IoT Based Mechanized Robot: An Integrated Process Involving Fulltime Multipurpose Control, Automation and Surveillance System. [Best Paper Award, IEEE-SOLI,2021, Singapore]

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IoT Based Mechanized Robot: An Integrated Process Involving Fulltime Multipurpose Control, Automation and Surveillance System

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***Abstract*— The Internet of Things (IoT) is the next generation of wireless technology that automates routine tasks and reduces labor. Software, sensors, and actuators are combined into a network of linked devices in the Internet of Things. The gadgets may exchange data and communicate over a network. Our laboratories have used this technology to make appliances more convenient and automated. One of the key reasons for this increase is its capacity to both secure and facilitate research. The IoT innovation can provide fantastic content for modern automation. This study proposes an internet-based smart laboratory and laboratory machine automation, cloud storage data gathering, and monitoring system to efficiently operate types of machinery, online live data streaming, and monitor mechanical work devices. The IoT microcontroller devices are connected to the robot to gather different sensors data, control and monitor the types of machinery and lab appliances in a smart lab environment. Any Android phone, laptop, or computer may operate the robot wirelessly. All sensors data and parameters can be collected from Google's cloud storage platform Blynk and used to operate all appliances and devices. It will supply us with live streaming video of the laboratories with a specific IP address, and we can monitor the laboratory using this robot.**

Keywords*— *IoT, Artificial Intelligence, Smart Laboratory, Automation, Cloud Storage, Data Collection, Monitoring, Robot

I. INTRODUCTION

We propose an IoT-based Mechanized Industrial Automation Robot, which refers to the intelligent networking of industrial machinery and processes using information and communication technologies. Robots are the key players in this transformation. Sensors and different devices are used to link the physical world with the help of virtual networking systems and digitalize traditional industrial processes. This improves manufacturing efficiency and lowers costs. Every sector requires a suitable environment for production, yet constant monitoring and control of the environment is tough. Our robot may support industries in monitoring or operating machinery from our office, lab, or anywhere else. It will explore its allocated region, gathering data from different tools and sensors and transmitting it to a monitoring panel through Wi-Fi, IoT, and GPS, among other technologies. [1].

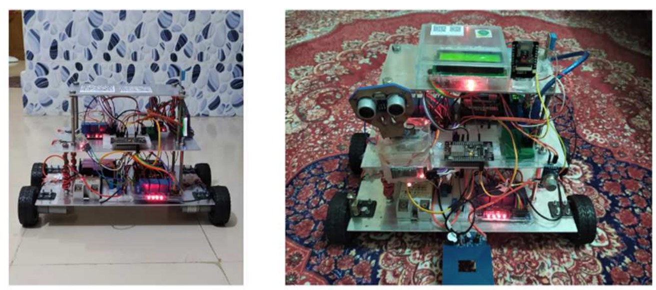


Fig. 1 Prototype version of IoT Based Mechanized Robot

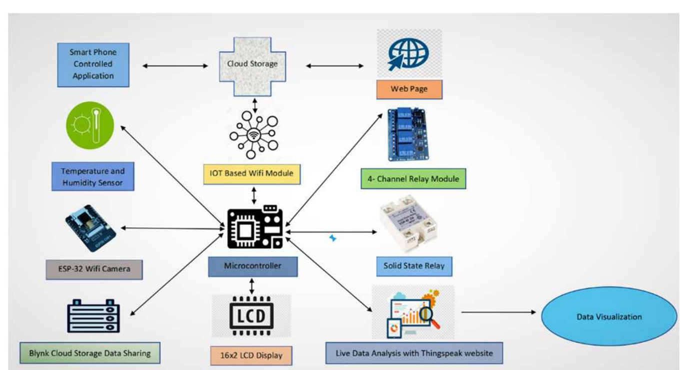


Fig. 2 An example of smart laboratory control and monitor architecture

The Artificial Intelligence assisted built-in camera may provide a visual of the production line or the security of an allocated area, monitor every lab machineries working procedure and in the event of an emergency, it can send a signal to all units, allowing everyone to control the situation more simply in the smart way.

