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IOT-BASED DURIAN FALL DETECTOR WITH TILT SENSOR: ENHANCING DURIAN FARMER HARVEST EFFICIENCY

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Abstract. *Market demand for durian fruit now steadily increases as more people know its benefit on health and its unique taste. At present many people seek the best quality durian, and the way to get the best quality durian is to get the durian fruit that has just fallen from its tree naturally. To help durian farmers and consumers to get the best quality durian, we proposed creating a durian fall detector to immediately find out the durian that has just fallen from the tree. What is more, this detection tool is the result of improvisation of a previously developed durian detection tool, where the tool has been developed by replacing some of its parts with certain components that allow the tool to work more efficiently, just like before where the tool used Internet of Things system and equipped with a tilt sensor to track the position of the durian, which will send notifications to durian farmers via cellphone to pick up the durian that has just fallen immediately. The device itself has been tested with many durians with different weights, with the result of 86% accuracy as opposed to a previous study with 82% accuracy.*

Keywords: Internet of Things, Durian, WeMos, Tilt sensor, Solar energy, Blynk platform

1. **Introduction.** The Internet of Things (IoT) is a technology that aims to expand the benefits of continuously connected Internet connectivity [1,2]. This also covers items when it comes to its application, which includes data sharing, remote control, and sensor reception. For instance, consumables, electronics, collectibles, and machinery, as well as items connected to local and international networks through permanently embedded sensors [3-6]. With the development of network technology that is increasing, the need for data exchange will also be higher. The Internet of Things (IoT) can also be assumed to be able to form a diverse global network infrastructure based on communication protocols [7]. IoT also includes other sensor technologies, such as wireless technology or QR (Quick Response) codes [8]. Some basic elements that make up IoT are Artificial Intelligence (AI), connectivity, sensors, active involvement, and the use of small devices [9].

This IoT concept can also be used in agriculture, especially in plantations where in our subject, we focus on durian fruit. Many people love this fruit because of its unique smell and exceptional taste, so that it is called the King of Fruits [10]. And, of course, consumers are looking for high-quality durians or even the best quality available [11]. The way to get the best quality from this durian fruit is to wait for the durian fruit to fall naturally from the tree. That is because the durian is at its ripest when it naturally falls to the ground. However, to meet market demand, durian farmers harvest durians prematurely even though it has not been fully ripe yet [12]. This causes the quality of durian to decline and makes durian consumers less satisfied with the quality of durians [13]. Therefore,

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we conducted research to make and improve the durian fall detector. To the best of our knowledge, no research has yet studied tools to detect falling durian fruit. We found a tool to detect falling fruit in general, but no specific research paper studied it. Thus, to answer the problem described earlier, we use Arduino WeMos D1R2 as the base of the tool because WeMos D1R2 has built-in Wi-Fi that can be controlled remotely via an Internet connection and can be accessed with Internet services such as Android/iOS smartphones or other applications that have the same way of working, with Internet protocols that make the work of durian farmers easier and improve the quality of durian in the market.

From the results of the discussion related to the problems previously described, this research was made to improve the development that had previously been implemented by adding the necessary components to make this durian detection device even preferable, as well as by changing several components and developing devices so that they perform better and more efficiently. This study aims to improve the existing development by adding the necessary components and comparing the accuracy of the durian detector.

2. **Proposed Method.** In previous research, we used gyroscopes and accelerometers as sensor modules, with results whose accuracy can still be considered quite high. However, there are still deficiencies where the sensor module does not catch several falling durian trials that affect the success rate and accuracy of the sensor module. Therefore, by using the tilt sensor as a sensor module, the device will collect information from the sensor, which is connected to the durian, to get the information on whether the durian has fallen or not [14]. And when the durian falls, the device will send a notification to the user's smartphone. The WeMos D1R2 is equipped with built-in Wi-Fi [15-17]. WeMos can send data that has been obtained to the Blynk cloud in real time. With this method, customers can check the app from their homes using a smartphone and Internet connection to see how many durians have fallen. Through this research, we want to improve the accuracy of falling durian detection to increase the efficiency of harvesting durian farmers.

