Progress on the Pilot Project 1 until 30.06.2023. (M1-M6)

Improved fire evacuation VR model of a ship engine room

CHALLENGE! To provide an improved, more realistic, albeit safer environment for onboard firefighting training.

HOW? By building a fire scenario in a virtual reality (VR) environment of a ship engine room (ER) based on fire spread results obtained by computational fluid dynamics (CFD) analysis.

WHY? The problem with the current VR models is that the fire is modelled rudimentary, i.e. as a concentrated flame that does not spread, making users less susceptible to the stimulus.

FINAL RESULT→ Functional VR model of fire spread in ship ER, reaching TRL4/TRL5.

GOALS FOR INNO2MARE PROJECT: To advance maritime fire safety and to digitalize the maritime education and training (MET) process.

PROGRESS ON ACTIONS:

Action	Start-End	Accomplished
1. State-of-the-art literature review, existing solutions analysis, mapping research gaps solutions	M1-M3	Yes
2. Selection and design of a representative ship ER	M1-M3	Yes
3. Building a VR model of ER	M4-M6	Yes
4. Developing and defining fire scenarios	M7-M9	Not started
5. CFD modelling of fire spread in ER	M10-M12	Not started
6. Implementing CFD analysis results in VR model	M12-M18	Not started
7. Testing of improved VR model	M19-M30	Not started
8. Equipment procurement & subcontracting	M3-M6	Yes
9. Dissemination	M1-M48	Ongoing

In the following, more details are given on every action performed.

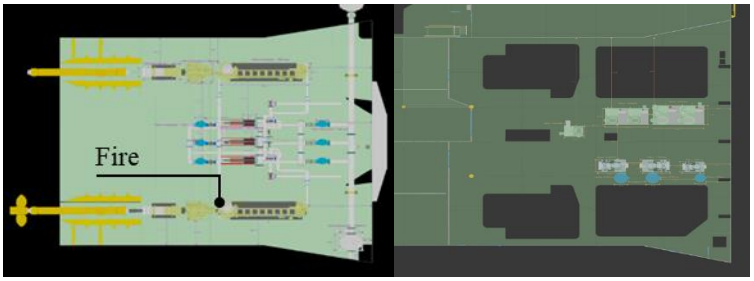
1. State-of-the-art literature review, existing solutions analysis, mapping research gaps solutions

The review aimed to answer two questions. The first was: what is the current state of using VR technology for maritime firefighting and evacuation training? As seen from the reviewed references, VR has been used relatively successfully for maritime firefighting training thus far, with most of the solutions offering a fully immersive experience. Fire spread is mostly modelled using the built-in features of the selected game engine, but researchers are becoming aware of the need to build the fire model on physics and evidence-based solutions. The second question was: what are the research gaps that need to be addressed to further accelerate the implementation of VR for maritime firefighting and evacuation training? The research gaps detected are: the possibility of the advanced modelling of fire spread in VR (modelling the fire spread in the virtual environment based on the fluid mechanics laws); developing fully immersive VR solutions for evacuation training (overcoming the problems of the needed computer resources, wearing headset

limitations and multiplayer challenges) and the possibility of developing specific onboard search and rescue scenarios (helping diverse rescue teams in performing coordinated missions).

2. Selection and design of a representative ship ER

A model of the ship engine room was created based on the design and measurements of the engine room of an actual RO-RO ship. The drawings were provided by the design office with the permission of the shipping company. It is a double-decked engine room with general dimensions of 16.1x19.6 m that consists of two main four-stroke diesel engines, each with a shaft generator, and three diesel generators, Figure 1 main and auxiliary engines are on the bottom deck, along with propeller shafts, sea and freshwater cooling system, pumps, and valves. The upper deck comprises two heavy fuel oil purifiers, one diesel oil purifier, two start air and one service air compressor, fuel and lube oil tanks as well as other necessary auxiliary equipment, valves, and pipelines. The ventilation system is branched throughout the engine room. It consists of 16 ventilation ducts that operate as delivery or reversible, with the initial input that the air exchange must be at least 30 exchanges per hour.



a) b)

Figure 1: Layout of the engine room: a) lower deck, b) upper deck.

3. Building a VR model of ER

VR content is developed using a dedicated programming environment (game engine) that includes relevant libraries and support programs. There are several game engines, and the selection of a specific one depends on factors like project requirements, familiarity with the engine, targeted VR platform, and the skillset of the development team. Here, Unreal Engine was selected because of several reasons. One is prior familiarization with it since authors have previously used applications developed in it as an aid in classes which brought positive teacher and student feedback at the end of the semester. Equally important, it was selected based on the thorough literature investigation where the previous studies (DOI: 10.1145/3059009.3059013, 10.17083/ijsg.v4i4.194) stated that this game engine is primarily focused on advanced 3D game development, offers extensive support for high-end graphics, and allows for realistic physics simulations which was of utter importance here. Unreal Engine presents better audiovisual performance than counterparts, while at the same time is an open-source engine. It is accessible to non-commercial users, provides realistic lighting and impressive visual effects, enhancing the overall sense of immersion. It also seamlessly integrates with Meta Quest 2 VR head-mounted display used subsequently. Accompanying handheld controllers Meta Quest 2 Touch allowed manipulation of objects and spatial

movements in virtual space by teleportation or joystick movement. Four high-performance computers were employed to allow for an augmented number of frames utilized within the virtual space because insufficient frame rates may diminish the realism of effects and potentially induce cybersickness among users. Images of ER in VR are given in Figure 2.

a) b)

Figure 2.: View of the engine room in virtual reality: a) lower deck, b) upper deck.

4. Developing and defining fire scenarios

Not yet started.

5. CFD modelling of fire spread in ER

Not yet started.

6. Implementing CFD analysis results in VR model

Not yet started.

7. Testing of improved VR model

Not yet started.

8. Equipment procurement & subcontracting

Four sets of PCs and VR headsets used for the work on Pilot Project 1 have been procured with the specifications as follows: PC with 16-core computer processor with 5.2 GHz and 32 GB RAM, dedicated graphics card NVidia RTX 4070 GPU with 12 GB GDDR6X memory; Meta Quest 2 VR head-mounted displays with Meta Quest 2 Touch handheld controllers. Additionally, a license for Smartfire software was acquired for CFD analysis. Company Adricom Ltd was subcontracted for the part of developing the VR environment of the ER.

9. Dissemination

The project has been presented at the following events:

1. UNIRI „Days of e-learning” 2023.
2. PFRI „Career day” 2023.