TECHNICAL UNIVERSITY OF MUNICH

DEPARTMENT OF INFORMATICS

Master's Thesis in Informatics

Vehicle Localization and Tracking for Collision Avoidance System

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Fahrzeuglokalisierung und -verfolgung für das Kollisionsvermeidungssystem

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I confirm that this master's thesis is my own work and I have documented all sources and material used.

Ich versichere, dass ich diese Master's Thesis selbständig verfasst und nur die angegebenen Quellen und Hilfsmittel verwendet habe.

Munich, 01.01.2020 Behtarin Ferdousi

Acknowledgments

Yet to be written

Abstract

This is the abstract. It is a short summary of your work, consisting of roughly one to three paragraphs. It should give the main ideas of your paper, i.e., the posed problem, a motivation for solving it, your solution method, and your results. Keep it understandable for a general audience. Do not include references.

Contents

1 Introduction

- Motivation
- Problem Formulation
- State of the art solutions
- Structure of the paper

2 Vehicle State Estimation

2.1 Kinematic Model

The vehicle to be tracked need to be modelled in order to apply state estimation algorithm. The vehicle model needs to be simple and linear for fast state estimation. The Kinematic Single-Track Model treats vehicle as two wheels connected by a wheelbase driving in a single track. This model considers the non-holonomic behavior and minimum turning radius (unlike point-mass model) and is simple enough to be applied to track vehicles where the dimension of the vehicles are unknown(which are necessary for complicated models like multi-body model).

2.1.1 Constant Acceleration Model

The tracked vehicle is assumed to have constant acceleration. The vehicle state is represented by:

$$x = [x \quad y \quad v \quad a \quad \dot{a} \quad \psi \quad \omega \quad \dot{\omega}]^T$$

The state transition matrix is derived as:

$$A_{CA} = \begin{bmatrix} 1 & 0 & \Delta T & \frac{1}{2}\Delta T^2 & \frac{1}{6}\Delta T^3 & 0 & 0 & 0 \\ 0 & 1 & \Delta T & \frac{1}{2}\Delta T^2 & \frac{1}{6}\Delta T^3 & 0 & 0 & 0 \\ 0 & 0 & 1 & \Delta T & \frac{1}{2}\Delta T^2 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & \Delta T & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & \Delta T & \frac{1}{2}\Delta T^2 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & \Delta T \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix}$$

The measurement matrix is:

2.1.2 Constant Turn Rate

The tracked vehicle is assumed to have a constant turn rate, ω, which can be calculated using the equation:

$$\omega = (v * a)/|v|^2$$

The acceleration is assumed to be normal to the velocity vector, so that the velocity is constant and the motion is expected in x-y horizontal plane for simplicity. The velocity components across the axes is considered as v_x and v_y in x and y axis respectively. The state of the tracked vehicle is represented by:

$$x = \begin{bmatrix} x & y & v_x & v_y & \psi & \omega \end{bmatrix}$$

The state transition matrix is derived by derivates as :

$$A_{CTR} = \begin{bmatrix} 1 & 0 & SW & -CW & 0 & 0 \\ 0 & 1 & CW & SW & 0 & 0 \\ 0 & 0 & C & -S & 0 & 0 \\ 0 & 0 & S & C & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & \Delta T \\ 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix}$$

where S,C, SW and CW are:

$$\begin{aligned} S &= sin(\omega \Delta T) \\ C &= cos(\omega \Delta T) \\ SW &= \frac{S}{\omega} \\ CW &= \frac{C}{\omega} \end{aligned}$$

Three main models of the vehicle dynamics are used. Formula x = Ax+1 + W.. y = Cx + V... The transition matrix varies for different models.

