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Machine Health in a Click: A Website for Real-Time Machine Condition Monitoring

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Abstract

Globalization in the current digital era has made it easier to use information technology to obtain fast and accurate information. One source of information is a website that can be used to monitor machine conditions in the industry. A good machine maintenance strategy is needed to maintain and increase machine productivity. Therefore, in this research we present the novelty approach to build a website to monitor machine conditions in real-time, by integrating it with sensors. The machine condition is monitored using sushi sensors to track parameters such as temperature, acceleration, and velocity. Deep learning analysis is then used to identify anomalies in the machine. Using the Scrum method, this website was built. From the results of tests carried out using unit testing and integrated testing, every methods and the test cases has passed the test. It indicates that website can work well.

A. Introduction

In this era of digitalization, advances in technology are growing rapidly. All humans around the world are inseparable from the need of technology. The need for information exchange is one of the reasons humans need technology. Information technology is a general term referring to any technology that helps humans generate, transform, store, communicate, and disseminate information [1].

Software can help the exchange of information that takes place in the digital age. Software itself is a computer program that has instructions that if executed can provide features, functions, and performance as desired [2]. In software development, a software engineering approach is required. Software engineering is a systematic approach to producing software that takes into account the costs, schedules, and needs of users and manufacturers [3]. In software engineering, some methods can be used to approach the production of software, one of which is Scrum which will be used as a method in the development of this website. Many studies discussed Scrum as a method for developing software. Utami et al. in the study that developed the Yes TBcare!, Android-based education of tuberculosis application, using the Scrum method for developing it. Testing was done using the black box method and User Experience Questionnaire (UEQ). The outcomes were as follows: 1) The black box method was used to do testing and the result shown to be 100% valid; 2) The UEQ test produced good ratings for attractiveness, clarity, efficiency, and novelty; on the other hand, great ratings were obtained for accuracy and stimulation scales [4]. Nugroho et al. constructed a web-based Sports Center Information System (SIGORA) using the Scrum method. As a result, automatic scheduling and transferable payment options feature in this website are really helpful for the employees and the clients [5]. Another study done by Nugraha et al. designed and built a company profile information system for PT. Hasna Satya Negara using Scrum method. The study yielded Hasna Group may develop a web-based business profile information system by the Scrum strategy [6].

Maintenance of machine reliability in the industry is necessary to increase asset availability. The monitoring of health machines in industry is usually difficult to identify because the process is complex and dynamic. Inadequate maintenance techniques can reduce overall production capacity by between 5% and 20% [7]. One strategy for maintaining machine reliability is to detect anomalies that occur in the machine itself. The classic definition of anomaly was given by Douglas Hawkins [8]: "An anomaly is an observation so deviated from other observations that it raises suspicions that it is produced by a different mechanism". However, the biggest problem faced by the manufacturing industry is the process in the industry that can only identify 20% of anomalies from data [9].

Some studies have already discussed the method to identify anomalies in industry or manufacturing such as Wang et al. [10] extracted the relevance between the log events using a natural language processing technique. The technique claims a 30x decrease in computational time and trains supervised models (Random Forests, Naive Bayes, and Neural Networks) to detect anomalies. Another study proposed a novel monotone split and conquer (MSC) technique. It is proposed by Dang et al. [11] to discover abnormalities in both short and long forms. There is an online detection phase and an offline training step in the MSC model. The technique creates a normal data profile by taking the data and

extracting sub-trends, then applying the multi-scale PCA algorithm to the data. Zekry et al.'s approach [12] suggests an Internet of Things (IoT) sensor-assisted convolutional long short-term memory (LSTM) model for connected cars to detect anomalies. Another study done by Graß, A, et al. [13], proposes a new generic anomaly detection model for production lines, to detect anomalies in real oven reflow using sensor data peered over seven years.

Website is one of the software that we use most often in this internet era. The simplest form of the web is a set of interlinked hypertext files, which present information using text and graphics and can be integrated with the database of a company or business website [2]. Websites can help make it easier for users to process data and information, one of which is as a machine monitoring website for a company, one of which is PT. Yokogawa. This website was built with a feature that can display data from machines based on a sensor called the sushi sensor. The sushi sensor itself will read data from the machine, such as velocity, acceleration and temperature, which will later be visualized, processed and entered into the website. This website will also display the condition of the machine and any anomalies that occur. With this machine monitoring website, companies can check conditions in real time, handle machines quickly or without delay, and carry out proper maintenance according to the detailed data obtained.

B. Research Method

There are 3 stages in this study, i.e. requirement gathering, software development, and the last stage testing the system.

