**IOT BASES SMART MULTI APPLICATION SURVEILLANCE ROBOT**

**OBJECTIVE**

The use of robots and their role in our day to day life has been rapidly increasing since the day they were introduced to the world, further reducing the errors and life risk to humans. The objective is to design and develop an Internet of Things (IoT) based autonomous multi-purpose surveillance robot at a low cost that will roam around freely and give live updates about their surroundings by broadcasting video and information through the sensors installed

**PROBLEM STATEMENT**

The field of robotics and automation has undergone a dynamic and enormous transformation, which spans all types of spaces. The act of closely monitoring the movement of domestic area and related people is known as domestic surveillance to ensure the safety level of that area without the intervention of humans. Therefore, surveillance is primarily needed in places like border regions, public spaces, offices, and industries. It is mostly employed for activity monitoring. Both humans and embedded systems, including robots and other automation equipment, can carry out the surveillance act in both indoor and outdoor settings. A robot is an automatic digital system that works based on programmed conditions.

**ABSTRACT**

The primary goal of this research work is to develop an autonomous robot that can do domestic surveillance primarily and muti-application regions generally. Robots now play a significant part in our daily lives by eliminating the need for human work and minimizing error. The developed robot can be operated manually by defining the surveillance area or automatically operating based on defined applications by the user or owner of the robot. The task of the proposed robot is to go around and collect audio and video data from the environment. The collected audio and video information is communicated to the user/owner of the robot. Further, the robot is operated through a smartphone or a general desktop computer with Internet of Things (IoT) via a communication module. A wireless camera on the robot is also used to feed live video during day and night. With the aid of an Arduino microcontroller, the robot is commanded manually as well as automatically. Additionally, this robot makes use of a few sensors to gather information and convey the information to the controlling authority, generally an Arduino microcontroller, which regulates the activities of the robot. The operator or owner of the robot can also detect the presence of metal explosives utilizing metal detecting elements in addition to the live video streaming to carry out environmental surveillance which can also be used for defense related application

**Introduction**

The field of robotics and automation has undergone a dynamic and enormous transformation, which spans all types of spaces. The act of closely monitoring the movement of domestic area and related people is known as domestic surveillance to ensure the safety level of that area without the intervention of humans. Therefore, surveillance is primarily needed in places like border regions, public spaces, offices, and industries. It is mostly employed for activity monitoring. Both humans and embedded systems, including robots and other automation equipment, can carry out the surveillance act in both indoor and outdoor settings. A robot is an automatic digital system that works based on programmed conditions. Autonomous safety robots have the capability to move in complex environments, detecting and reporting anomalies within the surroundings. Their sensors and cameras permit them with a high degree of stability, even when transferring via complex terrain. With upgrades in 5G networks, robots can traverse even large and more complicated areas. These automated robots are playing a significant role for the agencies that need an acceleration in their safety operations. Robots are suitable alternatives to replace human capital in hazarded areas and no-touch surroundings. Unlike protection specialists, self-reliant robots behave as a stand-alone object with a high degree of stability without stress for a very long span of time interval. This makes the reliability of surveillance operation human-less and error-less. Surveillance is ensured 24/7 time duration, without human intervention or less amount of human intervention. Robots are preferably successful to do plenty of work than automatic bots prefer to. Automated bots choose to gain surveillance and one more predominant usability that the maker might need to implement, and this is standard though. Multiple functionalities may be positioned in the vicinity if it is needed. Since autonomous robots and associated subsystems grow to be more state-of-the-art, highly reliable, and small, these robotic structures are widely used in various applications. Autonomous robots which can be operated under wireless mode remotely have worked well in various regions of rescue and navy related applications. The main idea is to save more solid lives for a contactless approach of them. And to tighten security in the borders and check posts. Lavanya et al [1] implemented a surveillance robot to replace humans in defense applications. They developed this robot with speech-based recognition and gesture control. Through these features they operated the robot to understand gesture by understanding the images along with metal and fire detection. Hoque et al [2] developed a war robot in which a control system was used with a wireless transmission system that controls the motors and actuators of the robot. Night vision was also added in the system to operate the robot during night hours also. The GSM module and a metal detector attached to the system could detect the bomb and other related dangerous hazards in the war field. Patoliya et al [3] developed a surveillance robot to observe human activities in the war field to reduce the involvement of humans. A night vision enabled wireless camera was involved in the robot and a wireless transmission system was also connected to the robot to transmit the video sequences to the destination control point. side.

