# Can Recording Expert Demonstrations with Tool Vibrations Facilitate Teaching of Manual Skills?

Ravali Gourishetti[1], Bernard Javot[1], and Katherine J. Kuchenbecker[1]

## I. Introduction

Learning complex manual skills such as metal sawing requires one to master physical processes that involve specialized tools and fine material manipulation. Professional tasks thus often take significant time, effort, supervision, and resources to learn well. To help novices acquire complex manual tasks on their own, we have developed a system that records and replays physical tool interactions of manual skills demonstrated by an expert; it includes video, audio, and naturalistic vibrotactile feedback. To evaluate the teaching potential of the developed technology, we designed a study to interview diverse experts, record manual tasks from their professions, let them experience their own recordings, and have them evaluate this training approach for their fields.

This WIP paper overviews our technical approach, describes the study methods for the first expert, reports a preliminary analysis of their results, and outlines future work.

## II. Methods

We have developed robust methods for recording tool vibrations along with sounds and videos of an expert performing manual tasks (Fig. 1), extending an approach developed for dentistry [1]. By attaching a tiny three-axis high-bandwidth accelerometer (STMicroelectronics, LIS344ALH) to each tool, we capture the rich physical contact vibrations felt by the expert without disturbing their movements. Simultaneously, we record a first-person video from a forehead-mounted GoPro 7 camera and the tool-interaction sound using a Rode directional microphone. A front-view video of the expert performing the task is recorded using a video camera; the instructional voice-over of the expert is recorded later using a lapel microphone. Finally, we combine the videos side by side and add the summed tool vibration signal, the interaction sound, and the expert narration as three distinct sound channels in 5.1 surround sound.

After securing ethical approval, we recruited a machine-shop expert with 30 years of teaching experience in metal manufacturing. The study consisted of three two-hour-long sessions on separate days. On the first day, we conducted an interview to gather the expert's opinions on current practices in their field and the challenges they face in teaching their craft. Then, we showed the expert a demonstration we had previously recorded, including tool vibration signals played on a Haptuator Mark II, sound, and video of a tool-mediated interaction; we then discussed potential tasks in their field that could be recorded with our technology. On the second day, we recorded the expert performing the two selected training tasks (metal sawing and metal filing) with instrumented tools. We then recorded them verbally describing the steps involved in each task as they would teach it to someone. On the third day, the expert experienced their two processed and combined task recordings with vibrotactile feedback. Finally, we asked them to evaluate this teaching technology with qualitative and quantitative questionnaires.

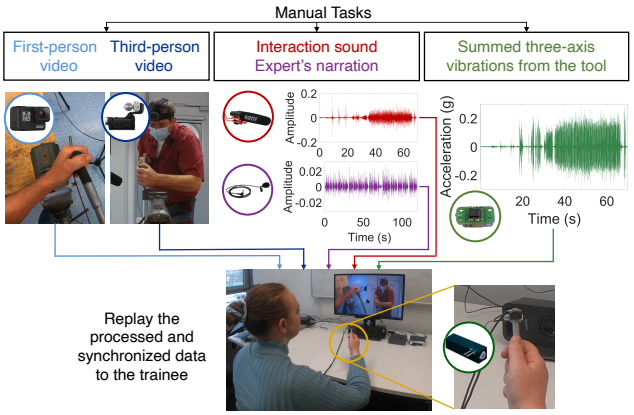


Fig. 1. **Sample recording of an expert demonstration.** The video, sound, and tool vibration data recorded while the expert performs a metal-sawing task are processed, combined, and synchronized for a trainee to experience.

## III. Preliminary Analysis and Future Directions

We conducted a preliminary qualitative analysis of the expert's evaluation of our technology. The expert highly appreciated having haptic feedback of the tool vibrations while experiencing the recordings. They mentioned that recordings replayed using our technology are "the reflection of how it feels in real life". They also suggested that these recordings could be "useful during theoretical sessions to demonstrate different interactions that students may not have experienced before". Next, we plan to record demonstrations and gather assessments from experts in other fields, including hair cutting, sculpting, and playing violin. We will also investigate how well novices can learn the demonstrated tasks by experiencing the expert recordings with and without haptic feedback of tool vibrations.

## References

[1] K. J. Kuchenbecker, R. C. Parajon, and M. P. Maggio, "Evaluation of a vibrotactile simulator for dental caries detection," *Simulation in Healthcare*, vol. 12, no. 3, pp. 148–156, 2017.

[1]Ravali Gourishetti, Bernard Javot, and Katherine J. Kuchenbecker are with the Haptic Intelligence Department, Max Planck Institute for Intelligent Systems, Stuttgart, Germany. e-mail: gourishetti@is.mpg.de