CSCI 538: Augmented, Virtual and Mixed Reality

CHLA - Cystic Fibrosis Therapy Game Design Document

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Introduction

Cystic Fibrosis (CF) is a hereditary disease that causes mucus accumulation in the lungs. The excess, sticky mucus interferes with the respiratory and digestive systems in patients, causing increased breathing difficulty and associated health complications. The disease can lead to fatal respiratory infections as well as other health issues as the mucus can be difficult to expel from the lungs.

Children suffering from CF must undergo daily airway clearance exercises in order to limit the accumulation of mucus in their lungs. The airway clearance exercises can minimize breathing difficulty and limit the possibility of respiratory infections if done correctly on a daily basis. However, due to their hindered respiratory capabilities, as well as mundane and archaic therapy methodologies, CF patients often do not fully complete airway clearance exercises on a daily basis. As such, our team is collaborating with the medical team at the Children's Hospital of Los Angeles (CHLA) to gamify the airway clearance therapy in hopes of providing a more joyful and entertaining therapy experience for children.

By creating VR applications that leverage existing airway clearance therapies, we hope to increase therapy completion rates in CF patients. The immersive VR applications we are creating utilize natural inhalation and exhalation processes in order to create an intuitive and easy to use game that will ultimately replace the current, physical treatments.

Game & VR Objectives

According to the Cystic Fibrosis Foundation (CFF), more than 30,000 people are living with cystic fibrosis in the United States. Additionally, approximately 1,000 new cases of CF are diagnosed each year and more than 75 percent of people with CF are diagnosed by age 2. Being able to identify the disease at an early age and administer effective therapy treatments can prolong the life expectancy of CF patients.

Based on information provided by the medical team at CHLA, including Dr. Jeffrey Gold, Director of the Children's Outcomes, Research, and Evaluation (C.O.R.E.) Program, the main barrier to therapy completion in children suffering from CF is motivation; the children do not complete the required in-home therapy as required since the current methodologies are unengaging. In order to increase therapy completion rates, our team is creating VR games that will mimic the therapy treatments in an immersive and engaging environment.

The VR games we are creating utilize a novel, digital spirometer to capture breath inhalation, holding, and exhalation. These natural respiratory mechanisms will be converted to digital signals and used as the gameplay controls. In doing so, we are hoping to increase therapy completion rate and create games that children will be excited to revisit as they complete their therapy.

In addition to creating the base games, we are hoping to add a multiplayer aspect to each game to increase the children’s drive to complete the therapy. The multiplayer aspect will vary for each game, but it will allow CF patients to compete/collaborate with each other in the VR environment.

Audience & Platform

Target Audience:

- Primary: Children between the ages 5-8 who are diagnosed with CF
- Secondary: Preteen children who are diagnosed with CF

Hardware Required:

- Oculus Go
- Oculus Quest
- Spirometer
- WiFi Router

Software Required:

- Unity
- Android
- Arduino

Gameplay Control Mechanism

The VR games we are designing rely on a novel, digital spirometer to capture respiratory data and convert it to gameplay controls. The spirometer captures input from users via natural inhalation and exhalation mechanisms. The data is then pushed to Unity, or directly to a headset, and is used as the controller for the VR game.

Above is a picture of the digital spirometer designed by Dr. Vangelis (left) and an individual month piece (right). The digital spirometer is custom built on top of the portable, easy-to-use, open source, IoT **M5Stick-C** development board. The digital spirometer is used in conjunction with Open Sound Control (OSC) to receive signals for inhalation and exhalation through the month piece.

Mini Games

The team is planning on producing three mini games for CHLA. Each game will have the same underlying control mechanism rooted in inhalation and exhalation. However, the games will be unique and the actual gameplay control will vary for each game. The games are as follows:

1) **Save The Village**

   Work together to save the village from dragons seeking to burn down your home. Players make use of the local well water supply, collecting water by inhaling and spraying a stream of water like a fire hose out towards burning items in the village by exhaling.

2) **Boat Racing (tentative name)**

   The player will control a toy sailboat using inhalation and exhalation. The boat will race down a river with several obstacles, such as rocks and animals. The player will exhale to accelerate the boat and inhale to decelerate the boat. The player will also race against other boats to complete the course and accumulate as many points as possible.

