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Graphical User Interface Based Wireless Controlled Environment Monitoring Robot

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Abstract: ***This paper is based upon building a wireless robot, which is controlled by the GUI (Graphical User Interface) on the PC. The robot senses the atmospheric temperature, gases, and humidity, displays the values on PC screen for regular check. User can control the robot wirelessly by the Buttons created on GUI that we have made using MATLAB. With the change in growing technology, we humans need to get things done more conveniently. Things look easier when it has been controlled by some Graphical devices. We use Arduino and MATLAB to accomplish our work, which is based on the wireless environment in which we employed communication technique USART for transmitting data serially via NRF transmitter and receiver. The robot can detect the various gases, temperature, and humidity with the help of sensors that relate to the bot and the data is monitoring onto our serial monitor in Arduino. The robot also has barrier detection mechanism that we have employed using the Ultrasonic sensor.***

Keywords: GUI (Graphical User Interface), PC (Personal Computer), USART (Universal Synchronous Asynchronous Receiver and Transmitter), NRF (Nordic Radio Frequency), TTL (Transistor-transistor Logic), IDE (Integrated Development Environment), Bot

I. INTRODUCTION

In today's world, robotics is not a new field. It has been emerged from more than a decade. The development of autonomous mobile bots is of increasing interest due to the growing need of applications in a human-friendly environment to improve standard of living and the declining price of sensors and computers. Moreover, it is generally believed that the need for service providing bots will grow exponentially over the next decade. Using wireless sensor networks (WSNs) to detect environmental changes has many advantages. Individual nodes in the network can detect their local area and interface with other nodes over radio channels to collectively produce a higher order characterization of environmental conditions. By using such a network, a wide range can be monitored at low cost. A mobile bot is a device attached to a mobile platform. Mobile bots are typically designed to navigate to a specific place or environment as directed by a controller. Today, mobile bots are widely used in many different types of applications such as health care, security, defence, industrial sector, and even in WSNs. Many home bots such as cleaning bots, general bots, social bots, and entertainment bots have evolved from simple mobile bots [1-4].

MATLAB is one of the most extensively used software in the field of research and engineering, we all are aware of its vast libraries and functions. Most of the climate detecting bots are made using its control over any button or axis-based hardware remote controller. Here, we have done this work using different approach. We have employed a GUI based remote control in MATLAB which controls the locomotion of the bot. Here we have used a bidirectional NRF which sends and receives information at both the terminals. Also, we can monitor our data on PC screen as well as we can control it on the same. This work is based on a wireless bot which is controlled by GUI (Graphical User Interface). With the change in growing technology, we humans need to get things done more conveniently. Things look easier when it has been controlled by some graphical devices. We have done this work using Arduino IDE and MATLAB. We have interfaced both the software in order to accomplish our work. We have made our work wireless in which we have employed communication technique USART for transmitting data serially via NRF transmitter and receiver.

We have used MATLAB as a tool to make our GUI. It is one of the most used languages for many engineering fields. We have made our virtual remote control using graphical user interface in its GUI toolbox. The amount of data which we sent from our GUI is serially transmitted via TTL. We sent our data serially with a baud rate of 9600. Whenever we are using MATLAB, we most of the time uses serial communication method because it is very much easier for Microcontroller to get data and accordingly it will be given instructions.

We use TTL in our work which is connected to the PC and that sends our instruction to the Arduino Microcontroller. The temperature/humidity sensor and MQ4 sensor detects the respective values of temperature, humidity and several gases and the information is in the serial monitor of Arduino with a click of a button we have done in MATLAB. The robot also has barrier detection mechanism that we have employed using the Ultrasonic sensor.

II. BACKGROUND AND LITERATURE SURVEY

M. H. Zulkefli, S. H. Johari, K. A. Mohd Annuar, S. Ahmad, and S. H. Johari [1], Mobile robot architecture is about developing the art and skills to create robots useful for human applications. Every part of the electrical, mechanical, electronic and software requirements need to be examined to ensure that any mobile bot applications can run easily and finish the task on hand. In the mechanical part, all measurements of the mobile robot configuration must be detailed and modified. This is the most important criteria for the stability, fastness, and functionality of robots. In order to develop cheap, robust, and powerful mobile robots, research must also be done on electrical and software components.

Abdellatif [2] presents a mobile service robot with tools for understanding robot classes and, enabling locomotion or object guidance in spaces such as home and office environments. The development of autonomous mobile robots is affected by falling prices of sensors and computers. There is a lot of interest in advance while riding an autonomous mobile robot. It is also used to improve quality of life as the need for applications in human-friendly environments increases. The use of fuzzy logic (FL) approach in robotics has many effective applications and is said to be a method of intelligent computation. Fuzzy Logic Control permit the system to prevent hesitation from interfering with control actions. Alternatively, they propose a way to integrate action selection via latent field philosophies. I found it very well organized, especially for fast robots. Prototype imaging and measurements of target locations from color images show tone, saturation, and intensity. The HSI color space has been used since the moment it was discovered before and is perceptually constant. Another advantage is the ability to recognize objects based on the presence of color in the image for better results. They are related to the design of the agency's fuzzy logic controller, whose purpose is to enable mobile robots to specifically achieve two goals. Combining both behaviors in goal following behavior, obstacle avoidance behavior, and other methods. The robot controller is tested via the system structure. The success of the control system lies in its ability to control the robot and recognize the color of objects safely and reliably. Moreover, they separated self-determined behaviors and then led to connected behaviors. A vision-based control system was applied to allow the mobile robot to walk his sidewalks and track moving objects.

