ALVIN Submarine VR Simulation

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OVERVIEW

Many have wished to explore the vast depths of the ocean within the confined spaces of a submarine, but only a few have had the opportunity to experience it firsthand. Fortunately, virtual reality gives us the opportunity to create a world where anyone can pilot their own submersible. The submarine in this project is based off a real submarine created by Woods Hole Oceanographic Institution (WHOI) in Falmouth, MA. ALVIN is a research submersible that is own by the U.S. Navy and operated by WHOI for the use of collecting data on life in the ocean.

PROJECT DESCRIPTION

The intent of this project is to create an interactive, VR experience in the ALVIN submarine. The simulation begins with the submersible in complete darkness with a single monitor on, displaying multiple interviews of pilots and researchers who have worked on ALVIN. Once the interviews finish, ALVIN powers up. The monitors display a rotating symbol of the WHOI logo while the player waits for ALVIN to finish turning on. After they finish loading, the monitor on the left displays the location of ALVIN in the environment, the center one displays the oxygen levels and the overall health of the submarine, and finally the right monitor shows the location of the ships on the surface of the water. By exploring this VR experience, the participant will learn how to operate/pilot ALVIN while also learning about marine wildlife.
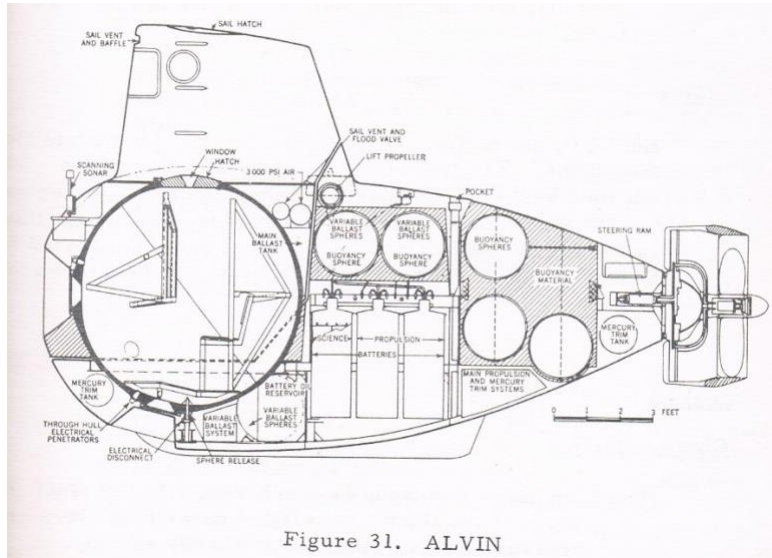
History of ALVIN and WHOI:

Figure 31. ALVIN

Figure 1: Diagram of ALVIN.

The Woods Hole Oceanographic Institution (WHOI) was founded in Woods Hole, Massachusetts in 1930. WHOI "is the world's leading, independent non-profit organization dedicated to ocean research, exploration, and education" [6]. Although WHOI was founded in 1930, ALVIN was not created until 1964. Allyn Vine, an employee at WHOI and also ALVIN's namesake, had been very intrigued by the idea of exploring the vast depths of the oceans' unknown waters. Vine attended a symposium in Washington on underwater vehicles in 1956. After successful negotiations with the Office of Naval Research (ONR), WHOI obtained the funds needed to commission ALVIN [4]. While looking for ways to obtain funding, WHOI's operational team decided to call themselves the Deep Submersible Group. Finally, WHOI commissioned Litton Systems to oversee the building of ALVIN and on May 26, 1964 it was delivered to WHOI [1]. On July 20, 1965, ALVIN made its first successful 6000-foot dive off the coast of the

