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Application of ESP32-CAM for Cloud-Based Surveillance System in 3D Printing

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ABSTRACT

The working monitoring process at this time requires accuracy and foresight to maximize the work results. One of them is the process of manufacturing on a 3d Printing machine that requires monitoring, where the printing process is very susceptible to failure caused by several factors when the machine is processing. Therefore, innovations are needed to anticipate work activities by utilizing the Internet of Things (IoT) feature to perform the monitoring process anywhere and anytime. We propose the new development system using ESP32-CAM microcontroller to be used in this study by utilizing the wireless features found on the board. The working process can be adequately monitored by connecting the IP address tunnel from the local port to the ngrok Server. The design and manufacture of this tool use ESP32-CAM which has been applied to a programming language that is uploaded using the Arduino IDE. The final result of this research is the manufacturing process on 3D printing machines can be monitored in real-time and cloud-based. The monitoring process will display an image connected to the local port using tunneling from the ngrok Server.

Keywords: *ESP 32-CAM. Internet of Things, cloud platform, system on a chip, Monitoring System*

1. INTRODUCTION

Changes in times continue to make humans live to develop according to the times. Nowadays, humans live in the era of speed. All things around humans happen, such as supersonic speed and digital media are given special access to transfer from one data center to another to find out the movement of each process. With so quickly time passing and is very valuable, people always have to save time in everything, one of which is monitoring work that can be performed wherever they are. Security and work monitoring play an essential role in daily life [1]. Authorization helps humans to gain access to some authorized information [2]. Security not only helps in maintaining the peace of life but also helps in preserving human life. Many work activities that fail and end up harmful occur in the community due to a lack of monitoring. This explains the monitoring process to regard it as an essential issue. So there is a need to increase the level of security in monitoring for integrity maintenance [3].

Various jobs require special attention in the world of large and small industries. For example, a job that is currently well-known in terms of the need for monitoring is the process of manufacturing objects using a 3d Printing machine [4]. The printing process often takes a long time and the machine needs further attention for a successful printing process. Currently, the security of a suitable 3d printing machine is still just an alarm when the filament from the machine runs out [5]. However, print failures caused by parameters still often occur, especially when using new materials and printing forms that are quite complicated.

In this study, we introduce a new method for monitoring in the printing process on a cloud-based 3D printer that can be accessed from anywhere and at any time to ensure that the work performed by the machine runs smoothly and does not waste material that costs a lot of resources. The method used in this study is to use a microcontroller with a System On a Chip (SoC) ESP32 CAM with Wi-Fi and Bluetooth wireless capabilities [6]. The ngrok-based Server is another essential component of the research where data first comes from the ESP32-CAM using HTTP requests. The proposed system is low-cost and easy to maintain. This can help production operators to be able to monitor and carry out further execution if the machine is finished or a problem occurs during the production process. In addition, the monitoring process can help save hundreds of grams of printer filament material.

The proposed system consists of Arduino IDE software to write code and a smartphone platform used for monitoring processes from the internet. It consists of an ESP32-CAM module and USB to TTL serial conversion module as hardware components. The following system can assist in monitoring other work that takes a long time. The remainder of this paper deals with related work, proposed methodology, results and analysis, conclusions and references.

2. LITERATURE REVIEW

The ESP-32 WROOM module is the successor of the nodeMCU ESP8266 microcontroller, which Rui Santos introduced from Espresso System in 2016 [7]. This microcontroller is one of the earliest hardware-based designs for image detection using the integrated camera on the ESP32 CAM type. This schematic detects the image and the ESP32 CAM displays the image on the internet according to the IP address connected to the chip. Shortly after its introduction, the ESP32 microcontroller became fully integrated into industrial automation, particularly embedded system deployments and IoT tasks. Its significant advantages are its price, circuit structure, the possibility of connecting IoT peripherals and modules and other sensors.

The ESP32 chip is implemented as a web server, using wireless Wi-Fi communication, Bluetooth and most MQTT communication standards at the level of exchanging messages with the environment. As a result, it often works with compatible microcomputers such as the Raspberry PI and Arduino.

In a study about the Design and Simulation of Remote Monitoring System of 3D Printer Based on Cloud Platform [5], they implemented a design, simulation, and remote monitoring system on a cloud-based 3d printer machine. In this study, monitoring the temperature and engine parameters becomes one of the focuses of the final result, where they can control the machine parameters while operating via the internet. Furthermore, the printing machine is integrated with the external processor module to use sensors and control the hotbed and extrusion head.