2.1. **The architecture of IoT Durian Fall Detector.** IoT Durian Fall Detector has 4 layers of IoT architecture, as seen in Figure 1. They are the perception, network, middleware, and application layers. In the first layer, namely perception, there is one sensor, namely SW520D (tilt sensor). The way the tilt sensor itself works is to detect the angle of inclination or degrees by using a metal ball which will change its position depending on the position of the tilt sensor itself [18,19]. After obtaining the data, it will then send the data by the network layer via the Internet network, which uses Wi-Fi as the medium, and then will be sent to the cloud as an intermediary between the device and the user application if it has been successfully sent, it will be sent again to the application layer which will display the number of fallen durians and notifications to the user's smartphone as processed data so that the user can immediately harvest the durian that has fallen and is ready to be sold or eaten. In the current work, we were able to make a case for the durian detector device, which had not been made before in the previous research, with the aim of making it easier to place existing components and prevent internal damage. This case was also designed so that it could be placed on the durian tree itself and extend the cable to the sensors so that it could detect more durians than in previous research.

2.2. **Sketch of IoT Durian Fall Detector.** A sketch of the IoT Durian Fall Detector can be seen in Figure 2. In this study, the WeMos D1R2 microcontroller is the main brain of this device. WeMos D1R2 requires a 3.7 V lithium-ion battery that is charged with TP4056 Charging Board and supplied with a solar panel as its power. The TP4056 board itself is used to keep storing electricity in the battery port even in the smallest amount that has been received by it and maintain the amount of power received so that there is no excess power that might cause the device components to catch fire. Then WeMos D1R2 can adjust the tilt sensor to get data in the form of a position. And then, after the

