Design and Implementation of a Surveillance Smart Home Robot

By
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Glossary

UWB	Ultra-WideBand
PIR	Passive InfraRed
ICs/IC	Integrated Circuit(s)
DC	Direct Current
AC	Alternative Current
ADC	Analog to Digital Converter
PIC	Type of microcontrollers
Arduino UNO	Type of microcontroller kit
Raspberry Pi	Type of on-board computer
INTF	Interrupt Flag bit
ATmega328	Type of microcontrollers
USB	Universal Serial Bus
KB	Kilo Byte
SRAM	Static Random Access Memory
EEPROM	Electrically Erasable Programmable Read Only Memory
TX	Transmitting pin
RX	Receiving pin
ATmega16U2	Type of microcontrollers
LCD	Liquid Crystal Display
CMOS	Complementary Metal Oxide Semiconductor
RFID	Radio Frequency Identification
PIC18F452	Type of microcontrollers
PC/PCs	Personal Computer(s)
UART	Universal Asynchronous Receiver Transmitter
DHT11	Temperature and Humidity Sensor
HC-05	Bluetooth Module
MQ-7	Gas Sensor
HC-SR04	Ultrasonic Sensor
L298N/L293D	Motor Driving IC
USART	Universal Synchronous Asynchronous Receiver Transmitter
MDF	medium density fiberboard.
AlexNET	Deep Neural Network

Abstract:

This paper presents a modern approach to monitoring homes' internal and external security. This robot can detect a human, whether authorized or not, using artificial intelligence techniques (face detection + face recognition) and see the leakage of flammable gases such as natural gas and butane through the gas sensor. The camera installed on the robot provides a continuous stream of the area in which the robot is located. The robot can also be controlled remotely to rotate the camera in a free 360-degree direction and move from one place to another. It also continuously broadcasts essential readings about the robot's conditions, such as temperature - humidity - gas percentage in the atmosphere - sound recording, and measuring the distances around it. Our research paper relies on two microcontrollers. The first microcontroller is a simple-level Arduino UNO, which handles simple tasks such as moving via Bluetooth and collecting readings from micro-sensors. The other is a high-level Raspberry Pi, which handles more complex tasks such as image analysis and face recognition techniques, and links to the Internet using IP via Wi-Fi.

Keywords:

Robotics, Artificial Intelligence, Machine Learning, Computer Science.

1. Introduction

Innovative new development in cutting-edge security and surveillance technology is the technology of autonomous security robots. Patrolling a space with batons and torches has never been particularly effective; nevertheless, intelligent security systems with embedded systems, mobile applications, independent control mechanisms, and smart sensors are becoming increasingly common. Everett, H. and Gage, D.W. presented the first security surveillance robot [1]. Since then, research and application have advanced, and interest in security robots has grown. Yoichi Shimosasa et al. created an autonomous guard robot that can accompany guests during the day and patrol at night by fusing security surveillance and service systems [2].

A group of mobile, intelligent security robots scour the various floors of a structure. When an abnormal event occurs, the mobile robot broadcasts the associated location (event's floor number) to the overseeing computer [3]. In the security system, an automatic patrolling vehicle serves as a security patroller and may keep an eye on such dead zones of the conventional fixed surveillance system. The wireless network can be used to improve the capability of remote monitoring. Additionally, facial detection technology has been modified to capture and examine intruders [4]. Mobile service security robots are used in various tasks today, including autonomous navigation, security patrols, housework, search and rescue operations, material handling, manufacturing, and automated transportation systems. Any mobile robot must have a reliable autonomous navigation system, regardless of the application.

Autonomous navigation still poses a significant barrier for the mobile robot sector, although several control algorithms and approaches have recently been developed to resolve this issue [5]. A surveillance robot using UWB for indoor locating in uncharted territory. It may be utilized in difficult situations when using humans is highly unsafe, like in the case of dangerous gas leaks [6]. The security patrol robot will use a variety of sensors and motors to explore buildings autonomously. Wi-Fi will also be used for communication and control [7]. Commercial security robots have widely entered the market. The robot security guards from Knightscope are cutting-edge physical security robots that patrol workplaces, parking lots, and even the open air. New social robots like Buddy, Riley, Aido, and Personal Robot include home security patrolling capabilities. Although there have been studies into design and implementation of security robots, the technology behind them makes them less affordable.

The present study suggests an economical and user-friendly low-cost autonomous mobile security robot based on a multisensor system to address this issue. The smartphone application is used to implement the intelligent security patrol robot. The robot can move and conduct independent patrols inside a predetermined region. It has a 6-sensor multisensor monitoring system. Due to its versatility, the robot may be utilized for notifications and patrols, depending on user preference. At the same time, many of the devices have just one function. Additionally, it has 4 different warning systems that may provide notifications of security violations.

Although today's robots can do highly complicated jobs, they still lack the adaptability to work in different contexts and complete other tasks. We are particularly interested in security robots that will be used for surveillance, such as in the wake of a disaster in a hostile environment for people. The scenario is unknown beforehand and can be described as an organized indoor area with rooms, hallways, structural components, and important landmarks where the robot must be able to travel and orient itself. The robot is anticipated to roam such a setting, looking for unusual events and perhaps even the presence of people. How can a robotic system utilize in-depth environmental information to execute effective patrolling? Examples of the benefits of our robot include:

1) By separating rooms from other structural components, it is feasible to direct robots to follow particular patrolling routes;

2) Armed with information about a specific object, the robot can look for it in specific places and arrange its patrolling appropriately;

3) A robot can verify if a door is open by knowing how it relates to the surrounding walls; windows are important entrance sites, so robots should patrol these areas more frequently;

4) As the building closes, robots check that all windows and doors are shut, turn out the lights, and sound their speakers to alert occupants in the hallways;
5) Understanding ramps and steps enable better movement and inspection of the respective locations.

