RESEARCH ARTICLE OPEN ACCESS

# WIRELESS ROBOT USING ARUDINO AND ESP8266

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## Abstract:

Military surveillance nowadays has become one of the most necessary aspect of any country's national security. For any nation, the ability to properly survey and monitor anti-national activities could exponentially aid them in curbing such activities before they turn lethal and/or catastrophic for a particular region, province or state within the national boundaries of that country. While monitoring such activities within the bounds of a state, province or a district can be managed by local law enforcement bodies, monitoring such activities along the national border could prove much more challenging and tedious, not to mention monitoring and curbing any illegal/anti-national activities along the national border as well as preventing illegal immigration of anti-national elements from a neighboring country into another country could help drastically reduce any chances of further nuisance and terrorist attacks within the country. Recent advancements in Information Technology, Computer Science and Robotics could aid in such endeavors with increased efficiency and also help reduce chances of injury or death of military personnel due to attack by anti-national elements. The aim of this research paper is to propose a Remote Controlled Surveillance Rover that can be used to monitor and survey national boundaries and regions under military surveillance and provide a visual feedback of the region. The rover will be equipped with a rocker-bogie mechanism so that it is capable of maneuvering hard to navigate areas and high friction enhanced grip tires so that it doesn't slip or skid at any point along the path of surveillance. A set of night vision and thermal imaging camera systems will allow the rover to relay visual feedback to the control room. The rover will navigate the region, avoiding collision with any obstacles by means of proximity sensors. A steady relay of the rover's geo-location will be maintained over 5 second intervals by means of a GPS location sensor. All of these hardware components will be managed by a microcontroller board which will be equipped with wireless communication mediums such as Wi-Fi or Bluetooth to ensure proper two way communication between the rover and the controller.

*Keywords* — **IoE (Internet of Everything), Robot, Rover, Remote Control, Wi-Fi, Surveillance, ESP8266, MQTT, Arduino.**

## I. INTRODUCTION

Military surveillance is not a new concept, in fact, one of the earliest means of securing a region by any form of special security-centric agency involved getting a visual survey of the region required to be monitored and many national military forces from different regions have been known to make use of multiple methods in order to survey a region to get a better understanding of the environment, terrain, nooks and crevices along the region, and possible points of entry for any enemy or otherwise an intruder/outsider not belonging to the native group of individuals occupying the region. Since the advent of cheaper, more secure and compact electronic components and sensors along with advancements in robotics and IoT (Internet of Things), it has become relatively easier and logically safer for military and security forces to utilize such robots that are capable of surveying a remote region unmanned and efficiently thus eliminating the possibility of injury due to surprise attacks by the enemy or even loss of lives of soldiers. Currently, the military relies on geo-stationary satellites, UAVs, manual long distance surveillance, etc. to survey a region. While these methods do allow them to get a visual view of the region from an aerial perspective, the actual ground level surveillance still is performed manually which often has its downsides since even a trained soldier capable of above average surveillance is still limited by basic human limitations like field of view limitations, lack of vision at dark areas during the night, inability to perceive variations in thermal levels among different objects at a region under survey, etc.

The aim of this proposal and its research thereof is to design a rover capable of traversing remote terrain unmanned and controlled wirelessly over a wireless communication medium like Wi-FI or Bluetooth. This rover will be equipped with high resolution thermal and night vision cameras and will have 360-degree proximity sensing along the horizontal plane by means of ultrasonic sensors located at the front, back, left and right sides of the rover. A constant relay of the rover's geo-location along the patrol route will be maintained by means of a GPS sensor. This rover will be designed using the rocker-bogie mechanism to enable easy manoeuvre capabilities over rocky and highly uneven terrains. This rover will be operated remotely by means of either a remote control module and a display unit such as a laptop or a desktop system or a handheld smart device like a smartphone or a tablet with an integrated display. The video transmitted from the rover will be recorded and stored for future references as well as for record keeping purposes. This rover system will be powered by means of a high capacity portable Li-Po (Lithium-Polymer) or Li-Ion (Lithium-Ion) battery capable enough to run the rover for a full patrol without requiring a recharge, a similar but slightly lower capacity battery will be included in the system to act as a backup power system in case the primary power supply dies out or malfunctions mid patrol.

