

# وزارة التعليم العالي والبحث العلمي

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## MEMOIRE

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**Hardware and software improvement of pob-bot  
robot prospection and navigation.**

**Domaine : Sciences et Technologie**

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## Resume:

The mobile robots take a huge step for the technologies developpements in everyfield, thisthesis is a global mobile robot study of the diffrent navigation techniques, and shows how to translate thatidea into a simulation environment which simulates a mobiles robot's navigation in a known environnement. In addition it shows how both hardware design and software program are built for the robot prospector. As a result we've obtained a very interesting results and another rich and admirable techniques during the tests which may help the future studies in this area.

## Résumé :

Les robots mobiles ont atteint un grand succès pratiquement sur tous les domaines à cause de l'évolution immense des technologies en général. Ce mémoire décrit une vue global sur les robots mobiles et les différentes techniques de navigations, il montre aussi la traduction de ce qu'on vient de dire dans un environnement de simulation, ce dernier simule la navigation d'un robot dans un environnement connu, Ainsi il présente la conception hardware et la programmation en software pour la construction final du robot prospecteur d'incendie, cependant on a aboutis des résultats intéressants et aussi des techniques valable pour des futures projets.

## المخلص :

حققت الروبوتات المتحركة نجاحا كبيرا عمليا في جميع المجالات بسبب التطور الواسع للتكنولوجيا بصفة عامة . هذه المذكرة تناقش نظرة عامة على مستوى الروبوتات المتحركة و مختلف تقنيات التنقل كما تصف كذلك ما نريد قوله في مجال المحاكاة , هذا الأخير يحاكي ابحار روبوت على مستوى محيط معلوم , كما انها تقدم تصميم الهاردوير و البرمجة فيال سوفتوير من أجل الصناعة النهائية للروبوت المكتشف للحريق في الأخير قمنا بتحقيق نتائج معتبرة و كذلك تقنيات متاحة للمشاريع المستقبلية.

## Keywords:

Mobile robot, Navigation, Pob-Bot, Mobotsim, Sensors, Known environment, Prospection.

# **Dedicace :**

*Praise to the almighty god the clement and merciful who gave me strength, fortitude and patience to complete this work.*

*To my parents the reason of the good raise, who also planted the assistance, the admirable advices and the love inside me and make me pick up the fruits of success in my life. Besides when I was low they were always there for me and never left me alone because of their huge care, all the words can't describe how much their efforts meant to me.*

*To my elder brothers that i'm and always going to be proud of having them by my side the ones who always were here for me and made me feel secure and throw my fear apart.*

*To my twinbrother, my soulmate and my dear companion who was always there in the weal and woe whatever i am going to say it wont spread whats inside my heart for him he always guide me whenever i walk the wrong path.*

*I dedicate my work also to my life's sun and flowers, the best friends i've ever had, each one has its own special place inside me, I offer them special greetings, for all their support and their amount of happy moments that we've passed together.*

*I love you all more than words can say and i will always and forever do may allah keep you all safe.*

*Thank you so much.*

# Thanks :

Before i begin this work's presentation, i would like to thank the almighty god the greatest who gave me the strength and patience to realise this work.

- ❖ I want also to express and appreciate all the efforts and the support that the professor FEZARI gave me through accepting to frame this final project. Its disponibility, remarks and encouragements also the confidence that gave me all along the project's realisation.
- ❖ I thank the president and the members of the jury to judge this thesis.
- ❖ I thank everyone who have supported me all along the way and for all their advices.

Please find here the testimony of my deepest respect.

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## Global Introduction :

The mobile robot occupies an important place around the world. Most of the technologies development in each field from military, medicine and industries in general uses robots to help the human being for fast and safe tasks. It has become a necessary field because of its huge benefits that impact human lives. The robot prospect is one of these important additions that the mobile robot adds in the human life, despite that robot takes the human place in that area, it is just for his safety and minimizing his health's risks.

To settle and answer that problematic we've divided our theme into four main chapters. In the first chapter named « state of art », we're going to see what a mobile robot in general. Plus the different techniques which could've been implemented on the robot for its own safety and good navigation, and also the environment planning for both known and unknown environment. Besides, we'll read some works and researches that are projected in the same area so far.

In the second chapter written under the name « Mobotsim Simulation », we're going to simulate a navigation of a mobile robot in a known environment that reflects our department's both basement and second floor free corridors using Mobotsim simulator. First of all we'll build the environment ; walls, stairs, the start mark and the final point which refers the incident location. Then we'll build a robot with two distance sensors and program its navigation using these sensors to evade the obstacles previously mentioned and get to the final point .

In the third chapter intitled « Robot design », we will design and construct the hardware part of our project. We'll use the Pob-bot robot that was already designed to allow us to build our own mobile robot, moreover we'll add a daughter board that contains the different sensors which will help on both navigation and prospection tasks. Furthermore we'll see the different techniques which we've faced and could've helped to settle our project's problematic, Besides we'll cite the chosen design and its details.

However in last chapter, we will focus on the software part which means that we'll build our program that we will download and charge in the robot.

Nonetheless we will use the Pobotools4 programming environment to write down the program which will be implemented in C language and uses functions of pobotools and pobbeye. then we'll compile it and implement it in order to execute it after words using the reset button. The program will solve the problem, what is to say is that we will make both the safe navigation and prospection in a known environment.

Finally, we will finish with a global conclusion that includes all the treats, the different solutions and the future ideas which could help to build developed projects in that area as long as the electronic and embedded systems also robotic fields are developing exponentially by time.

# CHAPTER n°01 : STATE OF ART

## 1. Mobile robot :

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. Alternatively, mobile robots can rely on guidance devices that allow them to travel a pre-defined navigation route in relatively controlled space.

Nowadays the Mobile robots have become more commonplace; we may meet them everywhere and in any field such as military, medicines, industries and security.

The components of a mobile robot are a controller, control software, sensors and actuators. The controller is generally a microprocessor, embedded microcontroller or a personal computer (PC). Mobile control software can be either assembly level language or high-level languages such as C, C++, Java, Python or special real-time software.

## 2. State of art :

In last few years, Robotics has been developed and well progressed. It also noted a stunning success in performance, autonomy and decision making. That success has touched several fields such as mechanics, electronics, and computer science. These advantages had aimed to design and construct robots that react with the environment.

Two known cases of navigation can be noted, online and offline, In the first case the robot has to discover each time the environment where it's navigating using graph technique, it selects the path and it receives new information whenever we want or periodically. The second case we firstly should know the entire building's map and generate a scheme of the points including the starting and ending points that the robot will travel to.

Two main problems are confronted for the robots for both known and unknown environment which are:

**Path planning:** each mobile robot aims to navigate from a point to another; this technique is based on generating a map of potential shadow. From point destination, brought to zero potential, increasing spreading potential out as wave front will scan all available navigation cells.

**The obstacle avoidance:** Detection and obstacle avoidance is the base of almost all mobile robots. It aims to allow the robot to navigate his environment safely where in each obstacle he'll face in a fixed distance it avoids it. a negative potential is given to the segments which define the obstacles (wall), and a positive one is given for the free cells to navigate. There is in fact many types of sensors:

- Cameras: an image processing program is necessary.
- Laser sensors.
- Infrared sensors.
- Ultrasonic sensors.

Firstly, the planning techniques are presented to have general idea on possible techniques for path planning. Secondly, the used method on this paper is explained where potential field.

### a) Motion planning techniques:

In general there are four well known planning approaches

#### **Voronoi Diagram:**

Voronoi diagram is used as a mathematical tool to extract the structural information from simplified maps. The diagram has to be a skeleton of the corridors and also shows the configuration of doors along them.

#### **Visibility Graph:**

An old technique used to solve pursuit-evasion problems. In the last researches they used it to solve pursuit-evasion problems in known and unknown environment. It connects the starting point with all summits of the polygonal obstacles. At the end the path from the start to the end will be found.

#### **Potential Fields:**

This method has been first introduced by O. Khatib in 1986. Used for manipulators and robots. It's very different and unique from the other techniques because it doesn't use geometries. The proposed technique in this work is an extension for the Potential Field Technique.

#### **Visibility Graph:**

It is an old technique, aiming to settle pursuit-evasion problem, its main role is to connect the starting point with all the summits of polygonal obstacles that are visible from the robot.

### b) Previous works:

In 2008, A work of A software architecture for mobile robot navigation have been done by Phillip J. McKerrow and Sherine M. Antoun to build a system control using echolocation, otherwise they rebuilt a "Titan" robot and the experiment shew that the software architecture qualifies the programs of navigation to use directed sensing. Besides, it offers the possibility to deny collisions when only sensing simultaneously in the direction of navigation which mimics human navigation.

In 2012, Dr Mohammed FEZARI used multi-processors with new voice command system for tele monitoring the navigation of a set of robots and got a system control by simple voice commands. So a colony of robots and their navigation are done using a software design of master slave protocol system based on speech command in addition a hardware conception is used for a tele-operation the group of robots. In the other hand to increase the

recognition rate, the training and recognition phase were done in the same area of tests to decrease the effect of noise on the rate. This research reached the work's goal. Moreover many other works on software parts are developing by time.

In 2013 Ninad Pradhan, Stan Birchfield and Ugur Hasirci they've searched for an Indoor navigation for mobile robots using predictive fields A predictive field based path planner for mobile robot navigation in indoor areas is described. Predictive fields are used for incorporating moving obstacle information into the navigation function framework. They've demonstrated the applicability of navigation functions to practical environment and they've used the Predictive fields which effected at moving the robot away from the projected path of moving obstacles.

A paper published in 2013 used A SLAM algorithm for indoor mobile robot localization using an Extended Kalman Filter and a segment based environment mapping. It faced the Simultaneous Localization And Mapping (SLAM) problem for a mobile robot in an unknown indoor environment. A segment based mapping algorithm is proposed and used along with an Extended Kalman filter driven by measurements taken by ultrasonic sensors located on the robot. The proposed SLAM algorithm has been tested in both simulated and real experiments yielding to encouraging estimation and mapping results. However the performance of the proposed algorithm has been evaluated both numerical and experimental tests obtaing a very good results.

A research in 2017 By Dr Rabah LAKEL of this type used a navigation of a mobile robot in finite environment using potential field merging to help old people with certain tasks that are hard for them. It uses a planning technique based on Potential Field. However the main problems which are faced in this work are the weakness against local optimal, image processing and communication protocol, Hence these previous problems, the tests of the technique and the communication have been driven to a pretty good results.

Another **redictive field based ath for** mobile

### 3. Table of some applications which have been done about this topic so far:

Work	Research	Year	Author	Addition	Robot	Place
helping old people with certain tasks that are hard for them	Navigating mobile robot in finite environment using potential field merging	2017	Dr Rabah Lakel	Simulation of a mobile robot (pob bot) in labyrinth environment. Path planning	POB-BOT from POB-tech	University Badji-mokhtar Annaba

				and obstacle avoidance.		
System control by simple voice commands.	Tele monitoring the navigation of a set of robots using multi-processors with new voice command system	2012	Dr Mohamed Fezari	Uses a speech recognition kit from 'sensory' and implements it for a voice command of a colony of pob bot robot..	POB-BOT from POB-tech	University Badji-mokhtar Annaba
Finch robot, irobot, Vex Protobot, etc were used with an Arduino Uno and Mega as interfaces of communication.	Development of a universal robotics API for increased classroom collaboration within robotics education [6]	2012	Dr Chris Rogers	Robotics education as aids and contexts a number of disciplines and topics.	Finch robot, irobot, Vex Protobot.	Tufts University
System control using echolocation	A software architecture for mobile robot navigation	2008	Phillip J. McKerrow Sherine M. Antoun	Using echolocation technique using different types of sensors to command and navigate the robot	4 wheel Titan (outdoor robot)	University of Wollongong
indoor mobile robot localization	A SLAM algorithm indoor mobile robot localization using an extended Kalman Filter and a segment based environment mapping	2013	Luigi D'Alfonso  Andrea Griffo Pietro Muraca  Paolo Pugliese	Localization using Kalman Filter and a segment based environment mapping	Khepera III Robot	<u>Università della Calabria</u>
Indoor mobile	Indoor mobile Robot navigation	2013	<u>Ninad Pradhan</u>	Using predictive	(Simulation )	<u>Proceedin</u>

Robot navigation .	using predictive fields.		<u>Ugur Hasirci</u> <u>Stan Birchfield</u>	fields for mobile robot's navigation in unknown environment.		<u>gs of the American Control Conference.</u>
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Tab 4: Comparative table of the application used in this area so far.

