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Engineering of Information Monitoring System Sensor Reading Data Based on Smart Wireless using NVDIA Jetson Nano and Arduino Mega on Agricultural Spraying Machines

Ridwan Siskandar[1]✉, Tineke Mandang[2], Wawan Hermawan[2], Irzaman Irzaman[3]

[1] Agricultural Engineering Study Program, Graduate School, IPB University, Bogor, INDONESIA
[2] Department of Mechanical and Biosystem Engineering, Faculty of Agricultural Engineering and Technology, IPB University, Bogor, INDONESIA
[3] Department of Physics, Faculty of Mathematics and Science, IPB University, Bogor, INDONESIA

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✉Corresponding Author:
ridwansiskandar@apps.ipb.ac.id

ABSTRACT

The focus of the research is monitoring data from sensors on the agricultural sprayer. The monitoring system support by some sensors in camera, tank capacity, boom sprayer balance and battery capacity. The research method was carried out using the waterfall model, because according to the needs that require a sequential flow in the process. This model is divided into four parts, namely analysis (to identify problems and needs), design (plans to solve problems to be solved), implementation (implementation of plans that have been made), and testing. Engineering of Information Monitoring System Sensor Reading Data Based on Smart Wireless using NVDIA Jetson Nano and Arduino Uno on Agricultural Spraying Machines. The test results for the CNN model for the detection of the "Jajar Legowo" object were carried out to obtain 90% accuracy, 82.35% precision and 100% recall. Tests an accuracy value cappacity tank of 100%. Testing the balance sensor, if rotates clockwise on the Y axis the output voltage decreases, and vice versa. However, if the sensor at rest, the output voltage will same as the offset value. Besides that, testing the optimum PWM value fuzzy approach is carried out with aim that the droplets hit the target zone when sprayer is working. The result are Arduino IDE and Matlab produce same value, which is 42 for the optimum PWM value. Testing the battery capacity sensor get accuracy value of 100% by difference in the voltage increase of 0.5 volts is equivalent to increase of 10%. All information read by the sensors is displayed on the LCD using WMS-2000 (smart wireless).

1. INTRODUCTION

A monitoring system is a service that carries out the process of monitoring, supervising, and controlling data and conducting analysis of this data to maximize all available resources whether they are running or not (Putri *et al*., 2019; Cheng, 2020). Researchers have previously conducted research in various fields of agriculture using monitoring system methods, both data results displayed on an interface (liquid crystal display, website, application) and feedback output (motors, LEDs) (Fang *et al.*, 2021; Assunção *et al.*, 2022; Hasif bin Azami *et al.*, 2022; Zhang *et al.*, 2022; Bafdal *et al.*, 2022; Botero-valencia *et al.*, 2022; Bwambale *et al.*, 2022; Doan, 2022; He *et al.*, 2022; Yağ & Altan, 2022; Training *et al.*, 2023). So far two types of monitoring are widely applied by researchers in embedded system technology, namely cable-based monitoring and wireless-based monitoring (Siskandar & Kusumah, 2019; Siskandar *et al.*, 2020; Paul *et al.*, 2022; Radočaj *et al.*, 2022; Anastasiou *et al.*, 2023). Assunção *et al.* (2022) revealed that the implementation of a monitoring system on one of the agricultural spraying machines can provide an easy approach to obtaining precise data or providing notification of conditions from the measurement process of the applied sensors.

In research conducted by (Hidayat *et al.*, 2019; Indraswira *et al.*, 2021; Wahyudi *et al.*, 2021; Istiqomah *et al.*, 2022) explains that the control implementation of real-time clocks can be used in the agricultural spray system. However, the weakness is that it cannot determine the good accuracy of the conditions being monitored. In addition to this, it is also explained that the use of the ESP32-Cam camera can be seen that the website runs well in various web browsers (Opera, Google Chrome, and Microsoft Edge) because the application is a responsive website created using PHP programming. It's just that the weakness of the camera can-not inform the accuracy of the detected object. Another study, conducted by (Wijayanti *et al.*, 2023) explains that a monitoring system via a smartphone application can be used as a model to assist farmers in monitoring agricultural spraying activities through sensor notifications. However, development is still needed for other notification systems, such as image-based monitoring to produce better monitoring quality. Kusuma *et al*. (2021) in his research explained that the use of a raspberry pi-based camera can monitor the condition of rice fields through a smartphone application. However, the drawback is that it still requires a lot of memory when making applications because when the new program is stored, the old program is still stored.

Referring to research that has been carried out by previous researchers, researchers have reviewed and conducted research related to monitoring smart wireless based data information using the NVDIA Jetson Nano and Arduino Uno microcontrollers on agricultural spraying machines. The object of this research is to monitor data from each sensor (camera sensor, tank capacity sensor, boom sprayer balance sensor, and battery capacity sensor) on agricultural spraying machines. Utilization of the camera sensor is used to monitor images/videos of objects (“legowo” paddy fields) in real-time. Camera sensors can recognize objects so farmers can remotely control the movement of the sprayer machine. Object recognition and classification are performed using the convolutional neural network method in real-time. Utilization of the tank capacity sensor is used to determine the volume of water in the tank of the boom sprayer machine and whether it is still available or not. The type of sensor used is a float sensor. This sensor can detect two conditions, namely the availability or absence of water in the tank. Utilization of the balance sensor (gyroscope) on the 2 sprayer booms (right and left) is used to obtain optimum PWM data during the spraying process. Optimum PWM information is very important to obtain because it affects the effectiveness of spraying when the sprayer machine is running dynamically (avoiding the fall of liquid droplets in the non-target zone). Optimum PWM data is obtained through a fuzzy approach by inputting vibration values (gyroscope sensor) and electric motor PWM values. While the use of battery capacity sensors is used to provide data information on the availability of battery voltage in real-time. All information read by the sensors is displayed on a 3-inch liquid crystal display which is sent via wifi communication (WMS 2000).

