The International Journal of Engineering and Science (IJES)
|| Volume || 10 || Issue || 4 || Series I || Pages || PP 32-36|| 2021 ||
ISSN (e): 2319-1813 ISSN (p): 20-24-1805

Industry 4.0 – Advance To the Mechatronic and Management with Approach of Artificial Intelligence

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---***ABSTRACT***---
This research paper mainly concerns with product development advancing the mechatronics systems and management related to "industry 4.0" approaching artificial intelligence. The worldwide industry is forming into the 4th revolution of the industry, which mainly focuses on the IoT (Internet of Things.) The concept is to provide the highest possible service in the manufacturing area, heading vertically and horizontally effective manufacturing systems. Despite high variation in small lot sizes, the resulting smart factories can meet diverse consumer demands while combining human creativity and automation. These ventures have played by the same-called cyber-physical systems (CPS): physical entities (devices, workpieces) that installed technologies such as RFIDs, sensors, microprocessors, telematics, or integrated embedded systems. Through this paper, smart factory automation based IoT implemented, which would not only increase the productivity of the industries but also ensure the safety of the workers. And because it could manage from any place in the world with internet access using a mobile application, the human resources required to operate an industry will reduce. It will help monitor the manufacturing processes, detecting machine error, and regulating the rate of output according to customer interest.
KEYWORDS*:* *Industrial Automation, IoT, smart manufacturing, system engineering, mechatronic engineering, IIot, cyber-physical system, artificial intelligence, management.*

Date of Submission: 27-03-2021 Date of Acceptance: 10-04-2021

I. INTRODUCTION

Three technological transformations that occurred so far resulted in paradigm shifts in the manufacturing field- mechanization through water-powered and steam enforced, mass production in assembly lines, and IT automation. Nevertheless, in recent years, worldwide business and academics, and policymakers have steadily promoted a forthcoming technological revolution. Highly versatile processes in industries around the world that rapidly modified allow individualized mass production. " Industry 4.0" is the intelligent factory that interconnects smart digital devices and communicates with raw materials, goods, machinery, instruments, robots, and men. Flexibility, significant sage of capital, incorporation of clients and corporate partners into the business process define this industry. The fourth industrial revolution focuses mainly on combining service concepts within the IoT and the Internet sector, rendering intelligent factories with vertically and horizontally integrated manufacturing processes. The technological transition coupled with the Smart Production Movement and the implementation of the CPS presents companies, technology, and workers with many challenges. The product built to monitor mechatronic systems and administer production planning in order to achieve the maximum benefit with minimum power usage to contribute towards digital production. The intelligent machine is convenient and simple to manage. To communicate quickly, possible logical controls and remote controls were created. The variants are self-determined by-products that provide intelligent machines with their data, which are aware of the environment, share information, and control procedures in manufacturing and logistics. The new technology installation or upgrade from the traditional system is too expensive. For smaller industrial units that want to expand output with comfortable costs, the device built is cheaper and more commodity.

Fig. 1: Industry 4.0

II. PROCESS OF RESEARCH AND PRODUCT DEVELOPMENT

This product creation primarily aims at the improvement and advancement of the traditional and smaller to a bigger industrial unit to reduce energy consumption and result in the full output of the product using the intelligent method. Specifically, crafted commands monetize protection and privacy levels through the smartphone. The system's evolved artificial intelligence constantly tracks the system's operation and informs the smartphone whether any technological problems and misconceptions arise. The Arduino-Arduino link via wireless networking is structured correctly throughout the sector. An initial simulation phase has been carried out at the automation studio to create a well-planned and error-free framework that helps and provides the base idea in the development of the mechatronics system that considered management and artificial intelligence with the aid of IIot. The Control I/O is set up to simulate the PLC with the Factory I/O, to create the industrial environment. The programming in WinSPS-S7 was performed to render a logical ladder and communicate with Factory I/O.

The process divided into two parts:
1. The initial process of product development using simulation
2. Physical system development

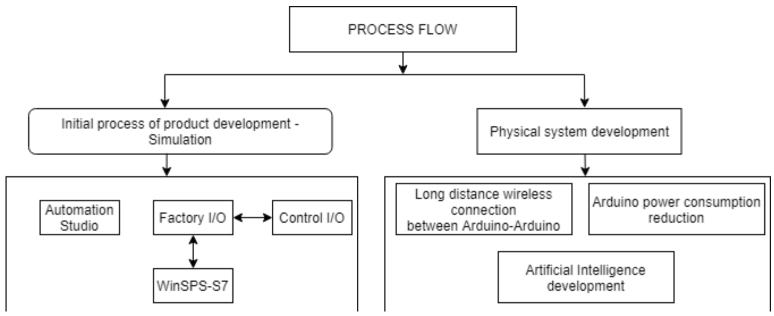

Fig. 2: Process chart

III. INITIAL PROCESS OF PRODUCT DEVELOPMENT USING SIMULATION

The preliminary planning process relates primarily to the manufacturing setting. It helps to have a strong, and appropriate foundation for advancing the traditional method or developing an entirely new system as needed. The initial phase includes PLC simulation, factory setting, and logical programming. After efficient simulation of the plant structure, the right design definition can be accomplished to realize how the sophisticated mechatronics and artificial intelligence system can be properly managed. The method for the simulation process is as follows:

3.1. Automation Studio

In the automation studio, the first programming control constructed to develop proper logic and grasp to the automation system. The automation studio offers circuit modelling automation, which allows to properly set up the Factory I/O simulation.