1. Requirement Gathering

   Requirement gathering was done by interview and observation. Stakeholders were interviewed to know what their needs of the system were. From this interview, the functional requirements of the system are defined, such as the system may create the user account; add, update, and delete the machine; monitor the machine in real-time; and give alert notification if there are anomalies in the machines. Observations were done to know how anomalies can be identified. Using a sushi sensor, the vibration and temperature of machines will be measured as an indicator of machine condition.

2. Software Development

   The software development method used to develop this system is the Scrum method. According to Pham, et al Scrum was developed by Jeff Sutherland in 1993 and the goal is to be a development and management methodology that follows the principles of the Agile methodology [14]. Scrum is one of the frameworks of the Agile method that focuses on developing products that are quite complex and can change according to the needs of customers. During the project, customers or potential users of the product are also involved in providing feedback and corrections. Therefore, agile Scrum processes are iterative. This means that in the middle of the process, it can be tested first and rearrange the focus of the project [2]. In this development, one of the agile software development methodologies was implemented, namely Scrum for the development of website machine condition monitoring. The stages in the Scrum methodology are as follows:

a. Product Backlog: At this stage, a record of features needed in the project that has a priority level is made.

b. Sprint Planning: Setting time constraints and ways of working on the most important tasks in the product backlog, which is organized into, Sprint Backlog (how the team can complete tasks quickly)
c. Sprints: Units of work required to meet needs that have been previously set in the backlog process corresponding to the time set in the time box (usually 30 days). While this process is running or in progress, the list from the backlog is attempted to have no additions.
d. Daily Scrum: 15-minute meetings per day to evaluate what has been done, discuss what obstacles have been passed, and the target of solving the problem then determine the work for the next meeting material.
e. Sprint review: Review the system that has been built.
f. Retrospective Process: Processing from beginning to end to be able to remember and redo it in the next project.

3. Testing

Unit testing and integration testing were done to make sure the system ran well. Unit testing was done by white-box testing and using *the* JEST framework, while integration testing was done using black-box testing.

C. Result and Discussion

1. Overview Analysis

A machine monitoring website is a website that is useful for monitoring anomalies of a machine. Anomalies often occur in a machine and anomalies that often occur are the sound produced by the engine tends to be rougher, the temperature in the engine increases, and the rotation is not straight. Before the existence of this monitoring website, checking would usually be done manually which was arguably less efficient. Therefore, this website can be designed and made according to its function, which is to monitor anomalies on a machine based on the data generated from the machine i.e. temperature, acceleration, and velocity. Users of this website can see statistical data in the form of graphs that will display the condition of the machine in units of days, weeks, months, and years. Website users who have access can also manage machine data manually through the website. Users who have different tasks and access to the software to be built. The roles are divided into several, namely:

a. Super Administrator: The section that deals with sensors and data residing in the database.
b. Administrator: The authorized party or authority in the company to manage machine data
c. User: Employee who is associated with the machine and who will monitor the machine through the website

2. Product Backlog

This stage defines the main features of the website. They encompass :

a. Management of machine data

Machine data comprises of ID, name, type, and location of the machine. Each machine has sensors to monitor its velocity, temperature, and acceleration. Machine data and its sensors can be added, updated, and deleted only by the

admin.

b. Monitoring the condition of machines

Users can monitor the condition of the machine, whether normal or abnormal, in units of days, weeks, months, and years. Its velocity, temperature, and acceleration measured by sensors are shown with the explanation of the machine's condition. The graph is provided to visualize the condition of the machine and help the user easily understand the information.

c. Notify users if anomalies occur and give predictive maintenance.

If the machine is abnormal, the system gives a notification to the user. It also gives predictive maintenance of the machines that inform the estimation of damaged machines, the prediction of indicators of damaged machines, and the estimation of the health of machines.

Based on these main features, the pages of the website are determined along with its priority level in the product backlog as shown in Table 1.

Table 1. Product Backlog

No	Item	Priority Level
1	Log In page	Medium
2	Dashboard page	Medium
3	Machine Type page	High
4	Monitoring page	High
5	User setting page	Medium

3. Sprint Planning

With a maximum duration of 4 weeks, the sprint is split into three. Every sprint has a sprint backlog that breaks down the product backlog into more specific tasks as shown in Table 2, Table 3, and Table 4. In sprint 1, Scrum teams design and code the interface of pages and also create a database for saving needed data. While Scrum teams implement all of the pages by coding in sprint 2, in sprint 3 they test it using unit and integration testing.