Bahamas. "A special catamaran was constructed, referred to as 'ALVIN's Momma'" [3]. Today, ALVIN can access about two-thirds of the ocean floor currently rated to 4,500 meters. Soon ALVIN will reach depths close to 6,500 meters making 98 percent of the seafloor accessible [5].
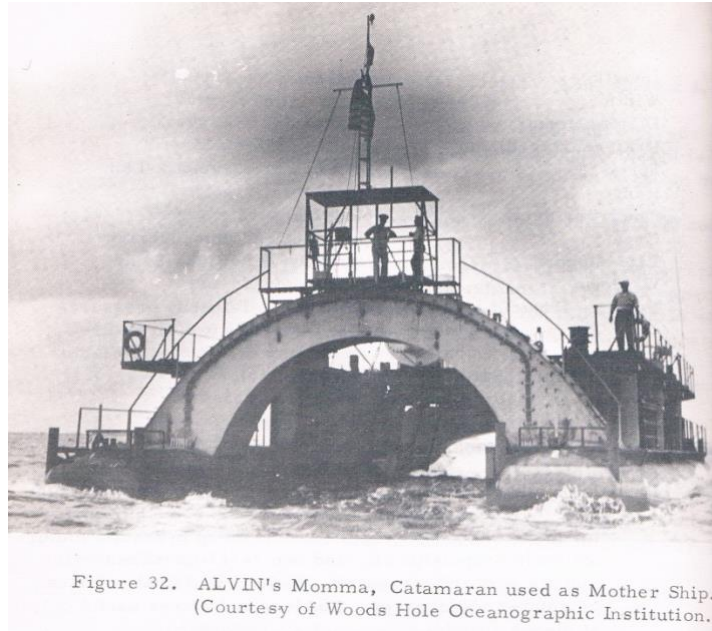

Figure 32. ALVIN's Momma, Catamaran used as Mother Ship. (Courtesy of Woods Hole Oceanographic Institution.)

Figure 2: ALVIN's Momma.

ALVIN has not only aided in the discovery and research on underwater life as an observation submarine but has also made a huge impact on history. In 1966 an Air Force B-52 and a tanker accidentally dropped an H-bomb into the Mediterranean after colliding over Spain. The search began the day the bomb was lost on January 17, 1966 [2]. In February, ALVIN was flown to Rota, Spain where it would spend the next few months searching for the bomb. ALVIN located the bomb on March 15 but lost the bomb again after it slid downward deeper into the sea after attempting to attach lift lines. The bomb was finally relocated again on April 2 and recovered five days later.
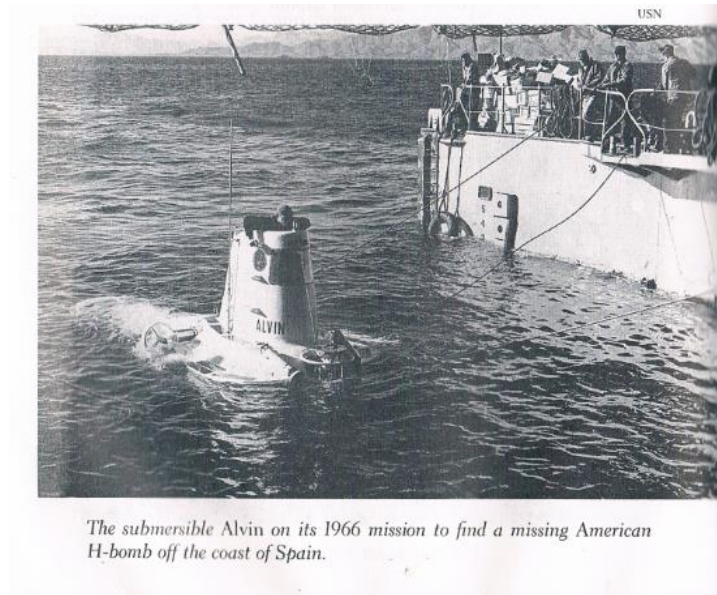
Figure : ALVIN preparing to search for H-bomb.