Many of the examples, including the ones above, are beyond the scope of present robot systems unless they are dealt with in ad-hoc methods by incorporating the environment's and the task's unique information into the system's implementation. Existing solutions are hence relatively rigid and unable to handle the degree of abstraction required by average users. This is largely due to the robot's inability to possess the necessary information on its own or learn it from the user. The primary challenge, thus, is to provide a situated world model for the robot that is small enough to only include elements necessary to carry out the intended activities. For proper motion in the environment, we might represent structural features like stairs, ramps, doors, floors, windows, and elevators. More generally, other interesting elements might include robot docking stations, crossings, humans, RFIDs, and artificial lights.

Many of these robots have already been considered in a number of earlier experiments with actual robots. However, the actual systems used rely heavily on the particular experimental circumstances. It is still difficult to obtain and ground contextual knowledge (according to Turner's definition [8]) which is provided in any explicit way. The sensory capacities of autonomous robotic approaches to symbol grounding are intrinsically constrained: it is challenging and error-prone to identify a priori unknown (or underspecified) elements of the environment. To find room spaces, Buschka and Saffiotti provide a local method. Their method divides the environment into spaces resembling rooms and corridors using range data and then extracts elements that are helpful for robot movement [9].

Their method, meanwhile, fails to differentiate between the many purposes of each area. In the work of Galindo et al. [10], environmental knowledge is modelled by anchoring semantic knowledge onto a topological map. To categorize rooms according to the pertinent items found inside, for instance, a fundamental form of reasoning is used. However, the method is limited to colour combinations and basic shapes like boxes and cylinders. By turning a 3D volumetric model into a highly accurate compact map and producing semantic descriptions, Nuchter et al. propose a semantic mapping system [11]. In human-augmented mapping, a human operator participates with the robotic system during the acquisition and grounding phases. Humans are, however, forced to use a remote graphical interface due to various ways. Using a mouse and keyboard to label items is a tedious and unfriendly activity for people. By using natural language to seek clarification from people, Kruijff et al. enhance the grounding procedure of a mobile robot [12]. Despite the use of spoken dialogues, humans only contribute to ambiguous circumstances that have already been identified by autonomous robot modules, not by offering novel insights. Theobalt et al. integrate a symbolic high-level spoken dialogue system with an advanced low-level robot navigation system [13].

In order to create new human-centred semantic mapping methodologies for smart patrolling, our solution is based on the merging of cutting-edge human-robot interaction metaphors with tried-and-true artificial intelligence techniques. We offer a robotic architecture that learns high-level contextual knowledge through a multimodal human-robot interaction (HRI) system, overlays semantic information on top of a metric map, and then utilizes it for robot patrolling in order to meet the aforementioned stated requirements. Our goal is to create a process for acquiring knowledge that is quick, continuous across time, and natural (for humans). Because of this, a lot of work is put into getting humans and robots to work together to learn complex information. An essential element to improve the acceptance of this technology is the use of an interactive process to teach the robots about the area and to explain patrolling tactics.

This paper includes 5 sections. The first section is an introduction and the second section is a literature review. Section 3 introduces the system methodology, and section 4 discusses the results. Section 5 highlights some conclusions and points for future work, and a list of the used references is provided at the end of the article.

2. A Literature Review

Robotics, in its simplest definition, is electro-mechanical equipment or apparatus operated by a computer program or an electrical circuit to carry out various physical activities. Scientists continually generate new theories and robot designs as technology advances. Robots are an increasingly important component of modern life [14]. As automation technology advances quickly, military robots are used as soldiers in conflict zones to lessen suffering and casualties [15]. The module is an embedded system gadget containing the primary microprocessor, a PIR sensor, and a metal detector. Two L293D drivers ICs drive the four motors. Drivers guarantee that a DC motor is operating at the correct voltage and shield the microcontroller from damage caused by the back emf generated by the motor [16].

The PIR sensor is connected to the external interrupt pin, and the analogue output of the metal detector is connected to the controller via the internal ADC in the PIC [17]. PIR sensors detect human movement in a particular area by picking up on people's heat radiation. After initialization, the controller on the robotic side offers a continual check of the PIR sensor's output. If the PIR sensor output is high, the controller notifies the remote station that an intruder has been discovered. A metal detector uses the electromagnetic induction theory to find metallic items nearby. The specific bombs in the border area will be found using a metal bomb-detecting sensor. This module will turn on the buzzer to signal a bomb detection if one is located in the border zones. If an explosive is found, the controller will sense it via an interrupt (INTF), and the remote station will get the message "bomb detected" [18].

The ATmega328-based Arduino Uno microcontroller board has 14 digital input/output pins. It can be powered by an external power source or USB port connection. Power input is chosen independently from an external (non-USB) source. A DC battery or an AC-to-DC adaptor (wall wart) can provide power. The ATmega328 has 32 KB of flash memory. The ATmega328 supports a 2 KB SRAM and a 1 KB EEPROM. 5V is the operational voltage. There are numerous ways for the Arduino Uno to interface with computers or microcontrollers. The pins 1 (TX) and 0 of the ATmega328, which provide serial communication at 5 volts, are easily accessible (RX). The ATmega16U2 microchip channels board may communicate serially through USB and is seen by computer software as a crucial com port.

The inbuilt resettable poly-fused in Arduino Uno helps shield computer USB ports from high currents and short circuits. Even though many computers have inherent safeguards, putting a fuse guarantees an additional layer of protection. When more than 500mA of current is applied to the USB port, the fuse connection is automatically broken until the short or overload is resolved. Visual surveillance of the external area will be conducted using a wireless camera [19]. The camera will record the visual data of the outdoor region, and that recorded data will be wirelessly transmitted to the base station. To the user side, it will send an audio and video signal. The camera is wired to a wireless transmitter, and calls go from a receiver to the camera and back again. With the aid of a transmitter, the camera image is sent over a signal to the remote location, where the detected quantity is shown on an LCD screen. From the base station, where the robot will be operated in user mode, it transmits real-time video and audio inputs that may be seen on a monitor. This camera's (CMOS) 140-foot field of view can capture full-motion, colour video in real-time without lag.

