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Implementation Of The Internet of Things for $\bar{X}$ and *R* Control Chart in Quality Control

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Abstract

Quality control is one of the important things in an industrial enterprise, but in carrying out the process the enterprise is constrained by the speed, and accuracy produced by the quality control process. A set of basic quality control tools are $\bar{X}$ and R control charts. These basic charting is sometimes face speed and accuracy problem due to the required measurement, data recording, and calculation processes. Considering these problems, an appropriate, fast and accurate quality control system is proposed and prototyped for computing the quality control process with the assistance of the Internet of Things. This system's prototype uses digital calliper, microcontroller-based wireless data recorder, database, and web-based application environment. System test is comprised of accuracy verification, speed comparison for quality control process, and process integration evaluation. System test has shown that this quality control system has the accuracy and speed in calculating the quality control process with an accuracy rate of 100% and a calculation speed of 4.731 seconds, significantly compared to manual system, so that it can overcome existing quality control problems.

Keywords : Internet of Things (IoT), Statistical Process Control, Digital Caliper, $\bar{X}$ and R Control Chart, Web Based System

1. Introduction

Increasing the quality and productivity of a product has become an important element for all companies. All companies compete to produce high quality products(Zhang *et al.*, 2015), but in making this happen sometimes the companies forget to carry out a quality control process, according to Bakhtiar (2013), quality control is activities to ensure whether the policies made at the beginning in terms of quality or standards can be reflected in the final results produced, while according to Nastiti (2015), the notion of quality control is the number and attributes or characteristics as described in the product concerned. From these notions can be interpreted in other words that quality control is an activity carried out in order to maintain and direct the quality of the products produced in accordance with the plan that was determined at the beginning of production.

Changes in the world that are currently entering the industrial era 4.0 or the fourth industrial revolution are driving the rapid development of information technology in every industrial activity (Rohida, 2019). Industry 4.0 is also a promising thing for the development of the production control process, which in technical aspects will apply a concept called the Internet of Things (IoT) and Cyber Physical System (CPS) industry to run the company's production system (Xu *et al.*, 2014). Manufacturing industry and IoT are two inseparable things in the development of industry 4.0 in the current era. With the IoT all things that are in a manufacturing industry can be connected, so the company can receive information about the company's condition in real time (Mahdavi, 2007). This information can contain data regarding the execution of production orders, the effectiveness of machinery and equipment, the circulation of finished and semi-finished materials, and the quality of the products produced (Ćwikła, 2013).

Quality control is one of the important things in a company, there are a lot of methods and ways to control the quality of a product, but for companies that are starting to develop there is one quality tool that is often used in companies and is quite easy to do that is the control chart $\bar{X}$ and R (Hidayatullah, 2018). The control chart is useful for monitoring the average size of the product produced, and can see how much variation in the size of the product produced, the data will be used as material for the analysis of the production process, to produce a stable product quality (Abdullah, 2010).

Companies that are starting to develop basically assume that the process for carrying out quality control requires quite a long time and requires additional experts who understand the quality control process, so the production control process is often missed (Gilchrist, 2016). However, with the current industry advances that have entered Industry 4.0, these constraints are very likely to be overcome. So that with the development of Industry 4.0, a quality control system can be carried out quickly, precisely, and accurately (Fereirra, 2018).

2. Design of the information flow system

The design of the information flow system describes the quality control system information flow that will be created, starting from the process of taking data to display data that will be presented on the web. This information flow starts from the measurement process which will be data in the form of digital measurement data which will later be sent to the microcontroller for processing. The following is a picture of the Design Of The Information Flow System, can be seen in Figure 1.

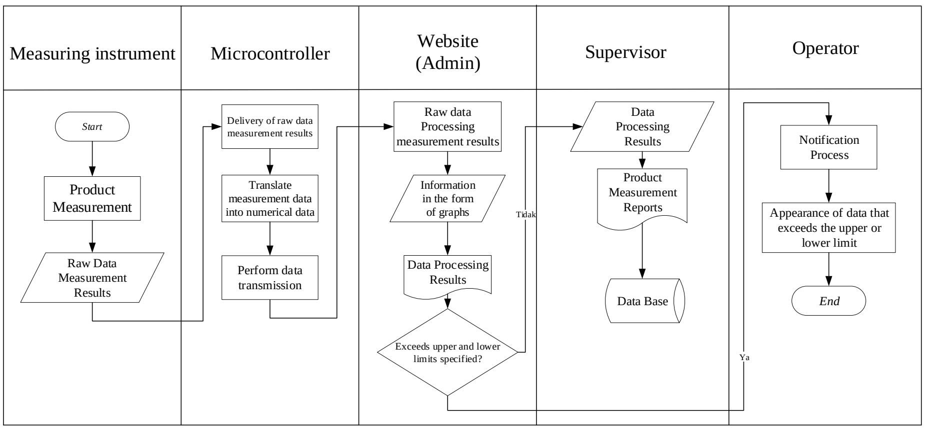


Fig. 1: Design Of The Information Flow System

2.1 Architecture Diagrams

This architectural system design is a picture of the entire quality control system that will be created starting from data retrieval to data appearance and storage in the database. The following is a picture of the architecture duagrams, can be seen in Figure 2.

