Human Computer Interaction opportunities in Hand Tracking and Finger recognition in Ship Engine Room VR Training.

Evangelos Markopoulos[1], Mika Luimula[1], Werner Ravyse[1], Jesse Ahtiainen[1], Ville Aro-Heinilä[1]

[1] Turku University of Applied Sciences. Faculty of Engineering and Management, Joukahaisenkatu 3, 20520 Turku, Finland.

evangelos.markopoulos@turkuamk.fi; Mika.Luimula@turkuamk.fi; werner.ravyse@turkuamk.fi; Jesse.Ahtiainen@edu.turkuamk.fi; ville.aroheinila@edu.turkuamk.fi

Abstract. The research conducted for this paper is an extension of the continuous efforts at the Turku University of applied Sciences to optimize the Maritime Immersive Ocean Technology (MarsISOT) by integrating advanced immersive technologies. This paper reports the integration of hand tracking and finger recognition in the ShipSEVR learning episode. ShipSEVR, part of MarISOT, is a VR Training next generation learning environment focused specifically on ship engines and engine rooms safety procedures. The technology has been designed and developed at Turku University of Applied Sciences for Wärtsilä Land and Sea Academy utilizing latest VR technologies. The delivered learning episode consists of a 3D ship engine room space where trainees are expected to find certain devices and equipment by utilizing the available technical drawings. This enhanced human computer interaction environment reflects to industry requirements the derived after the first version of the technology and its test with industry experts.

Keywords: Virtual Reality · Maritime Safety Training · Hand Tracking · Finger Recognition · Shipping · Human Computer Interaction · Engine Room · Ship · Maritime

1 Introduction

Over the last two years the Turku University of Applied Sciences has made the strategic decision to explore in depth the applications of virtual reality in the shipping and maritime sector. Turku hosts some of the world's leading maritime companies in ship building, ship operations and maritime education.

Since then, several projects and experiments have been implemented and international strategic partnerships have been formed. These activities resulted to the creation of the MarISOT technology [1]. Lately MarISOT received funding to explore its commercialization route and disrupt the maritime training markets with the introduction of advanced virtual reality applications specifically on the maritime safety sector. Industry experts believe that immersive learning with VR environments provide pedagogical practices and deeper understanding of the processes and procedures [2] required to undertake in a given situation [3].

In an attempt to keep up with the maritime technology trends, research was conducted to examine and develop ShipSEVR (Ship Engine Safety Education Virtual Reality) [4]. ShipSEVR is a next generation VR Training learning environment focused specifically on ship engines and engine rooms safety procedures. The technology has been for been initially developed for Wärtsilä Land and Sea Academy (WLSA) at the AVR Turku Innovation and Competence Factory (AVR Turku) with the latest VR technologies.

Furthermore, MarSEVR (Marine Safety Education with Virtual Reality) is a second core technology of MarISOT focused on virtual training on command bridge operations. [5]. The technology provides practical situational awareness and decision-making scenarios by replicating a ship bridge environment for virtual education in maritime safety training.

Both MarsSEVR and ShipSEVR adopt VR and game design principles to implement, immersive training scenarios in an engaging and interactive way that contributes to better understand decision-making factors in a gamified environment.

2 Research rationale

The research resented in this paper extends the functionality of the ShipSEVR technology with the addition of Hand and Finger Tracking. These technologies have been successfully implemented in the MarSEVR technology [6] which is also part of the wider MarISOT technology. Furthermore, this work resolves various technical challenge challenges identified in the first version of ShipSEVR.

The previous version of ShipSEVR was tested intensively by Wärtsilä at their Turku premises and the promising results helped the project to continue [7]. However there have been found some challenges in usability and user experience which were mainly caused by the use of controllers. Furthermore, the low resolution of the headset greatly hampered the immersive quality of VR.

