

The Future of Warfare: A Smart AR/VR AI-Driven Helmet for Real-Time Data Analysis and Tactical Advantage

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Abstract

This study explores the potential of a smart augmented reality (AR) / virtual reality (VR) helmet that uses artificial intelligence (AI) to provide real-time data analysis and decision support for military personnel in combat situations. The helmet integrates various sensors, cameras, and communication devices to collect and process data from the environment and the wearer, and displays relevant information and guidance on a transparent visor. The study aims to evaluate the usability, performance, and impact of the helmet on situational awareness and combat effectiveness of the users. The results show that the helmet can potentially improve the users' perception, comprehension, and projection of the situation, as well as their accuracy, speed, and confidence in decision making. The study concludes that the smart AR/VR AI-driven helmet is a feasible and beneficial technology for enhancing situational awareness and combat effectiveness in military operations.

Keywords- *Augmented Reality/ Virtual Reality, Artificial intelligence, Machine learning, Real-time data analysis*

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1. Introduction

Military operations are often fraught with challenges and risks that can jeopardize the lives and missions of soldiers. Some of these challenges include preventable deaths due to a lack of situational awareness, medical attention, or protective equipment; misinformation due to poor communication, coordination, or intelligence; and tactical disadvantages due to inferior weaponry, mobility, or visibility.

Miscommunication in the military can occur due to various factors, such as:

- Lack of clarity and conciseness in the messages sent and received by different units, commanders, and allies. This can lead to confusion, misunderstanding, or distortion of the intended meaning.
- Incompatibility of communication devices, systems, and protocols among different branches, services, and nations. This can hamper the interoperability, coordination, and collaboration of the military forces.

- Interference or disruption of the communication channels by natural or man-made causes, such as weather, terrain, jamming, hacking, or sabotage. This can impair the reliability, security, and availability of the communication networks.
- Cultural and linguistic differences among the military personnel and their counterparts or partners from other countries or regions. This can cause misinterpretation, mistranslation, or offense in the communication process.

A study by Smith et al estimated that 15% of all combat deaths historically consist of potentially survivable injuries, and of these, exsanguinating extremity hemorrhage is consistently the most common cause. Therefore, the percentage of preventable deaths in military due to hemorrhage in this estimate was about 15%

To address these challenges and enhance the combat efficiency and effectiveness of soldiers, a new smart helmet concept has been proposed. This smart helmet integrates various technologies, such as sensors, cameras, processors, display, encryption, and biometrics, to provide soldiers with real-time data analysis, decision support, threat identification, and secure communication. This smart helmet aims to improve the safety, performance, and capabilities of soldiers in various military scenarios by analysis all the data it can gather from its sensors in the battlefield, analysis it in real time and use AI and Machine learning to provide tactical advantages, optimal positioning and improve overall combat efficiency of the military personnel. Let's have a brief look at a few key areas of this smart helmet, such as:

- Build and Specifications
- Technologies Incorporated
- Comparison with similar devices

2. Build and Specifications

2.1. Building Material

Our smart helmet needs to be robust and durable while housing a lot of sensors and circuitry. It must also be light enough to be comfortable to wear for an extended amount of periods. For these reasons, Kevlar is chosen as the building material for our smart helmet as it fulfils all of these requirements.

- Kevlar is a strong, heat-resistant synthetic fibre that is widely used in personal armour, such as helmets and body armour. It has a high tensile strength-to-weight ratio, which means it is five times stronger than steel.
- It also has low moisture absorption, which makes it resistant to deterioration.
- Kevlar is durable and can withstand various hazards, such as falling objects, impacts, and electrical shocks.
- It also has UV resistance, chemical resistance, and impact resistance.
- The density of Kevlar is **1440 kg/m³**, which is lower than the density of steel (**7850 kg/m³**) or aluminium (**2700 kg/m³**). Kevlar is also lighter than E-glass, a common material used for helmets and body armor, which has a density of **2540 kg/m³**. However, Kevlar is not as light as carbon fibre, which has a density of **1750 kg/m³** and also has a higher strength-to-weight ratio than Kevlar, but Kevlar can absorb more energy from a bullet than carbon fiber.
- Kevlar is resistant to fire, abrasion, and chemicals, which means it can withstand various environmental conditions and hazards that may occur in military operations.

