Haptic Launcher: Collaborative Robots as base framework for augmenting haptic interfaces

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(a) Flat props to render surfaces and textures (b) Hand-shaped thermal props to render social touch (c) Extended Mid-Air Haptics

Fig. 1. Haptic Launcher is a framework to extend the quality and workspace of state-of-the-art active haptic interfaces

Haptic interfaces are generally narrow in the type of sensations they can provide and the workspace they can render. Using several haptic interfaces together in a multi-system approach can increase the range of stimulations that one setup can render. In addition, the popularization of collaborative robots can assist achieving this goal. We propose to use collaborative robots as launchers for small active haptic devices that can be combined in the end-effector of the cobot. In this paper, we explore this concept and present a set of use cases (Encountered-type, Social Touch and Ultrasound Haptics) to illustrate the new possibilities it opens up.

CCS Concepts: • **Computer systems organization** → **Embedded systems**; *Redundancy*; Robotics; • **Networks** → Network reliability.

Additional Key Words and Phrases: Haptics, Fabrication, Control-systems, Network protocols

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Albrecht Schmidt is a professor of computer science at Ludwig-Maximilians-Universität (LMU) in Munich, where he holds a chair for Human-Centered Ubiquitous Media. Albrecht is also a co-founder of ThingOS GmbH, the scientific speaker of the ZD.B and the scientific co-director of the Center for Digital Technology and Management (CDTM). His teaching and research interests are in human-centered artificial intelligence, intelligent interactive systems, ubiquitous computing, multimodal user interfaces, and digital media technologies.

Sven Mayer

Sven Mayer is an assistant professor (Jun.-Prof.) in computer science at the LMU Munich (Germany). His research is about modeling human behavior patterns for the next generation of interactive systems in which he uses machine learning to design, build, and evaluate future human-centered interfaces. Thus, his research sits at the intersection between Artificial Intelligence and User Experience Design. In particular, he focuses on hand- and body-aware interactions in contexts like large displays, augmented and virtual reality, and mobile scenarios.

1 INTRODUCTION

Haptic developers have been seeking an ultimate display capable of rendering the largest possible amount of tactile sensations. However, the complexity of tactile and kinesthetic mechanoreceptors poses a challenge towards such a goal. As a result, the phenomena rendered by a single interface are generally narrow.

Haptic devices are not homogeneous; Commercial haptic interfaces and research prototypes diverge in shape, size, software, and communication protocols. Such discrepancies among interfaces lead to fragmentation and increase the complexity of a multi-system network of devices.

As a result, haptic experience designers generally tend to limit the targeted sensations in their applications. In most cases, bound to vibrotactile stimulation or tangible props, and then enriching them using auditory and visual stimulation. This dynamic is notorious in consumer game consoles and VR headsets.

The steady increase in the small-sized collaborative robot market (cobots) and the increasing interest in integrating them in home setups for supporting everyday tasks emerge as an opportunity for haptic developers to take advantage of an upcoming generalized adoption of such devices to allow users to have room-scale haptic experiences in home setups.

This manuscript explores the concept of extending the workspace of active haptic interfaces by using robotic manipulators to facilitate multi-system haptic setups able to render room-scale sensations. We analyze the advantages, disadvantages, and challenges to realize this vision.

2 RELATED WORK

2.1 Encountered-type haptics in room-scale setups

Recent work has proposed alternative solutions for inducing haptic sensations on a larger scale [4–6]. CoVR [2] simulates large surfaces via a Cartesian robot that is mounted on the ceiling and moves a flat surface to emulate walls by rendering force feedback. Roomshift [11] is a system to move furniture in the real world to match the virtual experience; the system can map various parts of one physical object to match several virtual objects of varying sizes. Recently, encountered-type haptics has been employed for texture rendering using a rotary surface in a serial robot's end-effector [10].

2.2 Multi-system generalizable interfaces

The concept of using a collaborative robot for launching multiple sensations was first explored by Mercado et al. [9] with their method Alfred. The authors proposed to use the manipulator to extend the usage of tangible props in virtual reality. Whenever the user required interaction with a tangible object, the cobot would grab it and move it to a target position. However, their approach, only considered passive props to render tactile sensations. We propose to extend this approach to a broader set of haptic interfaces.

3 CONCEPT

We envision a comprehensive approach, where the end-effector does not only manipulate tangible props (passive objects) but is capable of driving and controlling active haptic devices. The proposed approach would combine the advantages of both passive and active haptic devices. Passive devices are less expensive and easier to handle, but they provide limited feedback. Active devices are more costly and harder to control, but they offer richer feedback. This brings up a new set of challenges to guarantee seamless integration of the components of the system. We argue that the main pillars of this new framework would be:

- **Physical interfaces to combine systems:** The system should easily allow a physical attaching point that enables other devices or manipulators to hold, or append to the device.
- **Universal Communication Protocol:** The communication protocol should comprehend a common set of instructions.
- **Homogeneous Sensation Generators:** There must be an abstraction level that is device independent and focus only on the type of sensations that are desired to render (as an example of a similar implementation, the reader can refer to the Ultraleap Sensation Editor)

A good example of such a general method is the Robotic Operating System (ROS) which allows robotic professionals to implement and rehuse code in a platform independent way.

4 USE-CASES

4.1 Encountered-type Haptics

When using a robotic manipulator, encountered-type haptics (ETH) is probably one of the first use cases to imagine. We implemented a virtual environment to replicate a simple ETH scenario; the participant's hand can be tracked using VIVE Trackers or Leap motion (or the headset built-in hand tracking). A straightforward approach to enable ETH is to move the robot in the plane of the surface that is required to be rendered, constrained to the hand's movement. Using our plugin, it is necessary only to trace a line from the hand position to the surface to be rendered and move the robot according to the hand movement.

4.2 Mid-air Extended Haptics

Ultrasound-based mid-air haptics uses sound waves generated by an array of transducers to render tactile sensations at the palm of the hand. A well-known constraint of mid-air haptics is the rendering workspace [1, 3, 8, 12], the usage of a cobot as a driver of the haptic array can help to overcome such limitations. State of the art approaches proposes to increase the number of arrays [12], attach the array to a rotary joint [8] or switch the positions of the array as required [3].

4.3 Social Touch

Social VR has been increasing its presence in VR stores; apps like VR chat, RecRoom or PokerStars VR are becoming more popular. Social VR allows multiple users to join in a shared Virtual Environment and let the participants interact in a more natural way than 2D interactions. However, touch is still a missing component in this context. Social touch has been demonstrated to increase the perceived human likeliness in virtual agents [7].

Figure 1b shows our implementation of social touch using a silicon human hand that features a heat-able foil. The prototype is driven by a cobot using the Cobity plugin. The participant interacts in a VR environment. Whenever the virtual avatar touches the user's shoulder, the robot moves the hand to their real shoulder. This setup could be further improved by using rigged hands as end effectors, for example, the Shadow Dexterous Hand[1].

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