**Literature survey**

**K. N. Lavanya, D. Ramya Shree, B. R. Nischitha, T. Asha, and C. Gururaj, “Vision interfaced war field robot with wireless video transmission,” In Proceedings of the 2nd International Conference on Trends in Electronics and Informatics, pp. 833-838, 2018.**

The main purpose of this project initiative is to design a remotely controllable Robot prototype that can detect live humans and transmit the location details wirelessly. It can also be used in war fields and places where disaster has occurred. Human detection is also required in hazardous sectors like boilers, reactors where only authorized person can enter. The live body detection is performed by a biomedical unit that comprises mainly of a temperature sensor combined with a pulse detector. Any alive body with a temperature above absolute temperature is measured tentatively. It senses these pulse variations in the given subject body with the help of a robotic arm with attached clipping mechanism for effective and reliable operation. Human identity is also carried using a wireless camera module. The remotecontrol unit is used to provide interconnectivity between the robot and human operator and the on-bot camera is used to detect the motion in any kind and will inform to micro controller and then via wireless transmission to an operator located at a remote place. In this project we propose to deploy wireless transmission of data using ZigBee based wireless system for the procurement of efficient communication. If the micro controller unit receives the detected signal, it will send a message through Zigbee signal transmitter to the remote-control unit. The GPS receiver receives the Longitudinal and latitudinal value when the robot continuously monitors to check for even the slightest movement of the human body it sends the location details to the remote-control unit at the earliest. Disaster sites may be complex and hazardous to be reached for rescue and there are great threat and risk linked to rescue workers and survivors trapped in such accidental sites. Even though, technology have been developed, still trained dogs and humans are used in this risky situation, which maybe time consuming and due to the vast area, that get affected it becomes more difficult. In order to curb this problem and to make the rescue operation safer and more effective “ALIVE HUMAN DETECTION ROBOT” is proposed which will work in disaster environments of man-made structures like collapsed buildings, war fields etc. It can be assisted for firemen, police, and disaster agencies with appropriate reconnaissance, site evaluation, human detection etc. Basically, the robot consists of a mechanical part and a biomedical part. The mechanical part consists of wheeled platform, arm and the biomedical part consist of microcontroller, temperature sensor. Sensors are used to sense the environment and give practical feedback to the device. Apart from this, it includes a robotic arm that is equipped with the pulse detector to access the pulse of the victim and thermal sensor to form a combined data set and transmits this real time data to the remote-control unit that helps in triggering rescue operations. The robot is controlled using a wireless sophisticated joystick. It has a display, where all the information from the robot are visually illustrated. A camera is used to capture the status of the surrounding and one can perceive the current condition of the casualty with the help of this camera.

**A. Hoque, M. B. H. Shorif, S. Nuruzzaman, and M. E. Alam, “Arduinobased battlefield assistive robot,” In 2017 IEEE Region 10 Humanitarian Technology Conference, pp. 304-309, 2017.**

Sophisticated technology advancing day by day and robotics has become a promising field for research in this race. Military forces now using robots for reducing causalities and to defeat their enemies. The major focus of this project, is on the use of robot in war, peace and as well as their impact on society. Here Radio Frequency modules signals are used in wireless remote control system for transmitting and receiving wireless signals to control the motors and actuators of robot control system. Night vision monitoring system has been added which will capture and transmit the information surrounding the robot to the operator. With this feature the robot can not only transmit real time videos with night vision capabilities but cannot also be identified by the enemies in war zone. A metal detector and GSM module has also been added which will inform us about any bomb underneath the robot vehicle. Another assistive feature here added that, is a robotic arm has been installed to pick or drop some object if needed.