Yuan Yuan Li and Lynne E. Parker [3] use wireless sensor networks (WSNs) to detect environmental changes. It may cost a small amount to monitor large areas that can be monitored through this network. They explored through "unknown environments" where intruder detection had previously occurred. To see if there is an intruder in the zone, the robot uses a camera as an additional sensor. However, multiple clustering schemes are better suited for certain categories of data or applications. This network used the architecture of sensor networks, fuzzy ART connections, and a prototype Markov expansion. At the hardware level, the wireless sensor network consists of two fixed sensors (Crossbow Mote) and a mobile robot (Pioneer 3 robot). Results come from many experiments, including intruder detection systems, performance metrics, time-varying detection experiments, and intruder detection experiments. This is a new approach system that detects temporal anomalies with an intruder detection system using a wireless sensor network and a mobile robot.

P. Sia Kwek, Chen How Wong, Zhan Wei Siew, B. L Chua, K. Tze Kin Teo [4], Tablets are highly functional and flexible platforms that can be combined with robotic autonomy and navigational control. The supremacy of remote control of bots via mobile devices is that they are location independent. The new research results are being integrated into more applications in mobile devices and robotics. The Communication technology that connects moving devices and bots is particularly important. This article details the design and development of mobile robotic systems using tablets. Describes wireless communication between microcontrollers, computers, and tablets. A user can navigate her robot on mobile and past points of interest via her GUI interface on a tablet. A mobile robot is a machine attached to a mobile platform. Mobile robots are typically designed to navigate to a specific area or environment as directed by a controller. Today, mobile robots are widely used in many different types of applications such as medical, security, military, industrial, and even wireless sensor networks. Many domestic robots, such as vacuum cleaner robots, social robots, and entertainment robots, have their roots in simple mobile robots. New technologies in mobile devices and mobile robots are creating a variety of new applications in the industry. Many computing platforms with compact form factor are equipped with many peripheral sensors and communication for omnipotence when multitasking.

The combination of mobile devices and robots brings new ideas in many fields. Mobile devices such as Android tablets are growing in popularity. It is a hybrid type of mobile device and laptop. They become more powerful, efficient, and user-friendly over time. It has so many functions that it is suitable as a platform for developing mobile robots. Tablets are more mobile, have longer battery life, and are more versatile than laptops. Many tablets come with a data plan provided by your mobile operator.
It is convenient for access in public places and when traveling. For mobile robots and tablet devices to interact, it is critical to establish a reliable wireless communication link between them. Communication allows robots to relay status information to human controllers and vice versa. The system's wireless communication capabilities are important because they let users know what they are experiencing.
Hasan Salman, M Sezadur Rahman, M. A Yousuf Tarek, and J. Wang [5], Environmental supervising is the collection of data about environmental parameters. Monitoring and analysing the natural resources is crucial for effective environmental planning, policy making, pollution awareness and solutions. Manual monitoring poses health risks in heavily polluted areas. To avoid these risks, remote monitoring technology using robotic systems with intelligent data acquisition, communication and processing is essential to revolutionize surveillance and protection. For remote monitoring, developing a system that allows monitoring without human intervention is an efficient solution.
Sharul Agrawal and Ravi N. Prakash [8], Wireless sensor networks (WSNs) have become a trend in recent years due to advances in wireless communications, information technology, and electronics. Wireless sensor networks are especially useful in areas where wiring is difficult, where tethered power is not easily accessible, and where human intervention is not possible. It can also make deployment easier by reducing the amount of cabling you run. A WSN's sensor nodes are small and can capture, collect, and process data during communication. The brain of each WSN node is a microcontroller that processes readings from its own sensors. A central base station is also required for all operations and monitoring. In this prototype system, we developed an embedded wireless sensor prototype system for temperature monitoring in a laboratory at the Plasma Research Institute (IPR). I used an XBee module based on the IEEE 802.15.4 standard and Arduino circuit board with an ATmega328 or 168 for convenient and interfacing with the XBee module and easy programming (in C) of the microcontroller. The Arduino boards comes with a library for interfacing with the XBee module and handling digital or analog inputs and outputs.
Microcontrollers are only a couple of decades old, but their impact (directly or indirectly) on our day-to-day life is profound. Generally, these should only be data processors that perform intensive numerical functions. But their presence goes unnoticed in most places, such as: supermarkets, washing Machines, Weighing Scales, stereo equipment, photocopier, security systems, home ovens, traffic lights, gaming equipment's, typewriters, and elevators etc.
What makes these devices intelligent? The answer is very simple that is the microcontroller. Growing approach for microcontrollers is unlike any other electronic or computer engineering development job. Before choosing this device for your end application, it is always advisable to realize what are the various characteristics and attributes are, and what they signify for developing your specific application.

