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CYBORG – A SURVEILLANCE DROID USING RASPBERRY PI AND INTERNET OF THINGS

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ABSTRACT: This paper presents the development of a robot named Cyborg, which is programmed to move around in a particular area in an industry(chemical) while collecting the surrounding conditions such as gas levels, etc. and displays the collected information on the IoT page through the internet. The bot also streams the live video on the IoT page with the help of a wireless pi camera on board. This Cyborg robot can also be manually controlled (when required) from the IoT page through any device such as a mobile phone or laptop using the Internet of Things (IoT). Anyone with the Raspberry Pi's IP address can view the sensor data (current temperature, gas levels, presence of obstacle ahead) and live streaming on the IoT page from anywhere, anytime with the help of only internet connectivity. Additionally, the bot also sends an alert SMS to the provided contact whenever the detected sensor values cross the critical threshold. The available robots are designed with either surveillance capability or collection of data using sensors whereas this paper combines the surveillance with data collection which provides enhanced industrial management.

Keywords: Raspberry Pi, Surveillance, Internet of Things, Gas detection, Live streaming, GSM.

1. INTRODUCTION

The World's huge chemical industrial disaster "The Bhopal Gas Tragedy" was due to a gas leak in the plant left unnoticed and the consequences of which is still experienced in and around the location. Such accidents taking the shape of disasters are rare in the chemical industry, but these rare instances have severe consequences on public health and safety. These accidents may be a result of many causes such as equipment failure, human error, physical attack, etc.

Technology has brought a dynamic and tremendous change in the robotics and automation field which ranges in all kinds of areas. Nowadays robots play a vital role in various surveillance applications thus reducing human labor and human error. The use of surveillance robots for detecting the gas leaks and other such anomalies in a chemical industry reduces the risk of chemical disasters. Surveillance is the process of close systematic observation or supervision maintained over a group or person, especially one in custody or under suspicion. Thus, surveillance is mainly required in areas such as border areas, public places, offices and in industries where human intervention seems difficult. The act of surveillance can be performed both indoor as well as in outdoor areas by humans or with the help of embedded systems such as robots and other automation devices. A robot is nothing but an automatic electronic machine that is capable of performing programmed activities thus replacing human work, providing highly accurate results and easily overcoming the limitations of human beings such as time consumption and the making of errors, etc. Thus, robots replacing humans in the field of surveillance is one of the greatest advancements in Robotics.

The Internet of Things (IoT) is the network of devices such as vehicles, and home appliances that contain electronics, software, actuators, and connectivity which allows these things to connect, interact and exchange data. The IoT involves extending Internet connectivity beyond standard devices, such as desktops, laptops, smartphones, and tablets, to any range of traditionally dumb or non-internet-enabled physical devices and everyday objects. Embedded with technology, these devices can communicate and interact over the Internet, and they can be remotely monitored and controlled.

This paper envisions the robot Cyborg which offers both security and surveillance simultaneously. By continuously monitoring the surrounding environment using the Raspberry Pi's wireless camera the bot streams the live images captured by the camera (surveillance) on the IoT page. Along with the live streaming, it also displays the gas levels and temperature conditions on the IoT page (security). The images captured by the camera and the sensor data are streamed live on an IOT webpage continuously and these data can be acquired from the internet thereby providing ubiquitous operation. Raspberry Pi 3 module is the heart of the robot controlling these two operations simultaneously. This robot also consists of DC motors, wheel chassis, battery, Wi-Fi module and various types of sensors such as IR sensor for obstacle detection, Gas sensors (MQ2, MQ9) for detecting gas leaks, temperature sensor (LM35) for monitoring the optimal temperature of the particular area. The robot can be either operated in an automatic or manual mode. The user

communicates with the robot via the internet by implementing the concept of the Internet of Things (IoT) and with the knowledge about the IP address of the Raspberry Pi.

