Advanced Smart Wearable Tactical Helmet

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Abstract:
Wearable technology has become more popular, especially in the defense sector where tactical helmets are crucial for workers there to have safety and communication. The Advanced Smart Wearable Tactical Helmet, the subject of this project, is intended to improve the users' operational efficiency and situational awareness. The helmet has capabilities including a two-way video feed a voice-activated AI assistant, and real-time video streaming. The helmet guarantees improved field performance through the use of cloud-based data exchange and sophisticated AI features and provides safety and comfort to the users and features built-in sensors including the DHT11, MPU6050, and NEO-6M that offer motion tracking, accurate geolocation, and real-time environmental data. Furthermore, soldiers may interactively view maps and building structures thanks to augmented reality (AR) capabilities, which allow for object interaction via simple hand motions.
This study demonstrates the system's efficacy and offers insights into significant prospective developments in wearable military technology.

Keywords: Military helmet, Voice command, AI assistant, Head-mounted Display, Sensors, Augmented Reality.

1. Introduction

In recent years, wearable technologies have become more advanced year after year and have gone beyond fitness tracking and personal health checkers to be important to use in defence and the military. This technology has become increasingly important in today's world where having a limited time to make decisions and situational awareness can change the outcomes of the situation.

This advanced smart wearable tactical helmet is intended to meet emerging requirements. Combining AI ASSISTANT with voice commands Computer vision and real-time video feeds with augmented reality in the system can change and improve situational awareness, communications which can help during operations.(.Kodam, S, 2020). Zhang et al. (2011) while a large-field-of-view display in helmets could enhance situational awareness, Loyd (1998) has shown the importance of head-mounted displays which can enhance soldiers' operational capabilities and awareness of their environments and also give us information on how the benefits of integrating smart technology into tactical helmets, showing how it can wide-angle displays and real-time data streams can increase the combat effectiveness of soldiers. Additionally, the problems associated with helmet-mounted displays were noted by Glover(2021), who noted that a careful and properly made design is necessary to prevent physical and eye strains on soldiers. The project's main goal is to improve the human recognition and use of AI voice assistants for hands-free operations and use a display camera for an optimized live camera feed the system can be implemented in the field with effectiveness and economy by guaranteeing low-latency performance on a Raspberry Pi 4B. (Rangan, R. P, 2018).

2. Literature Review

Rangan et al. (2018) introduce a voice-controlled smart helmet aimed at enhancing motorcycle safety through hands-free communication and functionality. This innovation addresses the need for reducing distractions while riding, as traditional systems often require manual input. Wearable devices in defense, particularly in the form of helmets, have been explored extensively in military research. While these innovations have significantly improved soldiers' capabilities, there remains a gap in the integration of real-time object detection, environmental sensing, and hands-free communication into a single, modular helmet system. Research in detection systems and using computer vision and machine learning for object detection remains scarce. There is a need for development in the system that integrates computer vision as a helmet to provide enhanced situational awareness, object detection, and hands-free operation. Object detection systems using machine learning, particularly the HAAR CASANDRA model, have gained widespread adoption for real-time detection due to their efficiency and accuracy in the casandra Model (Patel, k 2023).

3. Methodology

A smartphone serves as the main video input source for the robotic system with real-time object detection. It does this by using an IP webcam to stream a live feed from the phone's camera to a Raspberry Pi 4B (4GB RAM, 64-bit OS, 16GB SD card) over Wi-Fi. An 18650 lithium battery powers the system, supplying power to the Raspberry Pi and other electronic parts. The system's software is based on a 64-bit Raspberry Pi operating system, and Python 3.9.0rc2 is used for hardware interface and programming. A Flask server controls streaming and detection, and the Casandra model is used to detect human faces and poses in the live video feed. (Patel, k 2023).

