Haptic multimodal assessment of robot manual guidance for patient pre-positioning in proton therapy

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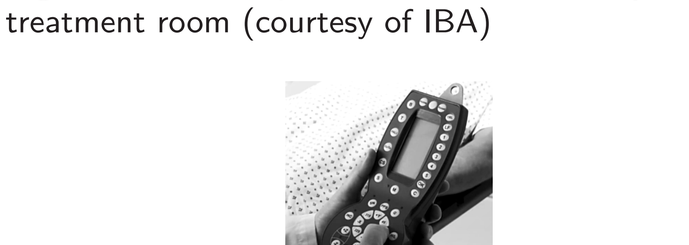
1. Medical Application

- **Intuitive** and **natural** manual patient **pre-positioning**
- **Fast displacement** using Human-Robot co-manipulation

Paramedical assistant can either (Fig. 3) :

- Use couch top mounted **U-Bar haptic sensor**
- **Grap the couch top from any location around it** (F/T sensor is located between couch top and robot end-effector)
- Use a **3D Joystick** fixed on or under the couch top

Figure 1: Intuitive and fast pre-positioning phase

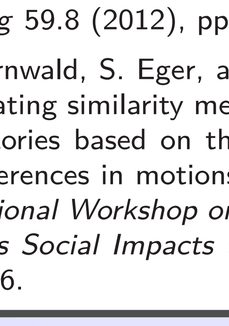


2. Scientific Objectives

- Human-Robot **co-manipulation**
- **Quantitative comparison** of manual guidance strategies
- Serial robot with **high inertia**

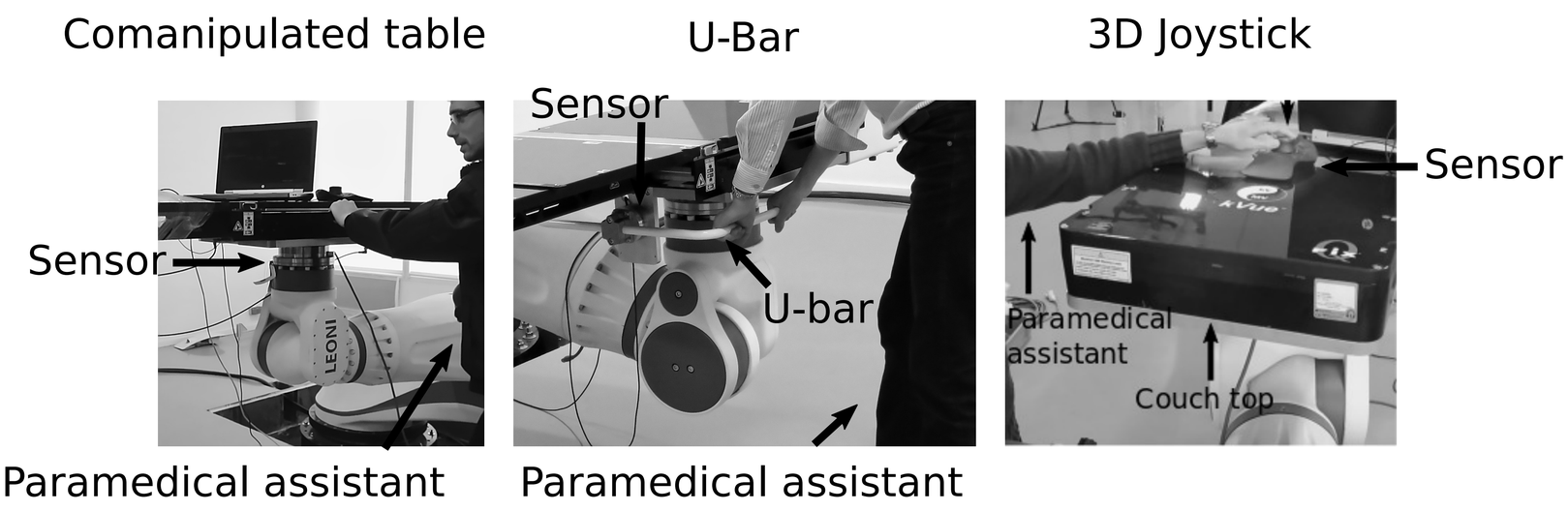
3. Current device

Figure 2: Teach pendant device currently used in treatment room (courtesy of IBA)



4. Intuitive pre-positioning haptic devices

Figure 3: 3 New strategies for patient pre-positioning (haptic devices)



