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Virtual reality and augmented reality in marine education and training

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Abstract. The paper presents the potential of smart glasses and remote support technologies in naval operations. It emphasizes the challenges of limited internet access at sea and proposes solutions like STUN and TURN servers for effective communication. Smart glasses offer real-time assistance, aiding in diagnosing mechanical faults and facilitating information exchange between on-board engineers and land-based experts. The system's architecture, optimized for low-bandwidth environments, consists of a Support Center and Client Device. Additionally, the implementation of virtual reality (VR) technology in maritime personnel training is explored, showcasing its potential for education and intervention management. Overall, smart glasses and remote support offer promising solutions for naval communication hurdles.

Keywords: smart glasses, augmented reality, Remote Assistance System, marine communications, low bandwidth

1. Introduction

The field of smart glasses and remote support technologies is undergoing fast development, presenting intriguing opportunities for the naval sector. Smart glasses that are available for purchase on the market include advanced capabilities such as high-resolution cameras, fast processors, and augmented reality (AR) overlays.

The potential of these capabilities for troubleshooting and visualising information in real-time on deployed boats is enormous.

Nevertheless, a primary obstacle for naval applications is communication. The constraints of limited bandwidth and unpredictable connectivity when at sea require the development of creative solutions. Continual research is being conducted to enhance the efficiency of data transmission in remote support systems. This involves investigating video codecs that are optimised for low bandwidth, having offline resources already loaded, and using store-and-forward capabilities to transmit vital data when there is a connection available.

In addition, there is ongoing research into the use of protocols and servers such as STUN and TURN to create strong connections in the presence of firewalls and NAT settings aboard navy boats.

Smart glasses and remote help technologies might potentially revolutionise the Navy's approach to troubleshooting equipment problems, maintaining operating efficiency, and using the experience of shore-based professionals to overcome communication obstacles.

2. Literature Review

Smart glasses have been used in several sectors such as healthcare, emergency services, agriculture, and others. Telemedicine is one of the most recent uses of smart glasses for remote help.

Smart glasses have been used to deliver technical assistance during mass casualty crises, facilitating the process of triage with the aid of technology and allowing telemedical applications [1]. Furthermore, they have been used in precision cattle husbandry, enabling the collecting of data in real-time, the exchange of information, and providing remote support without the need for manual intervention [2].

Smart glasses have been used in the healthcare industry to assist persons with Parkinson's disease. These glasses include e-health software and external cueing features, such as Google Glass and Vuzix M100 devices [3].

Furthermore, smart glasses have been explored in precision livestock farming, where they enable real-time data collection, sharing, and remote assistance, enhancing efficiency while working hands-free [4].

In addition, smart glasses have been used in augmented reality-assisted interventions, such as targeted prostate biopsies, demonstrating their potential in image-guided procedures. These applications highlight the versatility and effectiveness of smart glasses in providing remote technical support across different sectors.

In more technical setups, Matei et al. [5] [6] provide an architecture for serverless computing, that can be used in a serverless setup, and also provide a platform that uses this architecture [7]. Erdei et al. [8] propose a scalable architecture, used for both managing distributed learning, but also capable of interacting with any IoT device, including smart glasses.

2.1 Use-Case Definition

This research study examines the use of smart glasses and remote support technologies in the demanding context of naval operations. The scenario focuses on resolving important mechanical failures on deployed warships, where internet access is often restricted and unreliable.

Smart glasses, which are equipped with a high-resolution camera and provide a real-time video stream, serve as the primary tool. When feasible, the onboard engineer can establish a connection with a secure remote server, via which a real-time feed of the faulty equipment may be sent. Simultaneously, a highly skilled expert stationed on land, with an extensive understanding of the equipment, accesses the server and obtains the video stream.

This bilateral connection enables the expert to advise the engineer through the process of resolving issues, exchange pertinent material such as manuals and schematics, and even make annotations right on the engineer's smart glasses screen.