2.1.3 Constant Acceleration

The vehicle has constant acceleration in both x and y-axis. A= [] C = []

2.1.4 Constant Turn Rate

Derive A and C

2.1.5 Constant Turn Rate Constant Tangential Acceleration

2.2 Set based State Estimation Method

3 Problem Formulation

Consider the following system:

$$\begin{aligned} x_{k+1} &= Ax_k + Ew_k \\ y_k &= Cx_k + Fv_k \end{aligned} \tag{3.1}$$

4 Methodologies

4.1 Segment Minimization

- Formula to minimize segment to find lambda
- Fast and accurate
- Needs data to converge

4.2 Volume Minimization

- Reduce volume of zonotope intersecting estimation and measurement
- Volume measurement of zonotope is computationally expensive

4.3 Interval Estimation

- robust against noise and disturbances

5 Result

- Efficiency
- Accuracy
- Performance Metric
  h-infnity-approximation

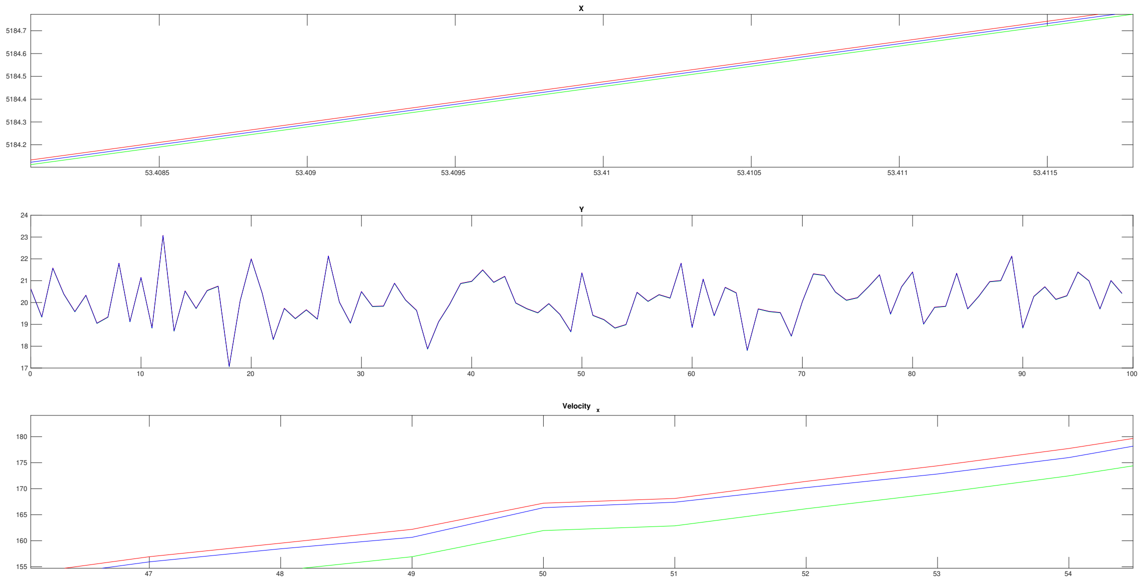

Figure 5.1: Predicting velocity from and x and y with segment minimization

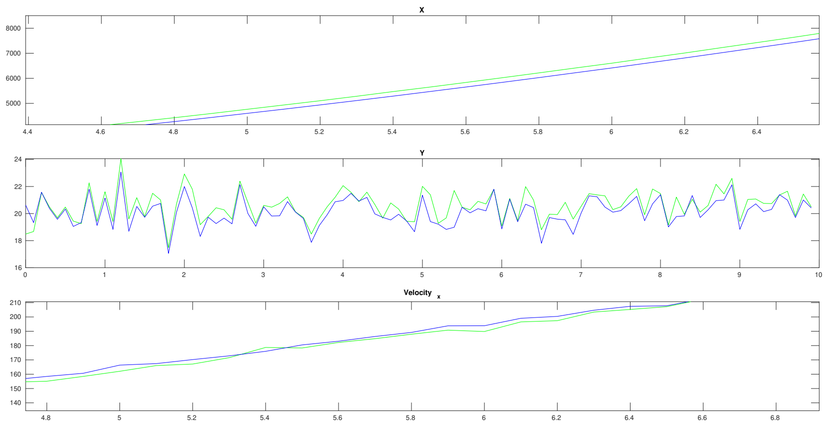

Figure 5.2: Predicting velocity from and x and y with H∞

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