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Vision Safe (ESP32 Cam-Based Eyeglass Monitoring Solution with Eyewear Detection System)

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Abstract: *This paper explores the integration and capabilities of the ESP32-CAM, a versatile development board combining the ESP32 microcontroller with the OV2640 camera module. Emphasizing its cost-effective solution for Wi-Fi-enabled cameras, the ESP32-CAM boasts a potent 32-bit microcontroller and microSD card support, making it ideal for diverse IoT projects. Its applications in security surveillance, particularly in DIY security projects and home automation, further underscore its versatility in remote monitoring and surveillance.*

Security is a top priority for the ESP32-CAM, featuring a secure boot to authenticate firmware and robust encryption protocols ensuring secure Wi-Fi communication. Over-The-Air (OTA) updates enhance security by allowing remote firmware updates while maintaining data integrity. Access control measures, strong credentials, regular updates, and network segmentation fortify security at both device and network levels.

The paper delves into the critical application of eye glass detection in industrial settings, emphasizing its role in ensuring occupational safety, regulatory compliance, and accident prevention. The ESP32-CAM's proactive approach in identifying non-compliance in hazardous areas contributes significantly to workplace safety and productivity. Integration with access control systems adds an extra layer of security, ensuring that only individuals with proper eye protection gain access to specified areas.

Key findings highlight the ESP32-CAM's contributions, including its impact on occupational safety enhancement, integration with access control systems, data insights for safety analytics, emergency prioritization, and the development of customized training programs. In conclusion, the ESP32-CAM emerges as a crucial technological solution for enhancing safety, security, and productivity in industrial settings, showcasing its multifaceted benefits and contributions to creating a safer and more efficient working environment.

Keywords: ESP32-CAM, Security, Eye Glass Detection, Occupational Safety, Access Control Systems, IoT Projects.

I. INTRODUCTION

In the realm of image recognition technology, continuous advancements have paved the way for the development of accessible and cost-effective solutions. Among these innovations, the ESP32 has emerged as a prominent player. Specifically, the ESP32-Cam variant has garnered attention for its ability to automatically recognize images or objects in its vicinity, presenting a compelling option for various applications.

One of the key applications explored in this paper involves the comprehensive analysis and detection of individuals wearing safety glasses. The importance of this endeavour lies in addressing the safety concerns prevalent in industries, where some workers neglect to wear protective eyewear, putting themselves at risk of serious accidents. To tackle this issue, our project aims to deploy a reliable and efficient system capable of identifying the presence or absence of safety glasses on individuals within a given environment.

The ESP32-Cam features the UFL Antenna, enhancing its wireless communication capabilities, specifically with the WiFi module. This paper provides a thorough examination of the ESP32-Cam's functionalities and its role in security applications. Notably, the ESP32-Cam's cost-effectiveness, compact size, and form factor make it particularly suitable

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for environments with space constraints. Additionally, its low power consumption proves crucial for battery-operated or low-power applications.

In comparison to alternative solutions, such as using Raspberry Pi with Python and OpenCV for eye glass detection, the ESP32-Cam offers distinct advantages. The ESP32-Cam integrates a camera, eliminating the need for additional peripherals for basic camera functionalities, unlike the Raspberry Pi, which typically requires a separate camera module. Moreover, the ESP32-Cam's IoT capabilities and connectivity further enhance its appeal in diverse applications.

This paper aims to provide a comprehensive exploration of the ESP32-Cam's features, emphasizing its significance in the development of a robust and cost-effective system for eye glass detection in various industries.

