



**DEVELOPMENT OF AUTONOMOUS MOBILE ROBOT
NAVIGATION USING RFID**

BY

MAHBUBA HOSSAIN

**A dissertation submitted in fulfilment of the requirements for
the degree of Master of Science (Mechatronics Engineering)**

**Kulliyyah of Engineering
International Islamic University Malaysia**

JANUARY 2015

ABSTRACT

Navigation techniques in mobile robotics system have gained significant research interest over the past few years. The mobile robot must be able to navigate through a known or unknown environment based on its necessities and applications. This can be achieved by determining its positions and selecting a suitable motion control. Conventional techniques include landmark or dead-reckoning with excessive number on sensors which increases complexities. Several other researchers have been done using both active and passive Radio Frequency Identification (RFID) Signal but there is still need for a more simple and suitable navigation system. This research has been done to present an effective navigation technique using passive RFID reader and tags. The proposed algorithm provides not only the estimation of the robot position in the environment but also the orientation of the autonomous robot. Polar coordinate system has been adopted on the navigation environment where the RFID tags are placed in a grid-like pattern with constant distance. The research objectives have been fulfilled via simulation and experimental validation through hardware implementation. The experimental results show effective and reliable results and the novelty lies in the use of simple technique to achieve the objectives. As a whole, this work has investigated and analyzed several navigation techniques and adopted the best technique for practical application with satisfactory results.

خلاصة البحث

تقنيات الملاحة في الروبوتات المتحركة اكتسبت اهتمام بحثي كبير في السنوات الاخيرة. الروبوتات المتحركة يجب ان تكون قادرة على التنقل عبر بيئات معروفة وغير معروفة بالاعتماد علي حاجاتها وتطبيقاتها. هذا يمكن ان يحدث بواسطة تحديد اتجاهاتها واختيار متحكم في سرعه مناسب. التقنيات التقليدية تتضمن نقاط الاستدلال والحسابات الميئة مع عدد كبير من الحساسات يؤدي الى زيادة التعقيد. العديد من الابحاث الاخرى استخدمت اشارات تحديد ترددات الراديو السلبية والايجابية لكن الحاجة الى لنظام سهل ومناسب للملاحة مازالت موجودة. هذا البحث يقدم لتقنيات تنقل فعالة باستخدام قارئ RFID السلي و الاوسمة التي لن توفر فقط تقدير الاتجاه في البيئة ولكن التكيف مع الظروف في الروبوتات ذاتية التحكم. النظام الاحداثي القطبي تم تبنيه في بيئة التنقل حيث RFID وضعت على شبكة مثل الرسم مع ازاحات ثابتة. اهداف البحث تم تنفيذها بواسطة المحاكاه والتجارب بواسطة التطبيق العملي. نتائج التجارب اثبتت فاعليتها وقابليتها للتطبيق والشيء الجديد يقع في استخدام طرق بسيطة لتحقيق الهدف. ككل, هذا العمل هدف الى بحث وتحليل عديد من تقنيات التنقل وتبني الافضل للتطبيقات العمليه مع نتائج مرضية

APPROVAL PAGE

I certify that I have supervised and read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Master of Science in Mechatronics Engineering.

.....
Muhammad Mahbubur Rashid
Supervisor

.....
Amir Akramin Shafie
Co-Supervisor

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Master of Science in Mechatronics Engineering

.....
Iskandar Al-Thani
Internal Examiner

.....
Shahrul Na'im Sidek
Internal Examiner

This dissertation was submitted to the Department of Mechatronics Engineering and is accepted as a fulfilment of the requirement for the degree of Master of Science in Mechatronics Engineering.

.....
Md. Raisuddin Khan
Head, Department of
Mechatronics Engineering

This dissertation was submitted to the Kulliyah of Engineering and is accepted as a fulfilment of the requirement for the degree of Master of Science in Mechatronics Engineering.

.....
Md Noor Bin Saleh
Dean, Kulliyah of Engineering

DECLARATION

I hereby declare that this dissertation is the result of my own investigations, except where otherwise stated. I also declare that it has not been previously or concurrently submitted as a whole for any other degrees at IIUM or other institutions.

Mahbuba Hossain

Signature.....

Date.....

