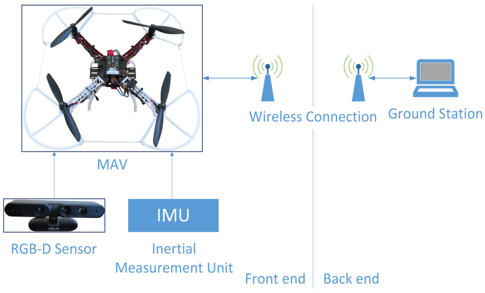

Michael
Eugster

Graduate Candidates	Gian Danuser, Michael Eugster
Examiner	Prof. Dr. Guido Schuster
Co-Examiner	Aggelos K. Katsaggelos, Northwestern University, Evanston, USA
Subject Area	Sensor, Actuator and Communication Systems

SLAM for Navigation of MAVs in Unknown Indoor Environments

Master Thesis

The MAV prototype with mounted Asus Xtion Pro Live



SLAM system for MAV concept overview

3D map of one of the offices of the image and video processing lab at Northwestern University

Introduction: Visual Simultaneous Localization And Mapping (SLAM) is a well known problem for Micro Aerial Vehicle (MAV) of building a map of an unknown environment and at the same time navigating in it. The constant movement of an MAV, the limited payload, and the on-board computation capacity are big challenges for a stable and accurate control. Furthermore, the odometry has to be measured indirectly to estimate the velocity and position of the vehicle. The objective of this work is to create a SLAM system for a small MAV to navigate in a GPS denied, unknown indoor environment. Therefore, the SLAM algorithm can only utilize on-board sensors of the MAV.

Objective: Without GPS the position estimate starts to drift due to accumulated errors. Thus, next to the InertialMeasurement Unit (IMU) an RGB-Depth (RGB-D) sensor, which provides absolute distance measurements, is applied to correct the drift of the position estimate. The SLAM system is split into two parts, namely the front end and the back end, where the front end consists of the critical flying parts and the back end is responsible for the global position, the creation of a 3D map, and the high-level navigation and planning. While the MAV is flying it captures a stream of RGB-D images. These images are processed to estimate the relative movement of the MAV and to create a 3D map of the environment. To achieve a global consistent map a pose graph is created by using the estimated movements.

Result: The hardware consists mainly of the MAV, the autopilot, the on-board computer, the RGB-D sensor, and the ground station. The front end is processed on the on-board computer and the back end on the ground station. These two main parts communicate over a wireless link. The designed and implemented Visual-SLAM system estimates the relative movements of the MAV based on features in the RGB images and their corresponding depth values. Furthermore, it builds a pose graph based on the relative movements, which is optimized to achieve global consistent and accurate 3D maps. Experiments showed that the Visual-SLAM system reconstructs the unknown environment precisely if enough features with valid depth information are available. Small rooms are usually better reconstructed due to the fact that the depth values of the features are mostly valid. However, in larger rooms and corridors the SLAM process is more challenging because of missing depth values at feature locations. Responsible for this issue is the limited depth range of the RGB-D camera.