II. COMPONENT

1. ESP-32 CAM Module

The ESP32-CAM stands out as a highly versatile microcontroller module, featuring the powerful ESP32-D0WDQ6 chip. With its dual-core 32-bit processing, integrated Wi-Fi (802.11b/g/n), and Bluetooth (v4.2 BR/EDR, BLE) capabilities, it caters to diverse IoT projects. Equipped with a 2-megapixel OV2640 camera module, 4MB Flash memory, and 520KB SRAM, it excels in applications requiring both wireless communication and camera functionality. Its support for various interfaces, including UART, SPI, I2C, I2S, and PWM, offers flexibility in connecting external devices. The module's compatibility with popular programming environments like Arduino IDE and ESP-IDF enhances accessibility. Noteworthy features include a microSD card slot for local storage, a wide operating voltage range, deep sleep mode for power efficiency, and firmware Over-the-Air updates for seamless maintenance.

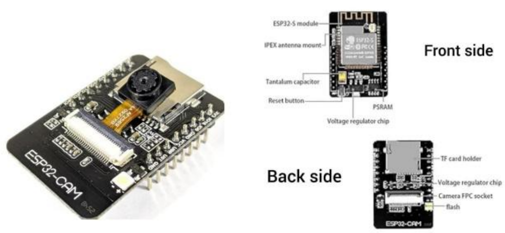

Fig 1: ESP32 CAM MODULE

Specification of ESP32 CAM MODULE

Specification	Details
1. Microcontroller	ESP32-D0WDQ6
2.Wii-fi	802.11b/g/n
3. Camera Module	v4.2 BR/EDR, BLE
4. Operating Voltage	5V (tolerates up to 6V)
5. Camera Module	OV2640 (2 megapixels, 1600x1200 pixels)
6. Flash Memory	4MB

2. USB to TTL/FTDI adapter (like the popular FTDI232 or CP2102)

A USB to TTL/FTDI adapter, such as the popular FTDI232 or CP2102, serves as a bridge between a USB port and serial communication, enabling easy interfacing with microcontrollers and other embedded systems. It provides a convenient way to program and communicate with devices that utilize UART (Universal Asynchronous Receiver-Transmitter) communication. These adapters typically offer configurable voltage levels (3.3V or 5V) to match the target device's requirements, making them essential tools for debugging, programming, and interacting with a wide range of electronic components.

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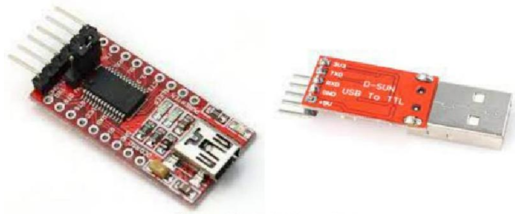

Fig 2: USB TO TTL/FTDI

3. Jumper wires

Jumper wires are essential electrical cables with male connectors on each end, used for creating connections on a breadboard or between electronic components. Typically made of flexible and insulated materials, they facilitate the prototyping of circuits in electronics projects. Available in various lengths and colours, jumper wires enable the easy transfer of signals and power between components during the development and testing phases, providing a convenient and temporary means of connecting elements on a circuit board without soldering.


Fig 3: jumper wire

4. Battery

Selecting an appropriate battery for the ESP32-CAM involves considering voltage compatibility (around 5V) and capacity (measured in mAh) to determine operational duration. The choice of battery chemistry, such as lithium-ion or lithium-polymer, impacts energy density and rechargeability. Voltage regulators help maintain stable power supply. Understanding power consumption profiles, including deep sleep modes, is crucial for optimizing battery life. If rechargeable batteries are used, considerations for charging circuitry ensure a seamless recharging process, contributing to sustained and efficient operation.

III. THEORY

The purpose of the project is to develop a system using an ESP32-CAM to detect the presence or absence of eye glasses on individuals. This technology could be applied in various contexts, such as security systems, access control, or automated monitoring. The goal of our project is to Implement a reliable eye glass detection algorithm, Achieve real-time processing capabilities, Integrate an alert system for status changes, Optionally create a user interface for visualization, Ensure accuracy and robustness under varying conditions. The project focuses on utilizing an ESP32-CAM for eye glass detection in various applications, such as security systems and access control. The key objectives include implementing a reliable eye glass detection algorithm, ensuring real-time processing capabilities, and integrating an alert system for status changes. Additionally, there's an option to create a user interface for visualization purposes. The project aims to maintain accuracy and robustness under diverse conditions, addressing the need for a versatile and effective solution in eye glass detection technology. This theoretical framework guides the development process, ensuring that the system meets the specified goals and can be applied in practical scenarios.

