Fraunhofer Center for Maritime Logistics

combining AR and VR technology to remotely support ship captains with the expertise of a shore-based pilot

the challenge

According to International Maritime Pilots' Association (IMPA) data, approximately 19% of pilot transfers in European waters fail to comply with safety regulations. A particular concern is the non-compliant pilot ladder arrangements, which contribute to deadly accidents.

RePO MAN (Remote Pilotage – Operational, innovative and Manageable Alternatives for Navigation routines) addresses this safety challenge by developing a mixed reality solution that enables pilots to provide their expertise without physically boarding vessels. The project tackles several key safety issues:

1. Elimination of physical transfer risks by allowing pilots to operate remotely
2. Maintenance of crucial situational awareness through advanced AR visualization
3. Enhancement of communication between pilots and shipmasters using intuitive visual interfaces
4. Provision of real-time navigational data overlay in the pilot's field of view

The project particularly focuses on maintaining the high level of situational awareness necessary for safe navigation while removing the physical risks associated with pilot transfers. This innovative approach not only protects pilots' lives but also ensures continuous access to vital pilotage services in adverse weather conditions where traditional pilot transfers might be deemed too dangerous.

the innovation

RePO MAN implements a mixed reality solution for remote pilotage, integrating Augmented Reality (AR) and Virtual Reality (VR) technologies to create remote navigation support between vessels and shore-based pilots. The system fuses two primary components:

Ship-side: An AR application utilizing Microsoft HoloLens 2 displays navigational information in the crew's field of view. The system processes real-time AIS data, calculating relative

distances and bearings to surrounding vessels. User interaction is implemented through hand tracking, enabling access to vessel information without physical controllers. The interface design maintains natural visibility while providing essential navigational data.

Shore-side: The pilot's workspace incorporates a VR environment receiving real-time 360-degree video feeds from ship-mounted cameras. This visual input is integrated with navigational data and electronic charts within the virtual space. The system processes and displays AIS data, radar information, and environmental parameters to maintain situational awareness.

The communication framework combines VoIP technology with visual interaction tools. The system enables pilots to designate points of interest and provide visual guidance through markers and indicators that appear in the crew's AR display. These elements are spatially anchored and maintain correct positioning relative to the vessel's movement.

how it was implemented

The implementation process followed a systematic approach spanning development and testing phases. The system utilizes MQTT protocol for data transmission, enabling real-time AIS data flow between ship and shore systems. On the ship side, the AR application was developed using Unity 2022 LTS with MRTK3 integration for HoloLens 2 compatibility. The shore-based VR component incorporates 360-degree camera feeds with Unity-based visualization of navigation data.

Initial development focused on hologram positioning algorithms, adapting the spatial anchoring system for maritime use.

Field implementation involved installation of 360-degree cameras above the ship's bridge, establishment of secure data transmission channels, and integration with existing ship systems. The implementation process included systematic testing of latency, data accuracy, and system reliability under various operational conditions.

result

Testing demonstrated successful data integration and visualization in both AR and VR environments. The system achieved consistent hologram positioning accuracy and maintained stable data transmission during operational testing. Latency measurements showed acceptable performance for real-time navigation support, with AIS data updates matching industry standards for update frequency.

Qualitative assessment by experienced pilots indicated that the system maintained required levels of situational awareness for remote navigation support. The AR interface demonstrated reliable gesture recognition and data presentation in varying light conditions. Shore-based pilots successfully executed navigation guidance using the VR interface while maintaining effective communication with onboard crew.

The system showed particular effectiveness in controlled testing environments, providing a foundation for further development in actual maritime conditions. Testing also identified

areas for future optimization, particularly in extreme weather conditions and high-traffic scenarios.

conclusion

The development and testing of RePO MAN demonstrates the technical feasibility of mixed reality solutions for remote pilotage operations. The system establishes a framework for reducing physical risks in pilotage while maintaining operational effectiveness. Results indicate that mixed reality technology can effectively support remote navigation assistance while preserving essential elements of pilot-crew interaction.

Key limitations include the need for reliable high-bandwidth communication infrastructure and the system's dependence on environmental conditions for optimal performance. Future development should address these constraints and expand testing across diverse maritime scenarios and vessel types.

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