The purpose of this study is to provide an easy approach to obtaining precise data or providing condition notifications from the measurement process for each sensor (camera sensor, tank capacity sensor, boom sprayer balance sensor, and battery capacity sensor). The novelties of the research carried out are: (1) camera monitoring can help farmers (remote control controllers) to control agricultural spraying machines from a distance (100 meters) through the point of view sent by the camera sensor; (2) monitoring the optimum PWM data value is obtained through a fuzzy approach by inputting vibration values (gyroscope sensor) and electric motor PWM values.

2. MATERIALS AND METHODS

This research was conducted at the Hardware Laboratory of the Computer Engineering Technology Study Program, Vocational School of IPB from November 2022 - March 2023. The tools and materials used were shown in Table 1.

Table 1. The need for tools and materials

No	Tools and materials	Function	Volume
1	NVDIA Jetson Nano	As a minicomputer that processes images and adds information from Arduino Uno (tank capacity sensor, boom sprayer balance sensor, and battery capacity sensor) into a video which is directly transmitted to the 3-inch LCD on the user's remote control	1 unit
2	Arduino Uno	The data processor that is read by each sensor is the tank capacity sensor, the boom sprayer balance sensor, and the battery capacity sensor)	1 unit
3	Camera Sensors (Logi Tech)	Take pictures/videos	1 unit
4	Servo Motors	Angle drive motor for camera sensor	1 unit
5	Smart Wireless Presentation System: WMS 2000	Transmitter and Receiver Data	1 unit
6	Tank Capacity Sensor: Float Sensor	Read the volume of fluid in the tank	1 unit
7	Boom Sprayer Balance Sensor: Gyroscope Sensor	Read the vibration of the sprayer boom (right and left) of the sprayer machine	2 unit
8	Battery Capacity Sensors	Read battery voltage	1 unit
9	Adapter/Battery	Power	1 unit
10	3 inch LCD	Displays camera sensor data, tank capacity sensor, boom sprayer balance sensor, and battery capacity sensor.	1 unit

2.1. The Monitoring System Design

The monitoring system design stage was carried out to provide an easy approach to obtaining precise data with the help of the sensors used (camera sensor, tank capacity sensor, boom sprayer balance sensor, and battery capacity sensor) to solve existing problems. System design carried out in this study includes block diagram design, flow chart design, hardware design, software design, and tool mechanical design.

2.1.1. Block Diagram Design

Figure 1 describes the operating function of the designed monitoring system. In principle, the remote camera monitoring system functions to help the controller (user) to be able to control agricultural spraying machines from the machine's point of view. The tool (transmitter-receiver) used in this remote monitoring system was WMS 2000. This tool had an operating distance of up to 60 m, and local 5g network connectivity emitted by the transmitter produces video transmission with low latency/delay. This tool was also easy to operate, only need to connect the transmitter and receiver without the need for additional installation. The NVDIA Jetson Nano function is as a minicomputer that will process images or videos and add other information such as (PWM, battery capacity, fluid tank capacity, and boom sprayer balance) received from Arduino Uno into a video which is directly transmitted to the LCD screen located on the remote control (user) via smart wireless.

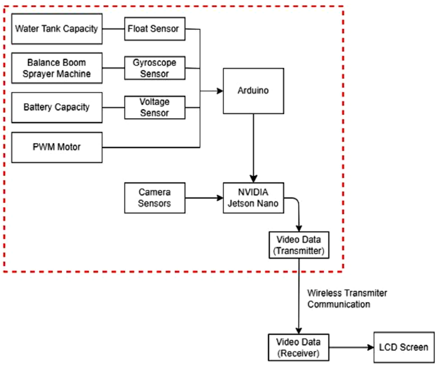


Figure 1. Block diagram of the agricultural spraying machine monitoring system

Figure 1 explains that there were two microcontrollers working on the monitoring system for agricultural spraying machines, namely Arduino and NVDIA Jetson Nano. Both were integrated into one core device system. NVDIA Jetson Nano is used to process images/videos that can be transmitted directly to the 3-inch LCD on the remote control. While Arduino was used to process reading data from several input sensors (PWM, battery capacity, fluid tank capacity, and boom sprayer balance). Arduino could not directly send reading data from several input sensors to the 3-inch LCD on the remote control, so sensor reading data is sent from Arduino to NVDIA Jetson Nano first. Furthermore, NVDIA Jetson Nano will add this data to the video which is directly transmitted to the 3-inch LCD on the remote control. So the NVDIA Jetson function in this system was to transmit both images/video from the camera sensor and transmit reading data from several input sensors received from Arduino.

