Fusion-SLAM by Combining RGB-D SLAM and Rat SLAM

A thesis presented in partial fulfilment of the requirements for the degree of

Master of Engineering

In

Mechatronics

At

Massey University,

Albany, New Zealand.

Robert Tsunemichi Tubman

2016

Abstract

Robotic Simultaneous Localization and Mapping (SLAM) is the problem of solving how to create a map of the environment while localizing the robot in the map being created. This presents a causality dilemma where the map needs to be created in order to localize the robot, but the robot also needs to be localized in order to create the map. In past research there have been many solutions to this problem ranging from Extended Kalman Filter (EKF) to Graph SLAM systems. There has also been extensive research in bioinspired methods, like ratSLAM implemented in aerial and land-based robots. The different research setups use sensors such as Time of Flight (ToF) e.g. laser scanners and passive devices e.g. cameras. Over the past few years a new type of combined apparatus has been developed by Microsoft called the Kinect. It combines active and passive sensing elements and aligns the data in a way which allows for efficient implementation in robotic systems. This has led to the Kinect being implemented in new research and many studies, mostly around RGB-D SLAM. However these methods generally require a continuous stream of images and become inaccurate when exposed to ambiguous environments.

This thesis presents the design and implementation of a fusion algorithm to solve the robotic SLAM problem. The study starts by analysing existing methods to determine what research has been done. It then proceeds to introduce the components used in this study and the Fusion Algorithm. The algorithm incorporates the colour and depth data extraction and manipulation methods used in the RGB-D SLAM system while also implementing a mapping step similar to the grid cell and firing field functions found in the ratSLAM. This method improves upon the RGB-D SLAM's weakness of requiring a continuous stream and ambiguous images. An experiment is then conducted on the developed system to determine the extent to which it has solved the SLAM problem. Moreover, the success rate for finding a node in a cell and matching its pose is also investigated.

In conclusion, this research presents a novel algorithm for successfully solving the robotic SLAM problem. The proposed algorithm also helps improve the system's efficiency in navigation, odometry error correction, and scan matching vulnerabilities in feature sparse views.

Acknowledgments

I would like to express my deepest gratitude and sincerest appreciation to Dr Khalid Arif for his supervision, enthusiastic guidance and continuous encouragement throughout the course of this study.

I would also like to express my appreciation to my co-supervisor A/Professor Johan Potgieter, and the University staff for continuous support and encouragement throughout the course of this study.

I am also thankful to my family and friends for continuous support, encouragement and emotional support throughout all of my achievements in life.

Table of Contents

List of Figures

List of Tables

List of Abbreviations

BRIEF – Binary Robust Independent Elementary Features

CMOS – Complimentary Metal-Oxide Semi-conductor

DoF – Degrees of Freedom

EKF - Extended Kalman Filter

FAST – Features from Accelerated Segment Test

GTSAM – Georgia Tech Smoothing and Mapping

ICP – Iterative Closest Point

IR – Infra Red

MAV - Micro Aerial Vehicle

ORB – Oriented FAST and Rotated BRIEF

RANSAC – Random Sample Consensus

RFID – Radio Frequency Identification Device

RGB-D – Red Green Blue Depth, Colour and Depth data

ROS - Robot Operating System

SIFT – Scale Invariant Feature Transform

SLAM - Simultaneous Localisation and Mapping

SPmodel - Symmetries and Perturbations model

SURF – Speeded Up Robust Features

ToF – Time of Flight

TSDF - Truncated Signed Distance Function