In 2019 a study about the Design of Remote Monitoring System for 3D Printing Based on Cloud Platform [8] discussed the design of a remote monitoring system on a printing based on the cloud platform. In this study, the printing machine was applied to the Internet of Things (IoT) to determine the machine's status. The status obtained in this study are the print model, monitoring the status of the printing device, query the model printing process, and reasonably allocating the print resources. However, this research has not yet applied a monitoring system to be able to see objects directly during the printing process.

In embedded systems and monitoring, the ESP32 development variant with a camera can be used in this research, either integrated into the ESP32 Wrover board or connected externally. Furthermore, a comparative analysis of ESP32 and other modules with ESP32 recommendations for the IoT area is discussed. Thus, it is expected that ESP32 will play a significant role in designing future IoT systems and embedded projects. The performance evaluation in china [2] Enabling ESP32-

based IoT Applications in Building Automation Systems confirms the suitability of using ESP32 in low-cost applications with industrial-class performance. The results of this article are essential for developing inexpensive but reliable industrial solutions based on SoC.

3. METHODOLOGY

Designing a monitoring tool using ESP32-CAM is an essential part of this research. In order to achieve efficiency, it is necessary to design a system with proper attention to all programming tools and components. The design of the automatic lighting system, the quality of the captured image, to the setting of the image location are the main components in the programming applied to the ESP32-CAM.

3.1 Block Diagram

This study has a simple circuit to facilitate the process of designing and analyzing the tool by referring to the block diagram.

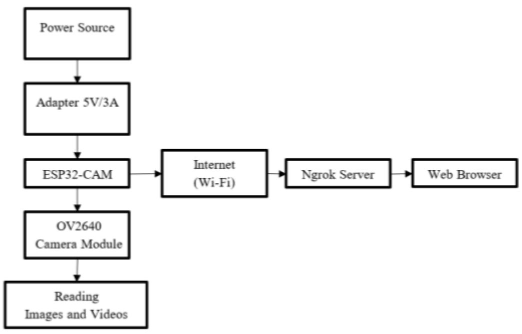


Figure 1. Block Diagram

The explanation of the block diagram in the design of the research above is as follows:

a. Power Source
The power source is a power supply for the components of the tool circuit.
b. Converter Adapter
The adapter converts the received AC voltage into a DC voltage form with a voltage value of 5V.
c. ESP32-CAM
This microcontroller functions as a module that can be used in the whole system and connects to the internet network.
d. OV2640 Camera Modul
This module functions as an image capture and work activity recorder from the printing process on a 3d printer machine.
e. Ngrok server
Ngrok functions as an exposing local server behind NAT and firewalls to the public internet through secure tunnels so that the resulting images can be accessed anywhere and anytime.
f. Web Browser
A web browser is used in this design to monitor work activities recorded by ESP32-CAM through a device.

3.2 Pinout Diagram of ESP32-CAM

The following Pinout schematic design of the ESP32-CAM is shown in figure 2.

Figure 2. Pinout Diagram of ESP32-CAM

3.3 Hardware Description

a. ESP32-CAM Microcontroller
The ESP32-CAM is a microcontroller with a camera module on the ESP32-S chip, as shown in Figure 3. The camera used is an OV2640, with several GPIOs to connect peripherals and a micro-SD card slot. This chip can also be connected using Bluetooth and Wi-Fi as wireless connectivity.

Figure 3. ESP32-CAM

b. OV2640 Camera Module
This camera is a module on the ESP32-CAM for image capture and recording in-frame on the board.

Figure 4. OV2640 Camera Module

c. USB to TTL Serial Conversion Module
We use the TTL module as a USB-to-serial converter in this design process, providing connectivity between USB and serial UART interfaces.

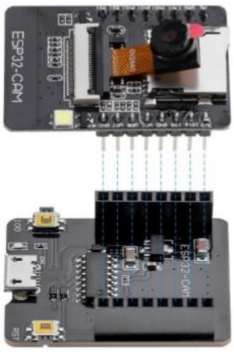


Figure 5. USB-TTL Serial Conversion Module

3.4 Software Description

a. Video Streaming
In this process, we program the ESP32-CAM using the Arduino IDE to write the program, compile and upload the program to the ESP32-CAM board. Furthermore, the board can connect to a Wi-Fi network. Programming is complete by setting the SSID and password, as shown in Figure 6.