The controllers were unwieldy to interact with the command bridge instruments. Dials with fine adjustments, closely spaced buttons and slider positioning proved to be most problematic. Although controllers were sufficient for manipulating a relatively large wheel and lever, users had to explicitly look at the virtual objects to line up the controller with that object to ensure successful interaction. Training experts felt that such repeated practice in a virtual environment could be habit-forming for real-world settings where seafarers should rather be able to blindly find the ship controls.

In addition, visualization of detailed engine schematics was difficult because of the lack of resolution. As a conclusion it has been decided to integrate one of the most promising new VR technologies which is the Varjo VR-2 glasses with human-eye resolution. This device is offered with Leap Motion sensor for hand tracking and finger recognition.

To be able to integrate hand tracking and finger recognition, new UI design, and UI assets had to be created. Also, interactions for teleporting and engine schematics were redesigned. For a fluent use of hand tracking and finger recognition it was decided to add a tutorial, a visible guidance to train inexperienced users. The use of hand tracking and finger recognition is not so common in gaming industry and there were some challenges to find best practices how to design a virtual UI and how to interact with engine schematics or navigate in the ship engine room fluently.

As a result, and after resolving the mentioned challenges the hand tracking and finger recognition was integrated in the ShipSEVR learning episode using Varjo VR-2 glasses with Leap Motion sensor. This effort conducted a pilot test with ten test subjects were usability and user experience were evaluated. These results are reported in detail in the paper.

3 Research Methodology

The research methodology followed in this research used a triangulation approach composed from the literature review the prototype developing, and two surveys, one for the user experience and one for the system's usability.

The literature review contributed on the identification of the best practices to integrate hand tracking and finger recognition in virtual reality applications for serious games and in the maritime industry in particular. The prototype development emphasized on the design a virtual UI to interact with engine schematics, engine room navigation and integration of the hand and finger tacking technology in the ShipSEVR application.

The usability survey included 15 participants that completed an online questionnaire consisting of two parts. The first section asked about their user experience with hand-tracking and the second section tested the usability of hand-tracking.

For the user experience, the participants were asked to rate (on a scale of poor, below average, average, above average and excellent) their experience with several interactions using hand-tracking and their most familiar controller. The interactions included: (a) button press; (b) lever pull; (c) wheel turn; (d) sensitive dial adjustment; (e) slider positioning; (f) teleport; (g) pick up object; (h) hold or carry object; (i) inspect object while holding it; (j) interact with menu options. They were also asked to list (in their opinion) any advantages or disadvantages with hand-tracking. Finally, they were asked to indicate how long it took to become accustomed to hand-tracking.

The usability section used questions from the System Usability Scale (SUS) [8] questionnaire. The statements were adapted to better elicit responses about hand-tracking in VR. For example, if the original statement read "I find the system unnecessarily complex"; the statement was changed to "I find hand-tracking in VR unnecessarily complex.".

4 Technologies Used and the Finger and Hand tracking Application tutorial

The previous version this ShipSEVR application [4] was used as a base application and two plugins namely Varjo VR-2 Pro Ultraleap SDK for Unity and Varjo Plugin for Unity were first installed. In addition, Steam VR plugin was already in use in the base application. Hand tracking and teleportation UI utilize prefabs from the Ultraleap plugin were modified to be used in the new version. Teleportation was developed so that the user can point to any surface that has the correct “teleport” tag assigned to it.

This project has been developed with Unity version is 2019.2.11. An interaction tutorial scene was developed for the use to learn how the teleportation works while using hand and finger recognition gestures (Fig. 1).