2.1.2. Flowchart Design

Figure 2 shows a flowchart of the monitoring system for an agricultural sprayer machine using the NVDIA Jetson Nano and Arduino Uno microcontrollers.

2.1.3. Hardware Design

The hardware design is made using freezing software. In designing a hardware circuit, three parts are needed, namely: input components (camera sensor, PWM motor for speed value, battery capacity sensor, fluid tank capacity sensor, and boom sprayer balance sensor); process components (NVDIA Jetson Nano and Arduino Uno, both of which are OpenCV. OpenCV is an open-source computer vision library for the C/C++ programming language and has been extended to Python, java, and Matlab. Libraries); and component output (3 inches LCD). The hardware design of the agricultural sprayer monitoring system is shown in Figure 3. Figure 3 describes the integration between the transmitter device (inside the green dotted line) and the receiver device (inside the blue dotted line) through certain pins.

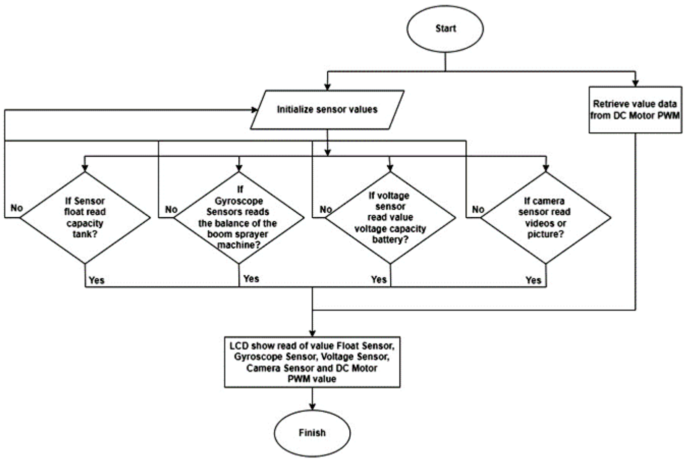


Figure 2. Flowchart of research on agricultural spraying machine monitoring systems

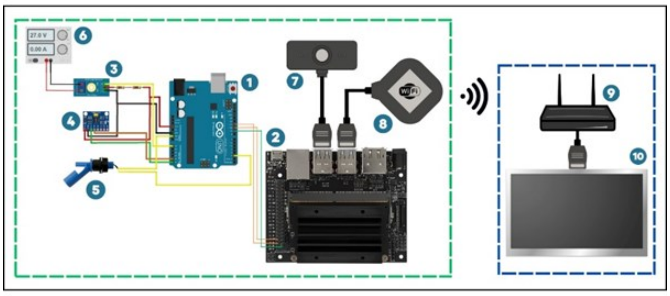


Figure 3. Design of agricultural spraying machine monitoring system hardware

The electronic components used in the agricultural spraying machine monitoring system shown in Figure 3 consist of: (1) Arduino Uno; (2) NVDIA Jetson Nano; (3) battery capacity sensor; (4) boom sprayer balance sensor; (5) fluid tank capacity sensor; (6) DC power 5 volts; (7) WMS 2000 transmitters; (8) camera sensors; (9) WMS 2000 receivers; (10) 3 inch LCD. The integration between electronic components on the microcontroller pin is shown in Table 2.

The calibration process is carried out on all input components (camera sensor, motor PWM for speed value, battery capacity sensor, fluid tank capacity sensor, and sprayer boom balance sensor). PWM motor calibration is carried out in the following steps: (i) Determine the range of PWM values to be used and adjust them to the reference values used by Arduino Uno (value range is 0-255), (ii) Convert values from Arduino Uno to PWM using the formula “[PWM value = (Arduino Uno value/value range) x 100]”.

The approach of calibrating the camera sensor is used to generate global coordinates. The global coordinates are deduced by a simple geometric transformation from the camera world to the real world. The way to do this is to use a "checkerboard" pattern to infer the camera parameters. Homomorphic transformation (translation from the image plane to the real world) can be used to deduce global coordinates.

The battery capacity sensor calibration is carried out in the following steps: (i) The battery is left alone until it is empty (0 volt) naturally, (ii) Wait for 3-5 hours to make sure the battery is empty (0 V), (iii) Charge the battery until full using the charger to full, (iv) Repeat the process of discharging and charging the battery up to three times to calibrate the battery capacity sensor.

Table 2. Integration of microcontroller pins (NVDIA Jetson Nano and Arduino Uno)

No	Port/Pin NVDIA Jetson Nano	Port/Pin Arduino Uno	Information
1	USB Port 1	-	as a camera for monitoring the “jajar legowo” track
2	HDMI Port	-	as monitoring the main remote control screen
3	USB Port 2	-	as a WMS-2000 transmitter port
4	-	Pin 2 Digital	As a cable for float sensor data (fluid tank capacity)
5	-	SDA	as a gyroscope sensor data channel
6	-	SCL	as canal or signal clock sensor gyroscope
7	-	Pin 10 Digital	as a DC motor PWM value data transfer
8	-	VCC	power for gyroscope sensor, float sensor, tension sensor
9	-	GND	ground for gyroscope sensor, float sensor, voltage sensor
10	GPIO 35	Pin 12 Digital	output transmission to LCD (fluid tank capacity)
11	GPIO 34	Pin 13 Digital PWM	output transmission to LCD (gyroscope sensor)
12	GPIO 36	Pin 9 Digital	PWM data output transmission to LCD
13		Pin 0 Analog	voltage sensor reading
14	GPIO 33	Pin 8 Digital	transmission of voltage output data to LCD

Fluid tank/float sensor capacity sensor calibration is carried out in the following steps: (i) Fill the tank with a reference fluid (water) until it reaches a certain level, (ii) Read the value indicated by the float level sensor, (iii) Adjust the value on the LCD with actual value (measurement using a ruler), then repeat the first and second steps until the value indicated by the float level sensor is accurate and corresponds to the actual level.

