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PROTOTYPE SMART CAR MECANUM WHEEL FIRE EXTINGUISHER BASED ON ESP 32 CAM WITH BLUETOOTH COMBINATION

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ABSTRACT

The development of microcontroller technology has been implemented in the robotics industry, particularly in performing tasks that are risky for living beings, especially humans. In this context, a wheeled smart car robot can automatically extinguish fires. The fire extinguishing system is taken over by the robot's system when fire or heat is detected, and the robot's controller activates the extinguishing system, spraying water at the fire point. The ESP 32 CAM microcontroller serves as the processing and controlling unit, handling data and displaying real-time camera images to ensure accurate fire extinguishing. Additionally, a mecanum wheel drive mechanism is added to enhance the robot's movement flexibility.

Introduction

Fires are often caused by small things, it can be from a short circuit or from a fire that was originally small there is a saying that says small fire, friends, but big fire is the opposite (Fortna, 2018). The method used to extinguish the fire can be done manually by humans which we usually see done by professionals or firefighting jobs if the fire is large or if the fire is only small and medium can be overcome by APAR (light fire extinguisher). In addition, there is a safer way can reduce the risk of injury, namely by extinguishing fires automatically in other words, humans can control and monitor from a safe distance, one of the most popular is done with robotics in the form of smart cars, robots although not yet fully able to replace the role of anointed humans with large blazes in skyscrapers (Supriyanto, Sufiyanto, & Kusnadi, 2018).

Today's technology is growing over time, one of which is the Internet of Things (IoT) which can optimize several tools and devices for the better. The Internet of Things or better known as (IoT) is a concept that aims to expand the benefits of continuously connected internet connectivity (Lee & Lee, 2015). As for capabilities such as data sharing, remote control, and so on, including objects in the real world (Afriansyah, 2022).

Essentially the Internet of Things refers to objects that can be uniquely identified as virtual representations in an Internet-based structure (Atzori, Iera, & Morabito, 2017). Many benefits are obtained from the Internet of Things the work we do becomes fast, easy, and efficient. We can also detect and control it as long as it is still connected

to the network. The Internet of Things refers to the identification of an object that is represented virtually in cyberspace or the Internet (Akbar, 2019). So it can be said that the Internet of Things is how a real object in this world is described in cyberspace (Internet). The Internet of Things has the potential to change the world as the Internet once did, maybe even better (Suari, 2017)

Therefore, research was made which is a development of previous scientific writing based on Arduino Uno entitled "4WD automatic fire extinguishing robot system based on Arduino Uno". In the study, the movement of the robot to reach the fire spot was fully taken by three ultrasonic sensors and it turned out that after the trial was obtained, the time obtained was quite slow from the start of the active system to detect the fire spot (Yoski & Mukhaiyar, 2020). Then extinguishing it is certainly a problem if it is not overcome, therefore the development of scientific writing is expected to be optimal and efficient, especially when robots look for fire spots because in testing previous objects the longer the fire gets bigger (Fathoni, 2017).

For this development, the microcontroller base that used to use Arduino Uno was replaced with ESP 32 CAM which has been equipped with built-in WiFi and a camera module with a capacity of 2MP, of course, as the name implies, the Internet of Things (IoT) must be monitored through a WiFi connection emitted by a microcontroller (Azis, Pribadi, & Nurcahya, 2020). And the camera module is equipped with an adjustable flash that can be very helpful in dark conditions. All of the above is displayed on a smartphone complete with a remote control that has become a system, of course, it can speed up the robot in reaching the fire point because it can be directly directed without relying on the navigation system that previously used the HC SR04 ultrasonic sensor (Hilal & Manan, 2015). Then in this development, the control is entirely on the operator via a smartphone, remote control, and the last part, namely the extinguishing component, in this case, the jet of water is now more flexible because it can be directed with pan and tilt movements assisted by two servo motors.