A. Microcontroller And Microprocessor

Controllers are used to control some processes. Traditionally, controllers consist of logical components and they are typically large boxes. Afterwards, microprocessors were used and allows all controls to be adjustable on a small-scale circuit board. That is commonly used in today's world. You can find a lot of controllers with one of the following popular microprocessors (Z80, Intel 8086/8088, Zilog, Motorola 6809, etc.).
In the procedure of progressive miniaturization, all components required for the controller were installed directly on the chip. The single chip computer or we can say microcontrollers were born. A CPU developed on one of the VLSI chips is termed as a microprocessor. This includes the instruction decoder, arithmetic logic unit, control unit, instruction registers, clock circuitry (external or internal), program counter, registers, and reset circuitry (external or internal). For example, the Intel 8085 is an 8-bit microprocessor whereas, the Intel 8086/80286/8088 are 16-bit microprocessors.
The microprocessor is a general-purpose central processing unit onto which additional external circuitry is included to make it a microcomputer. The 8-Bit, 16-Bit And 32-Bit Microcontrollers

1) *8Bit Microcontroller:* when the ALU carry out logical and arithmetic operation on 8 bits (i.e., one byte) of instruction. The microcontroller is known as an 8-bit microcontroller with an internal bus width of 8 bits. Some of well-known 8-bit microcontrollers are Intel 8031/8051, P1C1x and the Moto MC68HC11 families.

2) *16-Bit Microcontroller:* When the ALU carry out logical and arithmetic operation on words (i.e., 16 bits) of instructions. The microcontroller is known as a 16-bit microcontroller with an internal bus width of 16 bits. Few Examples of 16-bit microcontrollers are 8051XA, Intel 8096, Moto MC68HC12 and MC68332 families. The execution and processing power of 16bit microcontrollers are upgraded with greater accuracy as compared to 8bit microcontrollers.
3) *32Bit Microcontroller:* when the ALU executes arithmetic and logical operations on dual words (i.e., 32 bits) of instructions. The microcontroller is said to be a 32-bit microcontroller. The internal bus width of a 32-bit microcontroller is 32 bits. Some Examples of 32-bit microcontrollers are PIC32MK, PIC32ML, PIC32MX, Intel 80960, Moto M683xx and Atmel 251 families. Its performance and processing power are improved with greater accuracy as compared to 16bit microcontrollers.

B. Arduino

A microcontroller is also known as a mini computer which is fabricated on a single integrated chip including a processor, memory, and programmable I/O peripherals. The crucial part is the microcontroller which includes a processor (that all computers have), memory, and controllable I/O pins often called general purpose input/output pins (GPIO). The Arduino microcontroller is convenient, and robust single-board computer that adore very high popularity in the professional markets. Arduino is an open-source platform, so the hardware is economic and its programming software is free to use. The beginning of Arduino manufacturing was started in Italy to develop low-cost interaction design hardware. There are numerous types of Arduino hardware boards, where you can write programs to read switches and sensors, control motors and lights, and built interface circuits.