2. LITERATURE SURVEY

2.1 The Multi-Environment Robot for Surveillance & Live Streaming using Raspberry Pi
This paper elucidated an idea in which the robot performs the live streaming operation with the help of Raspberry Pi and its camera using the Bluetooth technology. The robot and the user are paired via Bluetooth through which the live images captured are transmitted over the range of Bluetooth connectivity. This robot is made compatible with various environments either smooth or rugged surfaces and works well in all kinds of environments.

2.2 Defense Surveillance Robot Based on RF and DTMF Technology
This paper intended to develop a robotic model for defense application with various features such as robotic arm for bomb diffusion, fire detection, magnetic field detection, other sensors for collecting data about the surroundings, wireless camera, etc. This model consists of the RF transmitter and receiver sections separately for the transmission of data using DTMF technology. The DTMF technology uses a mobile phone call control and the robot can be controlled over the RF range up to around 200 meters.

2.3 Military Spying Robot
This paper proposes an idea where a spying robot works on the RF transmission of commands from the remote zone to the robot using microcontrollers separately. The CCD (Charge-Coupled Devices) camera is used for video capturing and the captured video is transmitted from the CCD transmitter to the CCD receiver which is then viewed on a computer through the capture card. The CCD camera communicates the captured images only via the capture card. The microcontrollers on the remote and the robot modules process the various commands and robotic control.

2.4 The Raspberry Pi Controlled Multi-Environment Robot for Surveillance & Live StreamingA surveillance robot using Raspberry Pi was delineated, which performs live streaming of the surrounding environment using the Pi camera within a Local Area Network (LAN). This robot can be used in various fields for applications such as military, industrial, remote locations, and areas where humans can't reach for. The video streaming is done using MPEG (Moving Picture

Experts Group) streamer, while the server-client model is done using Java programming language.

2.5 Development of Microcontroller Based Mobile Gas Sensing Robot
This research article describes the mobile robot used for gas detection in gas pipeline pathways. The RF transmission technology is used for gas level communication with the help of microcontrollers. The LPG gas sensor is used for the gas detection while buzzer and LCD are used at the receiver end for alerting/notify the gas levels in the gas pipeline.

3. EXISTING MODELS

The available robotic models are implemented with various technologies as stated in the literature survey with their advantages and disadvantages. Robots can be designed and implemented for various applications including such as surveillance robots, environmental sensing robots, robots for military applications, etc. These robots can have different modes of movement or control such as automatic, manual or even self-moving intelligent mode.

The surveillance robots are more focused on the video surveillance in many cases. The robots used for monitoring the environment are designed with various sensors that collect data from the robot's surroundings and transmits that information to the user end via different communication technologies.

Robots communicate the observed information with the help of different technologies such as RF and DTMF, Bluetooth, CCD, Wi-Fi, Zigbee, etc. The limiting range of transmission of these technologies limits the communicable range between the robot module and the user end.

The type of controller used in the projects play a major role in the performance of the overall robotic module. The use of different controllers depends on the application for which the model is developed. The existing models use controllers such as PIC (Peripheral Interface Controller), etc. or various development boards such as Arduino, Raspberry Pi, etc.

"The Multi-Environment Robot for Surveillance & Live Streaming using Raspberry Pi" paper as stated in the second Literature Survey, has developed a surveillance robot for live streaming purposes with the help of Raspberry Pi controller and Bluetooth technology for transferring captured live images. The robot is designed for security purposes in a small area within the range of Bluetooth transmission.

"Development of Microcontroller Based Mobile Gas Sensing Robot" paper as stated in the sixth Literature Survey, serves the application of gas detection in LPG pipelines using RF technology for transmitting the sensor information. This robot can be made to move forward/backward along the pipelines in the absence of human activities and alerts the user in case of increased gas levels due to gas leakage.

"Defense Surveillance Robot Based on RF and DTMF Technology" paper as stated in the third Literature Survey presents the surveillance robot for defense application serving the appropriate requirements in the respective field. The robot has many features such as fire detection, metal detection, magnetic field detection, robotic arm to diffuse bombs, various sensors, and cameras for monitoring the robot's environment. The mode of communication in this model is through RF and DTMF technology, where the range is limited to around a few hundred meters.

