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DEVELOPMENT OF AN INTERNET OF THINGS (IoT) BASED SURVEILLANCE SYSTEM FOR EXAMINATION SUPERVISION

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ABSTRACT

Remote surveillance camera is used for detecting and averting illegal or suspicious activities in cities, campuses, business places, large gatherings and many other places. University examinations are faced with challenges of malpractices due to stress and an inadequate number of human invigilators. The Internet of Things (IoT) based remote surveillance camera system was developed to monitor students' conduct in the examination hall using ESP32 CAM project development board with an on-board camera for video capturing. The system was programmed with the Future Technology Device International (FTDI), powered with 5v dc and the Ngrok application was developed and used to access the system output remotely on the internet. The system was tested for surveillance from a remote distance over a local area network (LAN) and over the Internet which yielded satisfactory results. Furthermore, the captured image was fed into a trained face recognition model, and the candidate was recognized by name and matriculation number. The conduct of the examination can be effectively monitored in a wireless network over the local area network (LAN) and the wide area network (WAN) using the developed IoT-based remote surveillance camera system for closed supervision. The adoption of the study will enhance the supervision of examinations and reduce all forms of malpractice in the examination hall.

Keywords: *Camera, Examination, Internet of Things, Surveillance, Video*

INTRODUCTION

Surveillance means "to monitor", although every building requires some measures of security, monitoring activities in residential buildings are not very complex because threats to security in residential houses are restricted to limited geographical areas (Burkhalter, 2022). Supervision of examination is the act of keeping watch over candidates who are taking an examination to prevent them from indulging in examination malpractices and misconduct such as cheating (Waleed, 2023). Remote surveillance camera is used for detecting suspicious activity in cities, campuses, business places, large gatherings and communities (Uche *et. al*., 2021). This is very important as it helps in providing information needed to avert vices and malpractices in society. Capturing footage is usually done with the aid of cameras which must be continuously monitored, thus requiring constant network connectivity in other to be able to analyze the captured information and respond appropriately.

Other areas of application of remote surveillance cameras are in the surveillance systems for monitoring farms and properties from a far distance and in activities considered too dangerous for humans, like deep-sea exploration. It is also used for public safety and in asset protection devices for areas where it is not possible or affordable to install a cable network (Uche *et. al.*, 2021). Although close circuit television (CCTV) has been used in the past as a surveillance system, CCTV technology is faced

with some problems. One such problem is the high cost which makes it unaffordable for many people and purposes. It is also very large in size which makes it easy for people to detect. In addition, the CCTV system is also faced with the challenge of data loss which occurs when cameras are not properly configured or if the recordings are not securely stored. Also, it must be noted that while CCTV cameras can help provide some remote monitoring, they are not always effective against cyber threats (Nath and Rana, 2022; Burkhalter, 2022).

Surveillance involves monitoring, however the traditional means of monitoring residential places are limited to certain geographical locations and affected by stress. Real-time video surveillance and video capturing are accessed in a limited location from a central setup for surveillance (Kulkarni, 2019; Uche *et. al.*, 2021). This is not good enough for events like school examinations. Supervision of examination requires keeping watch over candidates that are undergoing examination to prevent examination malpractices and misconduct. Supervision can take two forms namely physical or remote supervision. Physical supervision involves using human invigilators for the supervision of examination while remote supervision involves the use of cameras to remotely monitor the students, either in paper-based and computer-based examinations. Examination being a means of evaluating students' understanding of the subjects being taught is a vital element of education that must be properly guided. Any action or issue that can disrupt or discredit the conduct of examination will hamper the goals of learning and hence the overall development of any nation (Al-airaji, *et. al.*, 2022; Xue *et. al.*, 2023), this is why examination supervision is very important in schools.

One of the major problems Nigeria and other developing countries of the world have been battling with over the years is the lack of proper monitoring and supervision of examinations which has seriously affected the quality of education and the acceptability of the academic credentials of these countries at the international level. Although human invigilators or supervisors have been employed in several examinations, they are affected by sentiments and fatigue (Mhasin and Khatri 2019; Genemo, 2022). Therefore, an automated system for invigilating examinations is more effective especially if it is being done remotely without having to be physically present in the examination hall using the Internet of Things (IoT).