In industrial applications, the ESP32-CAM-based eye glass detection system can be employed for enhanced workplace safety and security. By integrating this technology into access control systems, it ensures that only authorized personnel with the required safety gear, including protective eye glasses, gain entry to designated areas. The real-time processing capabilities and robust detection algorithm make it well-suited for manufacturing environments, laboratories, or construction sites where adherence to safety protocols is crucial.

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In next part there are flow char in fig 4 give the appropriate step for the project which is very essential and important.

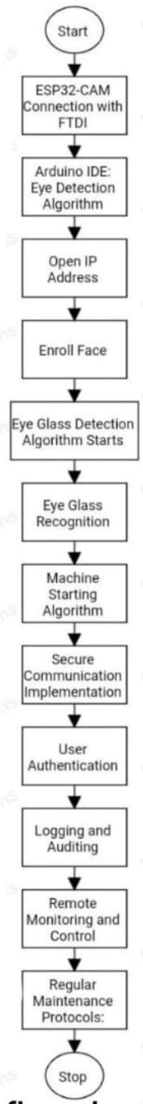

Fig 4: flow chart of project

ESP32-CAM Connection with FTDI

Establishing a proper connection between the ESP32-CAM module and an FTDI (USB to serial) adapter is crucial for programming and communication. The connections typically include:

-GND (Ground): Connect the ground pin of the FTDI to the ground pin of the ESP32-CAM.
-5V: Connect the 5V output of the FTDI to the 5V pin of the ESP32-CAM.
-TX (Transmit): Connect the TX pin of the FTDI to the RX pin of the ESP32-CAM.
-RX (Receive): Connect the RX pin of the FTDI to the TX pin of the ESP32-CAM.
-IO0: Connect this pin to ground for programming mode and leave it unconnected for normal operation.

Arduino IDE: Eye Detection Algorithm:

The programming structure can be seen in the body in Figure 6.

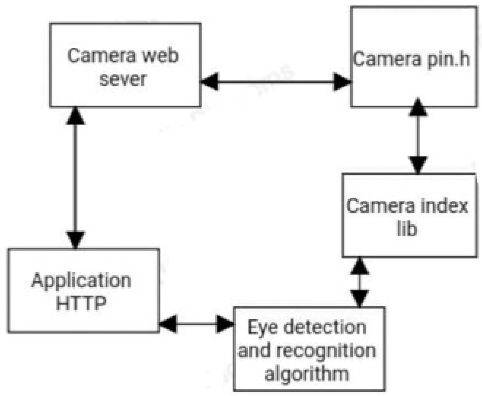

Fig 5 : programming structure

There are five core components in the Integrated Development Environment that are used to run ESP32- CAM. Camera Web Server, Application HTTP or application server, Camera Library, and Camera Pin Header and the most important is the Eye detection and recognition Algorithm that is being applied And each of these components must be a unified system. Moreover, the pseudocode used for minimal starting is shown in the following pseudocode

```
1. Start program
2. Initialize libraries: esp_camera.h and WiFi.h
3. Select Camera Model: AI Thinker with PSRAM
4. Initialize Camera Pins
5. Set WiFi SSID and Password
6. Set Serial Debug Output
7. Start Camera Server in void loop
8. Begin Void Setup
   a. Specify bitrate: 115200 bps
   b. Enable Serial Debug Output
   c. Configure camera and pins
   d. WiFi Configuration
   e. Camera Server ready
   f. Display WiFi IP Address Status: Connected
   g. Define Pin mode (relay as output) & Digital Write (relay low)
9. Define active relay condition
10. If matchFace is true and eye glass detected
   a. Set relay high
11. If matchFace is false or eye glass not detected
   a. Set relay low
12. If relay is high
   a. Switch on machine
13. If relay is low
   a. Switch off machine
14. Repeat automatic switch-on/off process with Face recognition and eye glass detection
15. End program
---------- Pseudocode ----------
```

