2016 IEEE First Conference on Connected Health: Applications, Systems and Engineering Technologies

Flappy Breath: A Smartphone-Based Breath Exergame

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***Abstract*—Clinical studies [1] has shown that patients with breathing disorders can have a better standard of living through breathing exercises. To this end, this paper presents an interactive game, Flappy Breath, in which users can learn and practice breathing exercises in a gamified manner. The game is meant to be not only beneficial to users health, but also enjoyable to play and easy to understand. The testing application is a Flappy Bird [2] like game developed for the Android OS. The User inhales and exhales in order to dodge obstacles. This application is targeted on making lung rehabilitation exercises accessible to anyone with an Android device, providing patient breathing data, and a simple interface for exercising. Throughout the applications lifetime, inhaling and exhaling data is saved and can be used to construct a model of the patients breathing cycle. Therefore, the application could provide vital information to aid in patient breathing exercises and lung health.**

I. Introduction

Many ailments can be treated or its symptoms reduced using breathing exercises. These ailments include Chronic obstructive pulmonary disease (COPD), Asthma, and pneumonia. Asthma is one of the most common long-term medical condition in the world and the United States twenty-two million people suffer from it [1]. Worldwide Asthma is responsible for approximately 250,000 deaths annually [1].

The most actionable practice to help sufferers of Asthma has proven to be breathing retraining. Breathing retraining attempts to normalize patients breathing pattern. Breathing retraining typically teaches slower breathing, longer exhales, and less air per breath [3]. While breathing retraining has not proven to aid pulmonary function, it has reduced the effect of Asthmas symptoms and patients tend to require their medication less frequently [3].

In order to practice breathing retraining patients must have access to a training Instructor. This however, can be expensive and time consuming. The proposed application can act as an inexpensive substitute for classes. Workouts can be done at any time in contrast to breathing classes which requires users to meet at a scheduled time.

In addition to Asthma, COPD is also a health issue that can be treated with breathing exercises. There is believed to be three million cases of COPD in the U.K. with only nine hundred thousand diagnosed. COPD is also the second most common cause of emergency hospital admission [4]. COPD can be treated with routine cardiovascular exercise but is often left untreated or ignored. In the U.K., 69.7% of those with COPD are 55 or older [5].

Going to the gym, for those with COPD, can be frustrating due to the need to periodically stop. However, by not exercising, COPD becomes worse. The severity of COPD may require costly hospital visits which account for half the price of caring for people with COPD [4].

To increase training accessibility for patients with breathing disorders, this work presents a smartphone-based breath exergaming system, namely Flappy Breath. The system comprises breathing input devices and a software app. Specifically, the breathing sensing device has two options, a Bluetooth chest belt and a built-in microphone, and the app processes the sensor data to control a mobi-game. The Flappy Breath system is low-cost and convenient to use. The gamified exercise program acts like a personal trainer; it allows users to exercise where they choose and access a breathing technique specifically made for their ailment.

II. System Description

A. Overview

Flappy Breath requires an Android Device and either adisplacement sensor built-in microphone or a Bluetooth chest belt. For testing a Nexus 7 and Samsung Galaxy Note 4 were used. The system diagram is shown in Figure 1.

B. Breathing Input Devices

In the system design, we consider two approaches to detect breathing: i.e., acoustic sensor (e.g., microphone) and displacement sensor (chest stretchable belt).

1) Acoustic Sensor: Most Android devices have built in microphones. Our application also allows users to plug in an external microphone at any time. With the microphone, the application can obtain the current frequency and strength of input sound. The application uses a calibration activity to save the frequency of silence, inhaling, and exhaling. The application also calculates the average volume of inhaling and exhaling to determine how The application can also connect to a Bluetooth chest belt. The belt transmits data detailing x, y, and z-direction acceleration and the current size of chest expansion (stretch sensor). The application uses the stretch sensor to determine if the user is breathing (stretching) or exhaling (compressing). During testing the application was able to record seven hours of data without error and can be several feet away from the phone. Battery life on the belt is also very high, lasting for over a month of testing.