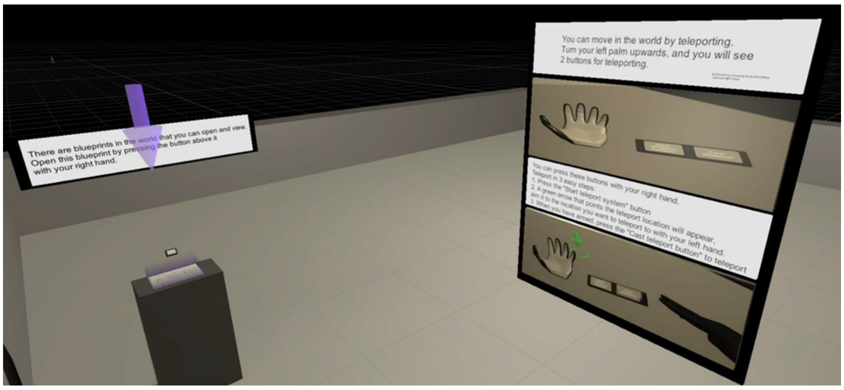

Fig. 1. Guidance signs in the tutorial scene.

In this tutorial, the user is also able to test how the blueprints work. This tutoring scene is a square shaped area with instruction signs that has as text and images on how to use the teleportation gestures. Next to the instruction sign there is a blueprint on a table, and a sign above it that explains how to use it. In addition, there is an exit sign and a button to exit the tutorial and move to the exercise. The player is forced to move in the environment by using teleporting before pressing the exit button.

5 Experiences of hand tracking and UI implementation

The ShipSEVR Hand and Finger tracking system was developed based on assets provided by LeapMotion, the hand tracking solution Varjo relies on, and built the rest upon that. The UI was designed utilizing the 3D in-world system based on LeapMotion's assets. Most of the VR middleware, such as SteamVR and Oculus, provide ready-made tools for basic functions such as teleporting around. In the case of Varjo glasses these type of tools were not available and such a system was developed from the scratch.

While designing teleport functionality, the UI system was already tied to the user's hand models. Ray casting can be activated by pressing one of the buttons on the UI, and subsequently aim around the scene by moving said hand. When the user has aimed their hand at a suitable spot where they can press another button on the UI to teleport there. The system relies on teleporting script making it easily adjustable and portable to other projects.

6 Graphic assets designed for hand tracking system.

In this version, a 3D teleport UI for the Varjo hand models was used. To use developed teleporting gestures explained above a rounded button assets and control panel asset for the hand controls was designed. In addition, two animated identicators were designed to visualize where the user is teleporting: a green arrow for possible places to teleport to, and a red cross to identicate places where the player cannot teleport (Fig. 2).

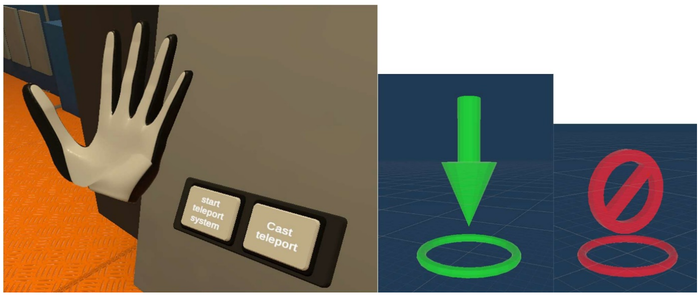

Fig. 2. Rounded button and control panel assets for the improved hand controls.

These additions improved the user experience and teleportation felt much more pleasant to use, and easier to understand. Also, blueprints were added to the scene, made to "pop out" from the surroundings so they catch the user's interest. Furthermore, a glow effect with a purple arrow for the blueprint pedestal was designed to improve the user experience (Fig. 3).

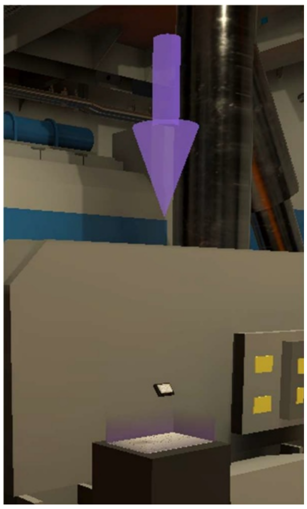

Fig. 3. A glow effect with a purple arrow for the blueprint pedestal.

