First Year Report on

Localization and Map Building Using Sensor Fusion for Autonomous Vehicle Navigation

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Abstract

The problem of Localization and Map Building(SLAM) has very often been recognized as one of the key problems in building autonomous capabilities for mobile vehicle navigation in the robotics literature. It is also widely accepted that the capability of simultaneous self-localization and map building without an a priori map would make a robot truly autonomous. A workable solution to the SLAM problem will be invaluable in several key areas including autonomous land vehicle operation in rough unstructured terrain, driver assistance systems, mining, surveying, cargo handling, autonomous under water exploration, sub-sea vehicle missions, aviation applications, autonomous planetary rovers for planetary exploration and military applications such as information gathering and surveillance using autonomous air-borne and all-terrain vehicles.

Present SLAM algorithms, utilizing available state of the art in signal processing and estimation are limited to structured or semi structured domains with limited operational capabilities. The work critically investigates the key issues in current state of the art and identifies (1) Type of sensor fusion algorithms (2) Algorithmic complexity and tractability (3) Data association problem (4) Feature extraction and representation and (5) Sensor and vehicle modeling as challenging and open research issues.

The work formulates the popular feature based SLAM using EKF, presents simulation and implementation results with real data, improves on an existing feature extraction method for efficient estimation of the radius and location of centers of tree trunks and proposes two extensions therein. First extension is towards joint tracking and parameter estimation in SLAM concentrating on the effects and estimation of slowly varying sensor biases and offsets in feature based localization and mapping. A proof for the convergence of bias estimation in this context is presented and observability issues are discussed in length. Then an efficient and robust data association algorithm that would perform well in fairly high clutter levels is proposed for SLAM and verified using simulations.

Extensions and proposal for future work are presented based on the conclusion that an efficient manner in performing outdoor navigation essentially lies with the extraction of important features(whether they may be landmark locations, color, texture or any other form) in the environment and the manner in which salient features are selected in an adaptive manner maximizing the utility of sensor resources available. Finally initial results and the proposal for future work are presented based on the conclusions drawn.