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Doorbell monitoring system using ESP32-CAM based on Internet of Things (IoT)

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ABSTRACT

One use of internet of things (IoT) technology is in remote monitoring systems, for example home monitoring systems. One medium that can be used to control an IoT system is a messaging application. In this research, a doorbell monitoring system using IoT-based ESP32-CAM was designed by connecting the doorbell with the ESP32-CAM. ESP32-CAM is used as a microcontroller that connects all devices. The advantage of the ESP32-CAM is that it has Wi-Fi, Bluetooth, a secure digital (SD) card module, and a camera that is directly embedded on the board. The doorbell and ESP32-CAM are connected to each other with the door lock solenoid and power supply. To operate the tool, a Telegram messaging application is used using Telegram's bot. Telegram bots can be accessed with a bot ID and bot token created using BotFather. This system has no noise when the doorbell is pressed. The ESP32-CAM camera can take good quality images and testing on the chat bot went well. The door lock solenoid can work according to commands in the Telegram chat bot and all commands have been tested and provide information in the form of chat in the form of text and images. The research results of this system allow homeowners to see and monitor guests via smartphone in real-time with a time range of 3 to 6 seconds.

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1. INTRODUCTION

One of the things that people often do when visiting someone else's house is to press the doorbell. A doorbell is a tool that functions to inform the occupants of the house that a guest has come and wants to enter. The doorbell is one of the important tools to maintain social relations between the occupants of the house and the guests who come [1]-[3]. However, the doorbells that are commonly used by people today are still conventional, namely only a button that when pressed will make a sound inside the house.

Conventional doorbells have several limitations that need to be considered. First, conventional doorbells are not able to provide visual information to the occupants of the house regarding the identity of the guest who comes. They can only rely on the sound of the bell without being able to see the face or appearance of the guest. This situation can cause discomfort and even security risks, especially if the occupants do not recognize the guest's voice or are busy in the house. Second, conventional doorbells cannot be integrated with the occupants' smartphones. They are only able to communicate with the speaker in the house without being able to send any information to the occupants' cellphones. Finally, a bell is a tool that can make a sound that is used as a code, communication tool, and reminder tool [4]-[8]. Concerning the sound produced by the speaker from the doorbell, it sometimes makes the homeowner uncomfortable, often visitors will press more than once or even press several times, in some cases the homeowner has a baby and often disturbs the comfort of the baby who is sleeping.

In the digital era and the advancement of Internet of Things (IoT) technology, there is a great opportunity to overcome these challenges by utilizing microcontroller-based devices connected to the internet. The Internet of Things or IoT is currently continuing to develop and is widely used where with this technology we can connect objects such as lights, fans, smartphones, sensors and actuators to the internet so that we can control them and enable communication between objects and with humans. The use of IoT can be applied to devices for smart homes by utilizing ESP32-CAM with IoT technology. ESP32-CAM is a very popular microcontroller module because it has strong Wifi capabilities and integrated camera capabilities. The combination of these two modules allows the creation of a door monitoring system that is able to take pictures every time the doorbell is pressed or used. In this context, the use of a communication platform such as Telegram is an interesting solution because it allows users to receive notifications directly or access images taken by the system in real-time, even when they are not nearby.

Many tools have been created that can monitor and control remotely using the internet and smartphones. Internet of Things is a concept and method for remote control, monitoring, data transmission, and various other tasks. IoT is connected to a network so that it can be accessed anywhere which can make things easier [9]-[12]. IoT is able to connect objects with an internet connection so that remote monitoring can be carried out via the internet network [13]-[15]. There are several studies related to the creation of tools for IoT-based monitoring systems, such as in research [16]-[18], a system was produced that can monitor the use of electricity in real time which can be accessed from the internet network using Ubidot. Furthermore, in research, a system was produced that can monitor room temperature using the LM35 sensor which then temperature data can be sent wirelessly using the ESP8266 to the internet. There are many ways to create an IoT-based monitoring system, usually a combination of Arduino Uno and the Esp8266 wifi module. Arduino uno is used as a microcontroller which is the center of the system, and the ESP8266 wifi acts as a liaison between the system and the internet. Although this concept is promising, there has not been much in-depth research or implementation related to the use of ESP32-CAM in a door monitoring system connected to Telegram. Therefore, this study aims to design and implement such a system in more detail, as well as evaluate its performance, reliability, and usability in real situations. ESP32-CAM is a dual-mode WIfi + Bluetooth development board that uses an antenna and a PCB board core based on the ESP32 chip. This module can work independently as a minimum system, This module is a wifi module that is equipped with an OV2460 camera. From this module can be used for various purposes, for example for CCTV, taking pictures and so on. Another feature is that we can detect faces (face detection) and face recognition. Thus, this ESP32-CAM module can be used to take pictures, and can also be used as a wifi module to send data [19]-[20].