Table 2. Sprint Backlog of Sprint 1

No	Sprint	Task
1	Log In page	design interface of page, create database, coding front-end
2	Dashboard page	
3	Machine Type page	
4	Monitoring page	
5	User setting page	

Table 3. Sprint Backlog of Sprint 2

No	Sprint	Task
1	Log In page	Implementation by coding
2	Dashboard page	
3	Machine Type page	
4	Monitoring page	
5	User setting page	

Table 4. Sprint Backlog of Sprint 3

No	Sprint	Task
1	Log In page	
2	Dashboard page	Testing: unit testing
3	Machine Type page	and integration
4	Monitoring page	testing
5	User setting page	

4. Daily Scrum

Every day while completing the website, a regular meeting will be held to assess the work performed, the challenges encountered, and the goals that need to be met at the following regular meeting.

5. Sprint Review

In this step, the Scrum team shows to the product owner the results of the daily Scrum (sprint execution) phases in sprints 1, 2, and 3 to ensure that the application is already in line with the product backlog.

6. Retrospective Process

Sprint retrospectives allow the Scrum team to assess each other's performance during the project's implementation process.

7. Results

a. Use Case Diagram

Use Case Diagrams are created to identify how actors play a role in the website and illustrate what each actor can do in the system. As shown in Figure 1, there are 2 actors, first as admin or operators and second as employee.

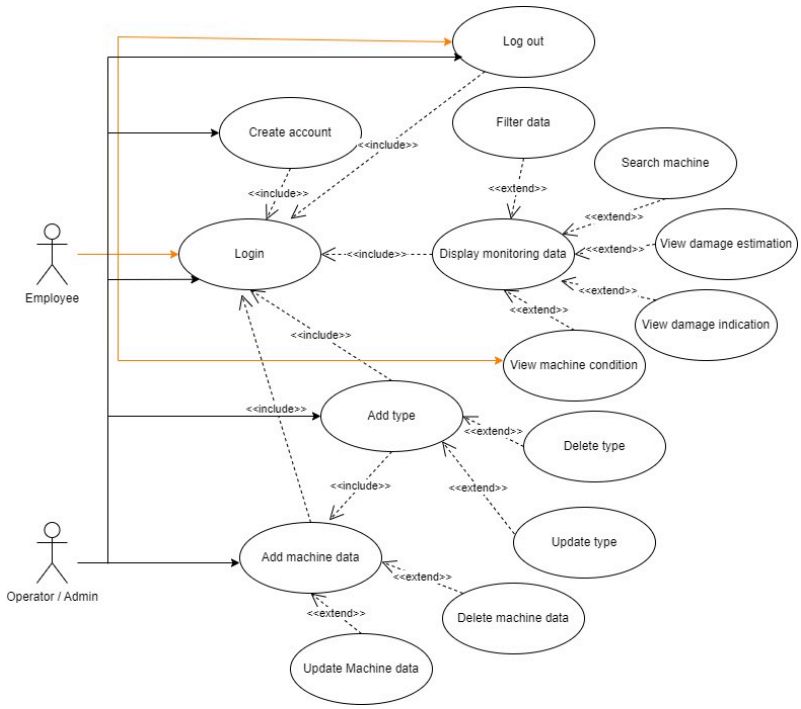

Figure 1. Use Case Diagram

Operators and employees can log in, but log in can occur if they have registered which can only be accessed by operators. After successfully logging in, operators and employees can log out. The actors can also monitor the machine but are required to log in first. After accessing monitoring, actors can perform filtering, search for machines, and see the estimation time of the machine will be damaged, machine health, and an indication of machine damage. Actors also get alert notifications if there are anomalies. Operators have additional access to be able to add machine types and additionally to be able to delete and update machine types, operators can also manage new machine data but are required to add machine types.

b. Activity Diagram

Activity Diagram is a diagram of activities carried out on the system. As shown in Figure 2, it describes the activities of widespread use of the system after identifying the actors involved.