Research Methods

Currently, robots are developed with various designs with certain purposes, one of which is a fire extinguishing robot. Fire extinguishing robots are a development of tools that can help to trace, detect, and of course, as the name implies, it is certainly able to extinguish fires which are usually in the form of various kinds of wheeled and legged such as smart cars, hexapods, and various others, of course, this tool can help humans. Fire extinguishing robots can be made using hardware and software controlled by various kinds of microcontrollers, both those that already support the Internet of Things or commonly called (IoT) or those that do not yet exist also in some cases, control is done using Bluetooth applied to smartphones with the Android operating system.

ESP 32 CAM

ESP 32 CAM is one of the microcontrollers that has additional facilities in the form of Bluetooth, Wi-Fi, cameras, and even to a microSD slot. ESP 32 CAM is usually used for IoT (Internet of Things) projects that require camera features. The ESP

32 CAM module has fewer I/O pins than the previous ESP 32 Wroom module, ESP 32 Wroom. This is because there are already many pins used internally for camera functions and microSD card slot functions. In addition, the ESP 32 CAM module also does not have a dedicated USB port (sending programs from the USB port of the computer). So to program this module you have to use USB TTL or we can add a module in the form of a special downloader for ESP 32 CAM.

Arduino Nano

Arduino Nano is a small board open-source microcontroller board and single board based on ATmega328P Microchip technology released in 2008. It offers the same connectivity and specifications as the Arduino Uno board in a smaller form factor.

The Arduino Nano is equipped with 30 male I/O headers, in a DIP-30-like configuration, which can be programmed using the Arduino Software integrated development environment (IDE), which is common to all Arduino boards and runs both online and offline. The board can be powered via a USB type B mini cable or from 9 V batteries. In 2019, Arduino released the Arduino Nano Every, the pin-equivalent evolution of the Nano. It features a more powerful ATmega4809 processor and twice the RAM.

Driver Shield L298N

It is a motor regulating module using the H Bridge range. The shape of this module is already in the form of a shield so it is suitable for use directly to various kinds of microcontrollers. Today, DC motors are used in the manufacture of many tools and fixtures. So, the speed and direction control of this motor is very common. The half-bridge circuit is one of the simplest methods of controlling a DC motor. This method not only controls the direction of the motor but can also be used to control the speed.

Results and Discussion

The fire extinguishing system with a distance from the fire spot can be said to be extinguishing the fire using the help of tools in this case in the form of a smart car robot. And full control on the operator for control the smart car for process blocks as can be depicted in the block diagram shown in Figure 1.

Figure 11. Block diagram system

In the block diagram above, ESP 32 CAM functions as the main processor of the controller with an activator in the form of a DC battery that outputs an output of 5V DC. Then input to run all commands based on the remote control smartphone displayed on the web server. There is a real-time camera captured by the camera module on the ESP 32 CAM then at the output, there are two servo motors and a drive, namely four DC motors controlled by the L298N driver based on the ESP 32 CAM command.

The components of the "Prototype Smart Car Fire Extinguisher Mecanum Wheel Based on ESP 32 CAM with Bluetooth Combination" have components, namely the ESP-32 CAM microcontroller, L298N shield motor, pan and tilt servo, DC water pump whose functions and explanations can be seen in Table 1.

Table 1

Component	Function	Information
Microcontroller ESP-32 CAM + *Driver Shield* L298N	System control center	Controlling the movement of the robot With *DC* motor input (*direct current*) and as a controller of the entire system.
Pan servo	Moving and transmitting the camera module on the ESP-32 CAM.	Move and march the camera module on the ESP-32 CAM to the left and right
Tilt servo	Moving and transmitting the camera module on the ESP-32 CAM.	Move and march the camera module on the ESP-32 CAM up and down
DC water pump	Spraying water	The system works based on user commands in the robot's control center.

In Table 1 there are components used in the tool made for this writing including an ESP 32 CAM microcontroller, two servo motors, and a dc water pump. The table also describes the functions and descriptions of each component used.