3) **Pebble Drop (tentative name)**

   Try to collect as many unique pebbles in a given time frame. The player can exhale to reshuffle pebbles in container ‘A’. The player will inhale while aiming at the pebble and attempt to hold the breath in order for the pebble to be stuck at the tip of the straw (something that’ll be projected out of the camera for player’s reference), and drop the pebble in container ‘B’ by exhaling.

Game Loops & UI

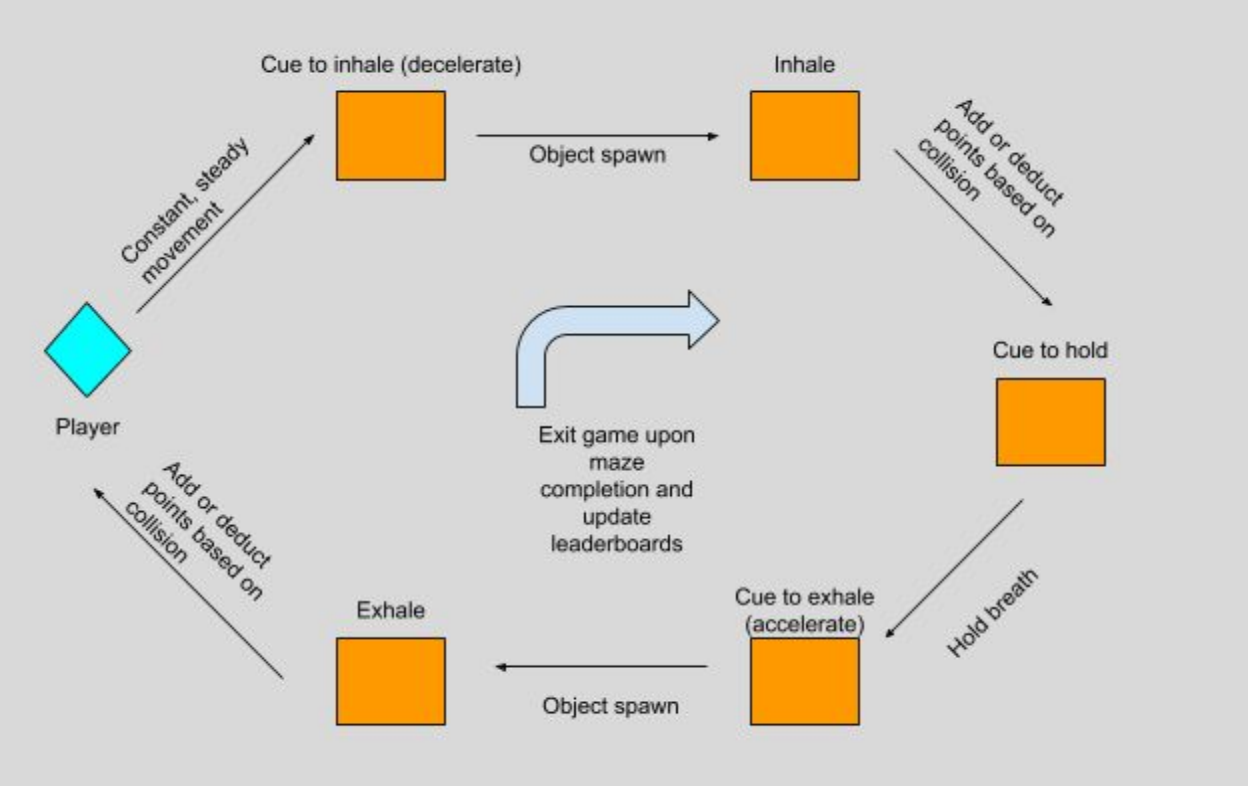
The core game loops will vary for each VR game and are represented as follows:

1) Save The Village

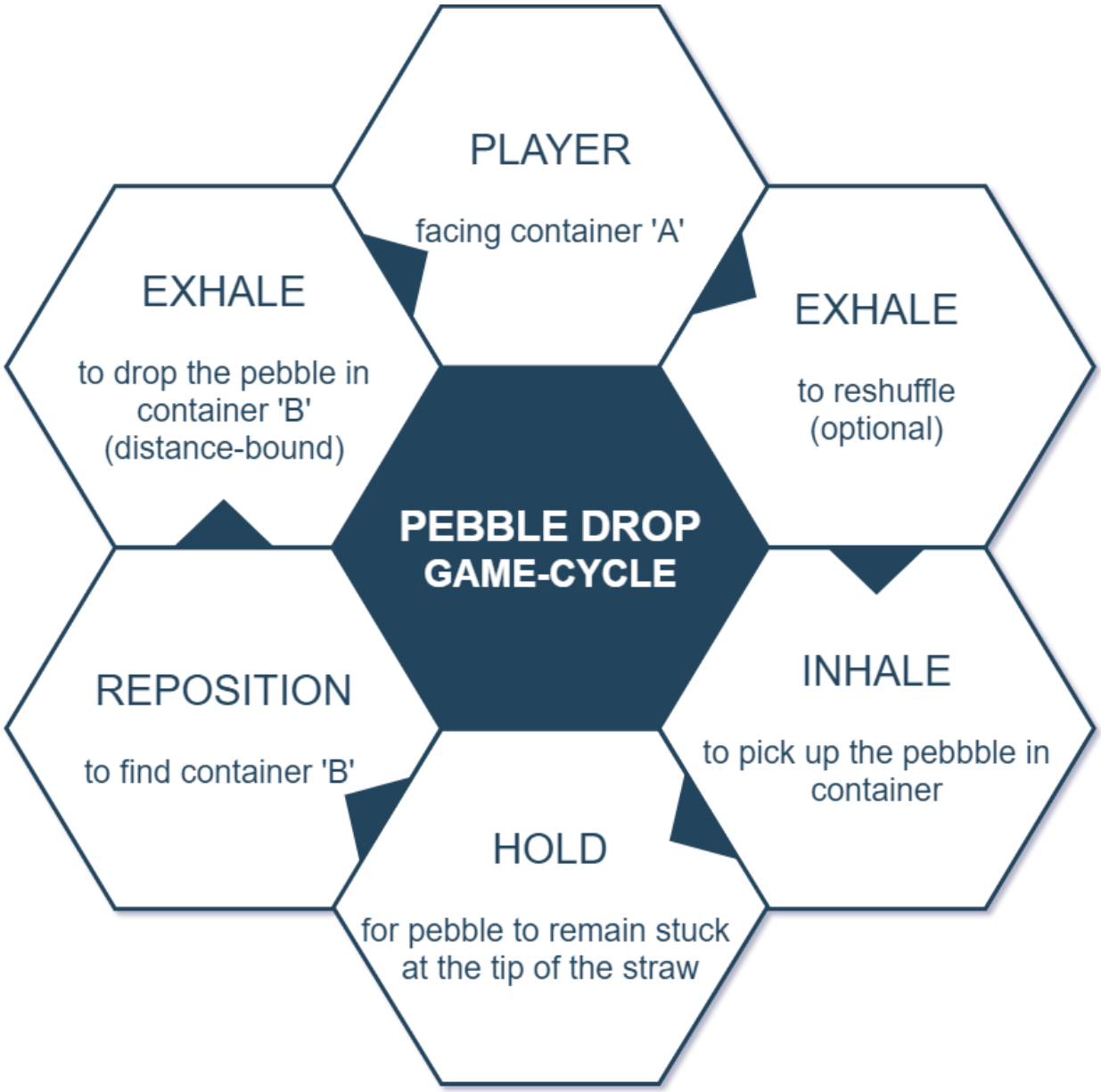
2) Boat Racing (tentative name)

The player will need to use exhalation and inhalation to accelerate and decelerate (respectively) the boat to avoid obstacles in the river. Successfully avoiding the obstacle will result in the player earning treasure, while colliding with

an obstacle will deduct from the total number of treasure pieces collected. The game will contain a leaderboard that will serve as the multiplayer aspect of the game. Additionally, the game will have other boats (not controlled by the player) that the player will race against.



3) Pebble Drop (tentative name)



Tentative Schedule

Due Date	Item - STV	Item - BR	Item - PD	Completed - STV	Completed - BR	Completed - PD
2/28	Complete understanding of STV and gameplay mechanics. Asset improvement	Complete gameplay control based on spirometer	Initial scene build w/ basic mechanics (at least primitives if not more). Identify possible assets			
3/6	Asset improvement cont. Rapid prototype initial scene for other games	Asset improvement. Basic level completion	Complete gameplay control based on spirometer. Basic level completion			
3/10	Submission for video and pres. complete	Submission for video and pres. completed	Submission for video and pres. completed			