Science has brought out wondering technologies to ease human life. Robotics is one of the branches of it, which has made human life easier and lessened the workload. It has also enabled us to reduce the participation of human in risky works. Nowadays robots are being used for various purpose in industries, labs, Space and also in battlefield. People are sending robots to places where man can hardly go like in space, underwater, bomb surrounded areas. Wireless communication system has become one of the essential features for commercial products and a popular research topic within the last ten years. There are now more mobile phone subscriptions than wired-line subscriptions. Lately, one area of commercial interest has been low-cost, lowpower, and short distance wireless communication used for personal wireless networks. Technology advancements are providing smaller and more cost effective devices for integrating computational processing, wireless communication, and a host of other functionalities. This project’s main functionality is to deal with tough situations where human beings cannot handle situations like darkness, entering narrow and small places and detecting hidden bombs etc. Such hostile situation is occurring day by day in different parts of the world through terrorist attack or in natural catastrophes. This system works using an RF signal through which the whole controlling of the system response is done. Using night vision camera attached to robot situations around the system is observed according which the robot is instructed to move or do other functionalities. Besides with the robotic arm anything can be picked and carried within its limit and with the help of metal detector and GPS system and a cell phone a signal will be obtained if there is ant short of bomb or metallic weapons around the robot. The robot along with camera can wirelessly transmit real time video with camera controlling capabilities and using a robotic arm anything can be picked or dropped within its limit. This kind of robot can be very useful for helping purpose in war fields. The project is also designed to search invisible metal stuffs from where people are not capable to reach and it is so designed to work in hostile environment where visible light will not be available.

**J. Patoliya, H. Mehta, and H. Patel, “Arduino controlled war field spy robot using night vision wireless camera and Android application,” In 2015 5th Nirma University International Conference on Engineering, pp. 1-5, 2015.**

The major goal of this design is to deal with delicate scenarios when people are unable to navigate scripts such as darkness, entering tiny spaces, and spotting retiring losers. The robot is an ideal machine for the defense sector, as it will help to reduce mortal life loss while also preventing illegal conditioning. The robot is tone-powered, with a backup installation in case the base station's connection is lost. Wireless cameras transmit real-time videotape and audio inputs to a base station examiner, which may be viewed, and action taken as needed. With a major view, to increase the amount of safety of the soldiers, if we know the activities of the enemy by maintaining a safety distance with them because, the flexibility of defense and attacking of the soldiers can be increased. It consists of a lock to position the enemy and to guide the missile, and the robotic system will also consists of a metal sensor that detects the metals such as land mines and other explosives that could cost the lives of our soldiers and the system can be controlled remotely. In creating this concept, we wanted to offer our army the ability to locate and land mains safely and attack them without damaging their lives. The project was created an army could locate explosives in the land safely, for increasing the safety of our army men and live to attack the enemies without putting our lives at risk. Every minute, robotics will advance, while our country's troops will perish in large numbers. We have to find a solution with that way we can design robots that are useful to the warriors, we can increase the safety of their lives. Nowadays there a particular number of robots which are assisting the soldiers, and it will be the future generation of robots that can be handled by anyone [1-5]. This robotic system will be adaptable to all types of environment. Then the mobile phone may manage it up to 800 meters away. We can assure this robot to detect any building because the robot can climb stairs. This robot will be able to adapt to any environment. It can be controlled from a mobile phone up to 800 meters away. we can send it to any building because it can climb stairs. It has a metal sensor that can start the movement if it detects land mains, and we may view the camera on our laptop, computer, or television. With our controller, we can turn off and on the metal sensor, then it has a laser that locks the position where the missile can be guided [6-8]. This chassis of this system was designed as a separate setup. This robot can run inverted on the rocks, stairs, and uninhabited lands as well as forward and backward. We use a stepper motor for this, allowing us to run for a complete revolution and to stop at a specific direction and angle. Our goal is that the adjustment of the motor’s position in order to raise and lower robot’s speed whenever we like. A “C” form has been carved out of the wheels to assist the user in climbing steps and stones [9-11]. The chassis was designed in Solid Works and printed using 3D printing, with ABS as the material.

**M. S. Shah, and P. B. Borole, “Surveillance and rescue robot using Android smart phone and internet,” In 2016 International Conference on Communication and Signal Processing, pp. 1526-1530, 2016.**

