

Sudan University of Science and Technology
College of Engineering
Electronics Engineering School



Prototype Design of Autonomous Mobile Agents for Environment Monitoring

A Research Submitted In Partial Fulfillment for the Requirements of the
Degree of B.Sc (Honors) in Electronics Engineering

Prepared By:

1. Eman Abdelghani Bakri Mohamed.
2. Maisan Abd Elgadir Omer Abd Elgadir.
3. Rawan Shreef Abd-alRazeg Ibrahim.

Supervised by:

Mr. Khalifa Eltayeb Khalifa

September, 2014

الآية

قال تعالى:

﴿ وَقُلْ اَعْمَلُوا فَسَيَرَى
اللَّهُ عَمَلَكُمْ وَرَسُولُهُ
وَالْمُؤْمِنُونَ ﴾ وَسَتُرَدُّونَ
إِلَىٰ عَالِمِ الْغَيْبِ
وَالشَّهَادَةِ فَيُنَبِّئُكُمْ
بِمَا كُنْتُمْ تَعْمَلُونَ ﴿

سورة التوبة (١٠٥)

DEDICATION

To Our Mother's A strong and gentle soul who taught us to trust in ALLAH, believe in hard work and that so much could be done with little.

To Our Father's For earning an honest living for us and for supporting and encouraging us to believe in our self

To Mr. Khalifa Eltayeb Khalifa Our great supervisor who spent a lot of time to help us in preparation of this project

To Our Brothers and Friends For being our guardian during our educational career

We extend our pleasures to the staff of **Sudan University of Science and Technology** and to all those who take our hands and helped us in the preparation of this project.

ACKNOWLEDGEMENT

First and foremost all praises are due to **ALLAH**, for all physical and mental support throughout our life and during this project phases, and his peace and blessing be on the prophet.

We are so grateful to **our parents** for taking care with us.

We would like to express our sincere gratitude to our *Supervisor Mr. Khalifa Eltayeb* who was extremely helpful and offered invaluable assistance, patience, support and guidance until reaching this state.

Special thanks to *Dr. Alaa Eldin Awoda* and to *ENG. Alaa youssif shammed*, also we have to thank our all friends for helping us to complete this project especially our fellow student *ENG. Safwat magdi*.

ABSTRACT

In recent years, remote environment monitoring has been significantly improved with wireless sensor networking technology. This improvement helps the human being to avoid access to hazard areas.

This research concerned with design and implement of an autonomous mobile robot agent that can access to hazard areas. This mobile robot will have the ability to move forward, backward, turn left and right, with characteristic of object detection and avoidance. The agent also has the capability to sense the environmental parameters of the region, and send that data to the remote monitoring terminal using wireless communication.

المستخلص

في السنوات الأخيرة حدث تطور كبير في كيفية مراقبة ورصد العوامل البيئية عن (مثل درجة الحرارة والرطوبة) نسبةً بعد لإستخدام تكنولوجيا شبكات الإستشعار اللاسلكية. هذا التطور أسهم في مساعدة الإنسان ليستطيع تجنب الوصول إلى هذه المناطق الخطره.

هذا البحث يهتم بتصميم وتنفيذ روبوت ذاتي الحركة الذي بدوره يستطيع الوصول والعمل في هذه المناطق الخطره. هذا الروبوت لديه القدرة على التحرك في جميع الإتجاهات بالاضافة لذلك فإنه يستطيع الكشف عن المعوقات التي تواجهه وتجنبها , كما لديه القدرة على إستشعار التغيرات في عوامل البيئة المختلفة , وإرسال تلك البيانات الي المركز المسؤول عن المراقبة عن طريق إستخدام شبكة للاتصالات اللاسلكية.