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After uploading the program to the esp32 cam from the Arduino IDE the bellow interface is seen

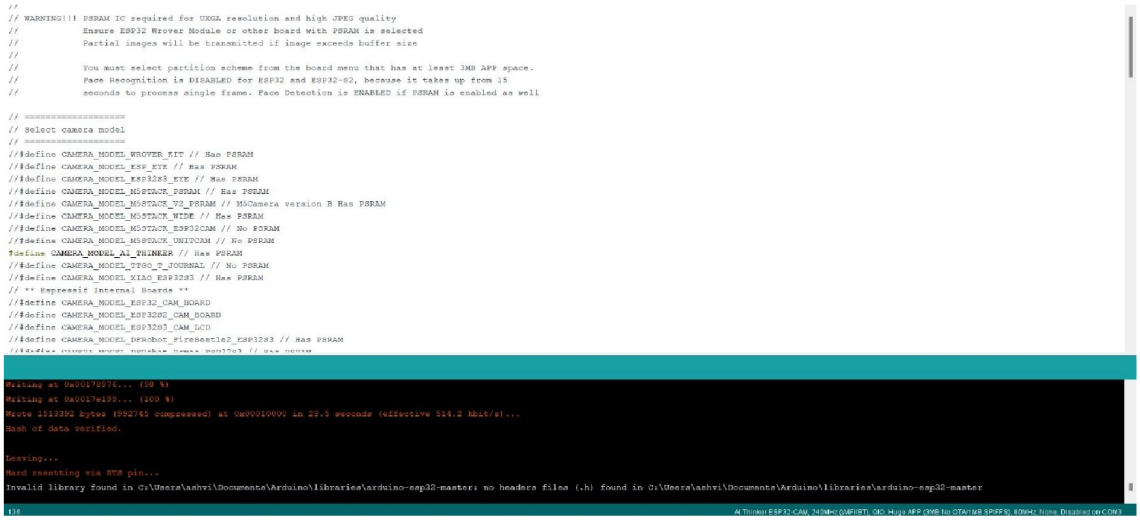

Fig 6: Arduino image

And the serial terminal interface is seen as given bellow it gives the output not only WIFI connected but also gives the indication of starting web server And Also gives the stream server on port also the serial terminal gives the IP address on that address we are able to detect the face and eye glass recognition.

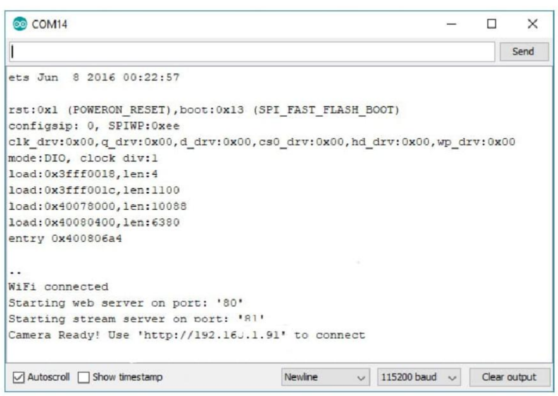

Fig 7: Serial terminal

Open IP Address:

Upon successful programming, open the IP address associated with the ESP32-CAM. This IP provides access to a web interface or another platform where the eye detection results can be visualized and configured.