2. METHOD

A system block diagram is a picture of the system as a whole, which explains how the various components interact with each other. Block diagrams have several important functions in the final project, especially in project design and documentation, such as system visualization, hardware design, software design, dependency analysis and development plans. Figure 1 shows the block diagram of the proposed system.

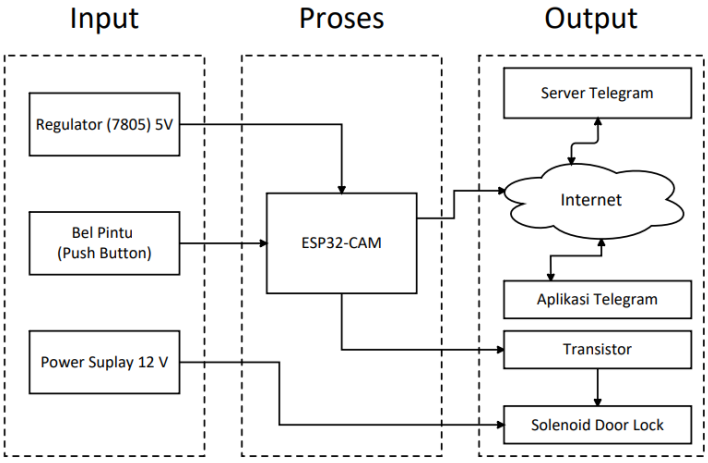


Figure 1. Block diagram of the proposed system

The working principle of the doorbell monitoring system design using ESP32-Cam based on IoT Telegram can be explained as follows: When someone presses the doorbell or approaches the front door area, the door sensor or button will detect this activity. Visitor activity will trigger the ESP32-Cam module to activate. This module functions as the main sensor to capture images from the front door. ESP32-Cam will take images from the front door. This process can be triggered by the activation of the door button, depending on the system configuration. The image capture distance is 1 to 5 meters. ESP32-Cam will connect to the WiFi network available in the vicinity. This allows the module to send the collected data to the cloud service or directly to the user's device. The image data captured by ESP32-Cam will be processed internally by the module. After processing, the data will be sent via a communication protocol to a cloud service or server running using the Telegram Bot API. The data captured by ESP32-Cam will be sent via the Telegram service using the available API. Telegram is a secure and encrypted communication platform, which will send real-time notifications to users. Users will receive a notification on their mobile device via the Telegram app when there is activity at the front door. This notification usually contains a picture or video captured by the ESP32-Cam. Users can control access to their Front Door Lock remotely using the Telegram app, by opening the Open or Close Lock.

Testing each component and program in the final assignment is very important, this must be done to see whether the components and programs are running well and as expected. This chapter will explain how to test each component (hardware) used. Based on the hardware testing, data and evidence will be obtained that will explain whether the program created in the software has run as desired.

3. RESULTS AND DISCUSSION

Testing each component and program in the final assignment is very important, this must be done to see whether the components and programs are running well and as expected. This chapter will explain how to test each component (hardware) used. Based on the hardware testing, data and evidence will be obtained that will explain whether the program created in the software has run as desired. Testing the ESP32-CAM module is carried out to determine whether the module is in good condition and can be used normally, testing the ESP32-CAM module is done by displaying images through the camera installed in the ESP32-CAM module. Based on the testing of the ESP32-CAM module that has been carried out, it can be seen that the module works well and can be used as a picture taking tool. Figure 2 shows the ESP32-CAM testing process.