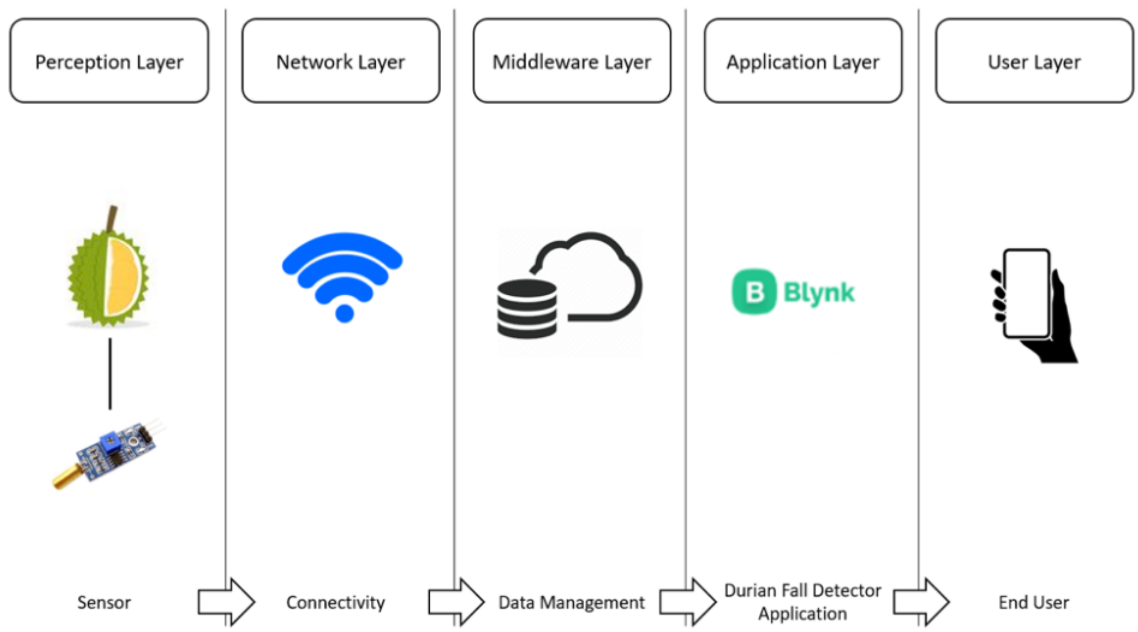

FIGURE 1. The architecture of IoT Durian Fall Detector

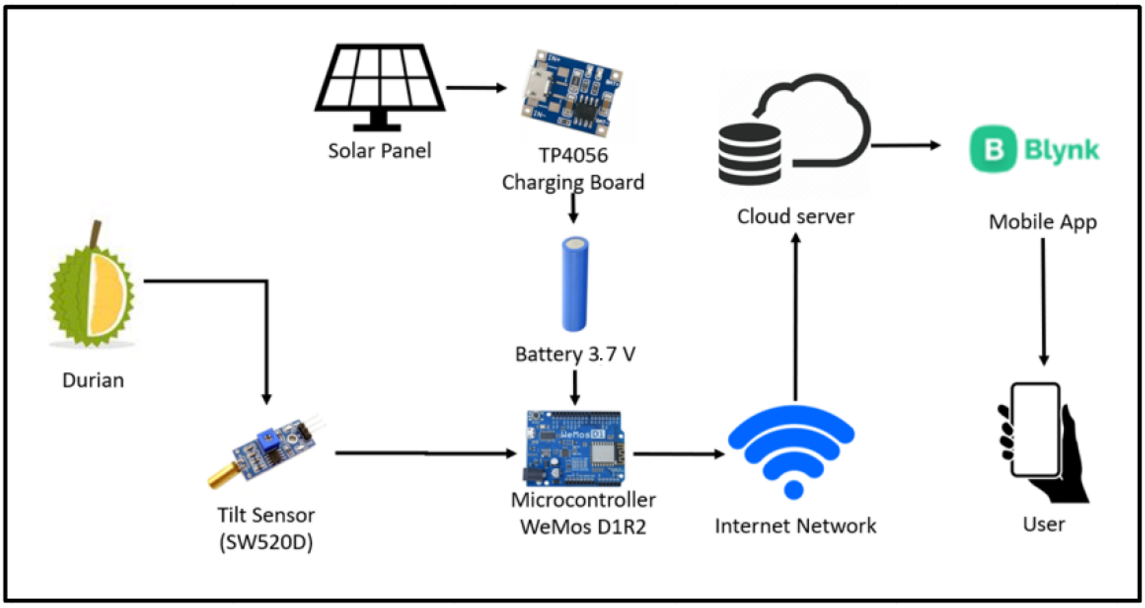

FIGURE 2. Sketch of improved Durian Fall Detector

device is properly installed and durian is sustainingly monitored, every second WeMos will send data to Cloud using an Internet connection through Wi-Fi available around the device. When the durian has fallen from its tree, the cloud server will send the data to the Blynk Mobile Apps installed on the user's smartphone as data on the increase in the number of falling durians and then send a notification to the user. The device prototype can be seen in Figure 3 and Figure 4.

2.3. **Flowchart of IoT Durian Fall Detector.** The flowchart is a graphical representation of the sequence of procedures on the system that depicts the work of program structures and other alternatives available in the operation to analyze its function [19]. Figure 5 shows the flowchart of the IoT Durian Fall Detector.