The system process when it will be run or started will first connect to the WiFi emitted by the microcontroller in this case using ESP-32 CAM then if the connection is

connected, the robot system will enter idle mode or be ready to use, otherwise the system will try to reconnect to the WiFi signal emitted earlier. In system idle mode, which means the connection is connected to a smartphone device, the system will wait for user commands or controlled users using a web server from the ESP-32 CAM microcontroller itself, which includes controlling the robot with the process as seen in the system process flow diagram Figure 2

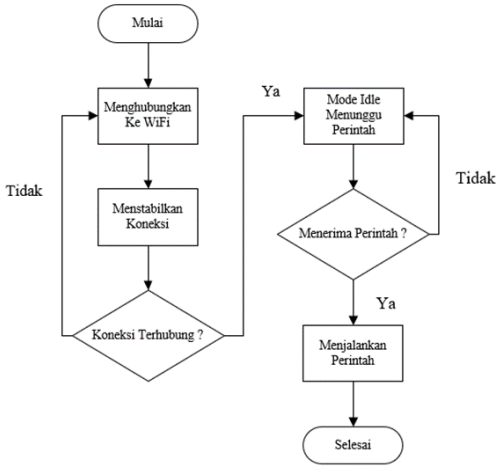

Figure 2. System flowchart

1. Network Schematic

The schematics needed for this "ESP 32 CAM Based Fire Extinguisher Smart Car Prototype with Bluetooth Combination" are as follows.

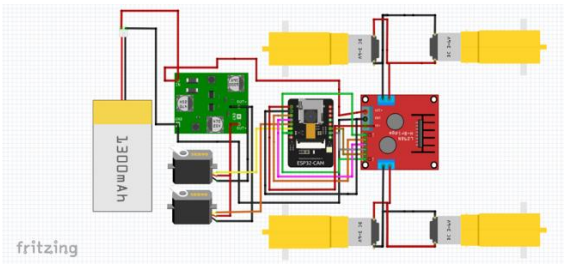

Figure 3 . Overall schematic

The schematic of the system circuit on the ESP-32 CAM and L298N Driver "Prototype Smart Car Fire Extinguisher Mecanum Wheel Based on ESP 32 CAM with Bluetooth Combination" looks like in Figure 13 with an explanation of the connection in Table 2 and the process on each pin and the connection to the microcontroller that has been adjusted to the commands as in Table 2.

Table 2
Koneksi ESP 32 CAM pada L298N Driver

ESP-32 CAM	L298N *Driver*
IO 2	ENA
IO 2	END
IO 12	IN 1
IO 13	IN 2
VOT	IN 3
VOR	IN 4
5V	5V
GND	GND

Table 2 explains that there is a connection between ESP 32 CAM on the L298N driver which is a connection for rotation and motion control of four DC motors by utilizing the H Bridge is a circuit that can adjust the voltage at the output with the reference to the PWM input given (Amanatiadis et al., 2020).

The servo motor used is the SG 90 type, a total of two pieces consisting of upper and lower servos mounted on pan and tilt brackets and the two servo motors can move the maximum bracket at 180 degrees in the left, right, up, and bottom directions in front of which is pinned with an ESP 32 CAM microcontroller so that when displaying a real-time camera on the web server, it can be controlled to look around by only moving the bracket assisted by two servo motors like a scheme in Figure 14. It has a 3-pin interface to the microcontroller with connections which can be seen in Table 3.

Figure 4. Bracket drive scheme

In Figure 14 there are two servo motors so that when installed on the bracket it will produce up and sideways movements.

Table 3
Koneksi ESP 32 CAM Pada Motor Servo

ESP 32 CAM	Motor Servo Pin
IO 14	PWM pan servo
IO 15	PWM tilt servo
VCC	VCC
GND	GND

There are two connections between the servo motors on the ESP 32 CAM microcontroller.

1. Magnum Wheel Drive

Due to its unique shape, the mecanum wheel allows omnidirectional movement (forward, backward, sideways, diagonal, rotating, etc.). This wheel works by applying force at a 45-degree angle to the rotation of the wheel. The combination of these forces allows the robot to move in different directions. Due to the mecanum shape of the wheel, turning the wheel causes it to apply force at a 45-degree angle to its rotation. The direction of rotation determines the direction of the force. The Mecanum wheel system is a wheel drive system used to drive this smart car. The design of the mecanum wheel system is done by making modifications to the wheel drive system or chain that was originally used in urban robots (Yeo, Balakrishnan, Selvaperumal, & Nor, 2022). The limitation of wheel or chain drive systems is the difficulty of changing the direction of movement of vehicles with a narrow bend radius. This greatly limits the flexibility of urban combat robot vehicles because routes for urban areas, especially dense settlements, have narrow and twisting road conditions.

