KALMAN FILTER IMPLEMENTATION ON LOCALIZATION OF MOBILE ROBOT

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B. ENG. (HONS.) MECHATRONICS

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This thesis is submitted as partial fulfilment of the requirements
for the award of the degree of
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LIST OF SYMBOLS

n_c	Counted pulses after rotation
n_p	Number of pulses generated per revolution
G_s	Gyro rate to angle scale factor
G_b	Gyro rate bias
A_s	Accelerometer full scale range
M_s	Magnetometer field range
s_r	Displacement of right wheel
s_l	Displacement of left wheel
s	Displacement of mobile robot
$\in_x$	x-coordinate error
$\in_y$	y-coordinate error
$\in_\theta$	Orientation error
$\hat{X}_k^-$	Prior state
P_k^-	Prior error covariance
K_k	Kalman gain
$\hat{X}_k^+$	Posterior state
P_k^+	Posterior error covarience

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ABSTRACT

Autonomous mobile robot field has gain interest among researchers in recent years. The ability of a mobile robot to locate its current position and surrounding environment is the key in order to operate autonomously, which commonly known as localization. Localization of mobile robot are commonly affected by the inaccuracy of the sensors. These inaccuracies are caused by various factors which includes internal interferences of the sensor and external environment noises. In order to overcome these noises, a filtering method is required in order to improve the mobile robot's localization. In this research, a 2-wheeled-drive (2WD) mobile robot will be used as platform. The odometers, inertial measurement unit (IMU), and ultrasonic sensors are uses for data collection. Data collected is processed using Kalman filter to predict and correct the error from these sensors reading. The differential drive model and measurement model which estimates the environmental noises and predict a correction are used in this research. Based on the simulation and experimental results, the x, y and heading was corrected by converging the error to10 mm, 10 mm and 0.06 rad respectively.

ABSTRAK

Bidang robot mudah alih autonomi semakin menarik minat di kalangan penyelidik dalam tahun-tahun kebelakangan ini. Keupayaan robot mudah alih untuk mengesan kedudukan semasa dan persekitaran adalah kunci untuk beroperasi secara autonomi, yang biasanya dikenali sebagai penyetempatan. Penyetempatan robot mudah alih biasa terjejas oleh ketidaktepatan sensor. Ketidaktepatan ini adalah disebabkan oleh pelbagai faktor termasuk gangguan dalaman sensor dan persekitaran luar yang tidak sekata. Dalam usaha untuk mengatasi ketidaktepatan ini, satu kaedah penapisan diperlukan dalam usaha untuk meningkatkan kebolehan penyetempatan robot mudah alih. Dalam kajian ini, robot pacuan-2-roda (2WD) mudah alih akan digunakan sebagai platform. Odometer, *inertial measurement unit* (IMU), dan sensor ultrasonik digunakan untuk pengumpulan data. Data yang dikumpul diproses menggunakan tapisan Kalman untuk meramalkan dan membetulkan ketidaktepatan daripada bacaan data sensor. Algorithm model memandu dan model pengukuran yang menganggarkan ketidaktepatan persekitaran dan meramalkan pembetulan digunakan dalam kajian ini. Berdasarkan simulasi dan keputusan eksperimen, x, y dan arah-tuju telah diperbetulkan dengan menumpu ketidaktepatan hingga masing-masing adalah 10 mm, 10 mm dan 0.06 rad.

CHAPTER 1

INTRODUCTION

1.1 PROJECT BACKGROUND

Autonomous mobile robot field has gain interest among researchers in recent years. The research on autonomous mobile robots led to many potential applications that would benefit the mankind. Studies have led to a vast utilization of mobile robot in various sector in our daily life. The purpose of building up the robots is mainly to ease the daily work and task handled by human. Whilst, some of it is created to do beyond human capability which in return brings back new development to the current ever-growing populated world. Working at a dangerous site which involves hazardous substances as such of radioactive would pretty much come in handy with the aid of autonomous robot. In terms of exploration, autonomous robots would be uses in exploring environments that is beyond human reaches. Exploring the solar system, inner part of the earth, undersea, and even more can be done. They work much efficiently in environmental extremes include chemical and biological contamination.

Almost all sector includes industry, health care, to military gadgets have creates a high demand on autonomous robots. This has somehow led to a large field of different types of it. In industrial sector, mobile robot is commonly used as a self-repair in terms of maintenance. As example, robots could be performing repairs and maintenance remotely. Unmanned Ground Vehicles (UGV) is the most widely used types of autonomous robots. In health care service, autonomous robots is deeply developed and research specifically in mobile robot assistants (RA) and automated guided vehicles (AGV). It is brought up by scenario-based design approach which is fulfilling the current needs in health care facilities [1]. Figure 1.1 shows some of the classified autonomous robots and some of its applications accordingly. As stated, UGV delivers the most application especially in military defence.

It is prior in the task of security service, surveillance, hostage situation, border patrol, riot control, bomb disarming, etc. it provides critical supporting capabilities in current military operations worldwide. These UGVs is vary in sizes in order to meet mission capability requirement [2].