- Kevlar is flexible and moldable, which means it can be shaped into various forms and designs to fit different head sizes and shapes, as well as accommodate other components or systems of your smart helmet.
- Kevlar is widely used and proven in military applications, such as body armor, helmets, shields, and vehicle armor, which means it has a track record of reliability and effectiveness in protecting soldiers from ballistic threats and shrapnel.

2.2. Hardware Specifications

1) Cameras

Our AR/VR helmet will feature multiple arrays of high-speed cameras which would capture footage from every direction the of helmet to gather as much information as possible about the surroundings of the wearer of the helmet. For the purpose of analysis, the footage captured from these cameras needs to be sharp enough and at a high framerate. 1080p footage at 120 fps would be suitable for the operation of our helmet. Any video configuration higher than that would prove too computationally demanding to process real time. To achieve this, our cameras must be 8 Megapixels or higher and its aperture size must be around $f/1.8$ or $f/2.0$ to gather as much light as possible from the sensor and have a sharper and brighter footage.

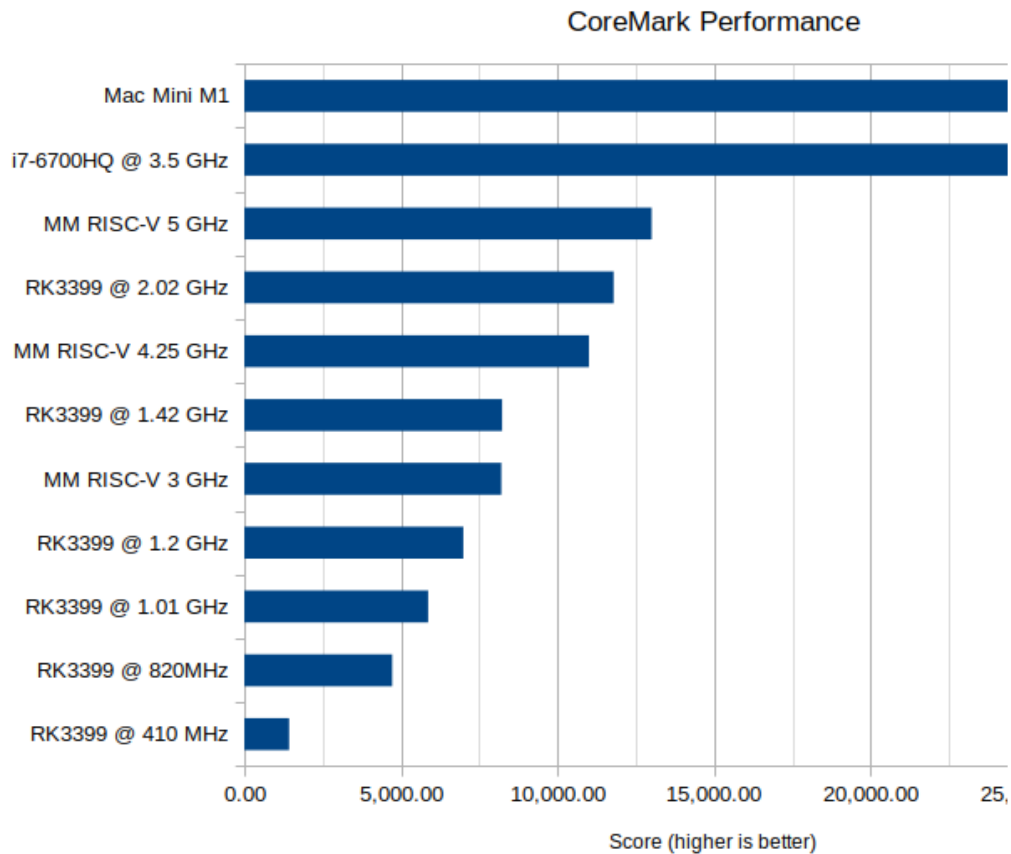
In case of low-light situations a couple of LiDAR sensors can help the helmet process the low light footage and use the LiDAR sensor data to process the distance between objects and the helmet.