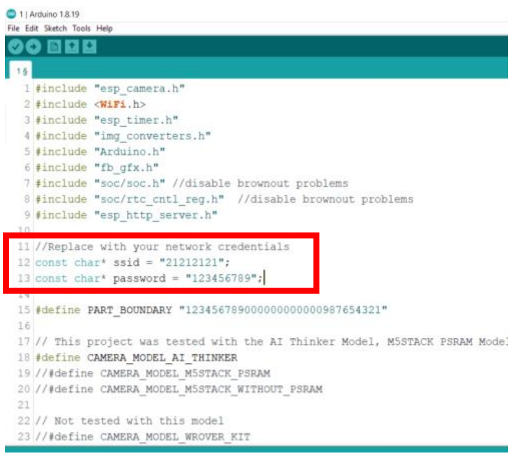


Figure 6. Program for Streaming Video

b. Ngrok Server
In this process, we use ngrok as a program that can create tunneling from the public internet to a local computer port on a Wi-Fi network connected to the ESP32-CAM. The Ngrok account registered and receiving the authentication token is connected to the tunnel shown in figure 7. The private network obtained on the ngrok Server is also used to access the web browser of the device we want to use as a monitor.

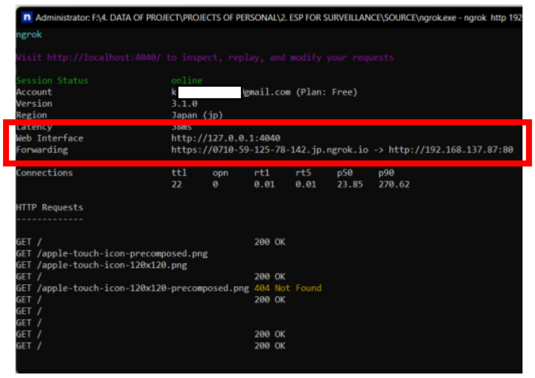


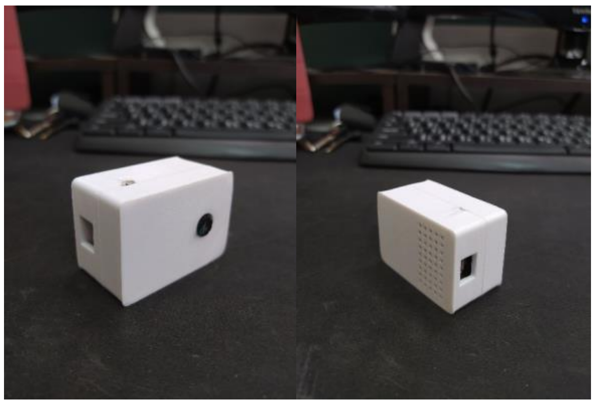
Figure 7. Ngrok Interface

The result of the registered authentication token is connected to the IP address of the ESP32-CAM connected to Wi-Fi. From the connection results, a forwarding link will be obtained to access the video streaming on the ESP32-CAM as shown in figure 7.

4. RESULT AND DISCUSSION

4.1. Experimental Result

The following is an overview of the ESP32-CAM used in this study. In addition, we have produced a case as a protector for this microcontroller. This case functions for ESP32-CAM can be protected from impact, water, dust and other components that can affect the performance of the ESP32-CAM as shown in figure 8. This case was produced through Solidworks software and manufacturing using a 3d Printing machine made of PLA Filament.



(a) **(b)**

Figure 8. (a) Front View of ESP32-CAM; (b) Side View of ESP32-CAM

The final application process is making a location for placing the ESP32-CAM on the 3D printing machine. This process adjusts from each desired view for monitoring the work process.

4.2. Testing on Arduino IDE

At this stage, ESP32-CAM is tested to connect to a Wi-Fi network set as a connection source.

From the results of connectivity, ESP32-CAM will get an IP address as an address to view streaming video results as shown in Figure 9.

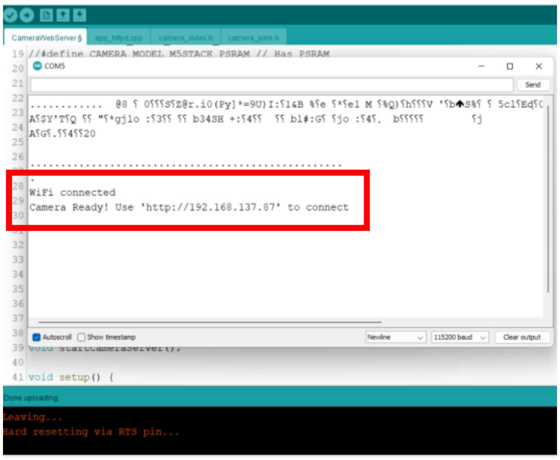


Figure 9. The IP address for ESP32-CAM

4.3. Testing on ngrok Server

At this stage, the IP address obtained through the Arduino IDE will be used as the primary address of the ESP32-CAM, which monitors the work on the 3D Print machine. The initial stage of this process is to connect the account to the authenticate token in ngrok, as shown in Figure 11. Furthermore, the IP address is used for HTTP tunnel forwarding on the Server's local port, as shown in Figure 12.