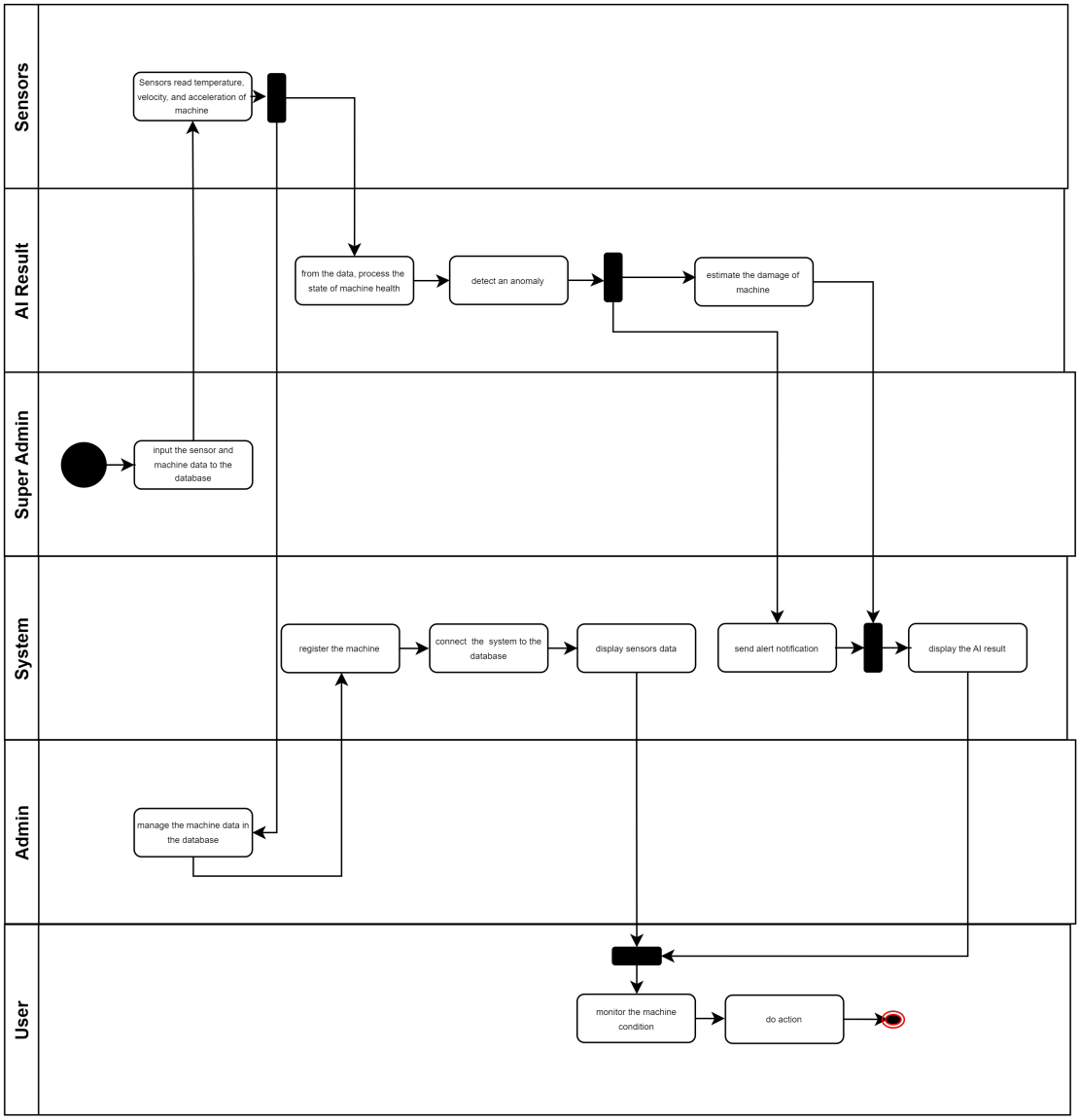

Figure 2. Activity Diagram

The acceleration, temperature, and velocity of machines captured by sensors are saved, managed, and used for advanced analysis to detect the anomaly that occurred. If there is an anomaly then the system will give the alert notification. The data is also used for estimating the failure of machines. Real-time sensor data are also visualized to help users monitor the health of the machines and interpret them easily.

c. Class Diagram

Class Diagrams are intended to provide an overview of the system structure. This diagram contains a set of classes and the relationships between these classes. In this design, the Class Diagram plays a role in distributing the data model to be developed. Apart from that, a Class Diagram will be created to visually illustrate the data needed by the system. This design is important because it can be a reference when building a system [15]. As illustrated in Figure 3, there are 7 classes defined in the class diagram. Admin class and Employee class are subclasses of the User class. They are used to manage user accounts. Machine Data class is used to manage machine data, while Type class is used to manage the type of machines. As mentioned before, every machine is monitored by using the sensor. Its sensor captured the acceleration, temperature, and velocity of the machine. This data is used to predict the decay of the machine that is saved in the AIResult class.

