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Helptic: DIY Haptic CPR Training with AI-Guided Feedback in AR

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I. ABSTRACT

CPR knowledge is an essential lifesaving tool. However, traditional methods of CPR training are lacking in engagement and retention of skill. The materials used in CPR training (manikins) are known to be expensive and inaccessible. Therefore, we propose an augmented reality (AR)-based CPR training system which simulates chest compressions using a spring-based physical interface, utilizes AI to track hand posture, compression rate and depth, while giving real-time feedback through an LLM-powered assistant, while using haptic feedback to enhance realism to the user.

II. INTRODUCTION

Out of hospital cardiac arrest, otherwise known as OHCA, is one of the top causes of death worldwide [1]. In Korea, according to the Korean Cardiac Arrest Research Consortium (KoCARC) registry, from 2015 to 2018, there were 7,577 incidents of OHCA [2]. It is reported that for every 5 minutes of delay to the return of spontaneous circulation (ROSC), it results in a 38% increased risk of mortality [3]. Hence, immediate cardiopulmonary resuscitation (CPR) is vital in such situations. However, traditional CPR training sessions have some drawbacks, such as the rapid decline of CPR skills, within six to nine months, if practice is not done regularly [4]. CPR manikins are also known to be bulky and expensive, ranging from a few hundred dollars to a few thousand dollars in some cases. Also, it is reported that there is a lack of accessibility to trainers to conduct CPR training [5]. Therefore, the main gaps identified in traditional CPR training methods are the lack of engagement of CPR training, resulting in the decline of skill retention, and expensive and inaccessible training materials. With that in mind, the main goal of our system is to improve CPR skill acquisition and retention, offer an engaging, self-guided training, as well to make CPR training more accessible by reducing the cost and space requirements.

III. PROPOSED SOLUTION

As seen in Figure 1, we developed an AR CPR training system which will simulate CPR chest compressions, using a spring-based physical device. With haptic feedback to enhance the realism to the user and increase the stiffness of the spring, incorporating AI to track the correct hand posture, compression rate and depth, provide real-time performance feedback through an LLM-powered assistant. Our system is cost effective, staying under $100, which is significantly cheaper as compared to conventional CPR manikins.

Our proposed system consists of the following components:

AR Manikin Setup: The user will put on the head mounted device (HMD), and the AR system will overlay a CPR manikin in the real-world environment of the user.

Hand Posture Checking: The user will be prompted to show the correct hand posture (with hands interlocking, one hand over the other). If the user shows the wrong hand posture, the AI system will recognize this as an incorrect hand gesture, and prompt correction.

CPR Training: By pressing down on the device, it will provide haptic feedback to the user, to provide a more realistic sensation of CPR. Using haptic illusion, the stiffness of the spring will also be altered to give a similar sensation to mimic real CPR. The device will also take note of the rate and depth of compressions, ensuring accurate CPR delivery.

Performance Feedback: Two types of feedback will be given to the user. The first feedback would be that of hand postures, taken every 30 seconds, without interruption to the CPR session. These images will then be analyzed by the OpenAI API, and feedback will be provided at the end. Next, the system monitors rate and depth of the compressions, delivery auditory and visual feedback every 10 compressions.

Overall Output: At the end of the training session, collected data will be sent to an OpenAI API, which will generate a summary.

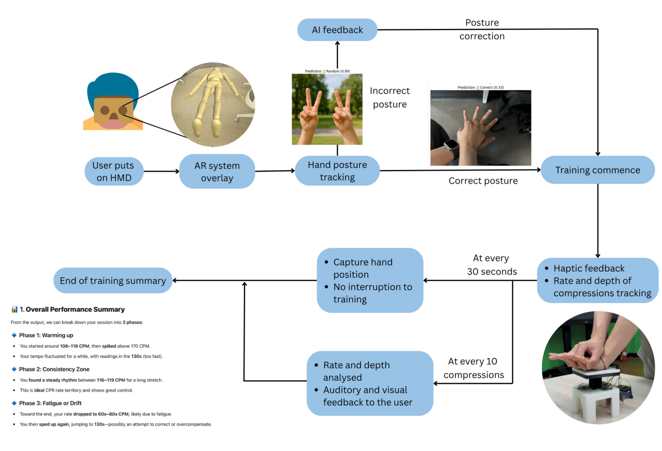

Fig. 1. Proposed Solution Outline

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IV. Implementation Detail

A. Haptic Hardware Design and Assembly

Our main objective is to implement a DIY haptic hardware system for CPR compression feedback that can be easily reproduced and deployed for widespread training use.

