Interactive Systems for Healthcare at ISIR

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This ISIR lab stand showcases some of the interactive systems developed in the past 5 years in relation to HCI and Health. Two types of medical applications are showcased: surgical procedures (e.g., assistance robots, videos in support of learning) and people suffering from a motor deficit (e.g., motorized prostheses, intelligent walkers, kinesthetic feedback for visually impaired assistance).

Le stand du laboratoire ISIR présente certains des systèmes interactifs développés au cours des 5 dernières années à l'intersection de l'IHM et la Santé. Deux types d'applications médicales sont présentées : le geste chirurgicaul (ex. : robots d'assistance, vidéos d'aide à l'apprentissage) et les personnes souffrant d'un déficit moteur (ex. : prothèses motorisées, déambulateurs intelligents, feedback kinesthésique pour l'assistance aux malvoyants).

CCS Concepts: • **Human-centered computing**;

Additional Key Words and Phrases: HCI, health, ISIR, demos

Mots Clés et Phrases Supplémentaires: IHM, santè, ISIR, demonstrations

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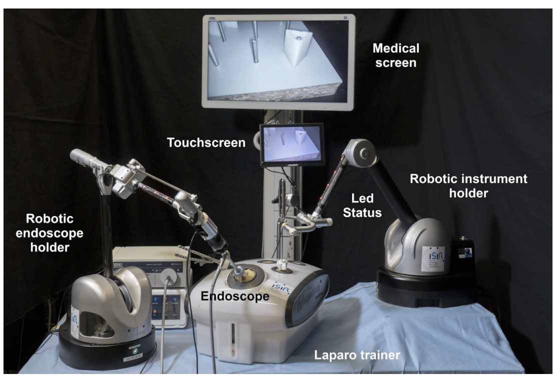
1 INTRODUCTION

This ISIR lab stand showcases some of the interactive systems developed in the past 5 years in relation to HCI and Health. Two types of medical applications are showcased: surgical procedures (e.g., assistance robots, videos in support of learning) and people suffering from a motor deficit (e.g., motorized prostheses, intelligent walkers, kinesthetic feedback for visually impaired assistance).

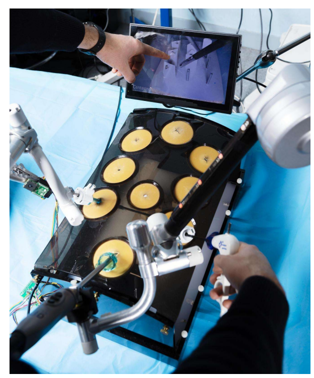
2 INTERACTIVE SYSTEMS FOR SUPPORTING HEALTHCARE PRACTITIONERS

2.1 Robotic Endoscope Manipulation for Telementoring using the Surgical Cockpit

Minimally-Invasive Surgery (MIS) involves the use of elongated instruments inserted through small incisions into an inflated abdomen. The surgeon manipulates these instruments and sees the surgical site though looking at a 2D monitor, which shows the video feed of an endoscopic camera. This surgical technique requires high dexterity with restricted degrees of freedom in task execution. The Surgical Cockpit platform [1] is designed to assist the surgeon's gesture during MIS to alleviate these constraints, while minimizing the impact to the traditional workflow. Two robots are showcased in this demo (Figure 1), one holding an instrument and the other the endoscope. The platform is able to detect trocars [5], compensates force distortions given the fulcrum effect [19], and compensate the gravity of instruments and the endoscope [17]. We focus on this demo on interaction techniques for the robotic endoscope [2], showing a touch interface that lets a remote surgeon control the endoscope through touch on a tablet. In a preliminary study, we show that remote endoscopic control can have communicational benefits during surgical telementoring, especially for tasks that require large an complex visual exploration, and to relieve operating surgeons from physical and cognitive load.



(a) Surgical Cockpit platform, including a robotic endoscope holder, a robotic instrument holder, and screens.



(b) A user tele-operates the endoscope using the touchscreen interface.

Fig. 1. Remote endoscope control on the Surgical Cockpit demo

2.2 REVAP: Réalité Virtuelle et APprentissage

Learning to perform surgery is a long endeavor that takes place inside and outside the Operating Room (OR). There has been an influx of technologies that support surgical learning before stepping into the OR, to practice and perfect skills and prepare for performing gestures on real patients, notably through VR technologies [7, 18]. Video material, as opposed to VR simulations, can be created more easily, as surgeons can summarise video recordings of actual surgery and use them as teaching tools [3]. In this demo, we present REVAP (Réalité Virtuelle et APprentissage), a virtual reality environment where students can visualize 3D videos of surgery under immersion, using a Head-Mounted Display (HMD) (Figure 2). In a study published as a full paper at IHM' 24, we show the learning outcomes when medical students visualize 3D video lectures of surgery under immersion using REVAP, and the impact of their visuospatial abilities on these learning outcomes.

