Immersive VR Trainer for Landing Signal Officers

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ABSTRACT

Training regimen of Landing Signal Officers (LSOs), members of a team that helps pilots land their planes on aircraft carriers deployed deep in the oceans, consists of two major components: (1) training on a large two stories-tall simulator - LSO Trainer (LSOT) also known as 2H111 device that is located in Oceana VA (part of LSOs Initial Formal Ground Training (IFGT)), and (2) training on the job. This approach to LSOs training has remained unchanged for several decades. The time that LSOs spend in 2H111 simulator amounts to six one-hour long sessions during which they practice operating in all five different positions and roles that members of LSO crew have during an aircraft recovery. Access to this simulator is generally a prohibitive factor in training of LSOs; in order for an LSO to use it outside of IFGT classes, the simulator needs to be available i.e. it should not be already in use as a part of IFGT rotation for another unit, and not undergoing any repair or upgrade. Additionally, unless LSO is not located near Oceana, that individual needs to travel there. This is typically very hard to organize given extremely busy schedule of each LSO in their respective squadrons.

The time spent in simulator during IFTG training rotation, is widely considered to be insufficient. There are three areas that have been identified as gaps in training: (1) training while preparing for subsequent deployment prior to attending IFTG, (2) low number of hours spent in simulator when LSOs attend IFTG, and (3) refresher training after LSOs complete their IFTG. This gap in training served as a major driver and motivation for engaging in design and development of a lightweight training system that would be both affordable and mobile, providing LSOs with training opportunity any time such support is needed. Additional motivation factor was a number of reported mishaps, and their most probable causes. According to the Naval Safety Center, during the period 2005 and July of 2015, there were 108 landing-related mishaps on aircraft carriers, where 99 of them involved the LSO in some manner [1]. Both the gaps in training of LSO officers with 2H111 device and the number of costly mishaps that involved LSOs, were clear indicators that it would be highly beneficial to offer training force with additional, novel training system and that goes beyond current training capabilities. It was clear that that a novel solution will need to be lightweight and mobile, and as such be capable of providing unlimited number of training opportunities unrestricted by location and time. The main goal of this research demo is to introduce and demonstrate a prototype system that was built to address described training need in LSO domain. More extensive discussions of domain and descriptions of developed system can be found in [2] and [3].

Prior to design and development of the prototype of new training system, we adopted five major design goals. The system should: (1) support all major capabilities and training objectives supported by the 2H111 simulator, (2) leverage capabilities of immersive VR technology to enable training and interactive capabilities not currently supported by 2H111 device, (3) use only commercial off-the-shelf (COTS) solutions and make sure the system is truly 'lightweight', (4) minimize the potential for symptoms of cybersickness - it should be capable of maintaining a high frame rate throughout the interactive experience, (5) integrate a variety of typical COTS input devices and support both the trainees and instructors with different input modalities. Additional goals included ability to maintain and operate it with minimal costs, and the ease of adding new hardware and software components and upgrades while minimizing or completely avoiding the cost special software licenses.

Domain analysis: We conducted detailed task analysis for five different positions in LSO team, and collected data that reflected community understanding of user domain. The latter included information about current training practices; technical characteristics of 2H111 device; LSOs understandings of benefits and deficiencies of training in 2H111 device; LSOs system of values directly related to elements of training systems and processes; and LSOs attitudes and acceptance level towards different forms of training systems and training approaches (including potential obstacles in adoption of those solutions in everyday training practice).

System architecture: The prototype training system that has been developed in this effort, uses Alienware 17 R2 laptop with Intel Core i7-4980HQ CPU @ 2.80 GHz, 16 GB RAM and GeForce GTX 980M GPU. A set of COTS input and output devices include two Xbox Controllers for trainee LSO and instructor (one is used by a trainee for navigation and object manipulation, and one by instructor for scene manipulation), in addition to devices used only by the trainee LSO: headphones with microphone, head-mounted display (HMD) Oculus DK2 headset and Leap Motion Controller mounted onto front of Oculus Rift headset. Oculus DK2 has a resolution of 960 x 1080 per eye, with max refresh rate of 75 Hz, field of view (FOV) 100 degrees, and weight of device: .97 lbs (Figure 1).