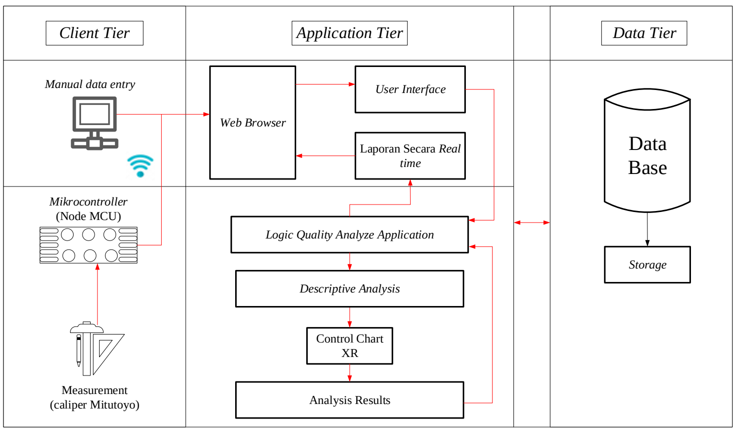


Fig. 2: Architecture Diagrams

2.2 Context Diagram

This context diagram draws all the inputs that enter the quality control system to be made, as well as all the outputs that are issued by the quality control system. Inputs that enter the system are the measurement data carried out by the operator and the management of the system by the admin who is the maker and manager of the web. As for the output released by the system, the information display will be used by the user to analyze the problems that occur in the production process. The following is a picture of the context diagram, can be seen in Figure 3.

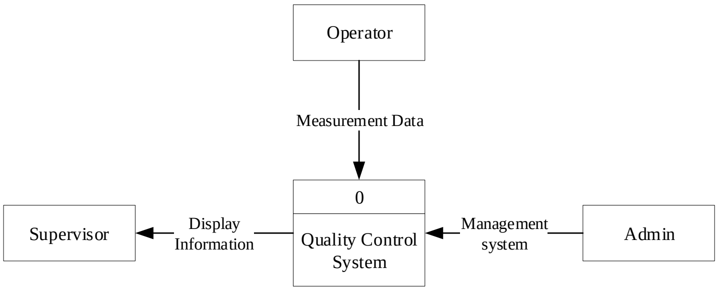
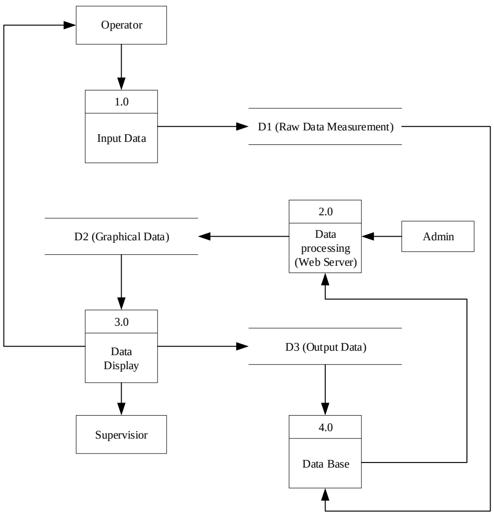
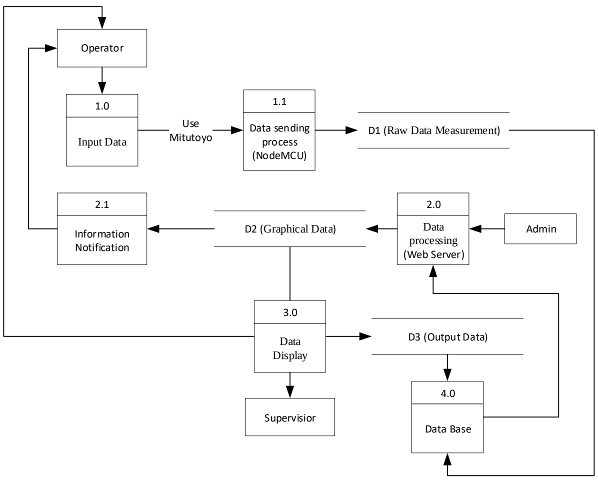


Fig. 3: Context Diagram

2.3 Data Flow Diagram Level 0 and level 1

Data Flow Diagram (DFD) level 0 is a more detailed development of the context diagram that has been made, which consists of operators, admins, and users. In level 0 DFD, the process that occurs between the system and the users of the system will be described again. Data Flow Diagram (DFD) level 1 is developed in more detail from DFD level 0, in DFD level 1 it will explain in more detail the data flow of each user starting from sending data to be displayed. The following is a picture of DFD level 0 and DFD level 1, can be seen in Figure 4a and 4b.