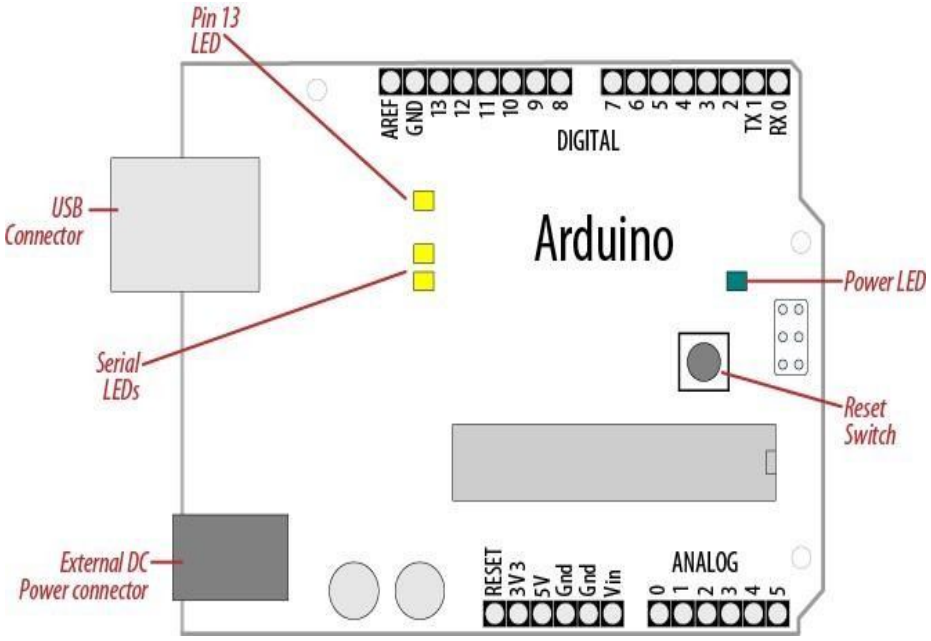

Fig. 2.1 Arduino with pin description

The Arduino microcontroller board with its pin description is given in fig. above. These boards provide a set of analog and digital I/O pins that can be used with various expansion cards and other types of circuits. These boards have a serial communication port, also includes USB on few prototypes for uploading programs from computers. To programme microcontrollers, the Arduino board allots an IDE software based on the Processing power, including support from the programming languages like C and C++. The primary Arduino was introduced in 2005 and was developed to provide learners and professionals an affordable and convenient way to build devices that employ sensors and actuators to interact with their surrounding environment. Examples of such devices for learners are simple bots, thermostats, and moving detectors. The Arduino boards are well familiar for its hardware structures, but we also require software to program this hardware. Collectively the combination of both is said to be an "Arduino". This integration allows you to develop projects that capture and control the physical growing world. Arduino software is an open source and free to use platform. These Boards can be purchased inexpensively, but you can also make your own one. The hardware design is also open source. Additionally, this microcontroller has dynamic and supportive Arduino committee that is approachable worldwide through the Arduino conclave and forums.

1) Arduino Software

The Arduino Software programs known as sketches are built on PC utilizing the Arduino IDE software. The IDE software permits you to read, write and correct codes and translate these codes into instructions that the Arduino hardware can understand easily. The IDE sends these instructions to the Arduino board and this process is known as uploading. The new versions of the Arduino IDE software are very fast and powerful tool. Along with a modern editor and a responsive interface, IDE also offers auto compilation, code navigation, and even a live debugger. His open-source and easily accessible Arduino software makes it convenient to write and assign code to the board. This software can be utilized with any kind of Arduino boards.

Fig. 2.2 sample program of ultrasonic sensor

2) Arduino Hardware

Arduino boards traditionally use Atmel 8-bit, 16-bit, or 32-bit AVR microcontrollers although 3rd party microcontrollers have been used since 2015 for easy programming and integration with other circuits. It consists of complementary components that facilitate programming and incorporate in other devices. A key feature of the Arduino is the standard connector that allows the user to connect his CPU board to various exchangeable add-on modules called shields. Few shields interface directly with the Arduino boards via different pins, but numerous are separately addressable via I^2C serial bus, so multiple shields can be stacked and utilized in parallel. The Majority Arduino boards includes a 5V linear voltage regulator and a 16MHz crystal oscillator, but some designs like the Lilypad run at 8MHz and have a specific form factor. The on-board voltage regulator is omitted due to the limitations of Arduino microcontrollers also come pre-programmed with a bootloader, making it easy to upload programs in on-chip flash memory as compared to another appliance that typically requires an external programmer. That makes using an Arduino board easy as you can use a regular computer as a programmer. The Opti bootloader is currently the default bootloader installed on the Arduino UNO.

Fig. 2.3 Arduino microcontroller hardware

C. MATLAB

MATLAB is a programming domain for numerical computation introduced by the MathWorks. MATLAB allows us to work with different types of matrices, graph plotting and data visualization, realize algorithms, build user interfaces, and interfacing with programs write down in different languages. We used MATLAB as the tool for creating the GUI. It is most broadly used languages for a lot of engineering applications. Here we have created a graphical user interface in the GUI toolbox. The amount of data which we sent from our GUI is serially transmitted via TTL. We sent our data in serial with a baud rate of 9600. Whenever we are using MATLAB, we most of the time uses serial communication method because it is very much easier for Microcontroller to get data and accordingly it will be given instructions. We use TTL in our work which is connected to the PC and that sends our instruction to the Arduino Microcontroller.

III. PROPOSED WORK

The aim of our project is to reduce the effort and risk that humans face when it is required to access various unsafe and unknown areas like caves etc. We have developed bot that can go into the unsafe and unfavorable areas and perform checks on the surrounding environment. The bot is controlled wirelessly, and the controller is a virtual remote (GUI) that we have employed using MATLAB. Also, the information sent from the bot on our PC is screened in real time, thus making very easy to know the surroundings and environment the Robot is surrounded by. An MQ sensor (MQ4) is used in order to detect presence of gases. Humidity and temperature sensors are incorporated to get the moisture and temperature details.

A. Components Used

Table I: Components used

Component	Proportion	Function
Arduino	Two	As a Microcontroller
NRF	Two	For Reception & Transmission
TTL	One	Use for Serial communication
MQ sensor	One	It is used for detection
L293D	One	Motor Driver IC
Humidity and temperature sensor	One	To sense the humidity in the surroundings
Battery	One	Power Supply to robot
Ultrasonic sensor	One	Obstacle sensing

B. Block Diagram

The block diagram of the overall system from the transmitter to receiver side is shown in fig below. From the controller side, GUI which we have employed by using MATLAB sent its data via TTL to Arduino which in turn relates to serial monitor. Arduino sends this data serially to NRF which is connected wirelessly with other NRF in the bot side. Now, the NRF again sends this data to other Arduino connected in the bot side and different types of sensors which relate to bot detects the temperature, humidity and gases in the environment and the result is displayed onto our serial monitor. The bot also has a barrier detection mechanism that we have witnessed using the ultrasonic sensor.