#### 4. Problematic:

We would like to design a mobile robot for prospection and navigation to insure security indoor. We do have in the LAB LASA "Pob-Bot Robot".

This robot does not have enough sensors to detect incidence.

Our aim concern is to add sensors to an existing platform for Pob-Bot robot.

We should find a solution how to insert necessary sensors to detect gas, high temperature, flood situation and sound in Electronic Departement corridors.

The robot should also send information to central unit using wireless communication.



# CHAPTER n°02 : FIRE TRACKING SIMULATION.

# 1. Introduction :

Before implementation of prospection sensors on the Pob-Bot robot we need to simulate the situation using MobotSim.

Mobotsim is a 2D software for mobile robots simulation, design, and researchs such as autonomous navigation techniques, obstacle avoidance and data sensors integration. So we're using such a program to simulate our robots navigation in a 2D plan Which represents our indoor departement environment.

Furthermore. This software eases our mobile robot movement and track. also its simpler to correct and detect problems before implementing the code in a real robot for a real application.

Moreover our robots is going to travel our department's hallway trying to search any type of issue that can be prived inside.

Ultimately we've simulated we're going to see a mobile robot's navigation indoor in two different environments for both departement's basement and second floor. Besides, it is going to search for the problem such as a fire incident as we're going to face in the simulations below while avoiding the human interaction with such a dengerous situation.

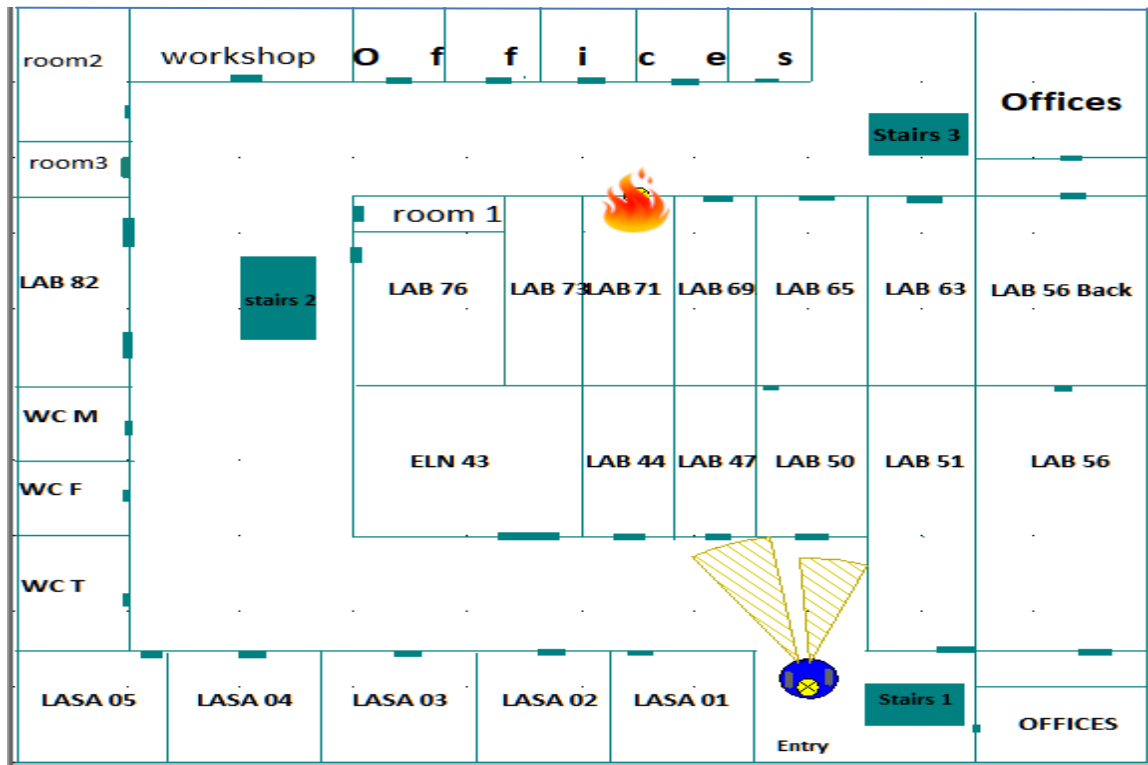
## 2. The simulations :

### 2.1. The basement :

In this environment we've designed the exact plan of our department's basement's environment with obstacles (walls, doors, stairs ...etc) and a robots that navigates within. The robot has two sensors that work as obstacle detectors they calculate the distance between a robot and the obstacle then with the program that we write it evades them to the right or left.

#### a) The start :

We've considered the entry of our department as the starter point of our mobile robot. The environment and obstacles are the diffrent blocs which represents the laboratories, stairs, offices as the figure (**Fig.2.1.a**) shows.



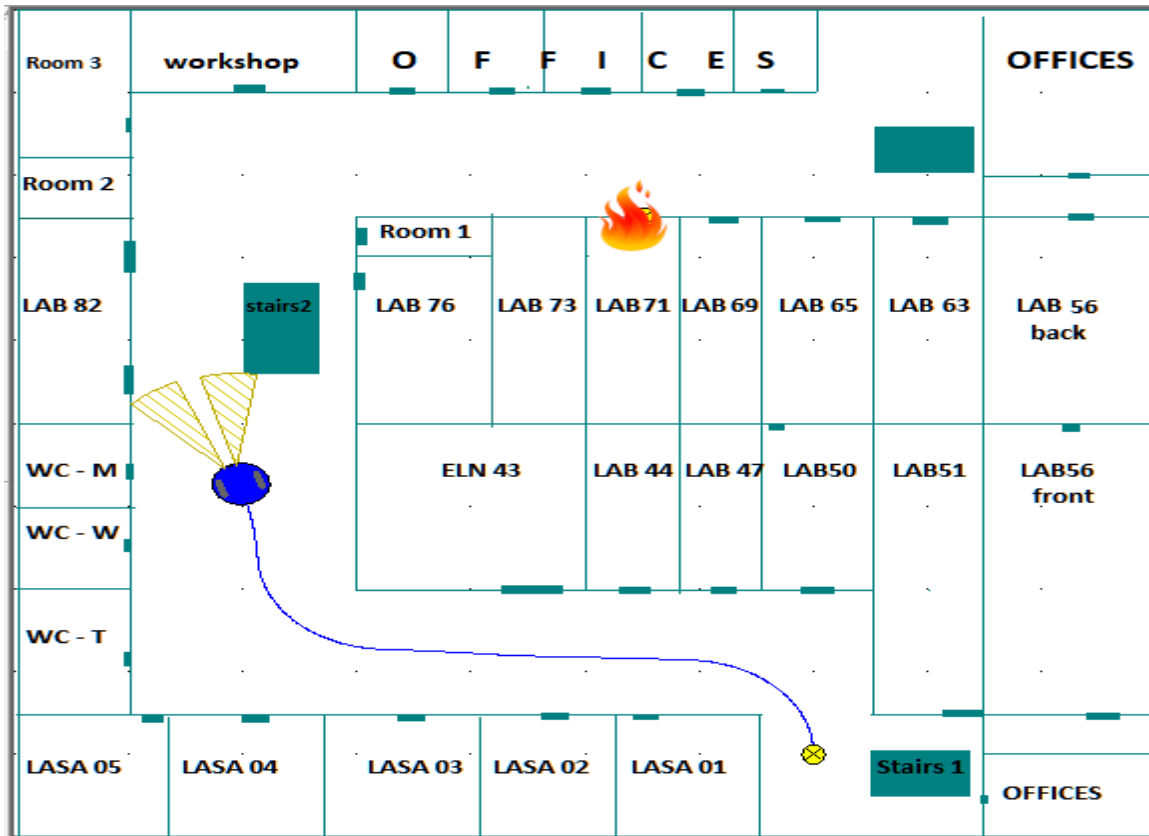
**Fig.2.1.a** The first point where our robot is going to start its navigation in the basement's hallway

We can see clearly that there is a fire incident in the LAB 71 that our robot have to detect while it's navigating the free space of the corridor. The start we've set out robot's position in the exact coordination that we've fixed as the start.

**b) The middle way :**

In the middle of the path that our mobile robot is going to take, we see how the both sensors doing their work to compare the distances in the front-left with the front-right that keep the robot still in the right path and avert any obstacle whom it faces along its way. One of mobotsim's benefits is that it draws the robot's trajectory showing both the way that it crossed and the line that it stucked with.

A shot has been taken in the simulation as it shows the figure (**Fig.2.1.b**) below :



**Fig.2.1.b the middle way of our mobile robots navigation and research in the basement's hallway**

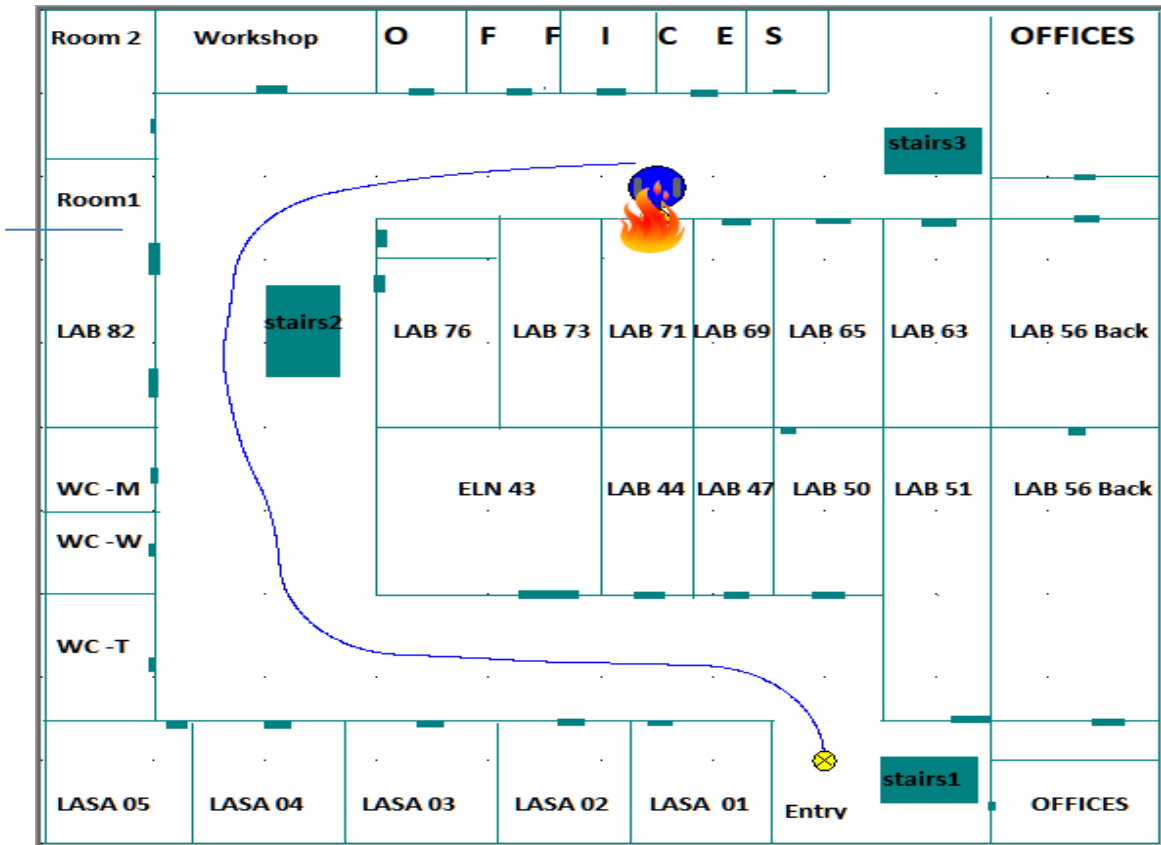
The robot keep going till it finds an issue of which it is sent to check or to detect on its way, when the robot faces an obstacle we're programming in an amount of a distance the robot will change his angle with a fixed speed and bypass whatever is considered as an obstacle.