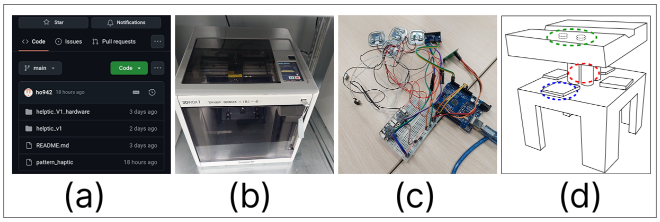

Fig. 2. Workflow of Helptic hardware

As shown in Figure 2, the construction process consists of three main steps: (a) downloading the files and (b) 3D printing the parts, (c) assembling the circuit on a commercial breadboard, and (d) integrating the components.

The instructions enable users to build the device using readily available materials and tools. The enclosure is 3D printed, and the circuit is built using off-the-shelf electronic components without a custom PCB.

The compression surface incorporates a mechanical spring, building on prior research that demonstrated springs can effectively mimic the compliance of the human chest during CPR [6]. This DIY workflow enables scalable deployment.

Figure 2(d) shows the fully assembled CPR feedback device, which integrates three major components: (Red) a spring-based compression surface that provides passive kinesthetic feedback, (Blue) a load cell beneath the surface that captures applied compression force, and (Green) Linear Resonant Actuators (LRAs) mounted near the contact area to deliver real-time tactile feedback based on compression force.

An Arduino Uno reads force data and activates the LRAs at predefined thresholds, offering users immediate, intuitive feedback. A tare and calibration procedure using known weights is performed at the start of each session. The complete system is enclosed in a durable, portable 3D printed housing. By mimicking the resistance of a human chest and enriching tactile sensation, the system supports effective CPR skill acquisition

B. AR-Based Software Design and Interaction Flow

Accessibility is one of the biggest challenges introduced by traditional CPR training. To address this, we propose a crossplatform augmented-reality (AR) application to allow users to train CPR.

Unity AR Foundation was selected as the developmental framework due to its robust performance and myriads of essential built-in functions, compared to other alternatives, including—but not limited to—real-time plane detection, object placement, and real-world object tracking. Using plane detection, suitable empty surfaces for placing our hardware prototype, as well as a virtual CPR are identified. Following the placement of the manikin, the position of the hardware prototype is tracked to make sure the placement of the manikin is persistent with its position. This allows for a smoother and more realistic experience. After the virtual environment setup is complete, users can check the correctness of their hand posture using the AR camera and the integrated hand posture classification model model. If the hand posture is correct, they can proceed with the training. During training, data from the Arduino Uno is read from serial ports or Bluetooth to later summarize the performance and give feedback to the user using OpenAI API. This approach offers users immersive CPR training that combines hardware feedback, AI-powered evaluation, and real-time interaction.

C. Hand Posture Classification and Performance Feedback

The proposed solution utilized AI in two methods - recognizing correct hand posture, and feedback summary. In the first method, classification model is utilized to recognize the correct hand posture, before starting CPR training. By extracting videos from YouTube and our own recordings, the individual frames of these videos were extracted. The images were passed through Meta's Segment Anything Model, to isolate hands, to train our model. There were 16,000 images classified as 'correct hands' and 16,000 images classified as 'random hands' in the training data set. The trained model was able to accurately differentiate the correct and random hand postures. For feedback, the OpenAI API was able to generate an overall summary of the CPR session after completion.

V. Conclusions and Future Work

To address the lack of real-time feedback, participation, and accessibility to materials, our goal was to build a system that resolves those issues. Using haptic feedback, an AR environment and a system that uses AI, we developed a system that was able to provide users with engaging, self-guided training and to make CPR training more accessible by reducing the cost and space requirements. We intend to conduct user studies to study the effectiveness of our proposed solution, believing that these explorations and results can shape the future of CPR trainings.

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