Level 0 **(b) Level 1**

Fig. 4: Data Flow Diagram

3. **Flowcharts of the data delivery**

The design of this delivery system aims to explain how the system that is done by NodeMCU in sending dimensional data from digital signals sent by Mitutoyo until it can be received by the web server and entered into the database. The process of sending data is assisted with a push button that is useful for giving orders to send measurement results produced by the caliper mitutoyo. The following is a picture of the data delivery scheme, can be seen in Figure 5.

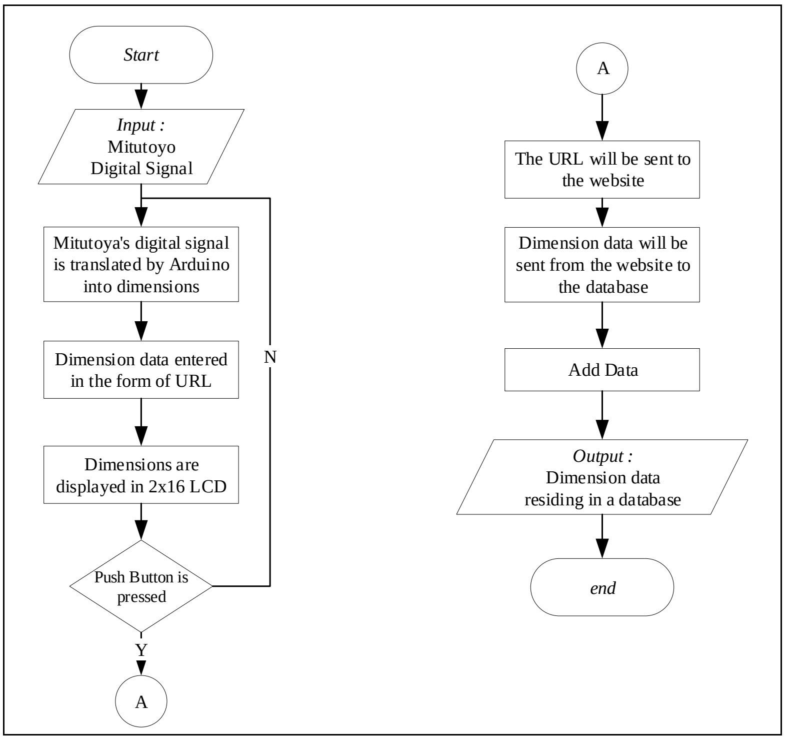


Fig. 5: Data Delivery scheme

4. **Flowcharts of the data processing**

This data reception design explains the next process after the measurement data has been received by the website and entered into the database. The measurement data will be processed into $\bar{X}$ control chart data processing and R control chart. The following is a picture of the data processing scheme, can be seen in Figure 6.