2. Blackout with Bluetooth

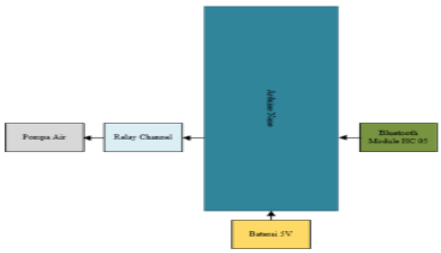

Figure 5 Block Blackout System Diagram

The Water Pump schematic uses a water pump that works at a voltage of 3-6 V DC because the microcontroller temperature is hot when given a voltage of 5V, then the inlet voltage is lowered to 3.7 V, but this makes the performance of the water pump used not optimal because the output voltage on each pin of the ESP 32 CAM microcontroller drops by the amount of voltage entering the VIN making the strength of the burst weaken because it will be maximum at a voltage of 5-6V so that the water spraying circuit is made separately but still controlled and integrated as a whole and can be controlled via smartphone with process and flow diagram blocks as in Figure 6.

Table 4
Komponen sistem pemadaman

Component	Function	Information
Arduino Nano	System control	Control the

Microcontroller	center	entire system.
Relay Channel	As a connecting switch and breaker	Forward Bluetooth commands to turn on and off the water pump.
Bluetooth Module HC 05	Bluetooth communication	The command turns the water pump on and off.
DC Water Pump	Spraying water	Spraying water from the water *storage tank*.

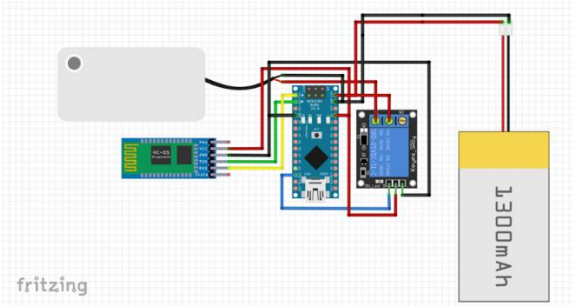

Figure 6 Schematic of the blackout system

Table 5
Koneksi sistem pemadaman

Arduino Nano	**HC SR 05**
RX	TX
TX	RX
VCC	VCC
GND	GND
Arduino Nano	***Relay Channel***
D 10	IN 1
VCC	VCC
GND	GND
Pompa Air	***Relay Channel***
VCC	*Normally close*
VCC voltage source	COM
GND	GND

1. Web Server Design Robot Fire Extinguishing Car

Robot control includes control of movement, limits on the rotational speed of DC motors, servo motors, and lights on microcontrollers controlled using a simple HTML web with the initial design as seen in Figure 7

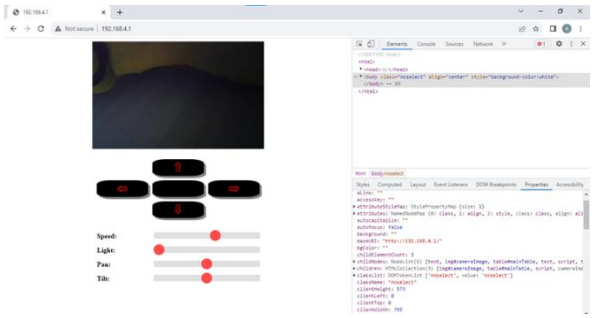

Figure 7 Web Server Design

In Figure 17, the initial design of the control includes the direction of rotation of the DC motor with movement controlled by the symbol of four arrows in the direction up, down, left, and right then there is speed, which aims to give a limit or limit on the rotation of the DC motor after that the control of the lights in the last light word control on two servo motors named pan and tilt. Pan itself is an upper servo motor that moves the bracket up and down while tilt is a servo motor that moves the bracket left and right.

