

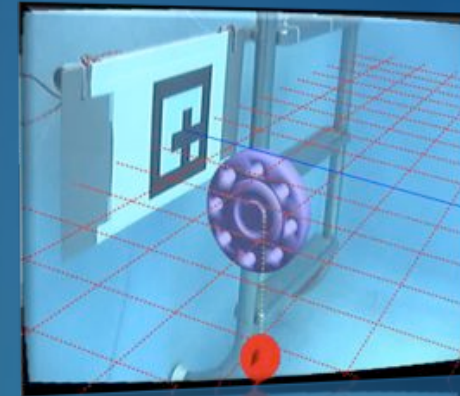
AN UNDERWATER AUGMENTED REALITY SYSTEM FOR COMMERCIAL DIVING OPERATIONS

ROGELIO MORALES-GARCÍA, PETER KEITLER, PATRICK MAIER, GUDRUN KLINKER

FACHGEBIET AUGMENTED REALITY (FAR)

This presentation describes the implementation of a novel prototypical Underwater Augmented Reality (UWAR) system that provides visual aids to increase commercial divers' capability to detect, perceive, and understand elements in underwater environments.

We accomplished our goal by assisting divers in locating the work site, keeping informed about orientation and position (constantly), and providing a 3D virtual model for an assembling task.



INTRODUCTION

DIVERS OPERATIONAL CONTEXT

Divers perform daily operations below the surface that are highly demanding and hazardous, having an important physiological and psychological impact on them, not to mention the challenges for their visual system.

Some manifestations of these activities appear in divers' lack of spatial positioning and orientation awareness, reduced cognition, and memory disorders.



UNIQUENESS OF DIVERS

Divers are unique in their capabilities of executing complex tasks (both mentally and manually), and performing a high level of adaptable and flexible thinking required in major underwater operations.

One example of this critical ability is underwater construction, concerned with the process of building and assembling structures in underwater or marine sites.

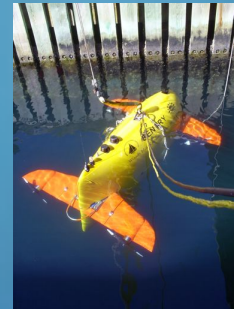
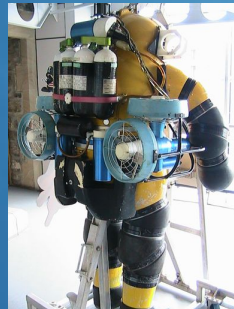
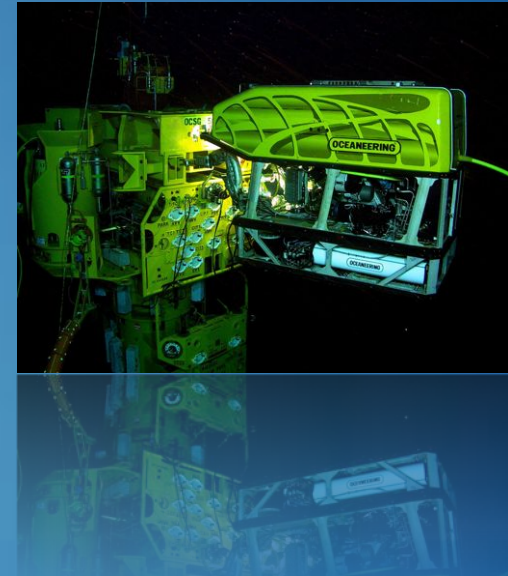


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PREVALENCE OF DIVERS

At the moment, divers capabilities cannot be matched by robotic systems, for instance, Remote Operated Vehicles (ROVs), Autonomous Underwater Vehicles (AUVs) or manned platforms, like Atmospheric Diving Suits (ADS) and submersibles.



Our goal is to provide visual cues to divers to compensate sensory impairment and cognitive changes, such as lack of orientation, position awareness, and memory disorders, in order to keep divers calm within acceptable levels of stress, and hoping to improve diver performance and safety.