This study aimed at providing a real-time system for offline and online monitoring of students' conduct in the examination hall with the capability of identifying the culprits with evidence. While the efforts of other researchers are commendable, the concern of this research is beyond the mere detection of suspicious movements of students without means of identifying them as seen in previous studies. Mare gestures and body movements could be disputed but the video of the actual occurrence with face identification of the offender will be strong exhibits against the offender.

Related Works

This section gives a report of related research that has been conducted by researchers in the field of security and IOT-based systems for monitoring examination and other security purposes. This would help in knowing the start-of-the-art as regards the field of research.

Kulkarni (2019) presented a study on Real Time Automated Invigilators in Classroom Monitoring Using Computer Vision. It was done by using computer vision techniques and developing a proficient examination invigilating model to detect the students' movements, poses, and expressions. The study suggested using Inception V3 for

detection works better and produces a 10% lower error rate instead of separately using segmentation, classification, and recognition algorithms.

Eziechina, Ugboaja, and Esiagu (2019) in Closed-Circuit Television Surveillance: An Antidote to Examination Malpractice in High Institutions in Nigeria. This paper discussed how CCTV has an advantage in supervision over human supervision stating that the CCTV surveillance advantages are video surveillance of examination, deterrent effect on potential offenders and evidence of occurrence or non-occurrence of malpractice. They discussed the components of CCTV cameras which are the camera, recorder, and monitors and how they can be used to curb examination malpractices.

Nishchal *et al.,* (2020) worked on automated Cheating Detection in Exams using Posture and Emotion Analysis. They worked on a project on detecting the cheating of students using the Open pose. The poses of the students were extracted by fetching the multiple joints of the body which increased the computation of the model and hence achieved only 63% accuracy. Because of this, the system may not be good for real-time application.

Guduru and Tatavarthy, (2020) developed an IOT-based home monitoring system. This system is used for theft detecting and monitoring children and pets. In this way, this system helps in home monitoring. Hardware used are Arduino, ESP 32-CAM buzzer, and PIR sensor to detect motion. Arduino is the main microcontroller and PIR sensor, which detects movement. An ESP 32 camera module is installed which can show the user what is going on in the house. The buzzer is also used to scare off an intruder or pet if there is any unwanted activity taking place. This system is more suitable for farms and some domestic control as it is not particularly designed for examination environments.

Khairnar *et al*., (2021) presented the use of Rasberry-pi-based IoT to control home appliances. It made use of Raspberry interfaced with a camera and wifi modem for transmitting and receiving commands over the internet. Once instruction is passed over the internet to switch on the appliance, the Raspberry Pi processes this command, and instructions and operates accordingly. Hardware used are Raspberry Pi, diode, LCD and resistor. The software used is Rasphian Os. This is an intrusion detection system, it cannot identify people.

Xue *et al.* (2023) proposed an intelligent examination invigilating system based on the efficientDet target detection network model and centroid tracking algorithm for online examinations. The model was trained to monitor students' behaviour in the examination as the basis for its classification. It recorded an accuracy of 81% but it was based mainly on the attitude in examination not detecting the actual act of malpractices, it was also designed for online examinations only.

Internet of Things (IoT)

The Internet of Things is a network of smart devices connected for the exchange of data through the Internet without human involvement. IoT architecture consists of wireless networks, cloud databases for the transmission of information, sensing devices, data processing systems and smart devices. These components interact closely with one another as IoT layers thus (Manohar, *et. al.*, 2018; Khairar *et. al.*, 2021):

i Smart devices collect, store and share data about the environment and other devices and components.

ii Embedded systems are used by smart devices, they include various processors, sensors and communication hardware. They are used to collect, send and act on data they acquire from environments.

iii IoT gateways are switches, hubs and other edge devices that route data between IoT devices and the cloud.

iv Cloud data centers operate with remote servers that exchange data through wireless connections.