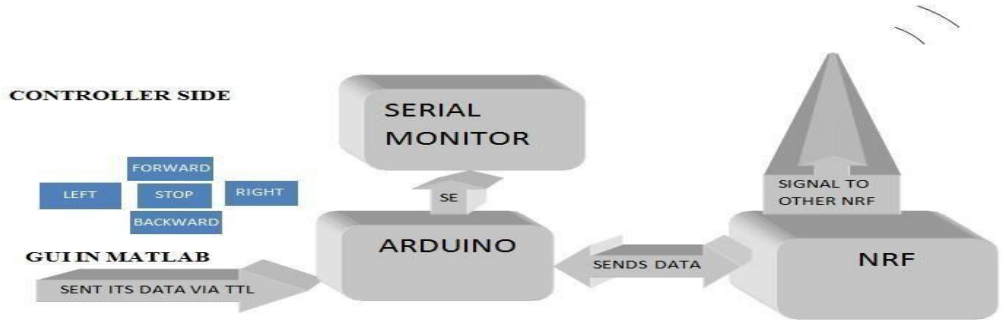

Fig. 3.1 Controller side block diagram

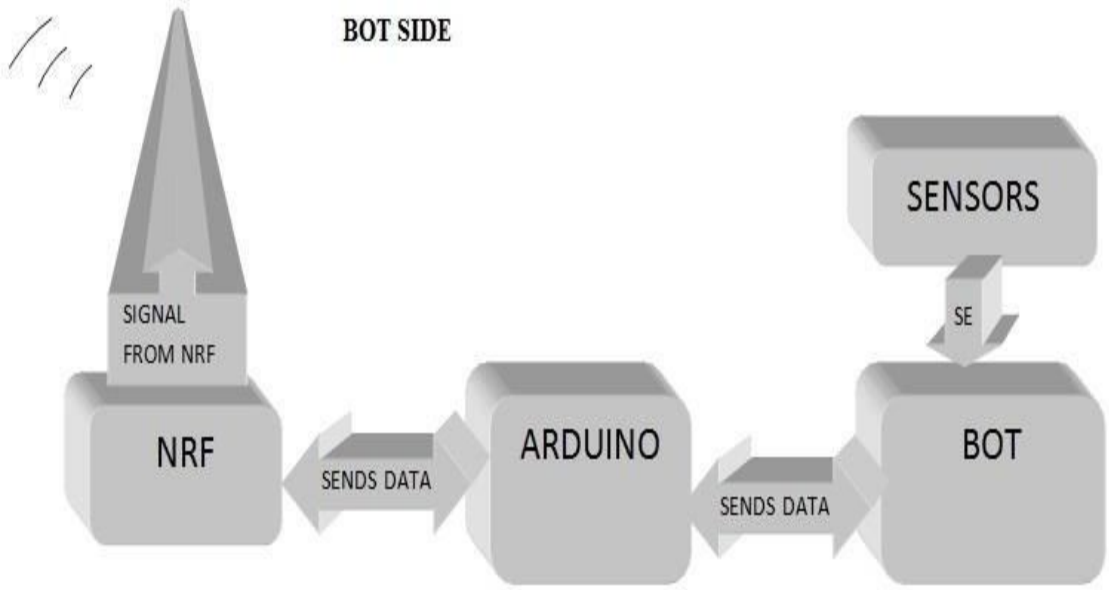

Fig. 3.2 Bot side block diagram

IV. RESULT AND DISCUSSION

The result is a mobile robot that can be remotely controlled and moved using wireless applications. Supervising is done via GUI by implementing MATLAB. The bot can provide various environmental feedbacks to the (GUI) using electronic devices. By using graphical user interface, we can control the bot whose programming we have employed using Arduino. Our robot can go forward, backward, and sidewards using the cursor key and by pressing the options made on remote in MATLAB.

Further with the use of the sensors, we get to know the various environmental conditions the robot is surrounded by. In our project we have tried to fuse up hardware and software in a delightful way. Mobile robots are used to monitor the situation in disaster areas. The situation in the affected areas is unsure and uncertain. Mobile robots can move on a variety of surfaces.