RFID is a catch-all name for various technologies that employ radio waves to automatically identify individuals or items using a specific serial number [20]. In 1948, Harry Stockman published a study titled "Communication using reflected power" that examined the technology used to communicate by reflected power and explored RFID technology. Advancements in RFID technology are still producing actual memory contents and more comprehensive reading ranges. RFID technology is used for automatic identification, which is increasingly regarded as a radical solution to improve data processing procedures and complementary to other data capture technologies like barcoding [21]. The PIC18F452 controller manages the entire robot's functionality [22]. Due to its dual 10-bit ADC and built-in temperature and gas sensors, the PIC microcontroller does not need an external ADC to produce digital data [23]. For monitoring purposes, we can obtain the robot's finished videos. We can control the horizontal movement of the camera and the robotic arm at the user's PC while watching videos in the web browser. For the wheels of the robots to move, DC motors are used. The robotic unit's PIR sensor provides us with information regarding cruising bodies. It connects a Raspberry Pi 3 to motors and a PIR sensor. Raspberry Pi uses the Internet to send edited videos to user PCs when processing videos.

Using the Internet, Wi-Fi as a communication protocol, and a raspberry pi as a server system, Ms Avanti Pawar et al. [24] sought to monitor the environmental parameters of the home and manage home appliances using a variety of sensors. The real benefit of this initiative is that small devices can connect to the Internet, making it simple for them to communicate, manage, and control without the need for human intervention. Additionally, it offers a high level of security, safety, comfort, and energy conservation. The Raspberry Pi is a small, affordable, portable single-board computer the size of a credit card proposed for use in home automation. It supports many peripherals and network connections such as Ethernet, USB, HDMI, and SD card slots. This study suggests a method for wirelessly connecting several nodes to the Raspberry Pi. Each node is capable of the sensed environmental parameter and taking controlling action through the relay, i.e. ON/OFF fan, light, TV, and AC accordingly, and transmitting all the data to Raspberry Pi. By connecting to the things around us, cloud-based systems enable us to easily access everything at any time or location through specialised portals and built-in applications. Consequently, the cloud serves as an access front end.

The Internet of Things has overtaken the Internet as the second-largest global network in the modern era. Its rapid development has made it a key technology in the information technology sector. As a result, more and more technology and scientific products are becoming part of everyday life [25]. Smart homes have advanced significantly in China since they were first developed in 2014. A complete transition from a single intelligent product to an entire system of intelligent devices has been fully completed through its development. The smart home system has also progressively gained public awareness, and more people are beginning to pay attention to the sector of intelligent homes [26].

This system creates a cloud database server with the help of the Alibaba Cloud platform. It uses short-range wireless ZigBee one-to-many networking technology, RFID technology, Android development and application technology, and Android technology to realize mobile phone clients' remote real-time acquisition of indoor and outdoor parameters transmitted by mobile robots as a monitoring system that can be automatically adjusted. The mobile robot car follows a predetermined path inside buildings as it detects the degree of the greenhouse effect, light intensity, combustible gas concentration, and other environmental factors at each location. It then transmits this information to the mobile APP terminal for real-time display. By contrasting the indoor terminal's set values with its parameters, the room's lighting, the fan's curtains, etc., can be modified manually or automatically using a mobile application.

ZigBee, also called purple bee communication, is a wireless communication technology with low energy consumption, cost, and minimal complexity. The IEEE 802.15.4 standard is the basis for its specification. Currently, there are two ZigBee operating frequencies: 868/915MHz and 2.4GHz, with 2.4GHz serving as the world's accessible frequency band [27]. Application, network, MAC, and physical layers are the four protocol layers that make up the ZigBee standard. Its standard streamlines the classic OSI seven-layer protocol's transport, session, and presentation layers. The interface connects each layer of the ZigBee protocol to the other layers, and the lower layer will support the top layer [28].

The star network structure, tree network structure, and mesh network structure are the three basic network topologies in ZigBee wireless sensor networks [29]. RFID, commonly referred to as radio frequency identification technology, primarily exchanges data through radio waves or electromagnetic radiation. It has a wide variety of applications and a high level of safety performance. It may operate without restriction in various working environments, and environmental factors like rain, snow, haze, paint, dust and other media have less impact on the signal. It's commonly employed. UHF, HF, and LF are typically its frequencies [30].

3. Methodology

3.1. Approach and Block Diagram

In order for the tasks entrusted to the robot to be carried out correctly and accurately, each of the main controllers cooperate through a basic means of communication between them via the UART, where both the Arduino Uno and the Raspberry Pi are connected by the UART wires and each of them communicates to implement the main goal From the robot, where the first controller (the Raspberry Pi) is connected with the camera directly and communicates with the rest of the sensors through the second controller (Arduino Uno) indirectly, and the first controller also communicates with the personal computer via the Wi-Fi network to allow storage and access to recordings and Readings and images, while the Arduino is in direct contact with each of the motor control circuit, sensors, microphone and Bluetooth module, which receives movement commands from the mobile phone, and Fig. 1 below is a diagram to illustrate the schematic diagram of the robot, where the direction of data flow, whether from or to Or to and from the controllers via arrowheads.