IoT technology finds applications in various fields such as manufacturing, agriculture, healthcare, logistics, energy and education. Smart devices range from cameras to various sensors depending on the IoT goals and architecture (Khairar *et. al.*, 2021). There have been several studies in the field of automated surveillance systems, and closely related ones were carefully reviewed before embarking on this design.

METHODOLOGY

This section explains the hardware interactions with a cloud server using Wi-Fi to connect to a local hotspot to remotely transfer the data specifically for remote surveillance-based applications. The hardware used in this project was a high-performance low-cost, low-power power and Wi-Fi-enabled development board: ESP32CAM board with an integrated camera. It has multiple general-purpose input and output (GPIO) for interfacing with external input and output devices.

System Architecture

The system architecture is shown in Figure 1. It describes an abstract design and implementation of the remote surveillance camera for supervision of examination using IoT. This study unified ESP32 chip controller, chip embedded with WI-FI, camera and micro-SD card.

System Flowchart

The system flowchart shown in Figure 2 describes the step-to-step function of the system. When power is supplied to the system with the availability of a Wi-Fi hotspot to connect, the ESP32CAM is turned on. It begins the execution of the code in the controller which initializes SD card storage and the camera module.

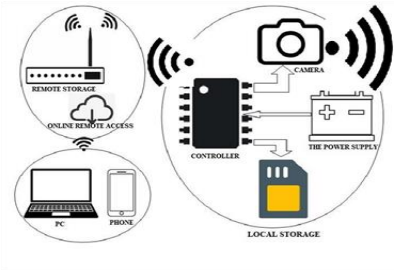

Figure 1: The architecture of the IoT-based remote surveillance camera system for examination supervision.

It connects to the Wi-Fi hotspot, with a Wi-Fi credential and then connects to online storage. If the connection is not true it keeps reconnecting until it is true. When it is true it begins to capture images and upload them into the local storage and the online storage where they can be accessible in real time. On the other side (a remote location), where it will be monitored, the user can use a mobile smartphone or personal computer to access the online storage in real time to monitor what the system captures.

Hardware Components

The hardware components are the physical components used in implementing the research. Table 1 shows the major hardware components used in actualizing the system. As shown in Table 1, the description of the hardware component used for the development of this system is analyzed. Components like power banks, USB cables and wires were discussed and described.

ESP32 Microcontroller

Processing of data was carried out in the ESP32 microcontroller which is a system on chip (SoC) widely used for IoT and related projects.

Table 1: List of Components

S/N	NAME	DESCRIPTIVE TERM
1	ESP32CAM Module	IoT microcontroller
2	FTDI Programmer	USB-to-UART interface
3	Power Bank	Power storage system
4	Switch	Power switch
5	Wires	Connecting wire
6	USB Cable	Universal Serial Bus Cable