The control display includes the direction of rotation of the DC motor with movement controlled by the symbol of four arrows with directions up, down, left, and right then there is speed, which aims to give a limit or limit on the rotation of the DC motor after that controlling the lights on the last light word control on two servo motors named pan and tilt. Pan itself is an upper servo motor that moves the bracket up and down while tilt is a servo motor that moves the bracket left and right.

1. Testing

Testing on this tool aims to test the circuit used and the work of the tool as a whole to know whether the tool that has been made can work as desired or not (Esario & Yuhendri, 2020). The test covers the performance of the components used including DC converter modules, servo motors, network coverage distances on ESP 32 CAM microcontrollers, DC motors, and DC water pumps.

ESP 32 CAM Network and Range Testing

The best and worst network range tests using this test distance parameter were conducted because almost all performance features depend on the WiFi network emitted by the ESP 32 CAM microcontroller. The test was carried out with two scenarios, namely with a barrier and without a barrier the barrier mentioned, which can be in the form of walls or partitions in the room, obtained test results as seen in Table 6.

Table 6
Pengujian Jarak WiFi Pada ESP 32 CAM

distance	No Barriers	Information	With Barrier	Information
1 M	- 46 dBm	Excellent	- 51 dBm	Good enough
5 M	- 47 dBm	Excellent	- 55 dBm	Good enough
10 M	- 51 dBm	Good enough	- 59 dBm	Bad enough
15 M	- 55 dBm	Good enough	- 61 dBm	Bad enough
20 M	- 60 dBm	Bad enough	- 65 dBm	Bad
25 M	- 75 dBm	Bad	- 83 dBm	Very bad

In Table 6 experiments were conducted six times with distances ranging from 1, 5, 10, 15, 20, and 25 meters with two scenarios namely without obstruction and with obstruction obtained the best results at a distance of 1, and 5 meters with unobstructed conditions obtained signals with strengths of -46, and -47 dBm (milliwatt decibels). While the worst signal is obtained at the farthest distance of 25 meters with a barrier obtained with a strength of -83 dBm (milliwatt decibels).

DC Motor Testing

Testing the condition of the DC motor is divided into two, namely the low condition (0) when the DC motor is not moving and the high condition (1) when the DC motor is active or moving (Bahari & Sugiharto, 2019). The voltage is measured on the output and ground lines, the results of the DC motor test data are carried out four times because the DC motor used is four pieces of DC motor capacity, the DC motor itself works at a minimum voltage of 3V, while if you want to get the maximum rotation, the DC motor must get an input voltage of 6V.

Pump and relay testing

Testing DC water pumps and relays aims to determine the performance condition of the relay and whether it is working normally or not. The test is carried out by giving commands on input signal 1 and off input signal 0 to turn on and off the relay so that it can be seen whether the relay can work properly according to its function obtained test results as seen in Table 7.

Table 7
Pump and Relay Testing

No.	Indicator	Input Signal	Relay *Conditions*	DC Water Pump Condition	Information

1.	Experiment 1	0	*LOW*	*OFF*	According to Conditions
		1	*HIGH*	*ON*	According to Conditions
2.	Percobaan 2	0	*LOW*	*OFF*	According to Conditions
		1	*HIGH*	*ON*	According to Conditions
3.	Percobaan 3	0	*LOW*	*OFF*	According to Conditions
		1	*HIGH*	*ON*	According to Conditions

In Table 7, after three experiments were carried out by adjusting the conditions of the input signal on the relay, quite good results were obtained, namely, all experiments got results that were by the conditions.

Conclusion

The results of system design testing show that after development with the addition of the Internet of Things (IoT) system, the system becomes better and more accurate compared to the previous version which relied on navigation from three ultrasonic sensors. The WiFi connection distance emitted by ESP 32 CAM shows the best signal at a distance of 1 meter without obstructions, with a signal strength of -46 dBm (Very Good), while the worst signal occurs at a distance of 25 meters with obstructions, with a signal strength of -75 dBm (Very Poor). Despite this, the robot can still be controlled well at a distance of 15-20 meters with even barriers.

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