Enrolment of Face:

Implement a face enrolment process through the web interface. During this step, capture and store facial features, including eye landmarks, for subsequent eye glass detection and recognition. when Eye glass detection process start it concentrate on eye land mark and using this landmarks we calculate the threshold limit of eye distance and using pre-trained model it is very easy to implement and using colour effect. This algorithm processes images to identify the presence or absence of eye glasses based on predefined criteria.

Image recognition

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The Figure 6 given bellow illustrates the comprehensive process of facial analysis and machine control using ESP32-Cam. The system initiates with Face Detection, where the Grayscale object captured by the camera undergoes analysis. Programming in C++ on the Arduino or Python IDE enables automatic detection of facial features, specifically focusing on the eyes and mouth shapes.it produces the landmarks on the eye, nose and lip area using this eye landmarks the eye glass detection algorithm works and Following Face Detection, the Face Recognition process commences. This involves Pre-Processing, Face Representation, and utilization of a Face Database containing numerous images for recognition of face and eye glass detection. The subsequent Face Classification step employs trained images for classification, leading to a verification or identification result.

With Eye glass   Without Eye glass

Fig 8 :Eye glass detection

In addition to face-related processes, the system integrates Eye Glass Detection and Recognition. The algorithm, programmed in C++ on the Arduino or Python IDE, examines captured images for the presence of eye glasses. This feature enhances the system's functionality in various applications.

Moreover, the ESP32-Cam controls machine operation with a focus on the power switch. When the Face Recognition system detects a match and eye glasses are identified, the relay is activated to switch the machine on. Conversely, if the conditions are not met, the relay deactivates, turning the machine off.

Pin no.	function	description
1	5v	Powers the relay
2	The	Ground
3	UOR Tx	Transmit data from ESP32-CAM TO Relay
4	UOR Tx	Receive data from ESP32-CAM TO Relay
5	I04	Input to relay for machine

Table 1 :connections

This integrated system, encompassing face detection, recognition, eye glass detection, and machine control, provides a versatile solution applicable to scenarios such as security systems, access control, and automated monitoring. The ESP32-Cam's capabilities in image processing and machine control make it a powerful platform for implementing sophisticated applications.

Eye Glass Recognition:

Eye Glass Recognition is a pivotal component in computer vision systems, involving the identification and analysis of eyeglasses within a visual input. This process is executed through advanced algorithms that can detect and assess the presence or absence of eyeglasses on an individual. Once eyeglasses are recognized, the system can dynamically adjust its internal state or initiate specific actions tailored to the context. This capability is particularly valuable in scenarios where the use of eyeglasses may have implications for subsequent processes or interactions with the system.When eye glass is detected it print the result on serial terminal it is given below-

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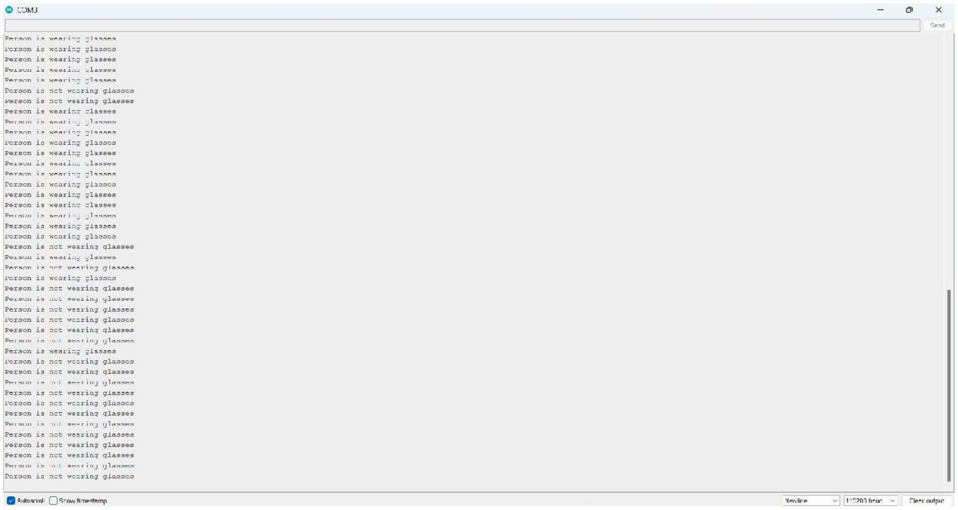

