S. Soon, A. Lugmayr, A. Woods, and T. Tan, "Head-Mounted FOV Simulator for User Testing of Maritime Object Detection Tasks," in 2018 IEEE International Conference on Artificial Intelligence and Virtual Reality (AIVR), 2018, pp. 183-184

Head-Mounted FOV Simulator for User Testing of Maritime Object Detection Tasks

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Abstract — Search and Rescue (*SAR)* activities involve missions to rescue people that are lost or in danger, in environments including sea, land, mountainous terrain or deserts [1]. Today, still- and video-camera technologies e.g. mounted on drones, are increasingly being used to capture views that may not easily be accessible. To conduct user tests of different image presentations, we implement a head-mounted 360° FOV simulator to gain new insights into how to improve object detection by operators. We describe the implemented simulator and give a brief overview of the demonstrator to be presented at the conference.

Keywords— Head mounted display, human visual system, field of view, AI, central vision, peripheral vision

I. FOV SIMULATOR OVERVIEW

This work focuses on the maritime SAR domain and presents a *Head Mounted Display (HMD)* simulator displaying 360° imagery of the sea. SAR personnel use the HMD to view imagery, building situational awareness of the environment in order to perform SAR missions. Our HMD simulation displays 360° computer-generated sea imagery showing sea, sky, and horizon (Fig. 1). The sea section of the image is dark and low contrast, with waves and sea spray. The object of interest is represented by only four pixels in the scene and can be located at different bearings and distances e.g. 1km. The goal of the SAR personnel is to detect the object (e.g. representing a person) when viewing the imagery through the HMD, as quickly as possible.

Our simulator can render sea imagery on different HMDs, e.g. the HTC Vive[1] (2160 x 1200) (Fig. 2), Vive Pro (2880 x 1600), and also the Oculus Go[2] (2560 x 1440). The Oculus Go is a lightweight onboard processing option.

In other work, we examine 8K real-time 360° video capture using daylight cameras, and consider the computational power and bandwidth for real-time stitching and processing of uncompressed video streams for this simulator environment.

Figure 2. Participant using the HMD simulator to detect an object of interest in maritime SAR imagery.

Interpreting SAR sea imagery can present some difficulties including that objects of interest can be low observability and difficult to detect. Imagery can contain people, boats, landmarks, equipment that are small and whose silhouettes are unidentifiable as they are far away, or be low contrast compared to their surroundings. In addition, environment and weather conditions may reduce the object's visibility, for example, night-time, heavy rain or fog or sunlight reflecting off water, snow or sand.

Our simulator is developed to test users viewing different image representations when detecting objects under low visibility conditions; and to investigate the capacity of the *Human Visual System's (HVS)* central and peripheral vision when performing detection tasks given different horizontal *Field of View (FOV)*.

We perform basic image processing to enhance the images in the simulation so objects can be more easily detected, and test these different image representations on real users. We

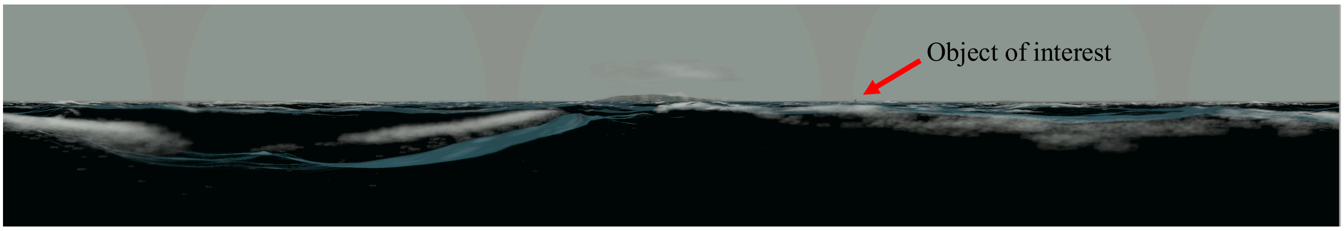

Figure 1. 360° computer-generated sea imagery representing a SAR scenario. The object of interest is at 1km from the viewer as indicated by the red arrow. The goal is for the user to locate the object of interest as quickly as possible within a 15s time limit.

[1] HTC Vive, 2018. Available: https://www.vive.com/au

[2] Oculus Go, 2018. Available: https://www.oculus.com/go/

run simple *Artificial Intelligence (AI)* image processing algorithms over the sea imagery such as those used to develop HMDs to assist individuals with low vision e.g. low central vision (scotoma) or low peripheral vision (tunnel vision) [2-4]. Our current implementation uses edge detection and image segmentation algorithms with FOVs of 30°, 70°, and 85° (Fig. 3). We use the Unity[3] game engine.

