Research Statement

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My research vision is **bridging our perception of reality** across **spatial and temporal dimensions**, across **body difference between people**, and across **physical and virtual mediums**, in doing so breaking the bounds of human self and physical reality, to **augment human perception** and enhance **human-to-human, human-to-world interaction**. My research is an intersection of research methods in human-computer interaction (HCI), virtual reality (VR), augmented reality (AR), mixed reality (MR), and embodied interaction.

In particular, I am fascinated by the notion of reality, which are uniquely built by our conscious experience through our sensory feedbacks and embodiment of these senses. As we perceive our senses and interacts with the physical environment with our one physical body, we create our unique one reality. In a series of research, I draw on methods of integrating multiple realities simultaneously to the user. My research demonstrated that when one is presented with more than one reality, one's **perception and interaction capacity is augmented**, as realized in **interaction across realities, augmented awareness, cognitive and motor adaptation**, and **improved interpersonal understanding**.

Bridging Realities for Augmented Perception & Interaction

The emergence of VR and AR researches in alternate reality experience have adhered to one principle, the one-to-one mapping of a human's self to the reality. However, this also limits the possibility to expand our cognitive perception. For example, when one is immersed in VR, one's perception of physical reality is diminished, thus the cognitive capacity is not augmented. The research question I sought to answer is how humans could be augmented by bridging realities.

Seamless Transition and Cross-Modal Sensory Channels

Alternate reality could be constructed in vivid sensory channels to improve immersion, but there is an immersion barrier in that we have a preconceived bias that an alternate reality is fabricated. For example, when we are about to put on a head-mount display (HMD), we already know what is about to be experienced in VR is mediated by the computer.

Figure 1. Cross-modality of audio-haptic creates the illusion of past events happening in live.

I researched how to remove this barrier by integrating alternate reality subtly into the physical reality through seamless transition and audio-haptic cross-modal sensory channels, so that user does not know when the physical reality ends and alternate reality starts [1]. This created the illusion to the user so the user could interact with past events as though happening in live (Figure 1). Through user studies, I find that seamless transition is essential as it retains the embodiment and conviction of reality, i.e. there is no break in presence between physical and alternate. Another interesting observation is the effect of illusory moving haptics influenced by the spatial sound. I see potentials of this research in applications such as mental trauma recovery where a live psychiatrist can intervene a patient's alternate reality in the past.

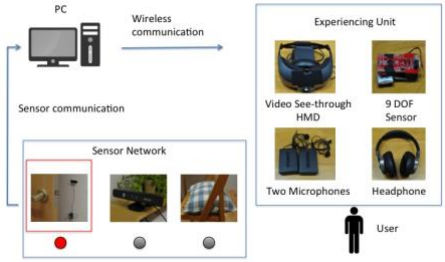

Figure 2. Furniture sensor network for embodied blending in household.

Embodied Interaction for In-Context Blending

Since observing that users could interact in the illusion of past events happening in live, I explored further the

experience of integrating the user's fully agented interaction to surrounding objects to enable an embodied interaction triggered blending of realities.

The research, Ubiquitous Substitutional Reality [2], was a step towards ubiquitous computing alternate reality experience. I explored this concept in a household environment with furniture sensor network (Figure 2) which triggers blending of realties from the past in visual-audio modalities, as users interact with the furniture such as opening a door or sitting on a cushion. As human's sensorimotor interaction influences how humans perceive the reality, I envision this research brings value to nostalgic belongings for in-context reminisce of memories.

Augmenting Cognitive and Adapting Sensor-Motor Functions

As we bridge alternate realities together, our cognitive capacity could be increased. For example, human vision is limited to the front, thereby we create our perception of reality as a frontal focused one, while the environment to the back of us is vaguely perceived through other sensory channels such as auditory. What if we expand the visual sensation so the reality in the back could be bridged?

Figure 3. Augmenting senses to see both front and back augments human's cognitive capacity.