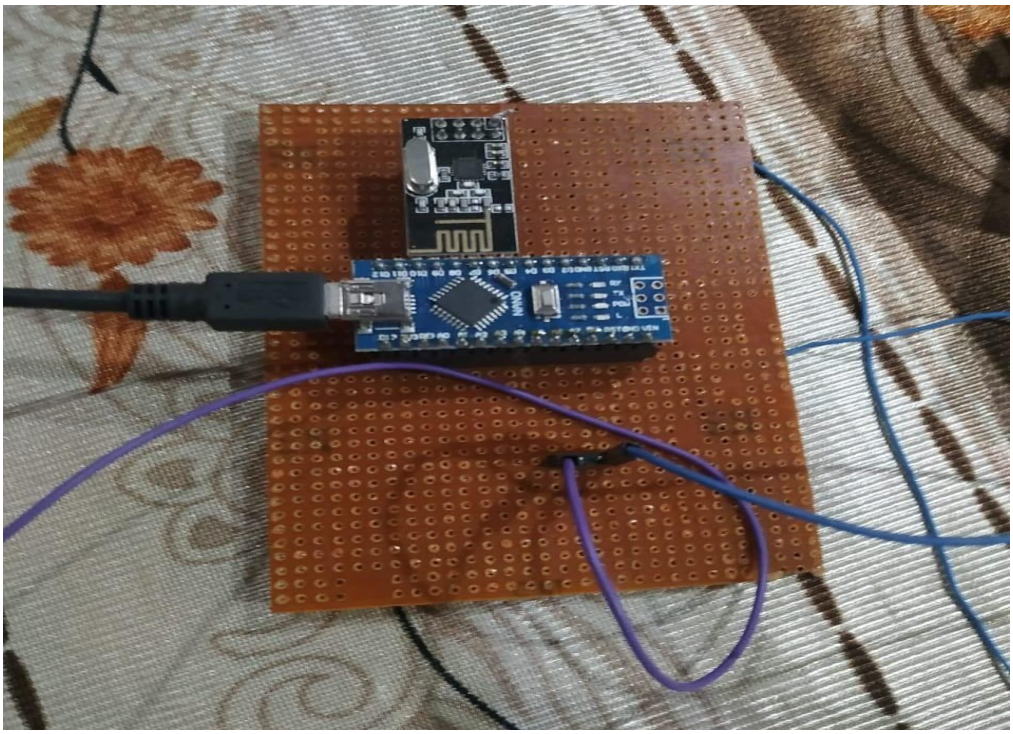

Fig 4.1 Arduino connected with NRF

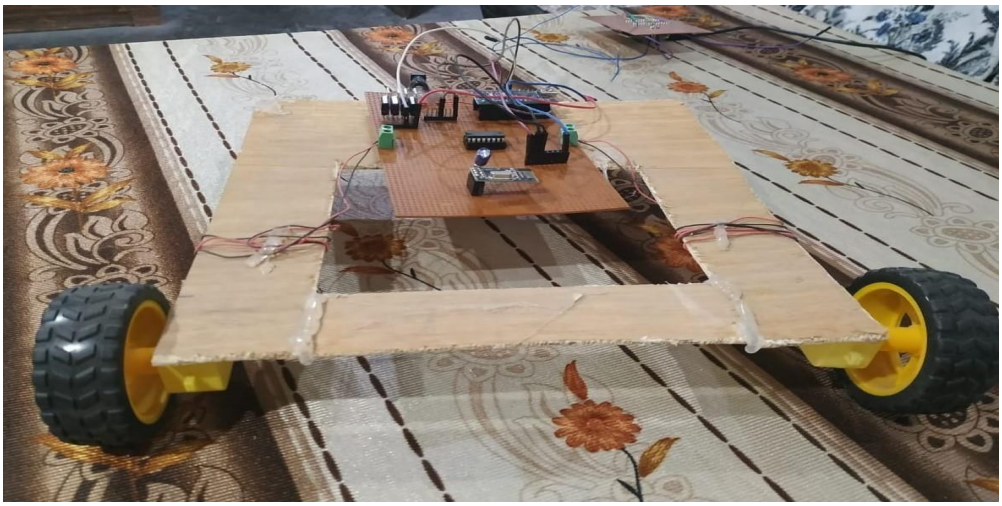

Fig 4.2 Bot side components Arduino Nano connected with NRF, L293D, other components, heat sink, battery connectors and diodes

