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How Simulation Training Can Benefit from Virtual Reality Extensions? - Case: A Virtual Reality Extension to a Simulated Ship Bridge for Emergency Steering Training

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Abstract. This paper presents a Virtual Reality (VR) training application that is connected to maritime training simulator. We call this a VR extension to simulation training. The solution enables a more comprehensive training scenario than a traditional simulator exercise. The case study concerns emergency steering procedure, in which the steering of the vessel must be handled manually from the steering gear room with only an audio connection to the bridge. The steering gear room is implemented as a VR training connected to the bridge simulator. The paper presents the technical implementation and the training process where the VR application has been integrated as a part of the simulator training. The implementation was tested with maritime professionals and teachers. The results validate the feasibility of the training scenario and the usability of the VR implementation. Furthermore, the interviews provide insight into the potential of VR-extended simulator training scenarios in maritime training.

Keywords: Simulation training · Virtual reality · Maritime education

1 Introduction

Simulation training is an important way of learning many complex tasks in maritime, aviation, and many more professions. Learning by doing in simulations enables training in areas that would be dangerous and expensive to practice in a real environment.

Virtual Reality (VR) is gaining popularity as a tool for implementing different training scenarios. VR training enables training in a realistic environment without building physical setups. The learning by doing practice in VR is similar to simulator training, except that the view is created with the help of VR glasses and interaction with hand controllers.

Even though simulator training and VR training are widely studied separately, their connection is not. In this paper, we present a VR training application that is connected to and utilizes maritime training simulator data flow. We call this a VR extension to simulation training.

The paper is organized as follows. The Introduction is followed by a view to the related work in Section 2. The use case is presented in sections 3 and 4 both form the technical and training arrangement perspectives. The completed test is described in Section 5 followed by the results in Section 6. Finally, conclusions and future work are presented in Section 7.

2 Related work

In maritime training, a simulation is an essential tool in mastering many seafarer's skills. Simulators provide opportunities to acquire technical, procedural, and operational skills without the risks and expenses associated with on-the-job training [1].

Maritime simulators and simulated training activities cover a range of skills: Navigation and bridge operations, engine rooms, communications, vessel traffic services, ballast and cargo, anchor handling systems, firefighting, rescue, oil spill management, drilling systems, pilotage, and crane operations [2]. Overall, the importance of the seafarer's skills has been emphasized by many articles: Modern and technologically sophisticated ships require increasingly competent seafarers [3]. One of the most critical elements of maritime operations is the seafarers themselves [4]. Therefore, The International Maritime Organization (IMO) defines the mandatory training areas that must be trained continuously in simulations or real environments [5].

As far as the authors are aware of, the combination of VR training to simulator training has not been reported before.

Virtual reality itself has high expectations as a training media. Skills acquisition is demonstrated in certain cognitive skills areas: psychomotor skills like observation and affective skills related to controlling emotional response in stressful situations. The drawback of virtual reality is the technical challenge and distractions from the learning tasks, putting an emphasis on the good design of the training application [6]. The new generation of virtual reality head-mounted displays promises a new revival in training and other usages of VR [7]. The market has been growing and forecast 2027 for the global market size is 57.55 billion USD [8].

Virtual learning offers support for many learning styles and makes learning accessible in the areas that require visual, auditory, and kinesthetic engagement [9]. Emerging technologies like VR offer new possibilities for simulation-based training. The advantages like cheaper price, more immersion, and compactness advocate the open-minded use of new technologies alongside traditional simulation [3].

3 Technical setup

VR steering gear room was built using Unity, for use with an HTC Vive Pro VR headset. Voice communication between the bridge simulator and the VR simulator is handled via an IP phone connection. The VR simulator communicates with the bridge simulator through a bridge interface that provides a REST API for reading and modifying simulator data. The relations between these components can be seen in Fig. 1.

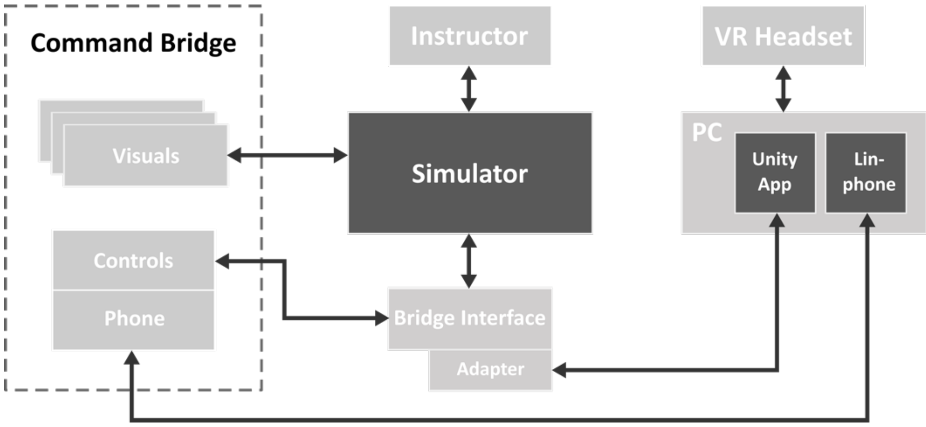

Fig. 1. The technical construction of the Virtual reality extension in Transas ship bridge simulation with IP phone connection.

