REVEAL: REal and Virtual Environments Augmentation Lab @ Bath

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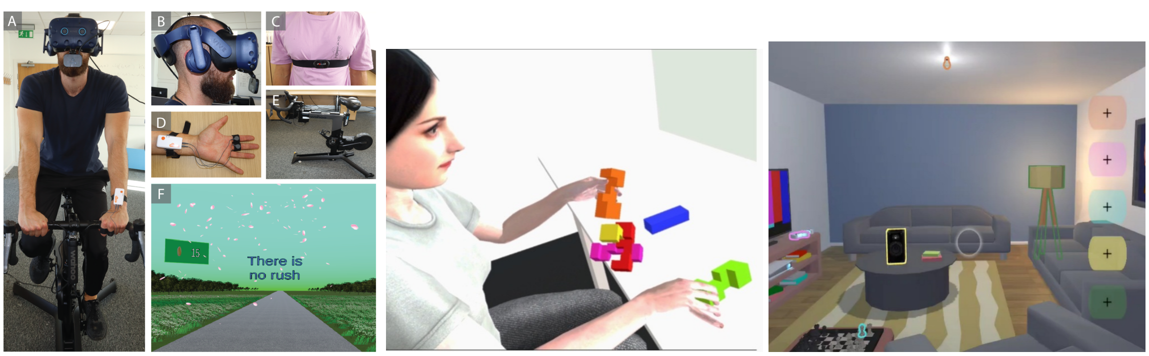

Figure 1: Left (A-F): In our affective VR exergame, a user wears sensors such as a face tracker (B), a heart rate strap (C) and skin conductivity electrodes (D) while riding a stationary exercycle (E) through emotion-inducing virtual environments (F). Middle: Our virtual learning environment for psychomotor tasks teaches users to complete a 3D Burr puzzle through observational learning (watching an avatar) or active learning (guided practice). Right: Users control a virtual smart home through eye gaze, e.g. activating a smart speaker or switching off lights by dwelling on colour-coded dwell buttons in their periphery.

ABSTRACT

The REal and Virtual Environments Augmentation Lab (REVEAL) at the University of Bath is an interdisciplinary research centre focusing on immersive technology. REVEAL investigates the fundamental principles, applications and interaction techniques of extended reality (XR), including virtual reality (VR) and augmented reality (AR). In this Interactivity demo, we will showcase some of our VR research across three areas: affective VR exergaming, learning with virtual avatars, and gaze interaction in VR.

CCS CONCEPTS

• **Human-centered computing** → **Human computer interaction (HCI)**; **Virtual reality**; • **Applied computing** → **Consumer health**; **Interactive learning environments**.

KEYWORDS

virtual reality, exergaming, emotions, affect, emotion recognition, learning, avatars, gaze, interaction

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1 INTRODUCTION

The REal and Virtual Environments Augmentation Lab (REVEAL) at the University of Bath is a research centre focusing on immersive technology. We investigate the fundamental principles, applications and interaction techniques of extended reality (XR), including virtual reality (VR) and augmented reality (AR). In particular, we look at how environments and activities in the real world and in virtual worlds can augment each other to improve outcomes for users such as their experience and performance.

In this Interactivity demo, we will showcase some of our VR research across three areas: affective VR exergaming, learning with virtual avatars, and gaze interaction in VR. First, we will demonstrate how sensors can be used to estimate how a user feels while exercising in VR, e.g. in order to assess or adapt an exergame. Second, we will demonstrate a virtual learning environment for psychomotor tasks, which teaches users to complete a 3D Burr puzzle through observational learning (watching an avatar) or through active learning (guided practice). Finally, we will demonstrate how gaze interaction can be used to control a virtual smart home using only the eyes, e.g. to activate smart speakers or turn on lights. All three demonstrations will allow visitors to experience our technologies live and engage with the research team that created them.

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2 AFFECTIVE VR EXERGAMING

Regular physical activity helps to maintain a good quality of life by protecting against chronic conditions, improving well-being, and sustaining cardiovascular health [7, 56, 65]. While sedentary behaviour is one of the leading causes of preventable death worldwide, 27.5% of adults and 81% of adolescents globally do not meet the recommended level of physical activity [40]. A contributing factor is the lack of intrinsic motivation for physical activities, i.e. engaging in an activity for its innate satisfaction and enjoyment. Exergaming, the combination of physical exercise with gaming, holds great promise for motivating physical activity [21, 33, 45, 51, 62, 64]. Combining exergaming with VR can distract users from the aversive elements of exercise through immersion in a virtual environment [4, 5, 10, 11, 18, 24, 54].