The boom sprayer/gyroscope balance sensor calibration is carried out in the following steps: (i) Place the gyroscope sensor on a flat and stable surface, (ii) Wait a few seconds to obtain an offset/zero value from the sensor, (iii) Rotate the gyroscope sensor at low speed until height in three different axes, (iv) Repeat step 1 to correct any offset values that may appear on the gyroscope sensor.

2.1.4. Software Design

Software design consists of programming language design. The C programming language and the Python programming language are used for microcontroller needs. The use of the C programming language is used on the Arduino Uno microcontroller, while the use of the Python programming language is used on the NVDIA Jetson Nano microcontroller. Making the Arduino Uno program code is done using the Arduino IDE software, while creating the Python program is done using Notepad ++ software. More specifically, the design of the programming language for the agricultural sprayer system is shown in Figure 4.

2.1.5. Design Monitoring System Design

The monitoring system design is designed with the aim that users can easily monitor data/results sent by the transmitter placed on the agricultural sprayer. The monitoring system (3-inch LCD), receiver and power are designed close together using a bracket designed using fusion 360 software and printed using a 3d printer machine. The bracket that is printed will also be attached to the main remote control system of the agricultural spraying machine. The infill used when printing is 80%, the goal is to get a strong print. In more detail, the design and printed brackets are shown in Figure 5.

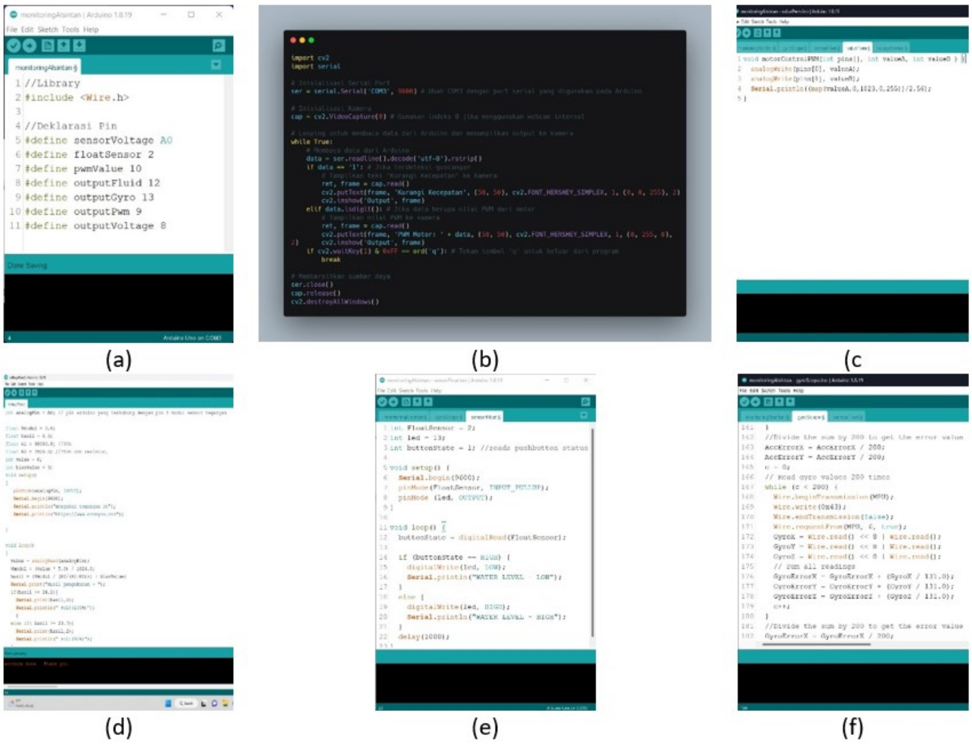


Figure 4. The design of the programming language for monitoring the agricultural spraying machine: (a) initialization of the Arduino pin and library (b) the camera sensor program code using Python; (c) motor program codes for PWM values; (d) battery capacity sensor program code; (e) tank capacity sensor program code; (f) boom sprayer balance sensor program code.

Figures 5(a) and 5(b) show sections of the bracket design for the 3-inch LCD (indicated by numbers 1 and 2), the bracket for the receiver section (indicated by number 4) and the bracket for the remote control section (indicated by number 5). Number 3 is a bracket switch to make it easier to on/off the LCD. More specifically, the part name of the monitoring system is in Figure 5.

2.2. Implementation and Testing Stage

At the implementation stage, integration is carried out between hardware devices and software devices that are made. After everything is integrated, then the testing stage is carried out. Stages of testing are carried out to determine the compatibility between hardware devices, software devices, and integration between the two. Tests on the monitoring system include: camera sensor testing, battery capacity sensor testing, fluid tank capacity sensor testing, boom sprayer balance sensor testing, data communication testing.