For addressing the reported [6] technical challenges with VR technology the VR software's user interface was built to be as lightweight as possible, and a quick tutorial was also included for users with no previous VR experience. It is also expected that the ability levels of trainees using the VR simulator can range heavily.

Particular emphasis was put on removing any unnecessary functionality. The two main ways to achieve this were to only utilize one button from each of the VR controllers and completely remove the need for teleporting in the VR simulator. The user interface is context-dependent and knows when to grab and when to toggle virtual buttons. The tutorial teaches basic knowledge about movement and interaction in VR.

The interface for the Transas simulator utilizes a representational state transfer application programming interface (REST API), which is implemented in the VR software. During live training exercises, the VR simulator constantly requests data about the ship's rudder angles and heading from the bridge simulator. This data is displayed on realistic meters inside the VR environment, as well as on a screen on the computer that is running the VR simulation (instructor view), as seen in Fig. 2. The VR scenario also controls the ship's rudder angles on the bridge simulator via the REST API.

Real-time voice communication between the bridge simulator user and the VR simulator user is accomplished via an external IP phone connection. A physical IP Phone is used on the ship bridge, and an IP phone software is used on the computer that runs the VR simulator. The microphone and speakers of the VR headset are utilized, so no other external audio source or recording devices are needed. A virtual headset is also implemented in the VR simulator, which suppresses the noise in the virtual engine room (to make voice communication easier).

Fig. 2. The instructor view in the Steering Gear room VR-simulation (Left) and decision making and communication in a bridge simulation exercise (Right).

4 Training setup

In the maritime sector, command bridge, engine room, and radio traffic simulators are commonly used as regulated by the international maritime Standards of Training, Certification, and Watchkeeping (STCW) [2]. However, command bridge simulators do not cover all the locations and responsibilities of deck officers. Here, a VR environment connected to the simulator's data creates a shared experience in a real situation that has not been trained to its full length before.

The scenario replicates a steering malfunction situation, where steering is lost on the command bridge due to an unknown reason. The location is in the open sea, and the weather is calm and there is some traffic. The bridge is manned by two trainees, as seen in Fig. 2, who took the roles of the Officer on Watch (OOW) and a lookout. The OOW of the vessel recognizes the loss of steering and sends the lookout to the steering gear room.

While the lookout is going to the steering gear room in VR, the OOW has to make a plan and inform others of the malfunction. Usually, the goal of the exercise is to stay in the fairways and safely meet the ongoing vessel and the goal is accepted by the instructor of the test. In the VR-steering gear room, a person (lookout) has to prepare the pumps for local control and run inspection according to the OOW's orders. To steer the vessel, the OOW gives commands according to his plan. The steering is possible only by proper instructions since no other information than a rudder angle and compass are available. The exercise takes 10-15 minutes and the testers can finish the exercise when they reach their goals. No artificial stress-inducing elements were added to the scenario.

5 Test setup

A total of 16 testers participated in the testing. The testers can be divided into two groups: 1) maritime professionals and 2) maritime teachers. Both groups are summarized in Figure 4.

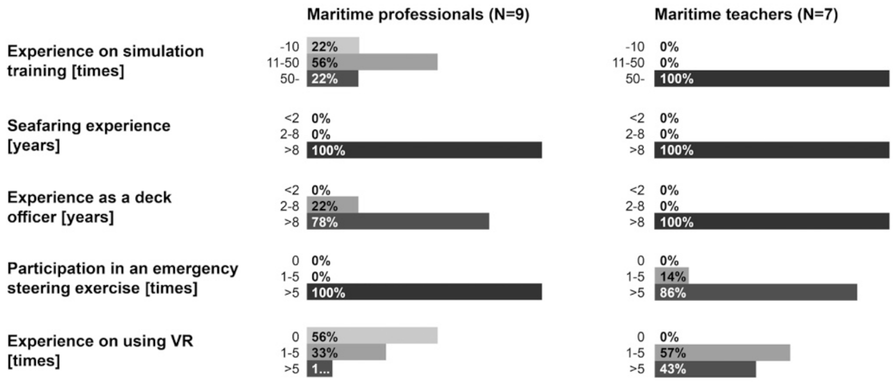

Fig. 4. Background information on the test participants.

