FUZZY PID BASED NAVIGATION OF AUTONOMOUS MOBILE ROBOT

HASIN ABRAR BISWAS

UNIVERSITI TEKNOLOGI MALAYSIA

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HASIN ABRAR BISWAS

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DEDICATION

This report is dedicated to my father and mother, who taught me that the best kind of knowledge to have is that which is learned for its own sake. It is also dedicated to my mother, who taught me that even the largest task can be accomplished if it is done one step at a time.

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ABSTRACT

One of the key aspects of smart manufacturing is the adoption of autonomous intelligent robots that are capable of self-navigating throughout the vicinity of factory without constant specific command by the operators and which can make discission making with regards to navigation. For such purpose many AI- based control systems have been developed however the simplicity and less computational requirement of PID systems are still more preferable to industry. So, there is rise in integrating and using AI based method like PSO, GA, ANN etc. to optimize the gains of PID system. However, adoption of fuzzy based system with PID for the given application is still not very much explored. Therefore, Fuzzy based PID system has to be investigated and developed. As part of the process, this study developed a robotic model from the robot pioneer 3dx and designed a simple PID controller with software tunning to be used as baseline comparison model for fuzzy PID controller.

ABSTRAK

Salah satu aspek utama pembuatan pintar ialah penggunaan robot pintar autonomi yang mampu mengemudi sendiri di seluruh kawasan kilang tanpa arahan khusus yang berterusan oleh pengendali dan yang boleh membuat keputusan berkaitan dengan navigasi. Untuk tujuan sedemikian banyak sistem kawalan berasaskan AI telah dibangunkan namun kesederhanaan dan keperluan pengiraan yang kurang bagi sistem PID masih lebih disukai daripada industri. Oleh itu, terdapat peningkatan dalam menyepadukan dan menggunakan kaedah berasaskan AI seperti PSO, GA, ANN dan lain-lain untuk mengoptimumkan keuntungan sistem PID. Walau bagaimanapun, penggunaan sistem berasaskan fuzzy dengan PID untuk aplikasi yang diberikan masih belum banyak diterokai. Oleh itu, sistem PID berasaskan Fuzzy perlu disiasat dan dibangunkan. Sebagai sebahagian daripada proses, kajian ini membangunkan model robot daripada perintis robot 3dx dan mereka bentuk pengawal PID mudah dengan penalaan perisian untuk digunakan sebagai model perbandingan garis dasar bagi pengawal PID kabur.

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LIST OF ABBREVIATIONS

GA	–	Genetic Algorithms
PSO	–	Particle Swarm Optimization ACO- Ant colony Optimization
MRAC	-	Model reference adaptive control STC - Self-tuning control
SMC	-	Sliding mode control
NFS	-	Neuro-fuzzy systems
FLC	-	Fuzzy controller
FRB	-	Fuzzy rule base
FIM	-	Fuzzy inference mechanism
IFU	-	Input fuzzification unit
ODU	-	Output defuzzification unit
COG	-	Center of gravity
MM	-	Mean of maxima
MLP	-	Multilayer perceptron
RBF	-	Radial basis functions
FFC	-	Feed forward controller
FBC	-	Feedback controller
FELN	-	Feed error learning microcontroller SMFLC - Sliding mode fuzzy controller

CHAPTER 1

INTRODUCTION

1.1 Introduction

Industrial revolution was the fundamental reason behind the success of modern civilization. With increased development in information technology, computer science, sensor and actuator technologies, the concept of industry has changed from mechanically labour based industrial setup known as industry 1.0, to Electric power integrated industries known as industry 2.0, to implementing automation through microcontroller in industry 3.0. Now, the world demands for an industrial setup, the concept known as smart industry where the components of manufacturing process, quality control, Inspection, logistics and other key paraments are designed to be interconnected in a network and autonomously controlled to yield highest output with least manual human touch. Such framework is said to be of the industry of future which is also called industry 4.0.

With such landscape in proposition, mobile robotics could play a fundamental role to achieve autonomy in a controlled setting of industries. However, one of the major concerns of such task is the robust and precise control of mobile robots in a manner that would be profitable and accurate for the industry owners. On such account, a control system adopting fuzzy concept with traditional PID control could serve as a solution to this problem.

