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An IoT-based Production Monitoring System for Assembly Line in Manufacture

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Abstract: In industry, a contamination in the product requires testing, inspection, diagnosis, repair and then more testing before the plant goes back on the production line. This process can take days and even months, depending on the type and extent of the contamination. Industries also need to ensure that the product can be manufactured in great quantity without any problems. The production time is very important to produce one product to ensure that the target number of products is achieved. The key to overcome this problem is to invent a device that can take care of the time management for this production. Therefore, a monitoring system for a worker in an assembly line is developed to solve this problem by using the IoT system. It adopts Arduino Mega as a microcontroller and IR sensor as a sensory input to detect the parts or products. It is also equipped with Liquid Crystal Display (LCD) to display the timer to guide the worker on the required production working time for one part in the assembly line. Besides that, ESP 8266 is also used to send data to the cloud for data storage and further data analysis. It is found that, with the implementation of this system in an assembly line, the efficiency of the worker is increased approximately around 4.5 percent. Furthermore, with the IoT system, it allows data to be transferred to the smart phone.

Keywords: Manufacturing, IoT, assembly line production monitoring

1. Introduction

In the factory, the lean manufacturing has become one of the chosen quality management practice and school of thought among manufacturers in Malaysia. This philosophy was established by the Japanese Toyota Production System, which then, rapidly welcomed in the worldwide manufacturing industry [4]. In the lean manufacturing principles, it combines few characteristics, namely, the just-in-time practices, the work-in-progress, the waste reduction, the improvement strategies, the defect-free production and the standardization. The primary goal of this practice is to minimize the manufacturing costs [1] and improve profits [4].

The first assembly line in manufacturing was first introduced by Ford Plant in Michigan, United States, which had remarkably changed the technologies in production and market demand. The breakthrough in global communication through the implementation of the IoT and the intelligent sensors in the manufacturing system has changed the world market perspective in the last few decades, which resulting a higher production efficiency, product quality and customer satisfaction. This scenario has sought to seize the opportunities that the fourth industrial revolution (IR 4.0) offers [3][7][9]. Unfortunately, for industry with aging production machines, it is hard to overhaul the whole manufacturing structure, which incur more cost in their whole process. However, they still need to upgrade their system by identifying the loop hole in their machines and processes through the exploitation and benefits offered by the IoT

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implementation to fulfill the demand of the market while reducing the manufacturing costs. There are many ways to minimize the manufacturing costs, and one of them is by reducing the error and time taken made by human for manual recording the finished parts in each process. A study made by [4], reducing the setup time or assembly time in one activity in the operation can affect the whole production process and time. The current state of techniques and technologies allows us to create tools and methods to manage technical systems, which possible to correct and optimize human activity in real-time, which increase the efficiency of production systems and product quality [5].

The monitoring system in the assembly line can be realized to help the process of reducing the manufacturing costs in the factory. It is a process of maintaining surveillance over the existence activity or state of the data flow in an assembly line system, which aims to identify faults and assist in their subsequent elimination. The techniques used in the monitoring of information systems intersect the fields of real-time processing, statistics, and data analysis [12]. It is also used to monitor the movement of employees during their working hours and to prepare materials for further processing operations. Through a careful monitoring system, it allows us to decrease the number of errors occurring when processing the output data, to better use the working hours by raising the quality of employee's personal approach to work duties by an increase in work morale, and to prevent overtime being claimed unjustifiably. Besides, it also can be used to monitor the output in real time and classifies the worker experience based on the produced outcome.

A wearable device, with the integration of IoT and cloud storage has been invented to help worker to stay productive and engaged in a discrete factory [6]. A study of the effect of the wearable device has boosted the employee's productivity by 8.5% and life and job satisfaction by 3.5%. However, the IoT-enabled assembly systems are still explored to increase the efficiency of the exchanging information capability autonomously while triggering actions and controlling each machine independently [8]. A radio frequency identification (RFID)-based intelligent decision support system to handle production monitoring and scheduling in a distributed manufacturing environment [2] and to improve the sequence operation of an automotive inbound logistics process [11] have been developed and tested. The effectiveness of the RFID system in the distributed manufacturing company has clearly demonstrated the significant contribution in 25% increase in overall production efficiency, 12% reduction in production waste and 8% reduction in labor and system costs [2].

Therefore, the main objective of this study is to develop an automated monitoring system to manage the operation time at one activity in the assembly line by comparing the desired working time with the actual and so that the target number of product parts to be produced can be achieved. The system also can be manipulated to record the production output per day automatically. Secondly, an IoT system is established to graphically show and interpret the production efficiency autonomously on the dashboard platform.