2) OLED Screens

High resolution OLED screens are required for the displays in our AR/VR helmet. They must have high refresh rate and high peak brightness to be comfortable for wearing the helmet for longer hours. 2K resolution displays at 120hz should suffice for the optimal use of this helmet.

3) Processors

The x86 platform of processors have been the most preferred architecture of processors for high computational demands. However, these processors are very energy inefficient and generate a lot of heat. These characteristics are highly undesirable for a helmet as it compromises safety and comfortability. And with the recent breakthroughs and evolutions in ARM processors, they are most suitable to be used in a smart device such as this AR/VR helmet. A custom developed ARM processors or multiple ARM processors can handle the processing workload of the helmet. The graph below shows the evolution of ARM processors in recent times.



4) **Biometrics**

There are hardware encryption modules and capacitive biometric sensors that can be used for enhancing the security and privacy of the data and the system. We can feature a capacitive fingerprint sensor to allow only authorized persons to use and interact with the helmet. In case the helmet gets in the hands of enemies they must not be able to access the data inside the helmet.

5) **Wearable body energy harvesters**

The helmet can be recharged via wearable body energy harvesters which would convert kinetic energy produced from body movements into electrical energy and therefore charge the helmet's battery. It would achieve this by augmenting inductors - coils used in power transformers - to capture the body's kinetic energy. The architecture of the inductors packs them in a small-size form, while still creating significant power

3. **Technologies Incorporated**

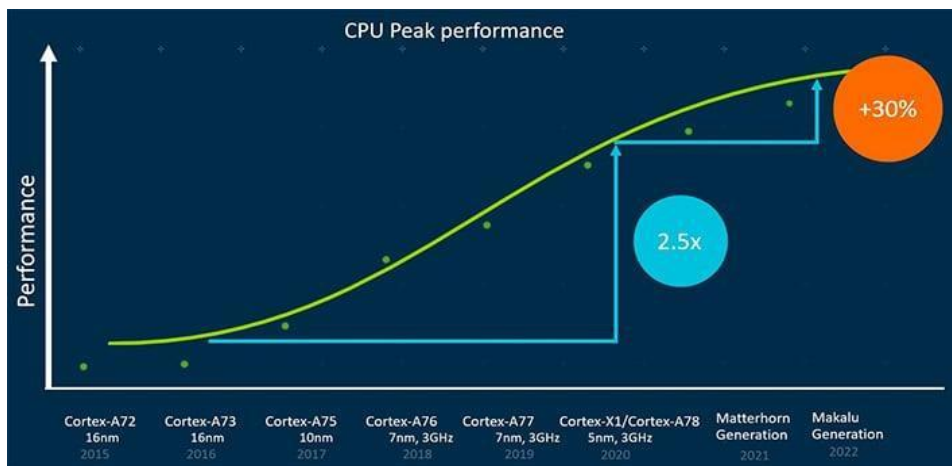
3.1. *Artificial Intelligence and Machine learning*

AI and ML are used in military operations for various purposes and domains:

- Intelligence, Surveillance and Reconnaissance (ISR): AI and ML can help collect, process, analyze, and disseminate large amounts of data from various sources, such as images, videos, texts, and signals. AI and ML can also help detect, recognize, and track objects, activities, and anomalies of interest, as well as provide situational awareness and decision support for military commanders and operators.
- Command and Control (C2): AI and ML can help plan, coordinate, and execute military operations

across multiple domains and actors. AI and ML can also help optimize the allocation and utilization of resources, such as personnel, equipment, and weapons. AI and ML can also help enhance the communication and collaboration among different units and platforms.

- Targeting: AI and ML can help identify, locate, prioritize, and engage potential targets in complex and dynamic environments. AI and ML can also help assess the effects and outcomes of the engagements, as well as minimize the collateral damage and casualties.
- Logistics: AI and ML can help manage the supply chain and transportation of military goods and services. AI and ML can also help predict the demand and availability of resources, as well as optimize the distribution and delivery of resources. AI and ML can also help monitor the condition and performance of assets, as well as provide maintenance and repair support.
- Natural language processing: AI and ML can process verbal communications, text messages and images from computer vision to identify and translate them in real time. This can be of crucial help to soldiers who might encounter foreign civilians, printed text or enemy intel in a foreign language.