INTERNATIONAL ISLAMIC UNIVERSITY MALAYSIA

**DECLARATION OF COPYRIGHT AND AFFIRMATION
OF FAIR USE OF UNPUBLISHED RESEARCH**

Copyright © 2015 by Mahbuba Hossain. All rights reserved.

**DEVELOPMENT OF AUTONOMOUS MOBILE ROBOT
NAVIGATION SYSTEM USING RFID**

No part of this unpublished research may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording or otherwise without prior written permission of the copyright holder except as provided below.

1. Any material contained in or derive from this unpublished research may only be used by others in their writing with due acknowledgement.
2. IIUM or its library will have the right to make and transmit copies (print or electronic) for institutional and academic purposes.
3. The IIUM library will have the right to make, store in a retrieval system and supply copies of this unpublished research if requested by other universities and research libraries.

Affirmed by Mahbuba Hossain

.....
Signature

.....
Date

To my Beloved Parents, Younger Brothers and well wishers

ACKNOWLEDGEMENTS

In the name of Allah (S.W.T.), The Most Gracious, The Most Merciful

Alhamdulillah, all the praises go to Allah Subhanahu WaTa'ala for showering His great blessings on me to carry out and complete this dissertation successfully throughout the years of my achievement toward searching knowledge.

At the outset, I gratefully acknowledge my supervisor, Assoc. Prof. Dr. Muhammad Mahbubur Rashid not only for his guidance, incessant encouragement and unwavering support but also helping me as a guardian.

I owe a great deal of appreciation and gratitude to my co-supervisor, Dr. Amir Akramin Shafie for his constructive comments and my sincere thanks are due to my lecturers in Mechatronics Engineering Department; Assoc. Prof. Dr. Md.Raisuddin Khan and others.

This acknowledgment would not be complete without mentioning the invaluable support offered by Tarek, Sayem, Aktaruzzaman, Rumana, Nor Saidah and Fharidatun that helped me overcome some difficulties encountered during research work.

Thanks to everyone who keenly helped me conduct this research. All of your kindness and support means a lot to me.

Words are not enough to express my sincere gratitude towards my father, Mohd. Mosharraf Hossain, my mother, Afroza Mosharraf and my two younger brothers for their unconditional love, devoted support and continuous encouragement throughout the journey.

Last but not the least, I express my indebtedness to this glorious institution, International Islamic University Malaysia.

Jazakallahu Khayran

TABLE OF CONTENTS

| | |
|---|-----------|
| Abstract | ii |
| Abstract in Arabic | iii |
| Approval Page..... | iv |
| Declaration Page | v |
| Copyright Page..... | vi |
| Dedication | vii |
| Acknowledgements | viii |
| List of Tables..... | xii |
| List of Figures | xiii |
| List of Abbreviations..... | xix |
| List of Symbols | xx |
| | |
| CHAPTER ONE: INTRODUCTION | 1 |
| 1.1 Background | 1 |
| 1.2 Problem statement..... | 4 |
| 1.3 Research Objectives..... | 5 |
| 1.4 Research Methodology | 6 |
| 1.5 Research Scope | 6 |
| 1.6 Dissertation Outline | 7 |
| | |
| CHAPTER TWO: LITERATURE REVIEW | 9 |
| 2.1 Introduction..... | 9 |
| 2.2 Omni-Robot | 9 |
| 2.3 Navigation..... | 19 |
| 2.3.1 Dead-Reckoning Based..... | 20 |
| 2.3.2 Landmark Based..... | 22 |
| 2.3.3 Natural Landmarks | 24 |
| 2.3.4 Artificial Landmarks | 24 |
| 2.3.5 Line/Route Based Navigation | 25 |
| 2.3.6 Vision Based..... | 26 |
| 2.3.7 Map-Based Navigation | 27 |
| 2.3.8 RFID-Based Navigation..... | 29 |
| 2.3.8.1 RFID Signal Measurement from tags/ RSSI | 30 |
| 2.3.8.2 Passive RFID Navigation | 34 |
| 2.3.8.3 Advantages of RFID | 38 |
| 2.3.8.4 RFID Control Function..... | 38 |
| 2.3.9 Overview of All the Navigation Strategy..... | 40 |
| 2.4 Summary..... | 41 |
| | |
| CHAPTER THREE: SYSTEM DESIGN | 42 |
| 3.1 Introduction..... | 42 |
| 3.2 System Description | 42 |
| 3.2.1 RFID System..... | 42 |
| 3.2.2 System Architecture and Design | 43 |