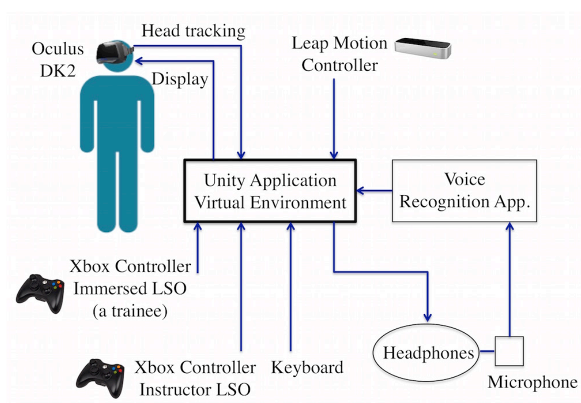

Figure 1: Hardware and software architecture.

Input devices: Having several input devices like game controller and Leap Motion controller, provides the system with desired operational flexibility. It supports individual operator's

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LEAVE 0.5 INCH SPACE AT BOTTOM OF LEFT COLUMN ON FIRST PAGE FOR COPYRIGHT BLOCK preference when it comes to the choice of interaction modality and input device to accomplish a variety of tasks in the system, and it provides useful backup functionality in case one input device or one mode of interaction fails. Leap Motion controller is used to support intuitive manipulation and interaction with virtual Landing Signal Officer Display System - LSODS (Figure 2). This instrument provides a wide range of information to LSO, from live video feed of platform camera (space in the center of landing area), to gear status and divert information. A sizable effort had been invested to simulate all capabilities of this important instrument.

Audio communication: The communication between LSO and pilot in an operational situation is done by UHF headset. In prototype training system this is accomplished by using a microphone and a headset. The actual utterances (communications) done by LSO are processed by a custom-made voice recognition application. The result of this communication is reflected in changed behavior of the approaching aircraft.

Head-mounted display: The choice of display solution - in this case head-mounted display - was governed by a need to have fully simulated (virtual) training environment and to provide stereoscopic depth cue to the trainees. Recent developments in HMD technology and a rise of inexpensive, good quality HMD solutions, was an additional factor that benefited the work on this system. Our choice was to use Oculus DK2 headset. The line of Oculus Rift products has been evaluated as very promising - they were well supported by industry allowing for easy integration with Unity package and a range of input devices, and they were perceived as having a high probability of continued line of perfected products in the future. This held a promise of easy upgrades and extension to networked version of the training system.

Figure 2: Aircraft landing and user interaction with Landing Signal Officer Display System (LSODS).

3D tools and assets: The three-dimensional (3D) content and object behaviors used in this application were developed using Unity game engine; the same system supports real time scene simulation and user interaction. Blender and 3DS Max were used for additional model creation and editing, Photoshop for editing of textures and Audacity for audio editing.

We purchased several models of aircraft from the Turbo Squid 3D modeling website and 3DWarehouse; our goal was to ensure that system had 3D models of higher fidelity both in terms of geometry and textures. This action was in direct response to LSOs remarks about low fidelity of models being used in current 2H111 device (that had a most direct influence over perceived lack of realism). Having highly complex 3D models of aircraft and carrier also resulted in reduced frame rate. In order to address that issue we invested considerable efforts to optimize solution by reducing the size of the models while making sure that the overall level of realism and visual appearance remained high. As an example, the final 3D objects used in basic scenarios had following polygon counts: 3D model of T-45C 3D aircraft had 110K vertices, 3D model of A-18G 3D aircraft had 50K vertices, and 3D model of Nimitz Class carrier had 9K vertices.

Behaviors and environment simulation: Basic Unity assets were used to simulate additional elements important for LSO's decision-making during recovery of the aircraft. Those included ocean wave motion that affects pitching of the flight deck (LSO needs to constantly compare this with the trajectory of the approaching aircraft). Unity package was leveraged to support visual water effects, while simple behavior for ship movement had to be added; this enabled believable movement in the pitch, roll, and heave of the ship. Skybox assets from Unity package were used to simulate a variety of environmental conditions in which LSOs need to operate (examples: clear day, clear night, and overcast day).

System performance: The framerate that the final system is capable of generating (this includes rendering of all 3D models and behaviors) ranges between 60 frames per second (FPS) for situation when only a smaller portion of scene is in a field of view, and 37 FPS when user is looking at six aircrafts lined up on the deck of the carrier. Further system optimization is planned to address this and increase framerate even in the worst-case scenario when the largest portion of 3D assets is visible to the user.

Demo experience: Research Demo audience will be able to experience several elements and aspects of user operation in developed prototype system. They will be able to (1) navigate across virtual aircraft carrier and conduct close inspection of 3D assets made available in the scene; (2) interact with Landing Signal Officer Display System (LSODS) by using game controller and Leap Motion controller; (3) conduct in-session selection of different aircraft, and (4) experience simple aircraft recovery (both day time and nigh time).

References

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