Re-Touch: A VR Experience for Enhancing Autobiographical Memory Recall Through Haptic and Affective Feedback

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Figure 1: The Re-Touch system enhances autobiographical memory recall through an immersive VR experience: (a) Users start in a virtual room, receive instructions, and enter the Memory Portal; (b) Inside the virtual environment, users interact with a glowing ball agent; (c) Using haptic feedback gloves, users engage with personalized memory frames, deepening sensory and emotional immersion to promote effective memory recall and emotional well-being.

ABSTRACT

Autobiographical memory recall can be triggered through sensory stimuli, often creating a positive impact on emotional well-being. However, there are few systems that can adapt to users' emotional state and provide personalized stimuli to better support this process. Re-Touch enhances memory recall through the integration of Virtual Reality (VR), haptic feedback, and affective computing. It allows users to revisit their personal memories in a controlled VR space. By monitoring physiological responses (photoplethysmography (PPG) and electrodermal activity (EDA)) the system adjusts the haptic feedback intensity and the VR content to match the user's emotional needs, enhancing sensory and emotional immersion.

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CCS CONCEPTS

• **Human-centered computing** → *Virtual reality*; *Natural language interfaces*; **Haptic devices**.

KEYWORDS

Virtual Reality (VR), Haptic Feedback, Autobiographical Memory Recall, Affective Computing

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1 INTRODUCTION

Autobiographical memory, comprising episodic and semantic memories, forms a vital part of our identity and emotional well-being. These memories are often triggered by sensory stimuli and can be vividly recalled, impacting our sense of self, decision-making, and

social interactions. Studies have shown that VR can help individuals with memory impairments or emotional traumas by creating controlled and engaging environments that facilitate memory recall and emotional processing [Reggente 2023] The application of haptic feedback in VR can significantly enhance the user's sense of presence and immersion, making the experience more tangible and emotionally impactful. Haptic feedback can enhance the realism of virtual interactions, providing users with a richer and more nuanced sensory experience[Pacchierotti et al. 2024]. By integrating affective computing techniques, systems can adapt to the user's emotional state, providing personalized and emotionally appropriate responses that enhance the overall experience. This convergence of VR, haptics, and affective computing creates a powerful tool for enhancing autobiographical memory recall[Schöne et al. 2019]. Arousal levels, which can indicated autobiographical recall, play a crucial role in this adaptation process[Gupta et al. 2022].

Re-Touch is a VR system that uses artificial intelligence (AI) to recreate users' autobiographical memories in a virtual environment. Inspired by Pizzoli's Personalized VR [Pizzoli et al. 2019], which creates tailored virtual content to enhance well-being through the recollection of significant life events, Re-Touch offers new ways to explore personal memories with significant therapeutic potential. By integrating haptic feedback and AI, the system enhances interactivity and immersion, providing personalized and emotionally engaging environments. The main novelty of Re-Touch lies in its ability to dynamically adjust haptic feedback and VR content based on real-time physiological data (PPG and EDA) and using generative AI to create contextual environments from users' verbal memory descriptions. This approach allows the system to adapt to users' emotional states, deepening sensory and emotional immersion, and fostering memory recall and emotional processing, thereby marking a significant advancement in affective computing and immersive experiences.

2 PROTOTYPE IMPLEMENTATION

Re-Touch uses the Quest3 with bHaptics TactGloves [1]to deliver precise haptic feedback, allowing users to feel virtual objects. An Emotibit [2] collects real-time physiological data (PPG and EDA) to understand the user's emotional state and calibrate the system's response patterns. Natural Language Processing (NLP) converts users' verbal descriptions of their memories into generative prompts, which are processed by Stable Diffusion (text-to-image)[3] and Meta Audio Craft (text-to-audio) [4] systems to create corresponding visual and auditory content. This content is integrated into a Unity environment, constructing VR scenes that reflect the emotional aspects of the memory. The audio is converted into vibrational feedback for the haptic gloves, ensuring that tactile sensations align with the virtual objects, enhancing sensory immersion. Machine learning models trained using the DEAP dataset[5] predict users' arousal levels based on physiological data collected during the calibration. These models provide real-time analysis, categorizing arousal into low or high levels and dynamically adjusting the VR environment to enhance the emotional impact. This ensures that each user's experience is uniquely tailored to their memory and emotional responses.

[1]bHaptics TactGloves
[2]EmotiBit
[3]Stable Diffusion
[4]Meta Audio Craft
[5]DEAP dataset

3 USER EXPERIENCE

The system begins with Calibration, where users are presented with emotionally evocative scenarios (happy or horror) to elicit strong emotional responses measured through PPG and EDA. This data is used to train a machine learning model, predicting arousal levels and personalizing the immersive experience by categorizing arousal into low or high levels. Following calibration, the Memory Collection stage begins, during which users provide detailed verbal descriptions of their memories, including sensory elements like sights, sounds, and tactile sensations. These descriptions are converted into generative prompts to create visual and auditory elements. Next, in the Interactive Exploration Stage, users navigate the generated virtual environment through portals that appear next to the question frame. They explore the environment and interact with objects using the haptic gloves. They are tasked with finding a glowing ball agent, which activates the haptic gloves and guides them towards framed images generated by AI. As users approach and interact with these images, the system predicts their arousal levels. High arousal levels trigger the opening of additional portals to different aspects of their memory. When users interact with the image frames, the haptic gloves produce sensations that mimic the feel of the objects described during the memory description, reinforcing the emotional and sensory aspects of the memory. The experience will take around 5 to 6 minutes in total.

4 CONCLUSION

Re-Touch provides a deeply interactive and emotionally resonant user experience that allows users to revisit and interact with personal memories in a controlled and supportive environment. Future work will focus on its significant potential for preserving memories, processing difficult emotions, PTSD treatment, and assisting those with memory loss, highlighting its broad potential applications in therapeutic settings.

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