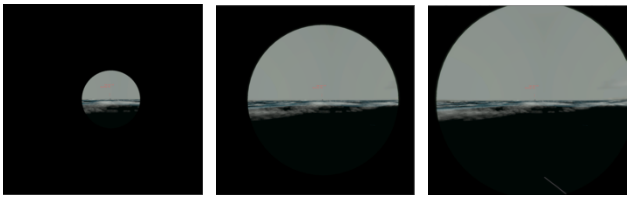

Figure 3. 30°, 70°, and 85° FOVs of SAR imagery. The user is asked to detect the object of interest using three different FOVs. The user scans their scene through 360° to find the object of interest.

In the HVS, highest visual acuity is achieved in the central region of the retina (1-2° eccentricity) containing cone cells, where individuals with an average HVS can achieve 60 *Pixels Per Degree* (*PPD*) visual acuity.

The simulator helps to investigate whether small or large FOVs are more effective when trying to detect an object in a wide-open maritime environment. Whilst employing high acuity central vision when restricted to a small 30° FOV is similar to foveated or gaze-contingent rendering, we observe that small FOVs may not be useful for these types of visual detection tasks where broad scanning of the scene is required.

Low visual acuity peripheral vision is dependent on rod cells in the retina which are useful for low light and motion visibility, however, less useful in distinguishing colour. To utilise peripheral vision, wider 70° and 85° FOVs are tested in our demonstration. The HTC Vive has a maximum FOV of 110°[4], although in practice FOV is measured to be 90°.

Whilst not examined here, we expect video to be more useful than still imagery for object detection as motion detecting peripheral vision can be employed, however, factors such as wave motion may obscure the object.

The operation of the simulation toggles over five images with random object bearing, for each of three image types (original, Canny and inverse) (Fig. 4), over 30°, 70° and 85° FOVs. Participants are timed on how quickly they detect the object, and are given a maximum of 15 seconds per test.

The three different image types are: (a) original computer-generated imagery; (b) edge detection of the original image using a Canny filter - details such as waves and objects are more visible, however, realism is reduced where the image appears more 2D; and (c) inverse image of (b) - the image is segmented into broad areas, has lower contrast and reduced clutter and noise, increasing object visibility in the scene.

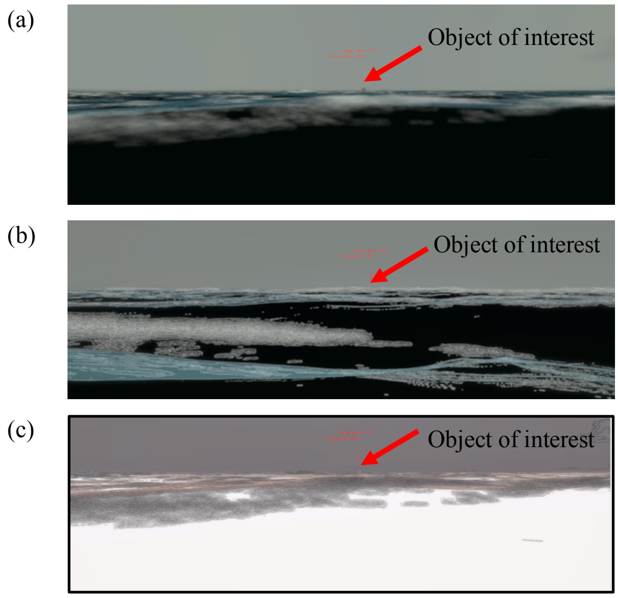

Figure 4. Three visual representations: (a) original; (b) edge detection (Canny filter); and (c) inverse edge detection.

First user trials were conducted at Curtin University's HIVE visualisation facility (Fig. 5) [5]. With this demonstration we will show our FOV simulator and present the results of our pilot user-study. We also indicate how users can detect objects more quickly when applying image enhancement techniques.

ACKNOWLEDGMENT

We thank Richard Palmer, Ryan Day and Jesse Helliwell for programming assistance.

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Figure 5. 360° image of the Curtin University HIVE (Hub for Immersive Visualisation and eResearch) visualisation facility. It houses four large-scale immersive displays: (a) Dome - four-metre diameter domed screen; (b) Wedge - two rear-projected 3.8m diagonal display in a 90° wedge configuration; (c) Cylinder – 3m high 8m diameter cylindrical projection display; and (d) Tiled – 12 x 55" Full HD displays.

[3] Unity, 2018. Available: https://unity3d.com

[4] HTC Vive, 2018. Available: https://www.vive.com/au