(a) Virtual Reality environment where medical students can visualize 3D videos under immersion, using a Head-Mounted Display. The image shows a course on a C-section, and a dashboard where users can navigate chapters.

(b) Surgeon wearing a Head-Mounted Display showing REVAP.

Fig. 2. REVAP demo.

2.3 Per-O-Scope: Surgical Video Summarization Through Live Tags

Although videos play a valuable role in the field of surgery, serving various purposes such as education, case discussions, and the dissemination of scientific knowledge, they need to be summarized in order to be useful, as they can span several hours and include repetitive gestures (sutures or dissection) as well as unusable footage (blurry or overexposed images) [3]. To support video summarization in surgery, we have created per-o-scope (for per-operative endoscopy), a web-based prototype running on Webstrates [11] and Videostrates [12] (Figure 3). The system lets users create tags on a video timeline as a mechanism to select footage to keep in a summary, as well as tag categories, specifying a name and color. Tags can be resized, renamed, moved, deleted, deactivated from the summary, all of which have an instant effect on a summary timeline, which is computed as a concatenation of all tags. Surgical recorded video can be navigated through hovering on both timelines, which seeks to the corresponding frame on the video footage. Multiple users can work on the same project, their modifications are instantly synchronized across users. Attendees will be able to interact with a mock project to showcase the concept of summarizing surgical videos through tags, also being able to collaborate with another attendee to test the collaborative functions.

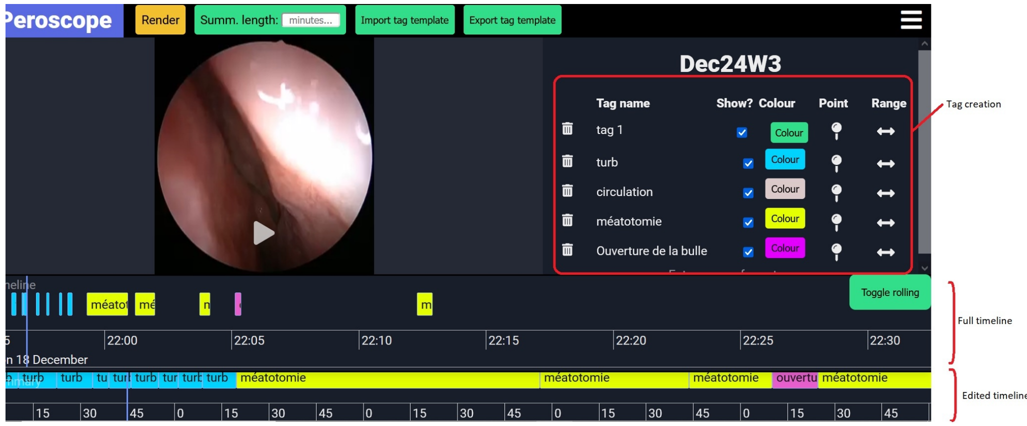


Fig. 3. per-o-scope demo. The interface contains an area with tag categories, a full timeline and a summary timeline.

3 INTERACTIVE SYSTEMS FOR SUPPORTING PATIENTS

3.1 Find Your Way Through Touch

Vibrotactile sensations can be used to elicit the Apparent Haptic Motion illusions (AHM), which consists in using discrete patterns to convey an illusory continuous moving sensation across the skin. This demo wishes to enable participants to experience the AHM through 2 modes of stimulation—vibrations and continuous skin stretch called "taps"—in a situation of assistive navigation. To that aim, the set-up is composed of 2 handles, both housing 5 custom designed electromagnetic actuators inspired from Duvernoy et al. [6], actuated asynchronously to convey a sensation of motion with a reduced amount of material, around and along the handles [13, 14]. Participants will be sat on a chair with the handles in hands (Figure 4). On a screen, the participant will see the view of a virtual scene observed. Haptic sensations corresponding to the walker motion will be conveyed on the user's hand.

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(a) Experimental setup : The photo shows the handles mounted on the walker. Signals are amplified and sent to the handles by the M5 Stacks controllers connected via WiFi and powered by a power bank.

(b) The users test tactile patterns conveyed by the handles with visual feedback. For this Demo we do not use the walker, the users sit and grasp the handles.

Fig. 4. Find your way through touch demo

3.2 Intuitive Control of a Prosthesis Through Body Compensations

To control the robotic joints of an upper limb prosthesis, most existing approaches rely on decoding the user motor intention from electrophysiological signals (generally muscle contractions signals measured at the surface of the stump) produced by the subject, and then executing the desired movement. This suffers from important limitations and requires extended training, particularly when a large number of prosthetic joints have to be controlled. Even when they master the control of their prosthesis, many amputees underuse the prosthetic mobility to the benefit of compensatory body movements, whose generation is less expensive and more natural from a cognitive point of view. Indeed, with an arm prosthesis, hand movements result from a combination of human and robotic joint motions. We recently proposed an innovative approach (Compensations Cancellation Control or CCC [15]) and evaluated the ability of arm amputated users to control multiple DoF prostheses simultaneously [16]. In this demo we propose attendees to perform a task (see Figure 5) from the "arm prosthetic race" of the Cybathlon international competition [20] entitled "Wire Loop" with a forearm prosthesis which can be controlled whether through conventional voluntary control (with two push buttons mimicking conventional myoelectric control) or through CCC to illustrate the benefits of our method and its ability to be mastered by naive subjects with no or very short training period.

