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THE DEVELOPMENT OF GAS DETECTION ROBOT

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REPUBLIC OF TURKEY
ADNAN MENDERES UNIVERSITY
GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES
AYDIN

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I hereby declare that all information and results reported in this thesis have been obtained by my part as a result of truthful experiments and observations carried out by the scientific methods, and that I referenced appropriately and completely all data, thought, result information which do not belong my part within this study by virtue of scientific ethical codes.

21/ 04/ 2016

Özgür KANLI

ÖZET

GAZ ALGILAMA ROBOTUNUN GELİŞTİRİLMESİ

Özgür KANLI

Yüksek Lisans Tezi, Makine Mühendisliği Anabilim Dalı

Tez Danışmanı: Prof. Dr. İsmail BÖĞREKÇİ

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İş kazaları, endüstrideki büyüme ile artmaya devam etmektedir. İş kazalarından kaynaklanan maddi ve can kayıplarının önüne geçebilmek ya da azaltmak iş güvenliğinin artırılması ile mümkün olabilecektir. İş güvenliğini arttırmaya yönelik iş yerlerinde alınabilecek önlemlerden biri de yangın öncesi olası gaz kaçaqlarını tespit etmektir. Literatür taramasında, gaz kaçaqlarını tespit etmek amacı ile sabit ya da mobil sistemlerin kullanıldığı görülmektedir. Tezin amacı doğrultusunda yapılan modelde, bir mobil robot tasarımı yapılmıştır. Şu ana kadar yapılan modellerden farklı olarak GPS modülü kullanılarak bulunduğu yeri tespit edebilme, bilgisayar üzerinden kontrol olanağı sağladığı gibi görüntü aktarımı yaparak, robotu görmeden de kontrol imkanı sağlamaktadır. Robot, bu özelliklere ek olarak sahip olduğu gaz sensörü ile gaz kaçağı algılaması yapabilmektedir. Robottan alınan gaz konsantrasyon değerleri bilgisayarda değerlendirilerek, gaz konsantrasyon sınır değerlerini aşıp aşmadığı belirlenir. Böylece tehlikeli durum önceden tahmin edilebilmekte ve gerekli önlemlerin alınması için uyarı mekanizması geliştirilmektedir.

Robotun geliştirilmesi, tasarımı, mekanik ve elektronik sistemlerin dizaynı ve yazılımın hazırlanması şeklinde olmuştur. İmalatı gerçekleştirilen robot, hava sızdırmaz test odasında, 0.5 m/s hızında giderken farklı (0-200cm) mesafelerden propan gibi yanıcı bir gazı, algılayabilmiştir. Yapılan bu model ve alınan sonuçlar, ileride yapılacak projeler için ön çalışma olma niteliğindedir.

Anahtar Kelimeler: Gaz Kaçaqları, Gaz Kaçağı Algılayan Mobil Robot, İş Sağlığı ve Güvenliği

ABSTRACT

THE DEVELOPMENT OF GAS DETECTION ROBOT

Özgür KANLI

M.Sc. Thesis, Department of Mechanical Engineering

Supervisor: Prof. Dr. İsmail BÖĞREKÇİ

2015, 101 pages

As the development continues in the industry, the increase in occupational accidents is inevitable. It is possible with the improvement of health and safety conditions to prevent or decrease the number of these kinds of accidents. One of the precautions to be taken for health and safety conditions is to detect gas leaks before a possible fire. It can be seen in the literature review that some devices and mobile systems have been used to detect gas leaks. In accordance with the aim of this thesis, a robot was designed and developed. This robot was able to determine the location of the robot by using GPS module, and capture images from a camera. This robot has machine vision system that can be controlled by a remote control. In addition to these, this robot was able to detect the gas leaks and to determine the amount of gas. The computer received the data from robot and decided whether or not the amount of gas within limit values and produced the warning.

The process of developing robot consisted of mechanical, electronics and software design. After the design and development of robot, the robot was tested in an airproof testing room. According to the results obtained from the tests, this robot was able to detect some combustible gases such as propane (C_3H_8) from different distances (0-200cm) at 0,5 m/s speed. This robot and results from this study can be used as a base for the future projects and studies related to the gas detection systems with robots.

Keywords: Gas Leaks, Mobile Robot for Gas Leak Detection, Occupational Health and Safety

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TABLE OF CONTENT

APPROVAL OF THE THESIS	iii
SCIENTIFIC ETHICS	v
ÖZET	vii
ABSTRACT	ix
ACKNOWLEDGEMENTS	xi
TABLE OF CONTENT	xiii
LIST OF ABBREVIATIONS	xvii
LIST OF FIGURES.....	xix
LIST OF TABLES	xxi
1. INTRODUCTION.....	1
1.1. What we need?	1
1.2. What is the engineering solution?	1
1.3. Motivation	1
1.4. Purpose of Thesis	2
2. LITERATURE REVIEW.....	3
2.1. Industrial Gas Leaks.....	3
2.1.1. Gas Leaks Disasters	3
2.2. Early Gas Detection Methods and Devices.....	5
2.2.1. Smoke Detectors	5
2.2.1.1. Ionization Smoke Detector.....	6
2.2.1.2. Photo-Elektric Smoke Detector.....	7
2.2.1.3. Optical Beam Smoke Detector	7
2.2.1.4. Aspirating Smoke Detector	8
2.3. History of Robotics	9
2.3.1. Robots.....	10

2.3.2. The History of Industrial Robots	22
2.3.3. Mobile Robots or Vehicles	23
2.3.3.1. Unmanned Aerial Vehicles.....	25
2.3.3.2. Unmanned Underwater Vehicles.....	27
2.3.3.3. Urban Robots.....	27
2.3.3.4. Unmanned Ground Vehicles	28
2.3.3.5. Autonomous Robots	30
2.4. Compare Functional Blocks	32
2.5. Design Process of Mobile Robots	33
2.6. Related Works (Gas Detection Robots)	34
3. MATERIAL AND METHOD.....	36
3.1. Mechanical Part.....	36
3.1.1. Chasis of GDR.....	36
3.1.2. Traction Mechanism.....	38
3.1.3. Wheels.....	38
3.1.4. Steering Method	39
3.2. Requirements of Robot.....	39
3.2.1. Power Requirement Calculations	39
3.2.2. Torque Requirement Calculation	43
3.2.3. Motor Selection	43
3.2.4. Energy Supply	44
3.3. Wireless IP Camera	46
3.4. GPS Module	47
3.5. Gas Sensor.....	48
3.6. Gas Detection Robot Platform Configuration	51
3.7. Software of GDR.....	52

3.7.1. Arduino	52
3.8. Electronic Circuits-Hardware.....	53
3.8.1. Main Board.....	53
3.8.1.1. Microcontrollers	56
3.8.2. DC Motors Control Unit	57
3.8.3. Wireless Antenna for Wireless Communication	57
3.9. Notebook Computer	58
3.10. Modem for Communication	59
3.11. Equipment of Test Requirements	60
3.11.1. Airproof Testing room	60
3.11.2. Gas Tube... ..	61
3.11.3. Gas Supply Installation	62
4. RESULTS AND DISCUSSIONS	64
4.1. Gas Detection Test	65
4.1.1. Gas Detection Test Based on Distance.....	67
4.2. GPS Test.....	72
4.3. The Camera Test	73
5. CONCLUSIONS	74
REFERENCES.....	77
APPENDICES.....	81
RESUME.....	101

LIST OF ABBREVIATIONS

AS	Aspirating Smoke Detector
BEAM	Biology, Electronics, Aesthetics, and Mechanics
UAV	Unmanned Aerial Vehicle
PUMA	Programmable Universal Manipulator for Assembly
UGV	Unmanned Ground Vehicles
AUV	Autonomous Underwater Vehicles
UAS	Unmanned Aircraft System
UUV	Unmanned Underwater Vehicles
AI	Artificial Intelligence
N	Newton
mm	millimetre
GPS	Global Positioning System
GSM	Global System for Mobile
LED	Light Emitting Diode
LiPo	Lithium Polymer
mA	Mili Ampere
V	Volt
W	Watt
nm	Nanometer
ppm	Parts Per Million
ROM	Read Only Memory
RPM	Revolution Per Minute
USB	Universal Serial Bus
GDR	Gas Detection Robot
LPG	Liquid Petroleum Gas

LIST OF FIGURES

Figure 2.1. Gas leaks at industries.....	3
Figure 2.2. A firefighter watches the blaze after a gas line exploded near Fresno, California April 17, 2015. (Lisa Rapaport, Reuters) ..	4
Figure 2.3 Crews work to extinguish a fire following a gas explosion in Allentown, Penn., in February 2011. (Se Figure 2.4 Fatal occupational injures in the private mining industries ..	4
Figure 2.4. Fatal occupational injures in the private mining industries, 2007-2008 (Anonymous, 2010).....	5
Figure 2.5. Smoke Detector (Anonymous, 2015)	6
Figure 2.5. Smoke Detector (Anonymous, 2015)	7
Figure 2.6. Ionization smoke detector (Anonymous, 2015).....	6
Figure 2.7. Working principle of photo electric smoke detector (Anonymous, 2015).....	7
Figure 2.8. Optical Beam Smoke Detector (Jon Hind, 2009)	8
Figure 2.9. Main components of aspirating smoke detection system (Anonymous, 2015).....	9
Figure 2.10. A water clock	11
Figure 2.11. Automata	11
Figure 2.12. The elephant clock.....	11
Figure 2.13. Rossum’s Universal Robot	11
Figure 2.14. Science fiction short story “Liar”	12
Figure 2.15. Elmer and Elsie, two of the earliest autonomous robots.....	12
Figure 2.16. The first silicon transistor	12
Figure 2.17. The first programmable robot, “Unimate”.....	13
Figure 2.18. The first artificial satellite, “Sputnik 1”	13
Figure 2.19. First unimate robot.....	13
Figure 2.20. A single chip introduces “Moore’s law	14

Figure 2.21. Shakey robot	14
Figure 2.22. Lunar Module is used at The Apollo 11 mission	14
Figure 2.23. Lunokhod 1.	15
Figure 2.24. Microprocessor.	15
Figure 2.25. Viking 1 and 2.....	15
Figure 2.26. Robots are named R2-D2 and C-3PO from the film “Star Wars”.	16
Figure 2.27. Humanoid robot is called cyborg from the movie “Terminator”	16
Figure 2.28. ASIMO, first humanoid robot.....	16
Figure 2.29. SCAMP, first robot pet	17
Figure 2.30. BEAM, being an acronym for Biology, Electronics, Aesthetics, and Mechanics.....	17
Figure 2.31. First helpmate mobile autonomous robot.....	17
Figure 2.32. Sojourner, is the first rover to land on Mars	18
Figure 2.33. Lego Mindstorms is a first robot of Lego	18
Figure 2.34. AIBO, robotic dog and QRIO, humanoid robot	18
Figure 2.35. ASIMO, the first non-prototype release of its humanoid robot.	19
Figure 2.36. Predator, unmanned aerial vehicle	19
Figure 2.37. Roomba, a robotic vacuum cleaner.....	19
Figure 2.38. Actroid, a humanoid robot with strong visual human characteristics.	20
Figure 2.39. DARPHA, an autonomous vehicles for warfare	20
Figure 2.40. Spirit, is a rover robot on Mars	21
Figure 2.41. Robonaut-2, NASA’s humanoid robot astronaut	21
Figure 2.42. ATLAS, is a humanoid robot for rough terrain.....	21
Figure 2.43. Unimate, first industrial robot (Anonymous, 2013).....	22
Figure 2.44. Industrial robots at automotive industry (Anonymous, 2013)	23

Figure 2.45. ANKA, is an unmanned aerial vehicle developed by Turkish Aerospace Industries for the requirements of Turkish Armed Forces (Anonymous, 2012).....	26
Figure 2. 46. “Maveric” is an UAV (Photo courtesy Texas A&M).....	26
Figure 2.47. REMUS(front) is a UUV and belongs to The US Navy (Carafono, 2007).....	27
Figure 2.48. Urban robots, DustCart and DustClean (Damir, 2009).....	28
Figure 2.49. An Unmanned Ground Vehicle for Defence Industry (Anonymous, 2012).....	29
Figure 2.50. An Unmanned Ground Vehicle for Israel Defense Forces to operate as part of the border security operations (Anonymous, 2012)	29
Figure 2.51. DARPA is an autonomous robot. (Darpa Strategic plan, 2007).	32
Figure 2.52. Mobile service robots sales of units for professional usage for 2011-2012 (Sucuoglu, 2015).....	32
Figure 2.53. Example of Gas Detection Robot (Anonymous,2012)	35
Figure 2.54. Example of Another Gas Detection Robot (MIT)	35
Figure 3.1. Chasis of GDR.....	37
Figure 3.2. Wheel of GDR	38
Figure 3.3. The schematic view is for differential driving method (Anonymous,www.rakeshmondal.info, 2014)	39
Figure 3.4. Resistance forces (Anonymous, 2012)	40
Figure 3.5. 12 volt 120 rpm DC motor.....	44
Figure 3.6. 9V Alkaline battery.....	45
Figure 3.7. 10400 mAh recharge battery for IP camera.....	46
Figure 3.8. LiPo battery unit	46
Figure 3.9. Wireless IP camera	46
Figure 3.10. GPS module	48
Figure 3.11. MQ-9 gas sensor	49

Figure 3.12. Basic test loop of gas sensor	49
Figure 3.13. Configuration of MQ – 9 gas sensor	50
Figure 3.14 Carrier board.	51
Figure 3.15. Arduino UNO R3 programmable platform	53
Figure 3.16. Arduino UNO R3	55
Figure 3.17. Pin Mapping for Atmega 168 (Anonymous, 2015)	56
Figure 3.18. DC motor control unit	57
Figure 3.19. Wire Antenna for wireless communication.....	57
Figure 3.20 A notebookcomputer.....	59
Figure 3.21. A modem for Communication	60
Figure 3.22. A prefab for gas test room	61
Figure 3.23. Propane Tube.	61
Figure 3.24. Gas Supply Installation with gas tube.....	62
Figure 3.25. Gas supply Installation.....	62
Figure 3.26. A regulator for controlling pressure of gas	63
Figure 4.1. A simple picture from GDR	64
Figure 4.2. Speed test for GDR	67
Figure 4.3. Influence of temperature/humidity.....	68
Figure 4.4. Sensitivity characteristics.....	68
Figure 4.5. Between every striplines	69
Figure 4.6. Striplines are located in test room	70
Figure 4.7. GDR is in test room	70
Figure 4.8. Concentration of propane changes based on time.....	71
Figure 4.9. Concentration of propane based on distances from gas outlet	71
Figure 4.10. Control panel while GPS is working.....	72
Figure 4.11. Control panel while IP camera is working.....	73

LIST OF TABLES

Table 2.1. The history of robotics(Anonymous, 2008)	11
Table 2.2. Functional block compression between mobile robot and human being (Chen et al., 2009).	33
Table 3.1. Dimensions of Chasis.....	37
Table 3.2. Details of the wheels	38
Table 3.3. Coefficient of rolling resistance (Naunheimer et al., 2011)	42
Table 3.4. Specifications of 10400 mAH Battery (Data sheet)	45
Table 3.5. Specifications of Wireless IP Camera (Data Sheet).....	47
Table 3.6. The technical features of the MQ-9 gas sensor are (Anonymous, 2013)	50
Table 3.7. Names and functions of the components	51
Table 3.8. Technical Specs of Arduino UNO R3 (Data sheet of Arduino UNO R3	54
Table 3.9. Major constituents of dry air, by volume (Anonymou,2016).....	66
Table 3.10. Physical Properties of Propane Major constituents of dry air, by volume (Anonymous, 2016)	66

1. INTRODUCTION

1.1. What we need?

It is important to develop a proper gas detection system as a lot of people died of gas leaks in the past. There are still deaths because of this gas problem. While working, people must have safety conditions and engineers are the people who are responsible for this safety. It is necessary to develop a system which can detect flammable gases and warn us before a possible disaster. Industries use gases to produce things by transferring them through pipes and it is not a problem until a gas leak occurs. If a gas leak occurs and if it is not noticed, people at the industry can breathe it, and this may cause injurances or deaths. Another problem is that these flammable gases can cause fire and this may lead lots of financial damages or more seriously lots of deaths. Therefore it is inevitable to find a way to protect people from fire and dangerous gases.