| | |
|---|------------|
| 3.2.3 Grid Architecture and RFID Tag Displacement..... | 46 |
| 3.2.4 Wireless Communication System | 50 |
| 3.2.5 Real-time Viewing System..... | 51 |
| 3.3 Navigation Algorithm | 54 |
| 3.3.1 Navigation without Sensor..... | 57 |
| 3.3.2 Navigation with Sensor..... | 58 |
| 3.4 Mathematical Model of the Robot..... | 61 |
| 3.5 Summary..... | 63 |
| CHAPTER FOUR: EXPERIMENTAL SETUP | 65 |
| 4.1 Introduction..... | 65 |
| 4.2 Electrical Design..... | 65 |
| 4.2.1 Arduino Uno..... | 68 |
| 4.2.2 L293D H-Bridge Module..... | 69 |
| 4.2.3 XBee Wireless Adapter | 70 |
| 4.2.4 RFID Reader and Tags | 70 |
| 4.2.4.1 Low Frequency RFID selected..... | 71 |
| 4.2.4.2 RFID Tag..... | 71 |
| 4.2.5 GY-26 USART Digital Compass | 72 |
| 4.3 Mechanical Design | 74 |
| 4.3.1 3D CAD Design of Mobile Robot | 74 |
| 4.4 Material Selection for Robot Base..... | 75 |
| 4.4.1 Clear Acrylic | 75 |
| 4.4.2 Aluminium | 76 |
| 4.5 Mechanical Component Selection | 76 |
| 4.5.1 DC Gear Motor (Servo Hack)..... | 77 |
| 4.5.2 Wheel | 79 |
| 4.6 Summary..... | 79 |
| CHAPTER FIVE: ANALYSIS OF SIMULATION AND EXPERIMENTAL RESULTS..... | 80 |
| 5.1 Introduction..... | 80 |
| 5.2 Simulation Results | 80 |
| 5.2.1 Navigation without Obstacles | 80 |
| 5.2.2 Navigation with Obstacles | 83 |
| 5.3 Experimental Results | 87 |
| 5.3.1 Navigation without Obstacles | 88 |
| 5.3.2 Navigation with Obstacles | 110 |
| 5.4 Summary..... | 112 |
| CHAPTER SIX: CONCLUSION AND RECOMMENDATION..... | 114 |
| 6.1 Conclusion | 114 |
| 6.2 Recommendation | 116 |
| REFERENCES..... | 118 |
| LIST OF PUBLICATIONS..... | 123 |
| APPENDIX A | 124 |

| | |
|------------------|-----|
| APPENDIX B | 128 |
| APPENDIX C | 130 |

LIST OF TABLES

| <u>Table No.</u> | | <u>Page No.</u> |
|------------------|--|-----------------|
| 2.1 | Wheel configurations for rolling vehicles(Siegwart & Nourbakhsh, 2004) | 12 |
| 2.2 | Summarized Related Past Studies | 40 |
| 4.1 | Specification of ATmega328 | 68 |
| 4.2 | Motor calculations | 87 |
| 4.3 | Motor Specifications | 87 |
| 5.1 | Errors in angular displacement of the robot for no obstacle (test 1). | 92 |
| 5.2 | Errors in angular displacement of the robot with obstacles (test 2) | 95 |
| 5.3 | Errors in angular displacement of the robot with obstacles (test 3). | 97 |
| 5.4 | Tag position X, Y and desired and current angle | 91 |