Purpose:

The purpose of this project is to create a virtual reality simulation that will not only be fun and inspirational experience for all ages but also a great way to educate those who are interested in underwater life or submarines. While playing the simulation, the player will experience a very rare opportunity to operate a submarine. They will also hear what it is like from real pilots and researchers to be in and operate a real ALVIN submersible.
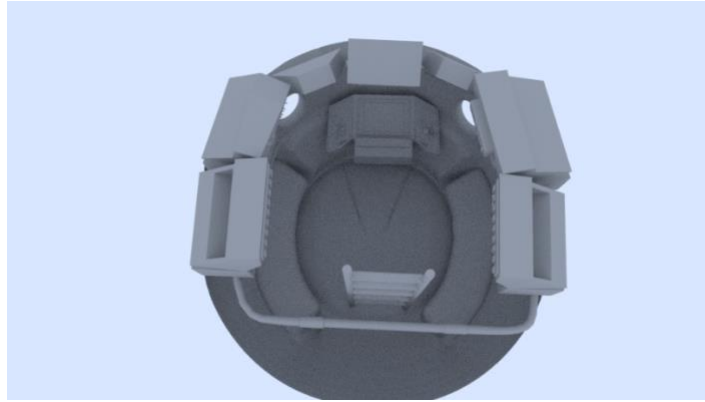
Process:

Figure 3: Arial view of ALVIN 1.0

This project began by doing research on the general operations of submarines and establishing a line of communication with WHOI. Once finally getting in touch with the institution, WHOI gave a tremendous amount of interest and resources in order to begin project production. Throughout the process of building the 3D model of the submersible in Maya, a software from Autodesk, a connection was made with the director of research at WHOI, Adam Soule. Mr. Soule gave a lot of helpful input on how to properly change the model to match more closely with the real ALVIN. Furthermore, he provided insightful input on how the simulation could progress. For example, Mr. Soule believed that this project would be a great asset to the institution for training and educational purposes. For example, making this project easily accessible to the public by installing it in museums that have an exhibit on ALVIN. This will give people who normally would not have the opportunity, to experience what it is like in a submarine deep underwater.
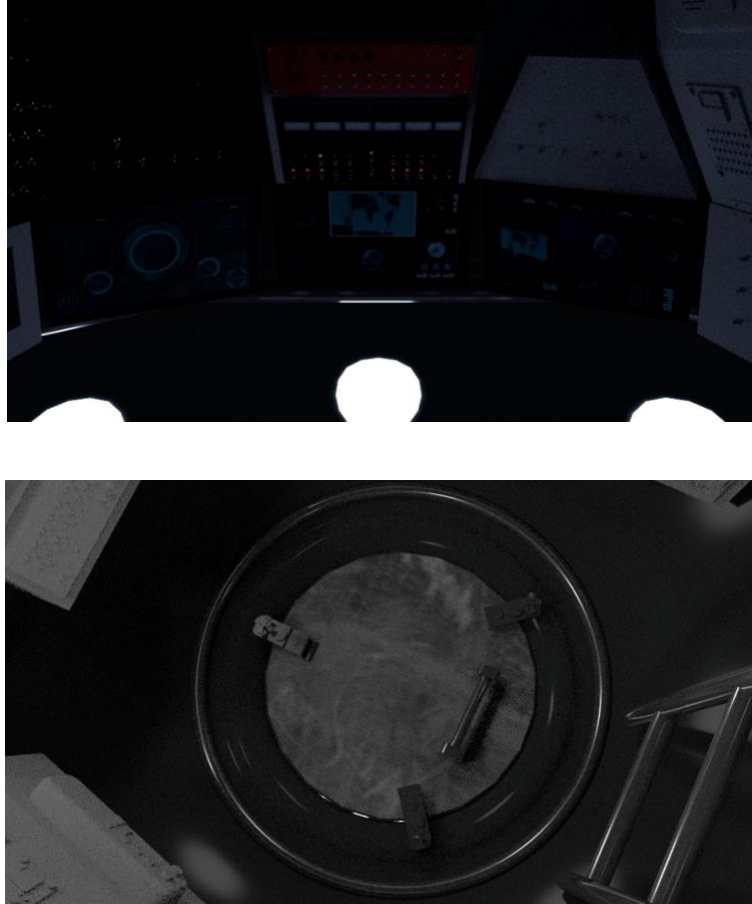
Figure 4-5: The controls and the hatch with textures before exporting to Unity (ALVIN 1.1).

