Online Optimal Controlled Mapping for Offline 3D Reconstruction

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Abstract: We aim to automate the gathering of sensor-data for later offline use. In this talk we present our method within the ArchEye Automatic project.

The goal of ArchEye is to develop new methods for autonomous documentation of historic buildings in 3D using unmanned aerial vehicles. For this purpose, a set of aerial photographs is produced by a multi-copter, which is used for offline 3D reconstruction utilizing a structure from motion software afterwards. The copter however are currently only controlled manually or by heuristic flight pattern, so that the quality and completeness of the resulting 3D reconstructions have to be doubted until final calculations are made, and are strongly dependent on the experience of the pilot.

We formulate an optimal experimental design problem which can iteratively be solved in real time to estimate the next-best-view for the next measurement, maximizing the quality of the reconstruction while keeping the total amount of measurements small. Since we have no preliminary information of the area where measurements are to be taken (e.g. geometry), we are keeping track of occupied, free and unknown space using an occupancy map stored in an octree, which allows us to optimize on different levels speeding up calculations and guaranteeing collision free path-planning. Moreover, we can add terms to the objective function that lead to an explorational behavior, ultimately resulting in the maps completeness within given boundaries. At the same time it allows us to work with different specialized robots and sensors, or to make manual improvements e.g. in areas which are hard to reach - all incorporated in the same map.

We also introduce our custom simulation framework using Gazebo and ROS, where we can use high resolution laser-scans as ground truth for benchmarking comparisons, as well as for visualizing the path and measurement updates from the optimal experimental design solutions.

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