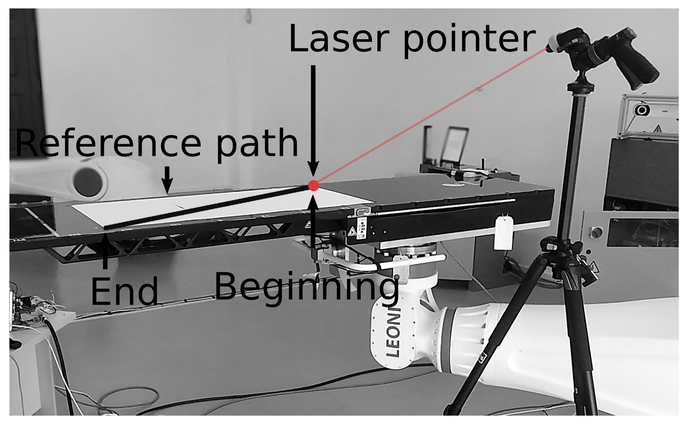
5. Experiment Material

- **Haptic devices** for robot manual guidance
- **LEONI robot** ([Bau+16])
- **Reference path** to be followed to assess intuitiveness
- **Laser pointer** to materialize current location

6. Experiment Setup

- Use the haptic devices to **follow a straight line reference path**
- Current location is shown by laser

Figure 4: Experiment setup with robot, Laser and reference path



7. Metrics

- **Duration** (s)
- **Smoothness** (Spectral arc-length [BMB12])
- **Accuracy** (using Dynamic Time Warping [TEW15])
- **Haptic rendering**

8. Preliminary Results : Fast and intuitive manipulation

Figure 5: Trained and untrained volunteer using comanipulated table

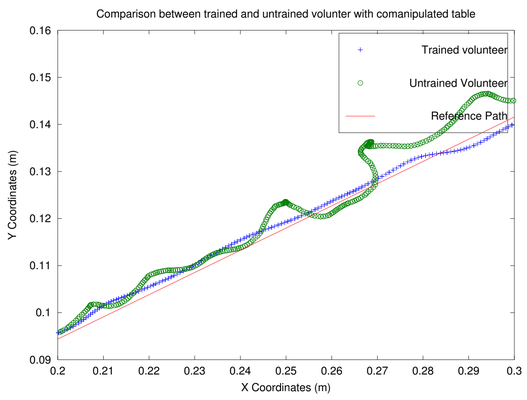


Figure 6: Haptic devices comparison along a reference path

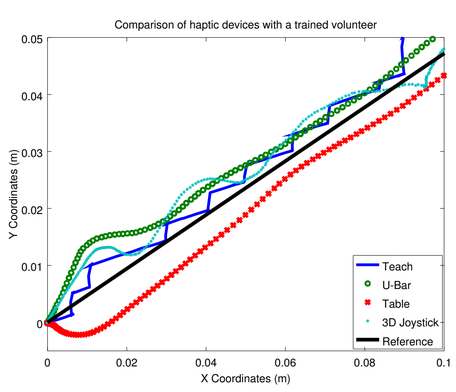


Table 1: Comparison of haptic devices with time and dynamic time warping metrics

	Time (s)	DTW
Teach	111	**4.59**
U-Bar	53	11.52
Table	**51**	7.89
Joystick	69	8.56

Conclusion and Perspectives

- Haptic comanipulation (**U-Bar and Table**) presents **smoothest trajectory** during patient pre-positioning and is **faster than Teach pendant**
- Untrained volunteer needs training and practice to use comanipulated table
- However Teach pendant should be used to accurratly follow a reference path
- **Further studies** will include **quantitative metrics** and **learning curve analysis**

References

[Bau+16] Julien Baumeyer et al. "Torque Collision Detection with experimental validation for protontherapy positioning robot". In: *Mediterranean Conference on Medical and Biological Engineering and Computing 2016*. Cyprus, May 2016.

[BMB12] S. Balasubramanian, A. Melendez-Calderon, and E. Burdet. "A Robust and Sensitive Metric for Quantifying Movement Smoothness". In: *IEEE Transactions on Biomedical Engineering* 59.8 (2012), pp. 2126–2136.

[TEW15] A. Turnwald, S. Eger, and D. Wollherr. "Investigating similarity measures for locomotor trajectories based on the human perception of differences in motions". In: *2015 IEEE International Workshop on Advanced Robotics and its Social Impacts (ARSO)*. June 2015, pp. 1–6.

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