**c) The end :**

We've fixed another mark point of which our robot will stop his navigation which we consider as a source of a fire incident besides we can localise the source afterwards if we add more other options to our robot.

In fact in mobotsim we can only add distance sensors and not more but in realiy we can add more sensors that helps us to localise the incident exact coordination.

The figure (**Fig 2.1.c**) below shows that our robot stopped when it finally have found the fire source In the LAB 71 room.



**Fig.2.1.c finding a fire incident at on one of Labs in basement’s hallway**

Finally we can see clearly the path that our robot drew on its way to the incident and every step that it has taken plus the obstacles that it has avoided.

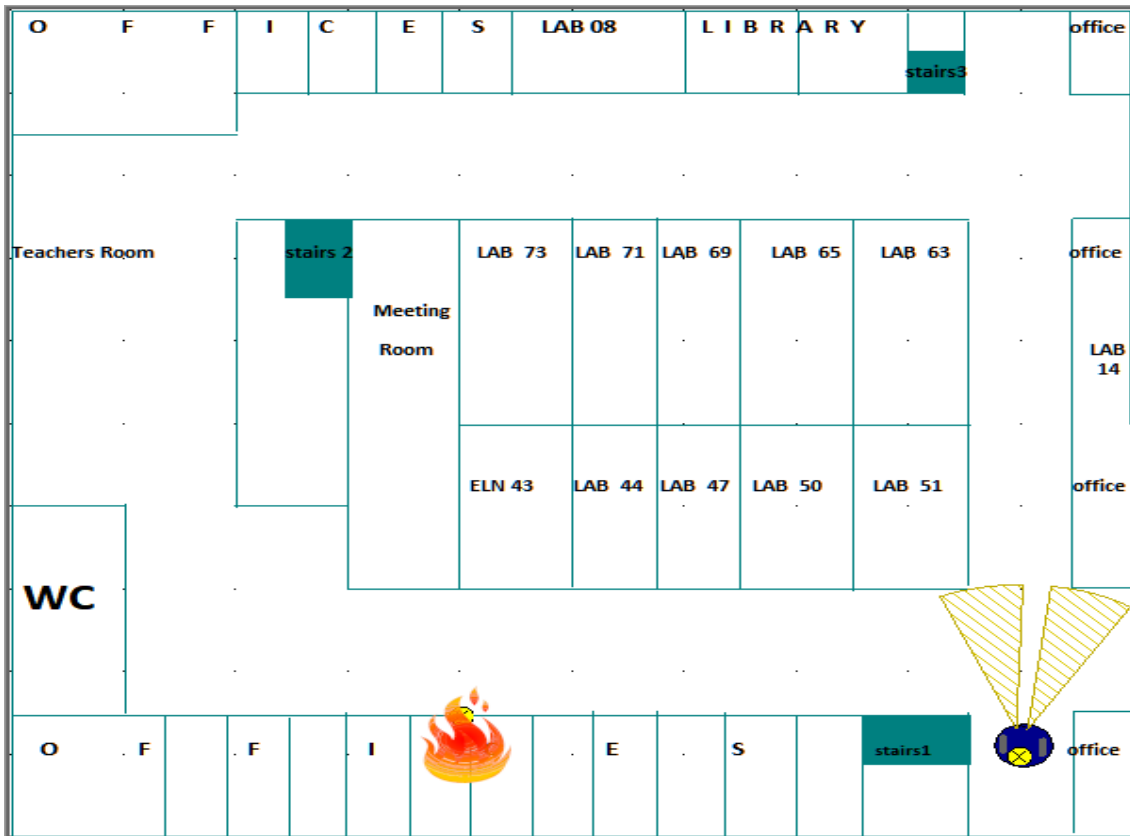
## 2.2. The Second floor :

Just like the previous attempt we’ve designed the exact plan of our second floor’s departement’s environment. Our mobile robot is going to navigate the free space in its hallway searching for any issue as it’s describen previously.

### a. the start

we’ve set the coordination at the bottom of the first stairs as start point where out mobile robot is going to start its road.

The figure (**Fig.2.2.a**) below shows the first step that our mobile robot have taken showing both the free space of corridor whom it will travel and the fire incident in one of the offices :



**Fig.2.2.a** The first point where our robot is going to start its navigation in the second floor’s hallway

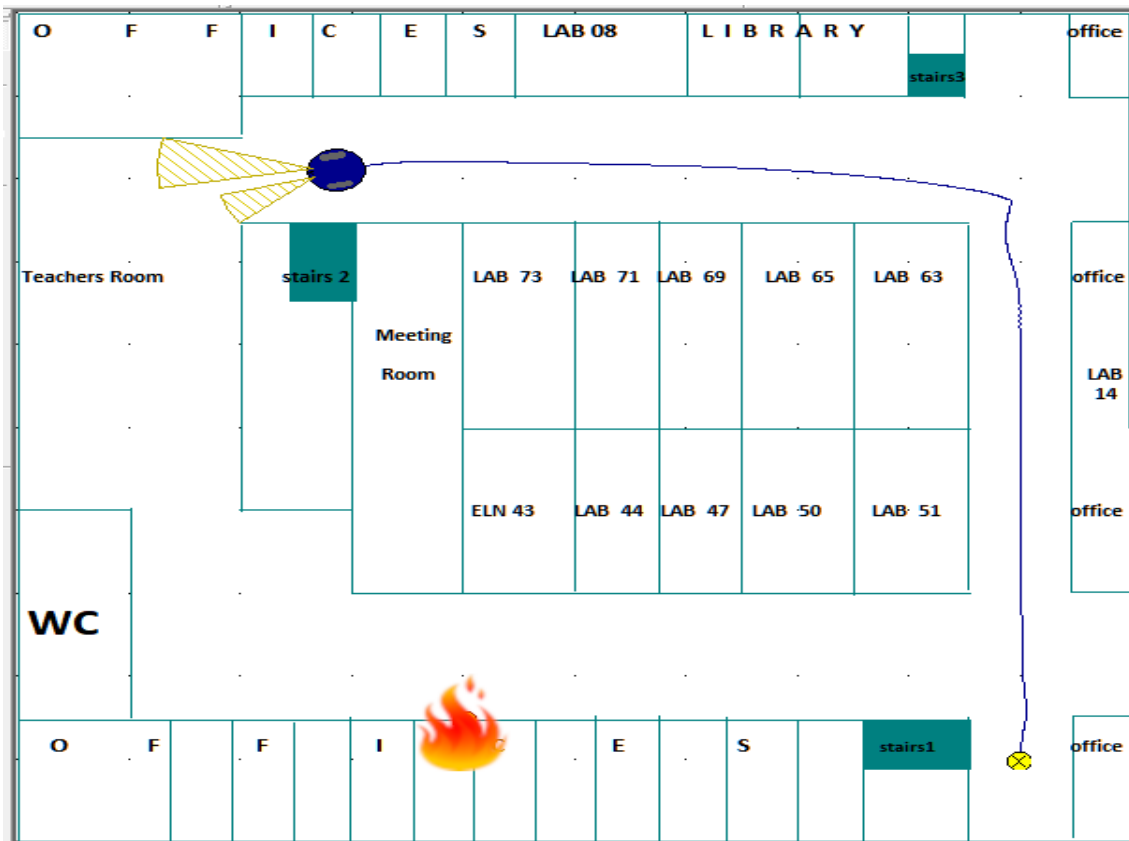
At the time we start executing and run the simulation the two sensors start working and the robot starts to move forward.

**b) The middle way :**

As in the basement attempt the mobile robot travels the free space in the hallway and the two sensors are keeping it in at least the middle to dont stuck with an obstacle and always driving it to a free environment to check it.

There are two points that we’ve intervened so that our robot wont stuck infront of the walls, we’ve made it turn into the right way since we’ve already known where it is going to.

The figure (**Fig 2.2.b**) shows how the robot shuns the obstacles that it faces along the way and the importance of the two sensors and their width in this application.

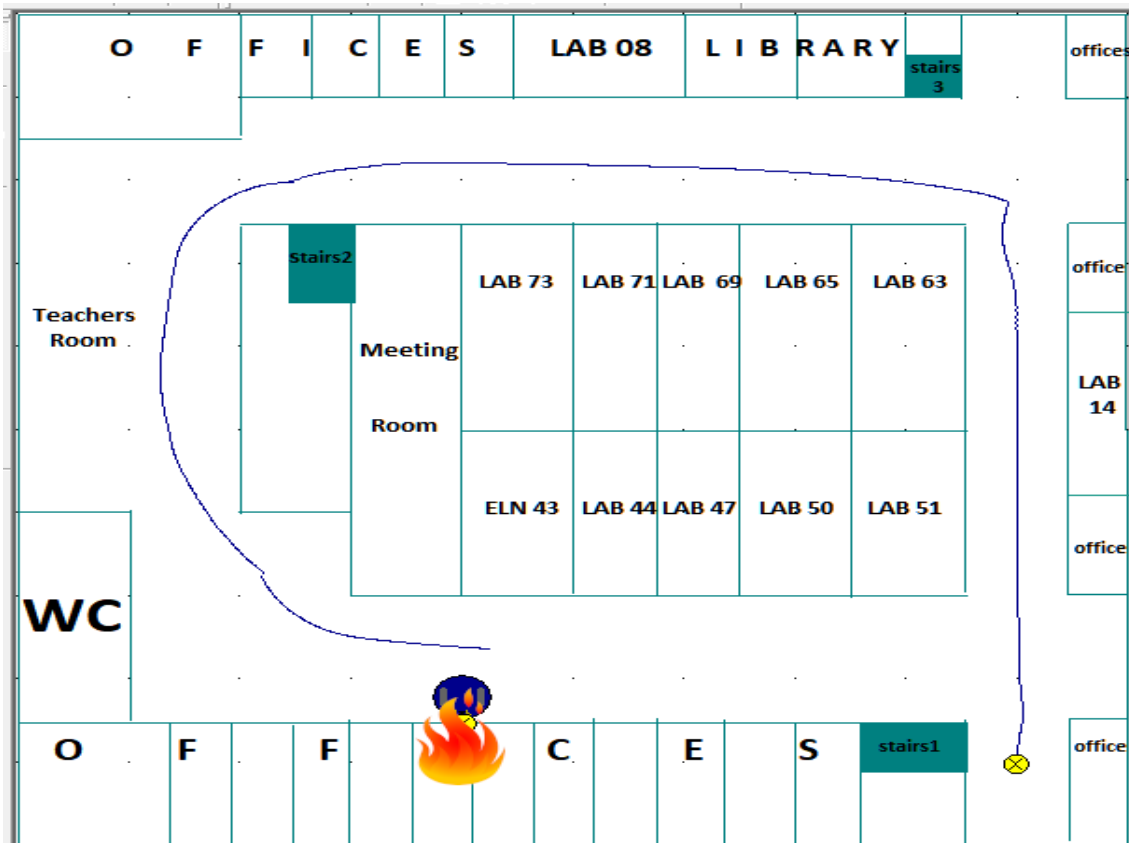


**Fig.2.2.b** the middle way of our mobile robots navigation and research in the second floor's hallway

**c) the end :**

In the robots trip around the corridor it finds finally the fire incident in one of the offices so it continues till it stops just beside it.

The figure (**Fig.2.2.c**) below shows the end of the navigation from the point of start till the end one and we can see also the trajectory and the line that our mobile robot draw on its way though.



**Fig.2.2.c Finding a fire incident at one of the offices in the second floor’s hallway.**

### 2.3. The program (macro):

The program is written in basic language, it is flexible for mobile robots.

We’ve built our program based on the functions written above in the basic language vocabulary using « for... Next» loops and « if... Then... end if » Conditions, we’ve also used a print function « Debug.Print » to print the distances when an obstacle get closer to the robot. And the start « Sub main » and the End « End » instructions which contain the main program to execute.

## 3. Conclusion :

In this chapter we have seen an interesting simulator that facilitate for us to design and simulate our project.

Besides it have helped us to make the exact plan of our departments both basement and second floor.

Furthermore We have made a robot with two sensors which calculate the distances between the obstacles and the mobile robot.



However we have written a program that secure our mobile robot's navigation in the both corridor's environments and keeps our robot still in the right path and avoids any type of obstacle that it may face along the way.