1.2. What is the engineering solution?

Engineers are the people change things and solve problems by using scientific ways. One of the problems that engineers deal with is health and safety at work conditions at work, especially gas leaks cause serious and dangerous problem at industries. One solution for this problem is to use GDR (Gas Detection Robot); it is a mobile robot which warns people before a dangerous situation happen by using a gas sensor.

This robot can be controlled via using a PC. There is an IP camera on the robot, which has rotational head that can move right andleft sides at the degree of 270°. Also with the help of the GPS system, the robot can give location information

1.3. Motivation

The main and most important motivation for this study is to protect people and to decrease the amount of dangerous situations caused by gas leaks at work. It is obvious that health and safety conditions in Turkey's industries are not enough. As a result of this fact, we conducted this study to design and manufacture a gas detection mobile robot.

Gas leak is a serious problem and it caused many disasters in Turkey in past. For example, in 2015, as a result of a disaster caused by methane gas, 2 workers died while they were working in sewage. Furthermore, another disaster had occurred in Soma one year earlier than Kuşadası and unfortunately it had resulted in massive deaths. 301 miners died and most of there were injured seriously. They were innocent people and their only aim was to earn money to continue their lives. In that serious accident, one man affected many people, including me, by saying he can take off his shoes not to make dirty the stretcher after severely injured because of CO gas. In this study, one of the starting points is to help people who have a pure hearth like this miner and decrease or even prevent this kind of accidents by developing a mobile robot which has got the ability to detect gases before disasters.

1.4. Purpose of Thesis

One of the important reasons of why this thesis has written is to design and produce a gas detection mobile robot and to test its system fuctions. This robot should be able to operate especially in industrial areas.

The aims of this thesis are as below:

1. To protect people's life and capital.
2. To use robots when detects gas leaks.
3. To know gas leaks before fire or disaster

2. LITERATURE REVIEW

2.1. Industrial Gas Leaks

An industrial gas is a type of disaster involving a conflagration that cause to irremediable harms in in industrial settings. In common usage, a gas leak refers to a leak of natural gas or other gaseous product from a pipeline or other containment into a living area or any other area where the gas should not be present. Because flammable gases may explode when exposed to flame or sparks, this situation is very dangerous to the general public. In addition to causing fire and explosion hazards, leaks can kill vegetation, including large trees, and may release powerful greenhouse gases to the atmosphere. At some factories is used gas detection systems but it is not enough so this leads to necessity of usage of mobile systems also known as gas detection mobile robot. (Lisa, 2010)

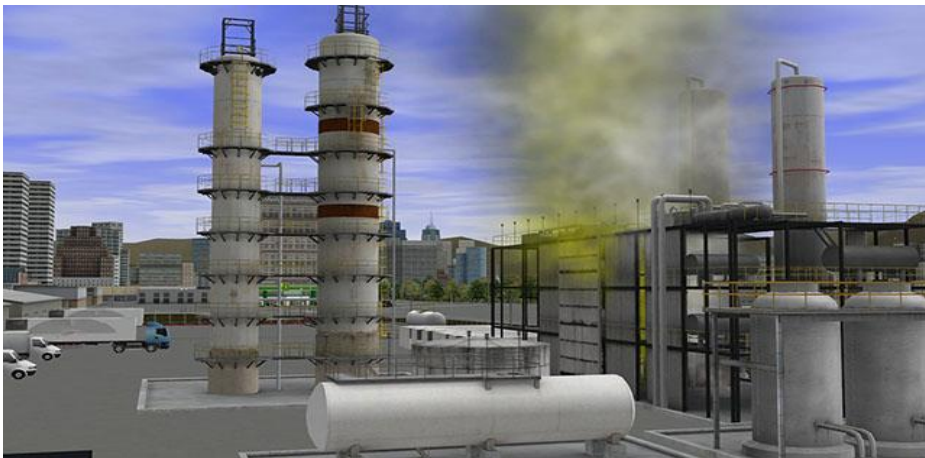


Figure 2.1. Gas leaks at industries

2.1.1. Gas Leaks Disasters

From past to today many industrial gas leak have occurred all over the world. Some of them are presented in this thesis study;



Figure 2.2. A firefighter watches the blaze after a gas line exploded near Fresno, California April 17, 2015 (Lisa Rapaport, Reuters)

American consumers are paying billions of dollars for natural gas that never reaches their homes, but instead leaks from aging distribution pipelines, contributing to climate change, threatening public health, and sometimes causing explosions.

It is seen a disaster caused by gas leaks in Figure 2.3 and firefighters try to put out the fire.



Figure 2.3. Crews work to extinguish a fire following a gas explosion in Allentown, Penn., in February 2011 (Sen. Edward J. Markey, 2013)

As below, in Figure 2.4 show us number of fatal work injuries between 2004-2008 at explosions caused by gas leaks.

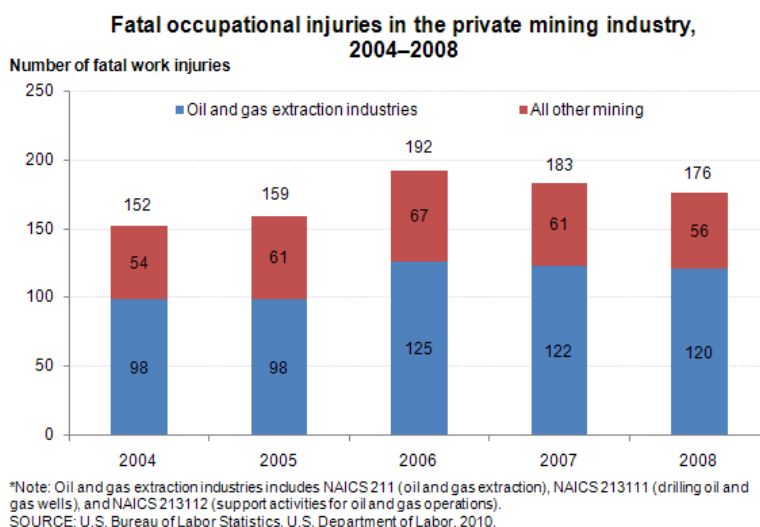


Figure 2.4. Fatal occupational injuries in the private mining industries, 2007-2008 (U.S. Bureau of Labor Statistics, U.S. Department of Labor, 2010)

2.2. Early Gas Detection Methods and Devices

Some of methods and devices are used at past for protecting people from hazards gas. One of method is give an alarm when hazard gases are in office, factory etc. Smoke detector can do these missions, at the same operation logic.

2.2.1. Smoke Detectors

A smoke detector is a device that senses smoke. Smoke detectors are typically housed in a disk-shaped plastic enclosure about 150 millimetres (6 in) in diameter and 25 millimetres (1 in) thick, but the shape can vary by manufacturer or product line. Most smoke detectors work either by optical detection (photoelectric) or by physical process (ionization), while others use both detection methods to increase sensitivity to smoke (Anonymous, 2015).



Figure 2.5. Smoke Detector (Anonymous, 2015)

2.2.1.1. Ionization Smoke Detector

Smoke detectors warn people from fire at buildings. Smoke is detected by the device then ring alarm. One type of smoke detectors uses americium-241, a source of alpha radiation, to detect smoke. The Figure 2.22 shows how it looks inside.

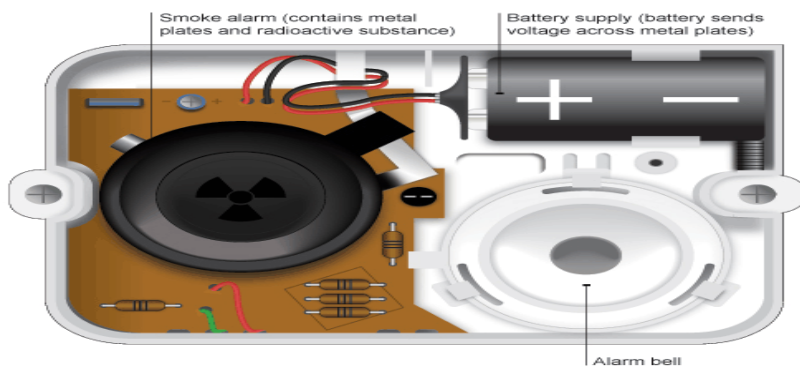


Figure 2.6. Ionization smoke detector (Anonymous, 2015)

The alpha radiation ionises the air particles inside the smoke detector. This allows a small electric current to flow. If there is a fire, smoke particles going into the detector are hit by alpha radiation. This reduces the ionisation of the air particles causing the current to drop. The drop in current is detected by the smoke detector, setting off the alarm. Smoke alarm contains metal plates and radioactive substance. The battery supply sends voltage across metal plates. People are alerted when the alarm bell sounds.

2.2.1.2. Photo-Electric Smoke Detector

The first smoke detector being discussed is used most commonly in public areas fit for larger domains. The Optical Smoke Detector, also referred to as a Photoelectric Type Device, uses a light source to detect smoke. The Infra-Red LED is a lens that shoots a beam over a large area. If smoke is present in the room, it enters the optical chamber, having smoke particles scatter and sensor sets of the alarm. In very large areas where a smoke detector is placed, there are two optical detectors that send the straight line of infra-red beam from a sender to a receiver. Optical Smoke Detectors are less sensitive to false alarm fire, such as minor smoke from candles, cooking, steam, etc.

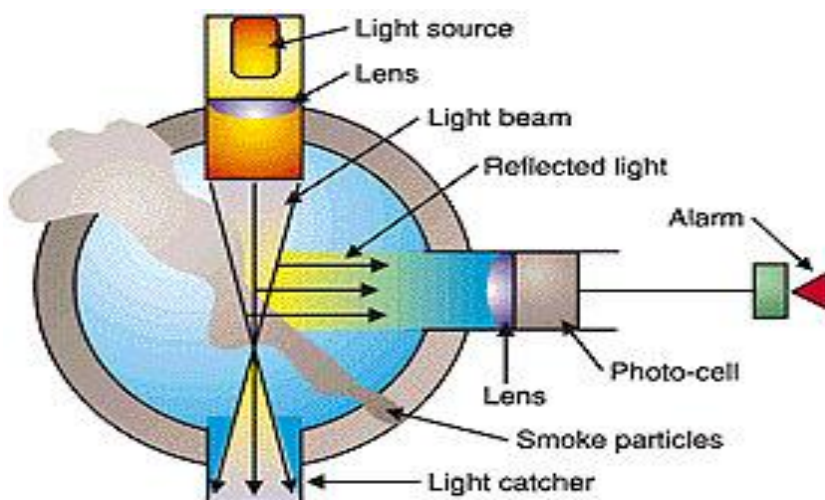


Figure 2.7. Working principle of photo electric smoke detector (Anonymous, 2015)

2.2.1.3. Optical Beam Smoke Detector

An optical beam smoke detector is a device that uses a projected beam of light to detect smoke across large areas, typically as an indicator of fire. They are used to detect fires in buildings where standard point smoke detectors would either be uneconomical or restricted for use by the height of the building. Optical beam smoke detectors are often installed in warehouses as a cost effective means of protecting large open spaces.

Optical beam smoke detectors work on the principle of light obscuration, where the presence of smoke blocks some of the light from the beam typically through either absorbance or light scattering. Once a certain percentage of the transmitted light has been blocked by the smoke, a fire is signalled. Optical beam smoke detectors are typically used to detect fires in large commercial and industrial buildings, as components in a larger fire alarm system (Jon Hind, 2009).



Figure 2.8. Optical Beam Smoke Detector (Jon Hind, 2009)

2.2.1.4. Aspirating Smoke Detector

The working principle of aspirating smoke detector (ASD) is the same with photo-electric smoke detector.

An aspirating smoke detector consists of a central detection unit which draws air through a network of pipes to detect smoke.

ASD design corrects shortcomings of conventional smoke detectors by using a sampling pipe with multiple holes. The air samples are captured and filtered, removing any contaminants or dust to avoid false alarms and then processed by a centralized, highly sensitive laser detection unit. If smoke is detected, the systems alarm is triggered, and signals are then processed through centralized monitoring stations within a few seconds.

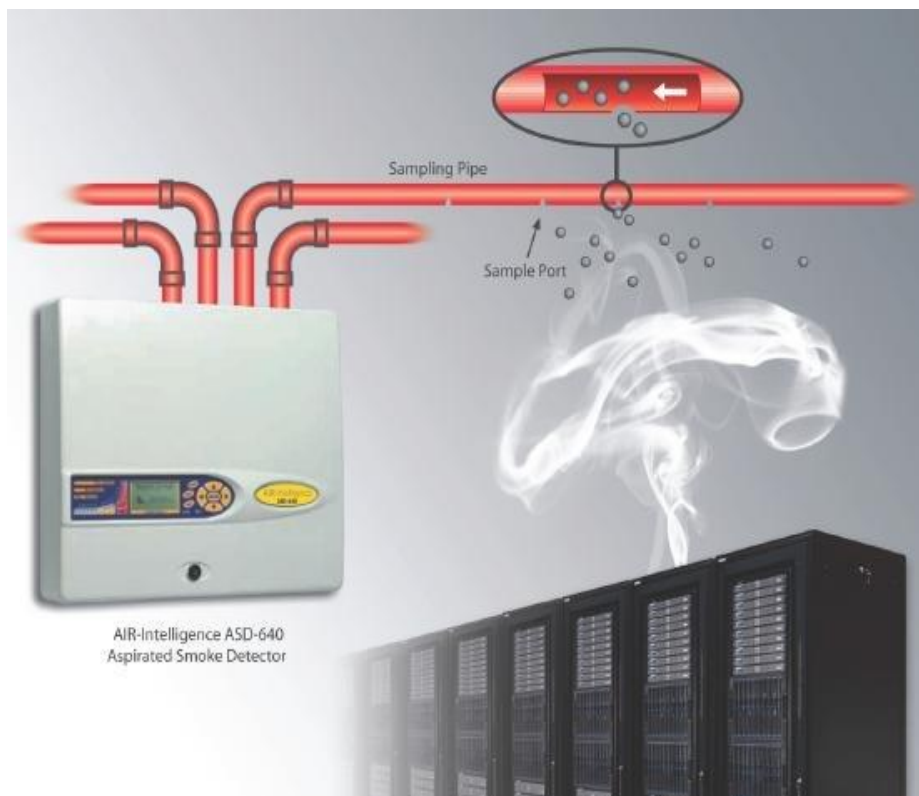


Figure 2.9. Main components of aspirating smoke detection system (Anonymous, 2015)

2.3. History of Robotics

This history of robotics is intertwined with the histories of technology, science and the basic principle of progress. Technology used in computing, electricity, even pneumatics and hydraulics can all be considered a part of the history of robotics. The timeline presented is therefore far from complete. Robotics currently represents one of mankind's greatest accomplishments and is the single greatest attempt of mankind to produce an artificial, sentient being. It is only in recent years that manufacturers are making robotics increasingly available and attainable to the general public. The focus of this timeline is to provide the reader with a general overview of robotics (with a focus more on mobile robots) and to give an appreciation for the inventors and innovators in this field who have helped robotics to become what it is today (Anonymous, 2008).

2.3.1. Robots

A robot is a machine designed to execute one or more tasks repeatedly, with speed and precision. There are as many different types of robots as there are tasks for them to perform.

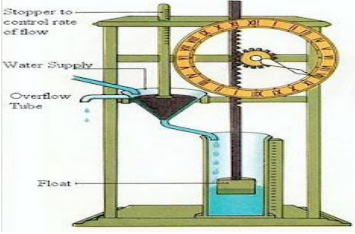
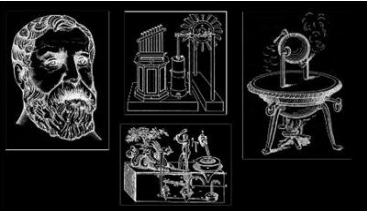


A robot can be controlled by a human operator, sometimes from a great distance. But most robots are controlled by computer, and fall into either of two categories: autonomous robots and insect robots. An autonomous robot acts as a stand-alone system, complete with its own computer (called the controller). Insect robots work in fleets ranging in number from a few to thousands, with all fleet members under the supervision of a single controller. The term insect arises from the similarity of the system to a colony of insects, where the individuals are simple but the fleet as a whole can be sophisticated.