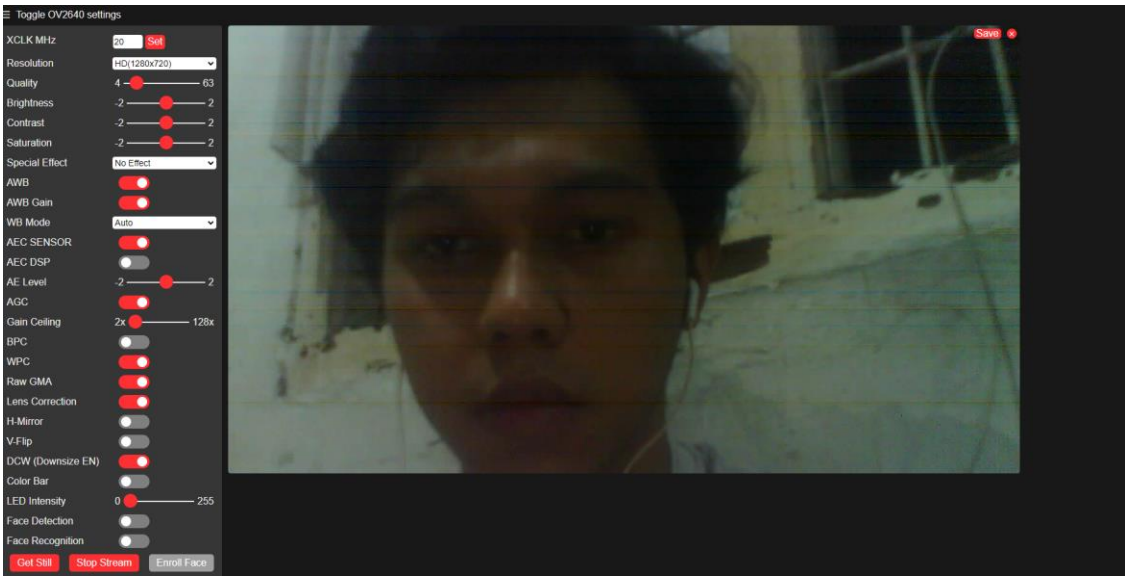


Figure 2. Check the ESP32-Cam Module

Telegram service testing is done to get a menu that will be used as a recipient of the required image results. Based on the Telegram service creation test, the author looks for data in the form of Token ID and also bot ID that will be needed when programming the Software, in the Botfather chat menu it is needed to get the token ID, and in the Bot ID chat menu it is used to get the Bot ID. Figure 3 shows the ESP32-CAM testing process via telegram.