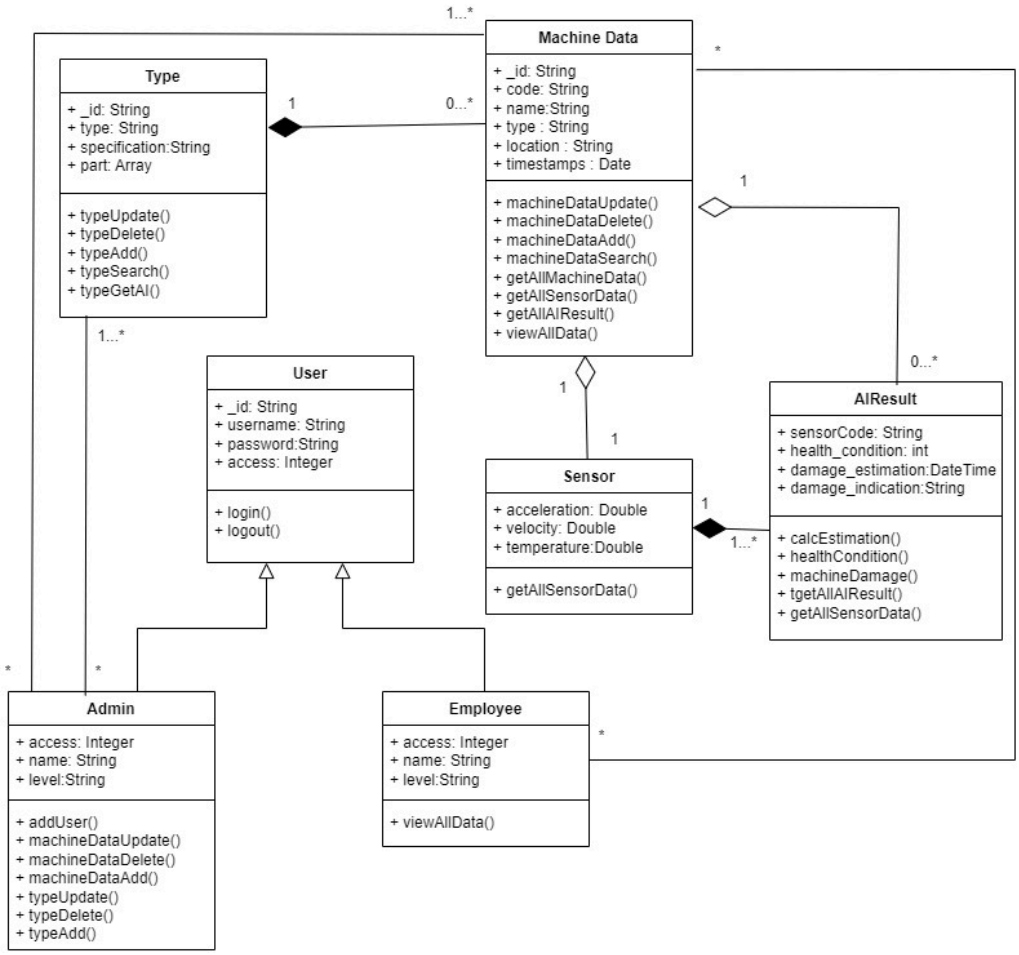

Figure 3. Class Diagram

d. Dashboard page

The dashboard page module, shown in Figure 4, has information about the summary of data on the system, such as the number of machine types, the number of registered machines, registered users, and anomalous machines.