3. RESULTS AND DISCUSSION

3.1. Camera Sensor Testing

Camera sensor testing is carried out to obtain image/video data with high accuracy values. The camera sensor is focused on displaying images and detecting the "legowo" line. Tests were carried out on the detection CNN model and the "legowo" row line CNN model. The display of the camera sensor reading results for detecting the "legowo" line is shown in Figure 6.

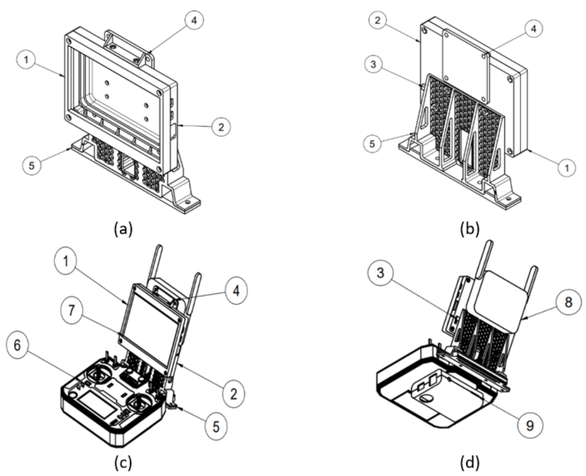


Figure 5. Monitoring system bracket design: (a) LCD bracket view; (b) the receiver bracket and the connecting bracket to the remote controller are visible; (c) complete appearance of the front design; (d) a complete view of the back design. (Part name: ① Cover LCD; ② Case LCD; ③ Switch; ④ Bracket Receiver; ⑤ Bracket Remote Control; ⑥ Remote Control Flysky FS 16x; ⑦ LCD 3 inch; ⑧ Receiver WMS 2000; ⑨ Power)

Figure 6. Display of the results of the "legowo" line detection

Figure 7 shows a continuous graph of training results per epoch, where the accuracy and loss values are well illustrated and are not overfitted. The final results of this model get a validation accuracy value of 99.43% and a validation loss of 2.13%. While Figure 8 describes the continuous graph of the training results of the CNN model of the “jajar legowo” path per epoch, where the accuracy and loss values are well illustrated and are not overfitting. The final results of this model get a validation accuracy value of 97.36% and a validation loss of 8.06%.

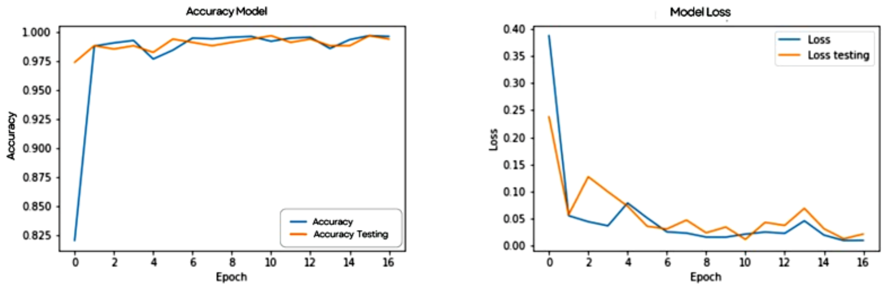


Figure 7. Graph of detection CNN model: (a) model accuracy; (b) loss models

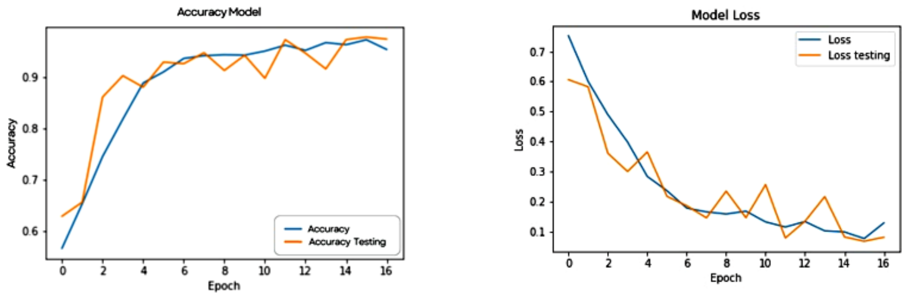


Figure 8. Graph of the CNN model of the “jajar legowo” path: (a) model accuracy; (b) loss models

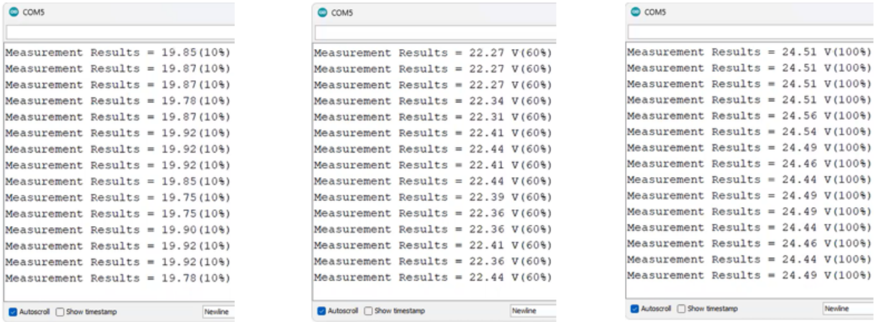
3.2. Battery Capacity Sensor Testing

The battery capacity test aims to determine the remaining battery capacity when used by embedded devices. The battery capacity test is equipped with several components, including a voltage sensor, a 20 Ohm/20 watt resistor, a 100 Ohm/20 watt resistor and a power supply (range 15 volts to 25 volts). This test is carried out to determine the remaining available battery capacity in percent units. The voltage difference is determined by a difference of 0.5V for each increase or decrease in voltage. Then the percentage of voltage is determined by a difference of 10% for each increase or decrease in voltage.