1.2 Problem Background

The fundamental problems of robotics include building an agent that can move in its environment, intelligently adapt to environmental changes if requires, learn from previous experiences and navigate by creating internal representation of surroundings. In context of mobile robots such key issues also exist inform of motion control, sensing, planning and navigation. Each issue requires its own elaboration in the present context.

The first problem to be tackled in the framework of fundamental mobile robotics is the efficient motion control of the robot which is done by the control system of the robot. Traditionally, for such purpose many kinds of intelligent controller have been developed. However, in the context of the industry, PID controller is proved to be quite popular and widely used due to its well-established working principal and simplicity. The problem arises due to the nature of locomotion in mobile robots which includes couple of nonlinear equation subjected to viscous damping. Traditional PID controller struggles to such non-linear behaviour of the system. Also, uncertain conditions can make an apparently well performing PID control law, react towards instability [2].

To address the uncertainties and non-linearity in system different types of control system have been developed however computational efficiency is another issue to be addressed. If the control system requires very complex calculation, it could cause expensive hardware to compensate for the quicker computational requirement. Scaling the cost to industrial size would result in a very expensive undertaking in implementing mobile robots for industries.

Therefore, both issues have to be addressed simultaneously and a control system that is both simple and reliable and can also account for uncertainties has to be developed for optimum performance.

1.3 Problem Statement

In light of the problems faced in industry in terms of performance of the control system that needs to be simple and reliable enough for wide implementation and at the same time can address the nonlinear characteristic requirement demanded by the application environment, it has to be investigated that if a possible fuzzy logic based PID controller can be developed and implemented in place of traditional PID controllers.

For such undertaking, it is to be first determined the best performances provided by traditional PID controllers on a given dynamics and kinematic situation of a particular mobile robot. It would then have to be compared and contrasted with developed fuzzy PID controller in terms of performance variable such as Rise time and overshoot. Such comparison would reveal the improvement to fuzzy PID controller over traditional PID controller

1.4 Research Goal

The research aims to ask the following questions:

i. Will Fuzzy PID based controllers perform better for mobile robots in comparison with traditional PID controller?

ii. Can Fuzzy PID based controller address the non-linear requirement of the mobile robot?

iii. How will the evaluation and degree of improvement of the performance of the fuzzy PID controller compare to PID controller for the robot movement?

1.4.1 Research Objectives

The objectives of the following research are as follows:

(a) Design a PID controller for the model.

(b) Develop a fuzzy gain scheduling PID controller for the same dynamic model of the mobile robot

(c) Compare and analyse the control performance in terms of rise time and overshooting, settling time. IAE, ISE, ITSE, ITAE

1.5 Scope and limitations

The current scope of the research includes developing a PID controller which will be used to compare the performance of fuzzy PID based controllers developed later. In addition, the PID controller developed is considered for a continuous system and assumed to have compensator therefore the input will not have any disturbances. Also, the classical tuning method namely Zieglar Nichols and auto tuning by Simulink software is used and modern approach like using optimization algorithms to tune PID controllers were excluded from this research since the objective is to purely compare the performances between PID and Fuzzy PID controller.

1.6 Significance of Proposed work

This research will allow us to develop a fuzzy PID control system and find its performance against traditional PID controller which would reveal the key factors dealing with non-linearity and uncertainty for other dynamic system. Since dynamics of many different forms of mobile robots share common non-linear characteristics, such model will also act as baseline. In addition, metaheuristics techniques can be incorporated with the PID and fuzzy PID model and from this it can be revealed the effect of optimization on these two types of control architecture. This analysis would help the control engineers to design an optimum robust control for mobile robots in industry.

1.7 Organization of research

The general idea and background problem is introduced in chapter 1 in addition to problem statement, aims and objectives, scope and significance of this research which would benefit the reader understanding the chosen literature for review in Chapter 2. In Chapter 3, the research methodology is explained in detail. Chapter 4 demonstrates the result and analysis of the results. The key points from the result section are discussed in Chapter 5 and finally conclusion and next phase of the overall research is discussed in concluding part in Chapter 6

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