To improve the system and give the user access to more usability, an AI assistant is placed to help with voice requests and to give real-time data and control. The smartphone's IP webcam software allows for code development and debugging in addition to streaming video feeds. The AI assistant gives the user access to make notes, reminders, and information about things using Wikipedia and Google search access. (Rangan, R. P, 2018).When the system starts, the camera feed from the Samsung M24 smartphone gets started system the video stream is given to the system through WIFI, and the live broadcast is delivered to the Raspberry Pi 4B using an IP address (e.g., 192.164.31.141), then video stream is taken and applied with the Casandra model, which gives a real-time face and pose detection. (Jalui, Sandeep, 2019). The Raspberry Pi handles this detecting process and utilizes the camera input from the smartphone to give live video processing and by processing spoken commands through the microphones the AI assistant included in the device gives customers hands-free control over a variety of features. Through a new IP address (e.g., 192.168.31.x:5000), the processed video feed with detection overlays is rebroadcast, enabling the user to watch the live stream straight from the helmet using a smartphone browser. (Jalui, Sandeep, 2019). To improve user interaction with the system and get better data on their surroundings, the AI assistant gives real-time feedback according to their given commands. The system's performance shows that the Raspberry Pi's processing power and network latency cause a 6-second lag in the video feed it depends on the WIFI connections given to the Raspberry Pi. To deal with this problem the system could be enhanced by using a 5 GHz or a 5G WIFI network connection to give the AI assistant better connections to the internet so it can give a faster response to the given commands of the user. The Raspberry Pi 4B uses 40% of the battery, the display uses 30%, and the AI helper. Loyd (1998) has explored the early stages of head-mounted displays (HMD) in military applications and how by integrated display system on the tactical helmet can provide soldiers with real-time data and information about the surroundings. Integrating the HMDs with artificial intelligence could enhance situational awareness by enabling features like pose and face detection in the display feed this can help the soldiers in their operations. Zhang et al. (2011) pointed out that many of the military helmets have lacked the field-of-view (FOV) which limits the visual view of the user. To enhance situational awareness, the helmet integrates the DHT11 sensor for real-time temperature and humidity monitoring, MPU6050 for tracking head movements and recognizing gestures, and NEO-6M GPS for location and navigation data. [11] The helmet employs AR technology to project 3D maps or structural layouts into the user's field of view, enabling object manipulation via gestures tracked by the MPU6050 sensor. The system's software includes algorithms for gesture detection, allowing users to rotate, move, or place AR objects dynamically.[13] and the display on their helmets. Because of this, it restricts users' mobility operational efficiency, and usage, and the high cost of having the components and the helmet damaged or lost has further impeded their widespread use (Glover 2021).

Introducing AI assistants into the systems can help users with some of these challenges, and it provides real-time support for searching the internet taking notes setting reminders giving information regarding personnel from their databases. (Grover, Yash, 2022).

Comparison of the Existing System and My System Table [1]

ASPECTS	EXISTING SYSTEM	MY PROJECT
Technology Integration	Focus on static displays with no sensor or AI	Real-time sensor fusion with voice commands
Object Detection	Lacked object detection or machine learning	Haar Casandra Face and distance recognition
Field-of-view	Large but static FOV, no adaptability	Dual-feed FPV system with flexible, real-time video feeds
Power Source	Heavy power systems with limited operational time	Efficient 18650 lithium battery for extended use
Environmental Data	Temperature and, motion and GPS	Integrated NEO6m and DHT11 and MPU6050
AR Functionality	Providing Objects and directions	Real-Time AR integration

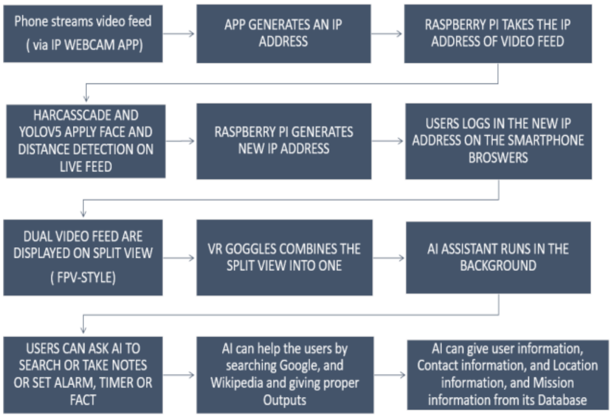
Systematic Design and Component Placement

Raspberry Pi 4B is the main processing system of the helmet which is mounted on the back of the helmet to maintain balance while ensuring airflow for heat emissions made by the Raspberry Pi in the front of the helmet there is an adjustable smartphone holder that aligns with the user's field of view and it captures and streaming real-time video with the smartphone.