## II. REVIEW OF LITERATURE

I. In our first reference paper, "iRovers: Real-time unmanned four-wheel iot vehicles for air and noise pollution monitoring", the authors explain and present a way to establish interconnection among one or more sensors to an unmanned vehicle for monitoring and feedback related jobs.[1]

II. In our second reference paper, "Disaster Relief and Data Gathering Rover", the authors of the paper propose and present a rover like vehicle that allows its user to collect data by surveillance and help form a reconnaissance plan that is cost effective, and efficient.[2]

III. In our third reference paper, "MQTT-Based Prototype Rover with Vision-As-A-Service (VAAS)in an IoT Dual-Stack Scenario", the authors present a method to implement a wireless remote-controlled vehicle with live video streaming capability to provide VAAS (Vision-as-a-Service) using MQTT.[3]

IV. In our fourth reference paper, "Augmented Reality Tourism using Tele-Rover", the authors depict a method to design a vehicle with a high-resolution camera, and a joystick to maneuver the vehicle. The vehicle is designed using a rocker-bogie mechanism that enables navigation through rough terrains whilst maintaining vehicle stability.[4]

V. In our fifth reference paper, "Cost effective motion based stair climbing rover for rescue purpose", the authors propose a method to design a rover that is capable of scaling vertical obstacles by making use of a combination of servo motors and geared motors.[5]

VI. In our sixth reference paper, "Wireless Surveillance Robot with Motion Detection and Live Video Transmission and Gas Detection", the authors propose a method to design a rover capable of real-time video transmission.[6]

## III. PROBLEM STATEMENT

This project and its research thereof aims to design and develop a Surveillance Rover that can be deployed at the required region and can successfully survey the region unmanned and relay the visual feedback from the region back to its controller to ensure efficient surveillance and prevent loss of human lives or injury.

## IV. OBJECTIVES

The objective behind designing this rover are:

1) To efficiently and effectively survey a region.

2) To provide a visual feedback of the region under surveillance.
3) To traverse remote locations and uneven terrains unmanned.
4) To prevent injury or loss of lives of security personnel or soldiers.
5) To enable sophisticated tracking of anomalies and intrusions by means of night vision or thermal imaging.

## V. PROJECT DETAILS/FLOW

The Flow of the project will be as follows:

1. The region to be surveyed is approached.
2. An initial manual survey of the starting point of the patrol route is performed and a preliminary status report is made.
3. If there is any discrepancy at the starting point the discrepancy is handled and resolved and a secondary manual survey is performed.
4. The starting point is confirmed safe for rover deployment.
5. The rover is assembled and tested for visual, sensory, geo-location and motion related feedback.
6. The rover is assembled, tested and verified okay for deployment.
7. The rover is deployed at the starting point of the patrol route.
8. The rover begins along its patrol route providing visual and sensory feedback along the route.
9. The rover is constantly in communication with the controller or the control room.
10. The rover encounters an obstacle.
11. If the rover is capable of overcoming the obstacle by means of regular manoeuvrability it proceeds along the course.
12. If the obstacle is not overcome by means of regular manoeuvrability the rover proceeds to generate a diversion by performing a left-right alternating pivot manoeuvre until the obstacle is crossed.
13. If the rover encounters any one of the following:
    - An unwanted/illegal intrusion along the route.
    - Any unwanted movement along the route.
    - Presence of a hideout/trap-door/tunnel along the route.
    - Running low on battery.
    - Malfunction in any one or more of its components.
14. If the rover completes a patrol route successfully, it is instructed to return to the control room where its disassembled and stored safely/securely for future operations.

