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by

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To my family for their steadfast support and love.

Abstract

Abstract in English.

Résumé

Résumé en Français.

Acknowledgements

Acknowledgements here.

Preface

The contributions of this thesis that are original to the author's knowledge are as follows.

- Chapter 1
  - Solving the batch SLAM problem using a right-invariant framework while explicitly considering bias states.

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List of Abbreviations

SLAM Simultaneous Localization and Mapping

List of Symbols

$\|\cdot\|$	the Euclidian norm of a physical vector
$\mathbb{R}^n$	the vector space of real n-dimensional vectors
$\mathbb{R}^{m\times n}$	the space of real $m \times n$-dimensional matrices
$(\cdot)^\mathsf{T}$	transpose
$(\cdot)^\times$	cross operator for $\mathfrak{so}(3)$
$(\cdot)^\wedge$	operator mapping an element of $\mathbb{R}^d$ to $\mathfrak{g}$
$(\cdot)^\vee$	operator mapping an element of $\mathfrak{g}$ to $\mathbb{R}^d$
$\mathbf{0}$	zero matrix
$\mathbf{1}$	identity matrix
$\mathrm{diag}\,(\mathbf{M}_1, \ldots, \mathbf{M}_n)$	block diagonal matrix with $\mathbf{M}_1$, ..., $\mathbf{M}_n$ on diagonals, and zeros elsewhere
$\underrightarrow{\mathcal{F}}_i$	reference frame
$\underrightarrow{r}$	a physical vector
$\underrightarrow{r}^{zw}$	the position of point z relative to point w
$\underrightarrow{r}^{\bullet a}$	the time derivative of $\underrightarrow{r}$ with respect to $\underrightarrow{\mathcal{F}}_a$
$\underrightarrow{r}^{zw\,\bullet a} = \underrightarrow{v}^{zw/a}$	velocity of point z relative to point w with respect to $\underrightarrow{\mathcal{F}}_a$
$\underrightarrow{\boldsymbol{\mathcal{F}}}_a$	a vectrix, that is a matrix of unit length physical vectors that form a basis for $\underrightarrow{\mathcal{F}}_a$, where $\underrightarrow{\boldsymbol{\mathcal{F}}}_a^\mathsf{T} = [\underrightarrow{a}^1 \;\; \underrightarrow{a}^2 \;\; \underrightarrow{a}^3]$
$\mathbf{r}_a$	the physical vector $\underrightarrow{r}$ resolved in $\underrightarrow{\mathcal{F}}_a$
$\mathbf{C}_{ab}$	a DCM parameterizing the attitude of $\underrightarrow{\mathcal{F}}_a$ relative to $\underrightarrow{\mathcal{F}}_b$

$\underrightarrow{\omega}^{ba}$	angular velocity of $\underrightarrow{\mathcal{F}}_b$ relative to $\underrightarrow{\mathcal{F}}_a$

Chapter 1

Introduction

High-level introduction to the field of research.

1.1 Thesis Objective

1.2 Thesis Overview

This thesis is structured as follows.

Chapter 2 summarizes mathematical concepts and notation that are used throughout this thesis.

`\Cref{chap:iekf}>` outlines the IEKF. The relevant theorems and proofs are presented in continuous and discrete-time. The left-invariant extended Kalman filter and right-invariant extended Kalman filter are then detailed.

In `\cref{chap:SE3}>`, several examples of the IEKF are presented to illustrate how to practically implement an IEKF and to compare its performance to that of a standard multiplicative extended Kalman filter (MEKF).

In `\cref{chap:batch}>`, a solution to the SLAM problem in the invariant framework is presented. Simulation results are shown comparing the novel formulation to more traditional batch-based solutions to the SLAM problem.

This thesis is concluded in Chapter 3, where a summary of the findings are presented, along with recommended future work.

1.3 TEMPLATE: Using `cleveref` and `acronym`

A system of equations is given by

$$\mathbf{A}\mathbf{x} = \mathbf{b}. \tag{1.1}$$

Use `\cref` to reference a label (equation, figure, table, chapter, e.t.c.) in the middle of a sentence, and use `\Cref` to reference a label at the beginning of the sentence.

For example, (1.1) is an important equation. Equation (1.1) is used extensively in estimation theory (note how 'Equation' is automatically added when using `\Cref`).

The `acronym` package handles acronyms well using `\Ac` (at the beginning of the sentence) and `\ac` (otherwise). The package will take care of expanding the acronym when it's first used, and then uses the abbreviation/short-name afterwards.

For example, Simultaneous Localization and Mapping (SLAM) is an interesting field of research. Probability is extensively used in SLAM. The upper-case/lower-case rules of the long names (defined in `abbreviations.tex`) should be consistent for all acronyms.

Chapter 2

Preliminaries

Chapter 3

Closing Remarks and Future Work

3.1 Conclusions

3.2 Future Work

Appendices

Appendix 1

Appendix 1

A.1 Section 1

A.2 Section 2

Appendix 2

Appendix 2

B.1 Section 1

B.2 Section 2