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Curating novel datasets for the development of AI in laparoscopic surgical education worldwide

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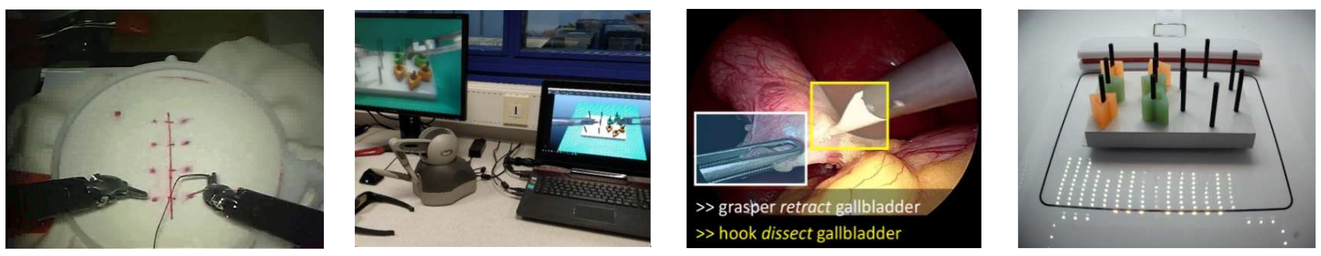
The Problem

Minimally Invasive Surgery (MIS), particularly laparoscopy, offers significant patient benefits but faces global adoption challenges, especially in low- and middle-income countries (LMICs) (Jaffray, 2005; Meara et al., 2015). Effective training is paramount, and computer-assisted systems powered by AI can provide objective skill assessment and democratise access to quality surgical education (Bodenstedt et al., 2018). However, developing such AI tools is hampered by a scarcity of publicly available, well-annotated datasets (Ali et al., 2023; Maier-Hein et al., 2022). Existing datasets may not fully align with the needs of conventional laparoscopic training or low-cost setups (Rodrigues et al., 2022). This work introduces a LASK (Laparoscopic Skill & Kinematics), a novel dataset designed to address these limitations.

Study Aim

Create novel multi-modal datasets in the domain of laparoscopic surgical training which could be used by AI researchers to develop AI-based surgical skill assessment methods to enhance worldwide surgical training



Current datasets are not suitable, being either **robotic**, **in simulation**, **in-vivo** or **lacking sufficient annotations**

Potential Benefits of MIS

Smaller Incision

Reduced Blood Loss

Less Scarring

Fewer Medication

Quicker Recovery

By performing **open invasive** procedures through **minimally invasive techniques**, we can contribute to **alleviating the burden on fragile healthcare systems**

Immaturity of Robotic Surgery

$0.5M - $2.5M/robot ~**$200,000/yr**

Used in **19%** of all surgeries in the UK (2023)

524% uptake (2016-2023)

Even though robotic surgery has had huge **recent growth**, it is still **far too expensive**

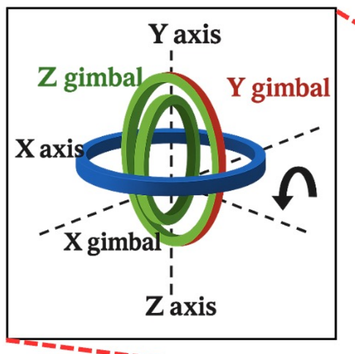
Training Disparities

1-to-1 training in the UK for at least **one hour** in dedicated bootcamps throughout the year