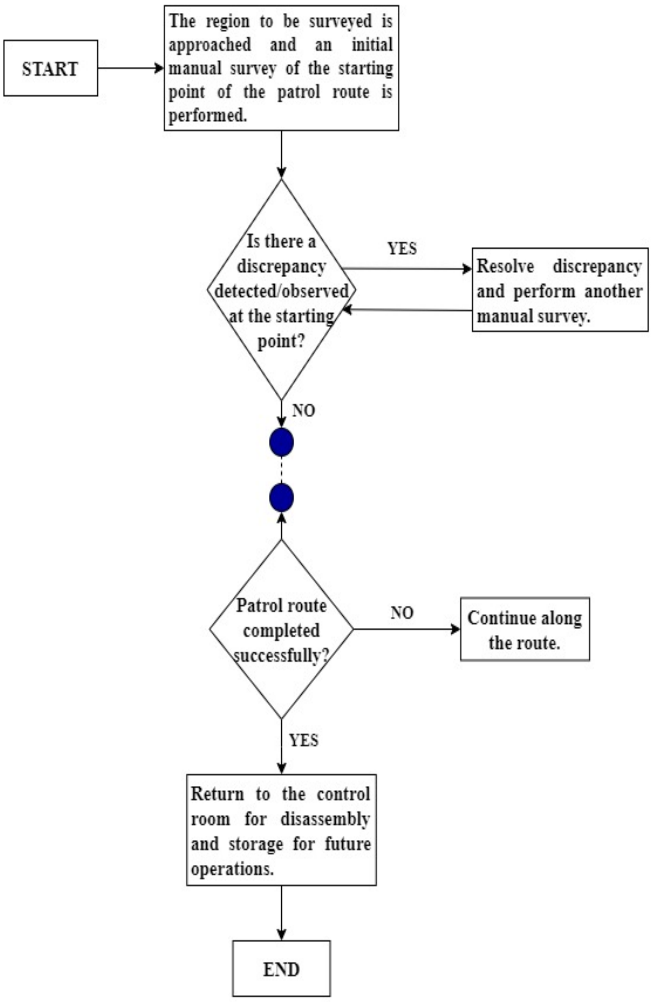


**Figure 1: Flow of Project – 1**

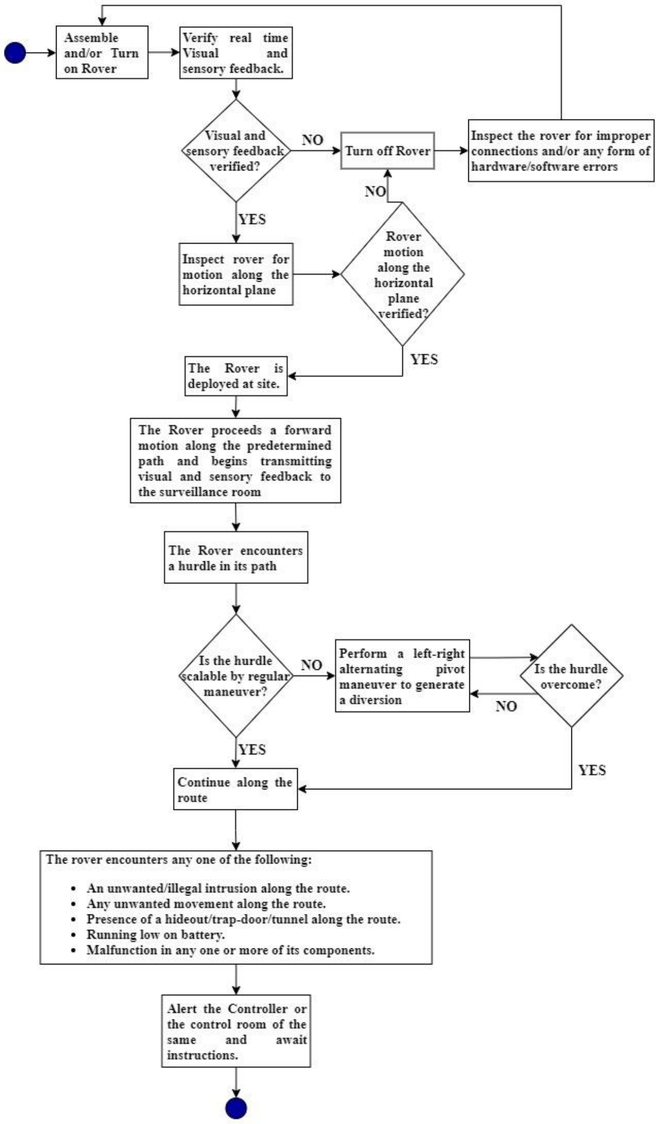


**Figure 2: Flow of Project – 2**

## VI. REQUIREMENT OF HARDWARE AND SOFTWARE

### *A. Arduino Mega 2560 Rev-3:*


**Figure 3: Arduino Mega 2560 Rev-3**

The Arduino Mega 2560 Rev3 Microcontroller Board acts as the central control board for the rover. This microcontroller board utilises the ATmega2560 chipset which is an 8-bit microcontroller based on the Advanced RISC architecture. The Arduino Mega 2560 Rev3 runs at an operating voltage of 5V and can input a recommended range of 7V-12V input voltage with a peak limit of 6V-20V input voltage. This board consists of 54 Digital I/O Pins out of which 15 can be utilised for generating a PWM output and 16-Analog input pins. Other features of the Arduino Mega Rev3 board consists of a 256KB Flash Memory, 8KB of SRA, 4KB EEPROM, a 16MHz crystal oscillator based clock, 4 UART hardware serial ports, A USB connection port, A power port and a reset button.