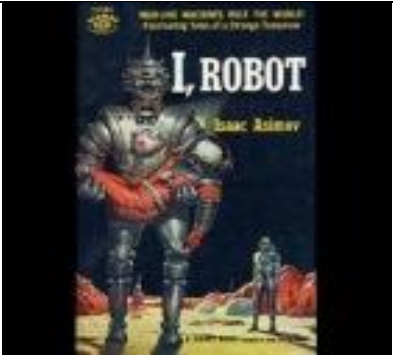
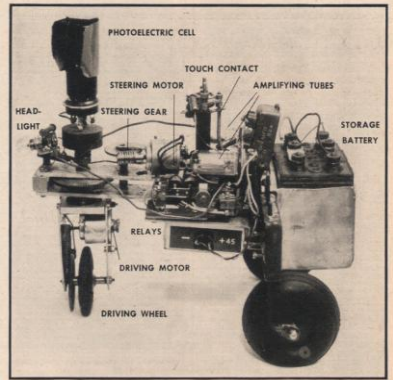
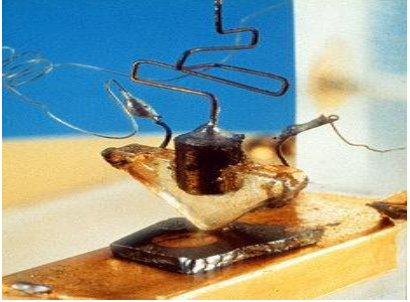
Robots are sometimes grouped according to the time frame in which they were first widely used. First-generation robots date from the 1970s and consist of stationary, nonprogrammable, electromechanical devices without sensors. Second-generation robots were developed in the 1980s and can contain sensors and programmable controllers. Third-generation robots were developed between approximately 1990 and the present. These machines can be stationary or mobile, autonomous or insect type, with sophisticated programming, speech recognition and/or synthesis, and other advanced features. Fourth-generation robots are in the research-and-development phase, and include features such as artificial intelligence, self-replication, self assembly, and nanoscale size (physical dimensions on the order of nanometers, or units of 10^{-9} meter).

This history of robotics is intertwined with the histories of technology, science and the basic principle of progress. Technology used in computing, electricity, even pneumatics and hydraulics can all be considered a part of the history of robotics. The timeline presented is therefore far from complete. Robotics currently represents one of mankind's greatest accomplishments and is the single greatest attempt of mankind to produce an artificial, sentient being. It is only in recent years that manufacturers are making robotics increasingly available and attainable to the general public. The focus of this timeline is to provide the reader with a general overview of robotics (with a focus more on mobile robots) and to give an

appreciation for the inventors and innovators in this field who have helped robotics to become what it is today (Anonymous, 2008).

Table 2.1. The history of robotics (Anonymous, 2008)

Timeline of Robotics	Figures
<p>≈250 B.C. - Ctesibius, an ancient Greek engineer and mathematician, invented a water clock which was the most accurate for nearly 2000 years.</p>	 <p>Figure 2.10. A water clock</p>
<p>≈60 A.D. -Hero of Alexandria designs the first automated programmable machine. These 'Automata' were made from a container of gradually releasing sand connected to a spindle via a string. By using different configurations of these pulleys, it was possible to repeatably move a statue on a pre-defined path.</p>	 <p>Figure 2.11. Automata</p>
<p>≈1206- The elephant clock was one of the most famous inventions of Ismail al-Jazari.</p>	 <p>Figure 2.12. The elephant clock</p>
<p>1921- The term 'Robot' was coined by Karel Capek in the play 'Rossum's Universal Robots'.</p>	 <p>Figure 2.13. Rossum's Universal</p>

	Robots
<p>1941 - Isaac Asimov introduced the word 'Robotics' in the science fiction short story 'Liar!'</p>	 <p>The image shows the cover of the book 'I, Robot' by Isaac Asimov. The cover features a large, metallic, humanoid robot in the foreground, with a smaller robot visible in the background. The title 'I, ROBOT' is prominently displayed in large, white, serif letters, with 'Isaac Asimov' written below it in a smaller font. The background is dark with some red and yellow highlights.</p> <p>Figure 2.14. Science fiction short story “Liar”</p>
<p>1948 - William Grey Walter builds Elmer and Elsie, two of the earliest autonomous robots with the appearance of turtles. The robots used simple rules to produce complex behaviours.</p>	 <p>The image is a technical diagram of the 'Under Turtle' robot. It shows a mechanical assembly with various components labeled: PHOTOELECTRIC CELL, TOUCH CONTACT, AMPLIFYING TUBES, STORAGE BATTERY, RELAYS, DRIVING MOTOR, DRIVING WHEEL, STEERING MOTOR, STEERING GEAR, and HEAD-LIGHT. The robot has a shell-like structure and two wheels. Below the diagram, there is a caption: 'UNDERTURTLE'S SHELL are organs sensitive to both light and touch. They send electrical impulses to relays and tubes that control mechanical creature's two motors.'</p> <p>Figure 2.15. Elmer and Elsie, two of the earliest autonomous robots</p>
<p>1954 - The first silicon transistor was produced by Texas Instruments.</p>	 <p>The image shows the first silicon transistor, a small, dark, rectangular component mounted on a metal base. It has several thin, wire-like leads extending from it. The component is placed on a wooden surface, and the background is a plain, light-colored wall.</p> <p>Figure 2.16. The first silicon transistor</p>

1956 - George Devol applied for a patent for the first programmable robot, later named 'Unimate'.

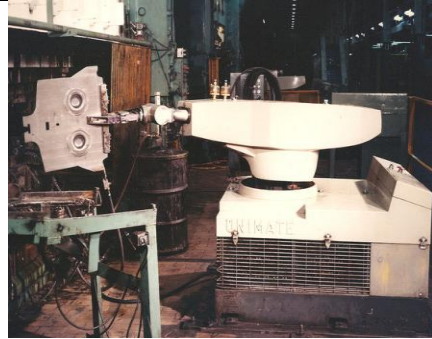


Figure 2.17. The first programmable robot, "Unimate"

1957 - Launch of the first artificial satellite, Sputnik 1.



Figure 2.18. The first artificial satellite, "Sputnik 1"

1961 - First Unimate robot installed at General Motors, used for die casting and spot welding.

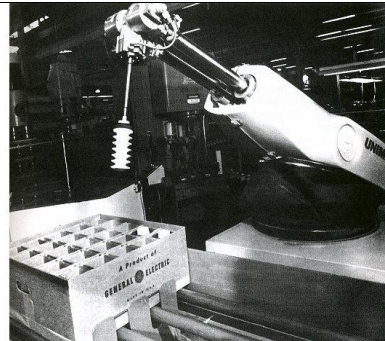


Figure 2.19. First unimate robot

1965 – Gordon E. Moore introduces the concept 'Moore's law', which predicts the number of components on a single chip would double every two years.



Figure 2.20. A single chip introduces “Moore’s law”

1966 - Work began on the 'Shakey' robot at Stanford Research Institute. 'Shakey' was capable of planning, route-finding and moving objects.



Figure 2.21. Shakey robot

1969 - The Apollo 11 mission, puts the first man on the moon. Landing was made inside the Lunar Module 'Eagle'.



Figure 2.22. Lunar Module is used at The Apollo 11 mission

1970 - Luna 17 lands on the moon, carrying the roving remote controlled robot, Lunokhod 1.



Figure 2.23. Lunokhod 1

1971 – Intel introduce the first commercially available microprocessor, the 4004.



Figure 2.24. Microprocessor

1975 - The space probes Viking 1 and 2 were launched each with an articulated robot arm.

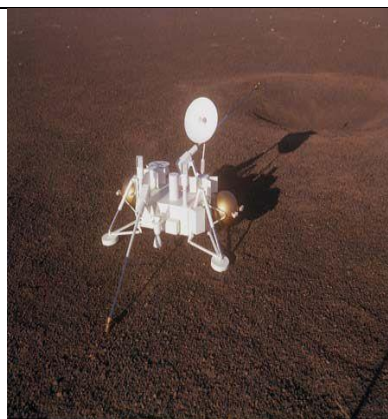


Figure 2.25. Viking 1 and 2

1976 - The film Star Wars is released introducing R2-D2 and C-3PO.



Figure 2.26. Robots are named R2-D2 and C-3PO from the film “Star Wars”

1984 - The film Terminator is released, with Arnold Schwarzenegger as a cybernetic organism or cyborg.



Figure 2.27. Humanoid robot is called cyborg from the movie “Terminator”

1986 - Honda starts work on its first humanoid, robot named 'EO' (later to become ASIMO).



Figure 2.28. ASIMO, first humanoid robot

1988 - SCAMP designed as the first robot pet with emotions.



Figure 2.29. SCAMP, first robot pet

1989 - Mark Tilden introduces BEAM robotics, beam being an acronym for Biology, Electronics, Aesthetics, and Mechanics.



Figure 2.30. BEAM, being an acronym for Biology, Electronics, Aesthetics, and Mechanics

1991 - First HelpMate mobile autonomous robot used in hospitals.



Figure 2.31. First helpmate mobile autonomous robot

1997 - Sojourner becomes the first rover to land on Mars as part of the Mars Pathfinder mission.



Figure 2.32. Sojourner, is the first rover to land on Mars

1998 - Lego enters the robotics market with its first version of Lego Mindstorms.



Figure 2.33. Lego Mindstorms is a first robot of Lego

1999 - Sony introduces AIBO, an autonomous robotic dog capable of seeing, walking and interacting with its environment. This was followed a year later by the SDR-3X humanoid robot later known as QRIO (both discontinued in 2006).



Figure 2.34. AIBO, robotic dog and QRIO, humanoid robot

2000 - Honda unveils ASIMO, the first non-prototype release of its humanoid robot.



Figure 2.35. ASIMO, the first non-prototype release of its humanoid robot

2001 - US Air force test the MQ-1 Predator, the first armed unmanned aerial vehicle (UAV) fitted with two Hellfire missiles.



Figure 2.36. Predator, unmanned aerial vehicle

2002 - iRobot introduces Roomba, a personal robotic vacuum cleaner.



Figure 2.37. Roomba, a robotic vacuum cleaner

2003 - Osaka University unveils their first 'Actroid', the term given for a humanoid robot with strong visual human characteristics



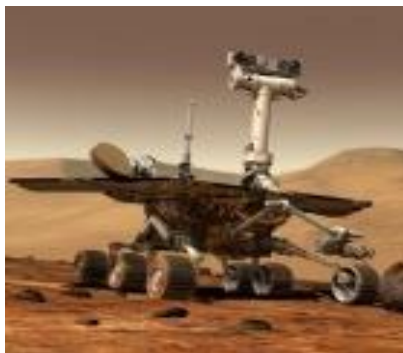
Figure 2.38. Actroid, a humanoid robot with strong visual human characteristics

2004 - The first DARPA Grand challenge is held. Sponsored by the US department of defence, the challenge is designed to create autonomous vehicles for warfare.



Figure 2.39. DARPA, an autonomous vehicles for warfare

2004 - The Mars rovers Spirit and Opportunity land on Mars. As of November 25th 2009 The rover Spirit has completed 2150 days of its 92 day (90 sol) mission.



Figures 2.40. Spirit, is a rover robot on Mars

2010 - NASA and General Motors join forces to develop Robonaut-2, the new version of NASA's humanoid robot astronaut.



Figures 2.41. Robonaut-2, NASA's humanoid robot astronaut

2013 - Atlas is a high mobility, humanoid robot designed to negotiate outdoor, rough terrain.



Figures 2.42. ATLAS is a humanoid robot for rough terrain

2.3.2. The History of Industrial Robots

George Charles Devol is often called the father of robotics. He invented the first industrial robot, the Unimate, in 1954. A few years later, Devol and Joseph F. Engelberger formed the first robot company, Unimation. In 1960, Unimation was purchased by Condec Corporation. General Motors installed the Unimate for die casting handling and spot welding in 1961.

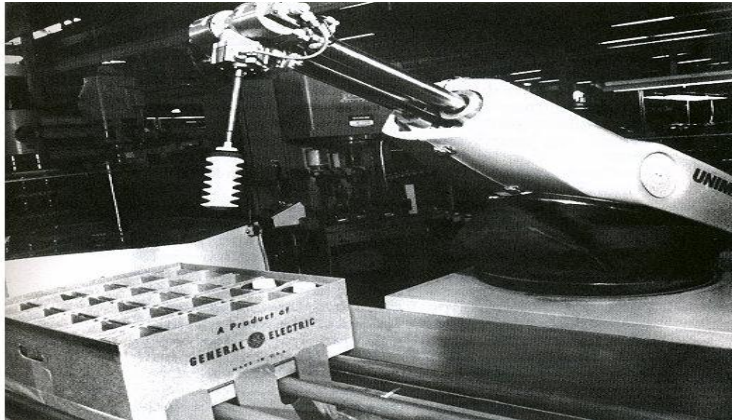


Figure 2.43. Unimate, first industrial robot (Anonymous, 2013)

Modern industrial robot arms continued to evolve in the 1960's and 70's. In 1963, the six-jointed Rancho Arm was created to assist handicapped. This was followed by the tentacle arm, designed by Marvin Minsky in 1968. It was able to lift a person and had 12 joints.

It was the 1969 Stanford Arm that eventually led to commercial arm production. The Stanford Arm was one of the first electronically powered, computer-controlled arms. By 1974, it reached a level of sophistication where it could assemble a Model T water pump.

The Stanford Arm was followed by the Silver Arm in 1974. The Silver Arm was created by MIT's David Silver to perform precise assembly using touch and pressure sensors and a microcomputer. These arms led to Victor Scheinman, the inventor of the Stanford Arm, to form Vicarm, Inc. in 1974 to manufacture industrial robotic arms. Scheinman was instrumental in the creation of the PUMA (programmable universal manipulator for assembly) for Unimation. In 1977, the European robot company ASEA, built two sizes of industrial robots.

The development of the computer directly influenced the advancement of industrial robotics. The automotive industry was another contributor. In the 1980's, automotive companies showered robotic companies with investments (Anonymous, 2013).



Figure 2.44. Industrial robots at automotive industry (Anonymous, 2013)

But the enthusiasm and funding were not always matched with understanding. General Motors Corporation spent more than \$40 billion on new technology in the 1980's. But a lack of understanding led to costly robot fiascos. In 1988, robots at the Hamtramck Michigan plant wreaked havoc - smashing windows and painting one another.

The premature introduction of robotics created financial instability. The robotics industry has only recently regained mid-1980 revenue levels. The American robotics market disappeared as Japanese and European bought up companies (Anonymous, 2013).

2.3.3. Mobile Robots and Vehicles

A mobile robot is a machine which has a capable of moving. Different types of robots are manufactured and their purposes are variable. Mobile robots have the capability to move around in their environment and are not fixed to one physical

location. Mobile robots can be autonomous which means they are capable of navigating an uncontrolled environment without the need for physical or electro-mechanical guidance devices.

Mobile robots may be classified by:

The environment in which they travel:

- Land or home robots are usually referred to as Unmanned Ground Vehicles (UGVs). They are most commonly wheeled or tracked, but also include legged robots with two or more legs (humanoid, or resembling animals or insects).
- Delivery and Transportation robots can move materials and supplies through a work environment
- Aerial robots are usually referred to as Unmanned Aerial Vehicles (UAVs)
- Underwater robots are usually called autonomous underwater vehicles (AUVs)
- Polar robots, designed to navigate icy, crevasse filled environments
- Urban Robots
- Autonomous Robots

The device they use to move, mainly:

- Legged robot: human-like legs (i.e. an android) or animal-like legs.
- Wheeled robot.
- Tracks.

We will give some information and examples for UAV, AUV, Urban Robot, Unmanned Ground Vehicles and Autonomous Robots.

2.3.3.1. Unmanned Aerial Vehicles

An unmanned aerial vehicle (UAV), commonly known as a drone, as an unmanned aircraft system (UAS), and also referred by several other names, is an aircraft without a human pilot aboard. The flight of UAVs may be controlled with various kinds of autonomy: either by a given degree of remote control from an operator, located on the ground or in another vehicle, or fully autonomously, by onboard computers (Anonymous, 2009).

The aerial robots vary in design from fixed wing airplanes, to conventional helicopters, (Mike, 2009) to ducted fans, to airships, and beyond to bizarre hybrid creations.

Aerial robots must be unmanned and autonomous, and must compete based on their ability to sense the semi-structured environment of the competition arena. They may be intelligent or preprogrammed, but they must not be controlled by a remote human operator. Computational power need not be carried on the air vehicle itself. Computers operating from standard commercial power may be set up outside the competition arena boundary and uni- or bi-directional data may be transmitted to/from the vehicles in the arena. Size or weight constraints are normally placed on the aerial robots, which must be equipped with a method of manually activated remote override of the primary propulsion system (Anonymous, 2009).