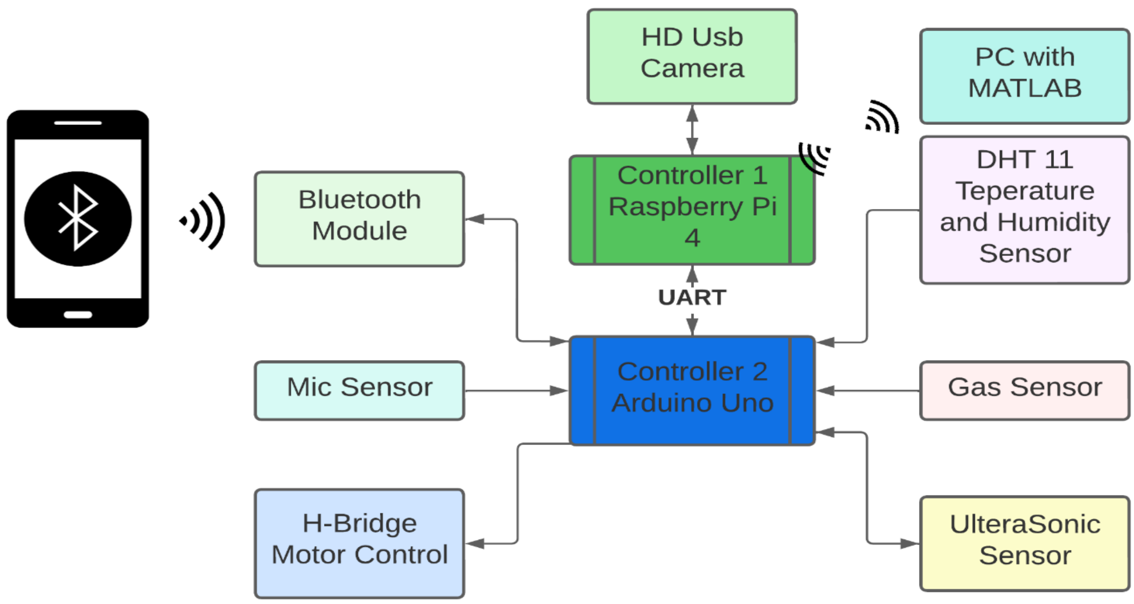

Fig. 1: Block Diagram of Surveillance Robot

3.2. Design System

3.2.1. DHT 11 Temperature and Humidity Sensor

We use the widely used DHT11 temperature and humidity sensor has an exclusive NTC for temperature measurement and an 8-bit microprocessor to output the temperature and humidity measurements as serial data. The sensor is shown in Fig. 2. The DHT 11 sensor module has three pins. The first is the VCC which will be connected to the Power supply from 3.5V to 5.5V. The second is the data pin which is connected to the A0 pin in the Arduino. The last one is the Ground pin.

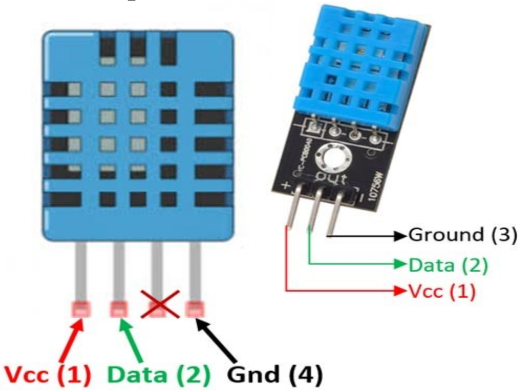

Fig. 2: DHT 11 Sensor

3.2.2. GAS Sensor MQ-7

MQ series sensors combine an electrochemical sensor with a tiny heater to monitor various gas mixtures. They can be calibrated, but to do this, a known concentration of the gas or gases being measured is required. Indoor gas sensor module utilized in a room-temperature environment. The MQ-7 sensor can measure the level of carbon monoxide in the air due to its excellent sensitivity to the gas. This sensor can measure concentrations between 20 ppm and 2000 ppm. The sensor is shown in Fig. 3. The MQ-7 sensor module has four pins. The first is the VCC which will be connected to the Power supply 5 V. The second is the Ground pin. The third is the digital data pin which is connected to the A2 pin in the Arduino. The last one is the analogue data pin connected to the A1 pin in the Arduino.

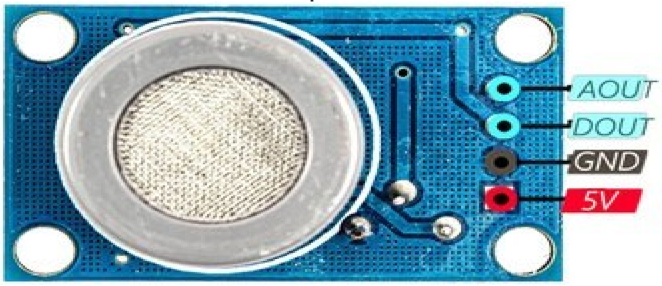

Fig. 3: MQ-7 Sensor

3.2.3. Ultrasonic sensor

To function, ultrasonic sensors must emit sound waves at frequencies higher than those heard by humans. The sensor's transducer serves as a microphone for ultrasonic sound transmission and reception. Our ultrasonic sensors, like many others, use a single transducer to transmit a pulse and receive the echo. By detecting the amount of time that has passed between sending and receiving an ultrasonic vibration, the sensor determines the distance to a target. The operation of this module is simple. A 40kHz ultrasonic pulse is sent by it, and if it runs into a wall or other object, it bounces back to the sensor. The distance may be calculated by dividing the travel time by the sound speed.

Using ultrasonic sensors to find transparent items is a great idea. For instance, applications that use infrared sensors have difficulty with this specific use case for liquid-level measurement due to target translucence. For presence detection, ultrasonic sensors can identify objects regardless of their colour, surface, or composition (unless the material is very soft, like wool, as it would absorb sound.) Where optical approaches may be ineffective, ultrasonic sensors are a reliable alternative for detecting transparent and other objects. We use the sensor HC-SR04, shown in Fig. 5. The Ultrasonic sensor module has four pins. The first is the VCC which will be connected to the Power supply from 3.5V to 5.5V. The second is the echo pin connected to pin 11 in the Arduino. The third is the triggering pin connected to pin 10 in the Arduino. And the last one is the Ground pin.