4. PROPOSED MODEL

The proposed model named 'Cyborg' is designed for the application in the chemical industry with the combination of both surveillance and environmental monitoring. This robotic module is specifically designed by considering the difficulty and risk in the presence of humans in areas containing hazardous chemicals in an industry. Cyborg performs both the operations, surveillance and detecting abnormalities such as gas leakage or sudden temperature increase.

The gas leaks in chemical industries result in greater disasters and can have aftermath effects for a prolonged period over larger areas in and around the incident. The cause of these outbreaks are not gradual changes or slow processes to be controlled, they can only be identified through continuous monitoring of the industrial conditions with proper precisions in measurements. This continuous monitoring can be easily implemented with the help of growing technological advancements. Robots have become part of human life due to the rapidly developing technologies such as RPA (Robotics Process Automation), AI (Artificial Intelligence), IoT (Internet of Things), etc. Thus, replacing the human workforce by robots has been a better choice in our current fast-paced world. Especially in places where human reach is dangerous and difficult such as fire, remote places, toxic gaseous environments, etc. use of robots are found to be of greater advantage.

The Cyborg (robot) can provide continuous monitoring of the industrial area using Raspberry Pi (a mini-computer) and sensors such as temperature sensors and gas sensors. The monitored information is provided to the IoT webpage which can be viewed by anyone with the Pi's IP address from anywhere anytime by utilizing the IoT (Internet of things) technology.

The robot consists of different sensors such as LM35 temperature sensor (for evaluating the surrounding temperature variations), gas sensors MQ2 (for detecting gases like LPG, Alcohol, Methane) and MQ9 (for detection of toxic gas like Carbon Monoxide(CO) and other flammable gases), IR (InfraRed) sensor for obstacle detection in the robot's pathway. These sensors are interfaced with the Raspberry Pi through an ADC (Analog to Digital Converter). The wireless pi camera interfaced with the Raspberry Pi uploads the live streaming video of the industrial area monitored by the robot on the IoT page. The whole robotic module is powered by a rechargeable battery on board. The robot's motors connected to the wheels are driven by the motor driver which is interfaced with the Raspberry Pi.

The robot's movement can be either of the two modes, Automatic or Manual mode. The bot can be manually controlled from anywhere (with internet connectivity) using the controls on the IoT page. The IoT page contains the Manual controls, Live Streaming video and the collected sensor data such as Temperature, Gas levels, and Object Detection. In manual mode, the robot can be moved forward, left, right, backward or it can be stopped using the controls on the IoT page. In automatic mode, the robot moves in a straight path unless it detects any obstacle. If the robot detects any obstacle (using an IR sensor), the robotic motion is stopped for a few seconds following which the robot moves left or right and corrects its pathway that is free from obstacles.