So when the robot travels the space mobotsim will draw the trajectory and the line that it has crossed while following the exact robot's movements.

Finally our mobile robot travels the free space in the hallway trying to find any type of incidents (fire incident, gaz, smoke...) using other integrated sensors in reality. And whenever it finds one it stops just beside the incident, we've could make that using a finish mark coordinations that our robot will stops whenever it passes by.

# CHAPTER n°03: ROBOT DESIGN AND SOLUTIONS TO INSERT SENSORS

## I) Introduction :

As we've mentioned in chapter one, we're going to improve a ready robot called POB-BOT which is a mobile programmable robot, it has been designed to allow us to build our own robot [8].

The POB-BOT includes three main circuits that help us in our application which are:

- a) POB-EYE: it's the intelligent color camera and a microprocessor type ARM which contains the main program that we're going to execute.
- b) POB-PROTO: It's a large circuit that contains the inputs and outputs such as (wheels motors, turning servomotors, head and grab servomotors and the Joystick) and that circuit allows us to add some other electronic elements such as sensors that we're going to work and manage with.
- c) POB-LCD: it's a graphical screen that allows us to visualize both messages and pictures which we receive from the camera.

In addition we've added to our robot a daughter board that contains different sensors which are connected to one of the POB-PROTO's port for both the navigation and the information's collects.

## II) Sensors problematic:

In our project we're aiming to build a navigator robot which is going to search for any type of incident that one of them we've already mentioned in the previous chapter, so in the robot we've added some sensors that will help us to search for the issue in the environment while navigating.

The different sensors that we've added are:

- A water level sensor that it is going to settle the temperature phenomena and search for any source of an unexpected high temperature in the environment (Simulated using VR).
- A gas sensor which indicates if there is a gas incident in the indoor areas it will help the robot to search for the source and stop whenever it finds one.
- Light sensor which helps for many other things for example it helps to know if the environment is dark or well lit.
- The three sensors can tell at the same time if there is a fire incident the temperature sensor is used to search for the hot temperature, the gas one confirms while searching for smoke, and the light one for the glowing fire.
- Three infrared distance sensors used for the navigation. They help the robot to manage its environment and avoid obstacles.

All the sensors previously described can finally combine both the navigation and collecting the information for the parameters cited above from the environment.

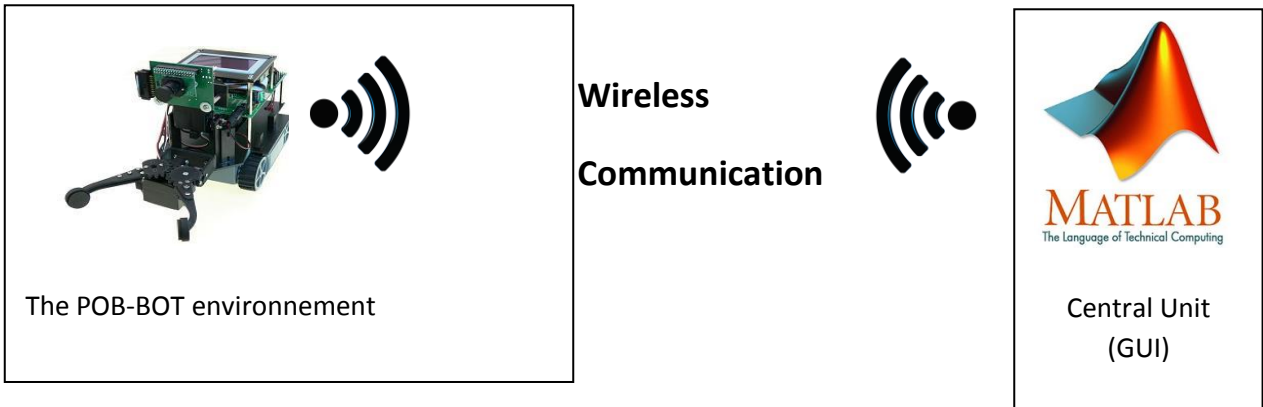


Fig 2. Synoptic of the global environment

### III) The different solution:

While designing our project we've come with so many technics and constructions that have driven us to many solutions to our initial problem:

#### 1. HE10 Bus:

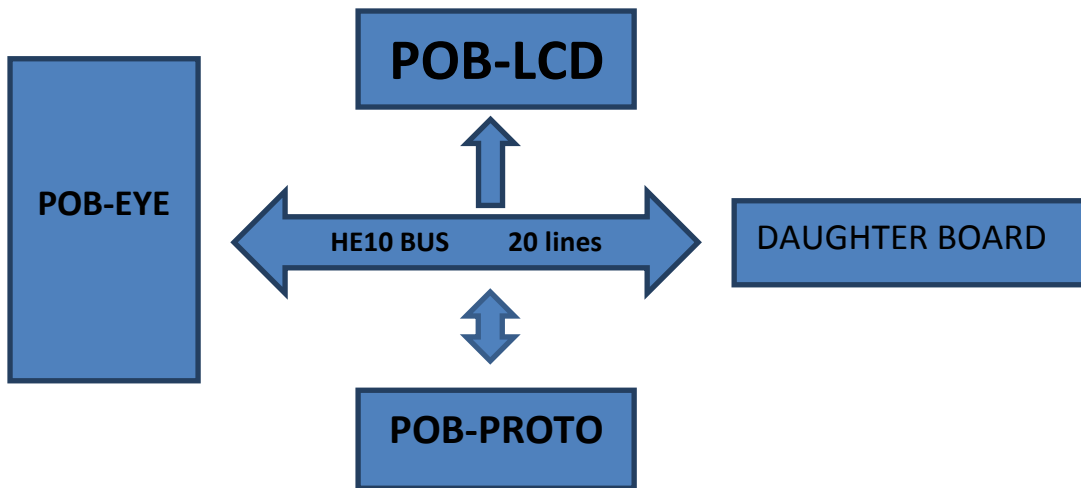


Fig 3.1.a: synoptic of the first solution using the parallel Bus HE10.

The HE10 bus allows the user to connect an extension board which communicates with the Pob-Eye.

That bus is uses parallel communication protocol. It has twenty pins that give access to the I2C bus in addition to the I/O and the alimentation pins.

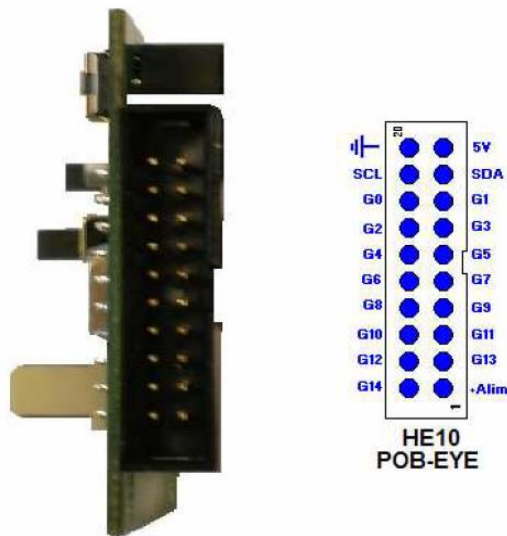


Fig 3.1.b: HE10 connector.

It uses the input/output on the HE10 connector as an address and data bus, the four addresses' pins "G11 to G14" are used to select the board with which the Pob Eye will communicate with, and the eight data pins "G0 to G7" are used for the data transmissions, "G8" is a Read/Write pin that specifies if we want to write in the other board or read an information plus "G9" is used to enable the board and "G10" an ACK pin to know the peripheral state as the following picture shows:

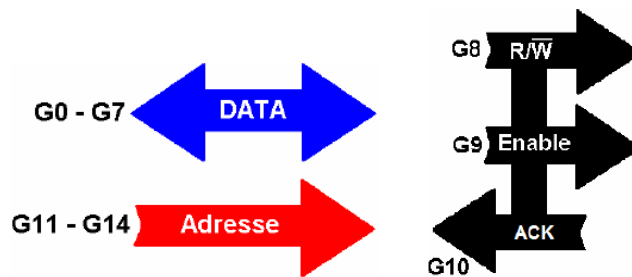


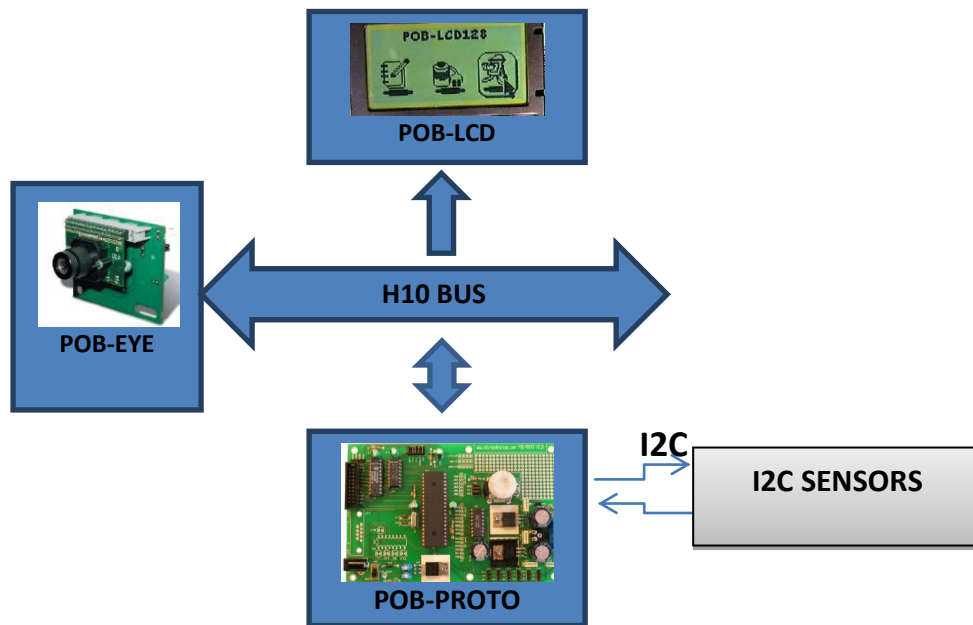
Fig 3.1.c: the distribution of the lines.

Two other pins are used for the I2C communication, one for alimentation and the last two pins are used for power and ground.

We had to use four pins for address selection and eight for data transmission between the boards that gives the sensors information and transmit them in the bus. We should add some external integrated circuits for the address selection and data transmission.

The daughter board is an electronic circuit that contains the sensors plus other integrated circuits that allows us to select reading information from the sensors using one of the HE10 addresses ("74HC245" for data reading and "74HC138" for the address selection) which we're going to talk about after.

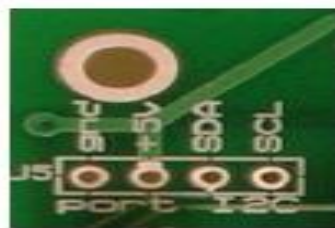
## 2. I2C communication:



**Fig 3.2.a: synoptic of the second solution using the I2C protocol.**

This technique focus more about the serial communication between a specific sensors and the Pob-Proto board using a serial cable which allows the transfer of the data's between the sensors and the boards.

The I2C protocol pins are situated in the top right corner which allows us to connect our cables easily



**Fig 3.1.b: I2C pins in the POB-PROTO.**

This popular serial interface protocol allows a microcontroller board, such as PIC 16F877 in our example, to communicate with a peripheral device, such as a sensor, using two communication wires, clock and data (SCL and SDA), and two power supply wires (Vcc and GND). Each I2C peripheral device is addressable, allowing multiple devices to be attached to the same I2C connections and that is a major reason for its popularity.

As long as we address the considered sensor we activate it and we read the information or the serial data. Also the programming must follows the I2C protocol of communication for receiving data.