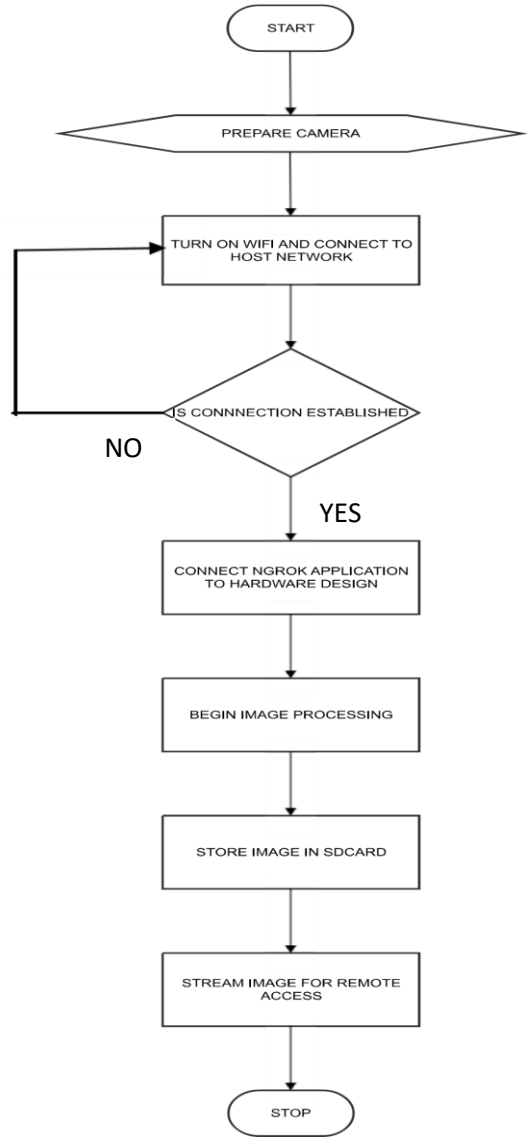

Figure 2: System Flowchart

The microcontroller is rugged operating effectively up to 80^{oC} temperature, needing just 3.3v and 80mA dc to power. It uses 448KB ROM, 520KB SRAM and integrated connectivity protocols – WiFi and Bluetooth, operating at a frequency of 40MHz. The ESP32 development board architecture is shown in Figure 3.

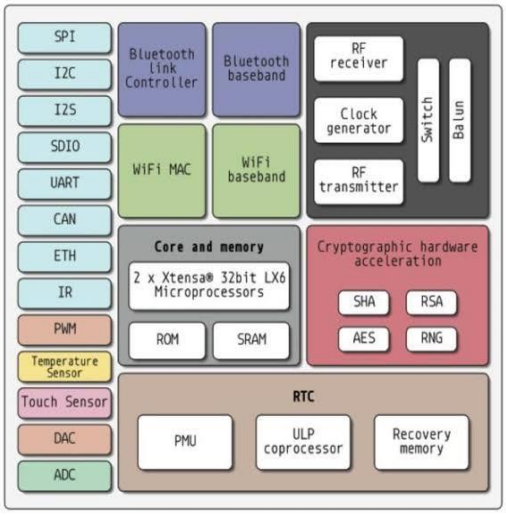

Figure 3: Architecture of ESP32 development board

Software Component

Arduino IDE was used for developing the control program for this research because it is open-source software that is mainly used for writing, compiling and uploading directly into many supported microcontrollers. Several Arduino IDE versions have been released over the years. There are numerous microcontroller boards also that are supported by IDE for programming. The microcontroller board includes Arduino Uno, Arduino Nano, Arduino Mega and many more. The Arduino IDE version used for this work is version 1.8.8, this is not a recent update but a stable version and it is an open source. This is the main purpose of this environment in this project. The physical connections of the ESP32 board with the camera and Arduino board are shown in Figure 4.

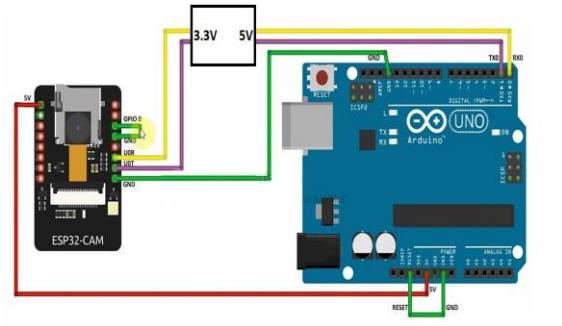

Fig. 4: Physical connections of ESP32 board with camera and Arduino board

Ngrok Application and Web Browsers

The Ngrok Application was used to exchange data with the Ngrok server. This application is available both in the App Store for IOS phones and Google Play Store for Android OS phones. It is the mobile interface between the smartphone that was used and the Ngrok server. An account was created to get access to the controls available in the Ngrok system. The browsers are of great importance as they are used to read and render web pages, play web games, analyze data, run simulations and all sorts of things that usually run on popular operating systems. However, they can be leveraged as the primary operating systems. They serveas messenger apps that are used to communicate between web servers and web users. The browser can also be used to view local server and remote servers. In this study, the web browser was used mainly to access a local remote and internet-based server.