There is a wide variety of robots used for different applications, ranging from simple to complex. The concept presented here focuses on acquiring data from hazardous places, specifically radiation-affected areas. These areas encompass various types of radiation, such as ultraviolet radiation, nuclear radiation, x-ray radiation, and electromagnetic radiation. These places are dangerous for humans to enter, making remote-controlled robotic vehicles ideal for gathering data on the surrounding environmental conditions. Although it is challenging to create other types of radiation for demonstration purposes, our project generates electromagnetic radiation to prove the concept practically. Radiation refers to energy that originates from a source and travels through space. In our project, the source is created using a power transmitting coil, while a power receiving coil is arranged on the robotic vehicle to capture the electromagnetic radiation when the vehicle enters the radiation-affected area. Electromagnetic radiation is associated with an electric field and a magnetic field. When the vehicle approaches this field, the buzzer integrated into the moving mechanism automatically activates. The alarm in the form of a loud buzzer sound indicates the strength of the field or the proximity of the vehicle to the source. Additionally, our robotic vehicle is equipped with a DTH11 sensor, capable of measuring temperature and humidity, as well as a harmful gas sensor that can detect various toxic gases, including carbon dioxide. Furthermore, we have incorporated a live video monitoring system, featuring a 2D camera placed on the moving mechanism. This Wi-Fi camera enables the live video broadcast of the robot's surroundings. The innovative aspect of our design lies in the ability to control the camera through a remote control unit, allowing it to be transported as needed. Such cameras are highly beneficial for securing open land surrounded by buildings. Moreover, this robotic vehicle can also be employed in deep forests to collect environmental data while providing monitoring capabilities. To transmit the live video, we use a V380 Wi-Fi camera, which establishes a wireless communication link to the corresponding smartphone through the V380 Pro app. These wireless cameras offer greater flexibility compared to wired cameras, as they are not limited by wires, enabling the equipped vehicle to move freely in the field. The robot or remote-controlled vehicle is controlled via an RF communication system, allowing movement in all directions, including reverse. The mechanism is driven by DC motors, independently controlled through an H-Bridge IC. The remote control unit is constructed using an 89c2051 microcontroller chip, while the vehicle control circuit and data acquisition system are built using an Arduino Uno board. Note: One crucial aspect of this project is to hold the collected data until the robot returns to its home position, where it is controlled by the remote. This is essential to ensure accurate data from the radiation-affected area. To achieve this, a data hold key is provided, and the data remains unchanged until the release key is activated. In recent years, there has been a significant development in small intelligent robotic vehicles for various applications. These vehicles have become crucial in sectors such as defense, disaster management, wildlife studies, and data acquisition in hazardous areas. Our project focuses on designing a robotic vehicle specifically for collecting data from radiation-affected areas. Radiation encompasses a wide range of types, including nuclear radiation, toxic gas radiation, and electromagnetic radiation (e.g., radio waves, microwaves, infrared radiation, ultraviolet radiation). It also includes acoustic radiation such as ultrasound. Our project specifically considers the detection of electromagnetic radiation, where high-frequency electromagnetic pulses are generated and emitted into the air for demonstration purposes. The objective of our project is to gather data on ambient parameters such as temperature, humidity, and coordinates of harmful gases. To achieve this, we utilize a DTH11 sensor, which is interfaced with an Arduino board. The parameter values are displayed on an LCD screen. Ambient temperature refers to the actual air temperature in the surrounding environment. The DTH11 sensor is capable of measuring both temperature and humidity. To detect harmful gases in the radiation-affected area, we use a universal gas sensor capable of detecting various toxic gases, including smoke. Additionally, we incorporate a GPS module to obtain the coordinates of the presence of harmful gases. When the system detects the presence of harmful gases, an alarm is activated, and the LCD displays the information accordingly. By activating the hold button from the remote, the displayed information is retained until the robotic vehicle exits the affected area. Similarly, the system also detects electromagnetic field (EMF) levels, and the information remains displayed until the release key is activated. The Arduino Uno development board serves as the main processing unit, and the sensors are connected and interfaced with this processor. An independent LCD screen is used to display the parameter values. The DHT11 sensor, a low-cost digital temperature and humidity sensor, utilizes a capacitive humidity sensor and thermistor to measure the surrounding air's parameter values. Its digital output can be directly connected to the Arduino board's data pin.

**G. Anandravisekar, A. Anto Clinton, T. Mukesh Raj, L. Naveen, and M. Mahendran, “IOT based surveillance robot," International Journal of Engineering Research and Technology, vol. 7, no. 3, 2018.**

