The Virtual Human Breathing Coach

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ABSTRACT

Emerging technology such as Virtual Reality has been successfully explored in healthcare, including Virtual Reality Therapy in mindfulness and relaxation. However, most of these explorations lack the stimulating environment that gives users the sense of personal connection through the exchange of bodily cues with another human. We present a breathing relaxation system where a (virtual) human coach guides users' breathing to a relaxed state. Our virtual breathing coach is of a realistic human appearance, speaks in a human voice, produces human gesticulation, and displays breathing animations. Here we describe the theoretical background in human-to-human physiological entrainment and the framework of the Virtual Human Breathing Coach where the virtual coach guides users through a set of established "Box" breathing exercises. Lastly, we will describe how we quantify the success of the system in influencing the users' breathing to a level that is prescribed by the virtual breathing coach. The application of our system ranges from remote health monitoring to self-help training that can be accessed from the comfort of our homes.

Keywords: Breathing, virtual reality in healthcare, virtual agents, box breathing, breathing exercises, stress.

Index Terms: **Human-centered computing ~ Human computer interaction (HCI) ~ Interaction paradigms ~ Virtual Reality**

1 INTRODUCTION

People often resort to breathing exercises during distressful situations since the use of breathing exercises has been proven to relieve anxiety [1]. There are several breathing exercises that are either prescribed by therapists or are readily available as self-help exercises for people to use without any supervision. However, adhering to such self-help routines is often challenging.

The therapist provides a sense of personal connection through the exchange of verbal and nonverbal cues, which aid in achieving seamless and effortless results [2] and increase adherence to the interventions [3]. However, such professional help is often limited in affordability and accessibility.

The field of healthcare is changing rapidly due to technological advancements [4], [5]. Several applications are available for relaxation and mindfulness. In addition to such applications, there are some Virtual Reality (VR) applications that are used in healthcare interventions, but only a few of these use a human coach [6]. The advantage of using a virtual human coach is that they not only make the training affordable and accessible but also provide a stimulating environment for the user where the user feels the sense of personal connection through the exchange of bodily cues.

In this study, we are combining relaxation through guided breathing and VR. Due to the vital role that breathing plays in relaxation and the precedence of using VR in relaxation, we propose a framework for a relaxation system where a user's breathing is guided by a virtual human coach. Our novel implementation of a virtual human has human appearance, human speech, shows physiological movements such as breathing, can produce gestures and subtle nonverbal cues that coordinate with speech.

2 BACKGROUND

Virtual Reality has proven to be effective in addressing many health related issues such as treating anxiety, depression, schizophrenia, phobias [7].

The reason Virtual Reality is being extensively explored in such applications is that it allows full control over the environment the user is exposed to [8]. Although the users can recognise that the environment is not real, they behave and respond similarly to how they would in a real environment [9].

Using virtual coaches for breathing exercises can offer a realistic alternative which is available on demand and the users have access to it in the comfort of their homes. This is particularly important in situations when people are confined to their homes. Virtual humans as coaches in training, especially healthcare, is an emerging field [10]. A virtual coach as a physical instructor has been shown to have a significant effect on learners' experience [11], a virtual coach is used to alleviate chronic pain and stress [12], a conversational agent has been used as a meditation coach to induce relaxation [6], a virtual human that leads the user into a state of

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physiological synchrony [13], a real-time virtual tutor adapts its instruction resulting in significant learning improvement for students [14]. These are some of the examples of applications that are using a virtual human as a coach. Another example of a real-time virtual coach is Gabby who can read the breathing of the user and give instructions based on the user's breathing dynamically [15]. Although the coach has been successful in achieving relaxation, the system lacks feeling of immersion and realism necessary for having a realistic human to virtual human interaction.

3 The `Virtual Human Breathing Coach

We present the Virtual Human Breathing Coach – a relaxation system that alters users breathing physiology through a set of guided breathing exercises led by a virtual coach.

The core of the Virtual Human Breathing Coach is the influence – entrainment – of the breathing rhythm using an ecologically valid physiological signal observed by the user. In general, entrainment refers to the oscillation of one system being influenced by the oscillation of another system. In the Virtual Human Breathing Coach, the external pacemaker of the controller system, which is the Virtual Coach's breathing rhythm, is set to a fixed frequency independent of the frequency of the target system, which is the user's breathing rhythm (Figure 1). The external pacemaker oscillates at a predefined rhythm while the internal pacemaker initially oscillates at a different rhythm. The internal pacemaker senses the external pacemaker's oscillations and eventually gets influenced by these leading to a state of synchronised oscillations between the controller system and the target system.

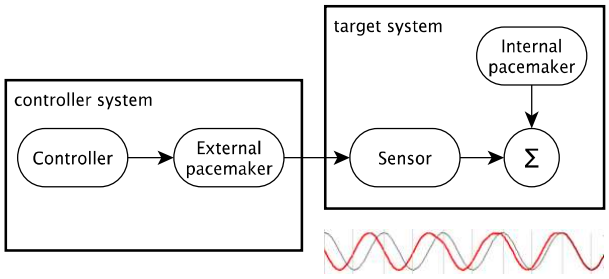

Figure 1: Concept of entrainment at the core of Virtual Human Breathing Coach.