### *B. L298N Motor Driver Board Module:*

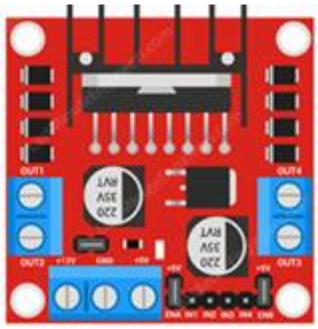

**Figure 4: L298N Motor Driver Board Module**

The L298N Motor Driver Board Module is a module capable of powering and controlling DC motors and stepper motors. The L298N Motor Driver Module utilises the L298 Double H-Bridge IC along with the 78M05 regulator capable of regulating 5V of power. This module is capable of controlling upto (but not limited to) 4 DC motors. Other features of this module include a maximum motor supply voltage of 46V and a maximum motor supply current of 2A, a driver voltage range of 5V-35V and a driver current of 2A, a logical current voltage range of 0mA-36mA and an overall maximum power of 25W.

### *C. 12V 500RPM DC Motor:*

We utilise a generic 12V 500RPM DC motor along with the L298N Motor Driver Board Module to enable motion to the rover.

Figure 5: 12V 500RPM DC Motor

We connect 6 such motors to the L298N Motor Driver Module such that two motors utilise the OUT1 and OUT2 ports of the Motor Driver Module and the remaining 4 motors are connected as a pair with two motors connected to the OUT3 and two motors connected to the OUT4 port of the Motor Driver Module respectively. These Motors are capable of running at an operating voltage of 12V, no load voltage of less than 80mA and a no load speed of 500RPM.

### D. Adafruit Ultimate GPS Breakout Version 3:


Figure 6: Adafruit Ultimate GPS Breakout Version 3

The Adafruit Ultimate GPS Breakout Version 3 makes use of the MTK3339 chipset to track 22 satellites over 66 channels culminating in a tracking sensitivity of -165dBm at 10Hz updates and built in data logging capabilities. This GPS breakout board uses 20mA power while navigation and can be powered with a 3.3V-5V DC power. The breakout board provides with a position accuracy of approximately 3 meters along with a warm/cold start of 34 seconds. This breakout board supports GPS technologies such as DGPS, WAAS, and EGNOS.

### E. HC-SR04 Ultrasonic Sensor


Figure 7: HC-SR04 Ultrasonic Sensor

The HC-SR04 Ultrasonic Sensor is a distance measuring sensor that utilises the principles of SONAR to accurately measure the distance and proximity of objects around itself along a range of 2cm-450cm with an accuracy of 3mm. The sensor module consists of a transmitter, receiver and a control circuit. The sensor works at an operating voltage of +5V with an operating current of approximately 15mA and an operating frequency of 40Hz. The measuring angle covered by the transmitter and receiver is approximately 15 degrees. The distance of the object from the sensor can be calculated using the formula

$$\textbf{Distance} = \frac{\textbf{343 x Time of Echo(High) Pulse}}{\textbf{2}}$$

### F. ESP8266 Wi-Fi Module:

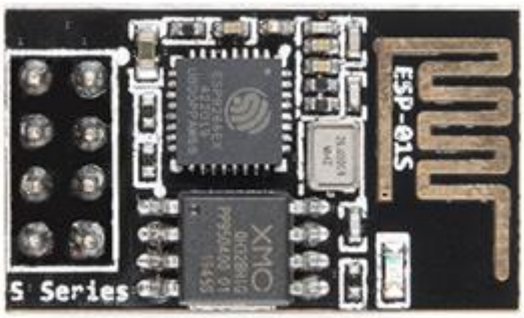


Figure 8: ESP8266 Wi-Fi Module

The Arduino Mega 2560 Rev3 board does not include any inbuilt wireless networking capabilities. For enabling wireless communication over Wi-Fi to our system we make use of the ESP8266 Wi-Fi module. The ESP8266 Wi-Fi module operates on the 802.11 b/g/n wireless protocol and features WI-Fi Direct (P2P) mode with soft-AP integration. The ESP8266 Wi-Fi module supports an integrated TCP/IP protocol stack, TR switch, BALUN, LNA, PLL, Regulators, Power amplifiers and power management units. This module contains a 4MB Flash Memory. This module consists of SDIO 1.1 and 2.0, SPI and UART communication ports and has support for STBC as well as 1x1 MIMO and 2x1 MIMO.