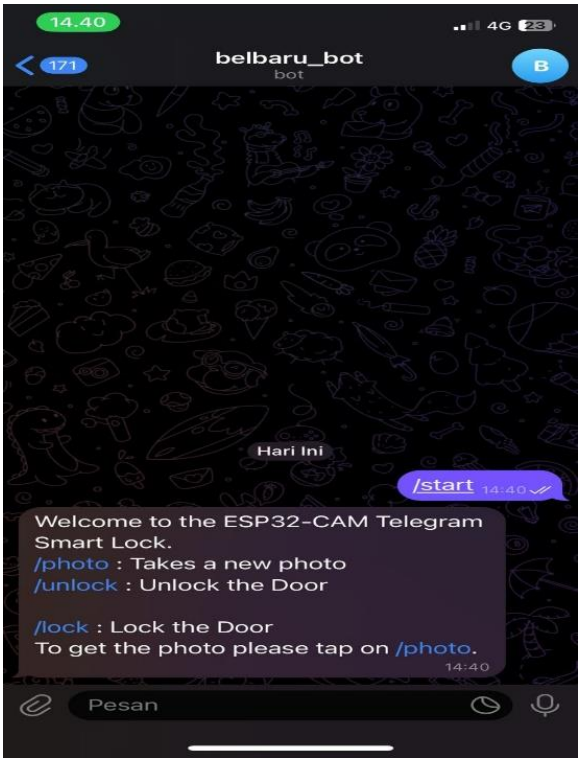


Figure 3. ESP32-Cam testing via telegram

Based on the tests that have been carried out, the application menu on the telegram is needed to obtain visitor information and also as a control on the solenoid door lock. Explanation of the use of the feature is when the /start command is sent, then the telegram replies by providing a menu in the form of a /photo command which functions to take a new photo, a /unlock command which functions to open the solenoid lock, and a /lock command which functions to close the solenoid lock. Overall testing is carried out after all the required components have been connected to each other. Testing is carried out when the equipment has been installed in the miniature house that has been made. Figure 4 shows the hardware design of the proposed system.

Figure 4. Hardware of proposed system

Figure 5. ESP32-Cam testing

Figure 5 shows the ESP32-Cam test. Test data can be viewed in real time on the telegram application that is connected to the ESP32-Cam module. And the solenoid door lock condition will work by calling the / lock and / Unlock commands. In the system error test, when the ESP32-Cam module does not receive a wifi signal, the command that will be given will not run the tool, but the command will be saved and will automatically run the tool when the ESP32-Cam module gets wifi conditions again. Tables 1 to 3 describe the test results.

Table 1. Testing door lock solenoid

No.	Camera Testing	Time (seconds)
1.	Test 1	4.50
2.	Test 2	3.92
3.	Test 3	4.20
4.	Test 4	6.28
5.	Test 5	4.14

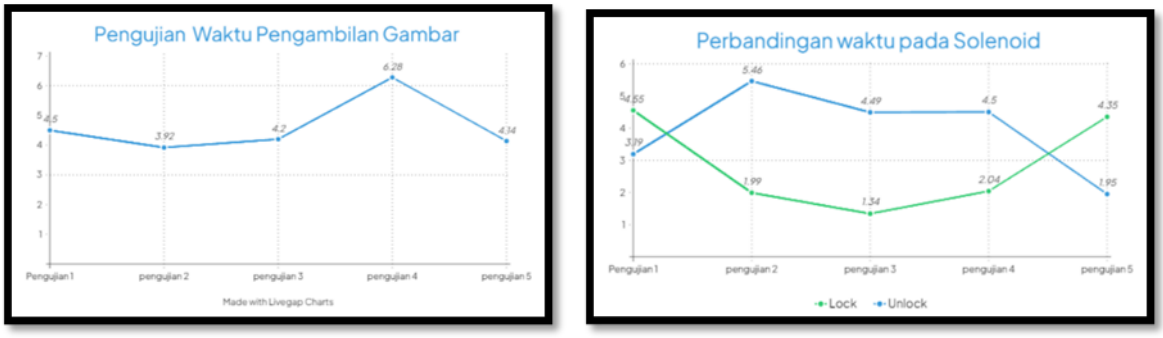
Table 2. Testing door lock solenoid

No.	Door Unlock Solenoid Testing	Time (seconds)
1.	Test 1	3.19
2.	Test 2	5.46
3.	Test 3	4.49
4.	Test 4	4.50
5.	Test 5	1.95

Table 3. Testing Door Lock Solenoid

No.	Door Lock Solenoid Testing	Time (seconds)
1.	Test 1	4.55
2.	Test 2	1.99
3.	Test 3	1.34
4.	Test 4	2.04
5.	Test 5	4.35

Figure 6 shows a comparison graph of the average time obtained when testing the camera, the solenoid in the unlock condition, and the solenoid in the lock condition.



(k) (b)

Figure 6. Experimental results

4. CONCLUSION

After conducting a complete test on the automatic cooling system based on this microcontroller, it can be concluded that the Telegram bot is able to give a command to take a photo to visitors and display the captured photo to the Telegram bot in real time even though the occupant is not at home. The tool successfully sends a photo to the bot after the doorbell is pressed, and there is no noise in the room. Taking a picture to be sent to Telegram takes around 3 to 6 seconds. Testing on the door takes around 2 to 5 seconds. The tool will work when the module is connected to wifi, if the module is not connected to wifi the command will only save but not run the tool.

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