In Figure 2.45, there is an example of unmanned aerial vehicle. It is called ANKA is developed by Turkish Aerospace Industries for the requirements of Turkish Armed Forces. ANKA flies every weather conditions and also night and observes surface of earth and has got ability take a picture from surface with good quality.

Some of characteristics of ANKA:

- Powerplant: turbocharged four-cylinder engine, 155 hp(114 KW)
- Maximum Speed: 135 mph(117 knots, 217 km/h)
- Range: 4896 km(3024 mil)
- Endurance: 24 hours with 200 kg useful payload

- Service Ceiling: 30.000 ft (9.144 m) (Anonymous, 2012)



Figure 2.45. ANKA, is an unmanned aerial vehicle developed by Turkish Aerospace Industries for the requirements of Turkish Armed Forces (Anonymous, 2012)

Another UAV is the some armed foces in useplane us an aerial robot that, armed with cameras, can fly over disaster areas and send back images that help responders search for bodies or survivors, make damage estimates, and determine the integrity of bridges and buildings. Robots can both store information on on-board discs and in some cases beam back both images and data to analysts (Anonymous, 2016).



Figure 2.46. “Maveric” is an UAV (Photo courtesy Texas A&M)

2.3.3.2. Unmanned Underwater Vehicles

Unmanned underwater vehicles (UUV), sometimes known as underwater drones,, are any vehicles that are able to operate underwater without a human occupant.



Figure 2.47. REMUS (front) is a UUV and belongs to The US Navy (Carafono, 2007)

The US Navy is currently creating unmanned vehicles to be used in oceanic warfare to discover and terminate underwater mines. For instance, the REMUS is a three-foot long robot used to clear mines in one square mile with 16 hours. (Carafono, 2007) This is much more efficient, as a team of human divers would need upwards of 21 days to perform the same task.

2.3.3.3. Urban Robots

A group of European companies and universities have collaborated to produce a series of multifunctional robots for urban hygiene tasks. With abilities ranging from door-to-door garbage pickup and transportation, to automated street cleaning



Figure 2. 48. Urban robots, DustCart and DustClean (Damir, 2009)

In Figure 2.48, robots recently demonstrated their skills at a station in the town of Atxuri, Portugal. The DustCart and the DustClean names are given them by their producer company. These robots are for use in unmanned garbage pickup and transportation, and automated street cleaning respectively.

The robots can control of the air quality thanks to embedded nitrogen dioxide, ozone and carbon monoxide sensors. The robot can warn if the levels are too high. The key idea is for pollution monitoring or even detection of poisonous gases.

Both robots incorporate a map of the surrounding environment which they can navigate safely, avoiding moving obstacles, thanks to a number of laser scanners and ultrasound sensors that detect them early and prompt the robot to figure out an alternative trajectory in real time (Damir, 2009).

2.3.3.4. Unmanned Ground Vehicles

An unmanned ground vehicle (UGV) is a vehicle that operates while in contact with the ground and without an onboard human presence. UGVs can be used for many applications where it may be inconvenient, dangerous, or impossible to have a human operator present. Generally, the vehicle will have a set of sensors to observe the environment, and will either autonomously make decisions about its behavior or pass the information to a human operator at a different location who will control the vehicle through teleoperation. Unmanned robotic systems are being actively developed for both civilian and military use to perform a variety of dull, dirty, and dangerous activities.



Figure 2.49. An Unmanned Ground Vehicle for Defence Industry (Anonymous, 2012)



Figure 2.50. An Unmanned Ground Vehicle for Israel Defense Forces to operate as part of the border security operations (Anonymous, 2012)

A remote-operated UGV is a vehicle that is controlled by a human operator via interface. All actions are determined by the operator based upon either direct visual observation or remote use of sensors such as digital video cameras. A basic example of the principles of remote-operation would be a remote controlled toy car.

There are a wide variety of remote-operated UGVs in use today. Predominantly these vehicle are used to replace humans in hazardous situations. Examples are explosives and bomb disabling vehicles. UGVs are also being used in Japan repairing nuclear reactors that are still emitting too much radiation to warrant a human presence.

UGVs are also being developed for peacekeeping operations, ground surveillance, gatekeeper/checkpoint operations, urban street presence, and to enhance police and military raids in urban settings. Furthermore, UGVs are now being used in rescue and recovery missions (Anonymous, 2012).

2.3.3.5. Autonomous Robots

An autonomous robot is a robot that performs behaviors or tasks with a high degree of autonomy, which is particularly desirable in fields such as space exploration, household maintenance (such as cleaning), waste water treatment and delivering goods and services. An autonomous robot may also learn or gain new knowledge like adjusting for new methods of accomplishing its tasks or adapting to changing surroundings.

An autonomous is essentially an autonomous robot that operates without the need for a human controller. The vehicle uses its sensors to develop some limited understanding of the environment, which is then used by control algorithms to determine the next action to take in the context of a human provided mission goal. This fully eliminates the need for any human to watch over the menial tasks that the autonomous robot is completing.

A fully autonomous robot may have the ability to:

- Collect information about the environment, such as building maps of building interiors.
- Detect objects of interest such as people and vehicles.
- Travel between waypoints without human navigation assistance.
- Work for extended durations without human intervention.

- Avoid situations that are harmful to people, property or itself, unless those are part of its design specifications
- Disarm, or remove explosives.
- Repair itself without outside assistance.

A robot may also be able to learn autonomously. Autonomous learning includes the ability to:

- Learn or gain new capabilities without outside assistance.
- Adjust strategies based on the surroundings.
- Adapt to surroundings without outside assistance.
- Develop a sense of ethics regarding mission goals.
- Autonomous robots still require regular maintenance, as with all machines.

One of the most crucial aspects to consider when developing armed autonomous machines, is the distinction between combatants and civilians. If done incorrectly, the robots deployment can be detrimental. This is particularly true in the modern era, when combatants often intentionally disguise themselves as civilians to avoid detection. Even if a robot maintained 99% accuracy, the number of civilian lives lost can still be catastrophic. Due to this, it is unlikely that any fully autonomous machines will be sent into battle armed, at least until a satisfactory solution can be developed.

Some examples of autonomous technology are:

In Figure 2.51, vehicle developed for the DARPA Grand Challenge. A quadruped robot, DARPA is being developed as a mule that can traverse difficult terrain for USA army.



Figure 2.51. DARPA is an autonomous robot. (Darpa Strategic plan, 2007)

Finally, from all these examples and Figure 2.52, mobile robots are used, developed and sold for defence industry oftenly.

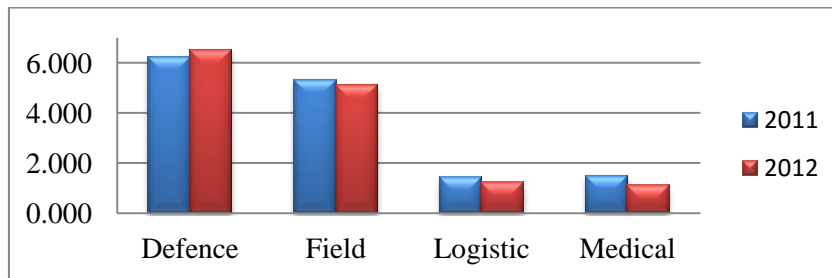


Figure 2.52. Mobile service robots sales of units for professional usage for 2011-2012 (Sucuoglu, 2015)

2.4. Compare Functional Blocks

When some robots design, engineers take an inspiration from human's behavior and movements. A functional block comparison between human beings and mobile robot (Chen et al., 2009) is given in Table 2.1.

Table 2.1. Functional block comparison between mobile robot and human being (Chen et al., 2009)

Functional Blocks	Human Beings	Robots
Intellectual	Brain	Microprocessor
Statue	Skeleton	Mechanical frame (airframe, chassis, hull)
Motivational	Limbs	Wheels, legs, tracks, propellers, grippers, etc.
Actuation	Muscles	Hydraulic, electric, pneumatic, piezoelectric, electrostatic actuators
Sensory (perception)	Eyes, ears, skin	Cameras, optic sensors, sonar, sound, infra-red light, magnetic fields, radiation, etc.
Communication	Speech, gesture	Data, image/video, sound
Energy	Food	Power source / energy storage

2.5. Design Process of Mobile Robots

The design process of the mobile robots can be categorized into three different parts;

1. Mechanical design
2. Electronics design
3. Software design

The mechanical part is divided into mechanisms and body design. Mechanisms are used to transform the actuator's motion. For example; the rotational movement of the motors can be changed to the translational one. The body is designed to protect the robot from environment and it gives totality to mobile system (Sucuoglu, 2015).

The electronics design can be two fold. Electronic parts (digital-analog and power electronic components) are employed to convert the software requests into actuator control signal and to scale, digitize the sensor signals. Actuators provide mobility to robot by converting the signal to the motion. Sensors measure the physical quantities from the environment and convert them into signal which is used for locomotion and monitoring.

The software design is divided into two parts. Mobile robot use high level software to carry out its mission and function autonomously. Low level software contains the basic motor functions such as steering and collision avoidance.

2.6 .Related Works (Gas Detection Robots)

Detection and localization of gas leaks in process industry and in particular in petrochemical industry is an important aspect of the inspection of industrial plants to prevent damages from people, environment and capital goods.

The inspection job could be mastered using autonomous mobile robot systems and novel infrared-based remote gas measurement devices in a timely and flexible way.

Therefore, employing such systems to inspect industrial sites is a logical step.

The objective of the project is to develop a robot prototype and the methods to detect gas leaks and to localize the corresponding leak under dynamically changing environmental conditions (e.g. varying wind ratios, obstructed carriage roads, etc.).

- Efficient strategies to detect gas clouds using remote-measuring systems.
- Strategies to localize gas leaks using remote-measuring systems.
- Methods for the decomposition, distribution and coordination of the inspection tasks for single- and multi-robot systems.
- Advancement of the existing simulator for single and multi-robot systems.
- Evaluation of measurement devices which are suitable to detect industrial gases and applicable to autonomous mobile-robot systems.

These and other questions will be solved, amongst others, using pattern recognition techniques, methods from the fields of artificial intelligence or methods based on models from nature.

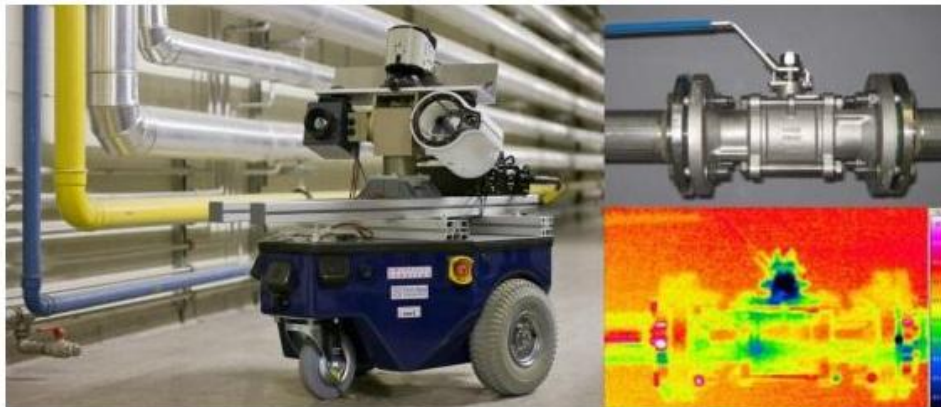


Figure 2.53. Example of Gas Detection Robot (Anonymous, 2012)

The planned strategies and test scenarios can be tested in the self-developed simulator.

These and other questions will be solved, amongst others, using pattern recognition techniques, methods from the fields of artificial intelligence (AI) or methods based on models from nature (bionics).



Figure 2.54. Example of Another Gas Detection Robot (MIT)

3. MATERIAL AND METHOD

In this section, it is important to give a warning before a disaster/accident occurs. The purpose of this thesis is to produce a prototype warning system that can measure gas leaks and give warning regarding the status of gas detection.

There are some gas detection systems available in the industry. These systems have pros and cons in different aspects. Our objectives are listed as follows:

1. To reduce the cost and time; the standardized available industrial components should be used.
2. The mechanical parts of the robot must be robust and able to carry payloads.
3. GDR velocity must be enough for using the robot in large areas.
4. The weight of the robot should be optimized. The weight affects the power consumption and balance directly.
5. Chasis dimensions must be selected carefully and must carry all parts of robot.
6. Energy requirement of the robot is an important parameter. Energy consumption is affected by dimensions, weight and motor selection directly. Thus, the components should be selected and designed as eco-friendly.
7. The programming of the robot should as accurately as possible so that understanding and changing will be easy.
8. Robot must detect gas more accuracy.

3.1. Mechanical Parts

3.1.1. Chasis of GDR

Chasis carry all equipments of robots. So it must be suitable design and material. Chasis has some specifications, these are:

1. Light weight

2. Easy machining
3. Resistant material
4. Good balance

Therefore, the material of the chasis was chosen as aluminum alloys. Chasis consisted of two parts. These two parts were assembled each other using screws. There are four DC gear motors and four transmission boxes between two sheet metals.



Figure 3.1. Chasis of GDR

Chasis of GDR, dimensions are chosen in Table 3.1. These dimensions are suitable for replacing all parts and components required for GDR.

Table 3.1. Dimensions of Chasis

Length	178mm
Width	135mm
Height	78mm

3.1.2. Traction Mechanism

Wheels are used at GDR because of its advantages. Also pallet can be used because of its advantages but we compare two of them and thought our system of robot requirements.

The advantages of the wheels

1. Wheel needs less power than pallet.
2. Better handling in dry conditions.
3. Wheels have low production cost and easy to use.
4. Wheels can reach high speeds.
5. Wheels usually lighter than the pallets.

3.1.3. Wheels

There are some traction mechanisms for vehicles available. One of them is using wheels. Wheels are chosen at GDR. After selection, the features of wheels must be defined. Then, material and size of wheel must be selected. Plastic material is used for the wheels and the diameter of wheel is 65 mm.



Figure 3.2. Wheel of GDR

Table 3.2. Details of the wheels

Diameter	65 mm
Width	10 mm
Motor connection hole diameter	6 mm

3.1.4. Steering Method

Kind of steering methods are used for vehicles or robots. Steering method affects the robot maneuverability or vehicles turning behaviours and angles. In this thesis, differential drive for steering is chosen.

Differential drive is generally used at mobile robots. A basic principle can be explained as follow: When wheels can be driven in the same direction and speed, the robot will go in a straight line. Wheels are turned equal speed in opposite directions, the robot will rotate about the central point of the axis. Differential drive is chosen for its low cost and simplicity.

The schematic view is for differential driving method is shown in Figure 3.3.

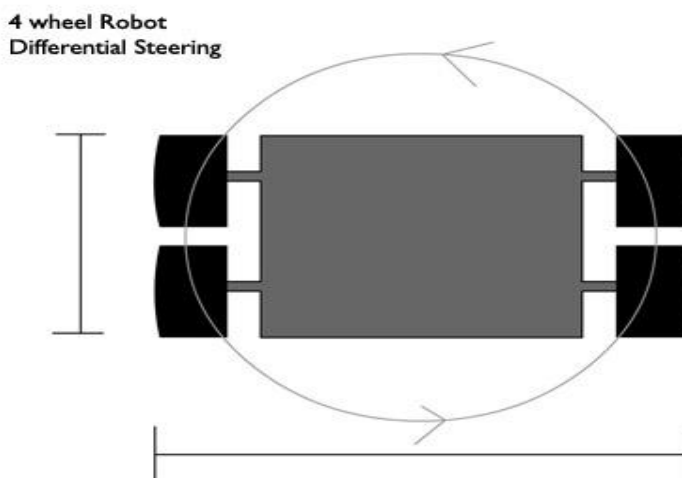


Figure 3.3. The schematic view is for differential driving method (Anonymous, www.rakeshmondal.info, 2014)

3.2. Requirements of Robot

The required power and torque for the robot motion is calculated. After the used motor set and battery unit are selected and explained.

3.2.1. Power Requirement Calculations

To find minimum required power, the maximum estimated total force and the desired speed must be known. The maximum total force is equal to sum of

resistance forces. The resistance forces are; gradient force, air force (assume as zero), rolling and inertial force which is equal to mass times acceleration.

$$F_{Total} = F_{gradient} + F_{air} + F_{rolling} + M_m \times a_{max} \quad (3.1)$$

Where:

F_{Total}	Maximum estimated total force
$F_{gradient}$	Gradient resistance force
F_{air}	Air resistance force
$F_{rolling}$	Rolling resistance force
M_m	Total mass of the gas detection robot platform
a_{max}	Maximum acceleration

The forces acting on the gas detection robot are described in Figure 3.4.