### *G. Adafruit MLX90640 IR Thermal Camera:*


**Figure 9: Adafruit MLX90640 IR Thermal Camera**

The Adafruit MLX90640 IR Thermal Camera is a low cost, high efficiency thermal camera breakout board. This camera breakout consists of a 24x32 thermal sensors that relay an array of over 700 individual IR Temperature readings over an I2C communication medium. This camera allows us a wide angle 110 degrees x 70 degrees field of view. The Adafruit MLX90640 IR Thermal Camera breakout board detects temperature variations along a range of -40 degrees C - 300 degrees C with an accuracy of +/- 2 degrees C. This camera module functions at an operating voltage of 3.3V to 5V.

### *H. Arducam IR Night Vision Camera Module:*

**Figure 10: Arducam IR Night Vision Camera Module**

The Arducam IR Night Vision Camera Module is a low cost IR camera capable of taking 2MP images and video recordings at 1920x1080 resolution. This sensor makes use of the OV2710 image sensor that supports high frame rate 1080p video at a framerate of 30FPS. This module comes with a motorized IR-Cut filter that makes use of a photoresistor to detect light levels at its environment and trigger on the IR LEDs accordingly when the ambient light reduces below a certain level. This sensor utilizes the OV2710 sensor that is capable of a focus range of 3.3ft and a Field Of View (FOV) range of 100 degrees along the horizontal plane and 138 degrees along the diagonal plane. This sensor works at an operating voltage of 5V and a working current of 300mA.

### *I. Miscellaneous:*

Apart from the above mentioned components we even make use of a few miscellaneous components such as capacitors, resistors, voltage regulators, diode rectifiers, etc. These components are connected in series or parallel with the above mentioned components to allow a steady flow of power to the components, avoid unnecessary voltage fluctuations, prevent damaging our components due to power spikes and/or uneven voltage supply, etc.

**Figure 11: Other Miscellaneous Components**

The other required miscellaneous components utilised in this system are as follows:

- Diode Rectifier - 1A 50V
- 8000mAh 6S 25C/50C Lithium polymer battery Pack
- Logic Level Converter - Bi-Directional
- N-Channel MOSFET 60V 30A
- 10K Ohm Resistor
- Voltage Regulator 3.3v
- Capacitor Ceramic 100nF
- Electrolytic Decoupling Capacitors - 10uF/25V
- BreadBoard
- Jumper Wires Pack - M/M
- Jumper Wires Pack - M/F
- Male Headers Pack- Break-Away

### J. Arduino IDE:

We make use of the Arduino IDE to write and upload our source code to the Arduino Mega 2560 Rev-3 board. The Arduino IDE is a Free Open Source IDE developed by Arduino LLC and actively maintained collectively by a community of developers via GitHub hosting.

ARDUINO

**Figure 12: Arduino IDE**

This IDE allows us to code and configure and interface the different components of our project with each other and also provides us with a serial monitor for effectively monitoring the output of the said components according to the project's requirement.

### K. MQTT.fx

MQTT fx

**Figure 13: MQTT.fx**

The MQTT.fx is an Open Source MQTT client written in JAVA and based on Eclipse Paho. This MQTT Client is Open Source under the Apache 2.0 license and already has packages available for all major OS such as Windows, Linux (64-bit Debian) and Mac. This client is compatible with most of our hardware and will help us implement the MQTT protocol to our communication.

## VII. IMPLEMENTATION

The implementation of the rover will be divided into three Sections:

- Assembly
- Software Upload and Configuration
- Deployment

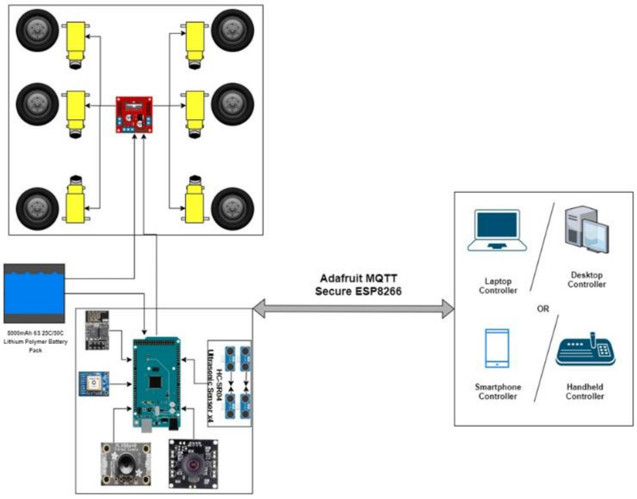


**Figure 14: Block Diagram for Wireless Surveillance Robot**

### *Assembly:*

For the assembly of the rover we utilise the Circuit diagram to connect all the components to each other and get the assembled rover ready for Software installation. At this stage we make sure that all the components are connected properly and that there are no loose connections present that may hamper the functioning of the rover.

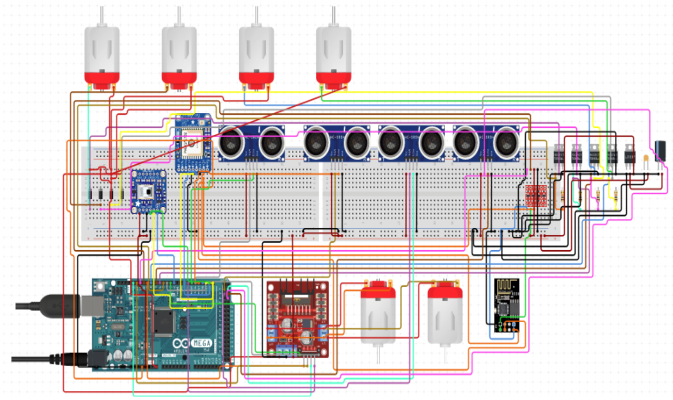

**Figure 15: Circuit Diagram**

We design the rover based on the Rocker-Bogie Mechanism since this mechanism allows the rover to traverse a path with ease no matter how uneven the terrain gets. The Rocker Bogie Mechanism enables the rover (upto a certain limit) to overcome obstacles bigger than itself whilst enabling proper ground contact between the wheels and the ground surface. This allows the rover enhanced stability and motion control.

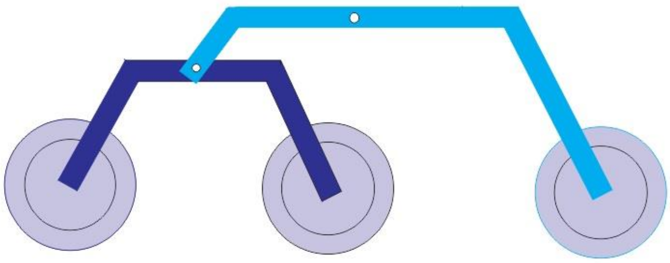

**Figure 16: Rocker Bogie Mechanism**

### *Software Upload and Configuration:*

At this stage we make sure that all the components are securely connected as per the circuit diagram and that we can proceed with the software configuration and upload.

a. *Configuring MQTT:*

i. We make use of the MQTT.fx which is a JavaFX based MQTT client and is Open Source under the Apache 2.0 license. This client can be installed on Windows, MAC OS or Linux and has packages available for all of them.

ii. We begin by downloading and installing the MQTT.fx software.

iii. We configure the software for adafruit.io since we make use of the Adafruit MQTT configuration in our source code to enable communication to and from the ESP8266.

iv. We enter the Profile Name according to our preference and enter the Broker Address as io.adafruit.com since we will not be utilising a static IP and we will be needing the Adafruit IO for enabling SSL.

v. We enter the Broker Port - 8883 for SSL connections and for Client ID we can utilise our AIO key.

vi. Next we configure our Connection Profile, for that we make use of our AIO login credentials as well as our AIO Key. Then we enable SSL for a secure connection, we select the "CA signed server certificate" over the TLSv1.2 protocol for the same.

vii. One all the above configurations are done, we click on OK or Apply and go back to the main screen where we can select our created channel by name and click Connect.

*b. Uploading the Arduino Code (Sketch) to the board:*

For this step we compile and upload the sketch for the Arduino Mega 2560 Rev-3 by means of the Arduino IDE. We connect the Arduino board to the computer via a USB cable and press the reset button to reset/clear the pins of any pre-configured values. Then we utilise the IDE to compile and debug the code of any errors or incorrect syntaxes. Once debugged and finalised, we upload the code to the Arduino Board and verify the data readings and function of the components with each other.