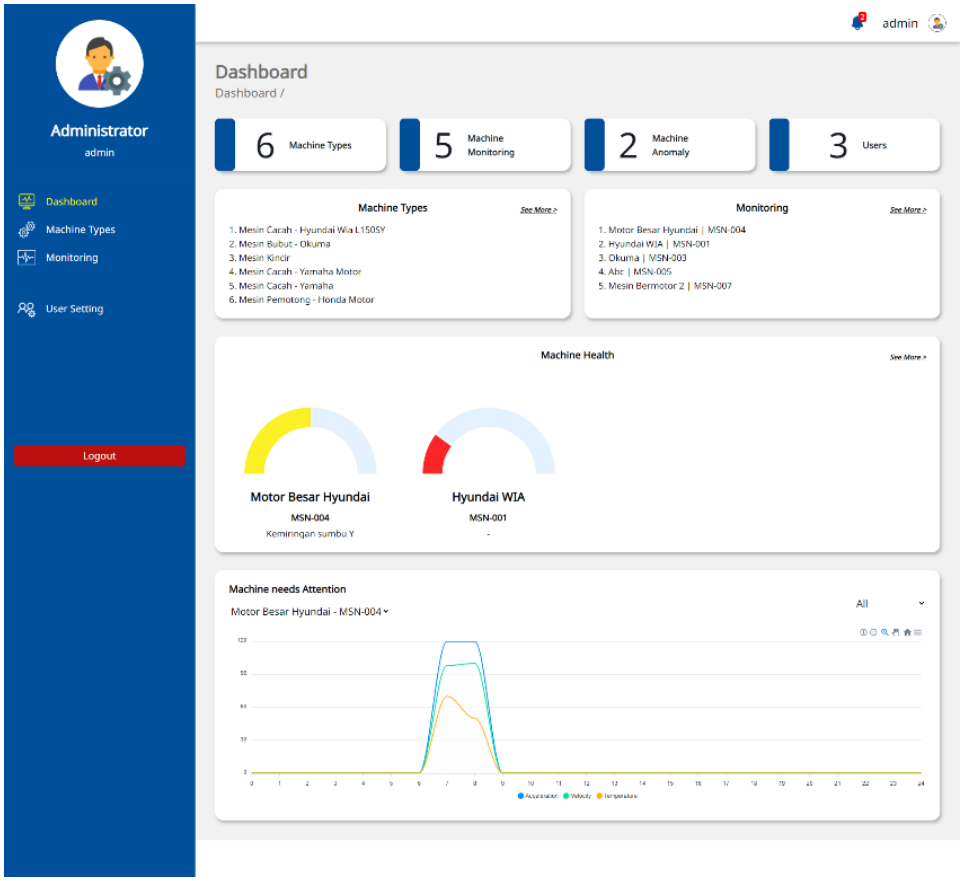

Figure 4. Dashboard Page

e. Machine Type Page

As illustrated by Figure 5, this page will display what types of machines are available or have been registered on the system. For admins, they have access rights to manage data, so there are options to create, read, update, and delete. But for employees, they only can view the data.

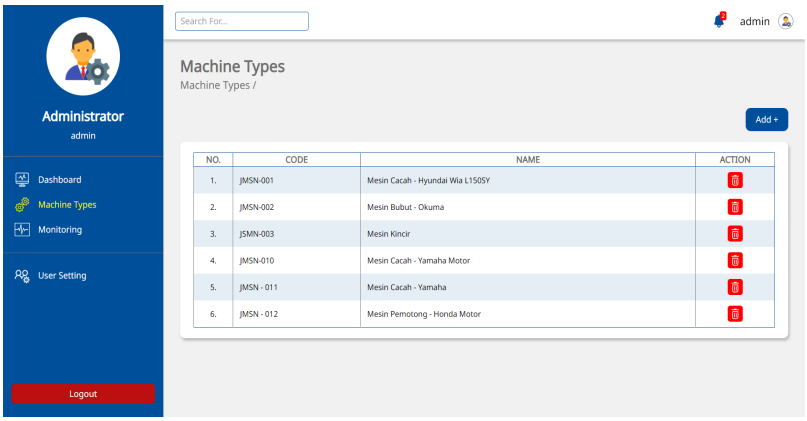

Figure 5. Machine Type Page

f. Monitoring Page

The monitoring page is used by the user to monitor the machine conditions. As shown in Figure 6, the user may get information on the details of machine data, the machine's condition whether it is in healthy or abnormal status, the value of acceleration, temperature, and velocity, and even the visualization of their values.

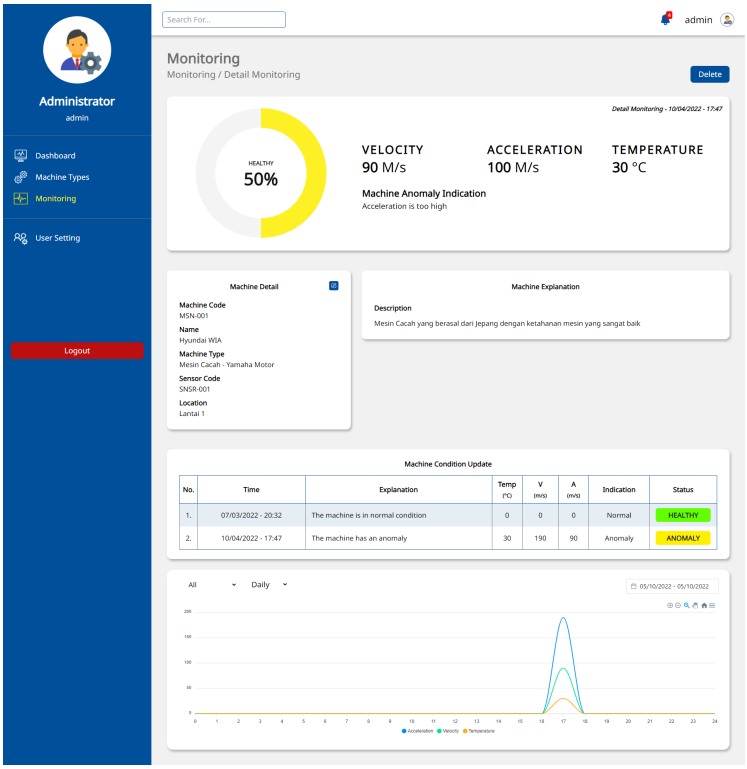

Figure 6. Machine Monitoring Page

g. User Setting Page

For managing the user account, the user setting page is provided in the system. Users can be added, deleted, and updated on this page as displayed in Figure 7. Only the administrator has access right this page.