List of Contents

DEDICATION	II
ACKNOWLEDGEMENT	III
ABSTRACT.....	IV
المستخلص.....	V
LIST OF CONTENTS	VI
LIST OF FIGURES.....	X
LIST OF TABLES.....	XII
ABBREVIATIONS	XIII
CHAPTER ONE: INTRODUCTION	2
1.1 PREFACE:	2
1.2 PROBLEM STATEMENT:	3
1.3 PROPOSED SOLUTION:	3
1.4 RESEARCH OBJECTIVE:	3
1.5 METHODOLOGY:.....	3
1.6 RESEARCH OUTLINE:	4
CHAPTER TWO: LITERATURE REVIEW ERROR! BOOKMARK NOT DEFINED.	
2.1 BACKGROUND:	ERROR! BOOKMARK NOT DEFINED.
2.1.1 The Robot:.....	Error! Bookmark not defined.
2.1.2 History of Robotics:	Error! Bookmark not defined.

2.1.3 Advantages and Disadvantage of Robotics:**Error! Bookmark not defined.**

2.1.4 Wireless Sensor Networks (WSN):**Error! Bookmark not defined.**

 2.1.4.1 Advantages and Disadvantages of WSN:**Error! Bookmark not defined.**

2.1.5 Mobile Wireless Sensor Network:**Error! Bookmark not defined.**

 2.1.5.1 Advantages and Disadvantages of MWSN:**Error! Bookmark not defined.**

 2.1.5.2 Applications of MWSN:.....**Error! Bookmark not defined.**

2.1.6 Differences between WSNs and MWSNs:**Error! Bookmark not defined.**

2.1.7 Sensors:**Error! Bookmark not defined.**

 2.1.7.1 Classification of Sensors: ..**Error! Bookmark not defined.**

 2.1.7.2 Navigation Sensors:.....**Error! Bookmark not defined.**

2.1.8 Motors:.....**Error! Bookmark not defined.**

 2.1.8.1 Dc Motor:.....**Error! Bookmark not defined.**

 2.1.8.2 Servo Motor:**Error! Bookmark not defined.**

 2.1.8.3 Stepper Motor:.....**Error! Bookmark not defined.**

2.1.9 Transmission Technologies:**Error! Bookmark not defined.**

 2.1.9.1 Bluetooth:.....**Error! Bookmark not defined.**

 2.1.9.2 Zigbee:**Error! Bookmark not defined.**

 2.1.9.3 Radio Frequency RF:.....**Error! Bookmark not defined.**

2.2 LITERATURE REVIEW:..... **ERROR! BOOKMARK NOT DEFINED.**

CHAPTER THREE: SYSTEM DESIGN**ERROR! BOOKMARK NOT DEFINED.**

3.1 BLOCK DIAGRAM OF THE SYSTEM:ERROR! BOOKMARK NOT DEFINED.

3.1.1 Navigation Sensors:.....**Error! Bookmark not defined.**

3.1.2 Information Sensors:**Error! Bookmark not defined.**

3.1.2.1 Temperature Sensor (LM35):**Error! Bookmark not defined.**

3.1.2.2 Gas Sensor (MQ-2):**Error! Bookmark not defined.**

3.1.2.3 Relative Humidity Sensor (HS1101):**Error! Bookmark not defined.**

3.1.3 Interface Circuit:**Error! Bookmark not defined.**

3.1.3.1 DC Motor Driver (L293D): **Error! Bookmark not defined.**

3.1.3.2 Stepper Motor Driver (ULN2003AN):**Error! Bookmark not defined.**

3.1.4 DC Motors:**Error! Bookmark not defined.**

3.1.5 Stepper Motor:.....**Error! Bookmark not defined.**

3.1.6 Microcontroller:**Error! Bookmark not defined.**

3.1.7 Transceiver Circuit (RF):.....**Error! Bookmark not defined.**

3.1.8 Voltage Regulator (L7805 – 5V):**Error! Bookmark not defined.**

3.1.9 Liquid Crystal Display (LCD): .**Error! Bookmark not defined.**

3.2 SYSTEM SCENARIO: ERROR! BOOKMARK NOT DEFINED.

3.3 FLOW CHART OF THE SYSTEM:.. ERROR! BOOKMARK NOT DEFINED.

3.3.1 Procedure to Gather Information:**Error! Bookmark not defined.**

- 3.3.2 Procedure to Move Right:.....**Error! Bookmark not defined.**
- 3.3.3 Procedure to Move Left:**Error! Bookmark not defined.**
- 3.3.4 The Main Flow Chart:**Error! Bookmark not defined.**