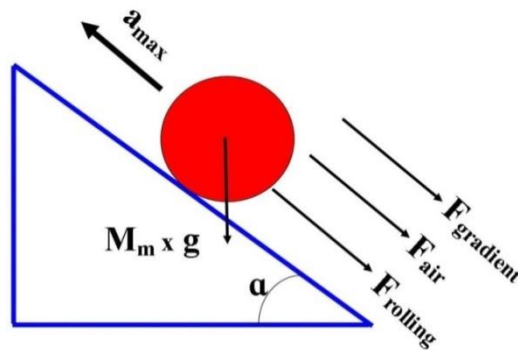


Figure 3.4. Resistance forces (Anonymous, 2012)

Gradient resistance force is the first calculated force. Gradient force is the component of the weight of the robot that is parallel to its path. The maximum force occurs when the robot climbs the maximum appointed angle. The maximum road angle is determined as 10° for this project. The estimated weight of the robot is 1,9 kilogram (Sucuoğlu, 2015).

The formula of the gradient resistance force is;

$$F_{gradient} = M_m + \sin a \times g \quad (3.2)$$

Where:

a	Angle of the slope that robot climbs
g	The acceleration of the gravity

The result of the (3.2) for 1.9 kilogram estimated robot weight and 10° slope is;

$$F_{gradient} = 1.9 \times \sin 10 \times 9.81 \approx 10.14 \text{ N} \quad (3.3)$$

The second calculated force is the rolling resistance force. The rolling resistance mainly changes due to the deformation of the road and surface of the wheel.

The formula of the rolling resistance force is;

$$F_{rolling} = f_r \times W \quad (3.4)$$

$$W = M_m \times \cos a \times g \quad (3.5)$$

Where:

f_r	Coefficient of the rolling resistance
W	Wheel load

The rolling resistance surface mainly depends on the rolling resistance coefficient and the slope angle that gas detection robot operates. The rolling resistance coefficient (Naunheimer et al., 2011) is selected from the Table 3.3.

Table 3.3. Coefficient of rolling resistance (Naunheimer et al., 2011)

Road surface	Rolling resistance coefficient (f_r)
Smooth tarmac road	0.010
Smooth concrete road	0.011
Rough, good concrete surface	0.014
Good stone paving	0.020

Bad, worn road surface	0.035
Soil	0.070-0.240
Loose sand	0.150-0.300

Rolling resistance coefficient is specified as 0.020 from the table. Using the formula (3.4) and selected coefficient; the rolling resistance force is calculated as:

$$F_{rolling} = f_r \times W = f_r \times \cos a \times g = 0.020 \times 1,9 \times \cos 10^\circ \times 9.81 \approx 0.3 \text{ N} \quad (3.6)$$

The last resistance force comes from the acceleration. It is assumed that the gas detection robot has an acceleration of 0.3 m/s^2 at the maximum power required condition. The total resistance force can be found with the results of the equations (3.3), (3.4), maximum acceleration value and the determined mass of the robot.

$$F_{Total} = F_{gradient} + F_{air} + F_{rolling} + M_m \times a_{max} = 10.14 + 0 + 0.3 + 1.9 \times 0.3 \quad (3.7)$$

$$F_{Total} = 11.01 \text{ N} \quad (3.8)$$

After the calculation of the total resistance force, the required power output of the robot can be calculated by multiplying the total resistance force with maximum operational speed of the gas detection robot. The required power is calculated as:

$$P_M = F_{total} \times V_{max} \quad (3.9)$$

Where:

P_M Required power output of the motor

V_{max} Maximum speed of the robot

Speed for the gas detection robot is determined in the range of 0.2 m/s and 0.6 m/s. For the power calculation, the maximum speed value is assumed as 0.6 m/s. With the equation (3.9) required power is calculated as:

$$P_M = F_{total} \times V_{max} = 11.01 \times 0.6 = 6.6 \text{ W} \quad (3.10)$$

We designed our robot with four steered wheels. So the calculated power requirement value is for four motors in our application. As a result, the power requirement of a single wheel is about 1.65 W.

3.2.2. Torque Requirement Calculation

The torque requirement is another important parameter to select the proper motors. Total weight and diameter of the wheels must be known to calculate torque requirement. The selected wheels have 65 mm diameters.

The formula of the torque requirement is;

$$T = [M_m \times g \times (\sin a + f_r) \times d] / 2 \quad (3.11)$$

Where:

T The torque of the axis

d The wheel diameter, in meter

The result of the (3.11) for 1.9 kilograms estimated robot weight and 10° slope is;

$$T = [M_m \times g \times (\sin a + f_r) \times d] / 2 =$$

$$[1.9 \times 9.81 \times (\sin 10^\circ + 0.020) \times 0.065] / 2 \approx 0.31 \text{ Nm} \quad (3.12)$$

3.2.3. Motor Selection

The motor rotates at 100 rev / min and powered with 12V DC. The rated power is 32 W with a torque of 2.6 Nm. Maximum power requirement of single motor was calculated about 0.66 W and torque requirement was about 0.053 Nm. The technical properties of the motor can easily satisfy the robot's power and torque requirements. Selected motor is shown in Figure 3.5.



Figure 3.5. 12 volt 120 rpm DC motor

As mentioned before, our maximum speed expectation is 0.5 m/s. The relation between the angular velocity and linear velocity can be calculated as;

The formula of the relation is:

$$V_{max} = r \times w \times 0.10472 \quad (3.13)$$

Where:

r The radius of the wheel

w Angular velocity of the motor, in RPM (Rounds per minute)

$$V_{max} = r \times w = 0.045 \times 120 \times 0.10472 = 0.566 \text{ m / s} \quad (3.14)$$

The calculated velocity of the motor can satisfy our speed expectation from the robot.

3.2.4. Energy Supply

GDR needs energy to make its mission. 3 pieces connected in parallel 9 V Alkaline battery is used for GPS module, gas sensor and Arduino board.



Figure 3.6. 9V Alkaline battery

10400 mAh Power Bank recharge battery was used for camera of robot (Table 3.4). It has got 1 micro USB port input and 2 USB 2.0 port outputs.

Table 3.4. Specifications of 10400 mAh Battery

Capacity	10400 mAh
Size	88,8mm x 44,3mm x 44,3mm
Input	DC 5V/2A
Output 1	DC 5V/1A
Output 2	5V/2A
Weight	241g
Interface	1 Micro USB port, 2 USB 2.0 ports



Figure 3.7. 10400 mAh recharge battery for IP camera

12 V, 1.3 Ah rechargeable dry type battery is used for 4 DC motor.



Figure 3.8. LiPo battery unit

3.3. Wireless IP Camera

Wireless IP Camera is used to see environment and see what happens around the robot. It mounted front of chasis. Using wireless IP camera, controller can see around of robot on computer screen, then remote control to move every way the robot from computer keyboard. Also camera can move its lens and look different views and has got a night view.



Figure 3.9. Wireless IP camera

Table 3.5. Specifications of Wireless IP Camera (Data Sheet)

PC client	Install program to computer, view 16 cameras in LAN or from internet, recording, snapshot, 2 way audio available, Multi-language.
TF Card Record	Support 32G TF card.
Lens Type	Glass Lens Standard: 3.6 mm
Image Compression	MJPEG
Image Frame Rate	25fps

Resolution	640 x 480(VGA), 320 x 240(QVGA)
Flip Mirror Images	Vertical / Horizontal
Video Parameters	Brightness, Contrast
Night Visibility	13 Φ 5 IR LEDs, Night visibility up to 10 meters
Audio Input / Output	Built-in Microphone and Speaker, Two way audio
Audio Interface	Audio IN / Audio Out
Rotation Angle Pan:	270°, Tilt: 90°
Rotation Speed	10 Level PT Speed Optional, Speed Range 5-50°/Second
Preset	Support 16 Preset Positions
Network	Ethernet One 10/100Mbps RJ-45
IP Mode	Dynamic IP address, static IP address
Online Visitor	Support 4 visitors at the same time
Wireless	Wireless Standard IEEE 802.11b/g/n
Wireless Security	WEP, WPA, WPA2 Encryption
Power	DC5V 2A
Working Temperature	-10~50 °C
Working Humidity	95% RH
Size	Item Size: 112 mm x 98 mm (HxW)
Weight	290g

3.4. GPS Module

GPS (Global Positioning System) is in any unobstructed line of sight in the world, four or more satellites and in all weather conditions by providing space-based satellite navigation was time information system.

GPS module was used to see location of robot.GPS module with high quality and precision, often used in projects that require location information by GPS. It has a sensitivity of about 5 meters.



Figure 3.10. GPS module

3.5. Gas Sensor

Project of GDR aims to detect combustible gases like propane (C_3H_8) detect when it moves and before disaster give a warning. Using a gas sensor is necessary for this project. Pololu MQ-9 model gas sensor (Anonymous, 2013) shown in Figure 3.11 as a smoke sensor in the system.

The developed probe sampling system for semiconductor gas sensor. In conventional applications the most important parameter of chemical sensors is the accuracy of measurement of gas concentration. On the contrary, in mobile robotics applications the key parameters for sensors analyzing the robot environment are:

sensitivity to tested chemical, detection the hold, and time of reaction to changes of gas concentration.

Sensitive material of MQ-9 gas sensor is SnO_2 , which with lower conductivity in clean air. It make detection by method of cycle high and low temperature, and detect CO when low temperature (heated by 1.5V). The sensor's conductivity is more higher along with the gas concentration rising. When high temperature (heated by 5.0V), it detects Methane, Propane etc combustible gas and cleans the other gases adsorbed under low temperature.

MQ-9 gas sensor has high sensitivity to Carbon Monoxide, Methane and LPG. The sensor could be used to detect different gases contains CO and combustible gases, it is with low cost and suitable for different application.



Figure 3.11. MQ-9 gas sensor

The gas sensor of MQ-9 basic test loop is shown in Figure 3.9.

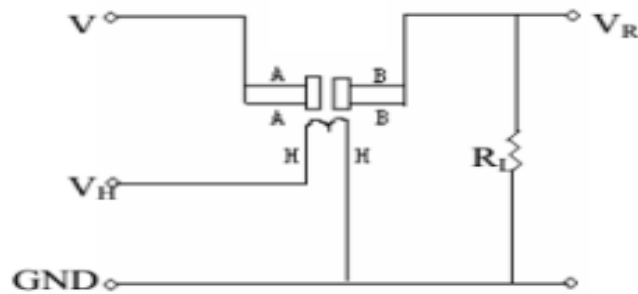


Figure 3.12. Basic test loop of gas sensor (Data sheet of MQ-9 gas sensor)

Character of MQ-9 gas sensor

- Good sensitivity to CO/Combustible gas
- High sensitivity to Methane, Propane and CO
- Long life and low cost
- Simple drive circuit

Application of MQ-9 gas sensor

- Domestic gas leakage detector
- Industrial gas detector
- Portable gas detector

Configuration of MQ-9 gas sensor

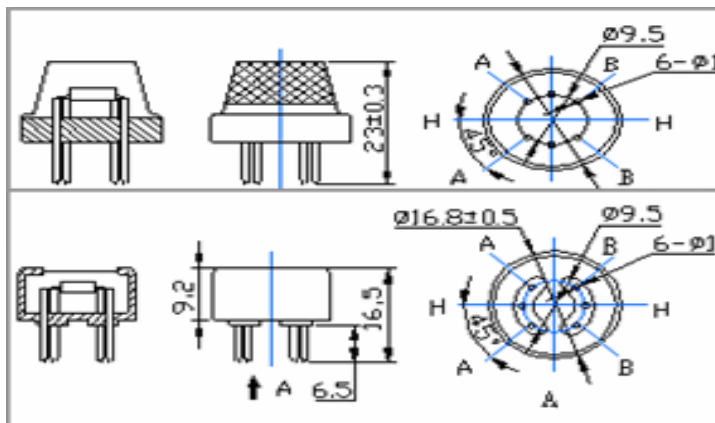


Figure 3.13. Configuration of MQ – 9 gas sensor (Data sheet of MQ-9 gas sensor)

Table 3.6. The technical features of the MQ-9 gas sensor are (Anonymous, 2013)

Model No	MQ-9
Sensor Type	Semiconductor
Standard Encapsulation	Bakelite
Detection Gas	CO and combustible gas
Concentration	10-1000ppm CO, 100-10000ppm combustible gas
Load Resistance RL	Adjustable
Heater consumption	PH \leq 350mW
Sensing Resistance Rs	2K Ω -20K Ω (in 100ppm CO)
Sensitivity S	Rs(in air)/Rs(100ppm CO) \geq 5

The MQ-9 sensor was used with Pololu Carrier board (Anonymous, 2013) shown in Figure3.11. This board simplifies the interface from 6 pins to 3 pins. Three pins are; ground, power and analog voltage output. Board has two mounting holes and provides convenient pads for mounting the sensor's required-setting resistor.

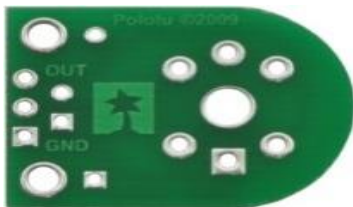


Figure 3.14. Carrier board

3.6. Gas Detection Robot Platform Configuration

As mentioned before, aluminum material were chosen to build carrier board of the robot. Motors, battery unit and data acquisition and control circuits were mounted to aluminum layer of the carrier board. IP camera were mounted to front side of the carrier board.

Table 3.7. Names and functions of the components

Number	Name	Function
1	Chassis	Carrier board was used to carry components of robots such as batteries, camera, electronic circuits.
4	Motor	DC motor was selected. It was used for differential steering system of the robot.
5	Motor-wheel connector	Motor-wheel connector was used for motor wheel connection. Bolts are used for assembly.
6	Wheel	Four pieces of wheels were used as steering wheel in the system.
7	Batteries	3 different kind of batteries was used for motors, cameras and electronic circuits, sensors.
8	GPS	GPS module was used to see location of robot.
9	Motion control unit	Motion control card was designed and produced to control the brushed DC motors.
10	Gas detection sensor	There is one gas detection sensor used. It's mission is detect gas.

3.7. Software of GDR

Software is a brain at this project. Without software, GDR is not able to move or to do something. So it is really important part of robot. C Sharp and Arduino programs are used for GDR.

3.7.1. Arduino

Arduino is an open source electronics platform based on easy to use hardware and software. It is intended for anyone making interactive projects. Arduino hardware is Arduino board.

Arduino senses the environment by receiving inputs from many sensors, and affects its surroundings by controlling lights, motors and other actuators.

Arduino software; we can tell Arduino what to do by writing code in the Arduino programming language and using the Arduino development environment.

User community that designs and manufactures microcontroller based kits for building digital devices and interactive objects that can sense and control the physical world.

The project is based on a family of microcontroller board designs manufactured primarily by SmartProjects in Italy, and also by several other vendors, using various 8-bit Atmel AVR microcontrollers or 32-bit Atmel ARM processors. These systems provide sets of digital and analog I/O pins that can be interfaced to various expansion boards ("shields") and other circuits. The boards feature serial communications interfaces, including USB on some models, for loading programs from personal computers. For programming the microcontrollers, the Arduino platform provides an integrated development environment (IDE) based on the Processing project, which includes support for C, C++ and Java programming languages.

The first Arduino was introduced in 2005, aiming to provide an inexpensive and easy way for novices and professionals to create devices that interact with their environment using sensors and actuators. Common examples of such devices intended for beginner hobbyists include simple robots, thermostats, and motion detectors.

Arduino boards are available commercially in preassembled form, or as do-it-yourself kits. The hardware design specifications are openly available, allowing the Arduino boards to be manufactured by anyone.

3.8. Electronic Circuits- Hardware

3.8.1.Main Board

Arduino UNO R3 programmable platform is selected for GDR is used control the robot.

Arduino Uno is a microcontroller board based on the ATmega328P. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started (Anonymous, 2015).



