Workshop on Augmenting Human Dexterity: From Multisensory Feedback and Motor Capabilities to Skill Acquisition

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Figure 1: Recent HCI research in augmenting human dexterity, examples include multisensory skill guidance (visual [14], tactile [5], force feedback [20]), strategies for motor learning [9], and human-robot collaboration [3].

Abstract

Human dexterity enables versatile and precise manipulation in everyday life. Recent advances in wearable and mobile computing have opened new ways to augment this dexterity. These efforts go beyond traditional assistive tools—whose primary function has been to restore or enhance strength—and instead aim to support more precise and complex performance across diverse domains, such as playing musical instruments or performing precision tasks at a workbench. A range of technologies has been explored, including multimodal sensory cues, adaptive learning schemes, robots, and exoskeletons. Yet individual projects remain limited in scope, often confined to a specific technology or application domain. Because dexterity is inherently multifaceted, no single perspective is likely to capture it fully—yet UIST has not seen a dedicated effort to bring these perspectives together. We therefore propose this workshop, framing the topic as a broad goal: *augmenting human dexterity.* We aim to bring together researchers including those from mechanical engineering, neuroscience, learning science, domain-specific expertise, to discuss what dexterity entails and how technology might support it in a more holistic way. Through interdisciplinary talks, interactive demonstrations, and collaborative discussions, we hope to map out a broad research agenda in this direction.

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1 Introduction

Humans are remarkably dexterous in everyday life, manipulating tools and handling small or fragile objects with ease [23]. Through intensive practice and training, these innate capabilities can be honed into sophisticated skills, such as playing musical instruments or excelling in sports [30]. Because the loss of dexterity can severely affect quality of life, technologies such as prosthetics have been developed to restore motor function after injury and address diminished motor capabilities. For able-bodied individuals, exoskeletons have similarly been designed to augment physical strength during labor-intensive tasks.

While Human-Computer Interaction (HCI) originated in designing better interactions with digital interfaces, the field has expanded beyond the screen into the physical world, propelled by new possibilities in wearable and mobile technology. This shift has given rise to a growing body of research on using computing to support physical activity—ranging from enhancing fundamental motor skills to enabling domain-specific applications—with progress unfolding across HCI and broader engineering disciplines in recent years.

A substantial line of work has investigated how multisensory feedback can support physical tasks. Visualizing muscle activity, for instance, has been shown to improve piano learning [12], while auditory feedback can enhance golf-swing training [26]. Haptic feedback has likewise proven effective in supporting motor performance [7] and improving force accuracy during surgical tasks [21, 29]. Notably, motor learning can also occur passively, without active engagement [5]. Beyond skill enhancement, such technologies have also been developed for people with disabilities—for example, helping blind users grasp objects more effectively [28, 31].

Beyond feedback, researchers have explored how technologies can directly assist movement through exoskeletons or muscle stimulation [13, 20, 24]. Further work has focused on improving muscle control [15, 16, 18] and muscle synergy [17]. Electrical Muscle Stimulation [8, 25] and Transcranial Magnetic Stimulation [27] have both been used to accelerate reaction time while preserving users' sense of agency. Other work has examined how Electrical Muscle Stimulation can support multitasking in physical environments [19], and how extending the body with additional limbs can assist hands-busy tasks [22]. Research in Human-Robot Interaction also views collaboration as an opportunity for assisting physical tasks, such as in painting or fabrication [1, 3].

Within skill acquisition specifically, research has examined how different modalities of haptic feedback can support motor capabilities and, in turn, motor learning [9], as well as adaptive strategies for accelerating piano learning [2]. Other work has shown that demonstrating performance beyond an expert's current ceiling can help them play melodies even faster [4]. Beyond acquiring new skills, research has also explored how to restore motor function more effectively for daily life [10, 11].

Although this body of research may appear fragmented, with researchers focusing on different technologies and application domains, this fragmentation reflects the inherent complexity of human dexterity. The challenges include designing mechanical structures that accommodate the complex anatomy of the fingers and their multiple degrees of freedom (DOFs) while preserving the tactile acuity of the fingertip that plays a significant role in manual and social interactions, as well as understanding how such interventions influence somatosensory cortical activity and the consolidation of internal motor models. This draws on neuroscience, the psychophysics of perception and sensory integration, learning science, and integration of engineering disciplines such as mechanical engineering, electrical engineering, and computer science.

We propose viewing these emerging efforts collectively, as building both understanding and technology toward a shared goal—*augmenting human dexterity*. By adopting an interdisciplinary lens, drawing on neuroscience, cognitive science, design, domain-specific knowledge, and more, we may be able to untangle this complexity and surface insights at the intersection of these fields. This workshop aims to foster such a discussion on dexterity at UIST and to begin mapping out a broader research agenda that can catalyze future work in this space. We believe this is a particularly timely topic given the rapid rise of AI and robotics research. As assistive and autonomous systems become increasingly ubiquitous in everyday life, understanding the role of human dexterity in that future is more important than ever [6].

2 Scope

We will explore the following themes in the workshop:

Sensorimotor integration and augmentation. We will examine insights from human sensory and motor systems and assess how this research could be leveraged to augment dexterity. What sensory modifications would be most beneficial (e.g., tactile, force feedback)? What motor capabilities are desirable for particular skills? To what extent can we make humans faster, more precise, and more flexible in performing physical tasks?

Physical skill acquisition. We will discuss how physical skills are acquired. What are the most effective strategies for teaching, learning, and retaining physical skills in the long term? How can skills be transferred from one person to another, or even across different domains? To what extent can technology support this learning process? How might human-robot interaction shape the acquisition of physical skills?

Meta-dexterity. Augmenting dexterity can also change how we feel about our bodies and our actions. How should we address questions of agency, embodiment, responsibility, and meaning that arise from this augmentation? And how might augmenting dexterity reshape the way we think, act, and collaborate with others?

3 Workshop Format

The workshop is designed to accommodate 25-35 participants and will feature a series of interactive activities, including hands-on demonstrations and interdisciplinary discussions.

Interdisciplinary Talks. The workshop opens with short talks by senior researchers on selected topics, including motor learning, motor rehabilitation, sensory augmentation technologies, embodied cognition, and human-robot collaboration. These topics will be balanced between fundamental scientific discoveries and emerging technologies that assist dexterity. Because the workshop is intended to spark ideas from multiple perspectives, each talk will be followed Q&A and further discussion.

Hands-on Demonstrations. Organizers and attendees will present hands-on demonstrations of emerging technologies related to the workshop's theme, drawing on both published work and work in progress. Potential demonstrations include exoskeletons, wearable haptic devices, electrical muscle stimulation, AR/VR systems, sensory augmentation or substitution, and human-robot collaboration.

Brainstorming Research. Following a collaborative session in which attendees list and classify current related work on a shared Miro board, participants will be divided into small groups, each facilitated by a moderator, to generate new ideas at the intersection of different fields. Props will be provided to support brainstorming, including raw materials (wires, tape, paper) and objects associated with physical activities (rackets, musical instruments). Each group will build a paper prototype or concept that could form the basis of a future research topic, culminating in a collaboratively constructed 1-page paper that will eventually be presented to the full workshop.

Call for Participation. We invite prospective participants to submit short text describing how technologies could be used to augment human dexterity, and to indicate whether they would be able to bring a live demonstration to the workshop. A dedicated website will be publicized.

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