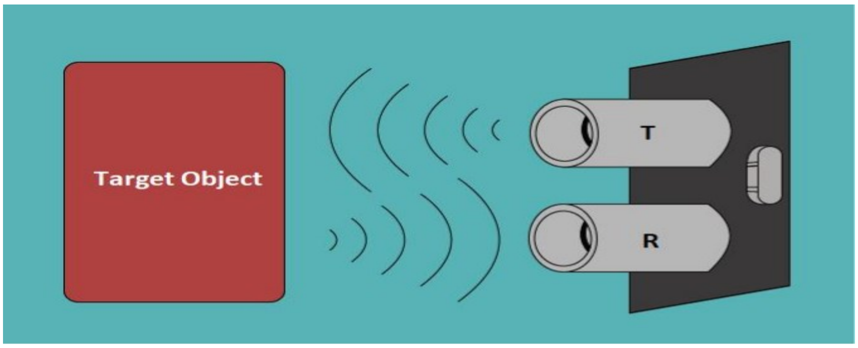

Fig. 4: Operating principle of Ultrasonic sensor

3.2.4. H-bridge Motor control

To control the motors, we need to control both the direction and speed of each engine, but there is a problem the dc motors consume high current and require a higher voltage than the ranges that Arduino can offer, so we use an auxiliary circuit called H-bridge which works as a bridge that consumes the current from an external supply but allows the Arduino for only controls the operations, the h-bridge can control up to 2 motors, but while we are using 4 engines, so we need 2 h-bridges, we use L298N h-bridge which is shown below in Fig. 6, the module has 6 controlling pins connected to Arduino, Enable A & B connected to PWM pins in Arduino to control the speed of motor A and Motor B respectively. However, in1, 2, 3, and 4 are connected to digital pins to hold the directions.

Fig. 5: HC-SR04 sensor

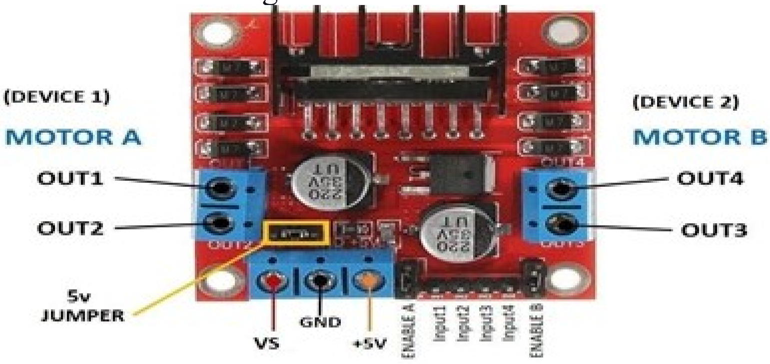

Fig. 6: L298N H-bridge Module

3.2.5. Mic Sensor

We employ a voice recording module to capture sounds made by the robot's surroundings. It utilizes a microphone to pick up sound, which is then fed into processing circuitry that includes an operational amplifier (LM393). Additionally, it has a potentiometer for adjusting the sound level, which makes it possible to control the output of the excellent sensor module. Similar to how an LED or other device could be connected to this sensor's output pins to check its work.

This sensor offers digital and analogue output, two different output kinds. When the sound reaches a specific threshold value, digital work is produced. The potentiometer is used to modify the digital output pin's sensitivity. The digital output will be low or high when a specific sound is either greater or lower than the threshold level. In our situation, the digital work will be HIGH before the sound is recognized and LOW afterwards.

The direct microphone signal, however, appears on the analogue output as a voltage level that fluctuates about the sound intensity. The excellent sensor is shown in fig. 7. The four pins Ao connected to A3 pin in Arduino, Vcc, GND, and Do (not used in our project) make up the sound sensor module. The Vcc pin is utilized to supply this sound sensor module with its 5V dc supply voltage, while the Ao pin is used for analogue output. Similar to sound sensor modules, this one has a GND pin for grounding and a D0 pin for digital work.

Fig. 7: Mic Sensor

3.2.6. Bluetooth Module

To establish the Bluetooth communication between the robot and the smartphone, we use the HC-05 Bluetooth module; a well-liked module called the HC-05 can give your project two-way (full-duplex) wireless connectivity. This module can connect with any Bluetooth-enabled device, including a phone or laptop, and two microcontrollers like an Arduino. The abundance of existing Android applications greatly facilitates this approach. The module can easily be interfaced with any microcontroller that supports USART because it communicates using USART at a 9600 baud rate. We can also set the module's default values using the command mode. The module is shown in Fig. 8. The Bluetooth module has six pins, but we use only four pins; the first is the VCC which will be connected to the Power supply 3.5V to 5.5V; the second is the tx pin which is connected to Arduino Rx pin 0, the second is the RX pin which is connected to Arduino Tx pin 1, the last one is the Ground pin.

Fig. 8: Bluetooth Module

3.2.7. Wi-Fi communication

To establish Wi-Fi communication between the robot and the personal computer, we use the built-in Wi-Fi module in the raspberry pi to get an IP over the WLAN. Then we can reach the robot from the personal computer throw an HTTP request with the command *raspi()*.