CHAPTER FOUR: CIRCUIT SIMULATION AND DESIGN

.....**ERROR! BOOKMARK NOT DEFINED.**

4.1 THE SIMULATION OF THE CIRCUIT:ERROR! BOOKMARK NOT DEFINED.

- 4.1.1 The Movement of the Robot:....**Error! Bookmark not defined.**
- 4.1.2 Information Gathering:**Error! Bookmark not defined.**
 - 4.1.2.1 Temperature Sensor:.....**Error! Bookmark not defined.**
 - 4.1.2.2 Gas Sensor:**Error! Bookmark not defined.**
 - 4.1.2.3 Humidity Sensor:.....**Error! Bookmark not defined.**
- 4.1.3 Virtual Terminal:.....**Error! Bookmark not defined.**

4.2 THE CIRCUIT OF THE PROJECT:... ERROR! BOOKMARK NOT DEFINED.

4.3 THE HARDWARE DESIGN OF THE CIRCUIT:ERROR! BOOKMARK NOT DEFINED.

- 4.3.1 The System Information Sensors:**Error! Bookmark not defined.**
 - 4.3.1.1 Temperature Sensor:.....**Error! Bookmark not defined.**
 - 4.3.1.2 Gas Sensor:**Error! Bookmark not defined.**
- 4.3.2 Stepper Motor Test:**Error! Bookmark not defined.**
- 4.3.3 Ultrasonic Sensor Test:.....**Error! Bookmark not defined.**
- 4.3.4 Robot Building:**Error! Bookmark not defined.**
- 4.3.4 The Final Circuit Design:**Error! Bookmark not defined.**

