Design of water height detector model in runway based on internet of things

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Abstract. The runway of an aircraft is designed to keep it dry even if it rains to avoid hydroplaning. Hydroplaning is a plane slip on the runway due to standing water. In accordance with regulations from the Direktorat Bandara, Ditjen Perhubungan Udara NO. KP 212 in 2017, the operational requirement for runways to be able to serve landings and aircraft flights is when there is a maximum of 3 mm of standing water on the runway surface. The design of the water level detector model on the runway uses the Arduino Mega 2560 as a microcontroller which processes and sends the detected data to the thingspeak via the internet network. Performance specifications for water level detector models are water level sensor designs, U detector pipes, runways, electronic circuits. The water level sensor is a touch sensor that is designed and printed on a PCB board with vertical strip designs. Detected data will be processed in Arduino Mega 2560 and typed into the thingspeak page using the internet network. Data output can be accessed via a PC connected to the internet network. The results of comparison with standard tools found the average percentage of errors for the vertical sensor strip design was 4.98%. From the comparison results, the average percentage of accuracy for the vertical sensor strip design is 95.01% with precision of 84.77%.

1. Introduction

Increased public interest in using airplane as an economically efficient transportation makes the air transportation traffic lane more crowded. According to the Central Statistics Agency for domestic flights in 2017 an increase of 8.81 percent compared to the previous year, and foreign flights in the last five years (2013-2017) also increased 5.03 percent annually [1]. Therefore the airline has a greater responsibility to maintain the safety of passengers in order to avoid flight accidents.

Airplane crash is influenced by three main factors namely technical factors, weather factors and human error factors [2]. Plane accidents caused by technical factors are aircraft runway conditions that are not operational standard. The runway of an aircraft is designed to keep it dry even in the rainy season. Wet runway conditions disrupt the flight process.

In the world of aviation is called a hydroplaning event. Hydroplaning is a plane slip event due to a puddle of water on the runway surface. Data from the Komite Naional Keselamatan Transportasi (KNKT) in 2016 stated that the cause of most plane crashes was hydroplaning with a percentage of 40.09% of 212 accidents [3]. Wet runway conditions affect friction so that the wheels are unstable. The friction coefficient of aircraft wheels ($\mu$) when the runway is dry is 0.4 and when the runway is wet is 0.25 [4]. The equation for calculating the friction of the wheel with the runway ($R$) is:

$$R = \mu(W-L)$$  

(1)
Where $\mu =$ coefficient of friction [5]

In accordance with equation (1) the coefficient of friction affects the friction force of the wheel with the runway. Wet foundation reduces the friction of the wheels so that it can cause the plane to slip. In accordance with regulations from the Airport Directorate, NO. KP 212 of 2017, runway terms and conditions can serve landing and flight flights are puddles on the runway maximum 3 mm.

The switch circuit will detect the water level and provide input data to the microcontroller. A series of 40 transistor switches are arranged to detect a maximum water height of 2 centimetres with the smallest scale of 0.5 millimetres. Currently for the detection of water levels on Indonesian runways done manually by airport officials who will see first-hand the runway conditions and measure them using the meter. This data is certainly not effective because the possibility of human error will be large depending on the perspective of the officer. For that we need a detector that can detect the height of water on the runway accuracy. This detector is designed using a transistor switch circuit. The composition of the transistor switch can be seen in Figure 1.

![Transistor Switch Circuit](image)

**Figure 1.** Transistor Switch Circuit

Figure 1 shows the switch circuit will detect the water level and provide input data to the microcontroller. A series of 40 transistor switches are arranged to detect a maximum water height of 2 centimetres with the smallest scale of 0.5 millimetres.

This water level detector data will be processed using the Arduino Mega 2560 microcontroller. Arduino is an open-source hardware and software that is designed in single-board microcontrollers. Arduino has been successfully applied to various systems ranging from simple to complex systems [6,7].

Arduino The Arduino Mega 2560 has 54 digital pins which are useful for inputting data from the transistor switch. The water level detector model uses the esp8266 WIFI module for sending data to the internet network. The esp8266 WIFI module is a module that has WIFI access that works at a voltage of 3.3 volts [6]. The results of the water level detector model on the runway are displayed on the thingspeak site in graphical form. Thingspeak is an open source internet of things platform. Internet of things is advances in technology that can connect all devices with internet media [7].

2. **Research Method**

Based on the problems raised in this research, this research is included in laboratory experiment research, which is a research that applies science into a design to get the performance as expected. The causal relationship or effect of an independent variable on the dependent variable can only be obtained through experimental procedures. Experimental research procedures are recognizing problems, identifying and defining problem boundaries, formulating problem hypotheses, selecting experimental variables, making experimental plans, conducting experiments, processing raw data and conducting
significance tests [8]. The design of the water level detector model on the runway of an airplane based on the Internet of Things has the block as shown in Figure 2.