1.1 Case Study: The Motivation

Fig. 1 shows the assembly line at the one of the automotive industries in Malaysia, PHN Sdn. Bhd., which is located at Shah Alam, Selangor that uses human as the operator for part welding. Initially, there is no monitoring system used in the assembly line and the industry need to hire the line supervisor to make sure the workers are doing their work properly and no line obstruction during the production time. On top of that, the line supervisor also needs to submit a manual report on the number of produced parts and send it to the management team for record keeping. All data are manually recorded by the worker, which may incur an incorrect data collection due to weak production monitoring system. To avoid this disadvantage, the assembly line needs to be upgraded by using the automation technology along with the integration of IoT system. The system is tested at the car inner rear side body parts welding activity in the assembly line. The worker usually takes longer time to weld this part and the number of produced parts is mismatched with the report. Therefore, a monitoring device is needed to overcome this issue.

Fig. 1 - An assembly line in the automotive parts industry without the advancement of the IoT-based monitoring system.

1. Methodology

1.1 System Overview

The proposed production monitoring system is basically adopted the microcontroller-based development, which integrates the development of a hardware and software in the same platform. It involves the part identification, to check the availability of the parts at the targeted process in the assembly line, timing recording, which to record the time consumed by the worker to finish the process carried on the parts, a buzzer, to acknowledge the worker that they have exceed the allowed time to finish the process, and lastly, the IoT system that integrates the Wi-Fi module, Excel database and Google dashboard to present the actual data obtained from the assembly line graphically.

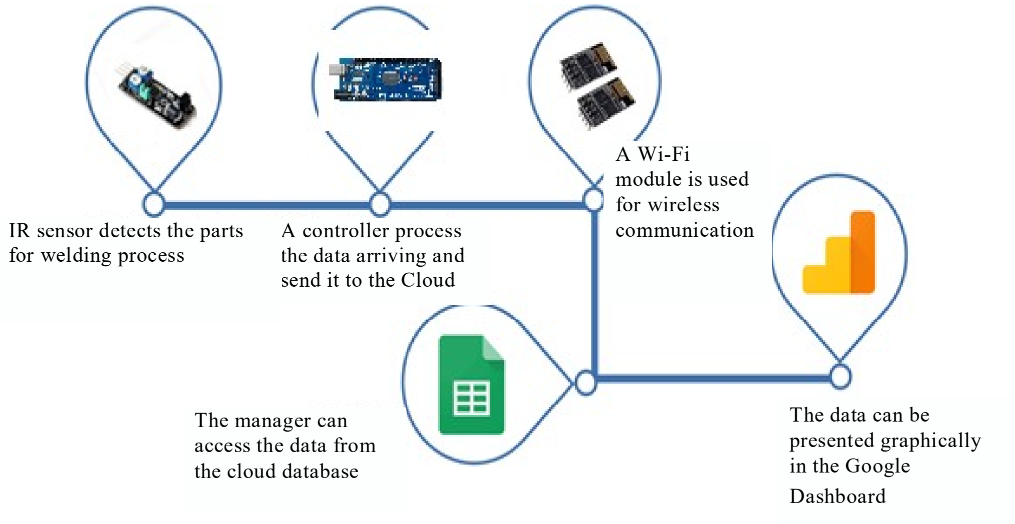

Fig. 2 - Block diagram of the overall production monitoring system

1.2 Development of an IOT-based production monitoring system for an assembly line in manufacture

The IoT-based monitoring system is designed to overcome the issues raised earlier in the previous section. The complete hardware circuit diagram can be viewed in Fig. 3. The system implements an embedded controller, an Arduino Mega, to govern all the invoked signals from the peripherals and process them before delivering instruction to the actuator. At the sensory peripherals, Infrared sensor is used to detect the incoming parts, which will eventually start the timer when it has arrived. According to this industry, to achieve the production target, the worker should spend at most 20 seconds to weld this part. To complement this approach, the timer is turned ON for 20 seconds before an alarm is activated through a frequency-based actuator, a buzzer. The Liquid Crystal Display (LCD) is used to display the running timer value and status of the timer. The user can set the timer value from the input keypad as well. The flowchart of the overall process for the monitoring system is depicted in Fig. 4. The system is worked well with the 5V input regulated from the main supply of 12V.

According to the flow chart, whenever the IR sensor detects the arrival of the parts, the timer will be turned on and it means that there is no delay coming from the previous section in the assembly line. If there is no parts coming to the current workstation from the previous workstation, the timer will be turned on for 20 seconds as well. If it exceeds, it will be restarted and accumulated to get the exact delay time caused by the previous workstation. It shows that, there is a delay process occurs from the previous workstation. The worker from the previous section needs to speed up his process and so that the waiting delay can be minimized by the current workstation. With this mechanism, instead of monitoring the current workstation working efficiency, it also can detects which workstation contributes more delay in the assembly line.