3.3. Implementation and Circuit Connection

And to collect all these tools together in one model, we designed an external body for the robot using the AutoCAD program, version 2015; unfortunately, a set of images that show the exterior design of the robot, and then the model was implemented using laser cutting technology for manufacturing on the material of the material. MDF is a material with medium mechanical properties but a competitively low price, in fig 9 we show the circuit connection of the overall robot control

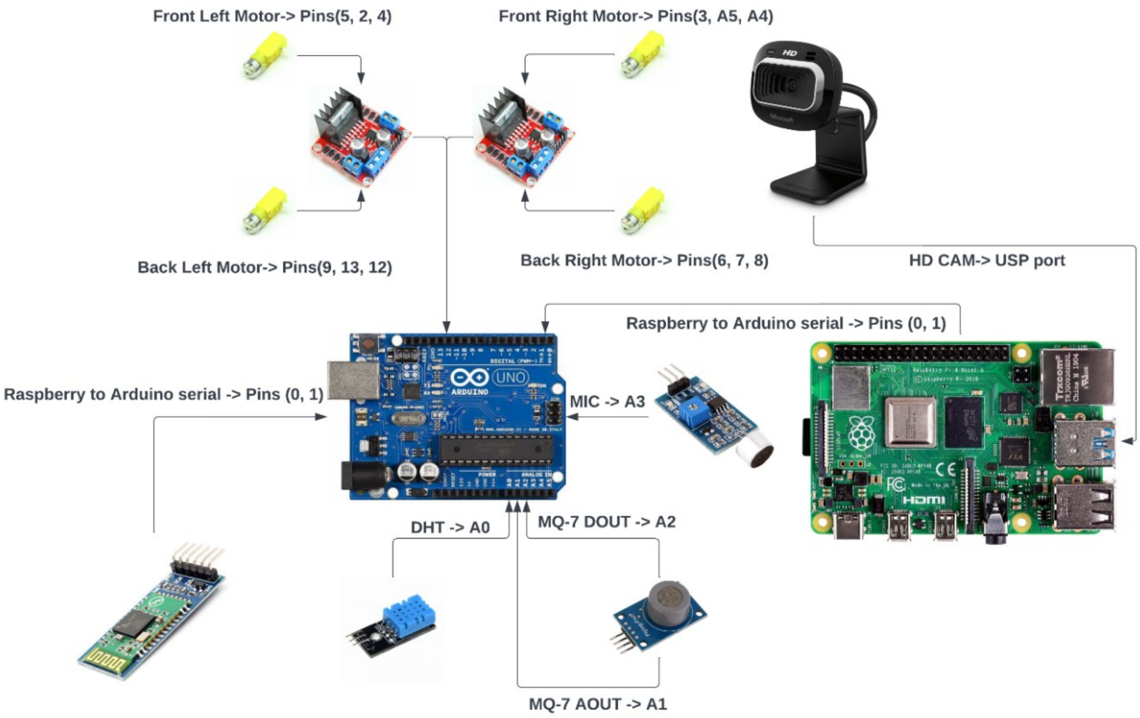

Fig. 9: Circuit Connection

3.4. Mobile App

To control the robot, we used the Bluetooth RC program to send some commands to the robot via Bluetooth to move it and control the direction of movement, and in Fig.10, we review the application's main interface.

3.5. Software tools:

To carry out the tasks of the robot, we have programmed both the first and second controllers using two different programming languages: The artificial intelligence part has been developed on the controller (Raspberry Pi) using MATLAB version 2021, where the controller performs three main tasks, the first is the database building phase, the second phase is the learning phase, the testing phase, and we will review each of them:

3.5.1. Database building phase:

In it, we build a unique database for each of the users of the robot, and here the person who wants to add the robot stands facing the camera. Then the robot records 20 photos of it and sends them to the particular database on the computer to add the new person.

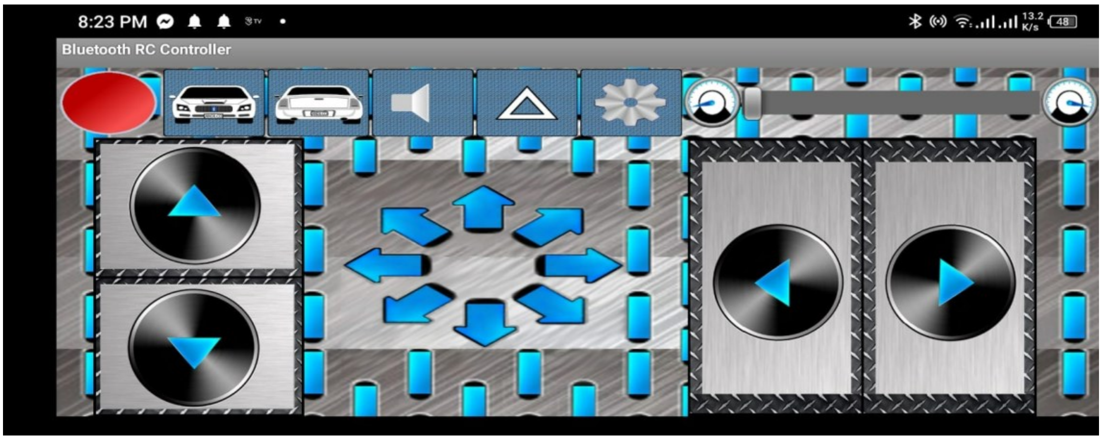

Fig. 10: Bluetooth control app

3.5.2. Learning phase

And at this stage, we do Transfer Learning for a deep neural network called AlexNET, which is one of the most common pre-trained neural networks due to its ease of modification, speed and accuracy of results, as well as the small area used, so we make after improvements to the database such as cutting faces only and make a face alignment process in the image to be moderate. Then we teach this network its severe characters. Then we save them for use with the robot, in fig. 11 we show the learning carves for AlexNET; the upper part offers the accuracy of the training process, the solid blue line indicates the training accuracy of the model at each epoch, the black dashed line shows the validation accuracy at each age, the lower part shows the training loss function and validation loss function at each period.