The main goal of IoT based Multipurpose Surveillance Robot is to design and develop a surveillance robot that is capable of being used for rescue and spying in military operations. It is known that humans cannot venture into hazardous/disaster-affected places as it can be lifethreatening and hence robots are required where human intervention is nearly impossible. Wireless surveillance robots can help to prevent the endangerment of humans or animals. The robot acts as a surveillance device to capture the intruder's surrounding information before the intruder attacks the soldiers. The issues related to short-range communication to control the movement of the robot are overcome by using IoT technology and therefore real-time video can be transmitted to the intended recipient. An android phone can control the robot's movement from a distance. This project comprises the following phases: controlling the robot in manual mode using IoT technology via android application, Phone acting as a camera for live video streaming, IR, Gas and Metal detection sensors, and rechargeable batteries. The work aims to reduce loss of lives during military operations, ensure safety on the war field and help provide footage of disasterstruck regions. This robot can perform multiple operations. When bombs are planted in a land mine-affected area, the robot can be made to act as a bomb detector robot using the metal detector sensor. The robot can also be used by rescue teams to detect human beings quickly during natural disasters like earthquakes if any human beings are trapped under debris. With the various and fast advancements in the field of Automation and Robotics, robots are playing a vital role in simplifying the lives of human beings by reducing human errors and human labor. A surveillance robot is a robot used for spying/monitoring purposes. Any remote/inaccessible areas can be monitored using surveillance robots. Surveillance is the method of systematic close observation of a person or area of suspicion. Surveillance is mainly required in the area of defense, intelligence gathering, disasteraffected areas and in public places. Nowadays, tracing, tracking and attacking enemy troops in different areas proves to be a tedious task for army personnel. There is always a chance of loss of the lives of soldiers on the battlefield and during emergencies. To develop a technology that serves the high speed and advanced capacity to control the robots and to devise new methods of control theory. To realize the above standards, some technical improvements along with the need for highperformance systems are required to create a faster, reliable, accurate and more intelligent robot. This can be devised by advanced control algorithms, robot control devices and new drivers. To meet the requirements, we can use multimedia to control the user-friendly robot. Earlier, the robots were being controlled through wired networks. But now, to make robots more user-friendly, they are framed to make user commanded work. The design of our project i.e., IOT based Multipurpose Surveillance robot encourages the development of a robotic vehicle based on Wi-Fi technology for remote operations connected with the phone that acts a camera mounted on the robot for monitoring/surveillance purposes. This IoT based Multipurpose Surveillance robot has or is embedded with a Node MCU (ESP8266) microcontroller for the desired operation and is generally used for monitoring purposes. The transmitting module on PC consists of push buttons that send commands to the receiving module for controlling the movement of the robot either to right, left, forward or backward. In the receiving module of this Surveillance robot, 2 DC motors are interfaced with the Node MCU(ESP8266) microcontroller to control its movement via motor driver IC(L298N). The Wi-Fi control transmits the signals to the receiver and has a range of up to 400m. The receiver collects and decodes the received signal’s before feeding them to the Node MCU (ESP8266) microcontroller to drive the DC motors via motor drivers(L298N). Interfacing is done between the device and the Wi-Fi module. Wi-Fi module device receives the signals or commands from the ESP8266 microcontroller.

**S. Chowdhury, and M. Rafiq, “A proposal of user-friendly alive human detection robot to tackle crisis situation,” In 2012 12th International Conference on Control, Automation and Systems, pp. 2218-2221, 2012.**

The main purpose of this project initiative is to design a remotely controllable Robot prototype that can detect live humans and transmit the location details wirelessly. It can also be used in war fields and places where disaster has occurred. Human detection is also required in hazardous sectors like boilers, reactors where only authorized person can enter. The live body detection is performed by a biomedical unit that comprises mainly of a temperature sensor combined with a pulse detector. Any alive body with a temperature above absolute temperature is measured tentatively. It senses these pulse variations in the given subject body with the help of a robotic arm with attached clipping mechanism for effective and reliable operation. Human identity is also carried using a wireless camera module. The remotecontrol unit is used to provide interconnectivity between the robot and human operator and the on-bot camera is used to detect the motion in any kind and will inform to micro controller and then via wireless transmission to an operator located at a remote place. In this project we propose to deploy wireless transmission of data using ZigBee based wireless system for the procurement of efficient communication. If the micro controller unit receives the detected signal, it will send a message through Zigbee signal transmitter to the remote-control unit. The GPS receiver receives the Longitudinal and latitudinal value when the robot continuously monitors to check for even the slightest movement of the human body it sends the location details to the remote-control unit at the earliest. Disaster sites may be complex and hazardous to be reached for rescue and there are great threat and risk linked to rescue workers and survivors trapped in such accidental sites. Even though, technology have been developed, still trained dogs and humans are used in this risky situation, which maybe time consuming and due to the vast area, that get affected it becomes more difficult. In order to curb this problem and to make the rescue operation safer and more effective “ALIVE HUMAN DETECTION ROBOT” is proposed which will work in disaster environments of man-made structures like collapsed buildings, war fields etc. It can be assisted for firemen, police, and disaster agencies with appropriate reconnaissance, site evaluation, human detection etc. Basically, the robot consists of a mechanical part and a biomedical part. The mechanical part consists of wheeled platform, arm and the biomedical part consist of microcontroller, temperature sensor. Sensors are used to sense the environment and give practical feedback to the device. Apart from this, it includes a robotic arm that is equipped with the pulse detector to access the pulse of the victim and thermal sensor to form a combined data set and transmits this real time data to the remote-control unit that helps in triggering rescue operations. The robot is controlled using a wireless sophisticated joystick. It has a display, where all the information from the robot are visually illustrated. A camera is used to capture the status of the surrounding and one can perceive the current condition of the casualty with the help of this camera.