DIVERS' DIFFICULTIES

PHYSIOLOGICAL • VISUAL • PSYCHOLOGICAL

During underwater operations, a great amount of stress is imposed on divers by environmental and working conditions such as pressure, visibility, weightlessness, current, etc.

Those factors cause a restriction in divers' sensory inputs, cognition and memory, which are essential elements for divers in order to accomplish their task.

Eventually, the associated stress driven by these factors compromise divers' confidence and safety, and therefore, reduce performance.



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DIVING PHYSIOLOGICAL EFFECTS

Pressure

Tactile-kinesthetic and vestibular system

Mobility

Hearing

Other factors

VISUAL PERCEPTION DIFFICULTIES

DIVING PSYCHOLOGICAL EFFECTS

Anxiety

Panic

Memory Disorders



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UWAR

UNDERWATER AUGMENTED REALITY

ORIENTATION AND POSITION AWARENESS

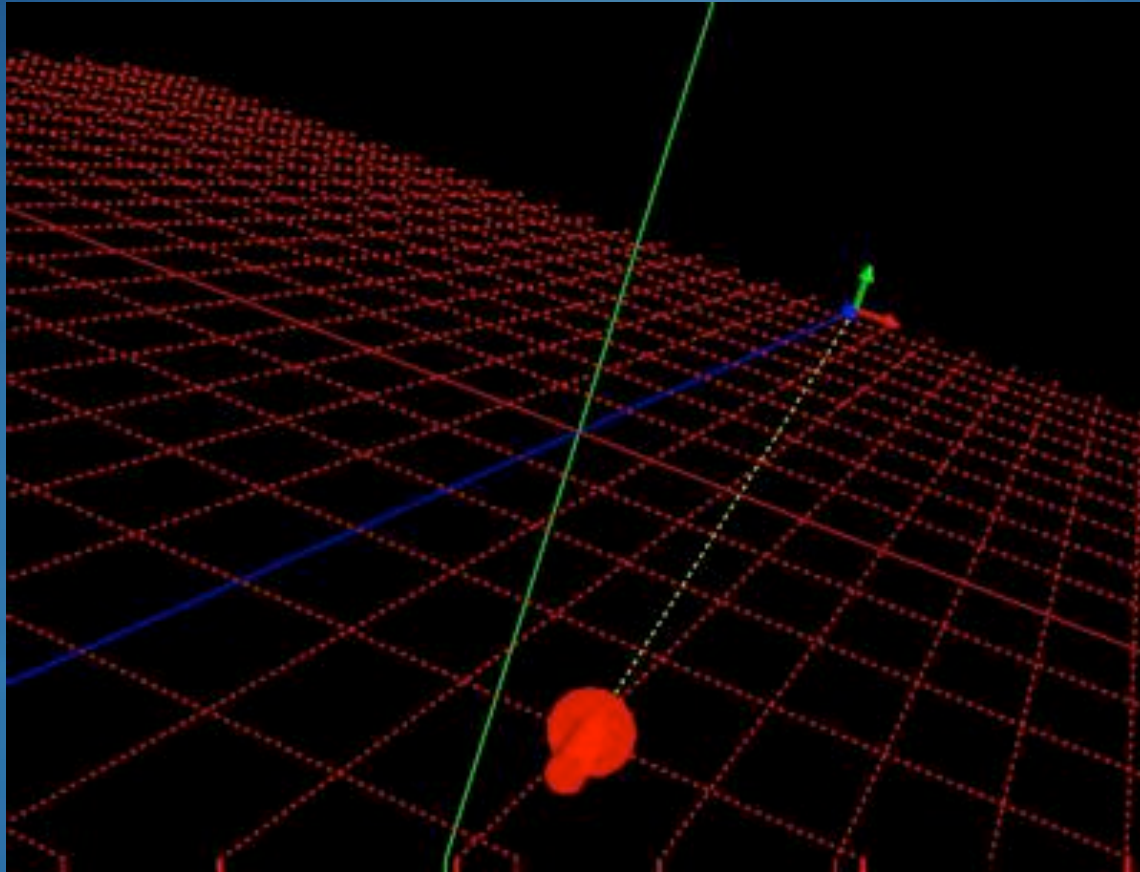
A visualization of an artificial horizon (red grid) to increase position awareness within the environment and work-site.