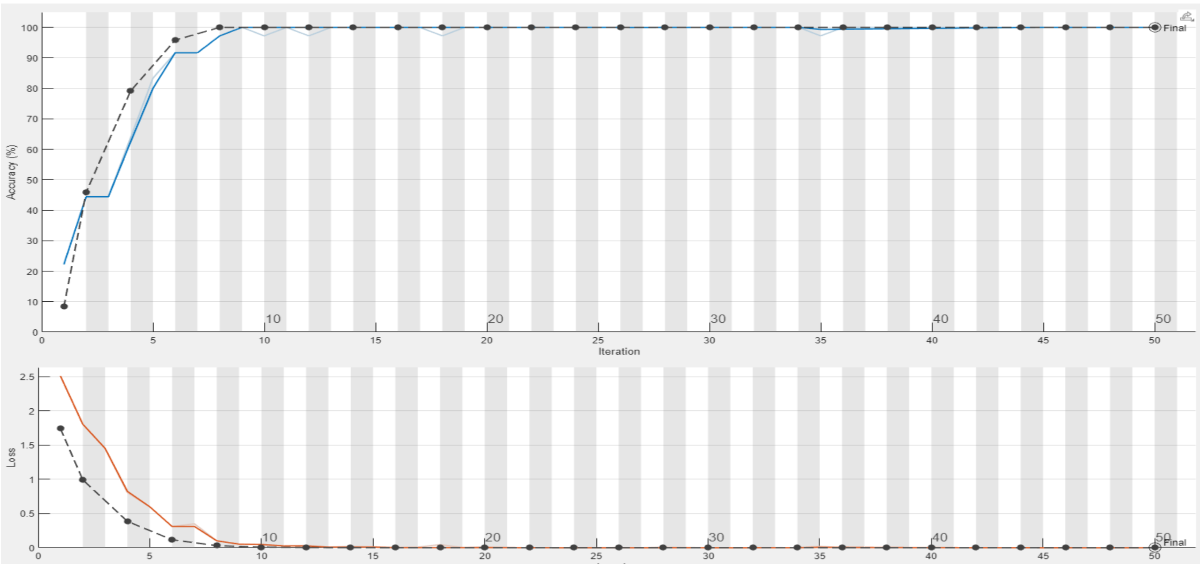

Fig. 11: AlexNET learning carves.

3.5.3. Testing phase

At this stage, we test the robot by connecting it and preparing it to work, so we issue a command to the controller (Raspberry Pi) to send a request for data from both the Arduino and the sensors as the camera. Then it starts to detect and analyze the content of the image frame to send notifications via The owner's email, including a report on the sensors' data, as well as a notification of the person present if he is a known person or sending a warning if he is a stranger.

3.5.4. Robot Control and sensor readings:

The part on the microcontroller (Arduino Uno) has been programmed using the Arduino C language, which is a language developed from the C++ language. And the Arduino receives commands via its serial bus, either from the phone via Bluetooth or from the controller (Raspberry Pi) via connecting wires.

4. Results and Discussion

Now it's time to show our final product, the intelligent home robot that lets users check on their homes and monitor everything happening inside. In the following fig12, we review the last look of the robot.

Fig. 12: Final Robot View

To recap what the robot can accomplish, it can keep an eye on the interior and exterior security of residences. Using artificial intelligence methods (facial detection + face recognition), this robot can identify humans, whether or not they are authorized, and can also detect the leakage of hazardous gases like butane and natural gas using a gas sensor. A live stream of the region where the robot is stationed is provided by the camera put on it. Additionally, the robot may be remotely directed to travel from one location to another and swivel the camera in any 360-degree direction. Additionally, it gives us access to a live, ongoing broadcast of some essential readings that inform us of the circumstances surrounding the robot, like (temperature - humidity - gas percentage in the atmosphere - sound recording, and measuring the distances around it).

5. Conclusion and Future work

Through this research, we designed and implemented a smart robot that can perform several tasks for the purpose of monitoring and internal and external security for medium-level homes. These tasks include the measurement and recording of temperature record, humidity, natural gas leakage, audio and video recording, control Remotely in motion using Bluetooth, alarm and alert, Wi-Fi communication, and finally artificial intelligence technology such as face detection and face recognition. The robot integrates all these tasks with the aim of providing an integrated control, monitoring and sighting system that can work with it remotely. Somewhere, the owner receives an alert notification via e-mail and enables him to control the robot through a mobile smart phone and a personal computer. The low cost of the robot can make it easy available for a large segment of low and middle-income users.

In the future, we aspire to develop the robot to cover larger areas, as well as to work in a team through a communication system with other similar robots. Also, our robot can be developed to adapt to withstand conditions and to take other measurements and integrate them with other modern smart home systems.

References

[1] K, P., R, A., S, K. and C R, MB (2015). Surveillance Robot Using Multi-Sensor Network. IJIREEICE, pp.113–115. doi:10.17148/ijireeice.2015.3223.

[2] Shimosasa, Y., Kanemoto, J., Hakamada, K., Horii, H., Ariki, T., Sugawara, Y., Kojima, F., Kimura, A. and Yuta, S. (2000). Some results of the test operation of a security service system with autonomous guard robot. 2000 26th Annual Conference of the IEEE Industrial Electronics Society.IECON 2000. 2000, pp405-409 doi:10.1109/IECON.2000.973184.

[3] Chia, S.H., Guo, J.H., Li, BY and Su, K.L. (2013). Team Mobile Robots Based Intelligent Security System. Applied Mathematics & Information Sciences, 7(2L), pp.435–440. doi:10.12785/amis/072l08.

[4] Lee, H.-T., Lin, W.-C. and Huang, C.-H. (2011). Indoor Surveillance Security Robot with a Self-Propelled Patrolling Vehicle. Journal of Robotics, 2011, pp.1–9. doi:10.1155/2011/197105.