II. Background

A. IoT Automation Systems

The Internet of Things (IoT) can be defined as a pervasive and worldwide network that aids and facilitates the integration of the physical world. This is performed by collecting, processing, and analyzing data generated by the Internet of Things (IoT) sensors, which will be embedded in everything and connected to the public communication network. The IoT concept's primary strength is the significant effect it will have on many areas of daily life as well as the behavior of prospective users. The Internet of Things (IoT) represents a new Internet revolution. Through the use of wireless communications and low-cost sensors, processing, and storage devices, it may link distant and mobile objects, machines, or assets. As a result, the Internet has evolved from a computer network to a network of things. Traffic monitoring, smart homes, smart parking management, vehicle tracking systems, and other industrial applications are just a few of the IoT's many uses. These devices' usage ranges from ordinary household objects to sophisticated industrial tools. With more than 7 billion connected IoT devices today, experts are expecting this number to rise up to 22 billion by 2025. Within 2025 world will be experiencing with Industrial Revolution 4.0.

B. Why is it necessary to control and monitor Internet based Smart laboratory with a mechanized robot?

There is a great deal of unnecessary electricity waste in the laboratory in the current situation. The appliances of the laboratory are left switched on even when not required. This leads to a rise in electricity consumption and hence excessive electricity bills. The main contribution of this study is the development of an efficient, low-cost, and portable system to monitor laboratory conditions continuously and comfortably control electrical appliances over the Internet regardless of time and location.

In the Covid-19 pandemic, Office jobs have become popular online. In addition, research tests in laboratories are time-consuming, so it is difficult and time-consuming for a laboratory operator to observe, monitor, and collect data for a long time. By setting up a smart laboratory, we can automatically control time-consuming operations and tests through robots. Testing observations can be monitored online with live streaming cameras. We can test research data, and their results can be accessed through the IoT-based Google Cloud Platform after a certain period of time. After all, we have easy access to operate the appliances, monitor, and gather laboratory research data from any location.

Furthermore, the user may utilize a smartphone, tablet, or laptop to operate the electrical appliances and monitor the laboratory conditions from anywhere by using this robot. For example, if the laboratory operator forgets to turn off the fan and has already arrived at his office, he may do it using his smart device because universal robots automated switches are connected with this robot. Sensors for smoke, carbon monoxide, and gas leakage may also be added so that if the laboratory air around them is harmful, the laboratory operator will be notified. through the alarm system. We can monitor every type of machinery screen data and control it by using Anydesk software with the integration of this robot.

If an event occurs in the security system, the user will receive an alert on their phone. They don't have to be concerned if an outsider tries to break into the laboratory because they can watch it from their phone. Here we will use a strong privacy protocol that will be saved in our database. The only registered person will get access to this smart online-based laboratory for research work.

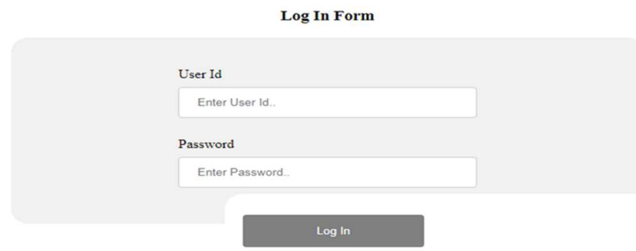


Fig. 3 Smart online controlled log in page

C. Limitations of the Existing Cyber controlled laboratories

According to studies, one of the primary concerns with most existing laboratory and industrial automation systems is their high implementation and maintenance costs which are out of reach for most users. Moreover, some existing systems give a view of the laboratories through a web application, which is inconvenient for users since they must use the Web every time they want to control or monitor the status of the laboratories. Furthermore, some laboratory automation systems do not offer user-friendly interfaces for monitoring and operating equipment. However, the communication technologies employed in present automation systems have considerable drawbacks[11].

As a result, in this research paper, We propose a novel approach to overcome the constraints of current laboratory automation systems. This may be accomplished by utilizing this low-cost IoT-based Automation System for Smart Laboratory Automation Prototype utilizing NodeMcu/Esp8266, an IoT microcontroller, and an Android-based smartphone. Any Android-based smartphone with built-in Wi-Fi capability may be used to access and control the devices in the laboratory.

When a Wi-Fi connection is unavailable, the system may connect to the internet using mobile cellular networks such as 3G or 4G to access the integrated system. The robot is designed to handle all electrical equipment in the laboratory setting easily and efficiently and enable remote control by utilizing the concept of IoT Technology.