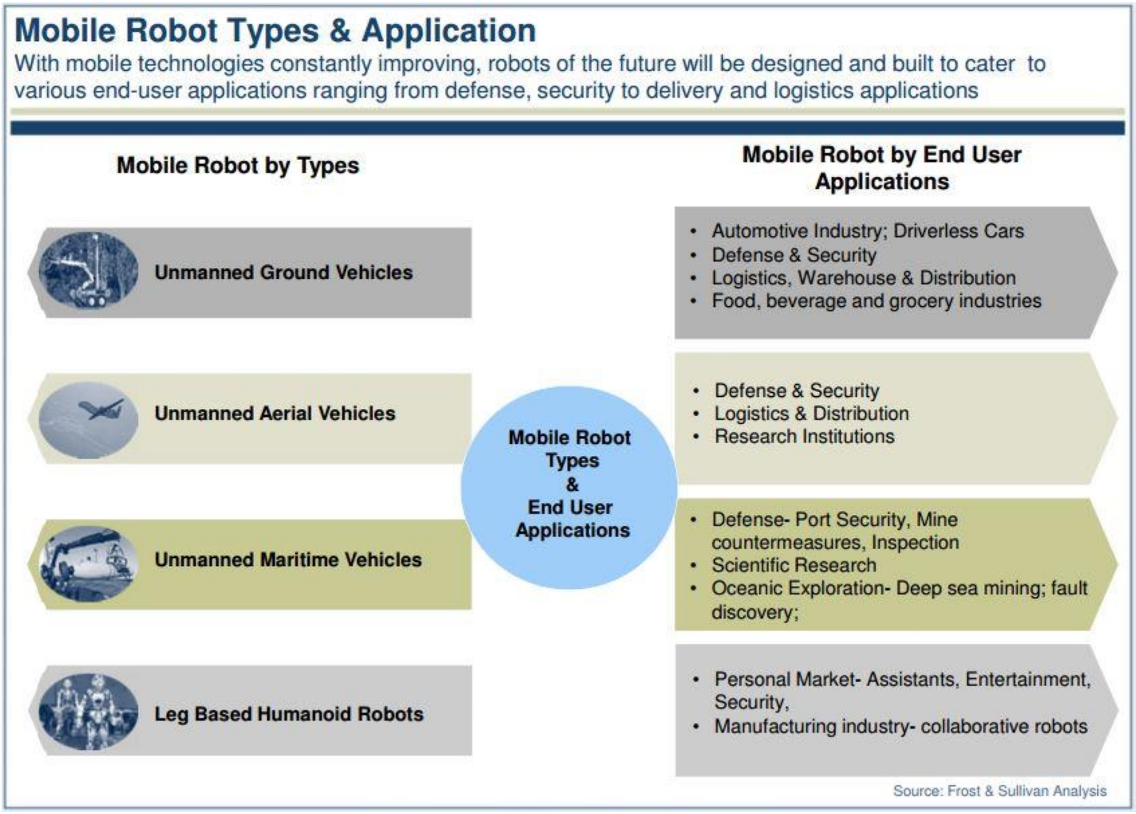

Figure 1.1: Types and Application of Autonomous Mobile Robot

Source: Frost & Sullivan Analysis 2014

In order to perform its designated task, these autonomous robots requires extremely high precision in terms of navigating and localization. Navigation is by far the most challenging parts of making one's robot moves autonomously. The robots parameters have to satisfy several components which stands as the building blocks of navigation. These building blocks includes perception, localization, cognition and motion control. Greatest attention of researchers falls on localization [3]. Localization defines the capability of robots to indicate its current whereabouts and condition includes its velocity, linear acceleration and heading. Ways of performing localization is vary according to the robots build and controlled parameters. Robot detects the current environment thru its integrated sensors. This sensor provides the current status information, refer to as the observations or measurements. This information explains the robots surrounding environments at a specific time and condition. Observations are then produces based on the information provided about the robot which is independent of any previous position estimation [4].

Mobile robots usually uses odometry sensors in estimating its position by measuring wheel revolutions throughout its navigation. Due to noise and wheel slippage, it will bring about some inaccurate readings in the data obtained. In the meantime, the robots cannot solely depends on the wheel revolutions alone to determine its accurate location and position. This inaccuracy brings about researchers to try and integrate the mobile robot with different types of sensors. Sensor data and readings is tend to be subjected to several sources of errors such as noise and aliasing [5].

An application may never depend on particular sensor information as it is affected by limited resolution, noise, and sensors deprivation. A method was introduced and developed known as the sensor fusion which implies the method of combining sensory data such that the resulting information gathered from several sensors in order to come out with an accurate and comprehensive information. The advantages of applying this method is that it is enabling the system becomes less vulnerable against interference and still can provide information regardless of facing partial failure [6]. Figure 1.2 represents the common categorization of sensor fusion based on sensor configuration. Implying this method will increase the accuracy of performing localization on autonomous robots.

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