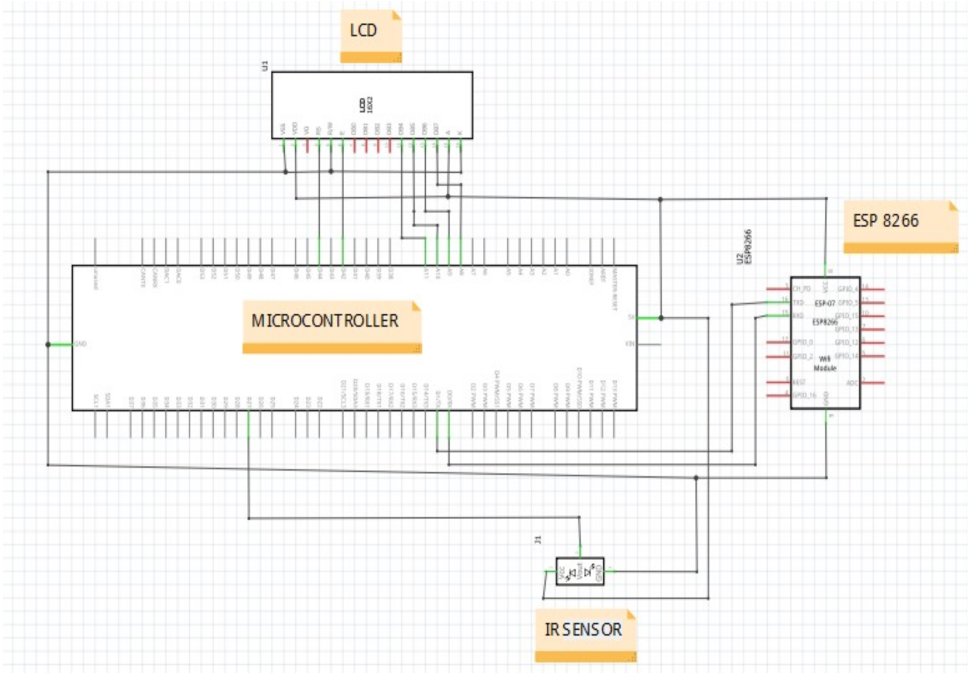

Fig. 3 - The hardware development of the IoT-based monitoring system in the assembly line for car inner rear side body parts welding section

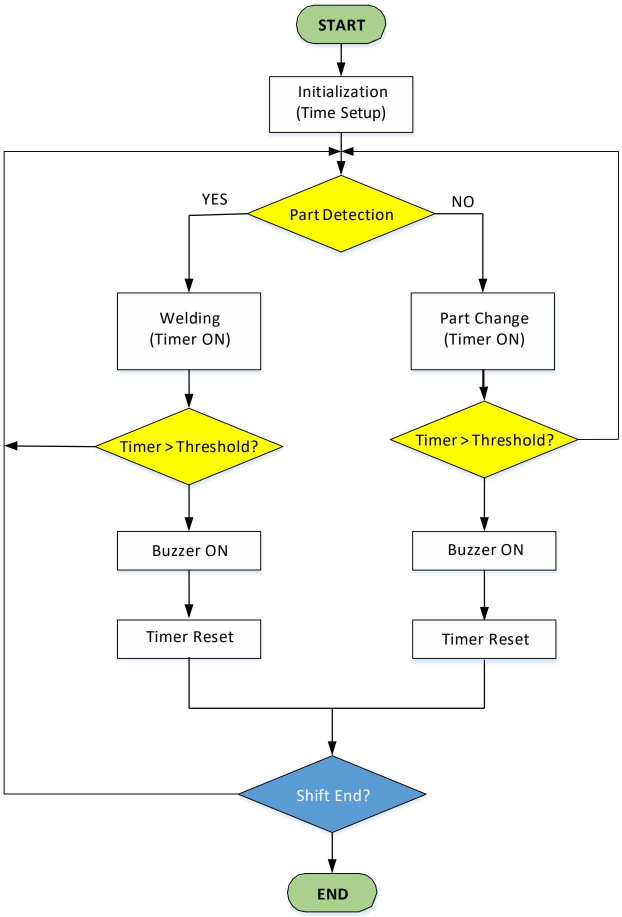

Fig. 4 - Flowchart Production Line Worker Monitoring System

A Wi-Fi module is used as the wireless data transfer between the embedded monitoring system and the cloud database. Every time the IR sensor detects the welding parts, it will update the database by counting the finished product at the workstation in real-time. With this implementation, the manual record previously done by the worker can be ripped off from the system as the data recording is done autonomously. Instead of checking the documents manually by the manager, he can now monitor the production output through the online system, a google dashboard, and the reporting process can be done immediately as shown in Fig. 5. Furthermore, he can observe the whole process and detect any abnormalities event occurs in the whole assembly line. If this happens, the immediate action can be taken to reduce the delay and increase worker integrity and efficiency.