The participants of the first group were deck officers of various ships (N=9 of which 7 from passenger ships and representing 5 different shipping companies). They had followed quarterly emergency steering procedures in their vessels.

The testers of the second test group came from two backgrounds: experienced master mariners and maritime engineers, both working as maritime institutes teachers (N=7) and having wide know-how both in simulation training and practical way of acting in real situations. In this group, 5 participants were more familiar with the deck officer's roles and 2 more familiar with the engine room activities.

All maritime professional testers were experienced seafarers and deck officers, almost all having more than eight years of experience in their profession. All maritime teachers had extensive experience and most maritime professionals moderate experience in simulator training. The experience on using VR was very limited: 56% of maritime professionals had never used VR before and also the majority of the teachers only 1-5 times before.

The testers started with the VR tutorial, familiarizing them with actions like moving, turning, catching, and pressing in VR devices. They also introduced themselves to the VR steering gear room before starting the exercise, which helped them orientate during the training. Also, the bridge simulator's devices were introduced to those who were not familiar with that particular bridge simulator before.

The test persons took the roles of OOW and lookout and were asked to act as they would in a real situation where one must take command and the lookout goes to the steering gear room due to steering malfunction. Both testers acted in both roles to finish the tests round, immediately following each other. The OOW of the second trial was allowed to use a different approach. Once a group finished their rounds, they were interviewed.

6 Test results

Both test groups found the VR extension easy to get started with. All of them reported they had experienced a real environment and a real situation. Overall acting in the environment was experienced to be natural. Only one of the testers reported slight nausea. The VR application usability was found intuitive and easy, and they found the controller buttons easy to use and virtual levers to function realistically. The noise level was lower than in the real environment (which was intentional to support pedagogical aspects).

As an educational environment, the communication and collaboration skills training was highlighted by both test groups. The actual steering malfunction practice is rarely done during navigation, and the extension gives an opportunity to practice in realistic situations. In the opinion of the maritime professionals, the extended environment fits well with steering malfunction training and practicing rudder commands and hand steering. Decision making and problem solving, anticipation, and commanding skills are developed. The skills learned were reported to be useful also in other situations. Testers targeted the training environment to be most valuable in deck and engine officers' collaborative training.

Teachers underlined the stress-free training to learn skills. For emergency steering training, they said all elements needed are included. An extended simulation environment provides more realistic training than before. The strength compared to real environment training is that virtual training allows trainees to learn at their own pace.

The maritime professionals suggestions for other VR extension scenarios to connect with a bridge simulator included blackout, mooring, lifeboat, and other critical situation operations, tug operations, anchoring, pollution control, safety thrills, etc., The extended environment also enables testing direct skills, such as holding a course, and indirect skills, such as giving the rudder command.

The future skills to pay attention to in deck officer training were said to be two-folded. On one hand, automation requires a deeper understanding of technology. Especially ship-specific know-how, not only the functions of the bridge systems but also knowledge of back-up systems is needed. To master the evolving systems, good basic skills are a must-have. On the other hand, basic seafarer’s skills are highly valued and should be practiced during studies, instead of leaving it only to the on-board training periods.

Generally, when the ship's crew is growing smaller resources for introduction training on-board are decreasing. The maritime academies and training centers can help in bringing a part of the training onto land.

7 Conclusion and future work

This paper presented a VR extension to simulation training enabling a more comprehensive training scenario than a traditional simulator exercise. The presented case study concerns emergency steering procedures and it was tested with maritime teachers and professionals.

The experiences in VR extended bridge simulation from both test groups are encouraging. The VR application is found easy to learn and use and it represents the real environment well. The training scenario was found reasonable and supporting learning of the needed skills. Thus, it can be concluded that the results validate the feasibility of the training scenario and the usability of the VR implementation.

Furthermore, the interviews provided insight into the potential of VR-extended simulator training scenarios in maritime training. Training the communication and collaboration between different professions and individuals onboard can benefit greatly from extended simulations. Preparing for emergency and malfunction situations is an important part of all maritime professions but it is even more crucial on passenger ships.

In the long run, the increasing automation together with the need to master elementary seafarer skills will require special concern in the future. Further development of existing infrastructure in training centers with emerging technology, such as virtual reality, seems to be viable way to address that concern. This research proves it can be implemented both technically and pedagogically. Even though this is a case study in maritime safety training, we believe our findings are relevant to many other sectors utilizing simulator training.

As for future work, the authors are planning a larger study on maritime students' learning outcomes when using the VR-extended simulator. Also, new VR-extended training scenarios based on ideas proposed in the interviews, are planned.

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