Although several web browsers work on almost all mobile smartphones, computers and tablets. This research was implemented using Google Chrome because of its speed, simplicity and security. Google Chrome was fitted with the fastest and most powerful JavaScript engine, its omnibox and multi-tabbed features make it very easy to use when comparing several web pages. Google Chrome also has inbuilt malware and phishing protection which ensures the security of data.

RESULTS AND DISCUSSIONS

The IoT-based remote surveillance camera system was tested to evaluate its performance. Three tests were carried out and the results obtained are shown in Figures 5, 6 and 7, respectively. The tests and the results are analyzed thus:

The first test carried out was on surveillance from a remote distance over the LAN. The result as shown in the screenshot in Figure 5 reveals that the clear video output can be accessed with the use of the web camera. The video quality can also be observed and adjusted for detail identification

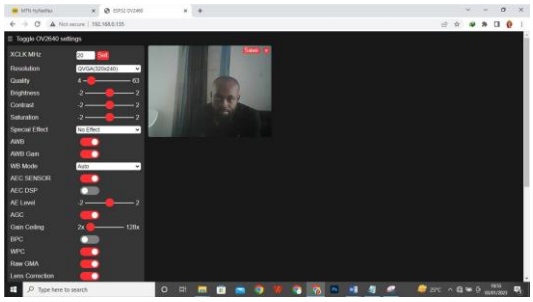

Fig. 5: Screenshot of Remote Surveillance Over LAN

The system was further subjected to tests in carrying out surveillance from a remote distance over the internet. The screenshot of the ping of the transmission over the internet is shown in Figure 6. It was observed that the delay time before the camera is accessed is based on the internet speed.

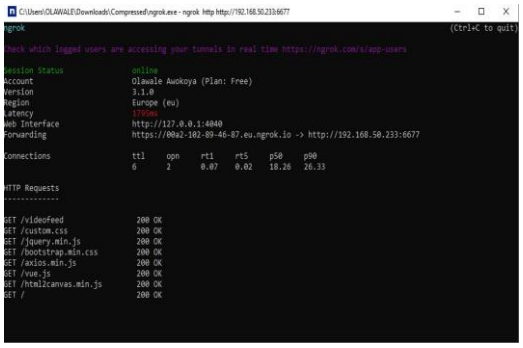

Fig. 6: The Ping Screenshot Transmission Over WAN (Internet)

In the third test, the captured image was fed into a trained face recognition model. From the result, as shown in Figure 7, the system was able to recognize candidates by name and registration or matriculation number which can be accessed locally with a wireless connection or on the internet.

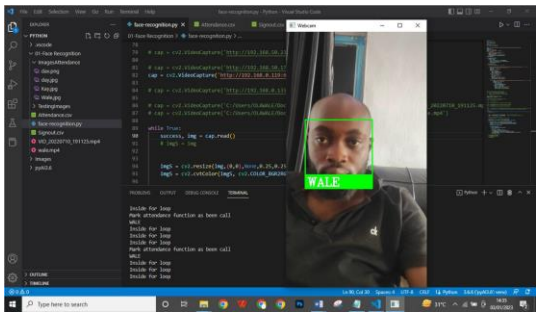

Fig. 7: The IoT-Based Remote Surveillance Face Recognition Screenshot.

CONCLUSIONS

The IoT-based remote surveillance camera system developed has provided a simple but intelligent way of invigilating examinations. Its ability to stream video of activities over a local network as well as over the internet with clarity will enhance a seamless way of ensuring security in examination halls, investigation by security agents and monitoring patients in intensive care units of hospitals. The face recognition feature has elevated this study beyond a misconduct or crime observatory unit to an intelligent detection system for security in sensitive environments. Examinations can now be monitored over a wireless network over the local area network and the wide area network anywhere in the world and records of malpractices accurately made using a surveillance camera for a closed supervision. Impersonation which is one of the major examination malpractices can be curbed completely using the system with the help of face detection and face recognition. Future research should focus on making the system detect other methods of examination malpractice such as side talk, body language and posture detection. The system should also be worked on to reduce its sensitivity to lighting and illumination.

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