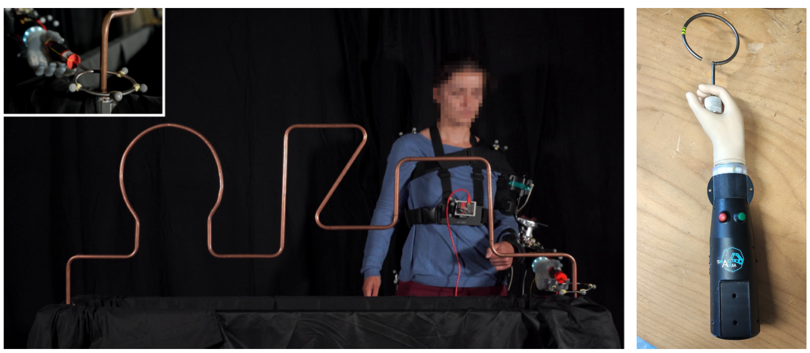

Fig. 5. Left: Experimental setup: Cybathlon wire-loop task with the adapted prosthetic device. The upper left insert shows the handle hold by the prosthetic hand. Right: View of the forearm prosthesis used for demonstration with asymptomatic users

3.3 A-EYE Hands-On Demonstration: Enhancing Navigation for the Visually Impaired through Interactive Kinesthetic Feedback

A-Eye device is a wearable robotic device developed specifically for the Cybathlon competition with the aim of assisting visually impaired individuals in navigating through cluttered environments. The primary objective is to replicate the kinesthetic feedback observed in sighted guide techniques, thereby facilitating intuitive navigation for the user. This entails emulating tactile sensations associated with directional changes and intricate communication, particularly in scenarios involving narrow passageways and reversals in direction. The wearable robotic interface of A-Eye operates by manipulating the user's hand in two dimensions, thereby providing directional cues in two distinct directions. The upcoming demonstration of A-Eye will involve a hands-on experience for participants to directly engage with the device during a simulated Cybathlon challenge (Figure 6). Specifically, the demonstration will focus on replicating the experience of navigating a cluttered sidewalk, mirroring real-world scenarios encountered by visually impaired individuals in urban environments. Obstacles include billboards, scooters and garbage cans.

Fig. 6. Left: View of our pilot using the A-Eye device at the Cybathlon-Challenges event in Zurich. Top Right: Close-up view of the system featuring a 3d stereoscopic camera above and a 2-degree-of-freedom kinesthetic feedback device below. Bottom Right: View of the "Sidewalk" challenge, the aim of which is to advance to the finish line without touching obstacles on the sidewalk.

3.4 Co-creation of musical interfaces for children with Autistic Spectrum Disorder (ASD)

The third wave of HCI involves users 'in the wild' contexts [4], with an emphasis on human meaning-making, situated knowledge and taking into account the full complexity of the system [9]. This third wave takes into account the 'messy' context of socially situated and embodied action, introducing humanistic and social science considerations into design research [8]. The research described in this study saw the development and practical use of tools embedded in the context of use to design for and with core users and their facilitators through an action research methodology [10].

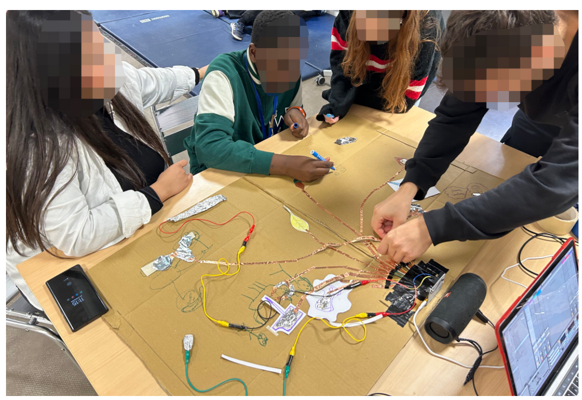

Fig. 7. Co-construction of a musical interface with children, moderators and researchers

More specifically, the research context is that of musical co-creation workshops in non-profit organizations and medical institutes with non-verbal children with autistic spectrum disorder (ASD). The workshops aimed at developing new research methodologies in a specific context and enabling children to explore different forms of musical expression with different interaction designs. In this demo, we present the different musical interfaces developed in co-creation with children and moderators of the non-profit organizations.

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