### 3. Port A connection: (The used technique)

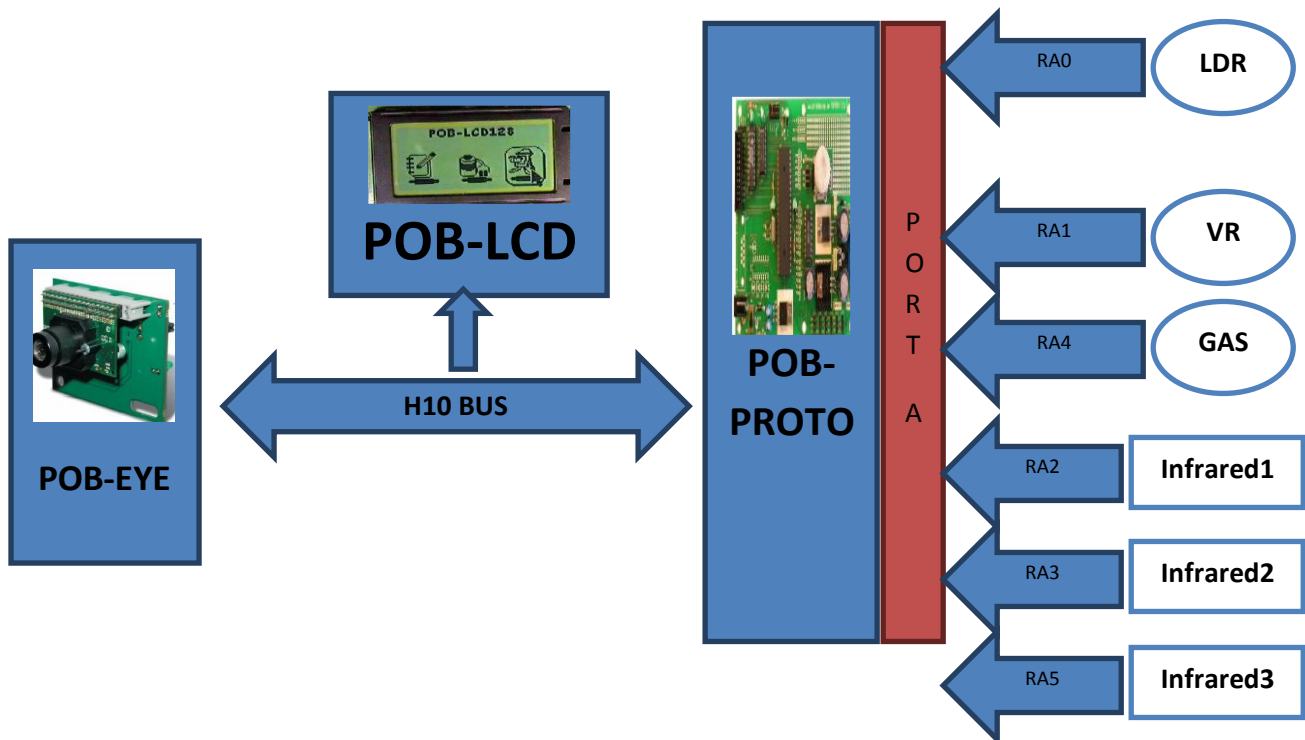


Fig 3.3.a: synoptic of the third solution using PORTA.

We've come also with another brilliant idea that allows us to obtain the same previous results just in a different way or another technique.

We've tried to benefit from the extra Pic 16F877 unused pins and ports to connect our sensors and try to program the POB-EYE to receive information and data from the sensors individually following an order of priority. And visualize the values on the POB-LCD. Also we've fixed the set-points for the Water level, gas, light. So whenever the measurement of any physical phenomena crosses any set-point it indicates an alert to the supervisor.

The Pic16F877 ports are already used in other materials (H Bridge, connectors ...) by POB-PROTO, nevertheless it is possible to unplug the existing connections of the materials and use the port as wanted.

### 4. Comparable studies between the three techniques:

The technique	Benefits	Ravages
HE10 Bus	<ul style="list-style-type: none"> <li>- No conflicts for data.</li> <li>- Once the address is selected it starts receiving.</li> <li>- Quick</li> </ul>	<ul style="list-style-type: none"> <li>- Heavy and big integration.</li> <li>- Demands lots of wires.</li> <li>- Extra integrated circuits should be</li> </ul>

	transmission.	included for security.
I2C	<ul style="list-style-type: none"> <li>- Uses less pins (only two pins clock and data).</li> <li>- Robust.</li> <li>- Synchronous.</li> </ul>	<ul style="list-style-type: none"> <li>- Uses its own type of sensors with a specified addresses.</li> <li>- Its sensors are generally expensive and rare</li> <li>- Programming complications.</li> </ul>
PORT A	<ul style="list-style-type: none"> <li>- Ship costing sensors.</li> <li>- Easy programmable circuit.</li> <li>- Sensor's and material's availability.</li> </ul>	<ul style="list-style-type: none"> <li>- Higher integration than I2C's technique.</li> </ul>

**Tab 3.4: comparative table of the three past solutions.**

## 5. The conception :

The following table shows the correspondence between the pins and the sensors analog outputs:

Sensor	Port name(number)
Gas	RA0
LDR	RA1
VR	RA4
Infrared	RA2 RA3 RA5

**Tab 5.b: correspondence between the pins and sensors**



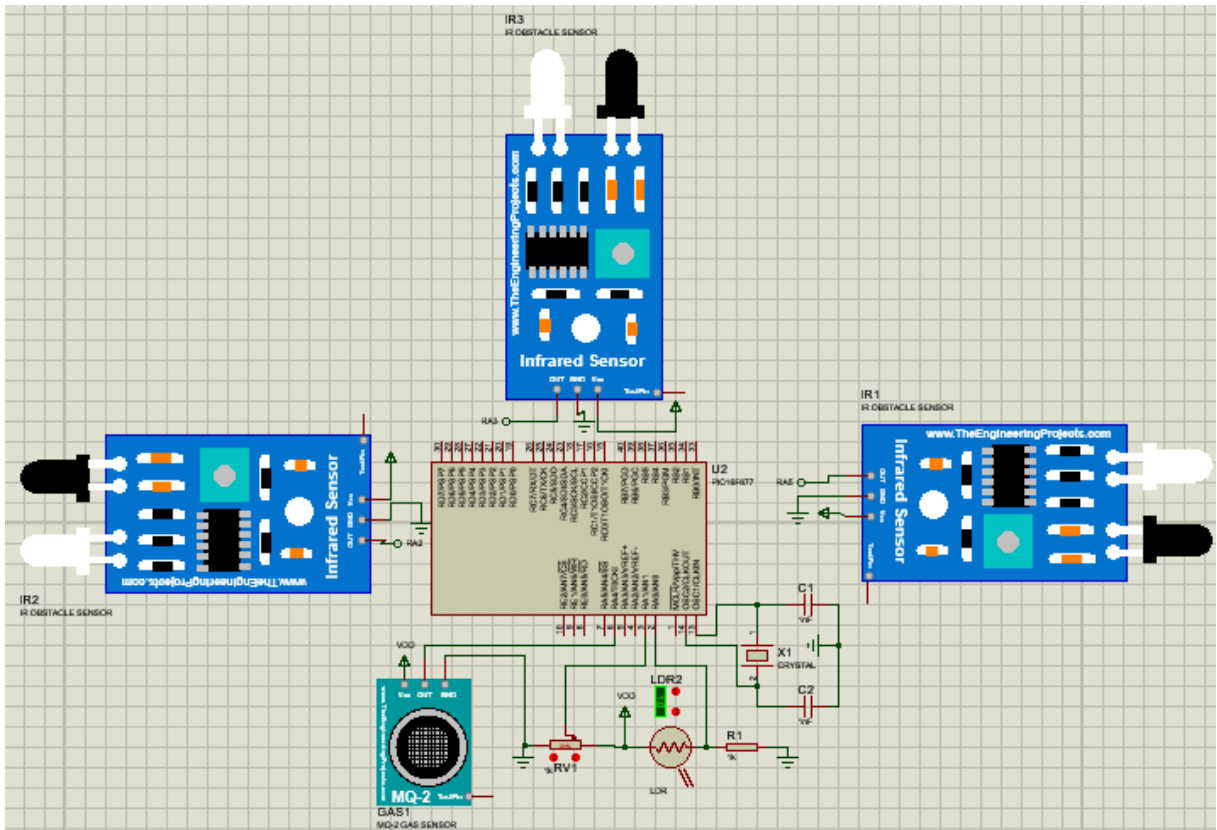
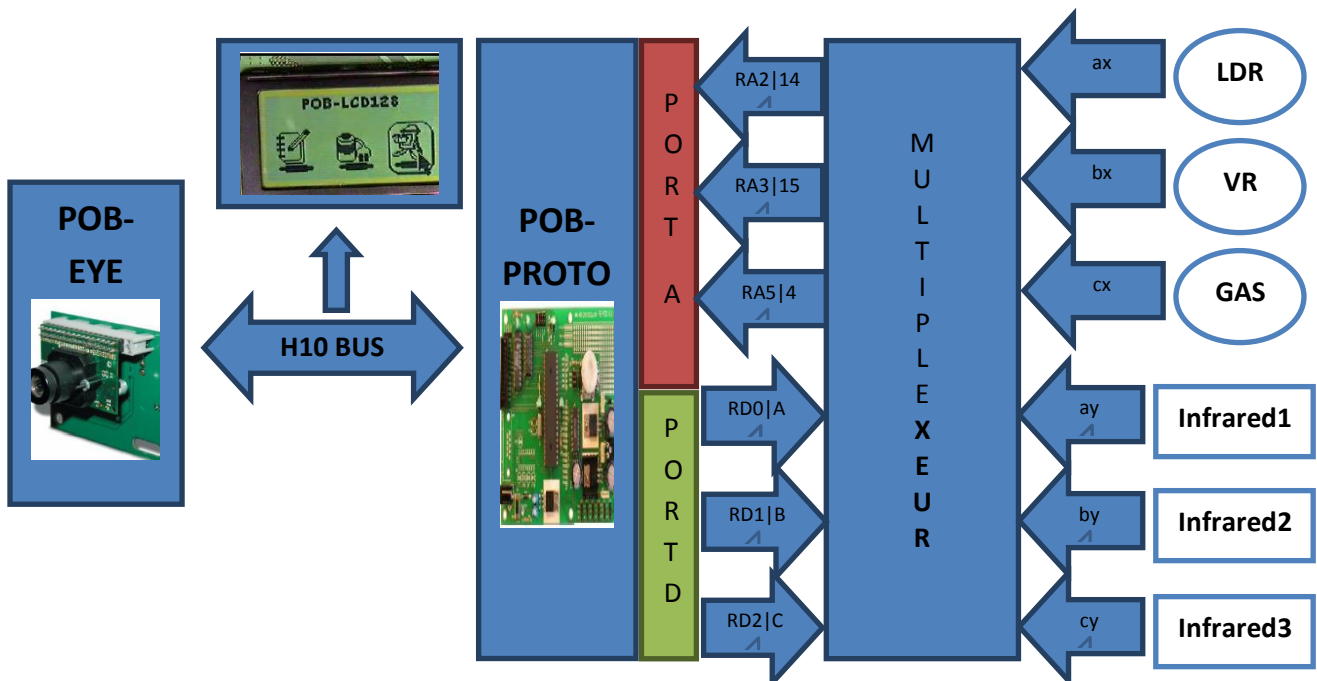


Fig 3.5.b: sensors wiring of the third solution using PIC16F877's PORTA.

## 6. The Proposed solution:

### a) Description:



**Fig 6.a: synoptic of the proposed solution using PORTA and an external circuit.**

This solution settles the previous issue which is the limited analog inputs which the PORTA of PIC16F877 contains.

As a matter of fact limited analog inputs implicate limited number of sensors. As a result we've come with the idea to include an analog multiplexer [13].

**b) Features:**

- Wide range of digital and analog signal levels: digital 3 – 15V, analog to 15Vp-p
- Low “ON” resistance: 80Ω (typ.) over entire 15Vp-p signal-input range for VDD – VEE = 15V
- High “OFF” resistance: channel leakage of ±10 pA (typ.) at VDD – VEE = 10V
- Logic level conversion for digital addressing signals of 3 – 15V (VDD – VSS = 3 – 15V) to switch analog signals to 15 Vp-p (VDD – VEE = 15V)
- Matched switch characteristics: ΔRON = 5Ω (typ.) for VDD – VEE = 15V
- Very low quiescent power dissipation under all digital-control input and supply conditions: 1 μW (typ.) at VDD – VSS = VDD – VEE = 10V
- Decoding addresses on chip.