LIST OF FIGURES

| <u>Figure No.</u> | | <u>Page No.</u> |
|-------------------|---|-----------------|
| 1.1 | Research methodology flow chart | 6 |
| 1.2 | Research scope flow chart | 7 |
| 2.1 | Locomotion mechanisms used in biological systems (Siegwart & Nourbakhsh, 2004) | 10 |
| 2.2 | Four basic wheel types: (a) Standard wheel: two degrees of freedom; rotation around the (motorized) wheel axle and the contact point. (b) Castor wheel: two degrees of freedom; rotation around an offset steering joint. (c) Swedish wheel: three degrees of freedom; rotation around the (motorized) wheel axle, around the rollers, and around the contact point. (d) Ball or spherical wheel: realization technically difficult (Siegwart & Nourbakhsh, 2004) | 11 |
| 2.3 | Structural model of mobile robot (Wang et al., 2013) | 15 |
| 2.4 | Representing the robot within an arbitrary initial frame (Siegwart & Nourbakhsh, 2004) | 17 |
| 2.5 | Model of two-wheel differential drive robot (Nawash, 2005) | 18 |
| 2.6 | Error propagation in Odometry for mobile robot model in Figure 2.4. (Siegwart & Nourbakhsh, 2004) | 22 |
| 2.7 | Z-shaped Landmark on the ground (Yeluri, 2003) Komatsu Ltd., Japan | 24 |
| 2.8 | a) A line following robot and (b) navigating environment (Dupuis & Parizeau, 2006) | 26 |
| 2.9 | An architecture for map-based (model-based) navigation (Siegwart & Nourbakhsh, 2004) | 28 |
| 2.10 | Showing sensor model (map Based) and no sensor model (Filliat & Meyer, 2003) | 29 |
| 2.11 | High-level system configuration with two RFID tags (Gueaieb & Miah, 2008) | 30 |

| | | |
|------|---|----|
| 2.12 | In phase (I) vs. Quadrature projection in 2D space | 31 |
| 2.13 | High level system architecture of the navigation system (Miah & Gueaieb, 2010) | 31 |
| 2.14 | (a) Robot's actual vs. Desired trajectory for open rectilinear path, and (b) RSS measurements received during navigation (Miah & Gueaieb, 2010) | 32 |
| 2.15 | Simplified architecture of RFID system (Gueaieb & Miah, 2008) | 33 |
| 2.16 | Ideal and actual (a) distances and (b) angles (Sabto & Mutib, 2013) | 34 |
| 2.17 | Proposed method of localization (Sunhong Park & Shuji Hashimoto, 2009) | 35 |
| 2.18 | Patters of robot movement (a) Turn left: $\theta_{rotation} > 0$ and (b) Turn right: $\theta_{rotation} < 0$ (Sunhong Park & Shuji Hashimoto, 2009) | 36 |
| 2.19 | Trajectory path from the start to the goal (Sunhong Park & Shuji Hashimoto, 2009) | 37 |
| 2.20 | Power supply to an inductively coupled transponder | 39 |
| 3.1 | System Architecture concept | 44 |
| 3.2 | Overall System Integration | 46 |
| 3.3 | RFID tag displacement and architecture | 47 |
| 3.4 | RFID tag displacement and actual working environment (114cm×90cm×0.1cm) | 47 |
| 3.5 | RFID tag with actual dimension (8.6cm×5.4cm×1.8cm) and coil dimension (6.5cm×4cm) | 48 |
| 3.6 | RFID reader with actual coil dimension (4.5cm×3.5cm) | 48 |
| 3.7 | RFID tag coil shown on actual environment (6.5cm×4cm) | 49 |
| 3.8 | RF detection area (15cm×11cm) | 49 |
| 3.9 | XBee wireless communication mounted on the robot and also to pc | 50 |

| | | |
|------|--|----|
| 3.10 | Plotting navigation path in C# | 51 |
| 3.11 | Circumference of the circle showing where the next points are plotted based on the compass angle | 52 |
| 3.12 | An example of the real time navigation window | 53 |
| 3.13 | Flow Diagram of the Navigation Algorithm | 55 |
| 3.14 | Window in C# (visual studio) | 57 |
| 3.15 | Mobile robot diagram outline diagram with important components (top view) | 59 |
| 3.16 | Actual mobile robot (top view) | 60 |
| 3.17 | Actual mobile robot (bottom view) showing the RFID reader | 60 |
| 3.18 | Actual mobile robot (front view) showing the ultrasonic sensors | 61 |
| 3.19 | Two-wheeled mobile robot with third point of contact with global reference plane and robot's local reference plane (Siegwart & Nourbakhsh, 2004) | 62 |
| 4.1 | Schematic Diagram of (a) the overall circuit and (b) power supply from voltage regulator(12V changed to 5V) | 67 |
| 4.2 | Schematic Diagram of motor driver | 70 |
| 4.3 | Digital Compass simplified diagram | 78 |
| 4.4 | 3D Design of Mobile Robot with attached parts | 81 |
| 4.5 | Exploded View of Mobile Robot Parts | 82 |
| 5.1 | Robot navigation with tag spacing (a) 25cm×25cm and (b) 20cm×20cm (No obstacles) | 91 |
| 5.2 | Orientation error during navigation process, (a) with tag spacing 25cm×25cm and (b) tag spacing 20cm×20cm (with no obstacles, test 1) | 92 |
| 5.3 | Test case 2; Simulation of the robot navigation (a) with Tags spacing 25cm×25cm and (b) with Tags spacing 20cm×20cm (With obstacles) | 94 |
| 5.4 | Graphs showing the orientation error during navigation process with (a) tag spacing 25cm×25cm and (b) tag | 95 |