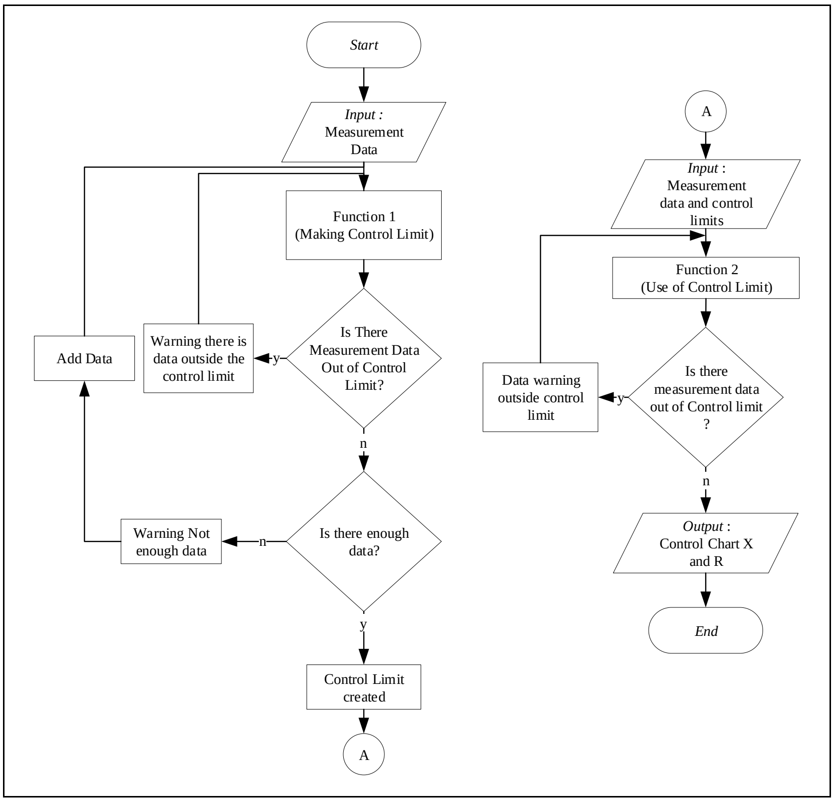
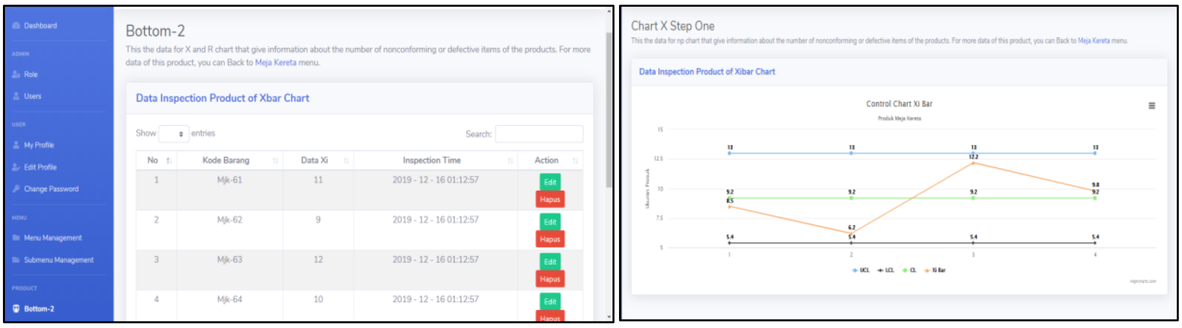


Fig. 6: Data Processing scheme

5. Program display design

This data appearance design will explain the data display from measurement data that has been received. The measurement data that has been received will be processed into a quality control tool in the form of $\overline{X}$ and R control charts. The purpose of this data display system design is to make it easier for users to get information about $\overline{X}$ and R control charts. The following is a picture of the program display design, can be seen in Figure 7.



(a) Measurement Data **(b) Control Chart $\overline{X}$ and R**

Fig. 7: Page Display

6. System testing

This system test is divided into several tests: accuracy testing and speed testing, the following is the result of that test. The following is a table of the comparison of measurement result and table of the comparison of counting speed, can be seen in Table 1 and 2.

Table 1: Comparison of Measurement Results

No	System Measurement Results (mm)	Digital Measurement (mm)	No	System Measurement Results (mm)	Digital Measurement (mm)
1	56.51	56.51	11	56.51	56.51
2	56.42	56.42	12	56.53	56.53
3	56.55	56.55	13	56.43	56.43
4	56.55	56.55	14	56.53	56.53
5	56.53	56.53	15	56.53	56.53
6	56.52	56.52	16	56.41	56.41
7	56.51	56.51	17	56.52	56.52
8	56.51	56.51	18	56.56	56.56
9	56,52	56.52	19	56.53	56.53
10	56,52	56.52	20	56.53	56.53

Table 2: Comparison of Counting Speed

No	Manual Counting Speed (seconds)	System Counting Speed (seconds)
1	181.32	4.38
2	179.67	5.23
3	185.45	3.66
4	175.44	4.67
5	180.65	5.11
6	177.68	5
7	189.01	5.06
8	175.01	4.34
9	177.33	5.43
10	178.45	4.43
Average	240.001	4.731

Based on the results of system testing that has been done, it is found that the accuracy of product size readings contained in the measuring instrument is the same as that displayed on the web page, this can show that the level of accuracy of sending data from the measuring tool to the web page is very accurate, so with a high level of accuracy this can help in the quality control process that will be applied.

However, in the time of sending data from measuring devices to web pages takes about 4.731 seconds before measurement data can be received by the web page. This causes the company to regulate the speed of its production so that there is no excess product buildup when conducting quality control processes.

7. Conclusion

The system that has been made has a fairly fast speed $\overline{X}$ and R control charts. This is evidenced from the results of the comparison of the speed of calculating the system with manual calculations, where the proposed system's speed in on the average of 4.7 seconds while the manual process produces an average time of 240 seconds.

The system that has been made has high accuracy in reading measurement results, this can be proven from the results of comparison of measurement systems that have been done, where the results of reading the measurement system with digital measurements have the same results while the results of manual measurements have some differences with the measurements using digital tool. So that the system that has been created can produce an appropriate, fast and accurate quality control system in carrying out the quality control process by using the $\overline{X}$ and R control charts.

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