7 Research results

The results from this research and the experiments conducted after the implementation of the hand tracking functionality seems to indicate that the hand tracking does not improve the user experience as it was expected. The comparisons between controllers and hand-tracking for the various interactions (Fig. 4) indicate that the test participants rated their experience with the controllers better, on average, for all but one (button press) of the interactions.

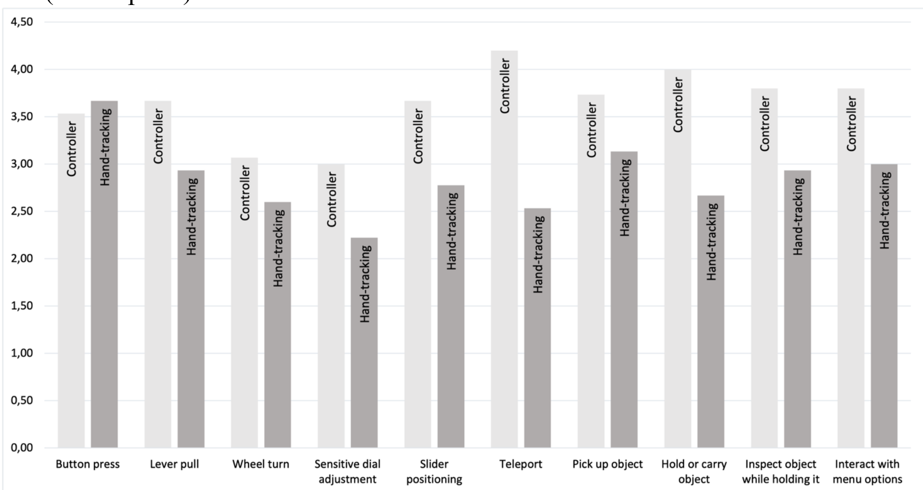

Fig. 4. Average comparative experience ratings between controllers and hand-tracking

Moreover, only one of the participants rated their overall experience with hand-tracking higher than with controllers (Fig. 5). Therefore, and based the these quantitative results, the hypothesis that hand-tracking improves user experience in a VR environment seems to be rejected.

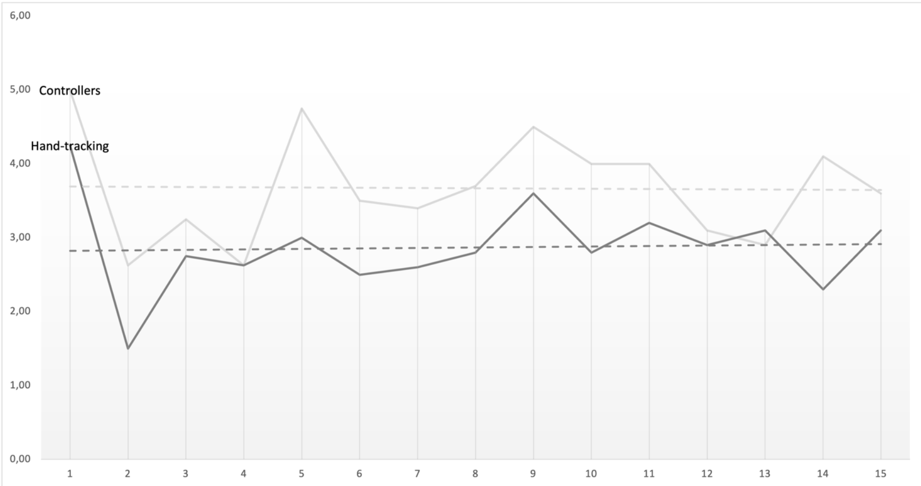

Fig. 5. Average overall controller and hand-tracking experience per participant

However, in scrutinising the answers to the question asking for the disadvantages of hand-tracking, this conclusion is probably rejected as the participants indicated that the lack of haptic feedback (mentioned by six participants) was at the root of the results favouring controllers: “lack of physical resistance, no haptic feedback or such”, “no haptic feedback when interacting with the world”, “lack of feedback (haptic or otherwise) when interacting with the world.”