| | | |
|------|--|-----|
| | spacing 20cm×20cm (with obstacles, test 2) | |
| 5.5 | Test case 3; Simulation of the navigation procedure (a) with tag spacing 25cm×25cm and (b) with tag spacing 20cm×20cm (With obstacles) | 97 |
| 5.6 | Graphs showing the orientation error during navigation process with (a) tag spacing 25cm×25cm and (b) tag spacing 20cm×20cm (With obstacles, test 3) | 98 |
| 5.7 | Real-time navigation path in Microsoft Visual C#, the plot on excel for 3 trials with starting point (0, 0) and goal point (100,80) | 99 |
| 5.8 | Angle error between desired angle and current angle for 3 trials with starting point (0, 0) and goal point (100,80) | 99 |
| 5.9 | Real-time navigation path in Microsoft Visual C#, the plot on excel and the angle error using 2 trials for the same starting point (60, 0) and goal point (100,80) | 100 |
| 5.10 | Real-time navigation path in Microsoft Visual C#, the plot on excel and the angle error using 2 trials for the same starting point (0, 0) and goal point (80, 80) | 100 |
| 5.11 | Real-time navigation path in Microsoft Visual C#, the plot on excel and the angle error with starting point (20, 0) and goal point (100,80) | 101 |
| 5.12 | Real-time navigation path in Microsoft Visual C#, the plot on excel and the angle error with starting point (40, 0) and goal point (100,80) | 101 |
| 5.13 | Real-time navigation path in Microsoft Visual C#, the plot on excel and the angle error with starting point (80, 0) and goal point (100,80) | 102 |
| 5.14 | Real-time navigation path in Microsoft Visual C#, the plot on excel and the angle error with starting point (100, 0) and goal point (100,80) | 102 |
| 5.15 | Real-time navigation path in Microsoft Visual C#, the plot on excel and the angle error with starting point (100, 20) and goal point (20, 40) | 103 |
| 5.16 | Real-time navigation path in Microsoft Visual C#, the plot on excel and the angle error with starting point (40, 20) and goal point (100,0) | 103 |

| | | |
|------|---|-----|
| 5.17 | Real-time navigation path in Microsoft Visual C#, the plot on excel and the angle error with starting point (60, 20) and goal point (100, 80) | 104 |
| 5.18 | Real-time navigation path in Microsoft Visual C#, the plot on excel and the angle error with starting point (20, 0) and goal point (80, 80) | 104 |
| 5.19 | Real-time navigation path in Microsoft Visual C#, the plot on excel and the angle error with starting point (40, 0) and goal point (80, 80) | 105 |
| 5.20 | Real-time navigation path in Microsoft Visual C#, the plot on excel and the angle error with starting point (100, 0) and goal point (80, 80) | 105 |
| 5.21 | Real-time navigation path in Microsoft Visual C#, the plot on excel and the angle error with starting point (100, 40) and goal point (80, 80) | 106 |
| 5.22 | Real-time navigation path in Microsoft Visual C#, the plot on excel and the angle error with starting point (100, 40) and goal point (80, 80) | 106 |
| 5.23 | Real-time navigation path in Microsoft Visual C#, the plot on excel and the angle error with starting point (20, 40) and goal point (60, 80) | 107 |
| 5.24 | Real-time navigation path in Microsoft Visual C#, the plot on excel and the angle error with starting point (40, 20) and goal point (60, 80) | 107 |
| 5.25 | Real-time navigation path in Microsoft Visual C#, the plot on excel and the angle error with starting point (40, 0) and goal point (60, 80) | 108 |
| 5.26 | Real-time navigation path in Microsoft Visual C#, the plot on excel and the angle error with starting point (100, 60) and goal point (60, 80) | 108 |
| 5.27 | Real-time navigation path in Microsoft Visual C#, the plot on excel and the angle error with starting point (0,20) and goal point (20, 80) | 109 |
| 5.28 | Real-time navigation path in Microsoft Visual C#, the plot on excel and the angle error with starting point (40, 20) and goal point (20, 80) | 109 |