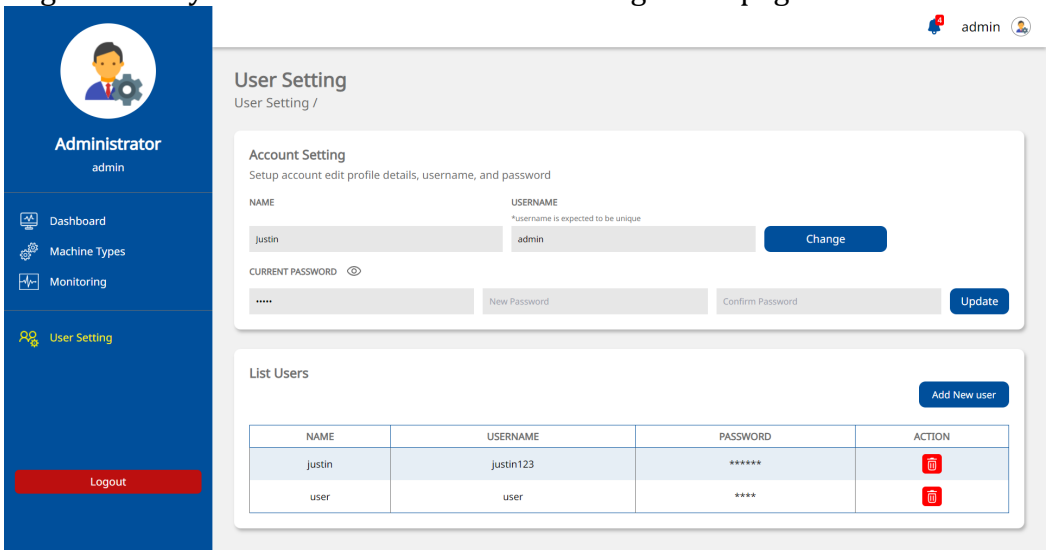

Figure 7. User Setting Page

h. Unit Testing

Unit testing is a testing performed on the smallest unit of a system, such as functions, methods, or existing modules. This test is done in isolation or independently which means that testing is done without connecting one function to another. This test is done by using white-box testing and the JEST framework. As a result of this testing, shown in Table 5, all methods run well and have no bugs.

Table 5. Unit Testing Result

No	Method	% of Pass	Status
1	addMachineType()	100%	Pass
2	editMachineType()	100%	Pass
3	deleteMachineType()	100%	Pass
4	addMonitoring()	100%	Pass
5	editDetailEngine()	100%	Pass
6	deleteMonitoring()	100%	Pass
7	getMachineType()	100%	Pass
8	search()	100%	Pass
9	getListUser()	100%	Pass
10	addDamage()	100%	Pass
11	removeDamage()	100%	Pass
12	getAllMonitoring()	100%	Pass
13	checkStatus()	100%	Pass
14	checkEngineAnomaly()	100%	Pass

i. Integration Testing

Integration testing is a testing software in testing modules to see if a module can be logically integrated for example into a database. A piece of software usually consists of several modules coded by different programs. The purpose of this test is to be able to see defects in the interaction between modules in interacting and focus on checking data communication between these modules. This test is carried out using black-box testing by looking at the output of the input results given to the system directly. As seen in Table 6, all features of each module have passed the test. It indicates that integration between features has been well implemented.

Table 6. Integration Testing Result

Module	Feature	Test Case	Description	Status
Page Machine Type	Add Machine Type	Positive Test Add Engine Type	Test Add a valid data engine type	Pass
		Negative Test Add Machine Type	Test Add Engine type invalid data	Pass
	Edit Machine Type	Positive Test Edit Machine Type	Test Edit Machine type valid data	Pass
		Negative Test Edit Machine Type	Test Edit Invalid data engine type	Pass
	Delete Machine Type	Test Delete Machine Type	Delete data Engine type of data	Pass

Page Monitoring Machine	Add Machine Monitoring Data	Positive Test Add Machine Monitoring Data	Test Add Machine Monitoring Data with valid data	Pass
		Negative Test Add Machine Monitoring Data	Test Add Data Monitoring machine with invalid data	Pass
	Edit Machine Monitoring Data	Positive Test Edit Monitoring Machine Data	Test Edit monitoring engine valid data	Pass
		Negative Test Edit Monitoring Machine Data	Test Edit monitoring machine data with invalid data	Pass
	Delete Machine Type Data	Test Delete Data Monitoring Machine Data	Delete Machine Monitoring data	Pass

D. Conclusion

Based on what has been done in this study, it can be concluded that designing and building a monitoring website for machine health can be done using the Scrum method. Machine-type data can automatically decrease, increase, or be deleted when admins perform data management. An anomaly can be detected as the result of AI algorithm. This website can help or make it easier for users to monitor the condition of the machine, estimate the damage of the machine, machine health status, and even indications of damage that occurs to the machine so that users can take actions that can maintain the machine to reduce maintenance costs.