At the implementation level, the virtual human acts as a relaxation coach and guides users' breathing through a set of relaxation exercises based on a well-established breathing exercise regime – Box breathing [16].

Traditionally the box breathing is 4x4x4 – i.e., the inhale is 4 second long, the hold is 4 second long and the exhale is 4 second long. In our implementation we adapted the difficulty level between exercises where one of the exercises is easier than the other. To make it easier for our participants, we used a 2x2x2 for the easy exercise and 3x3x3 for the difficult exercise, i.e., the inhale, hold and exhale are each 2 seconds long in the short breathing exercise, while 3 seconds long in the long breathing exercise.

The reason for shortening the timings for each sub-cycle within the Box breathing was that some people find it hard to inhale, exhale, or hold their breath for 4 seconds, there they are recommended to start with a 2 or 2 second cycle in order to ensure that it is comfortable to perform [17].

The adaptive difficulty level will help us compare between the conditions and inform us whether the virtual coach was able to help users adhere to the exercise. Each breathing exercise is 4 minute long. This is based on National Health Services recommendation of a standard breathing exercise that can be done in order to attain relaxation (https://www.nhs.uk).

The set up works as follows: The participant receives a clickable link which takes them to an environment with a virtual coach sitting on a chair. The virtual coach welcomes the participants and introduces itself as the breathing coach who will instruct and guide the participant's breathing. The virtual coach gives verbal instructions, on when to inhale, hold breath and exhale, to the participant using voice instructions and a variety of facial and body gestures. The coach uses the box breathing exercise to guide the participant to breathe slower with it, eventually leading to a controlled breathing. Each participant completes both the easy and the difficult breathing exercise with each exercise lasting around 4 minutes. After each exercise, participants fill in a questionnaire to report their experience of the breathing exercise that they have performed.

4 System Framework

The Virtual Human Breathing Coach is a relaxation system that has a virtual human at its core who acts as a relaxation coach and guides users' breathing through a set of relaxation exercises.

The virtual environment and the virtual human are created and rendered using the game engine Unity (https://unity3d.com). The advantage of using Unity is that we are able to create and deploy a realtime system without any need for prerecording. The sequential working of the system is driven by the finite state machines implemented within the game development engine.

The seamless and effortless deployment of the system using the WebGL (https://docs.unity3d.com/Manual/webgl.html) lets the system run standalone in the browser without a need for any installation.

The virtual coach is a high-quality, postprocessed, realistic character with human appearance and speech. The character is equipped with verbal as well as nonverbal dialogue skills displaying the animations for idle, standing, pointing, sitting, standing, acknowledging, nodding, looking around, shifting weight and waving.

For an advanced animation control, the character allows direct manipulation of skeleton model joints (e.g., the neck joint or the spine joint).

The virtual coach speaks in a natural human voice which is achieved using a pre-scripted and pre-recorded voice over. We are using lip-syncing for voice and mouth movements (https://crazyminnowstudio.com/unity-3d/lip-sync-salsa/).

Figure 2: A snapshot of the virtual coach sitting on a chair in the middle of a therapy room while giving breathing instructions.

To achieve smooth transition between all the executed gestures, movements, lip-syncing and breathing exercises whilst controlling

the state transition, finite state machines are used (https://hutonggames.com).

The input to a finite state machine triggers a transition that leads to an action that eventually causes a state change. There are multiple scenes in the Virtual Human Breathing Coach and each scene has multiple finite state machines for scene switching, flow control, character control including animations and speech, condition-based progression.

Figure 3 shows the finite state machine with multiple states which controls the breathing cycle of the virtual coach with the breathing movements, breathing instructions and time per state.

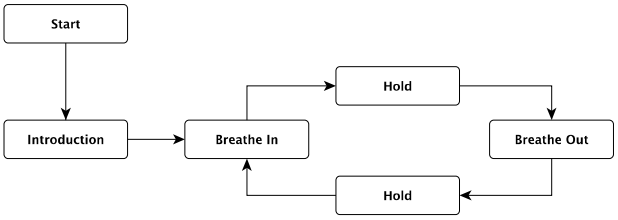

Figure 3: Finite state machine for controlling the breathing cycle of the virtual coach

5 Conclusion

Our project combines Virtual Reality technology with human physiology making the scope of our system multidisciplinary.

In order to get an insight into the usability of our system, and to validate the methodology, research design and data analysis, a pilot study will be carried out using the system. We will investigate how people perceive a realistic virtual human as a breathing coach and whether they are influenced from the coach. We will also extend the system in future to incorporate real-time user input to make the system interactive.

The goal of our system is to bridge the gap between healthcare interventions and technological developments. Although there are professional therapies available that are prescribed by trained professionals, these are often costly and time-consuming that only a small portion of the public can afford. Studies like this are a step towards improving the accessibility and affordability of such interventions. In addition to that, people are often unaware of their mental state and find it hard to accept that they need help. Use of virtual reality and virtual humans is exciting to most of the people and the stimulating interaction with a virtual human can encourage them to approach and use such systems.

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