An IoT Integrated Cybernetic System for Machine Control Operations on Industry 4.0

Abdullah All Mamun Anik
Department of Industrial and Production Engineering (IPE)
Military Institute of Science and Technology (MIST)
Dhaka, Bangladesh
abdullahalmamunanik28@gmail.com

Shuvodip Adhikary
Department of Industrial and Production Engineering (IPE)
Military Institute of Science and Technology (MIST)
Dhaka, Bangladesh
Shuvodip75@gmail.com

Md. Istiak Habib
Department of Industrial and Production Engineering (IPE)
Military Institute of Science and Technology (MIST)
Dhaka, Bangladesh
istiak.habib2@gmail.com

Dr. Abdul Gafur
Bangladesh Council of Scientific and Industrial Research (BCSIR)
Dhanmondi, Dhaka, Bangladesh
dr.abdul.gafur999@gmail.com

Abstract

The motive behind the research is, implementing several hypothesis of machine & appliance control process by the assist of IoT (Internet of Things) controller, arduino module & analysis real time data. The Internet of Things (IoT) is the next advance worldwide wireless technology, in which simple jobs are automated and manpower is reduced. This study also includes benefits of an industry where multiple devices can be connected by using Artificial Intelligence (AI), Internet of Things & Robotic Automation with the system & monitor the industrial automation control. An Android phone/Laptop can control the system wirelessly wherever we are in world. The study will help to optimize several limitations in cybernetic control system in industries. The incorporation of IoT, robotic systems and automation accelerates industrial operations such as material handling, manufacturing, and safety control. This cybernetic system can monitor and regulate the manufacturing environment, preventing these kind of uncertain safety hazards from occurring. It may gather data from the production area such as temperature, humidity, and gas leakage and monitor it as the desired stage for the production system. The collected data is processed by artificial intelligence and sends the necessary instruction to the main server or system in order to manage the specific equipment or device.

Keywords
IoT (Internet of Things), Automation, Arduino, Artificial Intelligence, Cybernetic Application

1. Introduction

The Internet of Things (IoT) is a network of interconnected devices that have software, sensors, and actuators built in. Data can be sent and received between the devices, and they can communicate with one another via a network connection. In our research, this technology has been used to make appliances more convenient and automatic. refers to the use of information and communication technology to dynamically interconnect industrial machinery and processes. The major participants in this transformation are robots. Sensors and other devices are utilized to connect the physical environment and digitalize traditional industrial processes via virtual networking systems. This increases production efficiency while lowering costs.

The IoT microcontroller devices are linked to the system in order to collect sensor data, control the process wirelessly in the industrial environment, and control the machineries and lab appliances in a short period of time using an internet connection. We can get all of the sensors' data and parameters from the Google cloud storage platform “Blynk” and control all of the appliances and machines. Using an IoT-based Artificial Intelligence-assisted camera, we will be able to view live streaming video of laboratories with specific IP addresses, and we will be able to monitor the laboratories using this device To increase the performance and accuracy of this system's sensors, we utilized the online-based IoT analytics real time data reporting website "Thingspeak". We can collect real-time data from various sensors and analyze it over a period of several days. In this case, we used a DHT11 Temperature and Humidity sensor, Smoke detector sensors and other sensors. The collected data is processed by artificial intelligence, which then sends the necessary instruction to the main server or system in order to manage the specific equipment or device. It is a fresh addition to our country's safety sector in industries. For machining processes, an artificial intelligence-based support system will be used. The artificial intelligence in this system outperforms thousands of hours of manual control of the safety system by humans. It can monitor and regulate the manufacturing area, reducing the likelihood of these types of unclear safety hazards occurring. Mechanical models were created and tested to ensure the device's accuracy. To upload the device's code to the IoT microcontroller, the Arduino IDE (1.8.16) application software was used.(Anandravisekar et al., n.d.)

1.1 Research Objectives

The objective of this research project is to create an efficient, low-cost, and portable system that can effectively monitor machine control operations and regulate electrical appliances through the Internet independent of time or place. The main objectives are:

1. To design, develop, and implement a smart control and monitoring system for electrical appliances in the industry utilizing IoT, Automated image processing and cybernetic application technologies.

2. To develop an algorithm, a web application and an android operating system based application.

3. To monitor every operations of machines and get the data in the cloud storage system.

4. To control the machines operating system from remote area.

5. To analysis long days’ different data and parameters of the machines.

6. To control the IoT cybernetic automation devices with wireless communication system.

7. To make production and controlling efficiency higher with this device without human interface.

8. To ease the usage of technology by allowing users to operate hardware items through the internet**.**

Now a day every company is going for automation. Controlling environment is important for many small and big industry. Main purpose of our product is to serve this small and big company, as our target is to make an affordable and reliable product. The outcomes of this research will reduce many industrial and laboratory control related problem.

2. Literature Review

The Internet of Things (IoT) is a global network that helps to integrate the physical world. Data created by Internet of Things (IoT) sensors implanted in everything and connected to the public communication network is collected, processed, and analyzed. The IOT concept's main strength is its potential impact on daily life and user behavior. The IoT heralds a new Internet revolution. It may link distant and movable objects, machines, or assets via wireless communications and low-cost sensors, computation, and storage. As a result, the Internet has become a network of things. Transportation, smart homes, parking, vehicle tracking systems, and other industrial applications are among the IoT's various applications. These gadgets are used in everything from domestic items to industrial machines. Experts predict the number of linked IoT devices to climb to 22 billion by 2025. The 4.0 Industrial Revolution will begin around 2025. Cloud computing is the part of the model, which consists of commodity services offered in this manner would provide monitoring devices, storage devices, analytics tools, visualization stages, and consumer delivery are all the part of the virtual framework for effective computing. Cloud computing's cost-based methodology will enable corporations to provide final services and users to applications have made from anywhere. These sum up the previous studies that have been applied on military assists, industrial & domestic automation processes. The concept "Industry 4.0," also known as the fourth industrial revolution, refers to "the application in industrial production of current, and frequently networked, digital technologies that enable new and more efficient processes, and in some cases generate new goods and services." The accompanying technologies are numerous, ranging from advances in machine learning and deep learning, which enable progressively autonomous navigation systems, to low-cost sensing devices that support the Internet of Things, to advanced control devices that enable second-generation industrial machine control operations".(Aadhityan A, 2014)

2.1 Industry 4.0

Industry 4.0 is rapidly transforming the way industries make, improve, and distribute their goods. Producers are incorporating modern technology into their manufacturing facilities and processes, such as the Internet of Things (IoT), cloud computing and analytics, and AI and machine learning. Advanced sensors, integrated development environment, and robotics are used in these smart factories to collect and analyze data, allowing for better decision-making.

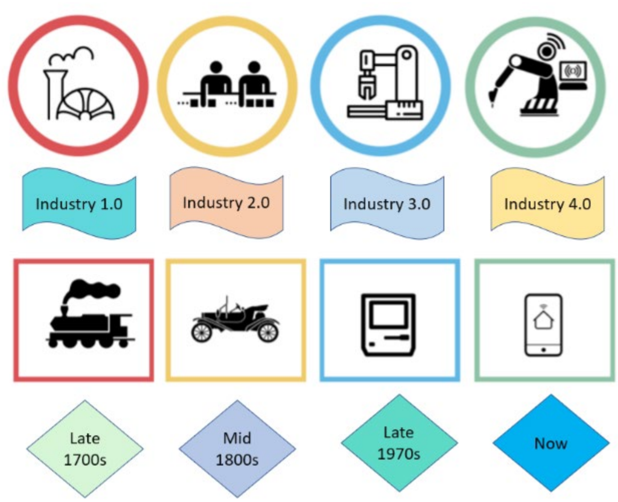

Figure 1: Four Different Industrial Revolution

The proto-industrialization period was followed by the first industrial revolution. It lasted from the end of the 18th to the beginning of the 19th century. The most significant changes occurred in the industries as a result of mechanization. Agriculture began to be replaced as the backbone of the societal economy by industry as a result of mechanization. The second revolution began at the end of the nineteenth century, when major technological improvements in industries aided the development of a new energy source electricity, gas, and oil. The internal combustion engine was born as a result of this revolution, and it began to attain its full potential. The steel demand development, synthesis of chemical, and communication systems such as the telegraph and telephone were also major aspects of the second industrial revolution. Electronics, telecommunications, and of course, computers all emerged during the third revolution. Through new technologies, the third industrial revolution paved the way for space exploration, research works, and biotechnology. The globe is shaped by the four Industrial Revolutions. They are the foundation of the world's economies. Worldwide, programs and projects are being created with the goal of assisting people in taking use of the fourth revolution's marvels in their daily lives. When data from manufacturing operations is coupled with operational data from ERP, customer service, supply chain management and other infrastructure components. Continuous innovation of visibility and insight are created from previously isolated data. Increased automation, predictive maintenance, self-optimization of operational efficiencies, and, most importantly, a new level of productivity and availability to consumers not before feasible are all benefits of digital technologies(Aadhityan A, 2014).

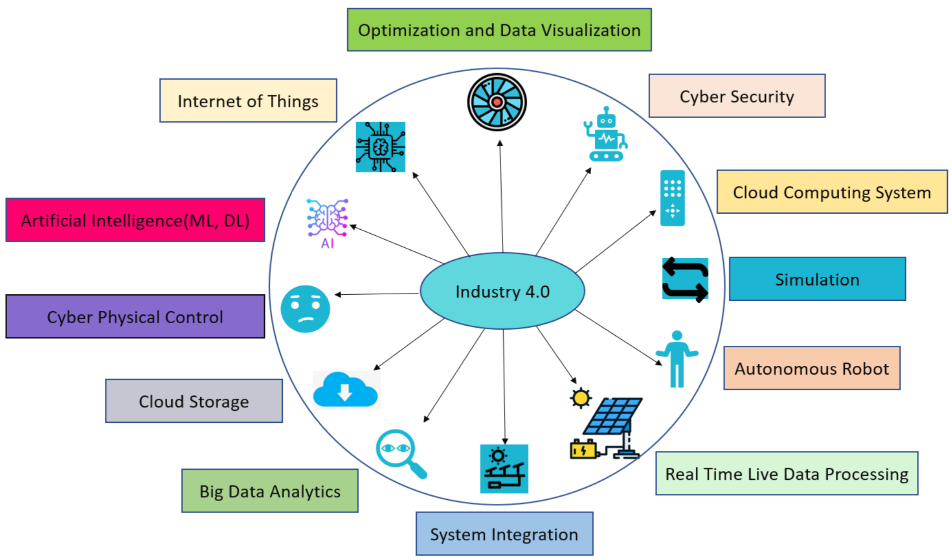

Figure 2: Industry 4.0 related Technologies

2.2 Applications of IoT

Medical sector: The usage of IoT external useable devices or sensors attached to patients enables doctors to monitor a patient's status outside of the hospital and in real time.

Traffic Control System: Our smartphones act as sensors, collecting and sharing data from our automobiles via specialized applications. Waze or Google Maps use the Internet of Things to provide accurate position and traffic information. It also displays us the traffic conditions along the road, the distance to the destination, and the projected arrival time.

Smart Grid and Energy Saving Sector: As upgraded power meters or sensors incorporated in them become more common, sensors installed at crucial places along the way from production plants to distribution stations allow for better monitoring and control of the transmission grid.

2.3 Benefits of IoT

Real-time data: In an IoT-based smart environment, organizations may gather real-time data on operations and items. It can give analyzed data to make appropriate judgments. As a consequence of the decisions made, the quality program may swiftly change and improve efficiency, increasing customer satisfaction.

Data storage: The superiority of storing each data in the cloud storage & follow up whenever necessary, has increased its acceptance.

Boost process control: Think of IoT's control-enhancing potential as new possibilities. New data access to automate management Big data analysis, AI, machine learning and deep learning are a few examples.

2.4 Necessity of Cybernetic control of machines in an industry

The production plants now use a lot of power. The plant's equipment might be kept ON even when not in use. This increases power use and hence electricity expenses. This study's key contribution is the creation of an efficient, low-cost, and portable system for remotely monitoring plant conditions and controlling electrical appliances. We can observe the plant even when there's no one inside with live streaming cameras. Furthermore, machine data can be accessed through the IoT based Google Cloud Platform after a certain period of time.

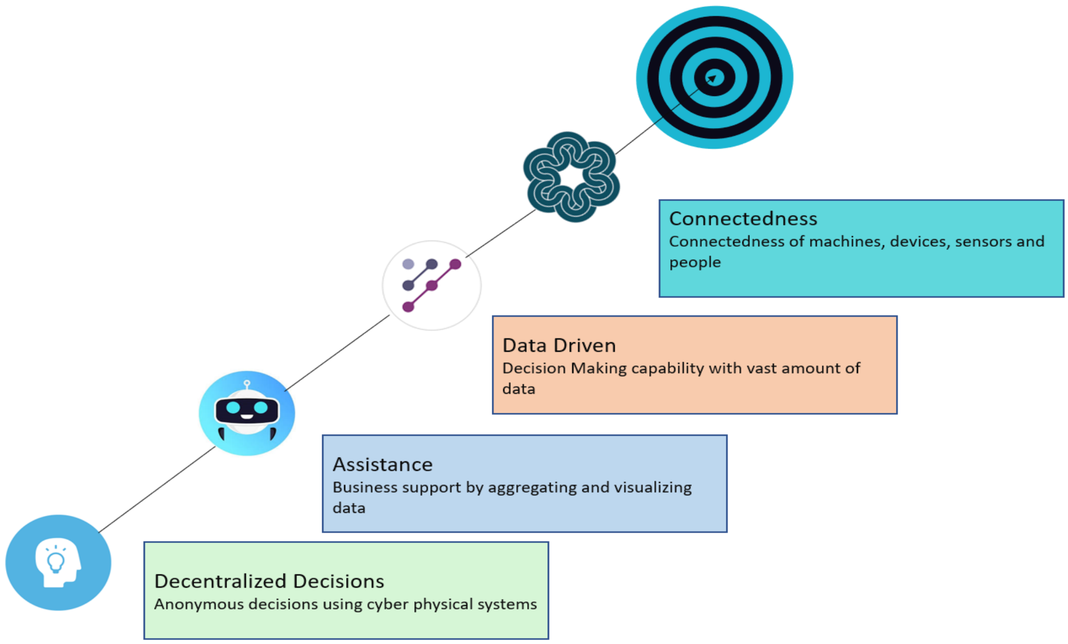

Figure 3: Necessity of Cybernetic control of machines in an industry

3. Methodology

3.1 Concept Framework: The infographic below displays the analytical model and research approach, as well as the processes of the study and the proposed system's development.. It also highlights our approach to building an IoT-based cybernetic control. The mechanism is chosen for its low manufacturing cost, design simplicity, synchronization, accuracy, etc. The system is then created and developed once the electronics and software are integrated. Mechanical, electrical, and software components of the machine must all work cooperatively.(Hegazy & Hefeeda, 2015)

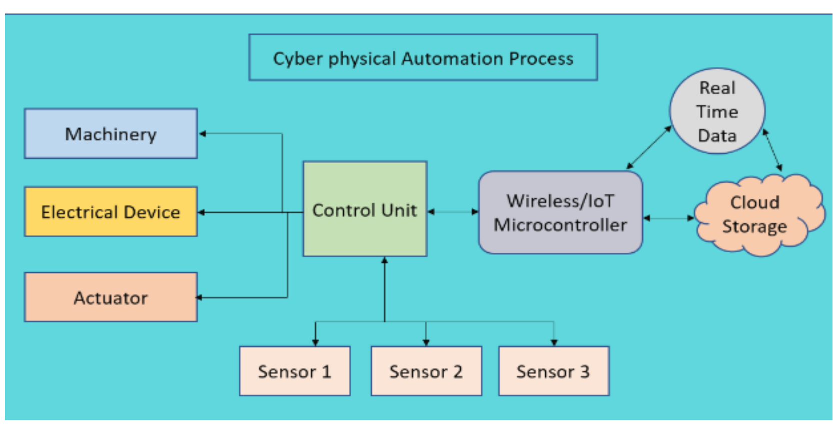

Figure 4: Concept Framework of Cybernetic Implementation

A schematic design prototype is shown in Fig, which is followed by the modelling phase, which uses all necessary equipment and materials to create a smart IoT-based prototype.

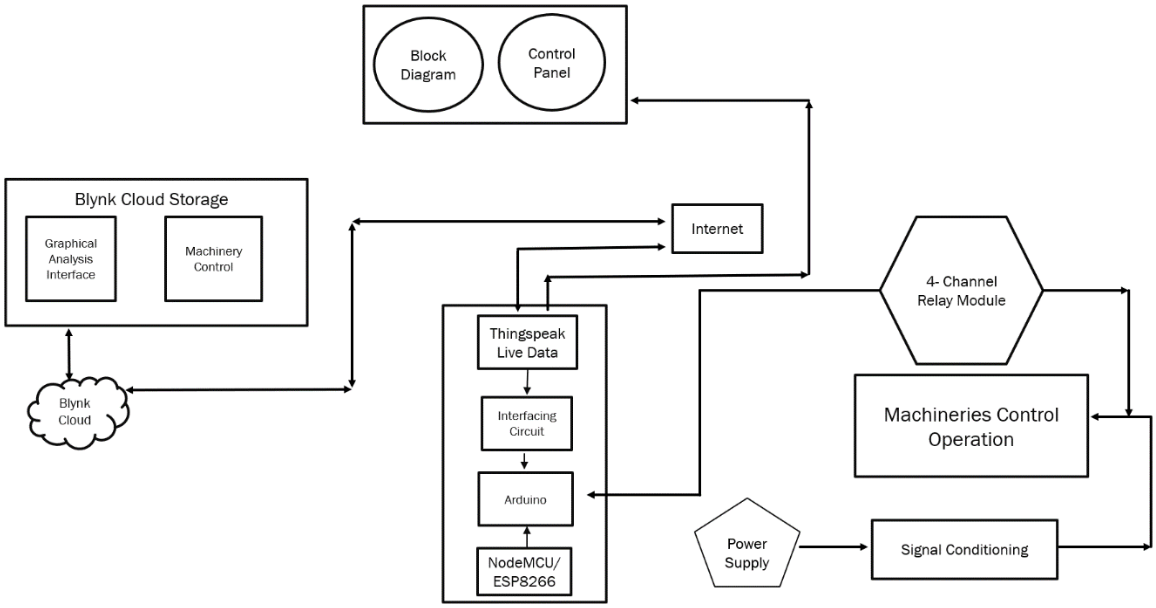

Figure 5: Block Diagram of Cybernetic System for Machine Control Operations on Industry 4.0

3.2 Main Components of Industrial Control and Surveillance System

Arduino: In this project, the Arduino Mega2560 is used as the main controller since it is cheap, cross-platform, has a simple programming environment, is open source, and can be extended. These are connected to the Arduino Mega's pins. The Arduino board can read input and output it, receive and transmit serial data, trigger an interrupt on a low value, and more. We can upload our code in the microcontroller by using Arduino IDE software.(Gubbi et al., n.d.)

Figure 6: Arduino Mega 2560

Figure 7: Arduino IDE Software

<u>IoT Module</u>: The ESP8266 Wi-Fi Module has 8 pins and is connected to the Arduino Mega. This module only works with 3.3V logic levels. For IoT applications, the ESP8266/NodeMcu was chosen for its low cost and robust feature set.(Abdulahad Aziz, 2018)

Figure 8: IoT Module (NodeMcu/ESP8266)

<u>4 channel relay module</u>: The 4-channel relay modules illustrated in Fig. 8 are also used in this project to link two or more sites in response to the input signal. It's connected to the fan and the bulbs that act as output. Relays are used in a wide range of applications due to their relative simplicity, long life, and proven high reliability. Its job is to keep track of, regulate, and control power. 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 samples for regulating plant equipment.

Figure 9: 4- Channel Relay Module

<u>Solid State Relay</u>: A solid state relay (SSR) is a device that allows us to manage high-current AC loads using low-voltage DC driver circuit. Compared to traditional relays, solid state relays provide a number of advantages. One of their advantages is that they'll be switched at considerably lower voltages and currents than traditional relay modules. Solid state relays can also be switched significantly faster and for much longer periods of time without wearing out because there are no moving contacts.With a 3-32V DC input and a zero cross trigger control technique, this SSR can switch current loads of up to 40A. Four screw terminals and a plastic covered screws that fits over the surface of the relay module to insulate the connections are included with each of these relays. By using control voltage: 24-480V AC output, we can control high voltage machineries control operations with the cybernetic application implementation system.(Adhav et al., 2019)

Figure 10: 3-32V DC input and Control Voltage: 24-480V AC output solid state relay

3.3 Cybernetic Machine Control System design with Proteus Software:

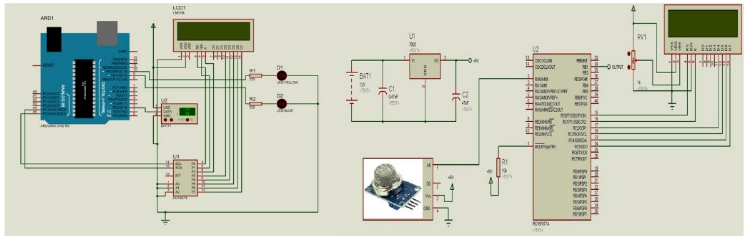

Figure 11: Machine Control Operation system schematic diagram

3.4 Different sensors and Machine control operations diagram with Tinker Cad software

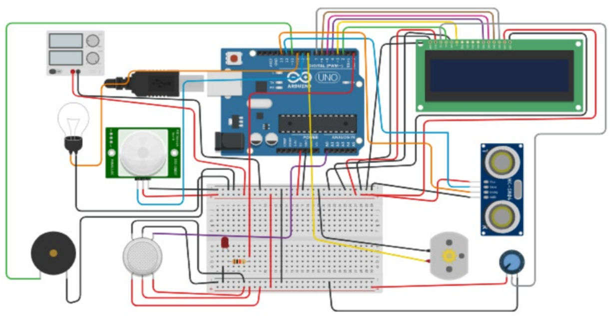

Figure 12: Different sensors connection and machine control schematic diagram

4. Data Collection

By using DHT11 Temperature and Humidity sensor we get data parameter of humidity and temperature of different days. Those different days data collection are given below:

	A	B	C	D	E	F	G	H
1	Creating Date	Entry_Id	Temperature	Humidity	Creating Date	Entry_Id	Temperature	Humidity
2	2021-09-29T05:42:30+00:00	1	30.6	89.00	2021-09-29T07:12:31+00:00	30	30.6	86.00
3	2021-09-29T05:42:46+00:00	2	30.6	87.00	2021-09-29T07:12:46+00:00	31	30.6	86.00
4	2021-09-29T05:43:02+00:00	3	30.6	87.00	2021-09-29T07:13:02+00:00	32	30.6	85.00
5	2021-09-29T05:43:20+00:00	4	30.6	86.00	2021-09-29T07:13:17+00:00	33	30.6	85.00
6	2021-09-29T05:43:37+00:00	5	30.6	87.00	2021-09-29T07:13:33+00:00	34	30.7	86.00
7	2021-09-29T05:43:54+00:00	6	30.6	86.00	2021-09-29T07:13:48+00:00	35	30.7	85.00
8	2021-09-29T05:44:12+00:00	7	31.2	88.00	2021-09-29T07:14:04+00:00	36	30.7	83.00
9	2021-09-29T05:44:32+00:00	8	30.7	86.00	2021-09-29T07:14:19+00:00	37	30.7	84.00
10	2021-09-29T05:45:03+00:00	9	30.6	87.00	2021-09-29T07:14:34+00:00	38	31.7	85.00
11	2021-09-29T05:45:20+00:00	10	30.6	87.00	2021-09-29T07:14:51+00:00	39	30.8	84.00
12	2021-09-29T05:45:39+00:00	11	30.7	87.00	2021-09-29T07:15:06+00:00	40	30.7	84.00
13	2021-09-29T05:45:56+00:00	12	30.6	87.00	2021-09-29T07:15:21+00:00	41	30.9	85.00
14	2021-09-29T05:46:14+00:00	13	30.6	87.00	2021-09-29T07:15:37+00:00	42	30.8	86.00
15	2021-09-29T05:46:44+00:00	14	30.6	87.00	2021-09-29T07:15:53+00:00	43	30.9	86.00
16	2021-09-29T05:47:00+00:00	15	30.6	87.00	2021-09-29T07:16:08+00:00	44	30.9	87.00
17	2021-09-29T05:47:17+00:00	16	30.7	88.00	2021-09-29T07:16:25+00:00	45	31	87.00
18	2021-09-29T05:47:33+00:00	17	30.6	87.00	2021-09-29T08:37:52+00:00	46	30.6	80.00
19	2021-09-29T05:47:50+00:00	18	30.6	87.00	2021-09-29T08:38:10+00:00	47	30.7	80.00
20	2021-09-29T05:48:06+00:00	19	30.6	87.00	2021-09-29T08:38:29+00:00	48	30.8	79.00
21	2021-09-29T05:48:22+00:00	20	30.6	87.00	2021-09-29T08:38:44+00:00	49	32.2	95.00
22	2021-09-29T07:09:53+00:00	21	30.1	89.00	2021-09-29T08:39:09+00:00	50	31.8	94.00
23	2021-09-29T07:10:11+00:00	22	30.1	87.00	2021-09-29T08:39:28+00:00	51	31.4	85.00
24	2021-09-29T07:10:26+00:00	23	30.3	86.00	2021-09-29T08:39:43+00:00	52	31.3	84.00
25	2021-09-29T07:10:41+00:00	24	30.3	86.00	2021-09-29T08:39:58+00:00	53	31.3	83.00
26	2021-09-29T07:11:00+00:00	25	30.3	86.00	2021-09-30T18:24:58+00:00	54	30.6	91.00
27	2021-09-29T07:11:29+00:00	26	30.4	85.00	2021-09-30T18:25:19+00:00	55	30.6	90.00
28	2021-09-29T07:11:45+00:00	27	30.4	86.00	2021-09-30T18:25:36+00:00	56	30.7	90.00
29	2021-09-29T07:12:00+00:00	28	30.4	87.00	2021-09-30T18:25:54+00:00	57	30.7	89.00
30	2021-09-29T07:12:15+00:00	29	30.5	86.00	2021-09-30T18:26:10+00:00	58	30.7	90.00
31	2021-09-29T07:12:31+00:00	30	30.6	86.00	2021-09-30T18:26:26+00:00	59	30.6	90.00

Figure 13: Humidity and Temperature sensors different days datasheet

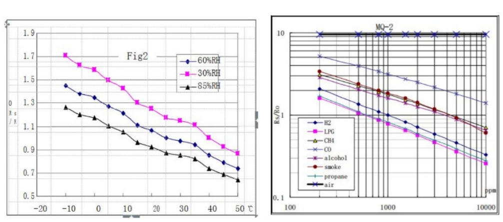

Figure 14: MQ-2 sensors, CO gas data graph and MQ-2 sensors, H2, LPG, CH4, CO, Alcohol, Smoke, Propane gases data collection graph

5. Results and Discussion

Introduction of Industrial Revolution-4.0 in the industrial sector set off a new era for industrial and production management. Addition of IoT, robotic system and automation speed up the industrial operation such as material handling, production and safety control. We have set up the universal IoT Integrated Cybernetic System for Machine Control Operations on Industry 4.0 system for connecting devices with 4-channel relay module and solid-state relay module through internet connected cybernetic system where artificial intelligence based assistance system will be involved for machining operations. Artificial intelligence in this system makes it better than thousand time of manually controlling the safety system by human. It can monitor and control the production area and minimize these type uncertain safety issues from happening. Collected data are analyzed by the artificial intelligence and then send appropriate command to the main server or system to control the specific machine or device. It is a new addition in safety sector in industries of our country. It can collect data like temperature, humidity from the production area and monitor it as the desirable stage for the production system and we can take the control of industrial machines and operations related cybernetic programmable devices by using this system where we can use anydesk and other software for taking the machine on screen control and get the machines data in the IoT based cloud storage. Finally, we can make data visualization and data analysis by using MATLAB and ANOVA software by using cybernetic advanced controlling and processing system. This intelligent internet-based communication with cyber controlling system will play important role in monitoring safety issues in the industrial environment and sustaining the desired environment in the production system. It also shows live monitoring of the industrial area by using advanced camera where entering for human is harmful for their health. In our country to ensure safety and control environment, manual labor is assigned. But there is a high probability of occurring errors in maintenance so our designed cybernetic control system can decrease this probability by thousand times.

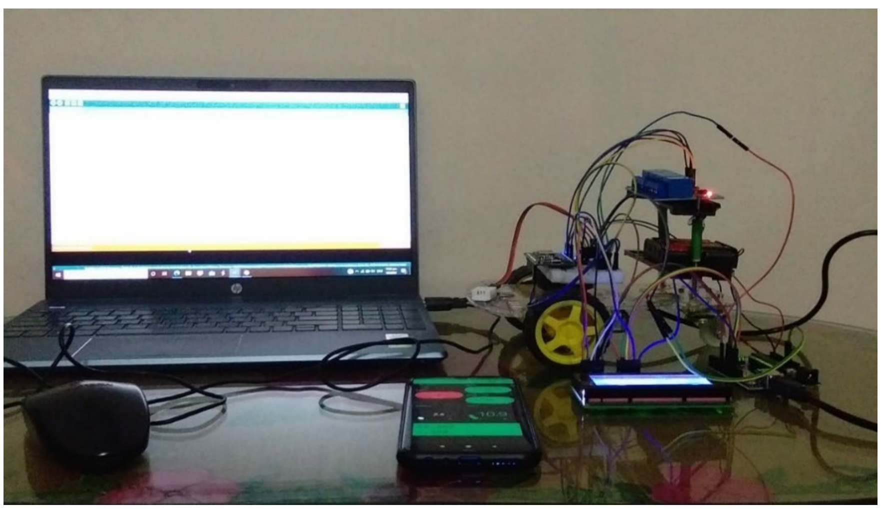

Figure 15: IoT Integrated Cybernetic System for Machine Control Operations

5.1 Graphical Results

Figure 16: Different sensors graphical data

5.2 Proposed Improvements

A robotic arm can be included to implement this work for doing many operations in each workstation in manufacturing plant. A DSS system can help to optimize process delay, machine control operations flexibility, long range communication system and improve productivity. It will ensure cyber security and labors safety.

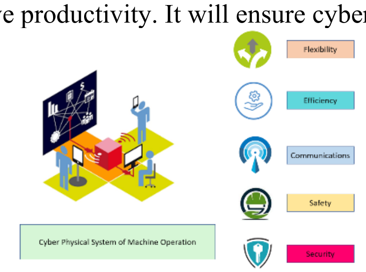

Figure 17: IoT Integrated Proposed Cybernetic Systems Improvement

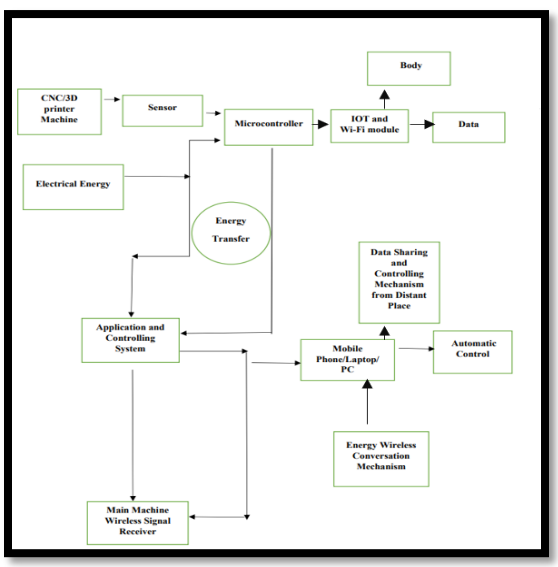

Figure 18: IoT involved cybernetic control block diagram for CNC machine/3D printer

5.3 Validation

We have compared data through the standard data. Data validation of our data seems almost same with the standard data variables. Recent data of different machines will be shared in the cloud storage where we can get the real time data. This system will minimize industry machine control operators long time work schedule. The built-in camera can give visual of production line or security of assigned area. In case of emergency, it can transmit signal to all units so that easily everyone can control that situation. Nowadays, every industry is aiming towards automation. Controlling the environment is critical for many small and large industries. The primary goal of our system is to serve both small and large businesses, since our goal is to provide an affordable and durable cybernetic system for machine control operations on Industry 4.0 s. This cybernetic application will help to solve numerous environmental control issues.

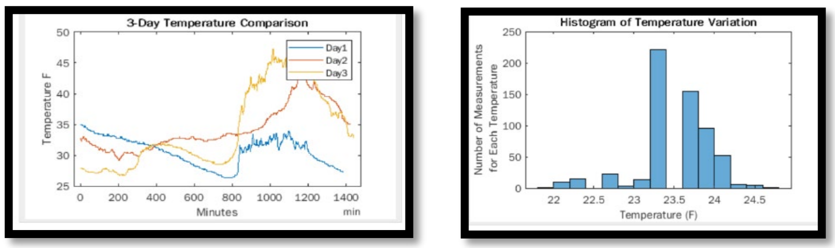

Figure 19: Time to time cloud storage temperature data comparison, analysis and temperature data variation.

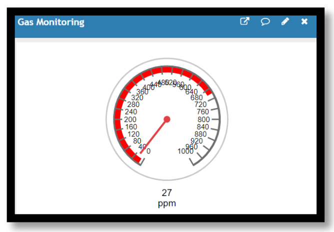

Figure 20: Gas leakage data sharing in the cloud storage

6. Conclusion

The target of the process was to design a system, easy to apply in industries and controlled by android mobile phones and internet based wi-fi platform. In Bangladesh, the majority of the industries manually control the machines and industry environment. This is inefficient and costly, so industries can employ our cybernetic regulating system to meet the demands of the Industrial Revolution 4.0. Integration of this technology will optimize several limitations of Industry 4.0.

Acknowledgements

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Biographies

Abdullah All Mamun Anik is a student of final semester of his B.Sc (Undergraduate) in the discipline of Industrial & Production Engineering (IPE) from Military Institute of Science & Technology(MIST). He has completed his undergraduate thesis on a project based task on 'IoT Based Mechanized Industrial Automation Robot". His research interest includes IoT based industrial automation & Modern Electronic systems, Industrial Automation, Operation Research, Lean Manufacturing, Six Sigma Implementation, Cybernetic control, Robotics & Artificial Intelligence.

Shuvodip Adhikary is a student of final semester of his B.Sc degree in the discipline of Industrial & Production Engineering (IPE) from Military Institute of Science & Technology(MIST).He has completed his undergraduate thesis on a project based task on 'IoT based Mechanized Industrial Robot & its multipurpose control systems.' His research interests include Polymers & Biopolymers, Nano-fluids, Composite materials, Modern Machining Processes, Supply Chain Management.

Md. Istiak Habib is a student of final semester of his B.Sc degree in the discipline of Industrial & Production Engineering (IPE) from Military Institute of Science & Technology (MIST).He has completed his undergraduate thesis on a project based task on 'IoT based Mechanized Industrial Robot & its multipurpose control systems.'

Professor Dr. Md. Abdul Gafur is currently working as Principle Scientific Officer at Pilot plant & process development center in Bangladesh Council of Science & Industrial Research (BCSIR). He received his B.Sc. degree in Material & Metallurgical Engineering (MME) from BUET. Later, he completed his MSc & PhD from BUET. His field of expertise include Nanomaterials, Advanced materials, Polymers, Removal of antibiotics, thin film & nanotechnology. He's been working on several projects of Bangladesh Govt. since years.