NAVIGATION AIDS

A guidance to the work-site implemented with a virtual red arrow sign pointing to the task location. Designed to show a diver's course constantly, and a yellow line that links the arrow with the target position.

CONTEXT-DEPENDENT MEMORY

A 3D model of an assembling task or project planned, intended to reduce mental workload and compensate any memory disorder.



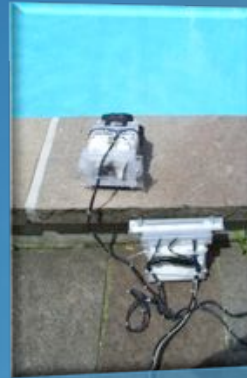
The 3D visualization model

EVALUATION SYSTEM

(a)



(b)



(c)



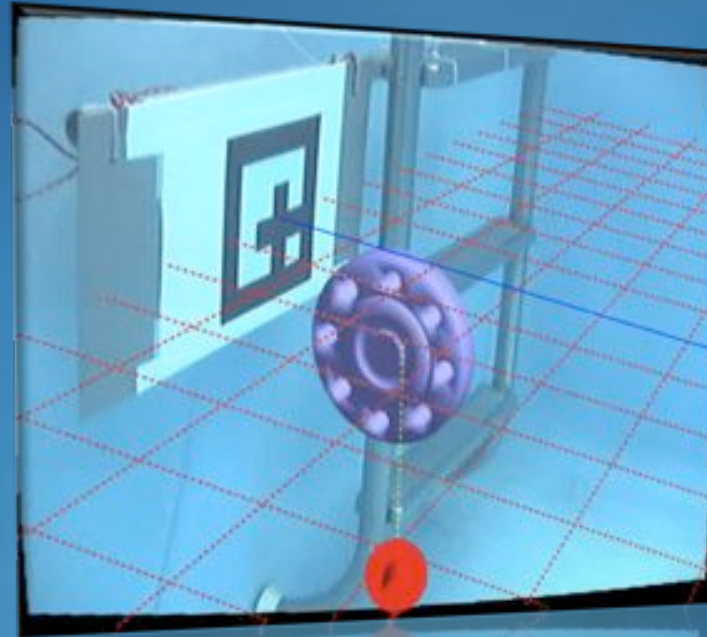
(d)



(a & b) Watertight housing for Logitech Quickcam Pro 4000 and eMagin Z800 3D Visor HMD.
(c & d) Calibration grid for camera calibration and optical square-marker for rendering.

RESULTS

& DISCUSSION

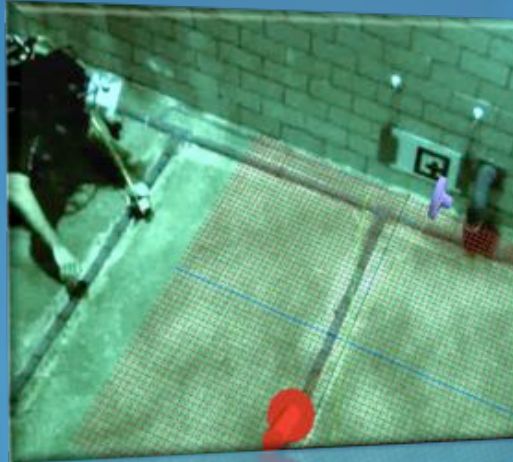


FEATURES OF THE VISUALIZATION. A navigation aid (virtual red arrow) that points to the work-site and a yellow line that connects the arrow tip with the location of the target (constantly). An artificial horizon (red grid) to aware divers of their orientation related with horizon. A 3D model of an assembling task (flange).