For research conducted at a later stage, this website can be improved and developed by adding suggestion actions when the anomalies are detected.

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F. References

[1] A. Maulana and Y. Wangdra, "Inovasi Layanan Transaksi Digital berbasis Online," *Snistek*, vol. 2, no. September, pp. 25–30, 2019.

[2] R. S. Pressman, *Rekayasa perangkat lunak: pendekatan praktisi*. Yogyakarta, 2012.

[3] I. Sommerville, *Software engineering*, 10th ed. Pearson, 2016.

[4] S. P. U. Atmoko, K. Eviyanti, W. Sari, and S. C. Haryanti, "Rancang Bangun Aplikasi Edukasi Tuberkulosis Menggunakan Metode Scrum," *INOVTEK Polbeng - Seri Inform.*, vol. 7, no. 1, p. 83, Jun. 2022, doi: 10.35314/isi.v7i1.2353.

[5] D. W. A. Nugroho, "Rancang Bangun Sistem Informasi Gelanggang Olahraga berbasis Web dengan Metode Scrum," *JATISI (Jurnal Tek. Inform. dan Sist. Informasi)*, vol. 8, no. 4, pp. 1733–1749, Dec. 2021, doi: 10.35957/jatisi.v8i4.1132.

[6] T. S. Nugraha, K. Kusnadi, and R. Hardian, "Rancang Bangun Sistem Informasi Company Profile dengan Menggunakan Metode Scrum pada PT. Hasna Satya Negara Berbasis Web," *J. Ilm. Intech Inf. Technol. J. UMUS*, vol. 3, no. 02, pp.

171–179, Nov. 2021, doi: 10.46772/intech.v3i02.583.

[7] Chris Coleman, Satish Damodaran, Mahesh Chandramouli, and Ed Deuel, "Making maintenance smarter," 2017. [Online]. Available: https://www2.deloitte.com/us/en/insights/focus/industry-4-0/using-predictive-technologies-for-asset-maintenance.html.

[8] R. Silipo, "IoT Anomaly Detection 101: Data Science to Predict the Unexpected," 2019. https://www.darkreading.com/threat-intelligence/iot-anomaly-detection-101-data-science-to-predict-the-unexpected.

[9] R. van Loon, "How Industrial IoT is Influenced by Cognitive Anomaly Detection The Digital Transformation People," 2018. https://www.thedigitaltransformationpeople.com/channels/enabling-technologies/how-industrial-iot-is-influenced-by-cognitive-anomaly-detection/.

[10] J. Wang *et al.*, "LogEvent2vec: LogEvent-to-Vector Based Anomaly Detection for Large-Scale Logs in Internet of Things," *Sensors*, vol. 20, no. 9, p. 2451, Apr. 2020, doi: 10.3390/s20092451.

[11] T.-B. Dang, D.-T. Le, T.-D. Nguyen, M. Kim, and H. Choo, "Monotone Split and Conquer for Anomaly Detection in IoT Sensory Data," *IEEE Internet Things J.*, vol. 8, no. 20, pp. 15468–15485, Oct. 2021, doi: 10.1109/JIOT.2021.3073705.

[12] A. Zekry, A. Sayed, M. Moussa, and M. Elhabiby, "Anomaly Detection using IoT Sensor-Assisted ConvLSTM Models for Connected Vehicles," in *2021 IEEE 93rd Vehicular Technology Conference (VTC2021-Spring)*, Apr. 2021, vol. 2021-April, pp. 1–6, doi: 10.1109/VTC2021-Spring51267.2021.9449086.

[13] A. Graß, C. Beecks, and J. A. C. Soto, "Unsupervised Anomaly Detection in Production Lines," Springer Berlin Heidelberg, 2019, pp. 18–25.

[14] R. Gutama and T. Dirgahayu, "Implementasi Scrum Pada Manajemen Proyek Pengembangan Aplikasi Sistem Monitoring dan Evaluasi Pembangunan (SMEP)," *J. Autom.*, vol. 3, no. 1, pp. 29–35, 2021.

[15] A. Andipradana and K. Dwi Hartomo, "Rancang Bangun Aplikasi Penjualan Online Berbasis Web Menggunakan Metode Scrum," *J. Algoritm.*, vol. 18, no. 1, pp. 161–172, Aug. 2021, doi: 10.33364/algoritma/v.18-1.869.