Concluding the modeling process in Maya, the 3D modeled ALVIN was imported into Unity, a cross-platform game engine developed by Unity Technologies. Unfortunately, the textures that had been previously applied to the model in Maya are not supported in Unity. As a result, new textures need to be created and applied to the individual components of ALVIN. Once the materials had been applied to each part of the submersible, the environment was made using the terrain tool. This tool allows you to sculpt a flat plane with a variety of brushes, as well as textures that could also be painted on the surface.

```
using System.Collections;
using System.Collections.Generic;
using UnityEngine;
using UnityEngine.SceneManagement;

public class MainMenu : MonoBehaviour
{
    void Start()
    {
        Cursor.visible = true;
        Cursor.lockState = CursorLockMode.None;
    }
    public void PlayGame()
    {
        SceneManager.LoadScene(SceneManager.GetActiveScene().buildIndex + 1);
    }

    public void QuitGame()
    {
        Debug.Log("Quit!");
        Application.Quit();
    }
}
```

Figure 6: Main menu code.

Creating the c# code was the most challenging part of this project. The main menu and in-game pause menu were created using Unity's canvas event system. In order to properly use this tool, some understanding of programming and Unity's build settings were necessary. On the main menu, if the "play" button was clicked by the player it would load the scene after the main menu in the build settings index. This next scene was the game scene where the player could control ALVIN. The in-game pause menu would activate if the escape button on the computer keyboard had been pressed. Once the pause menu was active, the player would have the option to resume the game, return to the main menu, or quit the game all together.

```
using System.Collections;
using System.Collections.Generic;
using UnityEngine;
using UnityEngine.SceneManagement;

public class PauseMenuNew : MonoBehaviour
{
    public static bool GameIsPaused = false;

    public GameObject pauseMenuUI;
    private void Start()
    {
        Cursor.visible = true;
        Cursor.lockState = CursorLockMode.None;
    }
    // Update is called once per frame
    void Update()
    {
        if (Input.GetKeyDown(KeyCode.Escape))
        {
            if (GameIsPaused)
            {
                Resume();
            }
            else
            {
                Pause();
            }
        }
    }
}
```

```
    void Pause()
    {
        pauseMenuUI.SetActive(true);
        Time.timeScale = 0f;
        GameIsPaused = true;
    }

    public void LoadMenu()
    {

        SceneManager.LoadScene("MainMenu");
    }

    public void QuitGame()
    {
        Debug.Log("Quitting Game...");
        Application.Quit();
    }
}
```

Figure 7: In-game pause menu code.

Features:

ALVIN has many buttons and switches with a variety of functions, but due to the submarine being owned by the U.S. Navy a lot of these features are classified. As a result, this project was given permission by WHOI to come up with creative ideas for the unknown buttons and switches. Some of the ideas included: turning the lights on or off inside or outside the submarine, changing the sounds that you hear in the simulation (such as changing the music playing in the background), or interacting with the people on the surface by use of a radio.

