Enhanced remote control of autonomous ship through Meta Quest VR

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Context

The maritime industry is experiencing a technological transformation, driven by advancements in automation and remote operation. Autonomous ships, which can operate without human intervention, promise to enhance efficiency, safety, and cost-effectiveness in shipping. However, situations like harbour maneuvering and auto-docking still present significant challenges in terms of situational awareness and operator interaction.

VR systems, such as the Meta Quest VR, are a well-proven technology in the gaming market. This gives opportunities for highly enhanced remote presence when controlling an autonomous ship from a distance. The question is to investigate possibilities and feasibility of using such VR platform for highly improved operational awareness by providing immersive and intuitive control interfaces.

Motivations

Enhanced Operational Awareness
Traditional remote control interfaces may not fully convey the spatial and environmental context of a ship's surroundings. VR can provide a more immersive experience, improving situational awareness and decision-making.

Improved Operator Performance
VR interfaces can reduce cognitive load and improve the ease of controlling complex systems by leveraging natural gestures and movements.

Training and Simulation
VR offers advanced training and simulation environments, allowing operators to practice and refine their skills in a safe and controlled setting.

Technological Integration
With the rise of consumer-friendly VR hardware like Meta Quest, integrating these technologies into maritime operations becomes more feasible and cost-effective.

State-of-the-Art

Autonomous ships
- Path planning in coastal areas commonly uses A* algorithm but some other, more efficient methods start to emerge, such as Deep Q Learning [3]
- Path planning in harbours is more difficult due to high density of traffic, complex navigation constraints, and frequent dynamic changes in the environment[7].
- Adaptive collision avoidance systems are being developed to safely integrate autonomous ships in the traffic [2].
- Automated docking is possible and getting sophisticated, though with notable trade-offs and limitations [4].
- Not all the ports are equipped to safely host autonomous ships [5].

Remote Control Systems
- Existing remote control systems typically rely on 2D screens and physical controls, which can limit the operator's ability to perceive and react to the maritime environment accurately.
- Advances in augmented reality (AR) and VR are starting to influence remote control interfaces, providing more intuitive and immersive experiences [1].

VR in Maritime Applications
- VR has been used in maritime training simulators to replicate real-world scenarios for crew training[6].

Research Objectives

1. **Assess the current limitations of remote control systems for autonomous ships.**

   → Key areas of focus include limited situational awareness, high cognitive load on operators, delayed response times, and the difficulty of integrating and interpreting data from multiple sensors.

2. **Design and develop a VR interface using Meta Quest VR, or a similar system, for remote ship control.**

   → The interface will aim to provide an immersive environment where operators can interact with and control ships more intuitively. The design process will include user interface (UI) and user experience (UX) considerations, ensuring that the system is both effective and user-friendly.

3. **Evaluate the effectiveness of the VR interface in enhancing situational awareness and operational efficiency.**

   → The evaluation will include both qualitative and quantitative methods, such as user feedback, performance metrics, and simulations, to assess whether the VR system provides significant benefits over traditional remote control methods.
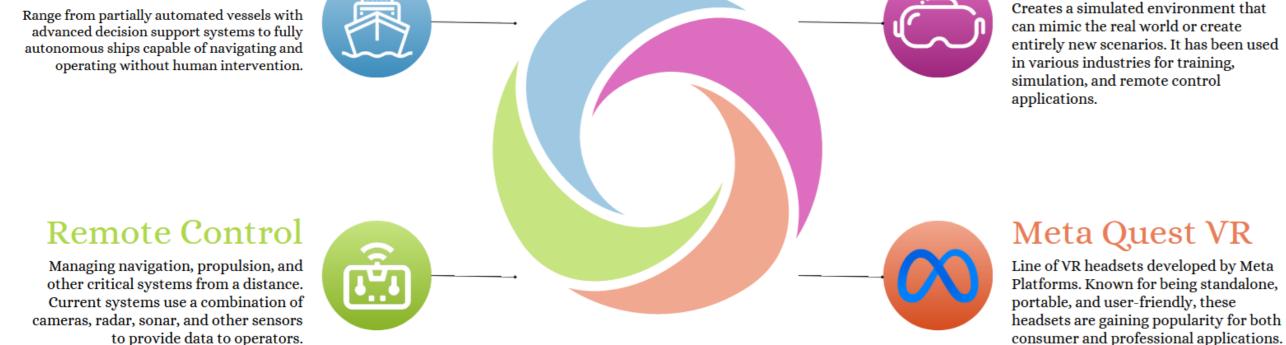
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Background

Autonomous Ships — Range from partially automated vessels with advanced decision support systems to fully autonomous ships capable of navigating and operating without human intervention.

Remote Control — Managing navigation, propulsion, and other critical systems from a distance. Current systems use a combination of cameras, radar, sonar, and other sensors to provide data to operators.

Virtual Reality (VR) — Creates a simulated environment that can mimic the real world or create entirely new scenarios. It has been used in various industries for training, simulation, and remote control applications.

Meta Quest VR — Line of VR headsets developed by Meta Platforms. Known for being standalone, portable, and user-friendly, these headsets are gaining popularity for both consumer and professional applications.