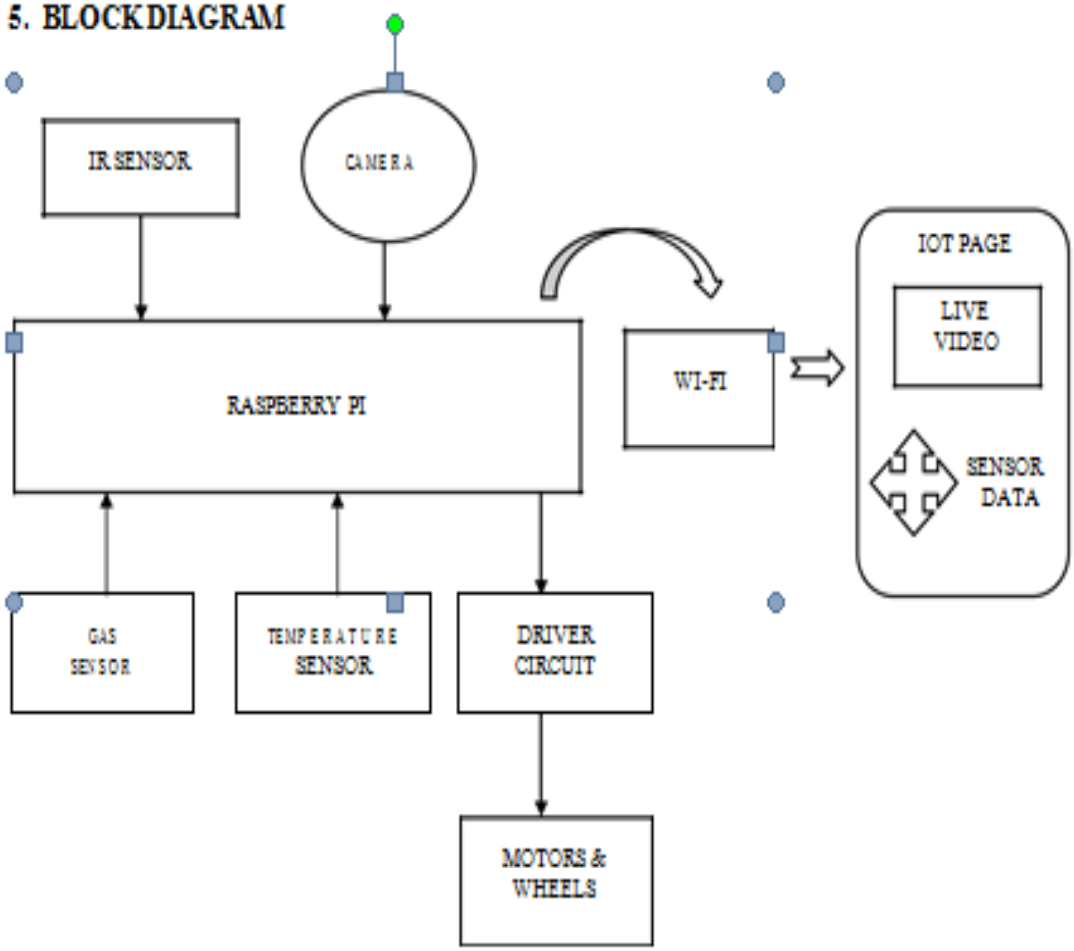
Using IOT facilitates the user to view the required details from anywhere around the world with a connecting device (like mobile or laptop) that has internet connectivity, which is one the main advantage of the proposed robotic model. Here the

robotic module and the user are both connected via the cloud and hence ubiquitous accessing of the location is made possible. The data transmission among the robot and the user takes place through the cloud over a particular port providing secured communication.

The Cyborg is designed not only for detection of hazards, but it also has additional capabilities such as alerting the person-in-charge for controlling the chemical valves or control valves (that operates to control flow, pressure, temperature, etc.,) about the sudden unexpected variations in either the temperature or gas levels. The alert is given via an SMS (Short Messaging Service) using GSM (Global System for Mobile Communications) to the person in control. The SMS gateway bought sends an alert message to defined mobile number using GSM whenever the temperature and gas levels exceed the critical threshold values as programmed in the Pi.

Thus, as a whole, the proposed model has certain advancements for prevention of the chemical disasters in industries due to a lack of continuous monitoring. The special features of the Cyborg are Live Streaming, displaying sensor data on IoT page, Automatic or Manual mode of operations and generation of alert SMS using GSM which is sent to the registered mobile number immediately without delay. Another advantage of Cyborg is the communication of the robot with the user via the internet where IoT comes into play and makes the control of devices from remote places with not much delay in data transfer and affordability by using only a mobile/laptop with internet connectivity.

5. BLOCK DIAGRAM



6. RESULTS AND DISCUSSION

The robot continuously updates the gas and temperature levels on the webpage along with the live streaming. The temperature is displayed in Celsius while the gas levels are in percentages. When the gas percentages or the temperature level rises beyond the defined value the Raspberry Pi sends an SMS to the registered contact with details about the highest sensor value and approximate location.