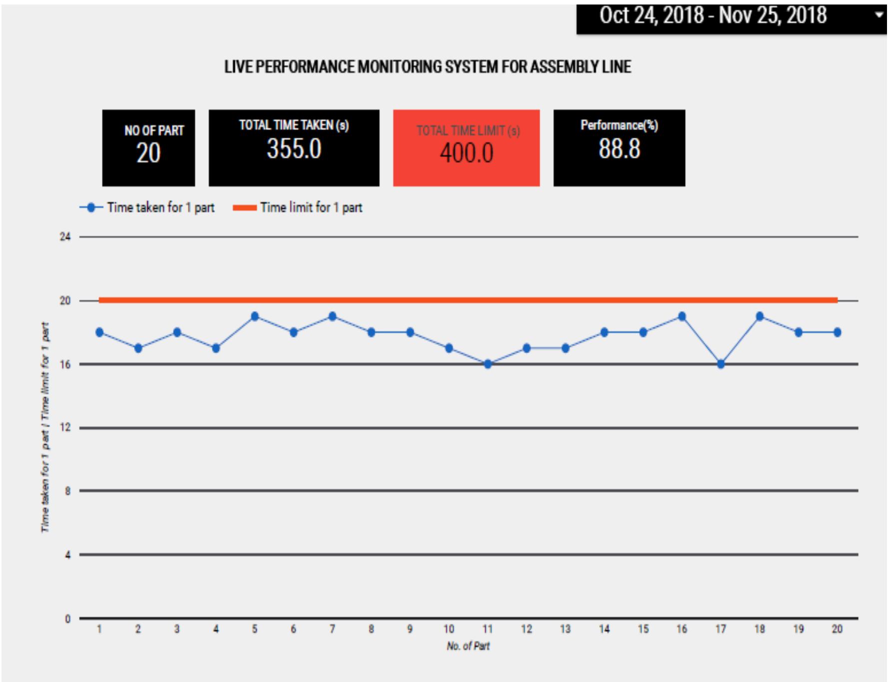

Fig. 5 - GUI of an online dashboard for assembly line monitoring system

2. Result and Discussion

This experiment is done by locating the assembly line monitoring system at the last welding workstation of car inner rear body parts, which is the pilot testing of this implementation. Before the implementation, all data were recorded manually by the worker, which is mostly inaccurate. The result of this experiment is compared between before and after the system implementation.

Fig. 6 shows the data collection done for 20 samples of the welded part at the last station of the car inner rear side body parts welding assembly line before the implementation of the proposed IoT device. Due to their procedure, the last part must be welded within 20 seconds to achieve the target production output. According to this graph, 25 percent of the samples were exceeded 20 seconds, and the total time taken to complete all samples are almost 360.5 seconds with the average of 18.03 second for 1 part. Even though the total time taken is still under the desired time, but, there are 5 parts that cannot be completed in time due to the problem or delay caused by the related workstations. This happened when the supervisor did not alert and monitor the assembly line properly. Furthermore, at some time, the worker weld the part quickly just to make sure it is done without properly check its finished outcome, which contributes to the higher number of the rejected product. At the end of the line, when the last workstation has completed their final welding process, the worker will tick the document manually to update the number of the finished product. Unfortunately, at certain time, they will only update it after few cycles, which makes the manual recording worsen when they unsure the correct count number.