Nevertheless, the limited data transfer capacity and the possibility of an untrustworthy connection present considerable obstacles. The system should be enhanced to maximise data efficiency. The smart glasses may save pre-loaded troubleshooting materials for offline use.

Real-time video may be optimised by reducing resolutions or using frame skipping to save data transmission. In addition, the system should have the capability to immediately reconnect after short interruptions and use store-and-forward capabilities to transmit vital data when the connection becomes stable.

Ultimately, the troubleshooting procedure must consider and accommodate for any communication delays that may arise as a result of physical distance. Precise instructions and sufficient time for the engineer to execute each step are essential for effective remote help.

This use case showcases the considerable capabilities of smart glasses and remote support technologies.

Although the onboard connection has its limits, this technology can provide real-time troubleshooting, accelerate repairs, and ultimately reduce the effect on the operation. Furthermore, it facilitates the exchange of information between seasoned experts and engineers on board, hence improving overall operational effectiveness.

3. Architecture of the System

The *Remote Assistance System* (RAS) has been optimized for low-bandwidth environments and is suitable for the provided use-case: remote assistance for naval applications. Throughout the design and development process, several hard constraints have been considered, validated and implemented into the system, to better mould it on the provided use case and address its needs.

The architecture, presented in **Error! Reference source not found.**, consists of two main components, the *Support Center* and the *Client Device*, each implemented specifically to allow for efficient scaling and decoupling.

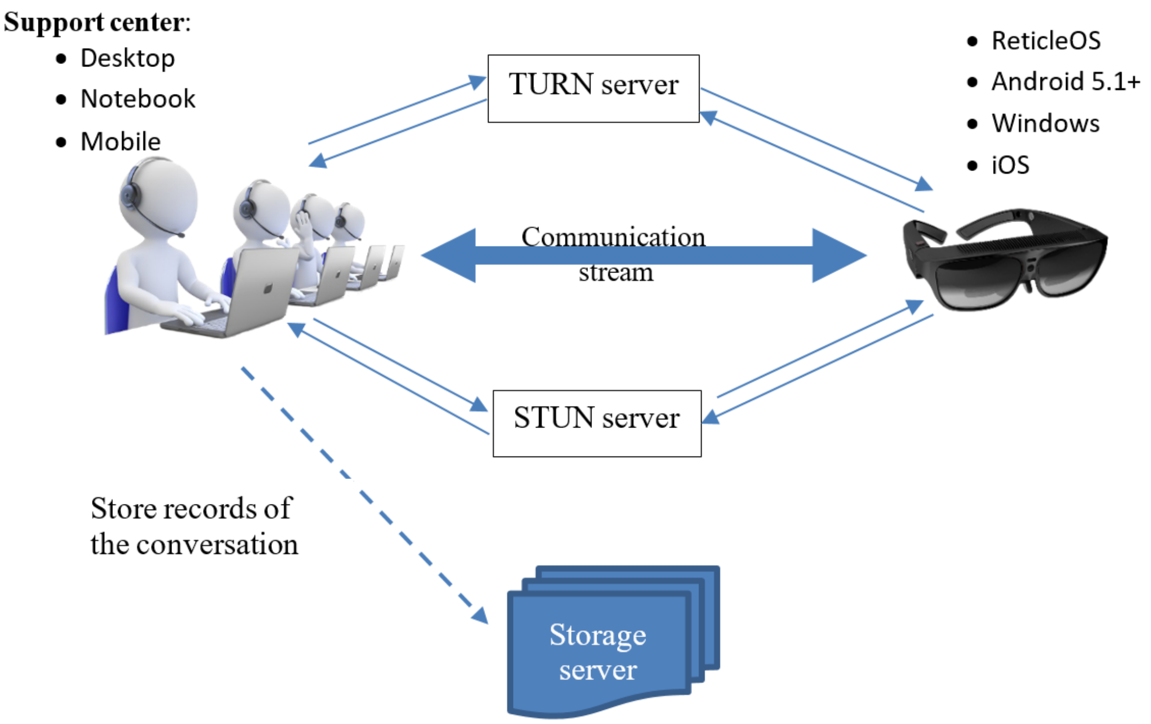

Figure 1. Architecture of the Remote Assistance System

The *Support Center*, implementable via any web-based technology, can be either centralized or installed at the client's premises (for more critical applications). It deploys three main components: the *support user interface*, used for interacting with the on-land specialists; the *storage server*, which keeps the connection history; and the *communication stream*, implemented via the TURN/STUN servers. These components provide the required level of abstraction and facilitate direct quality communication, even in the more challenging environments.