**a) Truth table:**

INPUT STATES				“ON” CHANNELS		
INHIBIT	C	B	A	CD4051B	CD4052B	CD4053B
0	0	0	0	0	0X, 0Y	cx, bx, ax
0	0	0	1	1	1X, 1Y	cx, bx, ay
0	0	1	0	2	2X, 2Y	cx, by, ax
0	0	1	1	3	3X, 3Y	cx, by, ay
0	1	0	0	4		cy, bx, ax
0	1	0	1	5		cy, bx, ay
0	1	1	0	6		cy, by, ax
0	1	1	1	7		cy, by, ay
1	*	*	*	NONE	NONE	NONE

**Tab 6.a: Truth table of the multiplexer’s functions**

**b) Types:**

- i) Using CD4053:

CD4053 is a triple 2-channel multiplexer having three separate digital control inputs, A, B, and C, and an inhibit input. Each control input selects one of a pair of channels which are connected in a single-pole double-throw configuration as the previous synoptic shows (fig 6.a).

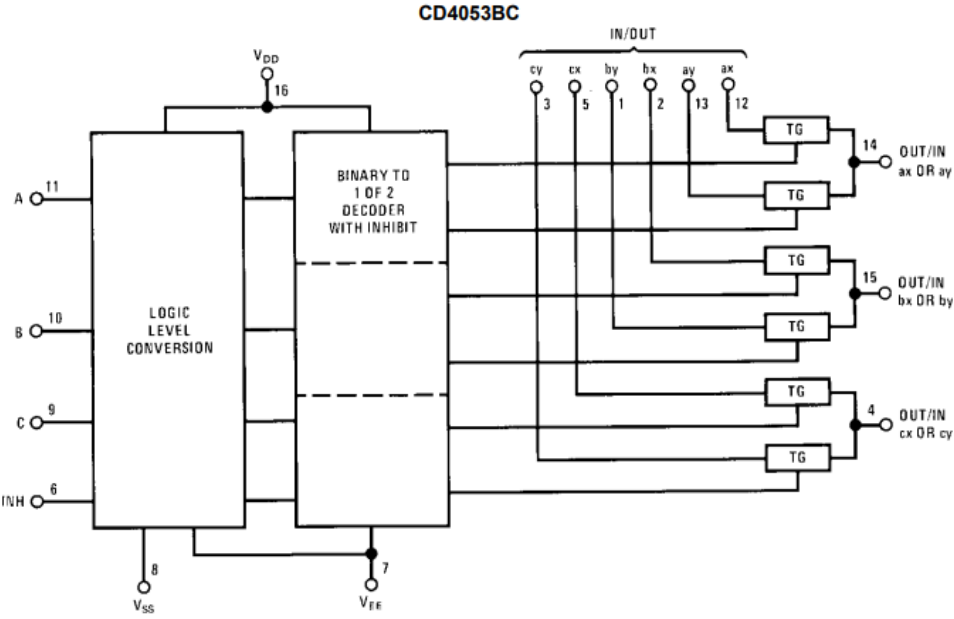


Fig 6.c.i: CD4053 logicdiagram

- Comment:

The multiplexer’s role is to use fewer Inputsfor all the sensors that we have.

We select ax bx cx, then ay by cy. Our robot will work parameter collector (gas, light and water level) then when we select the ay by cy we’re aiming to make the robot navigates using the infrared sensors

- ii) Using CD4051:

CD4051 is a single 8-channel multiplexer having three binary control inputs. A, B, and C, and an inhibit input. The three binary signals select 1 of 8 channels to be turned “ON” and connect the input to the output.

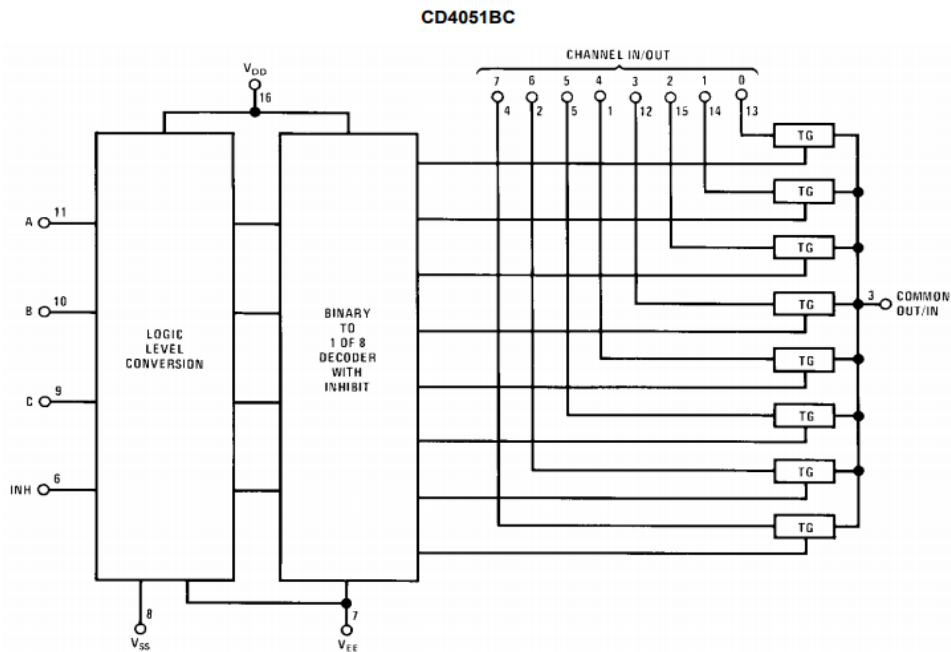


Fig 6.c.ii: CD4051 logicdiagram

- Comment:

This multiplexer reduces also the number of PORTA entries but this time we use it only to collect data from the gas, light and water level sensors and it goes to 8 different sensors.

We have to select which sensor that we will read using combinations by the PORTD outputs to A B C pins. The one and only output coming from the multiplexer contain the data which we've read from one of the sensors. That pin will be connected to one of the PORTA pins.

We connect another three pins of the PORTA with the infrared sensors which are used for the robots navigation

## IV) List of the sensors :

### 1) LDR sensor : [11]

It is composed of two cadmium Sulphide (cds) photoconductive cells with spectral responses similar to that of the human eye. The cell resistance falls with increasing light intensity.

#### A) Guide to source illuminations:

Light source Illumination	LUX
Moonlight	0.1
60W Bulb at 1m	50
1W MES Bulb at 0.1m	100
Fluorescent Lighting	500
Bright Sunlight	30000

Tab V.1.B: Guide to source illuminations

## B) Sensitivity:

The sensitivity of a photodetector is the relationship between the light falling on the device and the resulting output signal. In the case of a photocell, one is dealing with the relationship between the incident light and the corresponding resistance of the cell.

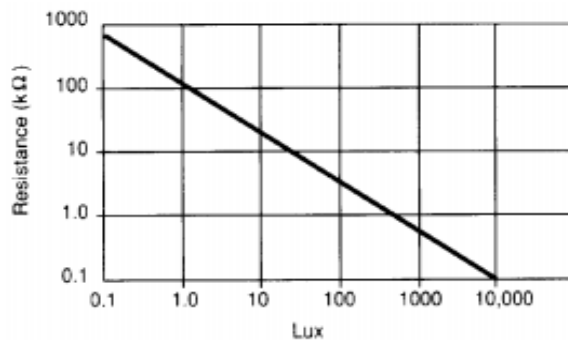


Fig V.1.C: diagram of the LDR's sensitivity

## 2) MQ-02:[9]

### A. Description :

The Grove - Gas Sensor(MQ2) module is useful for gas leakage detecting(in home and industry). It can detect H<sub>2</sub>, LPG, CH<sub>4</sub>, CO, Alcohol, Smoke, and Propane. It is based on its fast response time. Measurements can be taken as soon as possible. Also the sensitivity can be adjusted by the potentiometer.

## B. Benefits:

- \* Good sensitivity to Combustible gas in wide range.
- \* High sensitivity to LPG, Propane and Hydrogen.
- \* Long life and low cost and Simple drive circuit.

## C. Sensitivity:

According to the figure, we can see that the minimum concentration we can test is 100ppm and the maximum is 10000ppm, in another word, we can get a concentration of gas between 0.01% and 1%. However, we can't provide a formula because the relation between ratio and concentration is nonlinear.

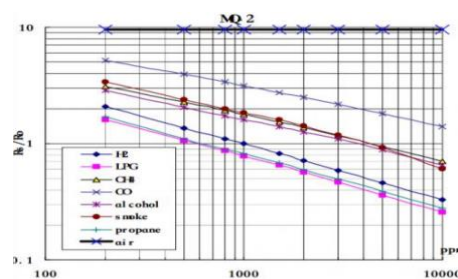


Fig V.2.C: Diagram of the MQ2's sensitivity

## 3) Variable Resistor:

### A. Description:

A potentiometer is a three-terminal resistor with a sliding or rotating contact that forms an adjustable voltage divider. If only two terminals are used, one end and the wiper, it acts as a variable resistor or rheostat.

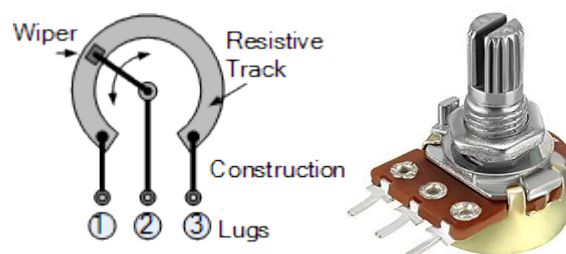


Fig V.3.A: VR function

## 4) Distance Sensors Sharp 2YOA21 [12]

### A. Description :

The distance sensor produced by Sharp is a popular and relatively low cost solution for measuring distance.

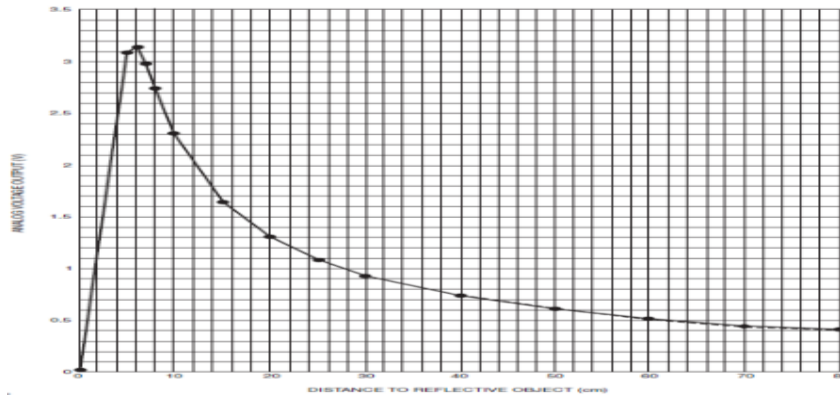
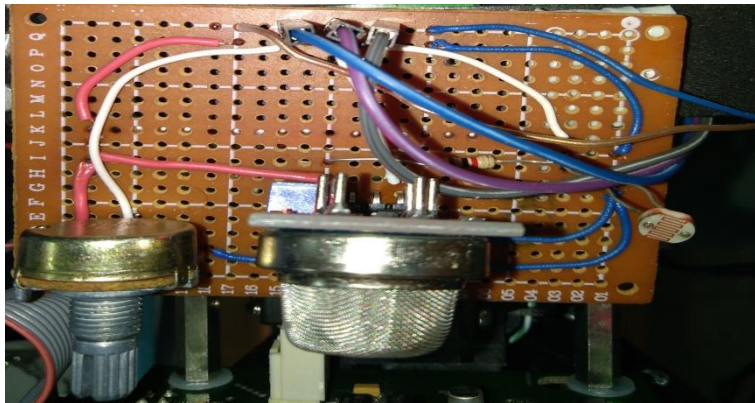
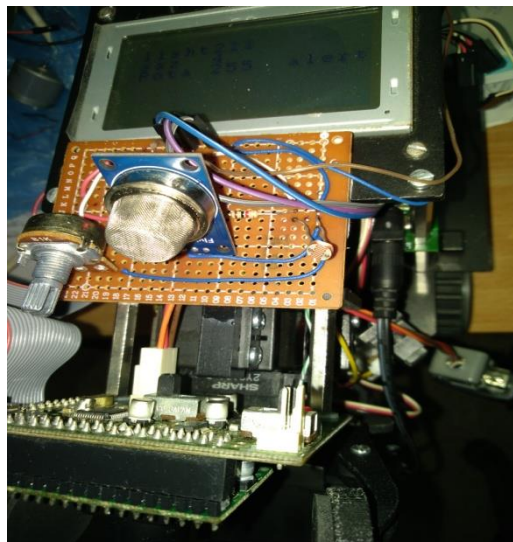


Fig V.4.C: diagram of the infrared sensors distance / output voltage

## V) Presentation of designed sensors module:



And finally here's the sensors module on the pob-bot:



## VI) Conclusion:

In this chapter we've seen the different steps we've taken to build and finally design the complete project. After that we've thought about some approaches which could've helped

us to settle our problematic. As a result we've chosen the PORTA solution because of its low costing and less integration daughter board and other benefits previously spoken. We've used different analog sensors the LDR, VR and Gas sensor for the environment perception and incident detection. Besides we've also integrated three infrared sensors for the robot's both navigation and obstacle avoiding.



