Reimagining Surgical Telementoring Tools for Learning

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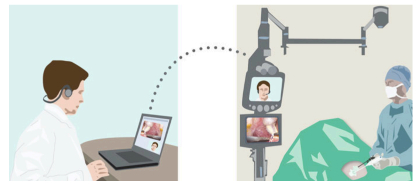
Context, Challenges and Objectives



Surgery is fundamental for treatment in healthcare, however, access to senior surgeons is a pressing concern: the number of surgeons per population is constantly declining (Sheldon et al., 2008), and one of the causes is the difficulty involved in learning surgery, which results in students dropping out of surgical school (Berman et al., 2008). Accessing experts for training in apprenticeship can be difficult, as often they cluster in specialized centers and are thus far from the learner[1]. Although computer systems are used for **surgical telementoring**, where an expert surgeon (*mentor*) can remotely participate in training a colleague (*mentee*), these systems support only *instruction*, through simple tools such as shared video, a pointer and annotations.

> **Surgical telementoring is a practice with a low adoption rate**, partly because of the stalled technological development: we have not yet designed tools that provide rich information exchange and seamless interaction between mentors and mentees that support *learning*.
>
> Our **goal** is to design novel tools that support mentoring practices at a distance.

Learning through mentoring, also called apprenticeship, is especially challenging in Minimally-Invasive Surgery (MIS) because it involves learning surgical gestures as well as how to manipulate tools through small holes while looking at an indirect view. **The first challenge lies in the rich communication used to efficiently convey knowledge**: non-verbal cues, such as eye gaze and hand pointing give support to verbal utterances, and awareness of others' actions are capital when effectively understanding complex instruction (Avellino et al., 2019; Lambert et al., 2024). **The second challenge lies in the perception-action cycle**: mentors engage in significant work of manipulating the endoscope (panning, rotating, moving in/out) to acquire a view that lets mentees effectively conceptualize the anatomy, compensating for the artificial artifacts (e.g., size and orientation of anatomy) of looking through an indirect view (Mentis et al., 2014). This process, called *shaping the surgical view* (Mentis et al., 2016), alleviates mentees from this task and reduces their cognitive load, enabling them to focus on learning surgery. Thus, the main **research question** of this thesis is: **how to achieve the level of performance and coordination of collocated mentoring that results in learning, when the expert is remote?**

Methodology and Scientific Approach

This thesis will follow a human–centered approach, as outlined below. We will ensure that all researchers involved have ethics training and obtain IRB committee approval. Studies will be pre-registered for scientific integrity, materials will be made available, and publications open.

[1] Observatoire Régional de Santé (ORS). Les Déserts Médicaux en Île-de-France : De quoi parle-t-on ? Quels leviers d'action ? Mars 2018

Step 1 - Understand Limits of Current Tools used for Surgical Telementoring
Virtual pointers on surgical views support mentors in fostering the adoption of a professional vision (Feng et al., 2018), can help guide the mentee's gaze (Feng et al., 2019) and can improve attention and quality of instructions compared to onsite telestration (Semsar et al., 2020). Still, recent work shows that pointers are limited in supporting mentoring practices (Lambert, Voros, Canlorbe, et al., 2024). As a first step, the candidate will **expand on the current understanding regarding the limits of current tools** used for surgical telementoring, namely shared video, pointers and annotations. As we cannot observe remote mentoring tools in use as they are seldomly adopted, we will **approach this problem through studying collocated mentoring during robotic surgery.** Robotic surgery can, inadvertently, reveal practices of both collocated and remote mentoring (Avellino et al., 2019). This setting constitutes "hybrid mentoring" as the expert surgeon sometimes communicates through the console (remote) through a virtual pointer on the endoscopic view, and sometimes face to face with the apprentice by disengaging from the console (collocated). This ebb and flow between both practices in a variety of cases (e.g., routine, anticipation of error, risky gesture) will elucidate existing principles and limitations of telementoring — i.e., lack of means to communicate through the console. This field study will consist of surgery observations and semi-structured interviews analyzed using Thematic Analysis (Braun et al., 2019), leading to an **empirical contribution**.

Step 2 - Designing and Building of Novel Telementoring Tools. With the understanding from the first study, we will conceptualize new tools for surgical telementoring in minimally-invasive surgery that overcome the limits of current tools. These may include the use of Augmented Reality to overlay information on the endoscopic video that mentees can interact with such as videos (Avellino et al., 2021), mentor's hands (Shenai et al., 2014) or virtual instruments (Shabir et al., 2023), as well as robotics for distant control of the endoscope (Avellino et al., 2020; Lelièvre et al., 2024). Although these approaches have been proposed, so far the literature has demonstrated their power to support communication and instruction, but not yet *learning*, which is the core of tele-*mentoring*. This prototype will constitute a **technological contribution**.

Step 3 - Evaluation. To validate the learning capabilities of the designed tools, we will conduct studies in the lab using standard and validated surgical training tasks. We will measure both surgical performance outcomes (time, errors, amount of movement) as well as learning (mentees understanding and knowledge retention). We will also consider as a second step performing ecological evaluations by either deploying them at the *École de Chirurgie* in Paris during the actual residency period of medical students or in operating rooms. This evaluation will yield novel insights on practices of mentoring, which constitute a **theoretical contribution**.

This thesis will contribute to increasing the adoption of surgical telementoring, and to the growing democratization of healthcare, reducing the current cost incurred by the time needed when surgeons travel for mentoring.

Co-advisory strategy

The candidate will be co-advised by a team of 3 researchers with complementary skills. Ignacio Avellino and Helena Mentis have studied the use of interactive systems in the operating room for surgical mentoring for the past decade from a Human–Computer Interaction perspective, and have contributed to the design and evaluation of novel systems. Geoffroy Canlorbe has taken an active role in some of these studies through the co-supervision of a thesis which finished in January 2025. He will ensure that the thesis candidate has access to the operating room and participants for field studies, as well as contribute to the studies through an active participation in data analysis and checking of results as a member of the studied population.

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