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Prototype System of Car Rat Detection Radar Using ESP8266 Microcontroller Based on Internet of Things

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***Abstract*— The advancement of technology in sensing and object detection systems has been widely applied in various fields. In object distance monitoring systems, radar systems are designed to address blind spots and measure approaching distances dynamically and accurately using ultrasonic waves. One utilization of object detection sensors is the ultrasonic HC-SR04 sensor. The ultrasonic sensor test aims to detect the accuracy of objects against rats that may appear in parked cars. This radar system implementation uses a buzzer and LED for sound alerts when a rat is approaching. This research uses the ESP8266 microcontroller as the control, to send the distance information received by the sensor via the Blynk application, and the buzzer gives a loud sound when the object approaches. This radar system can detect a maximum distance of 400 cm with an accuracy of 100 cm and a minimum distance of 2 cm at a 180˚ angle. Thus, the ESP8266-based radar system can provide accuracy in detecting the distance of objects detected by the ultrasonic sensor.**

Keywords— ***Radar system; ESP8266; HC-SR04***

I. INTRODUCTION

Rats are one of the obstacles that can disrupt human activities because they can damage property and spread diseases. Some parked cars often have issues with broken cables or dirty engine parts due to rats nesting under the car or hood. However, there are several weaknesses that rats do not like, one of which is sound. According to literature [1], the sound frequency that rats do not like is at a frequency of 23-50 kHz. Technology is constantly advancing and developing, providing various tools that can be developed as versatile and multifunctional prototypes. One component used as an information receiver prototype and detecting objects is the HC-SR04 ultrasonic sensor. This sensor is a versatile and cost-effective component that is widely used as a distance measuring tool in various applications. HC-SR04 utilizes electromagnetic waves to detect distances received through feedback [2], [3]. HC-SR04 can be used as a detector for objects within its reach [4]. HC-SR04 is not only used as a distance measuring tool but also as a radar system. Radar system technology has evolved since World War II, transforming from analog to digital technology, making its processing capabilities increasingly sophisticated [5]. The radar system is known as a tool to help detect objects and measure distances over a wide range through angles by utilizing electromagnetic waves [6]. In the application of components to be used as a long-distance monitoring system, the ESP8266 microcontroller is used. NodeMCU ESP8266 is an IoT platform commonly used as a WiFi module controller to collect information from connected sensors by processing, storing, and visualizing data remotely [7], [8], [9], [10]. The Internet of Things is referred to as a technology using the internet network, making it easy to obtain information remotely anytime and anywhere [8], [11], [12], [13], [14], [15], [16].

Previous researchers have conducted radar system testing using the ESP32CAM microcontroller applied in a bunker with the PWM (Pulse Width Modulation) method [6]. Radar technology utilizes the Arduino nano microcontroller component as the controller and can detect up to 40 cm at a 360˚ angle [17]. The application of radar systems in combination with PIR sensors and HC-SR04 sensors as object

detectors within range using Arduino Uno [18], [19]. HC-SR04 is applied to detect water levels using ESP32 as the control [20]. A radar system prototype is used to detect bird pests in rice plants using the ESP32 microcontroller [21] Konsep radar diterapkan sebagai pendeteksi tanda – tanda vital The radar concept is applied to detect vital signs of earthquake victims buried under rubble using drones as radar signal transmitters from above [22]. The application of radar to observe weather conditions using Web GIS and Android applications [23].

Based on previous researchers who have extensively developed radar systems, the author designed a prototype car rat detection system using the ESP8266 microcontroller based on the Internet. This prototype employs a servo that moves at a 180˚ angle, an ultrasonic sensor to monitor the distance of approaching rats, and a buzzer that emits a loud sound as the object gets closer.

II. METHOD

This research is developmental in nature using quantitative analysis techniques. The model used is ADDIE, which has five development stages including Analyze, Design, Develop, Implement, and Evaluate [24]. This model provides a structured framework to support the design and development process effectively [25], [26] .