| | | |
|------|---|-----|
| 5.29 | Real-time navigation path in Microsoft Visual C#, the plot on excel and the angle error with starting point (80, 20) and goal point (20, 80) | 110 |
| 5.30 | Real-time navigation path in Microsoft Visual C#, the plot on excel and the angle error with starting point (100, 0) and goal point (20, 80) | 110 |
| 5.31 | Real-time navigation path in Microsoft Visual C#, the plot on excel and the angle error with starting point (40, 0) and goal point (0, 80) | 111 |
| 5.32 | Real-time navigation path in Microsoft Visual C#, the plot on excel and the angle error with starting point (0,0) and goal point (40, 60) | 111 |
| 5.33 | Real-time navigation path in Microsoft Visual C#, the plot on excel and the angle error with starting point (100, 20) and goal point (40, 60) | 112 |
| 5.34 | Real-time navigation path in Microsoft Visual C#, the plot on excel and the angle error with starting point (80, 20) and goal point (20, 40) | 112 |
| 5.35 | Real-time navigation path in Microsoft Visual C#, the plot on excel and the angle error with starting point (60, 0) and goal point (20, 40) | 113 |
| 5.36 | Real-time navigation path in Microsoft Visual C#, the plot on excel and the angle error with starting point (40, 0) and goal point (60, 40) | 113 |
| 5.37 | Real-time navigation path in Microsoft Visual C#, the plot on excel and the angle error with starting point (20, 20) and goal point (100, 40) | 114 |
| 5.38 | Real-time navigation path in Microsoft Visual C#, the plot on excel and the angle error with starting point (80, 0) and goal point (100, 40) | 114 |
| 5.39 | Navigation in Microsoft visual C# (in column 2) compared with the real working (column 3) environment (a)-(r) showing the navigation path with obstacles and starting point (0,0) and ending point (100,80) | 115 |

LIST OF ABBREVIATIONS

| | |
|------|---|
| PWM | Pulse Width Modulation |
| RFID | Radio Frequency Identification |
| IDE | Integrated Development Environment |
| FLC | Fuzzy Logic Control |
| CCD | Charge-Coupled Device |
| CMOS | Complementary Metal-oxide Semiconductor |
| RSS | Received Signal Strength |
| RSSI | Received Signal Strength Identification |

LIST OF SYMBOLS

| | |
|-----------|---------------------|
| ω | angular velocity |
| $r\omega$ | radius of the wheel |

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND

Nowadays, Omni directional mobile robot navigation system has gone through great improvement in the robotics and control system design. Navigation is the most critical part in mobile robot system that needs to be considered in determining desired position. By using RFID as a means to navigate desired position, it can be more convenient to apply as it is a method which depends on storing and retrieving data by the use of data-carrying devices. RFID is used to identify an object and assist in determining its location and orientation.

Mobile robot navigation, as a whole, is evolving to be an attractive challenge in industry and also research. It is undergoing a major transformation in scope and dimension in both indoor and outdoor. Navigation of a mobile robot allows the robot to determine its own position in its frame of reference and find its target location. This can be divided into three main parts such as localization, path planning and map building.

Localization means determination of the mobile robot's position and orientation in its environment. The sensor used and effector uncertainties affect localization. Path planning is an effective extension for localization where it requires determining the robot's current position and its target position. Whereas, map building or cognition allows the robot to decide on how to respond and achieve the robot's objectives.