AI and ML will bring all of these features and capabilities into our helmet which will give a significant edge to the wearer of the helmet in the battlefield.

3.2. Augmented and Virtual reality

AR and VR technologies can help the wearer of the helmet in combat situations in several ways:

- AR and VR can provide immersive and realistic simulations for training and rehearsal of various military scenarios, such as combat, rescue, medical, and logistics. AR and VR can also provide feedback and assessment of the performance and skills of the wearer.
- AR and VR can provide situational awareness and guidance for navigation and decision making in complex and dynamic environments. AR and VR can also provide information and communication from various sources, such as sensors, maps, databases, and other units.
- AR and VR can provide enhancement and augmentation of the perception and cognition of the wearer. AR and VR can also provide distraction and relaxation from stress and fatigue.

3.3. Real-time data analysis

Data analysis is extremely crucial to military operations for improving the efficiency, effectiveness, and innovation of military capabilities:

- Data analysis can help improve the accuracy and timeliness of intelligence, which is essential for planning and executing military operations. Data analysis can also help detect and identify threats, opportunities, and patterns of interest from various sources of data, such as images, videos, texts, and signals.
- Data analysis can help optimize the allocation and utilization of resources, such as personnel, equipment, and weapons. Data analysis can also help enhance the communication and collaboration among different units and platforms. Data analysis can also help assess the performance and outcomes of military operations.
- Data analysis can help innovate and adapt to the changing nature and challenges of warfare. Data analysis can also help leverage new technologies, such as artificial intelligence, machine learning, and big data. Data analysis can also help develop new capabilities and advantages for military forces.

To have such data analysis in real time during combat can change the tides of the battle significantly and provide a tactical edge over the enemies.

- The helmet can provide situational awareness and guidance by analysing the data from its sensors and cameras and displaying relevant information and instructions on the visor. This can help the wearer avoid or respond to potential threats, such as enemy fire, explosives, or ambushes.
- It can provide communication and coordination by analysing the data from its network and database and displaying relevant information and messages on the visor. This can help the wearer communicate and collaborate with other units and platforms, as well as receive updates and orders from the command.
- It can provide enhancement and augmentation by analysing the data from your vital signs and biometrics and displaying relevant information and feedback on the visor. This can help the wearer improve their performance and cognition, as well as reduce their stress and fatigue.
 - It can also suggest changes in the tactics and strategy to better adapt the constantly changing situations in war.
- It can analyze the geographical environment and suggest optimal positioning, efficient routes and information about the environment such as humidity, temperature and weather forecasts.

4. Comparison with similar devices

Smart AR/VR helmets used in military have existed for over a decade now and have been quite effective in combat. Let's go over some of them and see how our helmet stacks up against them.

4.1. IVAS Smart helmet

The IVAS smart helmets are high-tech headsets that use Microsoft's HoloLens technology to provide soldiers with mixed-reality capabilities on the battlefield. The headsets project 3D terrain maps, holographic imagery, and other information onto the soldiers' field of vision, enhancing their situational awareness and performance. The headsets also allow soldiers to see in the dark, through smoke, and around corners. The IVAS project is a result of a close collaboration between Microsoft and the U.S. Army, which involved collecting feedback from soldiers and conducting multiple rounds of testing. The Army plans to start equipping soldiers with the headsets in September 2023. The IVAS headsets are expected to transform how soldiers operate and improve their survivability.



4.2. DRDO's Smart AR/VR helmet

The DRDO's smart military helmet is a device that can capture the 3D information of any unknown environment in real time and help soldiers in urban combat scenarios. The helmet has a sensor suite that consists of a solid-state LiDAR, an optical RGB camera, and an IMU-enabled stereo camera. The helmet can work in two modes: mapping mode and localization mode. In mapping mode, the helmet can generate a 3D map of the environment and store a database of unique 2D images that correspond to different locations on the map. In localization mode, the helmet can determine the 3D position of the soldier with respect to the map by matching the real-time images captured by the optical sensor with the stored database using an AI algorithm. The helmet can also transmit the positional information of multiple soldiers to a central hub using a wireless system. The helmet can serve as a local positioning system for areas where GPS is not available or reliable, and can improve the situational awareness and decision making of the soldiers. The DRDO has also developed a lightweight helmet-mounted display system (HMDS) for Indian Air Force pilots, which can provide them with information such as altitude, speed, weapon status, and target cues on a visor projection. The HMDS can also enable pilots to aim their weapons by looking at the target, and can reduce their workload and reaction time.