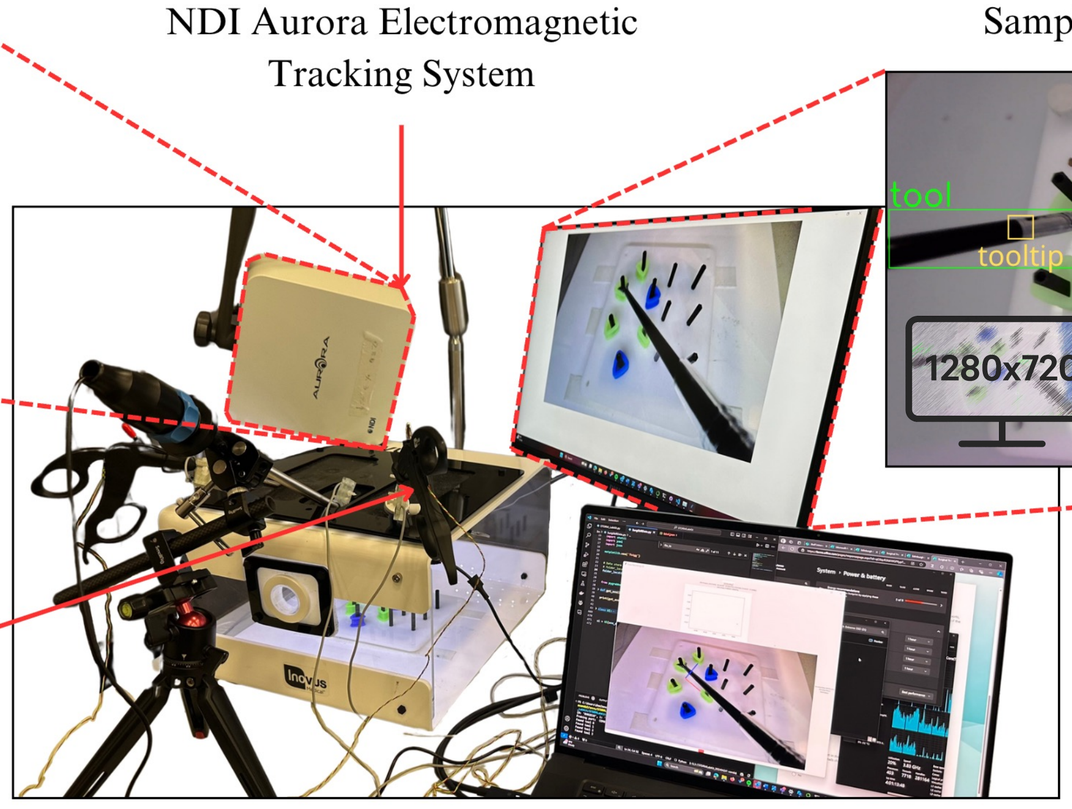
LMIC trainees get much fewer opportunities and may have up to 8 trainees per expert

In-House Dataset

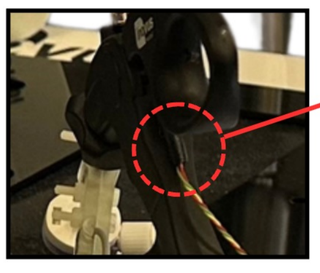
[x,y,z] 6D Pose $[q_w, q_x, q_y, q_z]$



NDI Aurora Electromagnetic Tracking System

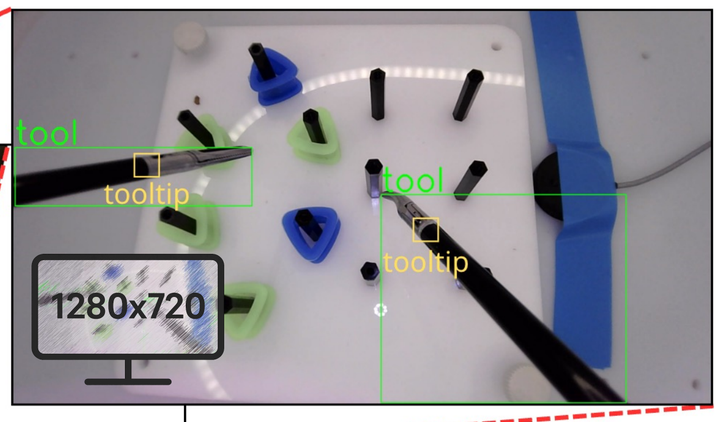


Jaw Angle Sensors



3,725 frames (inc. complete 2,680 test sequence)

Sample bounding box annotations



84 Adult surgeons | Paediatric surgeons 30

38 Low-Skill Novices
Early-Trainees

41 Medium-Skill
More Experienced Trainees

35 High-Skill Expert
Consultant Surgeons

Dataset Utility & Future Research

LASK is the first laparoscopic peg-transfer dataset with synchronised video and comprehensive kinematic data, tailored for skill assessment research. The dataset has huge potential to improve surgical training using AI in low- and middle- income countries. In future work, we plan to release the dataset with segmentation masks publicly, additional annotated validation videos and attained baseline benchmarks. The dataset is well-suited for:

- **Multi-tool detection** (preliminary benchmarks with state-of-the-art models show >95% accuracy) and **tracking**
- **3D tool pose estimation**, including jaw opening, from monocular video.
- **Objective surgical skill assessment** and **classification**.
- Investigating the **performance impact of handedness** and **experience**.

We hope this offers an essential resource to the computer vision and surgical data science communities, aiming to foster robust, data-driven training tools and democratise laparoscopic education worldwide.

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