Some exergames adapt themselves during gameplay to optimise the player experience, e.g. adapting their game difficulty [16, 25]. To enable more advanced adaptations, we need to estimate a user's emotional state during gameplay based on physiological sensor measures, known as *affect recognition* [43]. Affect recognition can be used to measure the player experience [34, 36] and it enables unique adaptations of exergames beyond difficulty adjustment such as emotionally-responsive, interactive storytelling [13, 35]. However, there are several key challenges: First, emotion-inducing exergaming environments are needed to develop and validate affect recognition approaches [26]. Second, physical movement and exertion interfere with physiological sensor measures [9, 15, 20, 46, 47, 63]. Third, interpersonal and environmental factors such as the VR stimuli need to be considered, as they influence the sensor measures.

We designed four virtual environments (VEs) for a VR cycling exergame to induce specific emotions (Happiness, Sadness, Stress, and Calmness), see Figure 1 A and F. The exergame allows users to cycle through the different VEs, which were designed based on the literature on emotion elicitation and stimuli [22, 28, 52, 57, 60, 67], as well as affective game design [12, 53] and gamification theory [29, 58]. While users are playing the exergame, their physiological responses are measured using pupillometry and face tracking sensors in the head-mounted display, a heart rate sensor, a skin conductance sensor, and a power output sensor in the exercycle (Figure 1 B-E). In a user study, we validated the VEs and used them to elicit emotions, collecting subjective data about how people felt, as well as physiological sensor measures. Based on collected data, we constructed and validated an affect recognition model that can estimate a player's emotions at different levels of exercise intensity.

In this demo, attendees will be able to try the VR cycling exergame and experience the four emotion-inducing VEs. We will showcase how emotions can be induced and measured during exergaming, and demonstrate our affect recognition model's real-time estimations of a player's emotions based on their physiological responses. The demo shows the cutting edge of exergame design, emotion elicitation using VR, and affect recognition technology. This demo accompanies a paper which is currently awaiting a decision from the CHI program committee.

3 LEARNING WITH VIRTUAL AVATARS

Virtual reality is increasingly being used to teach people new skills in the workplace by immersing them in realistic training environments [66]. Training in VR can be more enjoyable than its real-world counterpart and has been shown to be as [31], and in some cases more effective for learning [27]. The overwhelming majority of industrial VR training use cases involve procedural and psychomotor skills [49], i.e., skilled movements that require coordinated motor action and cognition [55]. The most common skills are manual tasks that involve learning a procedure or sequence of actions that require the user to grasp and manipulate objects, such as construction [1, 2, 6, 39], dental [38] and surgical [8, 23] procedures, equipment operation [19, 37, 48, 61], and tool use [42].

We have developed a VR training platform for psychomotor learning that supports two different methods of learning: 1) Active learning ('learning-by-doing') is the most common in VR and allows users to learn a task by performing it. Active learning approaches guide users to complete each step of the procedure while learning the skill through rehearsal [1, 8, 14, 19, 38, 44]. 2) Observational learning ('learning by watching') is often overlooked in industrial applications of VR but often used in real-world training, e.g. when learning from a teacher or a video. Both approaches have their advantages, and combining them is thought to be one of the most efficient and effective approaches to real-world training [3, 30, 50].

In this demo attendees will be able to experience active and observational learning in VR for a psychomotor puzzle task: a Burr puzzle in which 3D pieces are fitted together to form a consistent body (Figure 1 middle). Attendees will be able to train their Burr puzzle skills in VR and then apply them in the real world using a physical Burr puzzle. The demo illustrates the opportunities of VR learning, as well as the differences between different learning methods. The demo accompanies a paper which is currently awaiting a decision from the CHI program committee.

4 VR GAZE INTERACTION

Augmented reality headsets are growing in popularity and will likely become mainstream over the next years. Many AR headsets have built-in eye gaze trackers to enable users to interact with their physical and virtual environment directly, by looking at an object they want to interact with [17, 41]. This is becoming increasingly relevant for mainstream interaction in XR, especially with the release of the Apple Vision Pro headset which uses eye gaze interaction by default.

We have developed Actigaze [32], a gaze-only input method that allows users to click objects with a performance and accuracy close to the mouse. Actigaze has been applied in a gaze-controlled web browser and has also been evaluated for code navigation in an integrated software development environment [59]. Actigaze works by breaking clicks down into two steps: First, users look at the object they want to click, e.g. at the smart speaker on the table on the right side of Figure 1. Actigaze highlights clickable objects with different colours, e.g. the smart speaker is highlighted in yellow. In the second step, the user confirms the click by briefly looking at the 'confirm button' with the corresponding colour on the right side of their field of view, e.g. the yellow confirm button. This two-step process addresses two challenges of gaze-only interaction: 1) it disambiguates clickable objects that are close together, compensating for the limited accuracy of gaze tracking, and 2) it avoids inadvertent clicks through 'Midas touch', i.e. ensures users really want to click an object and not just look at it.

In this demo we will showcase how Actigaze can be used to control a virtual smart home. Attendees will wear a Pico VR headset with built-in gaze tracker and find themselves in the scene shown on the right side of Figure 1. The scene contains many objects that can be interacted with such as a TV, lights, a smart speaker, blinds, a chessboard, heating controls etc. The demo allows visitors to experience the possibilities of gaze-only interaction in XR.

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