We make use of the Arduino IDE's serial monitor and the MQTT.fx dashboard to verify sensor functions as well as communication.

*c. Deployment:*

Once the components are thoroughly connected and the software is properly installed and configured we proceed towards deploying the rover. The rover is deployed at the site of surveillance. A starting point for the patrol route is established and the rover is deployed at the location and collected from the end point location once the patrol is completed.

## VIII. CONCLUSION

While National Security and Border Security are of paramount importance for any country, the possibility of Securing National Boundaries and maintaining National Security while preserving human lives and preventing attacks and injuries to innocent soldiers, security personnel and other law enforcement bodies always takes precedence over the former. By properly implementing this project we aim to overcome this inevitability by utilising modern day robotics to provide an alternative to manual patrolling. This project aims to put forth a basic idea of how resolving the problem arising due to manual patrolling a region can be approached and helps provide a starting point to the roadblock of hardware selection/configuration for the same. In conclusion, this project provides a cost-effective, straightforward and fairly upgradable alternative to manual patrolling of a region that is also efficient and fairly advanced.

## REFERENCES


[1.] *S. Kafumbe, "iRovers: Real-time unmanned four-wheel iot vehicles for air and noise pollution monitoring," 2018 Advances in Science and Engineering Technology International Conferences (ASET), Abu Dhabi, 2018, pp. 1-5, doi: 10.1109/ICASET.2018.8376838.*

[2.] *S. V. V. Srinivas, A. K. Singh, A. Raj, A. Shukla, R. Patel and A. Malay, "Disaster Relief and Data Gathering Rover," 2018 3rd International Conference On Internet of Things: Smart Innovation and Usages (IoT-SIU), Bhimtal, 2018, pp. 1-4, doi: 10.1109/IoT-SIU.2018.8519868.*

[3.] *G. D. Salazar Ch, C. Venegas and L. Marrone, "MQTT-Based Prototype Rover with Vision-As-A-Service (VAAS)in an IoT Dual-Stack Scenario," 2019 Sixth International Conference on eDemocracy & eGovernment (ICEDEG), Quito, Ecuador, 2019, pp. 344-349, doi: 10.1109/ICEDEG.2019.8734341.*

[4.] *V. G. Yadav, T. Kazmi and K. Harshith, "Augmented Reality Tourism using Tele-Rover," 2020 7th International Conference on Computing for Sustainable Global Development (INDIACom), New Delhi, India, 2020, pp. 124-129, doi: 10.23919/INDIACom49435.2020.9083689.*

[5.] *S. A. Ahsan, A. Hamza, M. H. Rahaman, T. T. Anannya and M. M. Karim, "Cost effective motion based stair climbing rover for rescue purpose," 2018 IEEE International Conference on Applied System Invention (ICASI), Chiba, 2018, pp. 1095-1098, doi: 10.1109/ICASI.2018.8394471.*

[6.] *V. K. D. Priyanka, "Wireless Surveillance Robot with Motion Detection and Live Video Transmission and Gas Detection.," International Journal of Scientific Engineering and Technology Research (IJSETR), vol. Vol.04, no. Issue.17, pp. 3099-3106, June 2015.*

[7.] *G. N. Nagaraju Sakali, "Design and Implementation of Web Surveillance Robot for Video Monitoring and Motion Detection," International Journal of Engineering Science and Computing (IJESC), vol. Volume 7 , no. Issue No. 2, pp. 4298-4302, 2017.*

[8.] *Shahajada Mahmudul Hasan, Syed Mamun R Rasid, Avijit Mallik and Md. Rokunuzzaman, "Development of a Wireless Surveillance Robot for Controlling from Long Distance," International Journal of Engineering Research and Management (IJERM) ISSN: 2349- 2058, Volume-05, Issue-09, September 2018.*

[9.] *Kunal Borker, Rohan Gaikwad and Ajaysingh Rajput, "Wireless Controlled Surveillance Robot" International Journal of Advance Research in Computer Science and Management Studies Volume 2, Issue 2, February 2014 pg. 436-441.*

[10.] *Dr. Shantanu K. Dixit and Mr. S. B. Dhayagonde, "Design and Implementation of e-Surveillance Robot for Video Monitoring and Living Body Detection" International Journal of Scientific and Research Publications, Volume 4, Issue 4, April 2014 2 ISSN 2250-3153.*