SpiderVision [3] extends the human field of view to augment a user's awareness of things happening behind one's back. It leverages a front and back camera to enable users to focus on the front view while employing intelligent interface techniques to cue the user about activity in the back view (Figure 3). The augmented cognitive capacity and adaptation phenomenon were observed. The user study, which evaluates a user's performance on simultaneous front and back tasks, indicated that users could handle both realities' tasks without significant degradation compared with only one task. Furthermore, users' discussion suggest that they were able to cognitively distinguish between the two realities, i.e. they were able to identify in which reality an object belongs. Moreover, the users could adaptively use the augmented back eye to locate events in the back reality instead of turning.

Body Difference for Interpersonal Understanding

From findings in embodied cognition, our perception of reality is generated from our unique body interaction. Therefore, an objective physical environment is perceived differently by different people, creating unique realities for everyone. It is therefore a barrier for us to comprehend the reality and body capabilities of a different individual. VR has been frequently used in simulating a different person's body to the user. However, being a different person in VR diminishes one's own body, and is not transferrable to physical reality.


Figure 4. Embodying multiple digital humans simultaneously to promote interpersonal understanding.

In the research, Multi-Embodiment [4], I utilized VR and digital human technology to embody multiple bodies to the user while the user retains full agency of his original body, so the users could simultaneously see that in the same environment how would other bodies interact differently from him (Figure 4). Through user study, I found that by blending bodies, users were more effective in making correct ergonomics decisions for different people. Moreover, this effect lasts after VR exposure in the physical reality when compared to being simulated to a different person in VR. I believe this is due to the user's body being present in both VR and physical reality, so that it could be used as a reference in the physical reality for the interpersonal understanding gained in VR.

Future Research

My research demonstrated bridging realities augments human's perception and interaction capacity. With the findings in my previous research, I plan to focus my future research in the domains of HCI and MR that enhance **human-to-human, human-to-world interaction**.

Bridging the Physical & Virtual for Augmented Interaction

In our everyday life, each of us could usually predict, to a certain extent of accuracy, the outcome of an interaction with the world. However, sometimes these predictions are uncertain, especially when we are inexperienced in an interaction, or when the interaction is by different people as aforementioned in [4]. A future research I am greatly interested in is to augment our interaction with the world so we know the outcome before we take action. This involves real-time reconstruct the physical reality as a virtual solution space, run simulations of a predicted user interaction, then blend the simulated virtual outcome back to the physical reality to provide accurate hints to the outcome of our interaction and assist in intervention. To achieve this, challenges that have to be solved include 1) sensing and reconstructing the physical world virtually (computer vision), 2) detecting user's interaction intention (deep learning classification), 3) simulating interaction (digital human), and 4) augment the simulation to real world (MR). This research is interdisciplinary and brings out the strength of interaction of HCI, artificial intelligence, and MR.

Augmented Human in Dual Realities

I am interested to explore further the augmentation applications of bridging realities, and pushing the boundary of this augmentation. In [3] I observed users could perceive two realities simultaneously, which could see potentials in both telexistence operation and modality-based motor learning. In telexisence operations, users operate a surrogate robot remotely while their vicinity perception diminishes. A future research is enabling the operator to conduct interactions using both the surrogate (to the remote) and his own body (to the vicinity) simultaneously, with an efficiency that is two-fold. Human's motor learning skill is largely attributed to "learning by observing and doing". By bridging the reality of a professional performing a skill, to the reality of an amateur learning the skill in an embodied manner, I seek to understand the perceptual difference of each individual, and empathy in a two-way communication. Overall, I plan to explore the cognitive and perceptual science behind these augmentations to push the human boundary.

MR Interface and Interaction Methods

I am also devoted in designing novel methods in MR as demonstrated in [5] and [6], which explored augmented planet interface for MR with feet interaction, and head motion for navigation respectively. I strive to continue exploring new interfaces and interaction that utilize embodied interaction of our whole body, to bring MR ubiquitously to our lives.

Reference

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