III. Materials and Methodology

A. Conceptual Framework

The following diagram explains the conceptual framework and methodology used for this research study and the systematically arranged distinct stages of the research, and the particular implementation aspects of the proposed system. It also shows the methodology used by us in the construction of IoT Based Mechanized robots. The mechanism is chosen based on several variables such as minimum fabrication cost, design simplicity, synchronization, precision, and so on. The following step is the integration of electronics and software, after which the machine is designed and developed. The final phase is to synchronize the machine's mechanical, electrical, and software components [2].

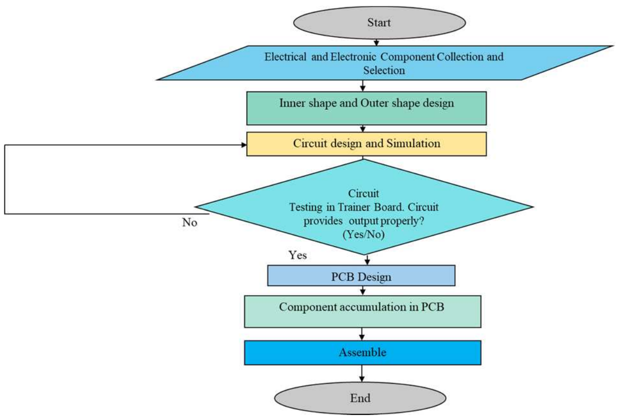


Fig. 4 Flow chart of research works

The functional schematic design of a smart laboratory prototype is displayed in Fig-5 which is followed by the modelling phase, where all of the essential equipment and materials are used to produce a smart IoT-based laboratory prototype.

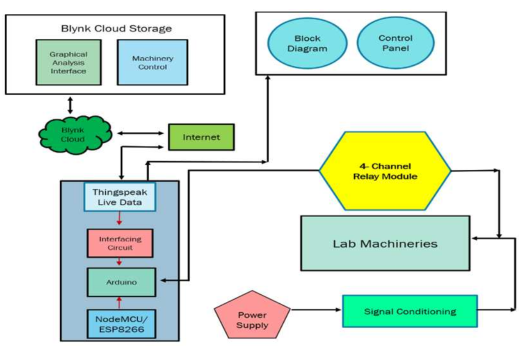


Fig. 5 Functional Diagram of Smart Laboratory

B. System of Systems (SoS) Communication

IoT systems are systems of systems, which is an important concept to grasp. When data from one system is coupled with data from other systems, we get the value that we wouldn't get if the systems were separated [9]. IoT Based Mechanized Robot's system of systems communication system is shown in Fig-6. System of system communication is divided into three types of capability. Capability Type-1 is for low voltage lab appliances with voltage ranges less than 220 volts, Capability Type II is for medium voltage lab appliances with voltage ranges similar to 220 volts, and Capability Type III is for high voltage lab pieces of machinery and laboratory instruments. This capability type's voltage range is more than 220 volts. Their maximum voltage range is 480v.

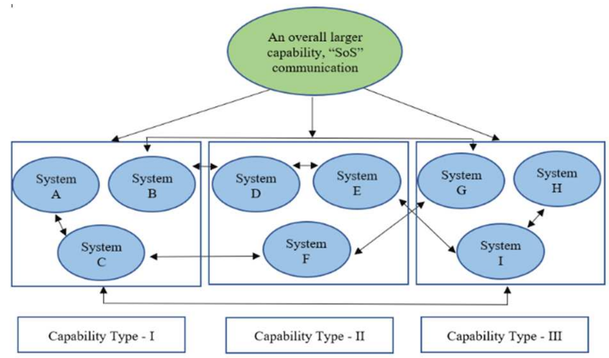
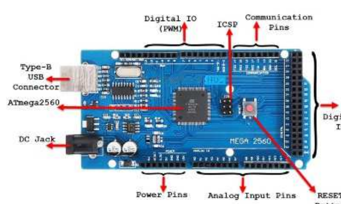


Fig. 6 IoT Based Mechanized Robot's system of systems communication system

C. Main Components of Industrial Control, Automation and Surveillance System

1) Arduino: The Arduino Mega2560, as shown in Fig. 7 (a), is selected as the central controller in this project because it is affordable, cross-platform, has a simple, clear programming environment, is open source, and is extendable software. The electrical appliances and sensors are wired to the Arduino Mega's pins. The Arduino board's functions include reading input and converting it to output, receiving and transmitting serial data, triggering an interrupt on a low value, providing 8-bit PWM output, and more.