Figure 3.15. Arduino UNO R3 programmable platform

Table 3.8. Technical Specs of Arduino UNO R3 (Data sheet of Arduino UNO R3)

Microcontroller	ATmega328P
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limit)	6-20V
Digital I/O Pins	14 (of which 6 provide PWM output)
PWM Digital I/O Pins	6
Analog Input Pins	6
DC Current per I/O Pin	20 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	32 KB(ATmega328Pof which 0.5 KB used by bootloader)
SRAM	2 KB (ATmega328P)
EEPROM	1 KB (ATmega328P)
Clock Speed	16 MHz
Length	68.6 mm
Width	53.4 mm
Weight	25 g

3.8.1.1. Microcontrollers

A microcontroller is a small computer on a single integrated circuit containing a processor core, memory and programmable input/output peripherals. The program can be stored in ROM (read-only memory) or Flash memory. Microcontrollers are low-power devices, consume about 50 miliwatts.

Code is developed for reading the digital compass, and also a pid controller is implemented to drive the motors. On the other hand, a library is created in Microsoft Visual Studio using C#. This library is used to communicate with the robot platform and to use it. The structure of the robot allows the user to attach any kind of sensor to the platform. A researcher will no longer spend time on low level implementation of the modules. Researchers will use the implemented serial protocol and high level function library and spend time on developing robotic algorithms.

Codes of GDR is given in Appendix. Which code used for what, it is written above or under the codes in Appendix.

The mapping for the Atmega 168 is shown as below.

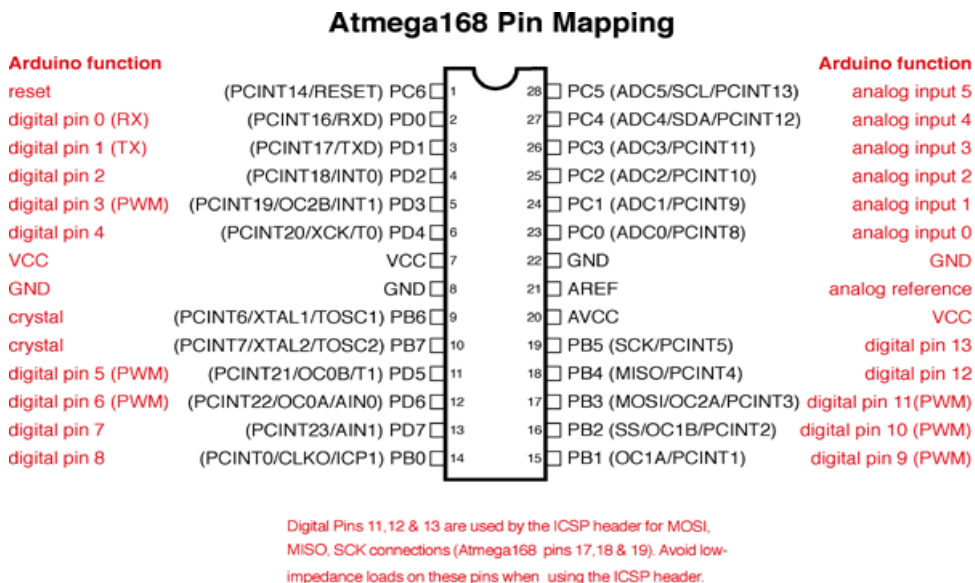


Figure 3.17. Pin Mapping for Atmega 168 (Anonymous, 2015)

3.8.2. DC Motors Control Unit

Motor driver shield is used for project's DC motor control unit. It was designed to control the speed and the direction of the rotation of the motors. This motor driver shield control 4 DC motor independently.



Figure 3.18. DC motor control unit

3.8.3. Wireless Antenna for Wireless Communication

Wire antenna is used for communicate with Modem take the commands from computer and at the same time send a signal (carry information, for example gas sensor values) to modem and modem send to computer. For this project, RN-XV WiFly Module is selected for communication in Figure 3.15.

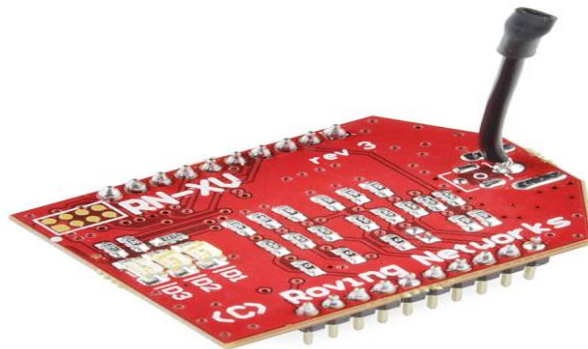


Figure 3.19. Wireless Antenna for wireless communication

The RN-XV module is based upon Roving Networks' robust RN-171 Wi-Fi module and incorporates 802.11 b/g radio, 32 bit processor, TCP/IP stack, real-

time clock, crypto accelerator, power management unit and analog sensor interface. The module is pre-loaded with Roving firmware to simplify integration and minimize development time of your application. In the simplest configuration, the hardware only requires four connections (PWR, TX, RX and GND) to create a wireless data connection (Anonymous, 2016).

Features:

- Based on common 802.15.4 XBee footprint
- Ultra low power: 4uA sleep mode, 38mA active
- Onboard TCP/IP stack includes DHCP, UDP, DNS, ARP, ICMP, HTTP client, FTP client and TCP
- Firmware configurable transmit power: 0dBm to 12dBm
- Hardware interfaces: TTL UART
- Host data rate up to 464Kbps over UART
- Supports Adhoc and infrastructure networking
- 8 general purpose digital I/O
- 3 analog sensor inputs
- Real-time clock for time-stamping, auto-sleep, and auto-wakeup modes
- Accepts 3.3VDC regulated power supply
- Wireless antenna

3.9. Notebook Computer

A notebook computer is needed for writing codes, using C sharp and control the robot from remote. Almost all notebooks and desktop computers which they have minimum requirements, they are enough for run writing code programs and control the robot. In Figure 3.16 show us we used this notebook computer at this project.

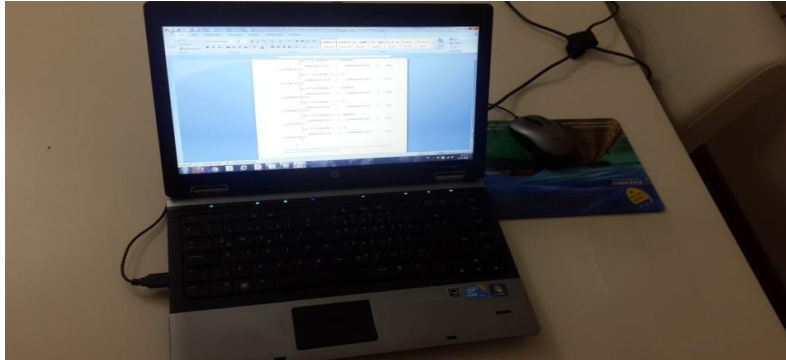


Figure 3.20. A notebook computer

3.10. Modem for Communication

To introduce a modem (modulator-demodulator) is a network hardware device that modulates one or more carrier wave signals to encode digital information for transmission and demodulation that demodulates signals to decode the transmitted information. The main aim is to produce a signal that can be transmitted easily and decoded to reproduce the original digital data. Modems can be used with any means of transmitting analog signals, from light emitting diodes to radio. A common type of modem is one that turns the digital data of a computer into modulated electrical signal for transmission over telephone lines and demodulated by another modem at the receiver side to recover the digital data.

For this project Air 5650 is used as a modem for wireless communicate between computer and robot in Figure 3.17.



Figure 3.21. A modem for Communication

3.11. Equipments of Test Requirements

GDR is tested in this chapter of thesis. To see its functions how will work and give us how accured values. Also making a test, give a chance to improve GDR much more. To ensure suitable condition, except robot, some equipments are needed, too while making a test. These are:

1. An airproof testing room, is for making a test in a closed section.
2. A gas tube, is for gas injecting to testing room.
3. Gas supply installation

3.11.1. Airproof Testing room

Gases can move fast to somewhere on the air. It is disadvantage for our test. Gases must be constant in certain area. So we decided to make test in somewhere which have airproof, fireproof, non interaction material and its measurements are constant and measurable. It can be a prefab, use prefabricated structural

component. As below measurement of airproof testing room are given in Figure 3.18.



Figure 3.22. A prefab for gas testing room

3.11.2. Gas Tube

The gas sensor can detect CO, methane, propan and some compustible gases. At this test, GDR will try to detect propan gas. The gas tube must use for storing propone. At below gas tube is given Figure 3.19.



Figure 3.23. Propane (C_3H_8) tube

3.11.3. Gas Supply Installation

Some pipes are used for moving gas from gas tube to airproof testing room. These pipes must be stiffness in compression. Other parts of gas supply installation are valves. Valves are selected suitable resistance under pressure and suitable diameter when assembling with pipes. In Figure 3.20 and Figure 3.21 show us gas supply installation.



Figure 3.24. Gas Supply Installation with gas tube



Figure 3.25. Gas supply Installation

A regulator was used to control pressure of gas tube. In Figure 3.22, show us pressure on analog display.



Figure 3.26. A regulator for controlling pressure of gas

4. RESULTS AND DISCUSSIONS

The test of the manufactured robot platform is discussed in this section. The tests are conducted in prefab for trying to catch real conditions. A sample picture of the manufactured robot platform can be seen in Figure 4.1.



Figure 4.1. A simple picture from GDR

If we compare GDR between one of design of rescue robots for mining industry, some similarities and differences will be seen. Before we must understand why rescue robot are needed for saving operations. Underground mining is beset with numerous problems such as ground movement (fall of roof/sides), inundation, air blast, etc.; apart from gas explosions and dust explosions that are restricted to coal mines. Whatever may be the cause and type of accident or the extent of damage caused, it is a horrendous task for the rescue team to reach the trapped miners. The accident/ irrespirable zone contains increased levels of harmful gases like carbon dioxide and carbon monoxide and explosive gases like methane apart from a deficiency of Oxygen. The entire gallery or roadway is filled with dust and smoke, or water in case of inundation, hindering the visibility of rescue personnel. Thus, it is not an ideal situation for the rescue team to perform the operations. The first few hours after the disaster are the critical moments that could be the difference

between life and death of the trapped miners. Hence, the ideal solution in such cases would be to deploy a wireless robot equipped with various gas sensors and cameras to aid visibility even in extremely low light conditions. These are similarities to our project. Differences are seen about GPS and wheels. Manufactured robot has got GPS sensor for finding position of robot. But rescue robots don't have got it. Rescue robots's wheels are designed more improved for rough terrain such as for big stones. As a result, rescue robots can used in closed areas such as mining industry without GPS but with developed wheels. The gas detections robots are used for both of open and closed areas. But GPS will work just open areas correctly, such as between the oil refiner pipes. Otherwise is possible to GPS won't work in closed areas. On the other hand, GDR's wheels are not so big and developed so it can move a road with a good quality surface.

4.1. Gas Detection Test

This test includes a gas detection based on distance test. The gas detection ability of GDR was tested using propan in testing room. Before the test, all necessary safety precautions were taken. GDR was put in testing room far away from 50cm, 100cm, 150cm and 200cm the one side of wall which is haven gas outlet. After energy was given to GDR. When researchers were left from testing room, no one wasn't been in testing room. The door was closed, well. The computer and program was opened and controlled for test. When the computer were ready, valves were opened for gas transfer. Regulator was set for pressure of gas storage. Finally test was began.

Before test results, we must know some information about atmosphere in Table 3.9. and propane (C_3H_8);

Table 3.9. Major constituents of dry air, by volume (Anonymous, 2016)

Gas		Volume	
Name	Formula	in ppm	in %
Nitrogen	N ₂	780,840	78.084
Oxygen	O ₂	209,460	20.946
Argon	Ar	9,340	0.9340
Carbon dioxide	CO ₂	397	0.0397
Neon	Ne	18.18	0.001818
Helium	He	5.24	0.000524
Methane	CH ₄	1.79	0.000179

Propane (C₃H₈) is a three-carbon alkane with the molecular formula (C₃H₈), a gas, at standard temperature and pressure, but compressible to a transportable liquid. A by-product of natural gas processing and petroleum refining, it is commonly used as a fuel for engines, oxy-gas torches, portable stoves, and residential central heating. Propane (C₃H₈) is one of a group of liquefied petroleum gases (LPG gases). Physical properties of propane is given as below.

Table 3.10. Physical Properties of Propane (C₃H₈)

Chemical Symbol	C ₃ H ₈
Atom/Molekuler weight (g/mol)	44.096
Compressibility Factor (Z) (15°C & 1.01325 bar)	0.9821
Water Solubility (1.013 bar 0°C) volumetric	0.039
Limit of Combustion in air (%)	2.2- 9.5
Melting Point (0°C)	-187.7
Normal Boiling Point (0°C) 1.01325 bar'da	-42.1
Density g/lt(15°C & 1.01325 bar	1.895
Specific gravity (15°C & 1.01325 bar)	1.547
Critical Temperature (0°C)	96.7
Critical Pressur (bar)	42.6
Critical Density (kg/m ³)	218
Viscosity- Liquid (cp) (Normal Boiling point)	0.196
Viscosity- Gas(cp) (15°C & 1.01325 bar)	0.0079

4.1.1 Gas Detection Test Based on Distance

The aim of this test was to determine the gas detection capability of the system when it works on patrolling task with 0.5 m/s speed and immobile. While robot was immobilizing and moving, the efficiency of the sensors was experimented. The reaction of the gas detection unit was investigated while robot was tracking its path and gas source was within detection range of GDR.

In Figure 4.3 chart is shown for speed test of GDR.

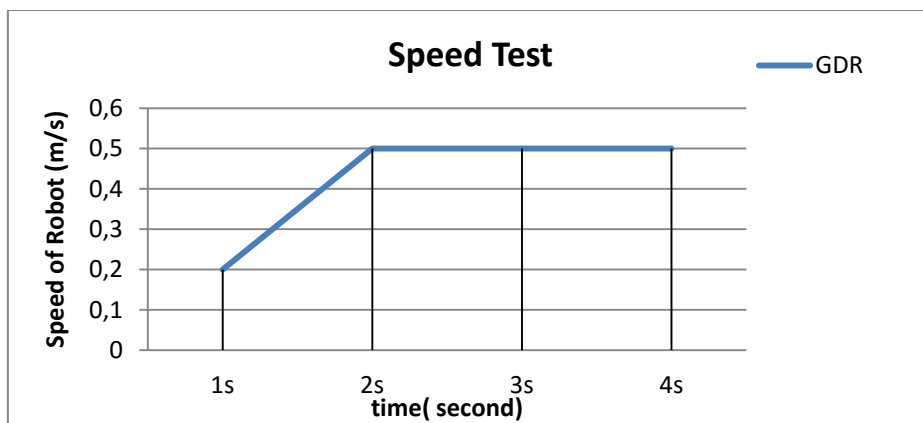


Figure 4.3. Speed test for GDR

Gas source is propane's behavior is investigated under standart conditions. During test, temperature and humidity is constant. In Figure 4.4 show us influence of temperature/humidity in 20 °C, $R_s/R_o \approx 1$.

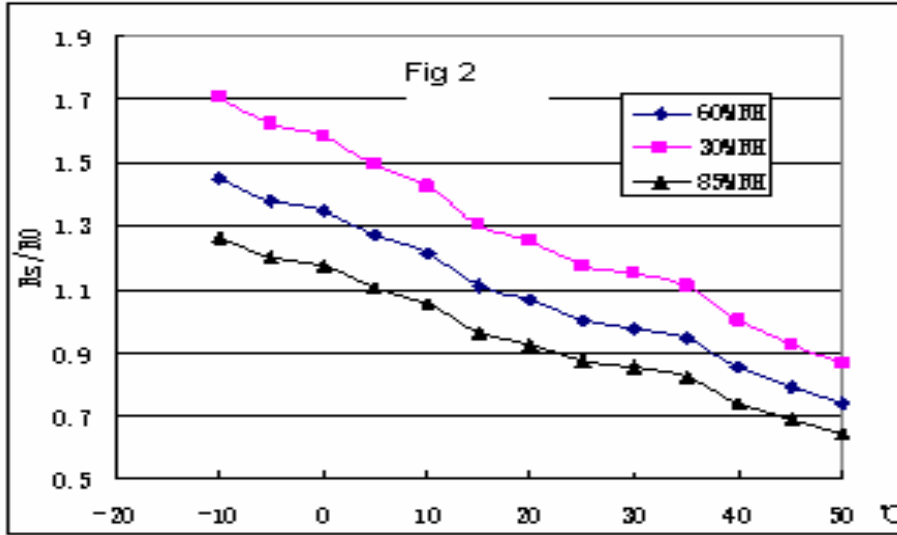


Figure 4.4. Influence of temperature/humidity

Figure 4.4 shows the typical temperature and humidity characteristics. Ordinate means resistance ratio of the sensor (R_s/R_0), R_s means resistance ratio of the sensor in 1000 ppm propane under different temperature and humidity. R_0 means resistance of the sensor in environment of 1000ppm Propane, 20°C/65%R.