## CHAPTER n°04 : SOFTWARE PROGRAMS

## I. Introduction :

In this chapter we're going to talk about the different tools that've helped us during the conception of our project specifically the software parts. Besides as we've said previously, basically the POB-BOT robot uses MASTER -SLAVE communication between the ARM (POB-EYE) and PIC16F877 (POB-PROTO) respectively.

The POB-EYE is the master board which is going to contain our main program that we're aiming to execute.

We've used tools to build our main program and import it into the POB-EYE card as we've used the POBTOOLS4 environment to write down our program.

## II. Programming steps:

The POB-BOT has its own software program whose name is POB-TOOLS4 which is a set of tools for programming, loading and controlling the POB-EYE module.

This program uses C, JAVA, BASIC programming languages, as a result to build our own program we have to choose first the tool which we're going to program "Pob-Eye1" in our project then we choose the C language of programming finally we create our project to start programming.

We've included the libraries that we've used in our programming instructions.

Set The POB-LCD and the POB-PROTO to use their functions.

We've programmed the POB-EYE, to receive the information from the different sensors which are connected to the PORTA in the POB-PROTO as follow:

We've programmed four analog inputs in the PORTA for the analog receptors which are: the VR, the gas sensor and the Light dependent resistor.

Then we have written the reading instructions to read data from the different pins which refer the data received from the sensors.

We've next built a program that uses the infrared distance sensors to aid us for improving a good navigation for our mobile robot we've placed three ones in the front right and left sides of the robot.

We've added more other functions using a library that allows us to give orders and manage the robot as aimed.

### III. The different functions:

First thing first we've included the "pob-eye.h" library that allows us to use the hardware properly. In addition we've included the "string.h" library which is used to draw different values on POB-LCD. Besides we've declared the functions that we're going to deploy currently in the program, including POB-PROTO initialization, and POB-BOT navigation's functions and LCD buffers.

### IV. The program:

#### 1. Global program:

First thing first we've included the different libraries needed in this program

We've then defined the constants of time that we've needed for the different navigation functions operations.

While starting the main function we've declared the variables which will take the data read from the PORTA furthermore we've fixed the set points of the different sensors.

We've initialized the hardware parts all POB-EYE, POB-LCD, POB-PROTO, Servo motors the graphical, the LCD and ASCII buffer.

Then in a loop we're going to read the data from the different sensors. So we can divide the program into two different programs. The first one will be the navigation program which will use the infrared sensors trying to keep the robot in a safe road and the second one is going to measure the gas, light and water level and convert it into values, display them in the POB-LCD and send them to the serial communication UART and obviously manage the robot depending on the values read. However both programs will be executed simultaneously, we read the data from the other sensors while the robot moves towards its goal forwardly.

The reading part is stopped whenever an obstacle appears and the robot tries to avoid it.

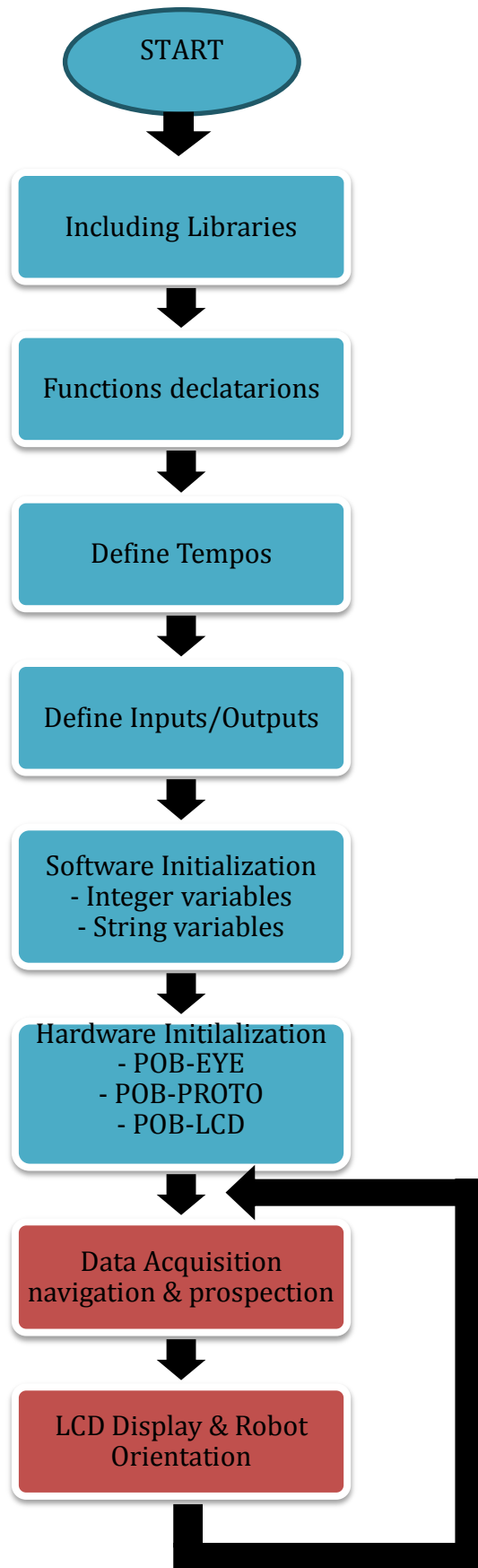


Fig 4.1: Global program's algorithm's diagram.

## 2. The navigation program:

This program is going to use the information coming from the infrared sensors to manage and build a safe navigation for the robot. We read the data from the pins to which the sensors are wired with, then the robot moves depending on the comparison between the new data conviction and the set-points. We use the `movebot()` and `movebotpendant()` functions previously declared to give orders to the robot's motors and keep the robot far from the obstacles.

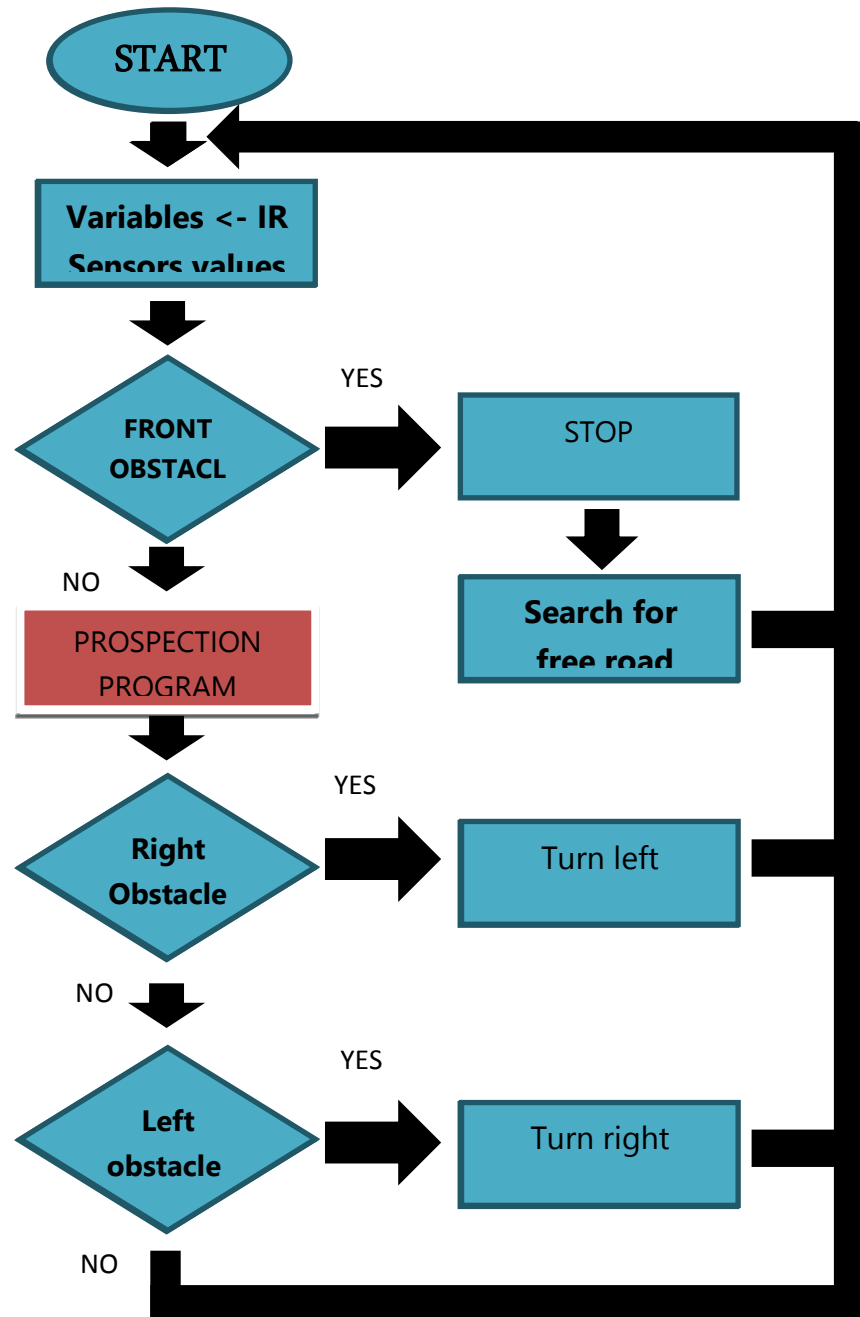


Fig 4.2: Navigation program's algorithm's diagram.

### 3. The prospection program:

This Program starts just when the test of the frontal infrared sensors goes to “0” logic, it means that there is no frontal obstacle. Therefore this program will use the water level, gas, and light sensors data to prospect the incident and stops the robots navigation whenever one of the read values reaches its set point. It also displays the values and the alert if found in the POB-LCD.