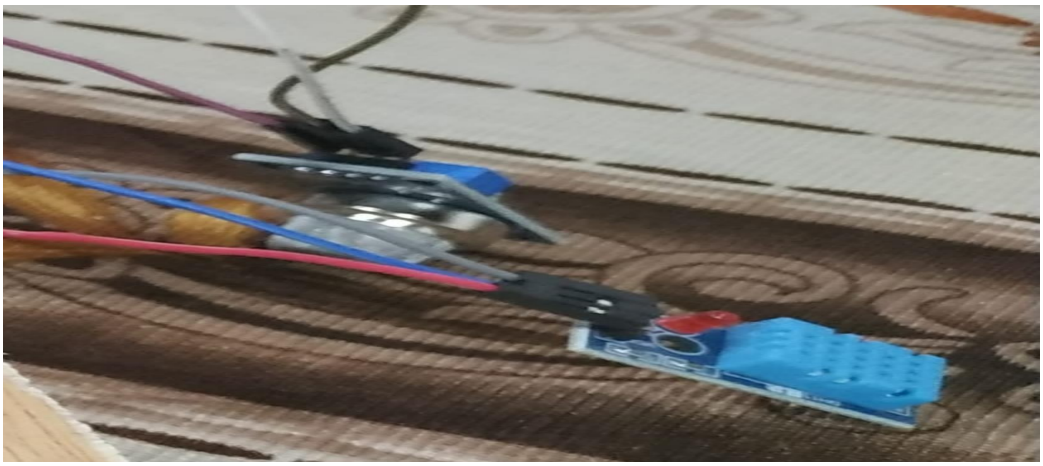

Fig 4.3 DHT and MQ4 sensor on the bot

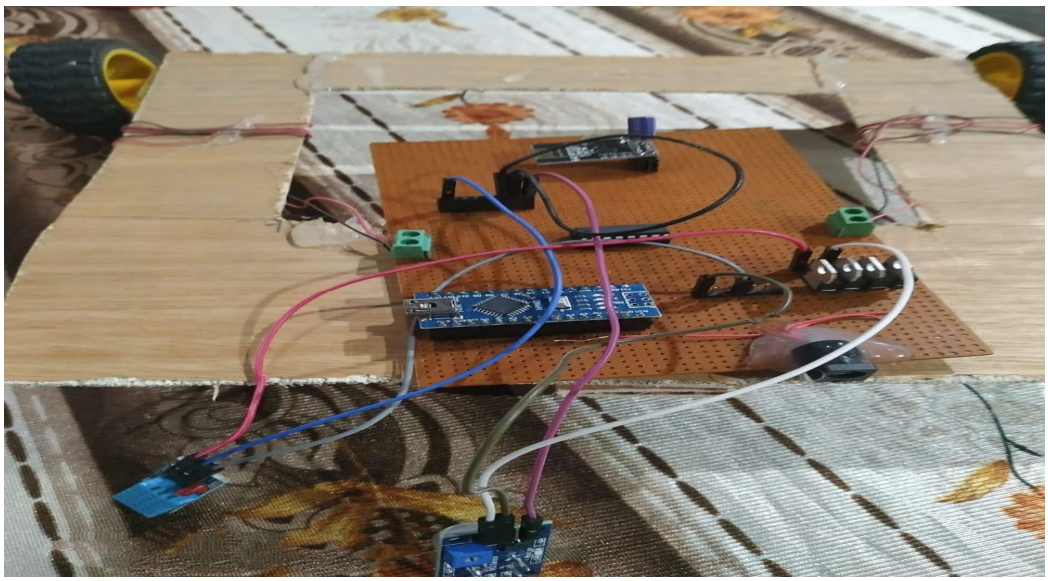

Fig 4.4 Top view of bot

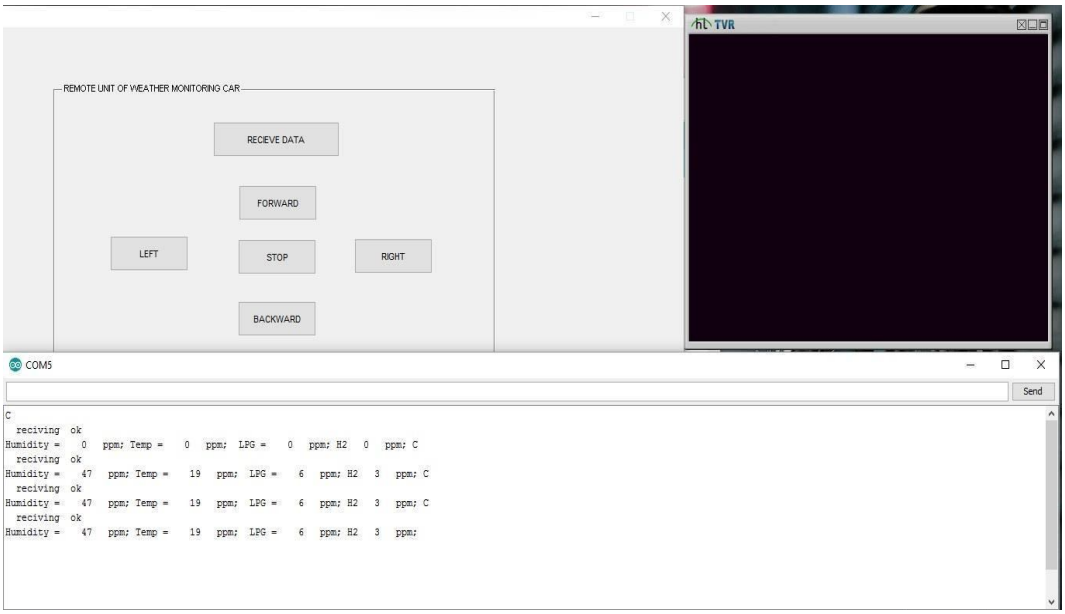

Fig 4.5 View of the GUI and the Arduino Serial Monitor with information about the surrounding Environment

V. CONCLUSION

By now we have concluded all possible discussion on the project titled *"Graphical User Interface Based Wireless Controlled Environment Monitoring Robot"*. An efficient technique to detect the various environmental effects is proposed in this work. Development of mechanical hardware, electronic hardware, and software for robot navigation plays a vital role in fully demonstrating the performance of moving robots with GUI control. In addition, the goal of using a GUI to control moving robots has implications for robot manufacturing. All the hardware and components required in our project has been described. The software aspects have also been explained briefly. By using graphical user interface, we control the robot whose programming we have done using microcontroller (Arduino). Our bot can move onwards, backwards, and sidewards using the cursor key and by pressing the options made on remote in MATLAB. Further with the use of the sensors, we get to know the various environmental conditions the robot is surrounded by. The robot also has barrier observation mechanism that we have witnessed using the Ultrasonic sensor. In our project we have tried to merge hardware and software in a very pleasant way.