2) IoT Module (ESP8266/NodeMcu): The ESP8266 Wi-Fi Module contains 8 pins, as shown in Fig. 7 (b), and is attached to the Arduino Mega. This module is only compatible with logic levels of 3.3V. The ESP8266/NodeMcu was chosen due of its inexpensive cost and strong feature set, making it a perfect module for IoT applications.



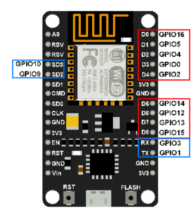


Fig. 7 (a) Arduino Mega2560 Fig: 7 (b) ESP8266/NodeMcu

3) 4 Channel Relay Module: In this project, the 4-channel relay modules different works are shown in Fig. 8 are also utilized to link two or more locations in response to the input signal. It is linked to the fan and the lamps that serve as output. Because of its relative simplicity, long life, and demonstrated high dependability, relays are utilized in a wide range of applications. The function is to monitor, regulate, and control power. In addition to these three main components, a variety of sensors and equipment are used to monitor or control the Smart laboratory, including a voltage regulator, temperature sensor, Humidity sensor, PIR motion sensor, Metal detector sensor, Different types of gas detector sensor, IoT Based Mechanized Robot's high torque motor control, buzzer alarm notification, and and samples for regulating laboratory equipment such as lights, fans, air conditioners,Universal Testing Machines, Heat Furnace and other machineries [3].

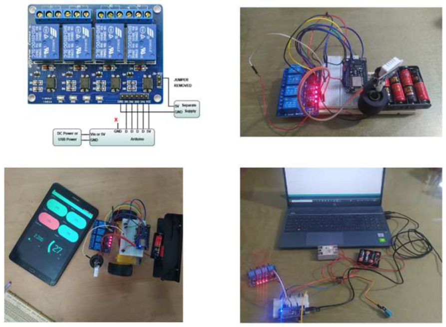


Fig. 8 Different sensors, mechanized robot's high torque motor control, and electrical lab appliances connection system port all were controlled by the four-channel relay module.

4) AI Assisted Wi-Fi controlled Thinking Camera: The ESP32-CAM is a smaller, low-power AI Assisted Wi-Fi controlled Thinking camera module based on the ESP32. It includes an OV2640 camera and an inbuilt TF card slot in the robot. The ESP32-CAM may be widely used in a variety of sophisticated IoT applications, including wireless system video monitoring, WiFi picture upload, QR identification, image processing and so on.

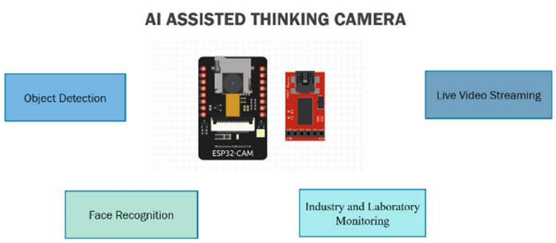


Fig. 9 IoT Based AI assisted thinking camera used for object detection, Live video streaming, Face recognition, Industry and laboratory monitoring system

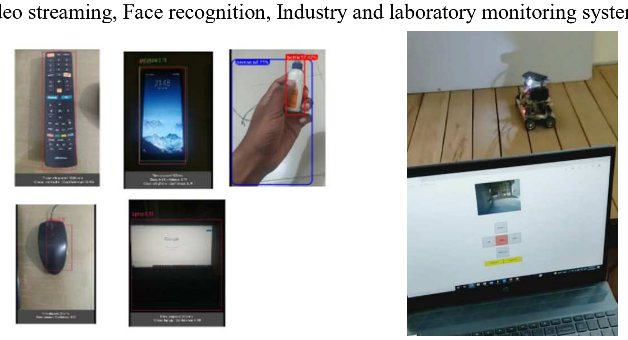


Fig. 10 AI Thinking Camera based object detection and surveillance system

D. Schematic Diagram of Circuit

The schematic diagram of the circuit board of the IoT Based Mechanized Robot's IoT based circuit is designed in the Proteus and Professionals software and robot controlling in the Tinker CAD software. Fig: 11 and Fig: 12 are shown the total schematic diagram of this robot.

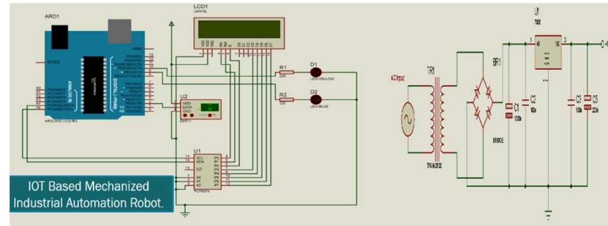


Fig. 11 IoT Based Mechanized Robot's IoT based circuit Circuit Diagram in Proteus and Professionals Software

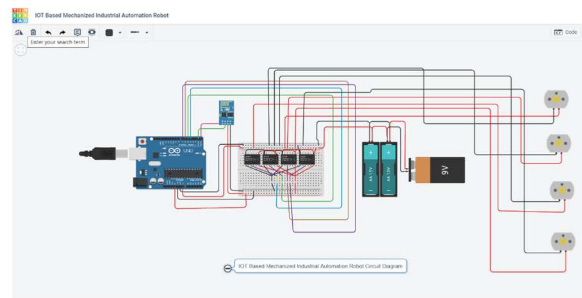


Fig. 12 Robot controlling Circuit Diagram in Tinker CAD Software

IV. System Architecture and Implementation

In this hyper connected world, digital systems can record, monitor and adjust each interaction between connected things. The physical world meets the digital world and they can cooperate with the help of IoT based wireless communication system. Fig-13 explains the step by step process of data storage and analysis system by using smart devices [5].

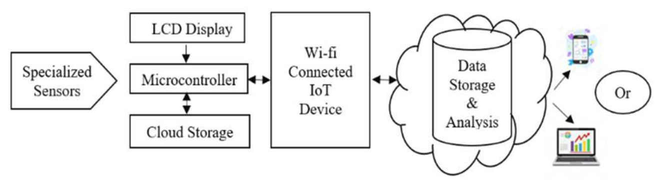


Fig. 13 IoT Based Mechanized Robot's system of systems communication system

We can get every sensors data and parameters from the google cloud storage platform Blynk and control every types of appliances & machines by using (ESP8266/NodeMcu) IoT and Arduino Mega2560 microcontroller devices [4]. Using an IoT-based Artificial Intelligence assisted thinking camera, we will be able to observe live streaming video of laboratories with specific IP addresses and we will be able to monitor the laboratories and industries by using this robot. To increase the performance and accuracy of the sensors of this robot we have used online based IoT analytics live data monitoring website "Thingspeak". we get the actual real time data of different sensors and make analysis of long days data [6].

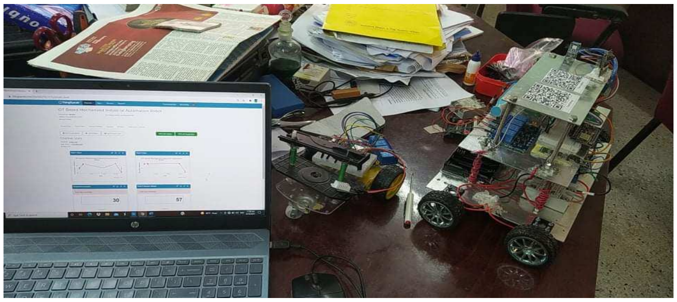


Fig. 14 Implementation and analysis system with IoT platform in the laboratory environment

V. RESULTS AND DISCUSSION

This section provides an example of testing and validating the proposed research work's implementation. The early findings presented in this research will be used for further extension and improvement. This article was successful in developing a Wi-Fi-Based Automation System for Smart Laboratories. Using an Android phone[9] .

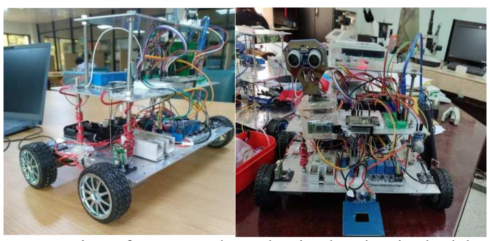


Fig. 15 Prototype version of IoT Based Mechanized Robot in the laboratory

At first, we must connect our Android-based smartphone to the accessible Wi-Fi. Then, on our mobile, launch the Arduino IDE program and enter the IP address before connecting. The IP address may be obtained in the PC's command prompt. Then we connect the Arduino application to Wi-Fi in the Blynk cloud storage platform. We can now control all of the laboratory's electrical equipment and monitor motion, temperature, gas leakage, and humidity. Electrical appliances such as lights, fans, and machines (UTM, Heat Furnace) may be controlled and monitored using the Android app shown in Fig. 16.

Secondly, the sensor DHT22 may be used to measure and monitor the temperature and humidity in the laboratory using an android-based mobile phone, and these parameters can then be utilized to fully automate the AC system and fans in the following stage.

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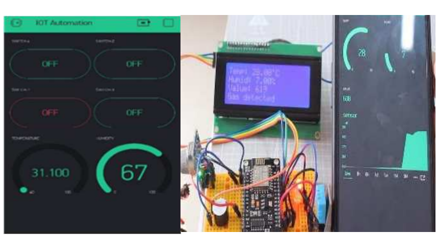

Fig. 16 Laboratory Appliances control system by using IoT technology and monitoring data from the cloud storage system

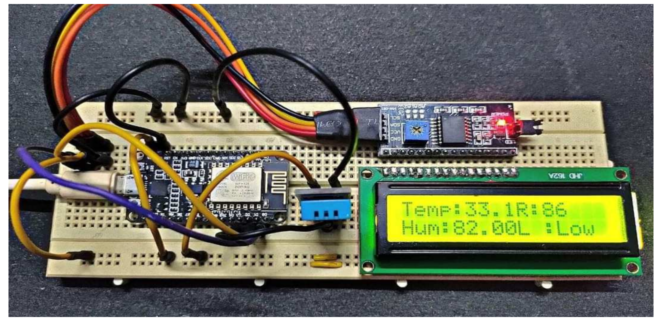

Fig. 17 IoT Based Different Sensors reliable data information

This information may be obtained quickly and simply utilizing the "Thingspeak" website, which is linked to an IoT system via an API id procedure. The motion sensor may also detect motion in a specified area and sound an alert through a buzzer, which can then be used in a security system or to automate the functioning of lighting [1]. We can watch the entire laboratory and industrial environment and observe the machine data screen from afar utilizing a live camera system [8]. We can operate the robot via a wireless system, move it about the industry and laboratory, and set up a proper surveillance system without a human interface. In the Fig.18 data Visualization, Live parameter data, and Matlab data analysis in the "Thingspeak" website is shown:

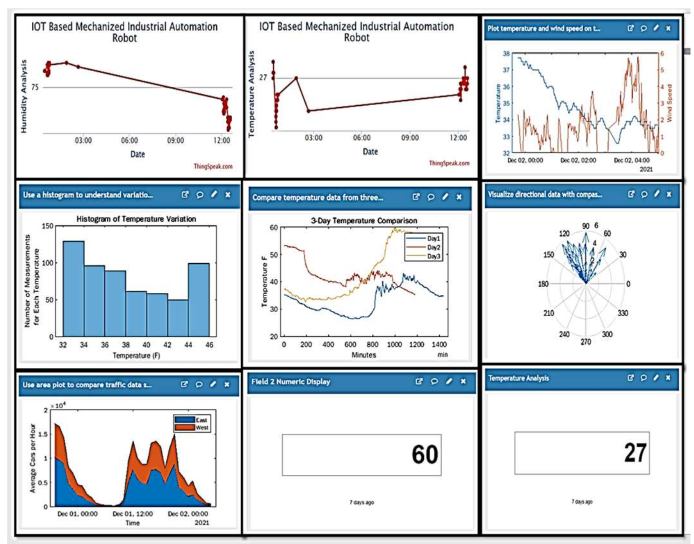

Fig. 18 "Thingspeak" website Data visualization and real-time data analysis.

This robot can analyze here different types of environmental parameters, Histogram analysis of temperature variations, Visualize the directional data with compass chart, Using area plotting to compare the traffic data, Latest 3 days temperature data compare, Plotting of temperature and wind speed of both robot's stable and automation condition and make the visualization of correlation between temperature and humidity of the environment with the help of data aggregation and analytics, algorithm development sensor analytics and Matlab data analysis. We can easily get access to cloud storage live data parameter and data analysis system of this IoT Based Mechanized Robot in the laboratory and industry environment by using Quick Response-QR Code scanning system. Here An

Integrated process involved for full-time multipurpose control, automation and surveillance system.

Fig. 19 QR Code Scanning System for Cloud Storage and Data Analysis System

VI. CONCLUSIONS AND FUTURE WORK

We conceived and executed an architecture for a low-cost and flexible industry, as well as a lab control and monitoring system that can be accessed via any internet browser and an Android-based smartphone. The system can be utilized for military reasons in the monitoring and surveillance system to complete certain tasks. To develop, establish, and manufacture a low-cost Wi-Fi-based Automation System for Smart Laboratory Control, Monitoring, and Surveillance System prototype, this research project implemented an Android smartphone, an ESP8266/NodeMcu, an ESP-32 AI Thinking Web Camera, an Arduino Mega2560, and an ESP-32 AI Thinking Web Camera [10]. It enables you to control all of our industries' and labs' electrical equipment over Wi-Fi, including lights, fans, air conditioners, and other appliances. This sensor may be used to monitor the laboratory's mobility, humidity, and temperature. The buzzer will sound when motion is detected in the house. The Smart Laboratory Automation System robot creates a pleasant, intelligent, safe, and high-quality living environment for its users. Using this clever technology, you may reduce your electric expenses. The next step in our research will be to enable remote control of the constructed system using the Internet of Things (IoT) concept, allowing users to manage it through a web server even when they are not at their lab or workplace. We'll increase the number and types of sensors available, as well as provide the option of fully automated laboratory appliances to improve safety and security. To prevent wiring concerns, we'll put up a gateway to connect all of the sensors to an IoT platform, and we may replace some of the sensors with wireless sensors. Small boxes that are readily connected to current smart industry or laboratory appliance switching boards through relay boards should be the goal of our ultimate solution.

ACKNOWLEDGMENT

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VII. REFERENCES

[1] T. Song, R. Li, B. Mei, J. Yu, X. Xing, and X. Cheng, "A Privacy Preserving Communication Protocol for IoT Applications in Smart Homes," *IEEE Internet of Things Journal*, vol. 4, no. 6, pp. 1844–1852, Dec. 2017, doi: 10.1109/JIOT.2017.2707489.

[2] O. T. Algoiare, "DESIGN AND IMPLEMENTATION OF INTELLIGENT HOME USING GSM NETWORK," 2014.

[3] Aadhityan A, "A Novel Method for Developing Robotics via Artificial Intelligence and Internet of Things," 2014.

[4] C. Balasubramaniyan and D. Manivannan, "IoT enabled Air Quality Monitoring System (AQMS) using Raspberry Pi," *Indian Journal of Science and Technology*, vol. 9, no. 39, 2016, doi: 10.17485/ijst/2016/v9i39/90414.

[5] T. Hegazy and M. Hefeeda, "Industrial Automation as a Cloud Service," *IEEE Transactions on Parallel and Distributed Systems*, vol. 26, no. 10, pp. 2750–2763, Oct. 2015, doi: 10.1109/TPDS.2014.2359894.

[6] J. Gubbi, R. Buyya, S. Marusic, and M. Palaniswami, "Internet of Things (IoT): A Vision, Architectural Elements, and Future Directions." [Online]. Available: www.buyya.com.

[7] W. A. Jabbar, M. Ismail, R. Nordin, and S. Arif, "Power-efficient routing schemes for MANETs: a survey and open issues," *Wireless Networks*, vol. 23, no. 6, pp. 1917–1952, Aug. 2017, doi: 10.1007/s11276-016-1263-6.

[8] *ISCE : the 15th IEEE International Symposium on Consumer Electronics : 14-17 June 2011, Singapore.*

[9] D. Abdulahad Aziz, "Webserver Based Smart Monitoring System Using ESP8266 Node MCU Module," *International Journal of Scientific & Engineering Research*, vol. 9, no. 6, 2018, [Online]. Available: http://www.ijser.org

[10] M. Ashokkumar and D. T. Thirumurugan, "Integrated IOT based design and Android operated Multi-purpose Field Surveillance Robot for Military Use," 2018.

[11] D. Adhav, R. Pagar, R. Sonawane, and S. Tawade, "\376\377\0001\0001\0003\000 \000S\000m\000a\000r\000t\000 \000L\000a\000b\000o\000r\000a\000t\000o\000r\000y," 2019.

[12] K. M. Lee, W. G. Teng, and T. W. Hou, "Point-n-Press: An Intelligent Universal Remote Control System for Home Appliances," *IEEE Transactions on Automation Science and Engineering*, vol. 13, no. 3, pp. 1308–1317, Jul. 2016, doi: 10.1109/TASE.2016.2539381.

[13] G. Anandravisekar, A. A. Clinton, T. M. Raj, L. Naveen, U. G. Students, and M. Mahendran, "IOT Based Surveillance Robot." [Online]. Available: www.ijert.org