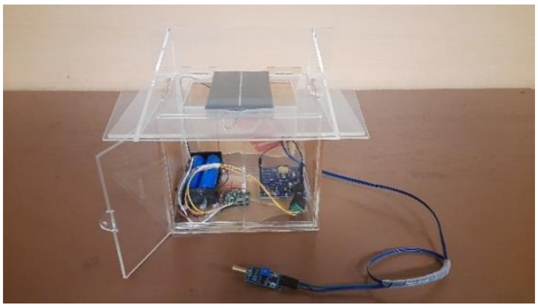

FIGURE 3. Durian Fall Detector device prototype

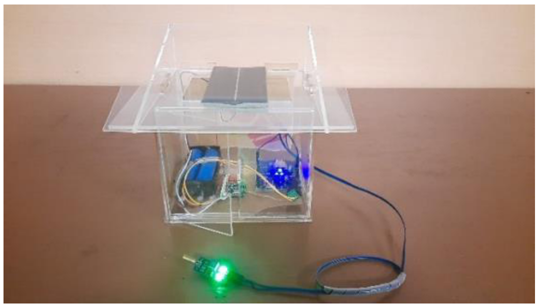

FIGURE 4. Durian Fall Detector device prototype activated

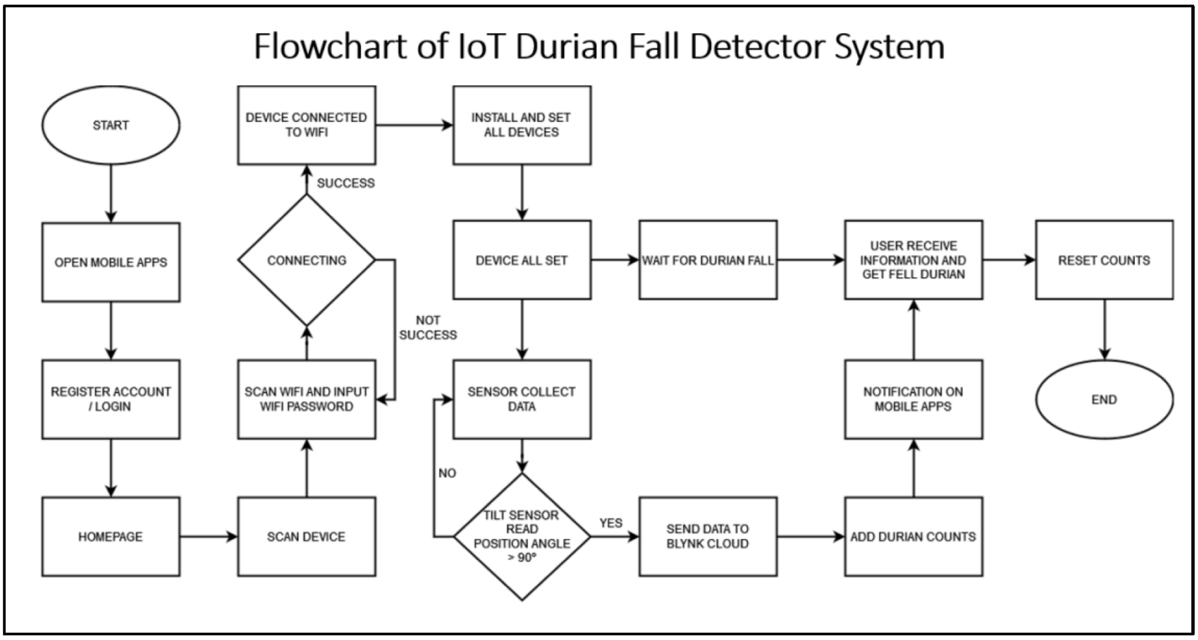

FIGURE 5. IoT Durian Fall Detector flowchart

The flowchart in Figure 5 shows the way IoT Durian Fall Detector system operates. The device is turned on at the start using a 3.7 V electric lithium-ion battery power. Then the device is automatically connected to Wi-Fi around the device whose SSID and password have been set, and then attach the sensor on the durian fruit just above it. After that, press the "ON" button as shown in Figure 6 to turn on the device. The device is all set and ready to use as it should and can be left thereafter. The device will read the durian's position at any time. If the condition has not met the set requirements, it will continue to monitor the durian and collect the data, and if the sensor gets the data that matches the conditions of a fallen durian, the durian can be declared that it has fallen from its stem. Subsequently, this device will send the data to the Cloud and proceed to the user's application to increase the number of fell durians, as seen in Figure 7.

3. **Experiment Results.** We conducted experimental research on the Durian *Matahari* variety. In this experiment, we could not use the still intact durian with the branch and wait without knowing when it would fall. However, instead, we used a simulation of the durian fall by using a rope to simulate as close as possible to the original durian fall, which can be seen in Figures 8 and 9. We did the test 10 times per durian, using 5 kinds of durian with different weights and various places and situations, as seen in Table 1.

In our experiments, by conducting 50 trials with 43 successfully detected and 7 errors, we thus concluded that the success rate of our IoT Durian Fall Detector test is 86% which

Figure 6. Blynk mobile apps, power off

Figure 7. Blynk mobile apps showing the number of fell durians

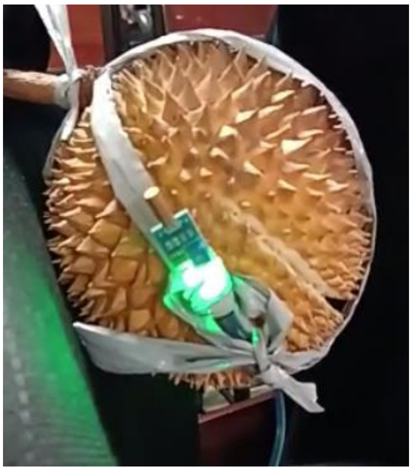

Figure 8. Tilt sensor ready to detect fallen durian

Figure 9. Durian has fallen.

can be seen in Table 1. The tests we did on various weights of durian had different results and errors. The error that occurred during the experiment was that the falling durian was not detected due to various reasons that will be further explained below.