VI. FUTURE SCOPE

Some upcoming additions could possibly be the addition of broad range and high-quality cameras, Infrared (IR) cameras more powerful MQ sensors like MQ4, MQ5, and MQ6 etc. to detect a wider range of gaseous compounds. Also, GPS can be incorporated that will give the speed and location of the Robot. Other modifications possibly could be insertion of GSM module, mighty and productive power sources. Upgradation can be done to the bot chassis making is tougher and fast by using more powerful mechanical components like motors etc.

VII. ACKNOWLEDGMENT

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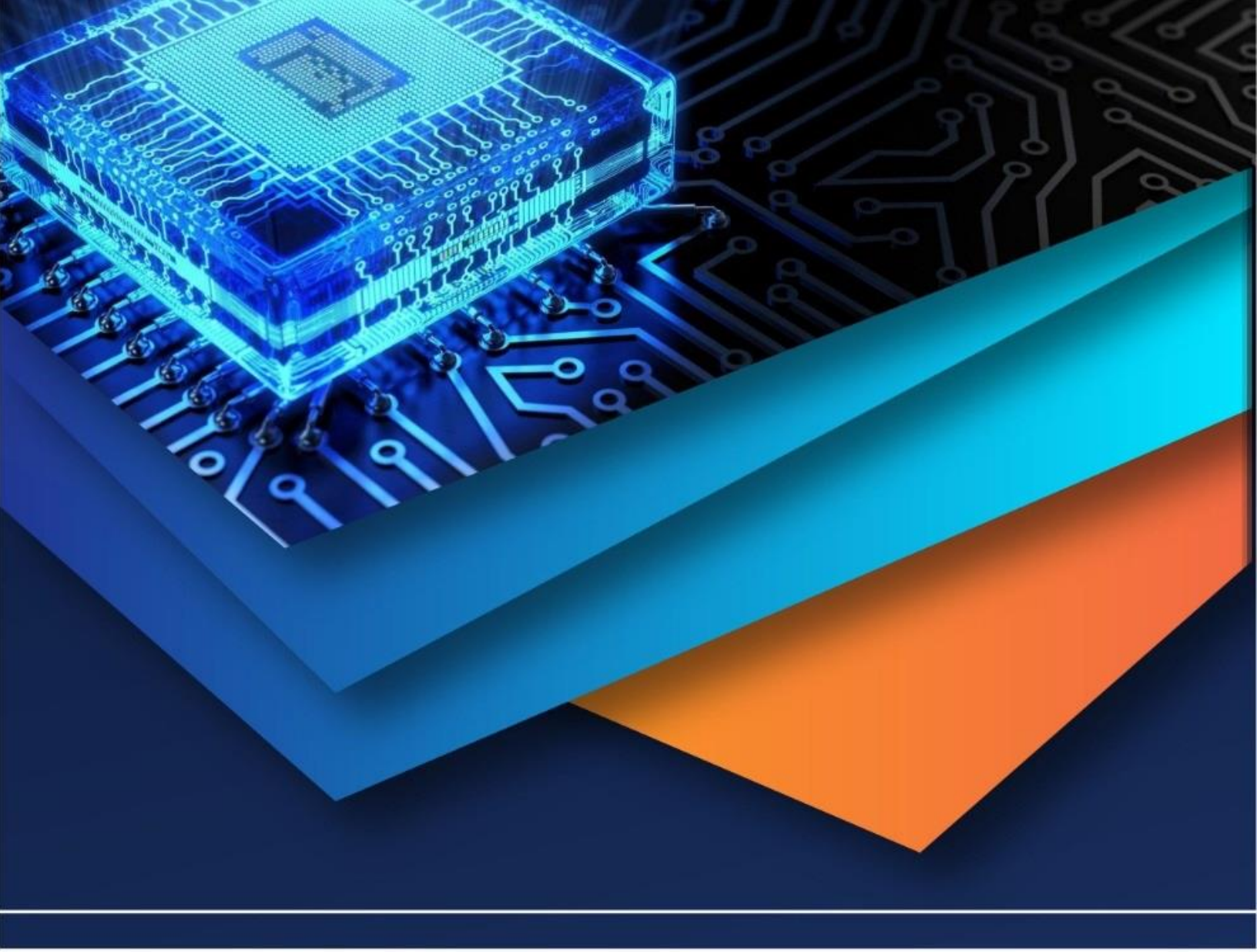

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