![Figure 2. Block Diagram of Water Level Detector Model on the Runway](image)

The block diagram in Figure 2 shows that the power supply is useful for activating the Arduino Mega 2560 and also the water level sensor. This water level sensor uses a sensor strip connected to the transistor switch as an indicator of water level and becomes the data input for Arduino Mega 2560. After the data is input the data will be sent with a WIFI signal to the thingspeak page and the water level display on the runway can be accessed using a PC that is far from the runway. The mechanical design of the water level sensing shown in Figure 3

![Figure 3. Mechanical Design of Sensor Strips](image)

In Figure 3 shows the mechanical design of the sensor which is designed to detect water level on the runway. Sensor (1) is printed on a 13 x 6 cm PCB board made with reciprocal paths. The sensor has 40 streets (2) with each street a distance of 0.5 mm. The front strip is 0.5 mm higher than the back strip. The sensor is installed in the pipe (4) to detect water level with a maximum height of 2 cm from the runway surface. The sensor is connected to the transistor switch circuit through the hider pin (3), this hider pin totalling 40 pieces. This sensor is expected to be precise and accurate to detect the height of water that works in the order of millimetres. The hardware design of the design of the water level detector model on the runway can be seen in Figure 4.
Figure 4. Design of Water Level Detector Model

Figure 4 shows the design shape of the water level detector model on an aircraft runway. On the runway a detector pipe will be implanted with the same height as the runway. This detector pipe will be connected to a pipe outside the runway. The detector pipe outside the runway is mounted with a water level sensor of 0.5 millimetre. Pipes outside the runway are made higher than inside the runway to detect water level that has a height above the maximum water level on the runway and also has a roof as a pipe cover to protect it from outside influences. Arduino IDE software design can be seen in Figure 5.

![Diagram of software design](image)

**Figure 5. Software Design**

In Figure 5 can be explained the flow of the software. The first step is the Arduino programming language that connects the Arduino Mega 2560 board to WIFI. If the board is not connected, it will start over and if it is connected, the water level sensor data can be read on the board. Data entering the Arduino Mega 2560 board is digital data from the water level sensor. Water level data to thingspeak with the internet network. In thingspeak the data will be plotted in real-time graphs.
3. Result and Discussion

The results of the design research of the water level detector model on the runway of the aircraft based on the internet of things produce detectors capable of detecting water level on the runway with a precision of 0.5 millimetres and the water level data is uploaded to the thingspeak page via the internet network. The water level detector is designed using a 2 inch pipe. The sensor used is a touch sensor that is designed using a vertical sensor strip design.

The graph analysis results from the water level detector using a vertical sensor strip design can be seen in Figure 6.

![Figure 6. Water Level Detector Data in Runway](image)

Figure 6 shows the graph of changes in water level in real-time from a height of 0 millimetres to a height of 14.5 millimetres. In Figure 6 there is also a comparison between the data detected by the sensor and the actual water level on the runway. From the graph of the increase and decrease in water, the difference between the data detected by the sensor does not differ much from the actual water level on the runway.

From the results of static analysis, the comparative value of the data from the detection of the water level sensor using a vertical strip design with a standard measuring instrument shows that the level of accuracy of sensor detection is quite high with a small percentage of errors. The average accuracy of the results of the detection of water level when the water rose was 96.26% with an average percentage error of 3.73% while for the average accuracy of the results of the detection of the decrease in water level was 93.77% and the average percentage error of 6.22%. For the precision of water level detector models, the average percentage of research was 84.77%. Accuracy data are obtained by repeated measurements of some variations in water level. The height variations of the water used are 0.5 mm, 1.5 mm, 2.5 mm, 3.5 mm, 4.5 mm.

The design of this detector model uses the Internet of things as communication to display data. Data is displayed on an open source internet of things license plate form page, thingspeak. Water level detector information on the runway will be sent to the thingspeak page and accessed using a PC connected to the internet network. The data display on the thingspeak page is plotted automatically into a graph. In the experimental simulation of the water level detector on the runway, measurements were made simultaneously between the data uploaded and the actual water level. Water level data is taken from 14.00 WIB until 23:30 WIB. Detector data uploaded in real-time. A simulation of detecting water level on the runway is plotted on the thingspeak page shown in Figure 7.
Figure 7. Simulation Data of Water Level Detection on the Thingspeak Page

In Figure 7 you can see a comparison of the water level data uploaded on the thingspeak page with the water level on the runway. The results of the data plotted on the thingspeak page do not differ much from the actual water level on the runway. The rise in the graph is due to random variations in water level on the runway.

The design of this water level detector has several disadvantages: first, the touch sensor that is used has not accurately detected changes in water level that occur, it takes suitable materials to print sensor strips, installation and transistor circuit switches that have not been stable so that it affects the data read on the microcontroller.

4. Conclusion

The design based on research that has been about the design of water level detector models on the runway based on the internet of things produces an average percentage accuracy of 95.01 and the average percentage of accuracy is 84.77. The design of this detector model is accurate enough to detect water levels.

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