Fortunately, the experiment done on 1.55 Kg durian did not produce any errors. However, some errors began to appear on the 2.10 Kg durian and forth. After we examined it more deeply, it turned out that the source of the error that mostly appeared was because the heavier the durian, the greater the possibility that the position of the durian after it fell would remain the same as before it fell (neither rotating nor upside down). Starting from the 2.10 Kg durian, the cause of the error was that the position of the durian changed after it fell, but not enough to trigger the tilt sensor, so it is not declared as a fallen durian by the sensor. While in the case of the 2.65 Kg durian, the case was like before, where the tilt sensor could not detect the change of position of the fell durian because it was a slight

Table 1. Result of experiment using tilt sensor

Number of tests	**Weight**				
	1.55 Kg	**2.10 Kg**	**2.65 Kg**	**3.10 Kg**	**3.40 Kg**
1st	Detected	*Error*	Detected	Detected	Detected
2nd	Detected	Detected	Detected	Detected	*Error*
3rd	Detected	Detected	*Error*	Detected	*Error*
4th	Detected	Detected	Detected	Detected	Detected
5th	Detected	Detected	Detected	*Error*	Detected
6th	Detected	Detected	*Error*	Detected	Detected
7th	Detected	Detected	Detected	Detected	Detected
8th	Detected	Detected	Detected	Detected	Detected
9th	Detected	Detected	Detected	*Error*	Detected
10th	Detected	Detected	Detected	Detected	Detected
Accuracy	**100%**	**90%**	**80%**	**80%**	**80%**
Average accuracy	**86%**				

turn that fell below the requirement needed to be counted as the falling durian. Next, in the case of the 3.10 Kg durian, one of the errors was because the sensor is not properly attached to the durian, which caused the sensor to detach from the durian before the durian even fell to the ground, thus triggering a false alarm that says that the durian has fallen while the fruit is still on the stem. And finally, in the case of the 3.40 Kg durian, the source of the problem from one of the resulting errors was the reverse of the previous problem, where before, the sensor was not properly attached, which caused it to detach from the durian. This error is caused by the sensor being attached too near to the stem so that it is attached to the stem more than it is attached to the durian. And because of that, when the durian falls, the sensor is still at the top, attached to the stem. So, it should be noted to check that the sensor is properly set and attached to the durian and safe to leave on its own.

In previous research, we employed gyroscopes and ultrasonic sensors [20]. We obtained an average accuracy of 82% after the same trial with 5 different weight durians and 10 times testing, as shown in Table 2. This is because the ultrasonic sensor has a flaw while reading a particular length of distance, causing the accuracy level of reading to be less precise. Combined with natural disturbances such as wind, which triggers gyroscope sensors and sends false alerts, the sensors cannot read the true durian falls. However, when compared to the traditional manual method, this current device will be more efficient and cost-effective in the future because it detects ripe durians that have just fallen without the need to wait manually, allowing durian farmers to use their time more efficiently while still obtaining good or better-quality durian yields, as the estimated cost for hiring people to do the manual labor of overseeing fallen durian is as follows: if 1 durian field is 4 hectares in area, then only 4 people are needed with operational costs of around 50,000-100,000 IDR per night. And when compared to the previous study's device, the current device is significantly better because it consumes less energy by using solar panels and is more efficient and accurate in the use of tilt sensors (Figure 8 and Figure 9), as demonstrated by the current device's experimental results, which produce an average accuracy of 86%.

We understand that there are still some drawbacks to this research. With the various errors we encountered, there are the shortcomings that we realized including other objects that could be detected incorrectly, natural factors that could disturb the sensor's reading, external factors that cause durians to fall before they are fully ripe, Wi-Fi signal disruption in the villages and forests plantation and other sources.

Table 2. Comparison of research experiments results

Number of tests	**Experiment using gyroscope and ultrasonic sensor**		**Experiment using tilt sensor**	
	Errors occurred	**Accuracy**	**Errors occurred**	**Accuracy**
1st 10 tests	2 errors	80% accuracy	0 errors	100% accuracy
2nd 10 tests	1 errors	90% accuracy	1 errors	90% accuracy
3rd 10 tests	3 errors	70% accuracy	2 errors	80% accuracy
4th 10 tests	1 errors	90% accuracy	2 errors	80% accuracy
5th 10 tests	2 errors	80% accuracy	2 errors	80% accuracy
Average accuracy	**82%**		**86%**	

4. **Conclusions.** The results of the experimental projects that have been implemented previously are that the sensor that has been rolled with the current one has an accuracy of 86%. In contrast, the accuracy of this experiment using a tilt sensor is a greater level proportion than the previous sensors, namely the gyroscope and ultrasonic sensor [20], which got an accuracy of only 82%. We also added several optimizations so that the current device consumes less energy while performing more efficiently. We hereby hope that the results of this project improvement can make it easier for owners and farmers to harvest durian with better efficiency and be able to obtain better-quality durian fruit. Even so, with the various errors we encountered, there is still room to improve the results of this project, and in the future, we hope to be able to perfect this project smoothly.

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