While interacting with the simulation, the player has the option to either move around in ALVIN in first person or move the submersible around in third person. In order to switch between these different controlling options, the player presses "1" for first person and "3" for third person. While in first person mode, the player can look around the inside of the submarine without worrying about the submarine moving. Once the player returns to third person mode, they can no

longer observe the activity inside ALVIN, but controls the submarines movement while preserving what is going on externally.

```
1   using System.Collections;
2   using System.Collections.Generic;
3   using UnityEngine;
4
5   public class switchMode : MonoBehaviour
6   {
7       public GameObject submarine;
8       public GameObject subCam;
9       public GameObject player;
10      public GameObject playerStartPos;
11      // Start is called before the first frame update
12      void Start()
13      {
14
15      }
16
17      // Update is called once per frame
18      void Update()
19      {
20          //set to TPS Mode//
21          if (Input.GetKey("3"))
22          {
23              submarine.GetComponent<Rigidbody>().isKinematic = false;
24              submarine.GetComponent<ALVIN>().enabled = true;
25              subCam.SetActive(true);
26              player.SetActive(false);
27          }
28
29          //set to FPS Mode//
30          if (Input.GetKey("1"))
31          {
32              submarine.GetComponent<Rigidbody>().isKinematic = true;
33              submarine.GetComponent<ALVIN>().enabled = false;
34              subCam.SetActive(false);
35
36              player.transform.position = playerStartPos.transform.position;
37              player.SetActive(true);
38          }
39      }
40  }
41
```

Figure 8: Code for switching between first- and third-person mode.

Future Work:

Throughout the development of this project, WHOI has offered several opportunities for this project to be continued into the future. First, WHOI wishes for this project to be presented in a conference in June for sponsors and employees. Next, WHOI would like to develop a version to be targeted towards people who are training to either pilot or record footage from cameras located on the exterior of ALVIN. Finally, the institution is interested in eventually displaying this project in future museums and science center exhibits on ALVIN.

Works Cited

[1] Journey to the Bottom of the Sea October 4, et al. "HOV Alvin." *Woods Hole Oceanographic Institution*, 15 Apr. 2019, www.whoi.edu/what-we-do/explore/underwater-vehicles/hov-alvin/.

[2] Marx, Robert F. *The History of Underwater Exploration*. Constable, 1990.

[3] Terry, R. D. *The Deep Submersible*. Western Periodicals Co, 1966.

[4] *Undersea Vehicles for Oceanography: Interagency Committee on Oceanography of the Federal Council for Science and Technology*. Government Printing Office, 1965.

[5] US Department of Commerce, and National Oceanic and Atmospheric Administration. "Human Occupied Vehicle Alvin: Technology: Submersibles: Vessels: NOAA Office of Ocean Exploration and Research." *Technology: Submersibles: NOAA Office of Ocean Exploration and Research*, 30 Oct. 2012, oceanexplorer.noaa.gov/technology/subs/alvin/alvin.html.

[6] "Who We Are." *Woods Hole Oceanographic Institution*, 30 May 2018, www.whoi.edu/who-we-are/.

Timeline Goal:

Week 1 (1/14)	Week 2 (1/21)	Week 3 (1/28)	Week 4 (2/4)
Class review / introduction / Capstone Survey	Research week (meet in the library lobby)	Finish and present proposal; Decide on Advisor Research/ Begin 3D modeling	*Individual meetings w/ professor Felice and faculty advisor* Begin importing 3D models into Unity
Week 5 (2/11)	**Week 6 (2/18)**	**Week 7 (2/25)**	**Week 8 (3/3)**
Prototype 1 and in progress documentation due for class critique	Public display poster design & press release due (designed / written by class) – Research Paper 1st draft due	Faculty visit/review #1	*Prototype #2 Due*
Week 9 (3/10)	**Week 10 (3/17)**	**Week 11 (3/24)**	**Week 12 (3/31)**
Spring Break	**Faculty visit/review #2** **Research Paper draft #2 due**	**Faculty visit/review #3**	*Capstone projects due for DA faculty review / final approval*
Week 13 (4/7)	**Week 14 (4/14)**	**Week 15 (4/21)**	**Week 16 (4/28)**
Public display installation	**Final Capstone critique!!!**	Resume / portfolio / internships / grad school / job opportunities post-graduation workshop	**Final research paper w/ documentation due for Oral defense presentations (Google Slides or Powerpoint format).**
Week 17 (5/5)			
Finals Week			