WebRTC applications depend on STUN and TURN servers in situations when direct connection is impeded by restrictive firewalls or Network Address Translation (NAT). STUN servers function as discovery mechanisms, facilitating the disclosure of public IP addresses and NAT type for devices operating behind NAT, hence allowing prospective peer-to-peer connections. If a direct connection cannot be established, TURN servers are used. These servers function as intermediaries, transmitting media traffic between devices that are unable to establish a direct connection, guaranteeing ongoing communication even under intricate network circumstances.

The *Client Device* is implemented as a mobile application, installable on any Android/iOS device. For compatibility purposes, we also target older devices, with a minimum Android version of 5.1, which will ensure the usage of a large range of smart glasses.

Although any mobile device can be used, it is preferable to use smart glasses, as they provide a host of options not available for other devices, such as a better angle for the camera, without the extra need for image stabilization, no need to hand-hold the device, enabling better handling for the required repairs, and better interaction with the local technician, as they can be engaged 100% of the time with the specialist, without the need to split the attention.

4. Implementation of the application in the training of maritime personnel

The tracking system is used to track the user's behavior within a 10m radius, and the user's behavior data is transmitted to the host VR via wireless transmission. The user-worn display device is wirelessly connected to the VR host for receiving and displaying VR data; the user control handle is wirelessly connected with VR host and VR host perform user gesture recognition.

The VR host is connected to the projector through the HDMI interface, and the projector and projection screens are connected to display the virtual reality scene and the operation process of the learners, for other learners and trainers to watch and learn in real time.

The training system supports multiple VR hosts. The VR host is connected to the server via the cloud.The server provides database services for multiple VR hosts, which can achieve remote data transmission. Trainers, examiners and administrators access the server through peripherals. Through the software, VR training tasks can be arranged, test instructions can be entered, evaluation scores and system supervision can be performed.

The system supports multi-user visual immersion, allowing multiple learners to collaborate on a single training load at the same time. Servers in different regions can be connected remotely through the cloud, so trainees can also participate in remote training and share data, greatly expanding the scope of training [9].