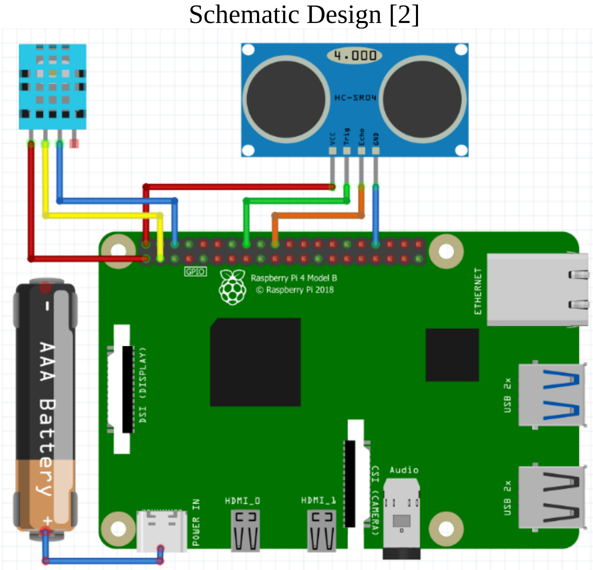
(Chiu, W. C, 2017) Wired headphones which are connected to the Raspberry Pi provide a voice input as well as audio output, while a sensitive microphone which captures voice commands, even in noisy settings.

The system is powered by a rechargeable 18650 lithium battery holder and is selected because of its lightweight and high energy capacity to give higher voltage to the system when required and ensure extended operation without frequent recharges.

WORKFLOW DESIGN [1]



Schematic Design [2]



Power consumption by the system [3]

Duration (Minutes)	CPU Temperature (°C)	GPU Temperature (°C)	Remarks
0-10	45	43	Stable temperature. DHT11 and HC-SR04 connected but idle.
10-20	55	52	Moderate load due to Haar Cascade XML file. Minor heat impact from sensors (+0.2°C
20-30	60	60	Threshold for performance dip. DHT11 and HC-SR04 active, negligible additional heat (+0.3°C).

Wearability and Comfort

The helmet used in the research is used because of its prolonged usage capabilities and its wearability which was a primary concern. The entire system is built around it because it's lightweight and has a shock-absorbing material typically used in tactical gear, ensuring that the user is comfortable wearing it for long hours. The components that are used are placed to balance weight distribution and minimize strain on the neck and head. The helmet's architecture is such that it can be used in different head sizes. It has features that use padded interior linings, making the helmet comfortable while offering protection and adaptability.

4. CHALLENGES

The development of the smart tactical helmet has some challenges which resulted in delays as it was unable to handle the processing needs of real-time video stream analysis and the execution of the haar casandra model and the live feed is dependent on Wi-Fi because a 4-6 second delay can cause errors and the users can make wrong decisions because of the problem in real-time performance due to network latency and handling Raspberry Pi is another challenge because the 18650 lithium battery need to maintain a proper balance of power input.

It is difficult to perform accurate voice command recognition in noisy environments, due to background noise interference the AI assistant is not able to understand the user's voice commands.

Addressing these challenges requires various solutions and ongoing considerations. The limitations of the Raspberry Pi’s processing power were discussed, with potential improvements involving using more powerful hardware, such as the Raspberry Pi 4B with 8GB RAM, or offloading some of the computational tasks to cloud-based servers. Enhancing voice command accuracy in noisy environments could be achieved by incorporating noise-cancellation algorithms or using higher-quality microphones to better filter out ambient sounds.

Despite this, the smart tactical helmet achieved promising results.

The system successfully gave real-time human face detection and pose recognition using the haar Casandra model, even though having some delay due to processing limitations and network latency. The AI assistant performed great and has enabled hands-free control of helmet functions, including voice-activated visor adjustments and information retrieval. The user experience has significantly enhanced the user's accessibility.

Battery life tests showed that power consumption was evenly distributed among the helmet's components, but further improvements are necessary to extend usage time during field operations. Additionally, the measured network latency revealed the need for faster connectivity solutions, with proposed future upgrades to 5 GHz Wi-Fi or 5G networks to minimize delay in real-time streaming and response.

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