3.2. Factory I/O

The Factory I/O will incorporate an industrial automation environment with the efficient implementation of studio automation simulation. The Factory I/O offers the Industrial Standard Automation in real-time simulation, and the PLC can be configured and operated through the built-in feature called control I/O. The programming of the ladder logic is then integrated separately into WinSPS-S7, which facilitates real-time simulation. The I/O control practically supports the PLC to construct the necessary automation, while the WinSPS-S7 controls the simulation logic ladder. The pick and place robot replicated to incorporate the advanced mechatronics and artificial intelligence system for the manufacturing process. The framework was then applied and organized according to the simulation and control units. CPS protection is assured with the respect to the traditional protection solution.

Fig. 3: Factory I/O

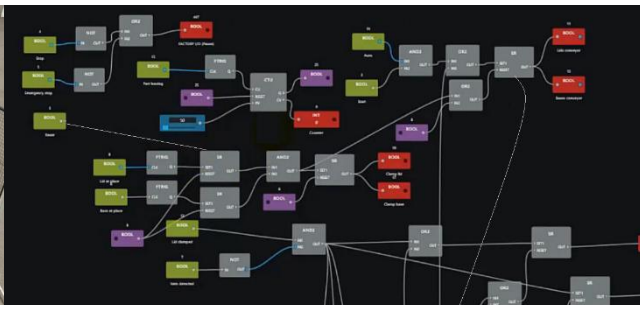

Fig. 4: Control I/O

IV. PHYSICAL SYSTEM DEVELOPMENT

The next step in assisting and improving the physical structure is the correct approach to the simulation process. After obtaining the values & data from the simulation, the structure organization and implementation carry out for the automation system and mechatronics for the individual component development.

The physical device comprised primarily related to,

1. Wireless communication,
2. Power management,
3. Implementation and communication of artificial intelligence through smartphone,
4. Security concern,
5. Production management

4.1. Wireless communication

The entire device was managed and tracked by two wireless connections. The first connection to Arduino was to monitor the movement from the premise, only. Another link made up of the Internet of things which artificial intelligence addressed briefly. The HC-12 module uses for long-range wireless communication to stable the network connectivity between the Arduino. One Arduino module used for the manufacturing system, while another used for the system's remote management. The remote with LCD design particularly for the purpose of updating the error warning and transfer notification with the movement and helping to monitor the device manually so that the autonomous system is trained on the correct course.

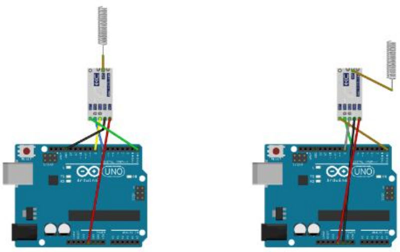

Fig. 5: Circuit schematic of HC-12

4.2. Power management

The power control only involves the unnecessary energy usage of the numerous Arduino modules. Any argument conserve resources here addressed. Arduino will operate with 3.3V rather than 5V, but the clock speed must be regulated by saying 8MHz accordingly. The external wake-up mode, and time to wake mode use to wake up the Arduino when necessary, which can also save power consumption. The turned-off Arduino can be wake through the sensor while it manages the power consumption, for which external sensor or specific high pulse command can be used. The slow-down clock speed has enough potential to lower the power consumption, most Arduino runs at 16 MHz and can reduce to 8MHz. This is some information related to reducing power consumption.

4.3. Implementation and communication of artificial intelligence through smartphone,

The artificial intelligence mainly operated on the DOIT Esp32 DecKit v1, whereas the main brain of the system is Arduino Uno. To establish the connection between the Arduino uno and DOIT Esp32 DecKit v1, the logic level convertor is used.

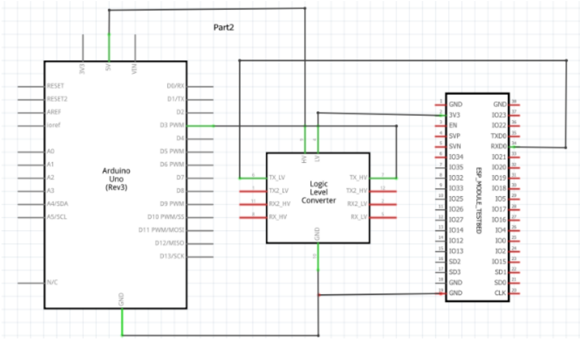

Fig. 6: Circuit schematic of logic level convertor

To develop the artificial intelligence, Naive Bayes is used, which is the Probabilistic machine learning algorithm. The naive formula for the prediction is shown below:

Posterior probability; Likelihood; Label/class prior probabilit; Feature/predictor prior probability

$$P(y|X) = \frac{P(X|y)P(y)}{P(X)}$$

Naive Bayes

$$\hat{y} = \arg\max_{y} P(y) \prod_{i=1}^{n} P(X_i|y)$$

Naive Bayes classifier

To understand the working of the DOIT Esp32 DecKit v1 for artificial intelligence in simple words, refer to the simple schematic diagram shown under which consists of SSD1306 0.96-inch OLED display module to direct the navigation of the system, DS1307 real-time clock, BH1750 light intensity sensor module, and LED. When the DOIT Esp32 DecKit v1 is in operation it shares the data to display as well as to the connected devices with an inbuilt Wi-Fi module. It also notifies the time and date, current light level, and the LED status. The programming can be done in Python and C, but we have to connect the Arduino Uno with the DOIT Esp32 DecKit v1, so the programming performance carries out in the Arduino platform.

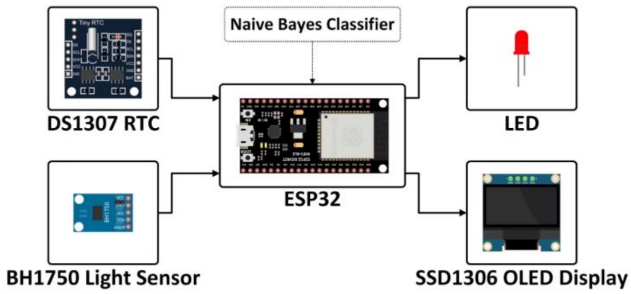

Fig. 7: Circuit schematic ESP 32

The ESP 32 provides broadband Internet connectivity, which allows multiple wireless contact. ESP 32 works with Arduino Uno to monitor the mechanism necessary to improve the system. The interchange rate of data between them was constantly evolving. In order to recognize data flow for the device, the ESP 32 sends point to point to value to the connected machine. The creator just has current values and forecasts. On the other side, the specially designed application holder will access the error message, monitor the production unit and teach the machine direction to replicate the process.

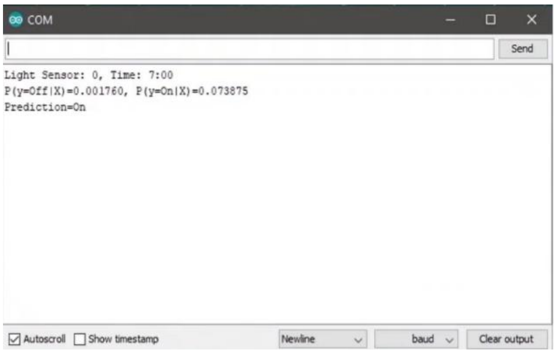

Fig. 8: Developer screen

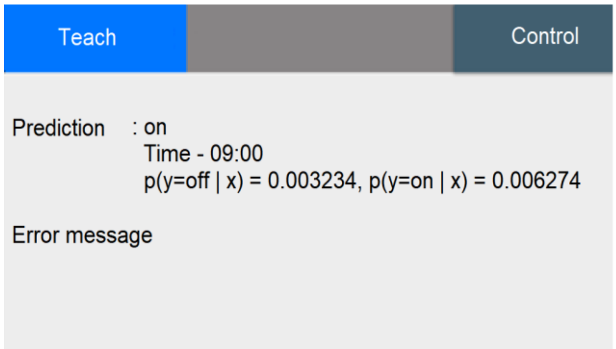

Fig. 9: Specifically developed application

4. 4 Security concerns

The major concern of the whole system development is security and privacy concern. The developed application has a login screen, and only an authorized person can get into the main screen. If someone able to breach the security level, the IP address is captured automatically. All the required data from the machinery events are stored in the local storage.

4. 5 Production management

The continuing exchanging of data and relevant error signals from each component is time-saving. The stored data from the previous computer allows to analyse the data, to solve the past problems and to simplify the operation. The user can monitor the device from anywhere when working on something else with the remote control and smartphone control. With less work and configuration, the batch products can easily manufacture. The maintenance period will significantly reduce due to the data protection and analysis from the previous mistakes and solutions.

V. CONCLUSION

The key focus of the paper was on the fourth industrial revolution, Industry 4.0, which enables smart, productive, competitive, personalized and cost-effective manufacturing. With faster processors, more intelligent devices, smaller sensors, less costly information storage and delivery, machines and goods can interact and learn from each other more intelligently. Industry 4.0 is the latest 21st-century industrial innovation that allows enterprises to produce "smarter" goods and services by cost-reduction and increased productivity, where the human component is essential for the implementation and work is dependent on the current local literature. Industry 4.0 is widely supported by a complete life cycle in both spatially and hierarchical structures, commodity, and collection. Smart goods are not only intelligent throughout the production process, they also have details on their condition during their lives. These details are used for proactive maintenance; they give the manufacturer valuable information on their goods' lives and reliability. The route to further deploy the manufacturing principle of Industry 4.0 remains lengthy. There are very few companies in Industry 4.0, only young ones designed to demonstrate the model. The majority of businesses can be expected to progressively incorporate Industry 4.0 elements and expand on existing equipment and software solutions, thus not disrupting production stability.

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