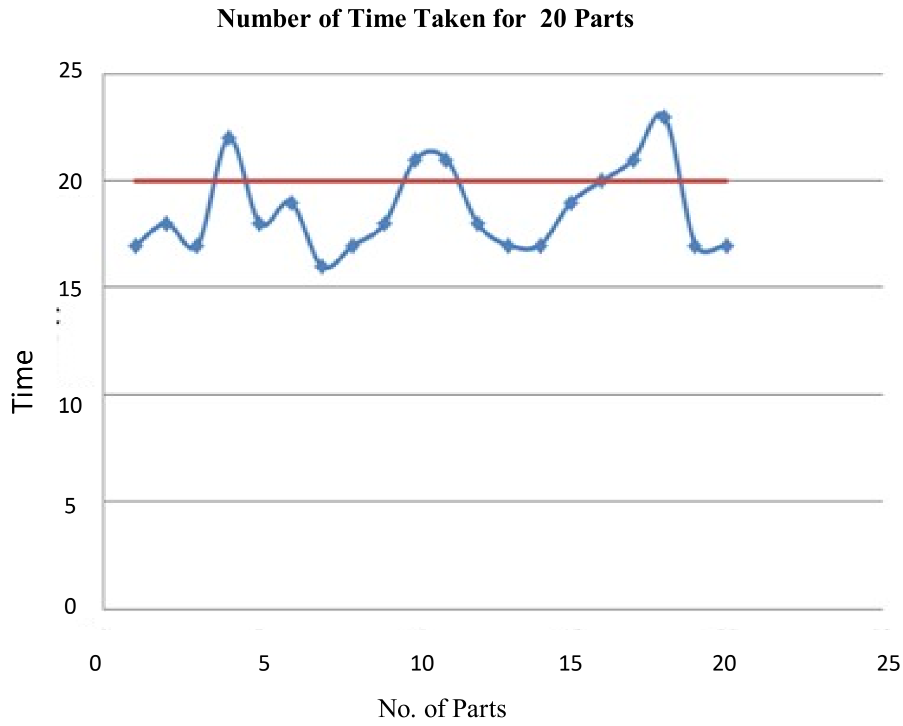

Fig. 6 - Result before implementation the IoT device

When the IoT-based monitoring device is placed at the end of the assembly line, there is some improvement in the completion time. The worker is briefed to always monitor the timer provided and so that they can alert with the time given to complete the welding. Fig. 7 shows the data obtained from the IoT-based monitoring system. The number of the finished product is automatically updated the Google spreadsheet and synchronously displayed to the dashboard through Google Data Studio. According to this graph, it shows that all of the 20 samples are completed within the allowed time. No samples exceeds 20 second, which clearly explains that there is no delay or problem arises in the assembly line. All 20 samples take an average of 17.75 second to be completed, which increases the work efficiency to 100 percent. No more manual recording done, and the supervisor can always monitor the dashboard wirelessly and only take action when an irregular data is displayed. It creates a super-efficient monitoring system to the worker and they can manage their working schedule in completing the product with a proper time management.

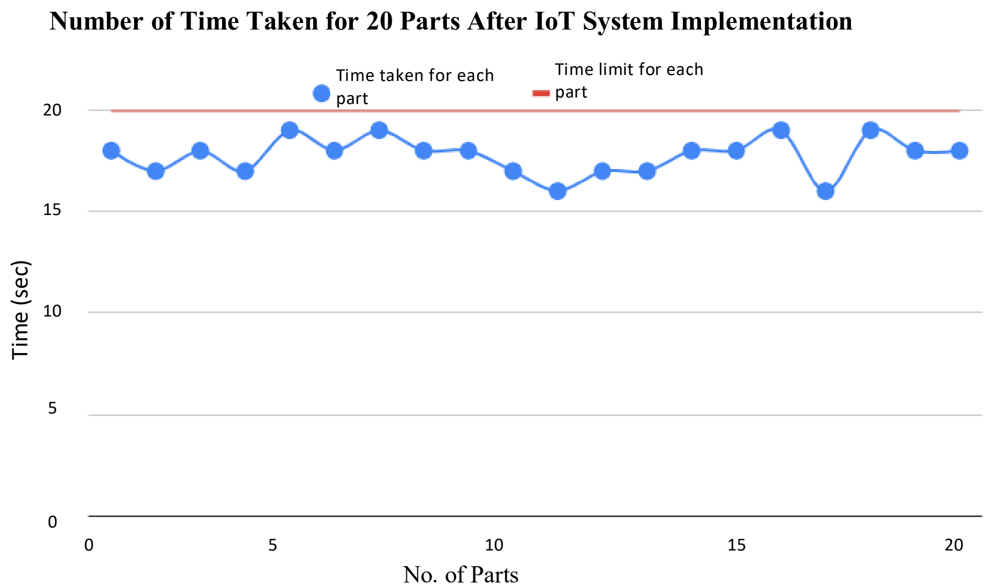

Fig. 7 - Result after implementation the device

3. Conclusion

The IoT-based monitoring device has been successfully implemented at one of the assembly line in PHN Sdn. Bhd. The monitoring system is not just monitor the worker to work within the specific time, but it also can count the finished product and update it in an online system for a transparent monitoring process. After the implementation, the work efficiency is increased 100 percent and accurate data is recorded in real-time. The 'miscalculate' problem done manually by the worker is improved for a better manufacturing practice.

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