The participants felt it strange to touch or hold an object without any sort of tactile feedback from, for instance, pulling a controller trigger or feeling the rumble from the controller when interacting with an object: “no feedback from for example rumble motors”, “feels strange to grab objects that aren't there”, “no feeling of actually grabbing object.”

Five of the participants also mentioned that hand-tracking technology is clearly in its infancy because the virtual hands would often flicker, disappear or track inaccurately. Two more participants echoed these sentiments by stating that the controller buttons were more reliable at this stage of testing the hand-tracking technology: “the technology is still experimental and has some bugs like hands disappear when hand is in a certain position”, “can be unreliable (hands flickering / shaking immediately breaks the immersion)”, “the tracking itself is shaky and inaccurate at times.”

Given these qualitative comments on the disadvantages of VR hand-tracking, it comes as no surprise that the usability score measured for hand-tracking in VR is 64,33. A score of 68 indicates a sufficiently usable interface with some work to be done [9].

This usability score indicated that there are advantages on the hand-tracking and that the hypothesis shall not be rejected. Eight of the participants claimed that the hand tracking felt more natural while six participants considered the immersion with hand-tracking is much improved over controller driven scenarios: “hand tracking feels very natural and immersive”, “hand tracking is intuitive way to grab and move objects”, “more immersive (minus the haptics)”, “when working as intended, hand tracking makes the experience much more immersive and learning instances will be closer to real life situations”, “hand orientation is more natural”

The greatest advantage hand-tracking has over controllers, is the intuitiveness of knowing how to use your hands and not being required to learn the various controller buttons—five participants mentioned this lower barrier to VR interaction: “you don't need to remember buttons”, “no need to memorize what each button of the controller does”, “no buttons are needed to learn on the controller”.

8 Areas of Further Research

The work delivered for the integration of the hand and finger tracking in ShipSEVR intends to continue optimizing this integration and extending it with eye tracking and multiplayer functionality. Specifically, the next phase intends to focus on improving user experience by bypassing the first button press. That is to say the teleportation ray could simply show up whenever the user raises their hand. The goal of this current solution was to tie other systems (mainly blueprints) into the UI. It has been discovered that the aiming target could be smoothed out a little, since in the current version it's very jittery due to how exact and accurate the hand tracking system is. This will also be fixed in the next phase of the development.

Regarding the and eye tracking functionality, ShipSEVR will follow the research done in MarSEVR where the eye tracking technology has been implemented successfully [10]. Eye gaze reflects the allocation of attentional resources and can be used as an index of the mental processes underlying behavior in VR environments [11].

Furthermore, research has been initiated for the implementation of multiplayer functionality that will allow more than one player to enter the virtual engineer room and collaborate on common activities and exercises with other users. This will advance the effectiveness of the technology as it is an industry requirement derived from the industry experts who participated in this research.

9 Conclusions

Hand-tracking in VR brings about an immediate immersion improvement over the controllers. Users are likely to feel more in control of the natural movement and hand orientation that comes with hand-tracking. Unfortunately, gloveless hand-tracking technology is still emerging and as innovators and early adopters of game technologies. It seems that the current state of this technology is not quite ready for regular consumption. Its primary pitfalls include a lack of haptic feedback and a sketchy tracking accuracy.

However, it can be said with confidence that hand-tracking, perhaps with the aid of haptic gloves, is a way of the future, or the very near future, considering the technology evolution pace. The clearly immersive quality of hand-tracking validates the hypothesis that hand-tracking can improve VR user experience. This integration has been industry requirement and will be based on experiments conducted on other MarISOT applications. Tests will continue with more participants primarily from the maritime sector with extensive expertise on the activities covered in the training scenarios. Regardless the outcome of these extended tests, hand tracking will be a leading feature of ShipSEVR, moving the technology ahead the current needs and ready to respond to near future ones.

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