[5] Chung, L.-Y. (2013). Remote Teleoperated and Autonomous Mobile Security Robot Development in Ship Environment. Mathematical Problems in Engineering, 2013, pp.1–14. doi:10.1155/2013/902013.

[6] Salman, R. and Willms, I. (2012). A mobile security robot equipped with UWB-radar for super-resolution indoor positioning and localization applications. 2012 International Conference on Indoor Positioning and Indoor Navigation (IPIN). Pp 1- 14 doi:10.1109/IPIN.2012.6418927.

[7] Garcia, J., Alsuwaylih, A. and Tosunoglu, S. (2015). Security Patrolling Autonomous Robot.

[8] P. Buschka and A. Saffiotti. A virtual sensor for room detection. In Proc. of the IEEE/RSJ Int. Conf. on Intelligent Robots and Systems (IROS), pages 637–642, 2002.

[9] C. Galindo, A. Saffiotti, S. Coradeschi, P. Buschka, J. Fernandez-´Madrigal, and J. Gonzalez. Multi-hierarchical semantic maps for mobile 'robotics. In Proceedings of the IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), pages 3492–3497, Edmonton, CA, 2005. Online at http://www.aass.oru.se/˜asaffio/.

[10] G. Kruijff, H. Zender, P. Jensfelt, and H. Christensen. Clarification dialogues in human-augmented mapping. In Proceedings of the 1st Annual Conference on Human-Robot Interaction (HRI'06), Salt Lake City, UT, Mar. 2006.

[11] A. Nuchter, H. Surmann, K. Lingemann, and J. Hertzberg. Semantic ¨ scene analysis of scanned 3d indoor environments. In: Proceedings of the Eighth International Fall Workshop on Vision, Modeling, and Visualization (VMV03), 2003.

[12] C. Theobalt, J. Bos, T. Chapman, A. Espinosa-Romero, M. Fraser, G. Hayes, E. Klein, T. Oka, and R. Reeve. Talking to Godot: Dialogue with a mobile robot. In Proceedings of IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS 2002), pages 1338– 1343, 2002.

[13] R. Turner. Context-mediated behaviour for intelligent agents. International Journal of Human-Computer Studies, 48(3):307–330, 1998.

[14] A.S.M.Md Saifur Rahman, Md Fahim-Al-Fattah, Md Arifur Rahman Zadid Shift, "A Practical Approach to Microcontroller Based Smart Phone Operated Robotic System at Emergency Rescue Scheme," 9th International Forum on Strategic Technology (IFOST), pp. 414-417, 2014.

[15] Pavithra.S and S.A.Siva Sankari, "7th Sense-A Multipurpose Robot for Military," International Conference In Information Communication and Embedded Systems (ICES), pp. 1224-1228, 2013.

[16] Mini Mohan and Siddharth Shelly, "OutdoorSecurity Robot," International Journal on Cybernetics & Informatics (IJCI), vol. 5, No 2, April 2016.

[17] Satoshi Hoshino and Takahito Ishiwata, "Probabilistic Surveillance by Mobile Robot for Unknown Introducers," IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), pp. 623-629, Sep 28-Oct 2, 2015.

[18] O. Simonin, O. Buffet and F. Charpillet A. Glad, "Theoretical Study of Ant-Based Algorithms for Multi-Agent Patrolling," 18th European Conference on Artificial Intelligence, pp. 626-630, 2008
[19] Tarunpreet Kaur and Dilip Kumar, "Wireless Multifunctional Robot for Military Applications," 2nd International Conference on Recent Advances in Engineering and Computational Science (RAECS), pp. 4673-8253, December 2015.
[20] Tawfiqur Rakib and M.A. Rashid Sarkar, "Design and Fabrication of an Autonomous Robot with Multisensor Fire Detection Using PID Controller," 5th International Conference on Informatics, Electronics and Vision (ICIEV), pp. 909-914, 2016.
[21] Khuswant Jain and Vemu Suluchana, "Design and Development of Smart Robot Car for OutdoorSecurity," International Journal of Computer Applications, vol. 76, pp. 0975-8887, August 2013.
[22] Dr B.Ramesh, Prof G Shivakumar, JR Manjunath C. Naveen Kumar, "Android Based Autonomous Intelligent Robot for OutdoorSecurity," vol. 1, pp. 2348-7968, July 2014.
[23] L. Iocchi F.M. Delle Fave. S Can, "Multi-Objective Multi Robot Surveillance," pp. 978-989, Feb 10-12 2009.'
[24] Avanti Pawar and Ajay Lahane (2020). Design and Implementation of IoT based Smart Surveillance. *International Journal of Engineering Research and*, V9(04). doi:10.17577/ijertv9is040501.
[25]Liu, F.(2017). An innovative home system combines a wireless sensor network and a mobile robot, Southwest University of science and technology, Mianyang. pp. 4-6
[26] Wang H, Ni GX, Chen JH, Qu JM. (2020)Research on rolling bearing state health monitoring and life prediction based on PCA and Internet of things with multisensor, Measurement, Commun., 157: 51–59.
[27] Liu, Q.M. (2019) Design and implement an intelligent home environment monitoring system based on ZigBee, Central China Normal University, Wuhan. pp. 12-13.
[28] Zhang, S.M. (2019) Research on RFID tag identification reliability technology in the Internet of things system, Beijing University of Posts and telecommunications, Bejing. pp. 23-24.
[29] Zhao, B.Y. (2019) Research and design the intelligent home system based on the Internet of things, University of Electronic Science and Technology Beijing. pp. 32-33. ISSMAS 2021 Journal of Physics: Conference Series 1846 (2021) 012084 IOP Publishing doi:10.1088/1742-6596/1846/1/012084 7
[30] Zhang, J.(2019) Application of remote monitoring and management of high-speed rail transportation based on ZigBee sensor network, EURASIP Journal on Wireless Communications and Networking, Commun., 1: 51–59.