In principle, the researcher starts by making a variable declaration of the resistor used in the program code. Next, create a formula to translate the voltage value according to the power supply range. Thus, the value in percent units will be obtained by dividing the result of the translation of the voltage range with the resistor series circuit of the resistance used. The results of testing the battery capacity value are shown in Figure 9.

3.3. Fluid Tank Capacity Sensor Testing

The tank capacity reading sensor used is a float sensor. This sensor serves to read the volume of fluid in the storage tank. This sensor is able to read the condition of the volume of fluid in the tank with the status of "fluid available (logic 1) and fluid empty (logic 0). The working principle is that the float sensor uses a float containing an internal magnet and a rod with a tightly closed reed switch. As the float rises and falls with the fluid level, its internal magnets cause the switch circuit to open and close. The results of the float sensor test are shown in Table 3. The test was carried out on a holding tank with dimensions of 66 cm x 48.5 cm x 25 cm or capable of holding 80 liters of fluid.



(a) (b) (c)

Figure 9. Test results for battery capacity values: (a) 10%; (b) 60%; (c) 100%

Based on the tests carried out 10 times, it can be concluded that the true positive, false positive, false negative and true negative obtained are 5, 0, 0, 5. So that the accuracy value can be obtained by using equation 1.

$$Accuracy = \frac{True\ Positive + True\ Negative}{Total\ Prediction}\ x\ 100 \quad (1)$$

$$Accuracy = \frac{5+5}{10}\ x\ 100 = 100\%$$

Table 3. Float sensor test results

Replay	Prediction of Storage Tank Conditions of Float	Sensor Reading Conditions
1	Available Fluid	Available Fluid
2	Available Fluid	Available Fluid
3	Available Fluid	Available Fluid
4	Available Fluid	Available Fluid
5	Available Fluid	Available Fluid
6	Empty Fluid	Empty Fluid
7	Empty Fluid	Empty Fluid
8	Empty Fluid	Empty Fluid
9	Empty Fluid	Empty Fluid
10	Empty Fluid	Empty Fluid

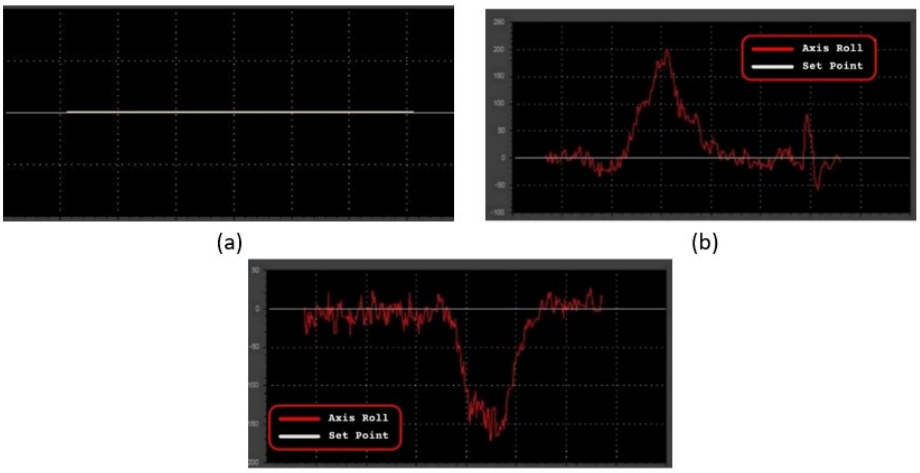
3.4. Testing of the Boom Sprayer Balance Sensor

The balance sensor used is a gyroscope sensor. This sensor works to determine the orientation of motion by relying on a wheel that rotates on a certain axis. Gyroscope sensor testing aims to determine the level of accuracy of the gyroscope in reading dynamic angular velocity changes from agricultural spraying machines.

The test was carried out on paddy field conditions/planting age of rice 38 days after planting. The condition of the “jajar legowo” track is still submerged in water with a hard pan / hard layer where the wheels of the agricultural spraying machine go as deep as 15 cm. The gyroscope sensor used will have an output value. If it rotates clockwise on the Y axis, the output voltage will decrease. Meanwhile, if it rotates counterclockwise, the output voltage will increase. If the gyroscope sensor is at rest, the gyroscope voltage output will be equal to the offset value. The results of testing the gyroscope sensor at rest, rotating clockwise with an angle of inclination of the X axis of about 10o and anticlockwise with an angle of inclination of the X axis of about 10^{o} are shown in Table 4. Meanwhile, the results of testing the response of the roll angle when tilted around 10^{o} are shown in Figure 10. The roll angle is the angle in the YZ plane with the X axis. The pitch angle is the angle in the XZ plane with the Y axis of rotation. The Yaw angle is the angle in the XY plane with the Z axis of rotation.