The robotic module as shown in Figure 1 contains the sensors, camera, Raspberry Pi, Rechargeable Battery, MCP3008 ADC, L293D Motor Driver, Motors, Wheels, and a power supply for Pi (power bank). The Cyborg starts when the Raspberry Pi and the sensors are powered. The sensors require precise power and hence a voltage regulator is being used for power conversion. The program written in Pi can be initiated through the terminal using VNC (Virtual Network Computing) protocol installed on either a mobile or laptop. In the terminal page, the folder name followed by the name of the script file needs to be entered to run the program and the Ctrl+C statement exits the running program

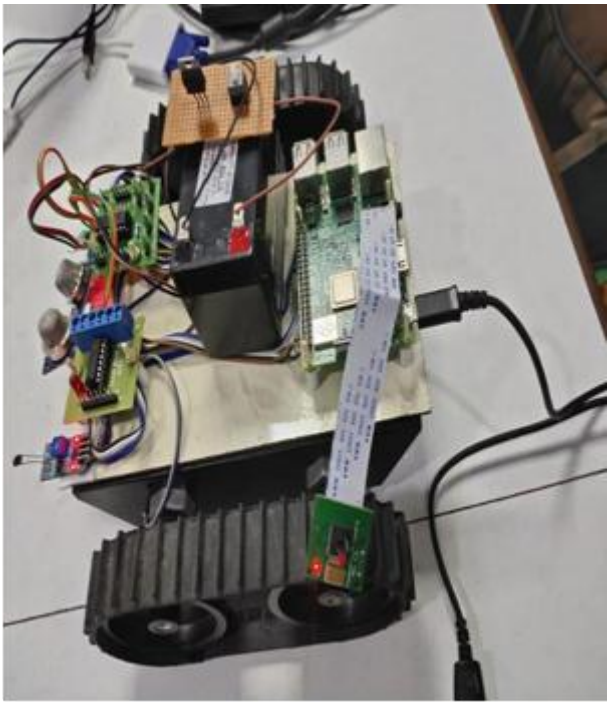


Fig1: Surveillance Robot using Raspberry Pi and IoT

Fig2: IOT page displaying Live Streaming and RoboticControl

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Fig3: IOT page displaying the presence of obstacle through IR sensor

Fig4: IOT page displaying an increase in gas levels (MQ2 and MQ9

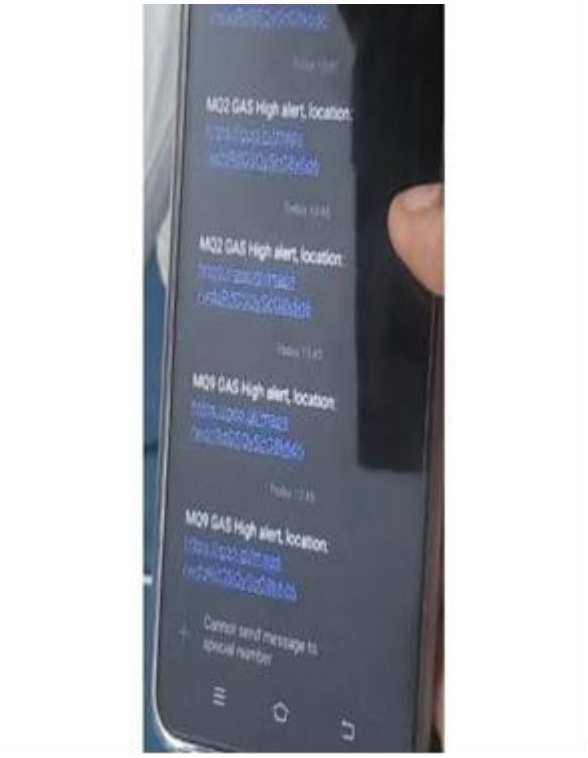

Fig 5: Alert message that indicates high gas levels

7. CONCLUSION & FUTURE SCOPE

This paper describes the application of Robotics in the field of Surveillance and Security by implementing continuous monitoring using better technologies like IoT. The robot developed has shown better efficiency in working and also in communicating the collected data using IoT. The robot prevents gas leaks in chemical industries and other such a nomalies and alerts the person-in-charge in case of critical conditions through SMS messages immediately. This robot can be further enhanced by providing intelligence to the bot and adding features like face detection, smart movement, etc.

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