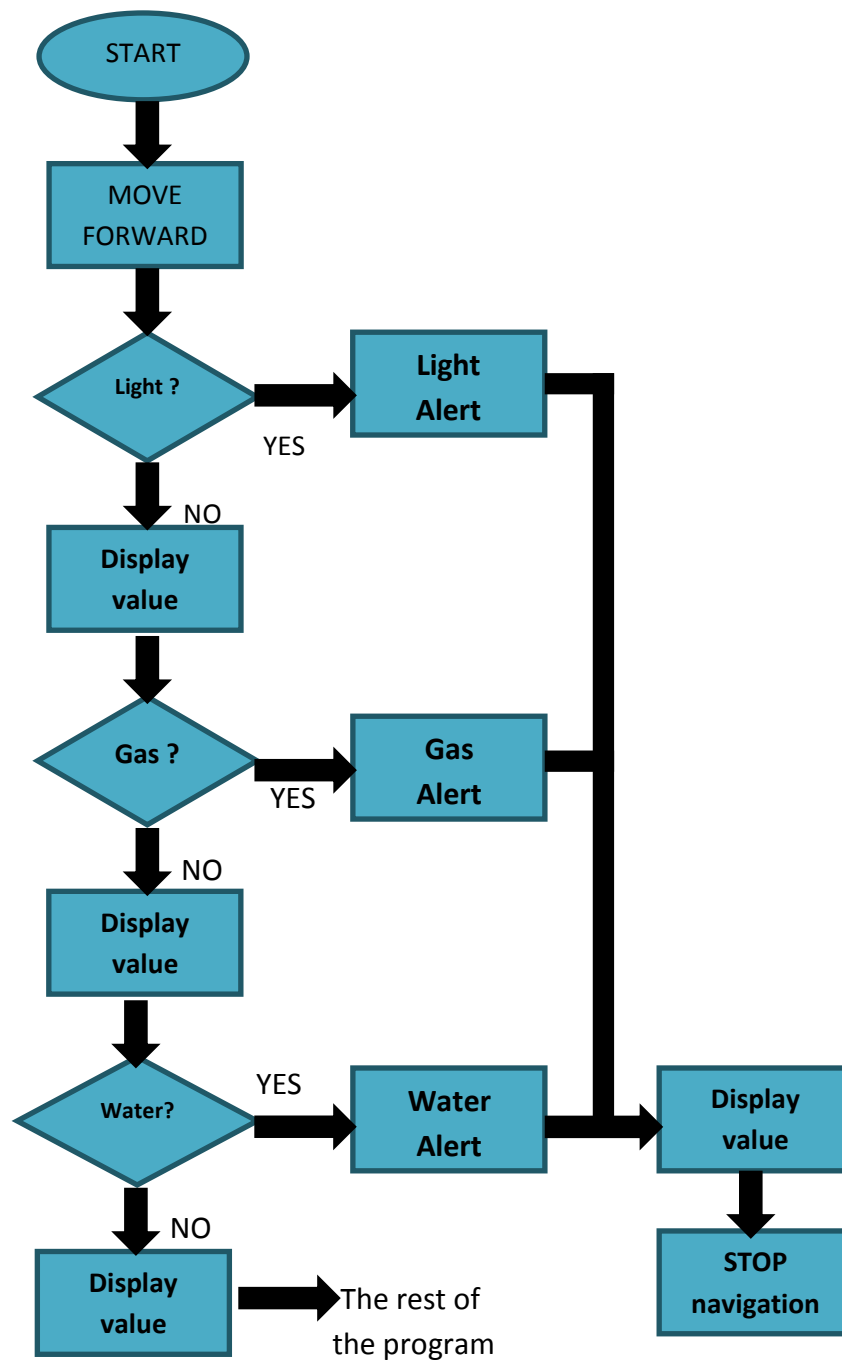


Fig 4.3: Prospection program's algorithm's diagram.

## V. The human machine interface :

### 1. Defenition :

The Graphical User Interface (GUI) is the interface to the operating system uses a graphical display that can be controlled using a variety of input devices such as a mouse, keyboard and others. On the GUI interface are menus, windows, buttons, icons and others who can design so much easier and convenient. Excess GUI is interest design and user friendly, not boring and does not remember the line of command. While the drawbacks need the hardware specs are larger and heavier performance.

In our case we're using the GUI using Matlab by Mathworks the programmation environment.

### 2. Presentation:

We have built a simple interface using gui based on the necessity in this project. Besides, the interface is as simple as a message that we receive whenever gas incident, light or the simulated flood describing a warning or an alert.

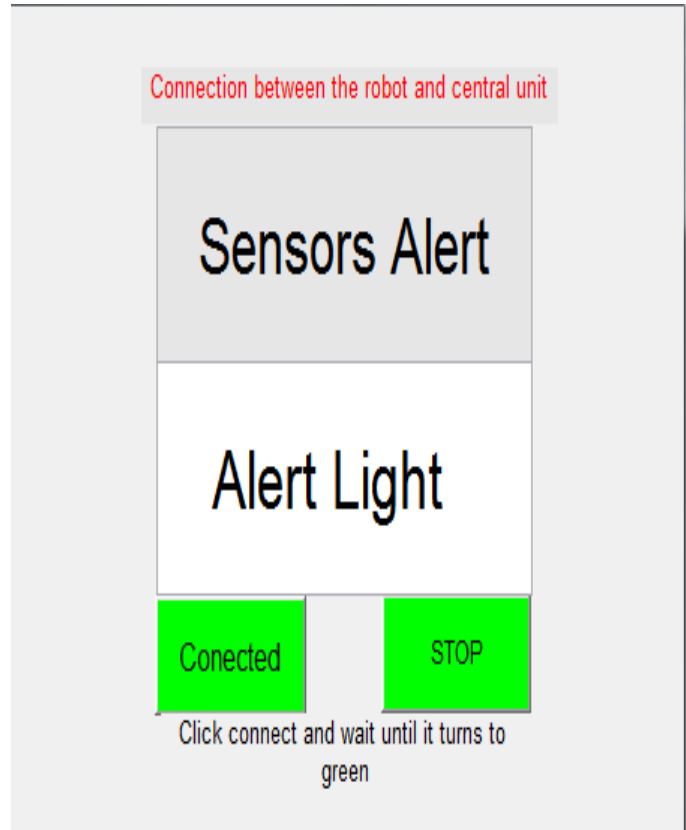
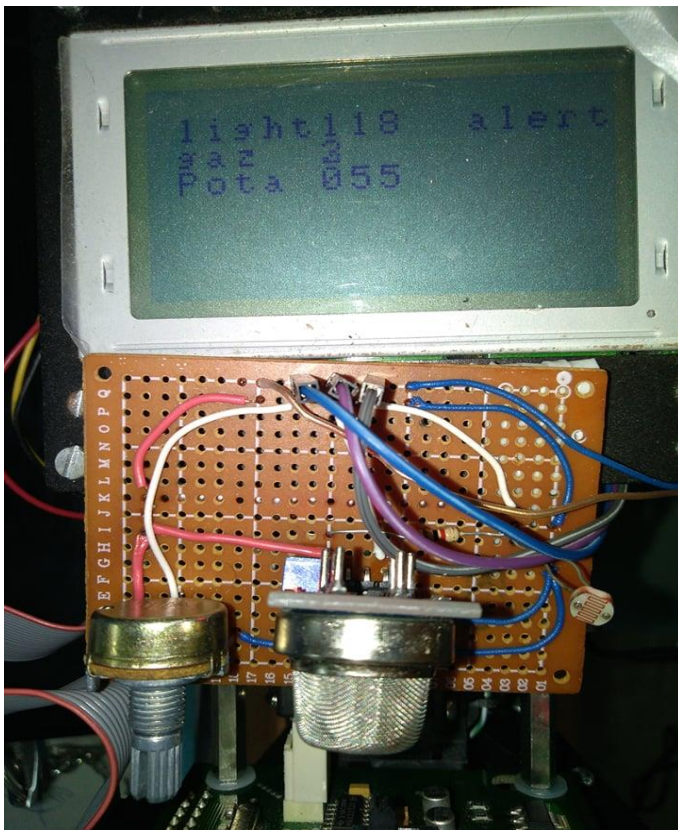
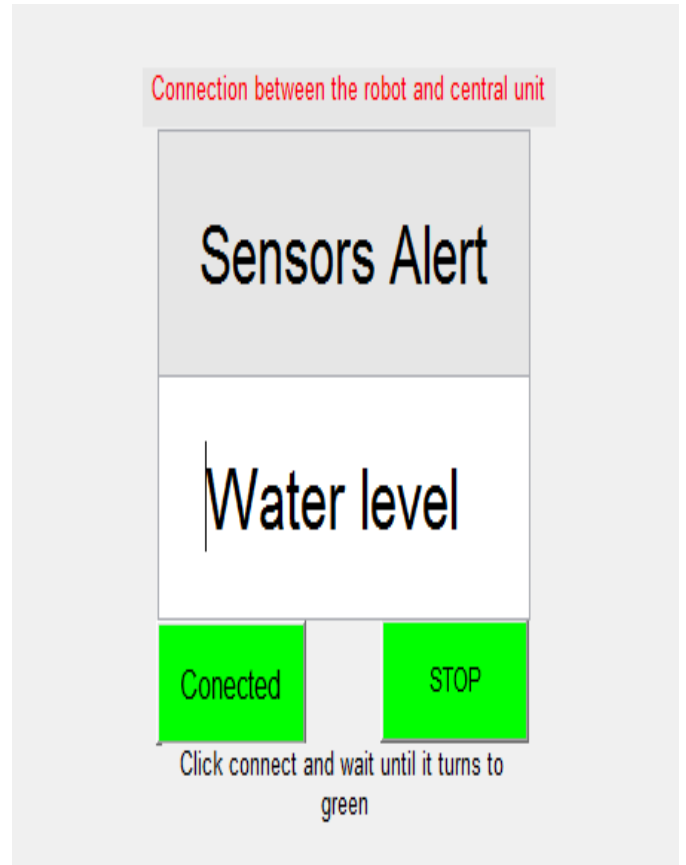
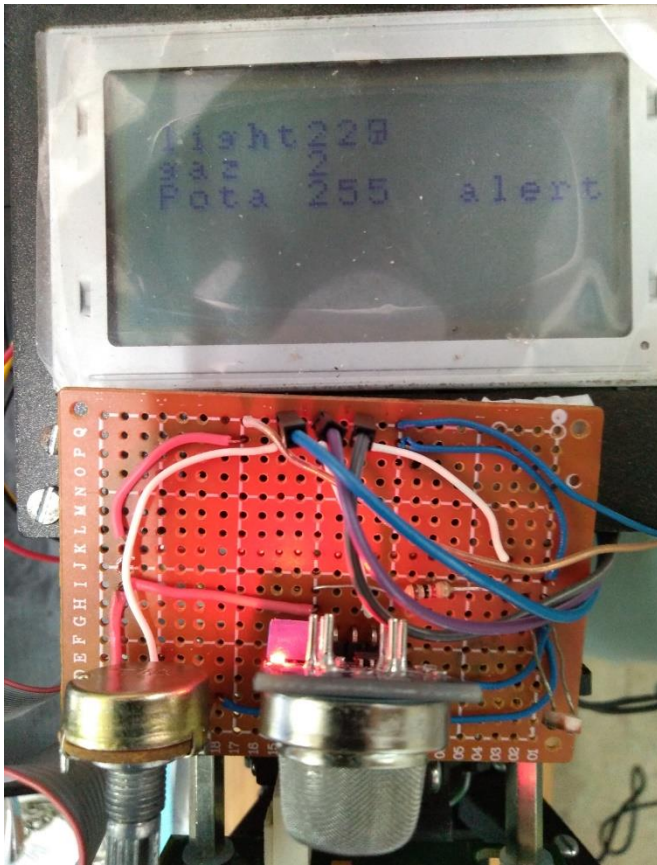


Fig 5.5.3: Two examples comparison between the LCD and the HMI display.



## IV. Conclusion:

In this chapter we've seen the different tools that we've used in the implementation and the build of our program step by step.

We've seen the combination of the two sub-programs in one main program which will settle out problem cited previously.

The first sub-program is the navigation program that uses the infrared sensors to create a safe and interesting navigation.

The second one is the prospection program that uses the VR, LDR and gas sensors to supervise the physical phenomena previously mentioned and whenever the robot finds an incident it stops just beside it.

We have finished this part with programming a Graphical user interface using Matlab environment that receives the alert message from the Pob-bot.

## Global conclusion

This memory deals with the navigation and prospection in a known environment by an autonomous mobile robot. We have used an extension of potential field navigation technique.

In the other hand we have seen a quick demonstration of the project in a simulation environment which helped us to build two different environments and to show how the robot is going to react with them while traveling the free space of the corridor to get to the final point that refers the incident location.

Moreover, we have included how did we manage and settle the sensors problematic using different techniques and why did we choose the one which we have worked with and design our robot properly. The sensors roles are both navigation and prospection.

Furthermore, we have also seen the algorithms we've written to answer and settle the problematic and build a good and safe navigation and prospection for the mobile robot.

Despite of the hard work, the low availability of the electronic elements and the unavailability of their documents, this project was an absolutely fascination experience and it fed me the robotic, electronic and embedded systems knowledge due to the rich information and techniques to learn during the whole project. As a result we have obtained very interesting results and too many information that we've added may help the future works and researches in this area, one of these information is the use of the Multiplexer to add more sensors for a deep prospection. We can also add a GPS to localize our robots emplacement in the environment and send it to a web site. In addition we can change the wheels type for harsh environment navigation.

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