Table 4. Results of gyroscope sensor testing

Replays	Silent Gyroscope State			Circumstances of the Gyroscope Rotate			The Gyroscope Rotates Counterclockwise		
	Roll	Pitch	Yaw	Roll	Pitch	Yaw	Roll	Pitch	Yaw
1	0	0	0	10	0	-2	-30	1	-2
2	0	0	0	50	-5	1	-40	5	1
3	0	0	0	60	-3	1	-50	6	1
4	0	0	0	11	1	0	-10	0	-3
5	0	0	0	200	-5	-16	-10	0	-1
6	0	0	0	20	-1	-3	11	-1	0
7	0	0	0	60	-3	1	-60	7	2
8	0	0	0	10	2	0	-190	6	17
9	0	0	0	50	-5	1	-60	7	1
10	0	0	0	10	-1	-3	-10	0	-1



(c)

Figure 10. Response of roll angle: (a) tilt angle 0^{o}; (b) tilt angle 10^{o} to the right; (c) tilt angle 10^{o} to the left

Fuzzy logic is built from two input variables, namely the gyroscope sensor value and the PWM value of the electric motor wheel of the sprayer machine. The fuzzy logic of the sensors' readings is used to process the optimum PWM. In this study, to determine the optimal PWM, the researcher used the defuzzification value of the gyroscope sensor and the PWM value of the electric motor wheel of the sprayer machine to determine the optimum PWM value when the sprayer machine was running. The membership set for the gyroscope sensor value and the PWM value of the electric motor wheel of the sprayer machine was created using the Matlab application. The membership function plot of the input and output variables is shown in Figure 11.

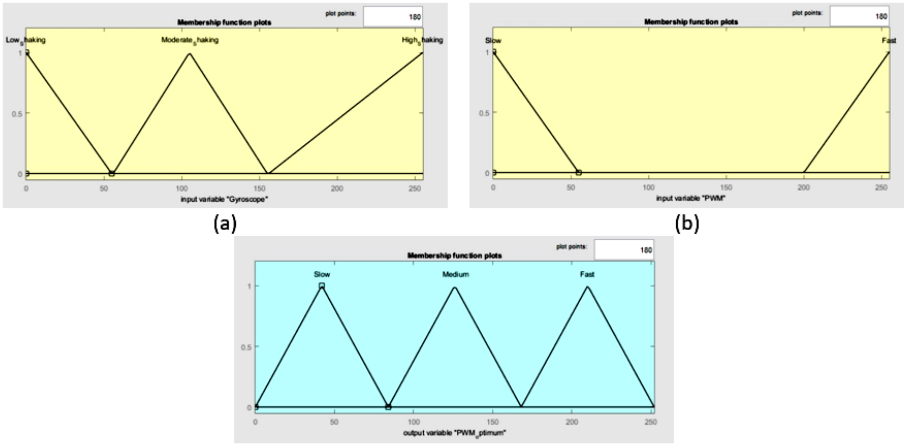


Figure 11. Membership function plot: (a) gyroscope sensor (input variable); (b) PWM electric motor wheel sprayer machine (variable input); (c) optimum PWM (variable output)

The results of the membership set of the gyroscope sensor (input variable) and the PWM electric motor of the sprayer wheel (input variable) produce a fuzzy rule base that applies to the optimum PWM (output variable). The fuzzy rule base is used to determine the optimum PWM fuzzy control value (output variable) using the "and" operator. Anfis If Than Else Rule The optimum PWM (output variable) is shown in Figure 12. The results of the “if than else rule” are used to determine the optimum PWM value (output variable) through a defuzzification process. The characteristics of the optimum "surface of anfis" PWM control (output variable) are shown in Figure 13.

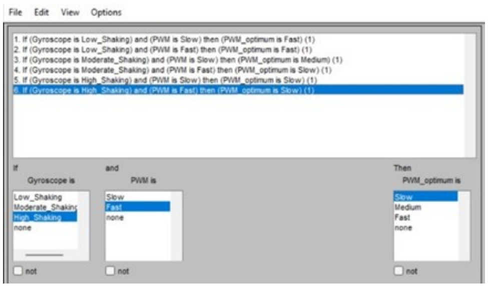


Figure 12. Anfis if than else rule

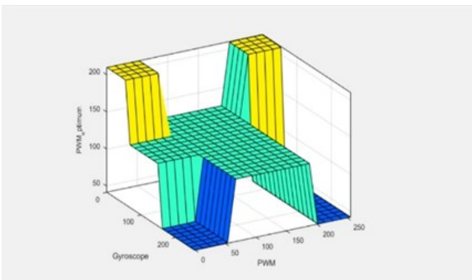
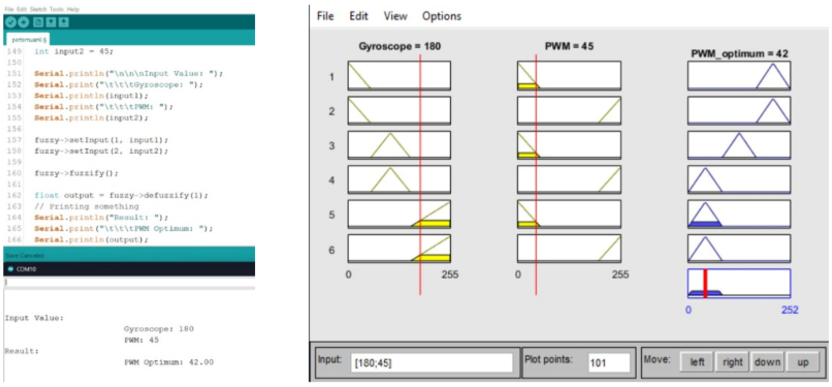