There are four main aspects of navigation involved to determine the success in navigation: perception, localization, cognition and motion control(Siegwart & Nourbakhsh, 2004). Perception includes interpretation of robot sensors to extract meaningful data; localization refers to determining the robot's position in the environment; cognition mentions the decisions to make in order to achieve goals; and motion control, where the robot controls motor outputs to achieve the desired trajectory(Siegwart & Nourbakhsh, 2004).

Various researches were done and are still continuing to enhance the mobile robot navigation systems. The research scopes can cover different methods in robot perceptions, on the use of suitable sensors; localization techniques, such as map-based localization, Markov localization, vision-based localization, landmark-based localization: artificial landmark and natural landmark, globally unique localization, route-based/line-based localization, RFID-based: passive RFID and active RFID and dead reckoning based; cognition techniques includes control strategies such as fuzzy logic control, artificial neural networks etc.; and the motion control techniques include the type of motor used to achieve the desired trajectory (Siegwart & Nourbakhsh, 2004).

Throughout the timeline of researches, it is crucial for the researchers to develop an efficient, effective, low cost and simplified navigation strategy for the mobile robot with specific objectives and tasks. The uses of different types of mobile robots for it specific purpose is also a challenge for the researchers. This depends on the kinematic and dynamic models of the mobile robots. There are robot manipulators, stationary robots used in manufacturing industries to assemble object parts, carry out special tasks such as pick and drop etc. There are also legged mobile robots and wheeled mobile robots. For legged mobile robots, leg configuration and stability is

important for locomotion. In case of wheeled-mobile robots, the trajectory depends on the type of wheel used and its position mounted on the robot. Omnidirectional wheel can move in any direction and said to be holonomic and standard wheels are non-holonomic. The locomotion of wheeled mobile robots depend on degree of mobility, degree of steerability, robot maneuverability as a whole, degrees of freedom and types of robots; holonomic or non-holonomic. The choice is totally based on the task the robot performs and therefore; it is a challenge to choose the right type of robot for its task.

The research aims to build an Omni-Directional Mobile Robot Navigation system using RFID (Radio Frequency Identification). A navigation algorithm is developed where the mobile robot is interfaced with RFID which allows it to determine its position in its navigating environment. Its orientation and path planning localization is determined by digital compass. This navigation mainly focuses on RFID system using customized RFID tag architectures. RFID system involves RFID reader, tags and software. When RFID reader scans the tags within its reading range, a pulse of radio energy is sent out to the tags which send back its specific ID number. RFID tags have specific ID number which makes it easy for the reader to allocate and know its position. During navigation, the robot must independently find the path based on the algorithm to identify the tag ID mentioned in the coding.

The use of RFID is valuable as it is abundant, inexpensive and flexible technology which can come in various uses. Recently it's being widely used in mobile robot navigation. RFID system communicates within a range determined by the output power of reader and the way it is designed. The RF field from an antenna extends into space and the strength of the field disappears with respect to the distance of tag. The type of antenna determines the shape of the field. Whereas, and the range is influenced

by the pattern between the tag and antenna. This research is done to provide a mobile robot to navigate in its environment with an optimizing, less complex algorithm to reach its target and perform a specific action. During its navigation, it will also consider any obstacles that come in its way. Its application can be widely used in indoor environments; such as hospitals, health industry, communication industry, libraries, human identification and areas where it is less convenient for human interaction. Offline and real time simulations of the navigation algorithm will be analyzed. The real-time simulations will come from the experimental results.

1.2 PROBLEM STATEMENT AND ITS SIGNIFICANCE

To enhance the navigation strategy as well as uphold enterprise economic benefit optimized navigation is a major concern. The development of suitable algorithm and strategy for navigation has shown to be not an easy issue. Most of the existing navigation technologies provide localization with its own shortcomings, affecting the results of the navigation process. Among the navigation techniques, RFID based navigation has demonstrated better reliability. The RFID tags location may not be restricted or restricted based on its application. If it is not restricted, the readers will unknowingly travel in its unknown environment trying to locate them. Here active RFID can be used to calculate the distances between the different sensing tags to find its actual location. While using passive RFID, the sensing range is small so this might not be achievable but its actual position can be identified when the reader is very close to the tag. There is a matter of computational complexities using active RFID and this can be quite costly as well. The detail of which will be explained in Chapter 2: Literature review. Therefore the problems highlighted to resolve for this research work are summarized below: