Smart factory for future industry development

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ABSTRACT

The paradigm of the smart factory is thought of as an innovative outline for the fourth industrial revolt. The GLOVA G7-DR20U is set as a programmable logic controller (PLC) for monitoring the performance of the smart factory while using the NodeMCU-V3 esp8266 as the internet of things (IoT) board for interaction between managers and the factory using the personal digital assistant (PDA) programming that has been written in the RabitMQ platform. The program logged inner PLC by applying ladder language for monitoring the performance of PLC. With the completion of intelligent PLC, it is likely to extend the existing making capability in the factory with simplicity. This work joins a PLC used as a parent control unit, apps, user programs, and human-machine interface, with the Internet. The proposed model of the smart factory holds two motors one for the parallel drive and the other for the upright drive. While running the system, we observe that the proposal is working correctly, and the reply to the interaction method via IoT is excellent.

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1. INTRODUCTION

The proposal is an extremely digitalized and experimentally associated food and beverage machinery facility that relies on intelligent industrialized. The simplified smart factory model, which is depicted in Figure 1, is thought to be a novel concept for the automation manufacturing revolution. This proposal is very helpful to our smart manufacturing factory automation machinery.

Manufacturing process increases so high and helpful for serving the customer. Long before the term “automation” was used, utopian visions of an automated world were common. Elektro, a robot that could walk, communicate, and count on its fingers [1]–[6], was the centerpiece of Westinghouse’s display at the 1939 World’s Fair. Regrettably, Elektro and his type were little more than examples of human operators controlling objects remotely. By the early 1960s, the computer had supplanted them in the public’s mind as something much more useful, but now, modern since is very improving “automation machinery” all over the world.

The use of outdated equipment and systems causes issues in a variety of areas, including increased manufacturing costs, labor expenses, and time, limited defect detection, increased maintenance, and inaccurate data analysis [7]. Many vintage machinery and devices have complicated problem detection and maintenance processes, which are typically time-consuming tasks, making analysis of them challenging. Another problem that affects many different companies is data analysis [8]. There is no such mechanism that can periodically supply the product information for each machine and device [9], [10]. It might be difficult to extract crucial inputs from parts like turbines, valves, motors, and pumps, and difficult to integrate systems for efficient coordination and communication, which eventually causes activities to be delayed. Issues with fault, error, and failure detection in machines, lead to higher production losses [11].

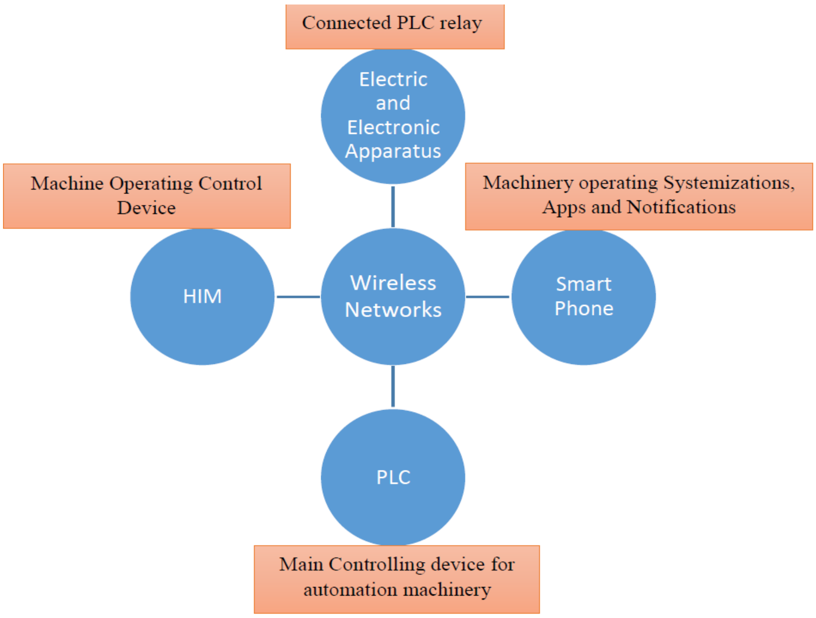

Figure 1. Wireless networks connected automation system

This proposal is very helpful to our smart manufacturing factory automation machinery. Therefore, our project increasingly discusses automation machinery instruments and equipment. Figure 1 graphically shows our proposed automated system. The wireless networks are connected to automation systems. For mortified smart programmable logic controller (PLC) and electric, electronic device namely server motor, motor drive, magnetic conductor, fuse, circuit breaker, electronic relay, timer, and connecting wireless network control device.

Various types of sensors, which can be categorized as chemical, pressure, temperature, position, force, proximity, thermal, presence, flow, optical, automotive, sound, speed, magnetic, electric, heat, analog, and digital sensors, are utilized in a variety of electrical and electronic applications. A sensor is a device that monitors changes in physical, electrical, or other qualities and, typically, outputs an electrical or optical signal as a confirmation of the change in that particular quantity. It can be used in smart sensors, apps, operating control by the human-machine interface (HMI), and smartphones.

2. LITERATURE REVIEW

Programmable controllers are required to transfer data via Web browsers, link to databases using Structured Query Language (SQL), and even access cloud data via MQ Telemetry Transport (MQTT) in the industrial Internet of things (IoT) and Industry 4.0 worlds of today [12]–[14]. The majority of industrial facilities and businesses are implementing Industry 4.0 methods to address these issues. To enable smart processes and efficiency in the overall manufacturing operations, the manufacturing units are integrated with linked devices and networks, sensors, machines (for machine to machine communication), artificial intelligence, and robotics [8], [11]–[17].

3. RESEARCH METHODOLOGY

The smart factory model, which is depicted in Figure 2, is thought to be a novel concept for the automation manufacturing revolution. Perceptibility, communication, and independence are the key characteristics of smart factories and smart homes that use electric equipment. Robotics are now more trusted by the industry. By using the Node MCU-V3 esp8266 as the IoT board for communication between the owner and the factory using smartphone programming, the GLOVA G7-DR20U is utilized as a PLC to control the operation of a smart factory.

The mobile phone's software was created using the RabbitMQ program. The program used within the PLC to control the PLC's operation was developed in ladder language. One motor was used for horizontal movement and the other for vertical movement in the smart factory prototype. The system also includes a wireless signal supply and electric switching sensors. Each motor has sensors and switches attached to control movement.

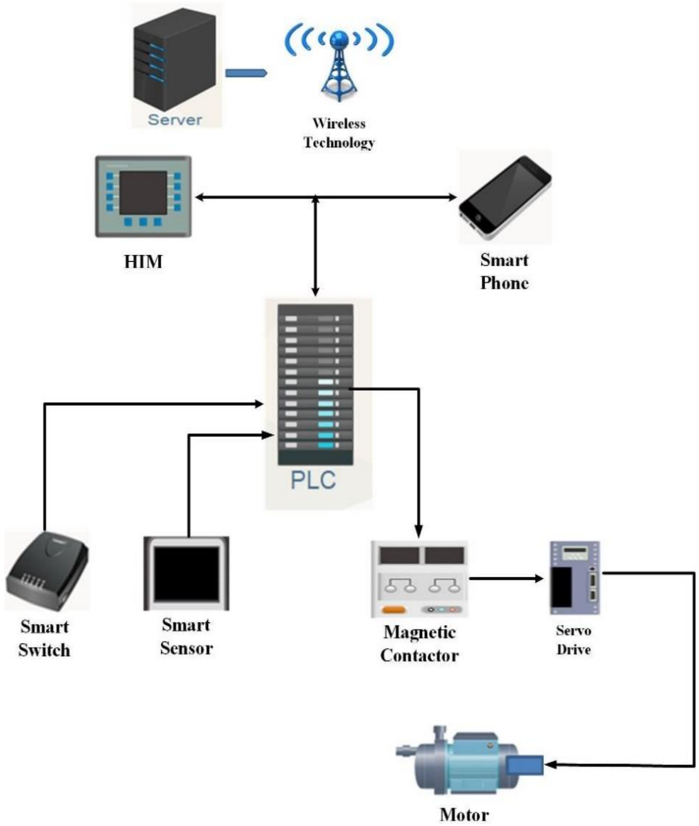

Figure 2. Wireless network signal used for machinery operator and switching system., i.e., model of smart factory

3.1. Human machine interface

A user interface or dashboard that links a human to a machine system or device is known as an HMI. Technically, the term can be used to describe any screen that enables user interaction with a device. HMI is frequently applied to industrial processes. Man-machine interface is another name for this technology, despite the fact that HMI is the more typical abbreviation. HMIs frequently use graphical user interfaces (GUIs) to provide visualization features.

3.2. Internet and manufacturing industry

The phrase "Internet and manufacturing industry" refers to the adoption of information and communication technology by conventional manufacturing businesses to alter their current manner of production. Traditional manufacturers can now add hardware and software to automobiles, home appliances, accessories, and other industrial goods to enable Wi-Fi management of smart devices, automatic data collection and analysis, and other features.

3.3. Smart sensor

Sensors are the standard sensors with embedded microprocessors and wireless connections that have the capability to track, inspect, and maintain a specific system. The primary distinction between smart sensors and regular sensors is that smart sensors offer a larger range of cognitive capabilities. Normal sensors typically have the ability to sense information and convert it into electrical impulses. The sensing element (transistor, capacitor, and photodiode), signal conduction and processing, and sensor interface are the three essential components of a typical sensor.

Smart sensors process data by carrying out predetermined actions and activities after receiving input from the physical world. In essence, it combines a sensor and an interfering circuit. Making decisions involves the use of smart sensors, which also aid in the logical operation and two-way communication. The market for smart sensors is anticipated to grow at a compound annual growth rate (CAGR) of 18% from 2016 to 2023. ESP8266's NodeMCU-V3 firmware is used. In essence, it is a system-on-chip (SoC). An integrated circuit that incorporates all of a computer's or other electronic system's components is called an SoC.

3.4. Full set of programming languages

The full set of programming languages that are used in our design includes ladder logic, function block diagram, structured text, and C block. The PLC required two different kinds of inputs, both of which are direct current (DC) and alternate current (AC). The AC was entering the PLC, and by regulating the PLC's starting switch, the NodeMCU-V3 board was used to link the PLC to the IoT. This means that the NodeMCU-V3 board and the manual start bottom button were the two techniques used to control the PLC work's initialization. The other method used was the IoT.

4. RESULTS AND DISCUSSION

We can add the machinery with a wireless connection to operate than using logic. Users can operate the machine from anywhere using the Internet through smart mobile phones and personal computers (PCs). As well as if there is any fault in the machine, then it will automatically send the notification to the users exactly where it happens. Therefore, those users can easily identify the problem if the machine does not work somehow. Manufacturing is an industry that really benefits from the IoT. Machines in the factory and even shelves in the warehouse can collect data to alert entities about problems and keep track of resources in real-time, improving efficiency and reducing costs. When the system is running, it is evident that it is operating very effectively and responding to the IoT communication system extremely well, as well as receiving and transferring information to the mobile phone without mistakes.

5. CONCLUSION

In conclusion, the use of outdated technology and systems causes issues in a variety of areas, such as increased manufacturing costs, time, and labor, limited defect detection, increased maintenance, and incorrect data analysis. Given that Industry 4.0 combines several of these key components: smart components, smart machines, digital factories, and connected factories, the ease of Industry 4.0 is somewhat of a challenge in present days. This paper focuses on building our smart manufacturing factory automation machinery by incorporating a PLC as the parent control unit, apps, and user program, HMI, with the Internet. When the system is running, it is evident that it is operating very effectively and responding to the IoT communication system extremely well, as well as receiving and transferring information to the mobile phone without mistakes. So, we can conclude that this research is very helpful to our smart manufacturing factory automation machinery.

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REFERENCES

[1] R. A. Nezhmetdinov, P. A. Nikishechkin, and A. N. Nikich, "Approach to the construction of logical control systems for technological equipment for the implementation of Industry 4.0 concept," in *2018 International Russian Automation Conference (RusAutoCon)*, Sep. 2018, pp. 1–4. doi: 10.1109/RUSAUTOCON.2018.8501768.

[2] C. Um, J. Lee, and J. Jeong, "Industrial device monitoring and control system based on oneM2M for edge computing," in *2018 IEEE Symposium Series on Computational Intelligence (SSCI)*, Nov. 2018, pp. 1528–1533. doi: 10.1109/SSCI.2018.8628736.

[3] A. Sapena-Bano *et al.*, "Automatic translation of programmable logic controllers (PLC) control programs in packaging machinery," in *2014 9th International Microsystems, Packaging, Assembly and Circuits Technology Conference (IMPACT)*, Oct. 2014, pp. 445–448. doi: 10.1109/IMPACT.2014.7048380.

[4] A. G. Gajjar, A. I. Patel, and R. G. Singh, "Design and development of bottle washer machine for small scale beverage industry," in *2015 International Conference on Advances in Computer Engineering and Applications*, Mar. 2015, pp. 325–331. doi: 10.1109/ICACEA.2015.7164724.

[5] A. M. Madni, "Smart configurable wireless sensors and actuators for industrial monitoring and control," in *2008 3rd International Symposium on Communications, Control and Signal Processing*, Mar. 2008, pp. 447–448. doi: 10.1109/ISCCSP.2008.4537267.

[6] D. S. Yun, Y.-J. Kwon, S.-J. Lee, and D. H. Kim, "Development of communication interfaces between the base-station and the user device for wireless automotive sensor network system," in *2015 International Conference on Information and Communication Technology Convergence (ICTC)*, Oct. 2015, pp. 1186–1189. doi: 10.1109/ICTC.2015.7354771.

[7] T. Jiang, C. Yang, Y. Yu, B. S. Doumbia, J. Liu, and Y. Ma, "Prediction and Analysis of Surface Quality of Northeast China Ash Wood during Water-Jet Assisted CO2 Laser Cutting," *Journal of Renewable Materials*, vol. 9, no. 1, pp. 119–128, 2021, doi: 10.32604/jrm.2021.011490.

[8] M. Ozdemir and H. Sadikoglu, "A new and emerging technology: Laser-induced surface modification of polymers," *Trends in Food Science & Technology*, vol. 9, no. 4, pp. 159–167, Apr. 1998, doi: 10.1016/S0924-2244(98)00035-1.

[9] J. Wahslen and T. Lindh, "Smartphone-centric Wi-Fi device-to-device sensor communication for user mobility in AAL services," in *2016 IEEE 27th Annual International Symposium on Personal, Indoor, and Mobile Radio Communications (PIMRC)*, Sep. 2016,

pp. 1–6. doi: 10.1109/PIMRC.2016.7794565.
[10] T. Kagawa *et al.*, "A study on latency-guaranteed multi-hop wireless communication system for control of robots and drones," in *2017 20th International Symposium on Wireless Personal Multimedia Communications (WPMC)*, Dec. 2017, pp. 417–421. doi: 10.1109/WPMC.2017.8301849.
[11] A. Rajalakshmi and H. Shahnasser, "Internet of things using Node-Red and Alexa," in *2017 17th International Symposium on Communications and Information Technologies (ISCIT)*, Sep. 2017, pp. 1–4. doi: 10.1109/ISCIT.2017.8261194.
[12] S. Chanthakit and C. Rattanapoka, "MQTT based air quality monitoring system using node MCU and node-RED," in *2018 Seventh ICT International Student Project Conference (ICT-ISPC)*, Jul. 2018, pp. 1–5. doi: 10.1109/ICT-ISPC.2018.8523891.
[13] H. T. A. A. Gharbawee, R. F. Chisab, and O. Bayat, "Design of communication system for smart factory controlled by plc based on IoT technology," *International Journal of Computer Science and Mobile Computing*, vol. 8, no. 3, pp. 294–256, 2019.
[14] R. Li, C. He, Y. Chen, and X. Wang, "Effects of laser parameters on the width of color change area of poplar wood surface during a single irradiation," *European Journal of Wood and Wood Products*, May 2021, doi: 10.1007/s00107-021-01706-1.
[15] P. Frantis and J. Hodicky, "Human machine interface in command and control system," in *2010 IEEE International Conference on Virtual Environments, Human-Computer Interfaces and Measurement Systems*, Sep. 2010, pp. 38–41. doi: 10.1109/VECIMS.2010.5609345.
[16] Z. Braier and P. Kloucek, "System of measurement and evaluation of AC servo motor's mechanic, electric and control quantities," in *2015 IEEE International Workshop of Electronics, Control, Measurement, Signals and their Application to Mechatronics (ECMSM)*, Jun. 2015, pp. 1–5. doi: 10.1109/ECMSM.2015.7208691.
[17] M. Panzner, G. Wiedemann, K. Henneberg, R. Fischer, T. Wittke, and R. Dietsch, "Experimental investigation of the laser ablation process on wood surfaces," *Applied Surface Science*, vol. 127–129, pp. 787–792, May 1998, doi: 10.1016/S0169-4332(97)00743-5.

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