(a)



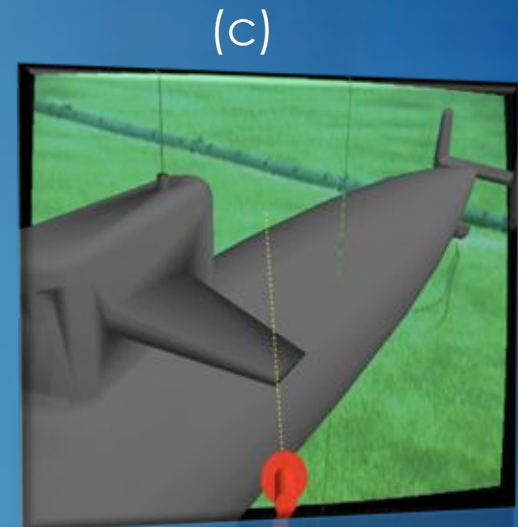
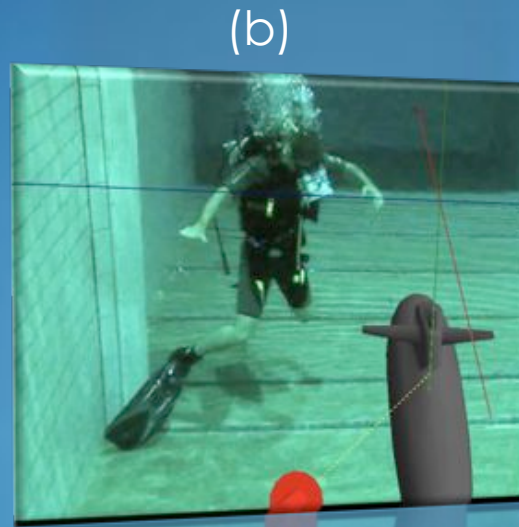
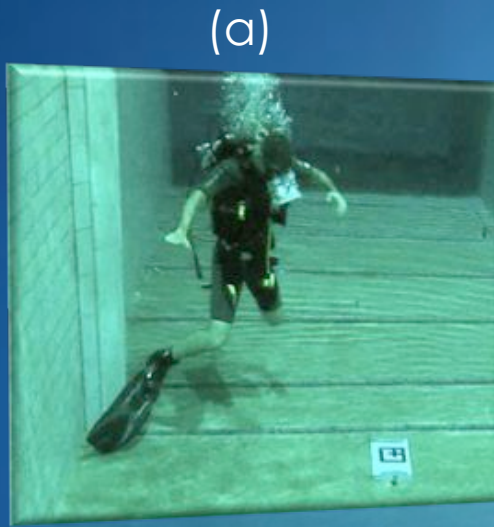
(b)



(c)



(a) Exocentric view without augmentation. (b) Exocentric view with augmentation. (c) Egocentric view with augmentation.



SIMULATION OF A VESSEL INSPECTION. (a) Exocentric view without augmentation. (b) Exocentric view with augmentation. (c) Egocentric view with augmentation.

CONCLUSIONS

& FURTHER DEVELOPMENTS

ACCOMPLISHED

The implementation of a basic augmented reality system for underwater applications.

An effective underwater camera calibration and rendering.

Navigation aids, artificial horizon, and memory clues for executing an assembling task and an inspection survey.

FURTHER DEVELOPMENTS

Implementation of an underwater acoustic tracking system for a wide spectrum of water conditions.

Usability of the system in real conditions.

Improvement of hardware to increase reliability and diver's experience.

Acoustic imaging system and Mixed Reality (MR).

Stress levels monitoring system.

AUGMENTED PERFORMANCE DIVER (AP-DIVER)

This diver-machine synergy could upgrade divers to a new level, in which they will perform beyond their actual capacities and abilities, making them Augmented Performance Divers. A concept that in addition to the cognitive side (approached in this research) could include physical augmentation, which is the amplification of human endurance and strength.

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