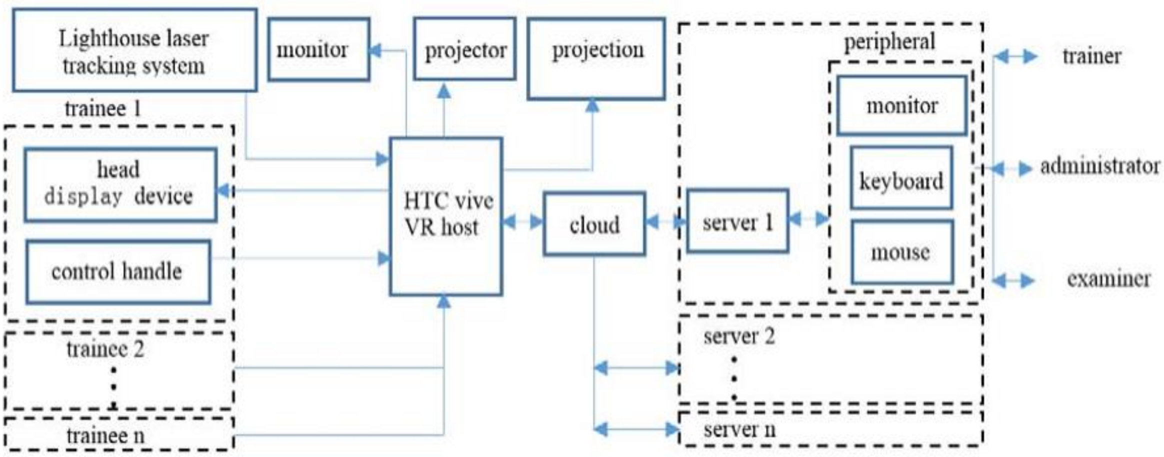

Figure 2. Architecture of hardware system

According to the system operation requirements, the virtual reality hardware platform was also built on it base, VR marine communications software development and ship power system equipment maintenance and a training and intervention management system was designed. Starting from the main training objectives in equipment maintenance and management of intervention operations, with this system three-dimensional processes and equipment are modeled and simulated, allowing students to perfect themselves in the field of equipment maintenance and operation.

Currently, there is no training system based on VR technologies implemented in the navy, in fields of education. A typical example of associated equipment is the switchboard in the ship's electrical plant. Fig.3 shows the application development concept in the electrical systems laboratory of the ”Mircea cel Bătrân” Naval Academy.

Figure 3. AR in marine power plant education and training

5. Conclusions

This paper examined the significant role of smart glasses and remote support technologies in solving communication challenges in naval operations.

The use case highlighted the difficulties of diagnosing key mechanical faults on deployed boats with restricted and intermittent internet access. Although there are certain restrictions, the system has the potential to provide real-time remote help by a professional on land, by using STUN and TURN servers to ensure good communication.

This not only accelerates the process of fixing problems and reduces the negative effects on the operations, but also promotes the exchange of information between experienced professionals and engineers on board. The combination of smart glasses and remote support technology offers a potential option to improve operational efficiency and resilience in the distinct setting of naval operations.

Referances

[1] A. Follmann, M. Ohligs, N. Hochhausen, S. Beckers, R. Rossaint and M. Czaplik, "Technical support by smart glasses during a mass casualty incident: a randomized controlled simulation trial on technically assisted triage and telemedical app use in disaster medicine," Journal of Medical Internet Research, 2019;

[2] M. Caria, G. Sara, G. Todde, M. Polese and P. A. L., "Exploring smart glasses for augmented reality: a valuable and integrative tool in precision livestock farming," Animals, 2019;

[3] Y. Zhao, T. Heida, E. E. H. v. Wegen, B. R. Bloem and R. Wezel, "E-health support in people with parkinson’s disease with smart glasses: a survey of user requirements and expectations in the netherlands," Journal of Parkinson's Disease, 2015;

[4] P. Sparwasser, M. Haack, S. Epple, L. Frey, S. Zeymer, D. R. and H. Borgmann, "Smartglass augmented reality-assisted targeted prostate biopsy using cognitive point-of-care fusion technology," The International Journal of Medical Robotics and Computer Assisted Surgery, 2022;
[5] O. Matei, I. Vlad, R. Heb, A. Moga, O. Szika and O. Cosma, "Comparison of various epson smart glasses in terms of real functionality and capabilities," Carpathian Journal of Electrical Engineering, 2016;
[6] O. Matei, R. Erdei, A. Moga and R. Heb, "A serverless architecture for a wearable face recognition application," Pattern Recognition. ICPR International Workshops and Challenges: Virtual Event, Proceedings, Part VII, pp. 642-655, 2021;
[7] O. Matei, K. Materka, P. Skyscraper and R. Erdei, "Functionizer-a cloud agnostic platform for serverless computing," International Conference on Advanced Information Networking and Applications, pp. 541-550, 2021;
[8] R. Erdei, D. Delinschi and O. Matei, "Security Centric Scalable Architecture for Distributed Learning and Knowledge Preservation," International Workshop on Soft Computing Models in Industrial and Environmental Applications, pp. 655-665, 2022;
[9] Li Bingchan, Bo Mao, Jie Cao, ‘’Maintenance and Management of Marine Communication and Navigation Equipment Based on Virtual Reality’’, in Procedia Computer Science 139 , pp.221-226, 2018.