Figure 13. Surface of anfis controller

Testing the listing program applied to the microcontroller using the Arduino IDE is shown in Figure 14(a) showing the optimum PWM value control results which are the same as the Matlab simulation results in Figure 14(b). Figure 14 shows that the optimum PWM value obtained from the same input (both using Arduino IDE and Matlab software) produces an optimum PWM output value of 42.



(a) (b)

Figure 14. The results of testing the Arduino IDE versus Matlab simulation

3.5. Data Communication Testing

The system in Figure 14 describes the design of the physical network topology between the transmitter device components and the receiver device components. This system uses WMS2000 transmission media in the form of 5G local (Smart Wireless). The transmitter consists of: input components ((1) camera sensor, (2) boom sprayer balance sensor, (3) fluid tank capacity sensor, (4) battery capacity sensor, and (5) PWM value); data processing components (Arduino Uno and NVDIA Jetson Nano); and its own transmitter device (WMS2000). In more detail, the input component parts are shown in Figure 13. The receiver device consists of: output components (3 inch LCD) and the receiver device itself (WMS2000).

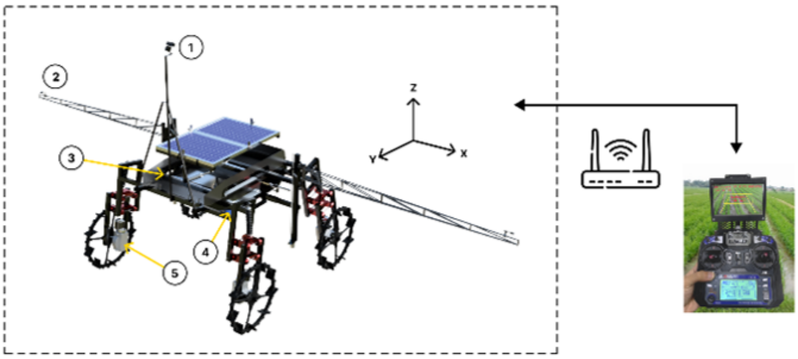


Figure 15. Data communication physical network topology

The working principle of the PX WMS-2000 communication, which is equipped with a receiver and transmitter, is that it can transmit images captured by the camera sensor to a 3-inch LCD via 2.4G and 5G networks. Meanwhile, the value from the reading of the sensors will be processed first by Arduino Uno and then sent to NVDIA Jetson Nano so that it can be transmitted to the 3-inch LCD. This is done because Arduino cannot transmit reading data from the sensors directly to the 3-inch LCD on the remote control. So that in this system, the performance of NVDIA Jetson Nano and Arduino cannot be separated. More specifically, the results of testing the success of data communication through the PX WMS-2000 are shown in Figure 16.

(a)  (b) 

Figure 16. Test results for the success of data communication through the PX WMS-2000

Figure 16 explains the success of the transfer of sensor-sensor data communication from the transmitter device component to the receiver device component. Figure 16(a) shows the successful transfer of Optimum PWM data, Fluid tank, battery. Meanwhile, Figure 16(b) shows the successful transfer of balance sensor data. “WARNING TOO FAST” indicates that the vibration value is too high.

4. CONCLUSION

The implementation of smart wireless-based data information monitoring using the NVDIA Jetson Nano and Arduino Uno microcontrollers on agricultural spraying machines has been successfully carried out. Utilization of camera sensors to monitor images and/or videos of objects on the “legowo” paddy field path in real time has been successfully detected. Camera sensors can recognize objects so farmers can remotely control the movement of the sprayer machine. The test results for the CNN model for the detection of the “jajar legowo” object were carried out to obtain 90% accuracy, 82.35% precision and 100% recall. Utilization of the tank capacity sensor used to determine the volume of water in the boom sprayer machine tank has been successfully made. The type of sensor used is a float sensor. This sensor can detect two conditions, namely the availability or absence of water in the tank. Testing the tank capacity sensor gets an accuracy value of 100%. The use of the balance sensor on the boom sprayer which is used to obtain optimum vibration data and PWM data (fuzzy method approach) has also been successfully carried out. The results of the balance sensor test show that if it rotates clockwise on the Y axis, the output voltage decreases, and vice versa. However, if the sensor is at rest, the output voltage will be the same as the offset value. Besides that, testing the optimum PWM value through a fuzzy approach is carried out with the aim that the droplets hit the target zone when the agricultural sprayer is working. The results obtained from Arduino IDE and MATLAB produce the same value. This shows that the data obtained is very good. Furthermore, the utilization of the battery capacity sensor which is used to provide data information on the availability of battery voltage in real time produces a value of 100% accuracy by showing that the difference in voltage increase of 0.5 volts is equivalent to the difference in increase of 10%. All information read by the sensors is displayed in the LCD via wireless communication (PX WMS-2000).

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