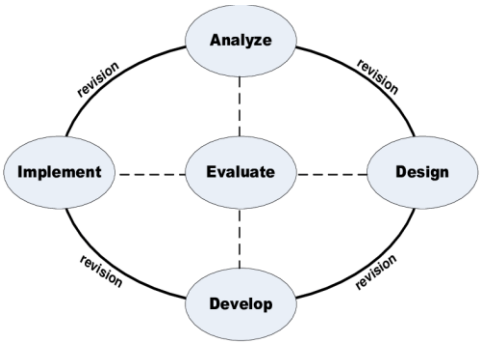

Figure 1. ADDIE Model

The research process is conducted in five stages, including:

1. Analyze

   The first stage involves data collection based on a literature review on the reliability of radar systems through the identification of existing radar prototypes.

2. Design

   The author creates a component design step as preparation for the tool testing process by making schematic diagrams and flowcharts as the workflow of the prototype system.

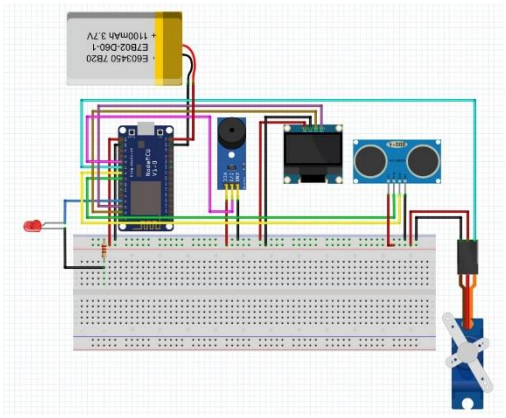

Figure 2. Prototipe Radar Schematic Design

3. Develop

   This stage aims to develop the implementation of the radar system utilizing the HC-SR04 sensor with NODEMCU ESP8266 as the main controller to send information about detected and undetected objects remotely and in real time.

4. Implementation

   The implementation process of the radar prototype is used as a tool to detect rats approaching the engine parts of a car, allowing space and distance to be covered by the HC-SR04 ultrasonic sensor.

5. Evaluate

   The final stage aims to evaluate the effectiveness of the radar installation under the car engine. The monitoring process of the radar prototype is tested when the car is in a parked position.

III. RESULTS AND DISCUSSION

A. Result

The test results are based on analysis of different distance and angle conditions, as a sensor calibration to measure distance accuracy through the reflection of ultrasonic waves received from the object.

TABLE I. ULTRASONIC SENSOR INDICATOR

Sensor Distance	Angle	Condition	Buzzer
400 – 61 cm	0 - 180˚	Safe	No sound
60 – 32 cm	0 - 180˚	Alert	Small Sound
31 – 2 cm	0 - 180˚	Danger	Loud Sound

The process of the system workflow is shown in Figure 3. The following flowchart.

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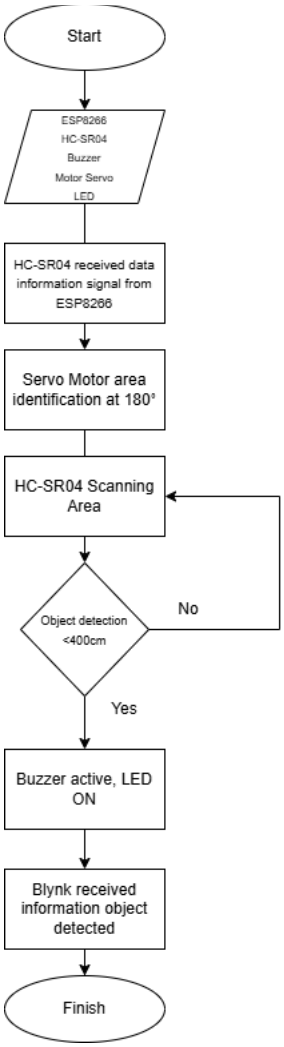

Figure 3. Flowchart radar system

The testing process is based on indicators of the radar's safety level on the targeted objects, with a safe range of 400 – 61 cm and a dangerous range of 32 – 2 cm. The prototype is installed under the parked car engine with the ultrasonic sensor facing downward, allowing the servo motor to rotate easily to the desired angle of 180˚.

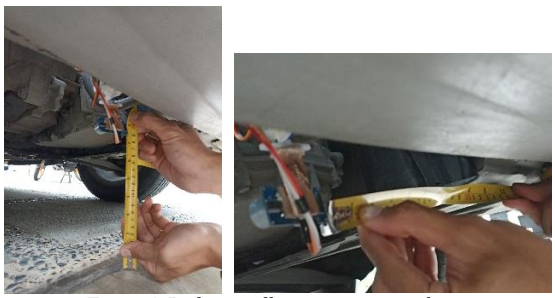

Figure 4. Radar installation position on the car

The sensor is installed at a distance of 19 cm from the ground and 20 cm to the side of the engine (Figure 4). This ensures that the prototype's position is unobstructed by any objects so that it can focus on detecting rats approaching or climbing onto the car engine.