4.3. How does our Smart helmet compare to IVAS' and DRDO's Smart helmets?

There are quite a few similarities as well as differences between these helmets:

1) Comparison with IVAS Smart helmet:

- **Similarities:** Both helmets use AR/VR and AI technologies to provide real-time data analysis and decision support for military personnel. Both helmets integrate various sensors, cameras, and communication devices to collect and process data from the environment and the wearer. Both helmets display relevant information and guidance on a transparent visor.
- **Differences:** Our helmet focuses on enhancing situational awareness and combat effectiveness, while the IVAS helmet also aims to improve training and simulation capabilities. Our helmet uses a single processing device attached to a combat helmet, while the IVAS helmet consists of a ruggedized version of Microsoft's HoloLens 2 headset, a computing unit, and batteries worn on the body.

2) Comparison with DRDO's Smart helmet:

- **Similarities:** Both helmets can provide situational awareness and real-time data analysis using sensors and cameras. Both helmets can track combat agents in No-GPS scenarios using optical sensors and AI algorithms. Both helmets are designed for military applications, such as combat and search and rescue.
- **Differences:** our helmet can also identify and track enemy threats using video analysis, while DRDO's smart helmet does not mention any threat identification capabilities. Our helmet can process all of the data on device with a series of ARM processors, while DRDO's smart helmet relies on a wearable compute to be worn around the waist. Our helmet has on device encryption and capacitive biometrics for authorized use only, while DRDO's smart helmet does not mention any encryption or biometric features.

Our Helmet can perform the same functions as the above-mentioned helmets and do much more than that.

- Our helmet can provide situational awareness by analysing the video capture from its camera sensors and displaying relevant information and guidance on the visor. This can help soldiers avoid or respond to potential threats, such as enemy fire, explosives, or ambushes.
- Our helmet can provide medical attention by monitoring the vital signs of the wearer and alerting the nearest medic or hospital in case of injury or illness. This can help soldiers receive timely and appropriate treatment and reduce the risk of complications or fatalities.
- Our helmet can provide protective equipment by using encryption and biometrics to prevent unauthorized access or misuse of the system. This can help soldiers protect their data and identity from enemy hackers or spies, and prevent friendly fire or sabotage.

5. Conclusions

The proposed smart helmet concept is a revolutionary innovation that could transform the future of military operations. By integrating various technologies, such as sensors, cameras, processors, display, encryption, and biometrics, the smart helmet can provide soldiers with real-time data analysis, decision support, threat identification, and secure communication. The smart helmet can also enhance the safety, performance, and capabilities of soldiers in various military scenarios. The smart helmet concept is superior to previous smart helmets, such as IVAS and DRDO's, in several aspects. For example:

- The smart helmet concept can provide more comprehensive and customized simulations for training and rehearsal of various military scenarios, using AR and VR technologies. The smart helmet concept can also provide more feedback and assessment of the performance and skills of the wearer.
- The smart helmet concept can provide more accurate and timely intelligence and guidance for navigation and decision making in complex and dynamic environments, using AI and ML technologies. The smart helmet concept can also provide more information and communication from various sources, such as sensors, maps, databases, and other units.
- The smart helmet concept can provide more protection and security for the data and the system, using encryption and biometrics technologies. The smart helmet concept can also prevent unauthorized access or misuse of the system.

Therefore, the smart helmet concept is a highly impactful and beneficial innovation that could improve the efficiency, effectiveness, and innovation of military capabilities. In future, the proposed technology can be improved by incorporating IoT/Cloud computing/Big Data and WSN technologies.

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Funding Information: The reported work did not receive any funding from any Institutions or Individuals.

Competing Interest Declaration: The authors do not have any competing interest with any Institutions or Individuals.

Ethical Statement: No human/animal clinical trials were conducted for this research. Further, this paper had used publicly available data sets/information.