CHAPTER FIVE: CONCLUSION AND RECOMMENDATION
.....**ERROR! BOOKMARK NOT DEFINED.**

5.1**CONCLUSION:**..... **ERROR! BOOKMARK NOT DEFINED.**

5.2**RECOMMENDATION:**..... **ERROR! BOOKMARK NOT DEFINED.**

REFERENCES:.....**ERROR! BOOKMARK NOT DEFINED.**

APPENDICES**ERROR! BOOKMARK NOT DEFINED.**

APPENDIX A: THE SIMULATION CODE**ERROR! BOOKMARK NOT DEFINED.**

APPENDIX B: THE IMPLEMENTATION CODE.....**ERROR! BOOKMARK NOT DEFINED.**

APPENDIX C: THE BUDGET FOR IMPLEMENTATION **ERROR! BOOKMARK NOT DEFINED.**

List of Figures

FIGURE 2-1: IR SENSOR **ERROR! BOOKMARK NOT DEFINED.**

FIGURE 2-2: PERMANENT MAGNET STEPPER MOTOR. **ERROR! BOOKMARK NOT DEFINED.**

FIGURE 2-3: VARIABLE RELUCTANCE STEPPER MOTOR..... **ERROR! BOOKMARK NOT DEFINED.**

FIGURE 2-4: HYBRID STEPPER MOTOR**ERROR! BOOKMARK NOT DEFINED.**

FIGURE 3-1: BLOCK DIAGRAM OF MOBILE ROBOT CIRCUITRY..... **ERROR! BOOKMARK NOT DEFINED.**

FIGURE 3-2: PIN DESCRIPTION OF ULTRASONIC SENSOR..... **ERROR! BOOKMARK NOT DEFINED.**

FIGURE 3-3: LM35 PIN DESCRIPTION. **ERROR! BOOKMARK NOT DEFINED.**

FIGURE 3-4: (A) AND (B) MQ-2 GAS SENSOR**ERROR! BOOKMARK NOT DEFINED.**

FIGURE 3-5: (A) AND (B) HS1101 HUMIDITY SENSOR **ERROR! BOOKMARK NOT DEFINED.**

FIGURE 3-6: L293D PIN DESCRIPTION**ERROR! BOOKMARK NOT DEFINED.**

FIGURE 3-7: ULN2003A PIN DESCRIPTION.....**ERROR! BOOKMARK NOT DEFINED.**

FIGURE 3-8: STEPPER MOTOR CONNECTION TO THE DRIVER..... **ERROR! BOOKMARK NOT DEFINED.**

FIGURE 3-9: ATMEGA 16 PIN DESCRIPTION**ERROR! BOOKMARK NOT DEFINED.**

FIGURE 3-10: THE BLOCK DIAGRAM OF RF CIRCUIT . **ERROR! BOOKMARK NOT DEFINED.**

FIGURE 3-11: 7805 VOLTAGE REGULATOR**ERROR! BOOKMARK NOT DEFINED.**

FIGURE 3-12: LCD **ERROR! BOOKMARK NOT DEFINED.**

FIGURE 3-13: PROCEDURE OF GATHERING INFORMATION **ERROR! BOOKMARK NOT DEFINED.**

FIGURE 3-14: PROCEDURE TO MOVE RIGHT**ERROR! BOOKMARK NOT DEFINED.**

FIGURE 3-15: PROCEDURE TO MOVE LEFT**ERROR! BOOKMARK NOT DEFINED.**

FIGURE 3-16: THE MAIN FLOW CHART**ERROR! BOOKMARK NOT DEFINED.**

FIGURE 4-1: SIMULATION OF THE ROBOT MOVEMENT**ERROR! BOOKMARK NOT DEFINED.**

FIGURE 4-2: SIMULATION OF THE TEMPERATURE SENSOR **ERROR! BOOKMARK NOT DEFINED.**

FIGURE 4-3: SIMULATION OF GAS SENSOR**ERROR! BOOKMARK NOT DEFINED.**

FIGURE 4-4: SIMULATION OF HUMIDITY SENSOR**ERROR! BOOKMARK NOT DEFINED.**

FIGURE 4-5: VIRTUAL TERMINAL..... **ERROR! BOOKMARK NOT DEFINED.**

FIGURE 4-6: THE REAL CIRCUIT DESIGN**ERROR! BOOKMARK NOT DEFINED.**

FIGURE 4-7: TEMPERATURE SENSOR CIRCUIT.....**ERROR! BOOKMARK NOT DEFINED.**

FIGURE 4-8: (A) AND (B): GAS SENSOR CIRCUIT **ERROR! BOOKMARK NOT DEFINED.**

FIGURE 4-9: STEPPER MOTOR TEST ... **ERROR! BOOKMARK NOT DEFINED.**

FIGURE 4-10: ULTRASONIC SENSOR TEST**ERROR! BOOKMARK NOT DEFINED.**

FIGURE 4-11: DC MOTORS TEST..... **ERROR! BOOKMARK NOT DEFINED.**

FIGURE 4-12: ROBOT BUILDING **ERROR! BOOKMARK NOT DEFINED.**

FIGURE 4-13: THE FINAL CIRCUIT DESIGN IN THE TEST BOARD..... **ERROR!
BOOKMARK NOT DEFINED.**

FIGURE 4-14: THE FINAL CIRCUIT DESIGN IN SOLDERING BOARD .. **ERROR!
BOOKMARK NOT DEFINED.**

List of Tables

TABLE 2-1: COMPARISON BETWEEN BRUSHED AND BRUSHLESS DC MOTOR	ERROR! BOOKMARK NOT DEFINED.
TABLE 4-1: DERIVING GAS CONCENTRATION FROM OUTPUT VOLTAGE	ERROR! BOOKMARK NOT DEFINED.
TABLE 4-2: DERIVING RH FROM FREQUENCY.....	ERROR! BOOKMARK NOT DEFINED.
TABLE 4-3: DERIVING RH FROM VOLTAGE OUTPUT.....	ERROR! BOOKMARK NOT DEFINED.
TABLE 4-4: MICROCONTROLLER PIN CONNECTION IN THE CIRCUIT:	ERROR! BOOKMARK NOT DEFINED.