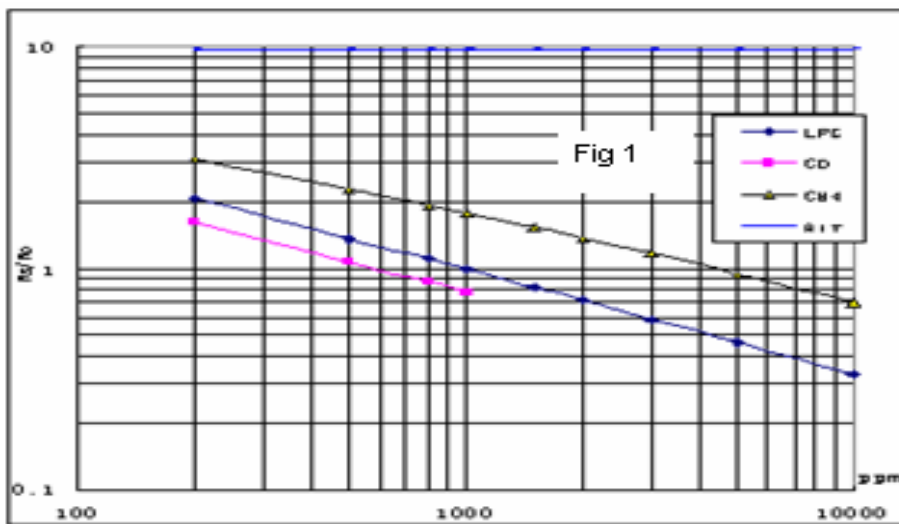


Figure 4.5. Sensitivity characteristics

Figure 4.5 shows the typical sensitivity characteristic of the MQ-9 gas sensor, ordinate means resistance ratio of the sensor (R_s/R_o), abscissa is concentration of gases. R_s means resistance in different gases, R_o means resistance of sensor in 1000ppm LPG. All test are under standard test conditions.

$R_s/R_o \approx 1$ is founded from Figure 4.3. If we look LPG (blue line), concentration of propane is seen between 900 ppm and 1000 ppm from Figure 4.4.

We think that gas detection sensor has a ability to detect gas from certain distance. Gas sensor can give us different values from different distances. We will learn with this test this idea is true or not.

Striplines were drawn in testing room. There is 50 cm between every striplines Figure. 4.7. Each stripline was measured via tapemeter shown in Figure 4.6. Then the distance between robot and gas outlet (from wall, vertically) were measured. GDR was tested every stripline path in Figure 4.8.



Figure 4.6. Between every striplines



Figure 4.7. Striplines are located in testing room



Figure 4.8. GDR in testing room

Propan is given to testing room slowly in 20 seconds. After the gas concentration is changed and increased to upper limit and after didn't changed, stayed constant. Figure 4.9 shows the changes of concentration for the propane (C_3H_8).

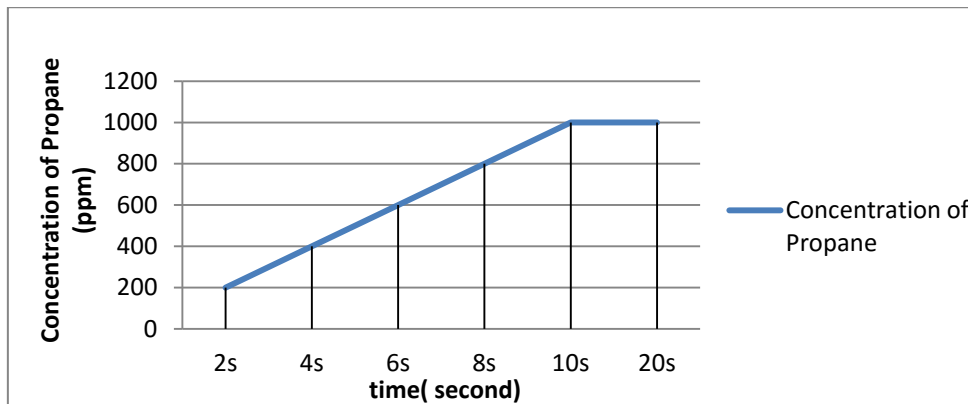


Figure 4.9. Concentration of propane (C_3H_8) changes based on time

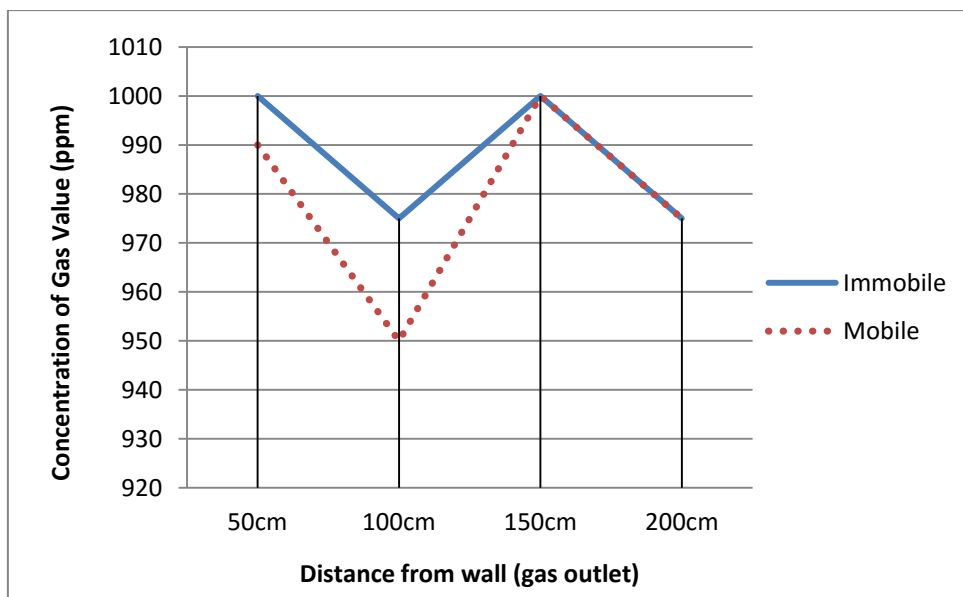


Figure 4.10. Concentration of propane (C_3H_8) based on distances from gas outlet

Then we compared the gas sensor results with the given set point. In Figure 4.10 show us, to be an immobile position and a mobile position give us almost same values between 950 ppm - 1000ppm. Test results are same MQ-9 gas sensor behaviour for propane.

All positions (mobile or immobile) give the same message to us. If robot goes far away, gas sensing value is almost don't change. Because temperature and humidity effect the concentration of gas. This test made in airproof testing room. So propane didn't have a chance to move so much, just can move in small volume and it doesn't change values so diffirent, just small diffirences we can realize.

Sensor outputs were compared for both immobile and mobile situations. It was observed from the tests that gas sensor could detect the gas outlet from 0-200 cm the wall. It means that sensor could sense the combustible gas in the path specified. As a result, gas detection robot could satisfy the gas detection requirements while it was executing the patrolling task. The system performance is demonstrated.

4.2. GPS Test

GPS gives coordinates and locates where the robot is on the earth using satellites. In this test, GPS was working and showing from map when the robot moved. But, if GDR works in a closed area, it won't work because of the coverage. Finally, GPS finds the position of robot. Figure 4.11 shows the position of robot in the map.



Figure 4.11. Control panel while GPS is working

4.3. The Camera Test

The Wireless IP camera was used by an operator while the robot was moving. The camera used in this system is able to monitor for all directions with a wide range of angles. The camera can produce with an acceptable quality of images. The resolution of IP camera was 640x480. To sum up, the IP camera has been successfully implemented. Figure 4.12 depicts the control panel of IP camera in operation and the image captured.

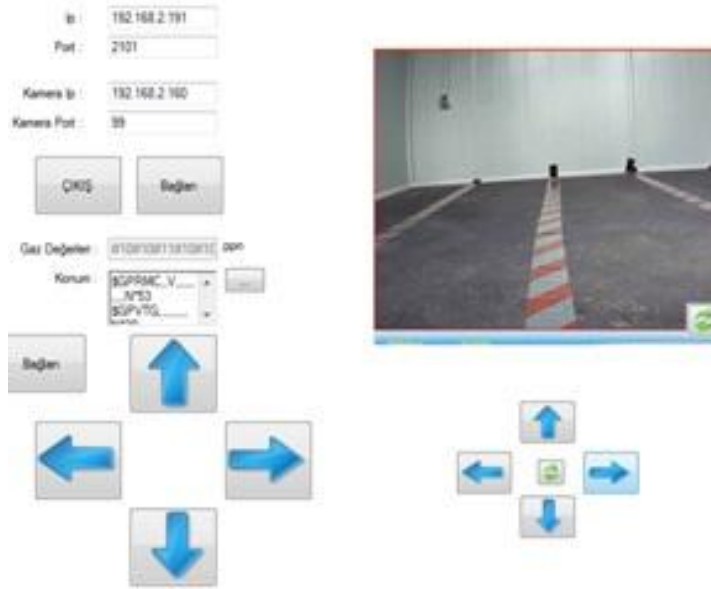


Figure 4.12. Control panel while IP camera is working

5. CONCLUSIONS

This thesis is about the design and production of a gas detection mobile robot which can operate especially in industrial areas. This system will produce a solution for the gas detection application in industries and houses where it has high risks for safety measures.

The goal of the project was to develop a mobile gas detecting system. Such a robot has real world applications that will allow us to keep people out of dangerous areas. For these aims, the functionality of the mobile gas detection robot has been tested in an airproof testing room. These tests include IP camera test view, gas sensor ability and gas detection based on distance. The gas sensing function was achieved by the gas sensor. The IP camera and computer controlled based gas detection mobile robot has been successfully implemented.

The budget of this thesis project was limited and advanced manufacturing parts, sensors and hardware cannot be used, so the robot was produced using low-cost components that could be found in any electronic shops. Despite the low-cost production, gas detection robot passed the functions tests successfully. It executed the patrolling task easily, passed the IP camera test and gas detection test, detected the gas source from zero point to 200 cm for stationary mode and mobile mode.

GDR, a prototype and low cost gas detection robot platform can be used for educational research purposes. GDR can be manufactured as a prototype robot for gas detection.

Robot industry in Turkey and in the world is developing rapidly. Researchers usually design a robot for making life for humanity easy. By further developments and improvements, gas detection robot will have more functions and produce more reliable gas detection results. To improve the gas detection robot functions some additions and changes can be done. Robot can be equipped with advanced gas detection equipment. With some changes; using more gas sensor instead of only one gas sensor, more reliable gas detection results can be obtained.

In this thesis, a prototype and low cost gas detection robot platform for educational research purposes was designed and manufactured. In the future works, more functional detection system can be developed.

Chassis and the main body of the robot can be manufactured using the interaction with non gas material. With the the interaction with non gas material, robot can get into region of dense gas. The gas sensor measurements can be carried out closer to gas source so that more reliable detection results can be obtained.

Instead of cheap GPS, RTK-GPS can be used for motion planning and navigation of the robot. With RTK-GPS receiver and a navigation algorithm the operation system of the robot is improved from semi-autonomous to autonomous.

Energy supply of robot can be designed and manufactured from just one battery. So robot will be more lighter and faster.

A suspension system will be implemented to the wheels so that the robot platform can also be used at rough terrain.

Airproof testing room can be developed. Some equipments are added to testing room such as ventilator for evacuating the gas.

Researchers can improve a software of robot to give fast reactions.

Methods of remote control can be developed much more to increase the distance for controlling robot.

Intelligent mobile phones are used by everyone oftenly. New generation operating systems for mobile phones is Android and etc are ability use functions and control of robots. For future projects we advise to control from mobile phones.

As future research directions, we intend to develop a prototype autonomous-unmanned equipment that can intervene field, forest and open area fire, and that can reach critical places which cannot be reached by the conventional vehicles so as to make first intervention, and to support rescuing operations during the fire or gas leaks incidents; and to test the equipment for its performance within the virtual and real time environments. Some project examples are given as below.

First, make a mobile rescue robot for mining industry is related our project. Especially for Turkey it will need much more because of disasters. Rescue robots play a crucial role in the post disaster rescue operations. A rescue robot helps find the location of accident, search for survivors to assist in first aid treatment and

informs the rescue team about environmental conditions and the possibility of survivors at the disaster prone area.

Second, Researchers can design a rescue robot or developed for earthquakes. In Turkey and all over the world lots of eaertquakes are happened and lots of people injured or died. After disaster to find people from wreck is very hard. Rescue robots designed for earthquakes can help really much to experts.

The last one, maybe most important to produce a robot for military usage. Generally in the world and Turkey, terrorist attacks are on the rise. One of the terrorists's method is put a bomb near the road, after during the passage of the vehicle, detonate the bomb using remote control. To prevent this situation, a robot which is able to detect a small gas molecules for bombs can be designed. A robot goes in front of military vehicles so have a chance to detect gas and find a bomb before explosion. It means lots of people can be alive.

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APPENDICES

```
private void webBrowser1_DocumentCompleted(object sender,
WebBrowserDocumentCompletedEventArgs e)
{
    // is zoom settings of camera
    webBrowser1.Document.Body.Style = "zoom:52%";
}
```

The default setting for camera control

```
string yenile = "http://192.168.2.160:99/index.htm";

string yukariya =
"http://192.168.2.160:99/decoder_control.cgi?command=0&onestep=&user=admin&pwd=";
string yukariya_du =
"http://192.168.2.160:99/decoder_control.cgi?command=1&onestep=&user=admin&pwd=";

string asagiya =
"http://192.168.2.160:99/decoder_control.cgi?command=2&onestep=&user=admin&pwd=";
string asagiya_du =
"http://192.168.2.160:99/decoder_control.cgi?command=3&onestep=&user=admin&pwd=";

string saga =
"http://192.168.2.160:99/decoder_control.cgi?command=6&onestep=&user=admin&pwd=";
string saga_du =
"http://192.168.2.160:99/decoder_control.cgi?command=7&onestep=&user=admin&pwd=";

string sola =
"http://192.168.2.160:99/decoder_control.cgi?command=4&onestep=&user=admin&pwd=";
string sola_du =
"http://192.168.2.160:99/decoder_control.cgi?command=5&onestep=&user=admin&pwd=";

string test =
"http://192.168.2.160:99/decoder_control.cgi?command=255&onestep=&user=admin&pwd=";
```

```
//*****
***
```

```
e) private void button2_Click(object sender, EventArgs
    {
        // Is a button if connection is cut, repeat the camera
        webBrowser1.Url = (webBrowser1.Url = (new Uri(yenile)));
    }
```

```
e) private void yukari_kam_MouseDown(object sender, MouseEventArgs
    {
        // section showing up camera
        webBrowser2.Url = (webBrowser2.Url = (new Uri(yukariya)));
    }
```

```
e) private void yukari_kam_MouseUp(object sender, MouseEventArgs
    {
        // stop the camera motion to up.
        webBrowser2.Url = (webBrowser2.Url = (new Uri(yukariya_du)));
    }
```

```
e) private void asagi_kam_MouseDown(object sender, MouseEventArgs
    {
        // this button makes camera moves up and down.
        webBrowser2.Url = (webBrowser2.Url = (new Uri(asagiya)));
    }
```

```
e) private void asagi_kam_MouseUp(object sender, MouseEventArgs
    {
        // if we stop the pressing down move button for camera, it doesn't move.
        webBrowser2.Url = (webBrowser2.Url = (new Uri(asagiya_du)));
    }
```

```
e) private void sag_kam_MouseDown(object sender, MouseEventArgs
    {
        // button for changing the camera view left and right.
        webBrowser2.Url = (webBrowser2.Url = (new Uri(saga)));
    }
```

```
private void sag_kam_MouseUp(object sender, MouseEventArgs e)
{
    // stop the camera motion.
    webBrowser2.Url = (webBrowser2.Url = (new Uri(saga_du)));
}
```

```
e) private void sol_kam_MouseDown(object sender, MouseEventArgs
{
    // it looks left side of camera.
    webBrowser2.Url = (webBrowser2.Url = (new Uri(sola)));
}
```

```
private void sol_kam_MouseUp(object sender, MouseEventArgs e)
{
    // stop the camera motion for left side.
    webBrowser2.Url = (webBrowser2.Url = (new Uri(sola_du)));
}
```

```
private void button3_Click(object sender, EventArgs e)
{
    // exit of program.
    Application.Exit();
}
```