Figure 5. Visualization of the process of radar detecting objects

Based on Figure 5. it shows that HC-SR04 receives signal information when an object is detected under the car when a rat is pottentialy climbing onto the engine.

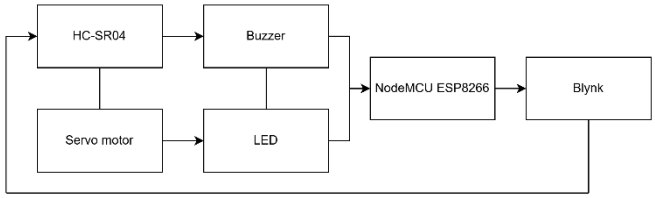

Figure 6. Process flow of components in a radar system

Figure 6 explains the prototype identification process for rat objects. The servo motor moves automatically along with the HC-SR04 sensor at a 180˚ rotation angle. With each rotation movement of the servo motor and sensor, the radar identifies approaching objects. When the detected distance is <400 cm, the buzzer and LED automatically sound, although the buzzer does not sound too loudly. The signal information received is managed and controlled by the ESP8266 microcontroller, which then transmits the distance and angle information as numbers to the Blynk application remotely (Figure 7).

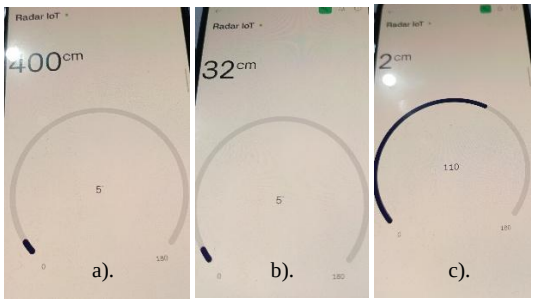

Figure 7. Sensor distance test results

Based on Table 1 of the sensor testing that has been conducted, Figure 7 part a) shows the safe distance from approaching rats, part b) identifies rats in an alert condition due to the potential to approach the car, part c) detected as a threat because the rats have approached the nearest part to climb onto the engine. Thus, from the testing, the test data table results are as follows.

TABLE II. TABLE HASIL PENGUJIAN PROTOTIPE RADAR

Number of test	Sensor distance	Angle	Buzzer	LED	Condition
Test 1	400 cm	5˚	No sound	Off	Safe
Test 2	360 cm	0˚	Small sound	On	Alert
Test 3	60 cm	160˚	Medium sound	On	Alert
Test 4	32 cm	5˚	Loud sound	On	Danger
Test 5	17 cm	5˚	Loud sound	On	Danger
Test 6	2 cm	110˚	Loud sound	On	Danger

The device testing has been conducted six times. These trials successfully demonstrated the device's accuracy in detecting at a distance of 360 cm at a 0˚ angle and the nearest distance of 2 cm at a 110˚ angle. Thus, in an alert condition, the buzzer is activated and emits a sound, although it is faint, the rats start to get disturbed by the sound emitted by the buzzer. As they get closer and detected by the sensor, the buzzer emits a louder sound.

B. Discussion

The application of HC-SR04 ultrasonic sensor is carried out on the angle control of RC aircraft using PID control [18]. Radar system developed by researchers [20] to detect flooding and utilize a buzzer as a warning sign. The ESP8266 microcontroller is a popular controller that is utilized to develop IoT-based prototype systems. Thus, in research [7], ESP8266 applied to control fire detection and warning system. Radar system developed as a tool for object monitoring using by applying the Pulse Width Modulation (PWM) method which produces a duty cycle value [1].

IV. CONCLUSIONS

Based on the analysis and testing conducted, this research concludes that the radar prototype system has successfully demonstrated the process of identifying objects at a sensor distance of 360 cm at a 0˚ angle and the nearest distance of 2 cm at a 110˚ angle. The sound produced by the buzzer effectively caused noise disturbance for the rats, prompting them to avoid the sound they received. Information can be monitored in real-time using Blynk as a remote application.

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