Fig 9:Serial terminal output

Secure Communication Implementation:

The implementation of Secure Communication is a fundamental measure to fortify the integrity and confidentiality of data during transmission between devices or servers. By employing robust encryption protocols, sensitive information becomes indecipherable to unauthorized entities. This ensures that even if intercepted, the data remains secure. This emphasis on secure communication is essential in safeguarding the privacy and security of transmitted information, particularly in contexts where data confidentiality is paramount.

User Authentication:

User Authentication is a cornerstone of system security, providing a means to verify and validate the identity of individuals seeking access. This involves the use of various authentication factors, such as usernames and passwords, biometric data, or multifactor authentication methods. The implementation of robust user authentication mechanisms ensures that only authorized individuals can access and control the system, preventing unauthorized use and fortifying overall system integrity.

After eye glass detection and recognition relay set at high and machine get started automatically by using the automatic switch and battery

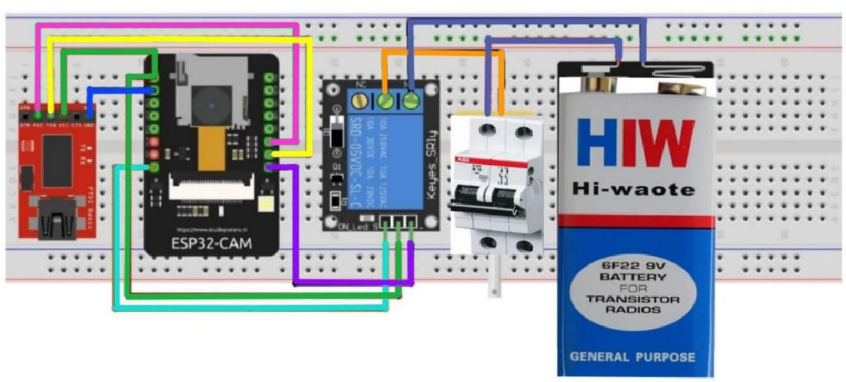

Fig 10 : connection of esp32 cam to switch of battery

Remote Monitoring and Control:

We are able to add The implementation of Remote Monitoring and Control capabilities empowers users to oversee and manage a system from a distance. This is particularly advantageous in scenarios where physical presence is impractical or inconvenient. Leveraging network connectivity, users can receive real-time updates on system status, monitor performance metrics, and execute control commands remotely. This capability enhances flexibility and accessibility in managing the system.

Regular Maintenance Protocols:

Establishing Regular Maintenance Protocols is a proactive strategy aimed at sustaining the health and optimal performance of a system over time. This involves the systematic execution of tasks such as firmware updates to introduce new features or security patches, calibration checks for devices like cameras, and ongoing system health monitoring. Regular maintenance protocols contribute to the reliability and longevity of the system, mitigating potential issues and ensuring continuous optimal functionality.

IV. CONCLUSION

In conclusion, the implementation of our eyeglass detection and recognition system, powered by the ESP32-CAM, stands as a transformative solution with significant implications for industrial safety and productivity. By incorporating cutting-edge algorithms for eyeglass detection and seamless recognition processes, our system serves as a crucial tool for ensuring occupational safety standards in industrial settings. Beyond safety compliance, the automated initiation of machinery upon successful eyeglass recognition streamlines operations, underscoring the system's practicality and potential for enhancing overall industrial efficiency. This project not only addresses safety concerns but also contributes to the advancement of smart industrial processes, showcasing the technology's relevance and impact in industrial applications.

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