**EXISTING SYSTEM:**

We consider intruders as robots which misbehave, i.e. Do not follow the rules, because of either spontaneous failures or malicious reprogramming. Our goal is to detect intruders by observing the congruence of their behaviour with the social rules as applied to the current state of the overall system. Moreover, the detection itself must be performed by individual robots, based only on local information.

Lavanya et al [1] implemented a surveillance robot to replace humans in defense applications. They developed this robot with speech-based recognition and gesture control. Through these features they operated the robot to understand gesture by understanding the images along with metal and fire detection. Hoque et al [2] developed a war robot in which a control system was used with a wireless transmission system that controls the motors and actuators of the robot. Night vision was also added in the system to operate the robot during night hours also. The GSM module and a metal detector attached to the system could detect the bomb and other related dangerous hazards in the war field. Patoliya et al [3] developed a surveillance robot to observe human activities in the war field to reduce the involvement of humans. A night vision enabled wireless camera was involved in the robot and a wireless transmission system was also connected to the robot to transmit the video sequences to the destination control point. side.

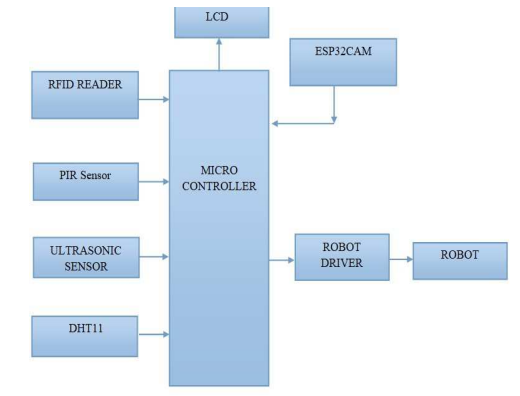
**DISADVANTAGE OF EXISTING SYSTEM:**

* Do not follow the rules
* Monitoring process only possible
* Prevention process not possible

**PROPOSED SYSTEM**

In this work, an IoT based multi-application surveillance robot is developed that can navigate autonomously in a given environment while performing surveillance tasks using various sensors and cameras. The robot is equipped with IoT capabilities to allow it to communicate with other devices, systems or users through the internet or a local network. It can detect and recognize objects, people, or potential threats or anomalies, and can deploy appropriate tools or mechanisms to mitigate them. The architecture of an IoT based Smart Multi-application Surveillance Robot typically includes a processing unit (such as a Raspberry Pi), sensors (such as cameras, proximity sensors, and GPS modules), actuators (such as motors), and a communication module (such as a NodeMCU or Wi-Fi module). The robot uses various controlling algorithms to detect and recognize objects and people and can use various tools or mechanisms (such as alarms, sirens, and water sprays) to mitigate threats or anomalies.

**Block diagram**



**Conclusion**

In this work, a manually and remotely operated multiapplication robotic system was developed and proposed. It could be controlled through a wireless communication module by the user and hence it eliminated the issue of constrained surveillance using IoT. The robotic setup can be controlled manually as well as automatic tracking can also be executed. The proposed robotic setup is small and can be used for locations where humans are unable to invigilate. This yields noticeably efficient tasks that replace humans for all kinds of monitoring works in a properly powerful way. The proposed robot can decrease the death toll in line areas, and special areas in which military reconnaissance is needed. With the assistance of live video, the administrator can play out the watching obligation and recce any disregarded territory.

**References**

[1] K. N. Lavanya, D. Ramya Shree, B. R. Nischitha, T. Asha, and C. Gururaj, “Vision interfaced war field robot with wireless video transmission,” In Proceedings of the 2nd International Conference on Trends in Electronics and Informatics, pp. 833-838, 2018.

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