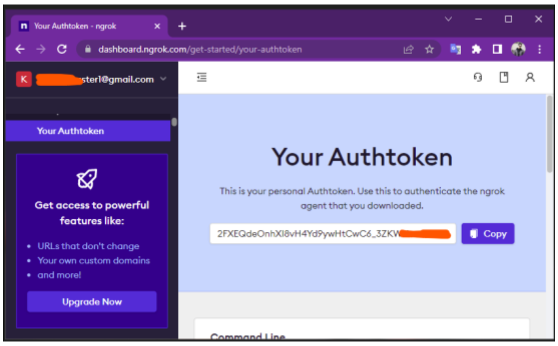


Figure 10. Ngrok account

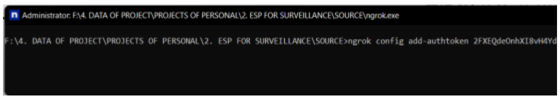


Figure 11. The IP address for ESP32-CAM

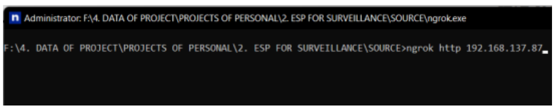


Figure 12. Start an HTTP tunnel forwarding to the local port

4.4. Testing of Video Streaming

From the results of the final process on the connection, connectivity testing is performed from several devices and through different networks.

The results in Figure 13 show that several features and advantages of the ESP32-CAM can be adjusted according to the user's needs. Figure 14 shows the process when ESP32-CAM that ESP32-CAM can capture images clearly and stream using a tunnel from the ngrok.io Server that has been integrated into the system.

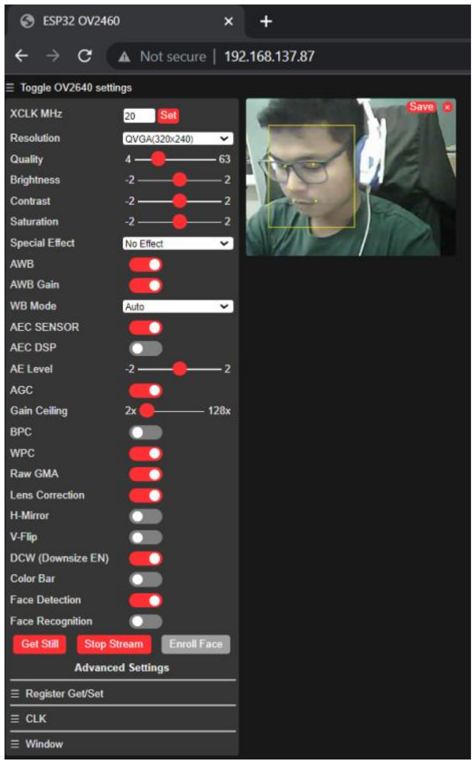


Figure 13. Feature of ESP32-CAM

(a) (b)

Figure 14. (a) Video When the print process fails; (b) Video when printing is successful

The OV2640 camera module used by the ESP32-CAM has several advantages compared to the Camera Wi-Fi available in the market. In addition to ESP32-CAM, various commands can be performed for Internet of Things (IoT) purposes. However, this module also uses low power consumption. The comparison of the system shows in table 1.

Table 1. Comparison with existing camera Wi-Fi

Methods Features	Avaro IP Camera PTZ	Yoose Onvif APK	Smart Camera V380	ESP32-CAM
Wi-Fi/ Bluetooth	Yes/No	Yes/No	Yes/No	Yes/Yes
Power Consump-tion	Medium	High	Medium	Low
Image Resolution	Full HD (1920x1080)	Full HD (1920x1080)	HD (960x576)	Full HD (1920x1080)
Feature	Audio, IR 10m, Motion Detection, night vision	Night Vision, IR 50m, Audio, Motion Detection	Face detection, IR 10m, Audio, Night Vision	All features in CCTV cameras except motion tracking
Price	Rp. 299.000	Rp. 423.000	Rp. 150.000	Rp. 115.000

Source: Internet

5. CONCLUSION AND FUTURE SCOPE

This paper presents the implementation and detailed design of a monitoring system using a cloud-based ESP32-CAM that is useful and the most economical and interactive using a tunneling system on a ngrok server so that the results of the image can be monitored via a web browser of any device. In our hardware-based designs, we have to learn about various aspects of the field and their implementation methods. A further notification-based alert system can be added to let the user know when the work process system fails or finish.

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