Abbreviations

A

AC	Alternative Current
ADC	Analog to Digital Converter

C

CCD	Charge Coupled Device
CISC	Complex Instruction Set Computing

D

DC	Direct Current
DVMT	Distributed Vehicle Monitoring Test bed

E

E-step	Expectation Step
--------	------------------

G

GHz	Gega Hertz
-----	------------

H

HB	Hybrid
----	--------

I

IEEE Institute of Electrical and Electronic Engineering

IR Infrared

K

Kbps Kilo Bit Per Second

L

LCD Liquid Crystal Display

LED Light Emitting Diodes

M

MANETs Mobile Ad hoc Networks

Mbps Mega Bit per Second

MHz Mega Hertz

Msec Milli Second

MWSN Mobile Wireless Sensor Network

M-step Maximization Step

P

PAN Personal Area Network

PC Personal Computer

PM	Permanent Magnet
PPM	Part Per Million
PSD	Position Sensitive Device
PUMA	Programmable Universal Machine for Assembly

R

RF	Radio Frequency
RH	Relative Humidity
RISC	Reduced Instruction Set Computing
R.U.R	Rossum's Universal Robots

T

T	Time
---	------

V

VR	Variable Reluctance
----	---------------------

W

WSN	Wireless Sensor Network
WPANs	Wireless Personal Area Networks

Chapter One

Introduction

Chapter One

Introduction

1.1Preface:

In this project a mobile robot designed to access hazardous areas that cannot be accessed by humans for the reason of collecting information through sensors.

A Mobile robot equipped with sensors is used to monitor the environment and gathered information to be capable to predict the environmental disasters before it begun and react accordingly, or just to collect information about any area that is dangerous to be accessed by human because it`s hazards.

This is done by sent information about what happened in this environment to the control station by Bluetooth, Zigbee or any other transmission circuit, so the users have the ability to avoid any undesirable action.

The robot has the possibility to work independently by sense the environment and avoid any obstacles in its way without user controlled with the help of necessary navigation sensors, this self control feature added to the design make it an autonomous mobile robot.

By added the mobility feature, large space can be covered by less number of agents rather than use of more number of wireless sensors network fixed nodes to cover the same area.

1.2 Problem Statement:

In wireless sensors network fixed nodes distributed in the environment that need to be monitored. So large number of nodes must be used and this required high cost. Also sometimes environment that must be monitored with the help of wireless sensors network nodes is dangerous places that cannot be accessed by human because of any risk factors such as Chemical contamination, Toxic gas, lack of O₂ or any other factor.

1.3 Proposed Solution:

Design and implementation of autonomous mobile robot equipped with the necessary sensors for self navigation and information gathering. It acts as Mobile Wireless Sensors Network agent (MWSN).

1.4 Research Objective:

1. Simulation of mobile robot and the physical phenomenon that should be measured.
2. Design of an autonomous mobile agent prototype can move (forward, backward, turn left, turn right), collect information, detect and avoid objects.

1.5 Methodology:

- In general all the needed Background about Wireless Sensors Network, Mobile robot and know the advantages, disadvantages and application of it.

- Determine the problem statement, proposed solution and objectives of using the mobile agent.
- Write Literature review about Mobile Robot, Wireless Sensors Network (WSN) and the previous related works.
- Draw the block diagram of robot prototype circuit and determine the components.
- Building the necessary simulation knowledge about the microcontroller.
- Simulation of mobile agent and sensing circuit.
- Evaluation of the mobile agent system performance.
- Hardware design is integrated with the software after developing it.
- Testing the mobile agent working.
- Show the results of the mobile robot and discuss this.
- Write recommendations deduced from this project.
- Write the final report about monitoring environment using Mobile Wireless Sensors Network (MWSN).

1.6 Research Outline:

- Chapter one include preface, problem statement, proposed solution, research objective and methodology.
- Chapter two includes definitions related to mobile robot, background, robot component, and literature review.

- Chapter three include block diagram, system component and flow chart.
- Chapter four include software and hardware design.
- Chapter five include conclusion and recommendation.