2) Displacement Sensor: There are a few off-the-shelf wearable sensors to measure the breathing, such as Wahoo [6] and Advanpro [7]. In this prototype, we choose Advanpro breath belt. The belt has a built in stretch sensor that provides a very precise position of the users chest. Also, it has integrated with a 3-axis accelerometer to measure the motion. The stretch

978-1-5090-0943-5/16 $25.00 © 2016 IEEE
DOI 10.1109/CHASE.2016.70

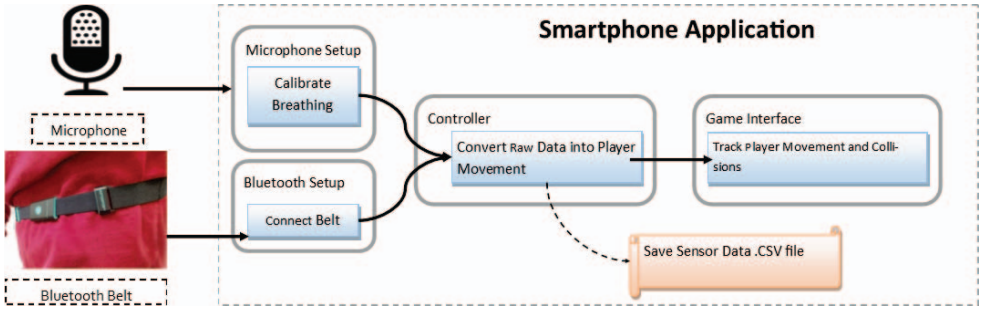

Fig. 1. System architecture of FlappyBreath.

and motion data can be streamed to the smartphone through the Bluetooth.

While, users are required to perform a microphone calibration before the game starts, the belt once it is connected can jump directly into the game. The Bluetooth belt is more comfortable since users hands are freed. Using the microphone requires users to hold the microphone to their mouth.

3) Comparison of two sensing modes: Both the microphone and belt approach have their own benefits and flaws. Detecting breathing on a microphone is easier to use and is no additional cost. The drawback of using a microphone is the distortion from background noise. Sounds in the users room like fans, music, or other people can make the microphone less accurate or even unusable. This problem has been reduced by several other universities who have looked at replacing existing pulmonary medical devices.

4) Related work on breath sensing modes: DUB Institute, University of Washington, tested the feasibility of an android phones to replace a pneumatic spirometer in the article SpiroSmart: using a microphone to measure lung function on a mobile phone. The research showed that while android microphones cannot replace professional medical instruments, they can replace handheld and other low end spirometers [8]. Stevens Institute of Technology wrote an article, Fine-Grained Sleep Monitoring: Hearing Your Breathing with Smartphones which tested mobile phones as a sleep monitor. The study states, experiments over a six months time period, show that the breathing rate monitoring is highly accurate and robust under various environments [9]. Both these articles make it clear that while a cell phones microphones cannot match a hospitals expensive medical devices the phone is still very accurate for our purposes.

C. Flappy Breath

The Flappy Breath Game was designed to be used by sufferers of Asthma. Once pre-game calibration completes for the respective input the users are ready to play. During the game users can adjust settings including speed, movement difficulty, and microphone sensitivity (as seen in Fig. 2). Adjusting speed will make obstacles move faster and require a quicker breathing cycle. Movement difficulty requires users to inhale or exhale harder to move. Microphone sensitivity allows users to adjust the volume of noise required for the user to move. As rooms grow louder or quieter this setting can cancel out ambient noise.

The game uses obstacles that users must dodge while subconsciously training a pattern of breathing. Inhaling moves

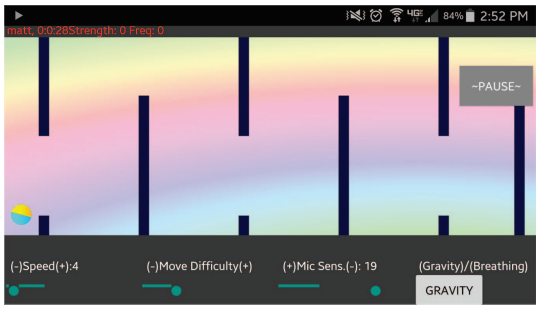

Fig. 2. Screenshot of Flappy Breath game interface.

the character up and Exhaling moves the character down. The rate of inhaling and exhaling is controlled by how quickly obstacles are spawned. The game also controls how heavy users must breathe. By slowing player movement, the game requires users to breath more per cycle. Using both breathing strength and frequency, the game can mask techniques utilized in the medical field to treat Asthma. The app recorded in this paper uses breathing sounds generated by airflow to capture breathing rate.

The game Flappy Bird which we base our game on was highly addictive and a number one download and the Apple app store [2]. Flappy Bird is fun because of its extreme difficulty, retro graphics, and simple concept. Flappy Breath hopes to capture some of these addictive qualities of Flappy Bird. Flappy Breath while not as difficult as Flappy Bird has an attractive design and simple user interface.

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