// We need to define a socket received data from WEB. We defined it will use the Public in every part of the program.

```
public static Socket Soket;
```

```
// For denominated incoming data byte, we define the byte array.
```

```
byte[] WifiGelenVeri = new byte[200];
```

```
// Sent to the microcontroller, which kept the car variable control data.
```

```
byte[] ArabaKontrolVeri = new byte[1];
```

```
private void button5_Click_1(object sender, EventArgs e)
{
    // Clicking the connect button,

    // Try - Catch This is the section where the error checking.
    try
    {
```

```

//*****
*****
// This section, is the section on the form which was sent to the IP
camera taken where necessary.

//*****
*****
        yenile = "http://" + kip.Text + ":" + kport.Text + "/index.htm";

        yukariya = "http://" + kip.Text + ":" + kport.Text + "/decoder_control.cgi?command=0&onstep=&user=admin&pwd="
        = ";
        yukariya_du = "http://" + kip.Text + ":" + kport.Text +
"/decoder_control.cgi?command=1&onstep=&user=admin&pwd=" ;

        asagiya = "http://" + kip.Text + ":" + kport.Text +
"/decoder_control.cgi?command=2&onstep=&user=admin&pwd=" ;
        asagiya_du = "http://" + kip.Text + ":" + kport.Text +
"/decoder_control.cgi?command=3&onstep=&user=admin&pwd=" ;

        saga = "http://" + kip.Text + ":" + kport.Text +
"/decoder_control.cgi?command=6&onstep=&user=admin&pwd=" ;
        saga_du = "http://" + kip.Text + ":" + kport.Text +
"/decoder_control.cgi?command=7&onstep=&user=admin&pwd=" ;

        sola = "http://" + kip.Text + ":" + kport.Text +
"/decoder_control.cgi?command=4&onstep=&user=admin&pwd=" ;
        sola_du = "http://" + kip.Text + ":" + kport.Text +
"/decoder_control.cgi?command=5&onstep=&user=admin&pwd=" ;

        test = "http://" + kip.Text + ":" + kport.Text +
"/decoder_control.cgi?command=255&onstep=&user=admin&pwd=" ;

        webBrowser1.Navigate(new Uri("http://" + kip.Text + ":" + kport.Text +
"/index.htm"));

//*****
*****

//*****
*****
// It takes the host address.
string host = Dns.GetHostName();

// It takes the IP address.

```

```

IPHostEntry IPAdresi = Dns.GetHostByName(host);

// It makes it necessary to define the socket.
Soket = new Socket(AddressFamily.InterNetwork, SocketType.Stream,
ProtocolType.Tcp);

// It connects to the network.
Soket.Bind(new IPEndPoint(IPAdresi.AddressList[0], 5529));

// We mentioned is connected to IP of car.
Soket.BeginConnect(new IPEndPoint(IPAddress.Parse(ip.Text),
int.Parse(port.Text)), new AsyncCallback(ModuleBaglandiginda), null);

// Shows the text " Connected"
textBox1.Text = "bağlandı";

}
// If there is an error, screen shows error.
catch (Exception ex)
{
    MessageBox.Show(ex.Message);
}
}
private void ModuleBaglandiginda(IAsyncResult ar)
{
    try
    {
        // To control when connected to module.
        Soket.BeginReceive(WifiGelenVeri, 0, WifiGelenVeri.Length,
SocketFlags.None, new AsyncCallback(PCVeriGeldiginde), null);
    }
    catch (Exception ex)
    {
        MessageBox.Show(ex.Message);
    }
}
string gelen;

private void PCVeriGeldiginde(IAsyncResult ar)
{
    // Control when data came.
    CheckForIllegalCrossThreadCalls = false;
    int GelenVeriUzunlugu = Soket.EndReceive(ar);

```

```

/*****
*****
//      This section is processed on incoming data, it is delivered to the
required location.

/*****
*****
// Until stop, it turns.
while (true)
{
// variable data came.
gelen = Encoding.GetEncoding(1254).GetString(WifiGelenVeri, 0,
GelenVeriUzunlugu);

byte[] bytes = new byte[256];
// The cutting of the report will be made.
string gelen_kes="";
// Variables which data is received.
int byteCount = Soket.Receive(bytes, SocketFlags.None);

if (byteCount > 0)
{
gelen_kes=Encoding.UTF8.GetString(bytes);
gelen_kes = gelen_kes.Substring(0, 1);
// if #, temperature
if (gelen_kes=="#")
{
textBox1.Text = Encoding.UTF8.GetString(bytes);
}
// if $, GPS
else if (gelen_kes=="$")
{
//listBox1.Items.Add(Encoding.UTF8.GetString(bytes));
rt1.AppendText(Encoding.UTF8.GetString(bytes));
}
}
}

}

// Car stop function.
public void dur()
{
ArabaKontrolVeri[0] = 0;

```

```
Soket.Send(ArabaKontrolVeri);
}

// if pressing forward button, car goes forward
private void ileri_MouseDown(object sender, MouseEventArgs e)
{
    ArabaKontrolVeri[0] = 1;
    Soket.Send(ArabaKontrolVeri);
}

// if we stop pressing button, stops the robo.
private void ileri_MouseUp(object sender, MouseEventArgs e)
{
    dur();
}

// if push the right button, robot will go right side.
private void sag_MouseDown(object sender, MouseEventArgs e)
{
    ArabaKontrolVeri[0] = 2;
    Soket.Send(ArabaKontrolVeri);
}

// if we stop press button, robot will stop.
private void sag_MouseUp(object sender, MouseEventArgs e)
{
    dur();
}

// if we push back button, robot will go back.
private void geri_MouseDown(object sender, MouseEventArgs e)
{
    ArabaKontrolVeri[0] = 3;
    Soket.Send(ArabaKontrolVeri);
}

// if we stop press button, robot will stop.
private void geri_MouseUp(object sender, MouseEventArgs e)
{
    dur();
}

// if we push the left button, robot will go left side.
private void sol_MouseDown(object sender, MouseEventArgs e)
```

```

{
    ArabaKontrolVeri[0] = 4;
    Soket.Send(ArabaKontrolVeri);
}

```

// if we stop press button, robot will stop.

```

private void sol_MouseUp(object sender, MouseEventArgs e)
{
    dur();
}

```

```

//*****
*****

```

// In this section, press section are responsive controls.

```

//*****
*****

```

```

private void Form1_KeyDown_1(object sender, KeyEventArgs e)
{
    tusb(e);
}

```

```

private void textBox1_KeyDown(object sender, KeyEventArgs e)
{
    tusb(e);
}

```

```

private void Form1_KeyDown(object sender, KeyEventArgs e)
{
    tusb(e);
}

```

```

private void ileri_KeyDown(object sender, KeyEventArgs e)
{
    tusb(e);
}

```

```

private void sag_KeyDown(object sender, KeyEventArgs e)
{
    tusb(e);
}

```

```

private void geri_KeyDown(object sender, KeyEventArgs e)

```



```
{
    tusb(e);
}

private void sol_KeyDown(object sender, KeyEventArgs e)
{
    tusb(e);
}

private void textBox2_KeyDown(object sender, KeyEventArgs e)
{
    tusb(e);
}

private void button1_KeyDown(object sender, KeyEventArgs e)
{
    tusb(e);
}

private void yukari_kam_KeyDown(object sender, KeyEventArgs e)
{
    tusb(e);
}

private void sol_kam_KeyDown(object sender, KeyEventArgs e)
{
    tusb(e);
}

private void sag_kam_KeyDown(object sender, KeyEventArgs e)
{
    tusb(e);
}

private void asagi_kam_KeyDown(object sender, KeyEventArgs e)
{
    tusb(e);
}

private void button2_KeyDown(object sender, KeyEventArgs e)
{
    tusb(e);
}

private void button3_KeyDown(object sender, KeyEventArgs e)
{

```

```
tusb(e);
}
```

```
/**
 *
 */
```

```
// Which key what will do when we push it.
```

```
/**
 *
 */
```

```
public void tusb( EventArgs e)
{
    if (e.KeyCode == Keys.W)
    {
        ArabaKontrolVeri[0] = 1;
        Soket.Send(ArabaKontrolVeri);
    }
    else if (e.KeyCode == Keys.D)
    {
        ArabaKontrolVeri[0] = 2;
        Soket.Send(ArabaKontrolVeri);
    }
    else if (e.KeyCode == Keys.S)
    {
        ArabaKontrolVeri[0] = 3;
        Soket.Send(ArabaKontrolVeri);
    }
    else if (e.KeyCode == Keys.A)
    {
        ArabaKontrolVeri[0] = 4;
        Soket.Send(ArabaKontrolVeri);
    }

    if (e.KeyCode == Keys.NumPad8)
    {
        webBrowser2.Url = (webBrowser2.Url = (new Uri(yukariya)));
    }
    else if (e.KeyCode == Keys.I)
    {
        webBrowser2.Url = (webBrowser2.Url = (new Uri(yukariya)));
    }
    else if (e.KeyCode == Keys.NumPad6)
    {
        webBrowser2.Url = (webBrowser2.Url = (new Uri(saga)));
    }
    else if (e.KeyCode == Keys.L)
    {

```

```

        webBrowser2.Url = (webBrowser2.Url = (new Uri(saga)));
    }
    else if (e.KeyCode == Keys.NumPad2)
    {
        webBrowser2.Url = (webBrowser2.Url = (new Uri(asagiya)));
    }
    else if (e.KeyCode == Keys.K)
    {
        webBrowser2.Url = (webBrowser2.Url = (new Uri(asagiya)));
    }
    else if (e.KeyCode == Keys.NumPad4)
    {
        webBrowser2.Url = (webBrowser2.Url = (new Uri(sola)));
    }
    else if (e.KeyCode == Keys.J)
    {
        webBrowser2.Url = (webBrowser2.Url = (new Uri(sola)));
    }
}

```

```

//*****
*****

```

// Stop push the button operations to be carried out.

```

//*****
*****

```

```

public void tusc(KeyEventArgs e)
{
    if (e.KeyCode == Keys.W)
    {
        dur();
    }
    else if (e.KeyCode == Keys.D)
    {
        dur();
    }
    else if (e.KeyCode == Keys.S)
    {
        dur();
    }
    else if (e.KeyCode == Keys.A)
    {
        dur();
    }
}

```

```

if (e.KeyCode == Keys.NumPad8)
{
    webBrowser2.Url = (webBrowser2.Url = (new Uri(yukariya_du)));
}
else if (e.KeyCode == Keys.I)
{
    webBrowser2.Url = (webBrowser2.Url = (new Uri(yukariya_du)));
}
else if (e.KeyCode == Keys.NumPad6)
{
    webBrowser2.Url = (webBrowser2.Url = (new Uri(saga_du)));
}
else if (e.KeyCode == Keys.L)
{
    webBrowser2.Url = (webBrowser2.Url = (new Uri(saga_du)));
}
else if (e.KeyCode == Keys.NumPad2)
{
    webBrowser2.Url = (webBrowser2.Url = (new Uri(asagiya_du)));
}
else if (e.KeyCode == Keys.K)
{
    webBrowser2.Url = (webBrowser2.Url = (new Uri(asagiya_du)));
}
else if (e.KeyCode == Keys.NumPad4)
{
    webBrowser2.Url = (webBrowser2.Url = (new Uri(sola_du)));
}
else if (e.KeyCode == Keys.J)
{
    webBrowser2.Url = (webBrowser2.Url = (new Uri(sola_du)));
}
}

//*****
//*****
// This section understand stop to push the button situation

//*****
//*****
private void ileri_KeyUp(object sender, KeyEventArgs e)
{
    tusc(e);
}

```

```
private void Form1_KeyUp(object sender, KeyEventArgs e)
{
    tusc(e);
}

private void sag_KeyUp(object sender, KeyEventArgs e)
{
    tusc(e);
}

private void sol_KeyUp(object sender, KeyEventArgs e)
{
    tusc(e);
}

private void geri_KeyUp(object sender, KeyEventArgs e)
{
    tusc(e);
}

private void textBox1_KeyUp(object sender, KeyEventArgs e)
{
    tusc(e);
}

private void textBox2_KeyUp(object sender, KeyEventArgs e)
{
    tusc(e);
}

private void button1_KeyUp(object sender, KeyEventArgs e)
{
    tusc(e);
}

private void button3_KeyUp(object sender, KeyEventArgs e)
{
    tusc(e);
}

private void yukari_kam_KeyUp(object sender, KeyEventArgs e)
{
    tusc(e);
}

private void sol_kam_KeyUp(object sender, KeyEventArgs e)
```

```

    {
        tusc(e);
    }

private void sag_kam_KeyUp(object sender, KeyEventArgs e)
{
    tusc(e);
}

private void asagi_kam_KeyUp(object sender, KeyEventArgs e)
{
    tusc(e);
}

private void button2_KeyUp(object sender, KeyEventArgs e)
{
    tusc(e);
}

```

For microcontroller;

```

// Descriptions
//*****

#include <SoftwareSerial.h>
//*****

// Variables
//*****

int sag1=2,sag2=3,sol1=4,sol2=5;

SoftwareSerial gpsSerial(8,9);

int gelenVeri = 0;

int don1=0, don2=0,deger=0;

//*****

// Fuctions primarily definitions
//*****

```

```
void dur();

void ileri();

void sag();

void geri();

void sol();

//*****

void setup()

{

Serial.begin(9600);

gpsSerial.begin(9600);

pinMode(sag1,OUTPUT);

pinMode(sag2,OUTPUT);

pinMode(sol1,OUTPUT);

pinMode(sol2,OUTPUT);

}

void loop()

{

//*****

//Read data from the serial and manage the motor.

//*****

if (Serial.available() > 0)

{

gelenVeri = Serial.read();

if(gelenVeri==1)
```

96

```
{
ileri();
Serial.write(gelenVeri);
}
else if(gelenVeri==2)
{
sol();
Serial.print(gelenVeri);
}
if(gelenVeri==3)
{
geri();
}
if(gelenVeri==4)
{
sag();
}
if(gelenVeri==0)
{
dur();
}
}

//*****
// Data rading from GPS.
```



```
/*******  
  
while (don1<100)  
  
{  
  
don1++;  
  
don2=0;  
  
if (gpsSerial.available())  
  
{  
  
int inByte = gpsSerial.read();  
  
Serial.write(inByte);  
  
}  
  
}  
  
/*******  
  
// Gas value reading  
  
/*******  
  
while (don2<5)  
  
{  
  
don2++;  
  
don1=0;  
  
deger=analogRead(0);  
  
Serial.print("#");  
  
Serial.print(deger,DEC);  
  
Serial.print("\n");  
  
delay(10);  
  
}
```

98

```
}  
  
//*****  
  
// Stop the motor functions.  
  
//*****  
  
void dur()  
  
{  
  
digitalWrite(sag1,LOW);  
digitalWrite(sag2,LOW);  
digitalWrite(sol1,LOW);  
digitalWrite(sol2,LOW);  
  
}  
  
//*****  
  
// function that describes the robot must go straight way  
  
//*****  
  
void ileri()  
  
{  
  
digitalWrite(sag1,HIGH);  
digitalWrite(sol1,HIGH);  
  
}  
  
//*****  
  
// function of the turning right.  
  
//*****  
  
void sag()  
  
{
```

```
digitalWrite(sag2,HIGH);  
digitalWrite(sol1,HIGH);  
}  
//*****  
// Left turn function.  
//*****  
void sol()  
{  
    digitalWrite(sag1,HIGH);  
    digitalWrite(sol2,HIGH);  
}  
//*****  
// Function is going straight for motors.  
//*****  
void geri()  
{  
    digitalWrite(sag2,HIGH);  
    digitalWrite(sol2,HIGH);  
}
```


RESUME

Personel Information

Adı Surname : Özgür KANLI

Place and Date of Birth : AYDIN 24.04.1989

Education

Undergraduate : Pamukkale Üniversitesi, Mechanical Eng. Dept., 2012

Post Graduate : Click here to enter text.

Foreign Languages : English

Scientific Activities

A) Proceedings

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Date :21/04/2016