

Transparency Optimization of the Galen Robot

Computer Integrated Surgery II

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Introduction

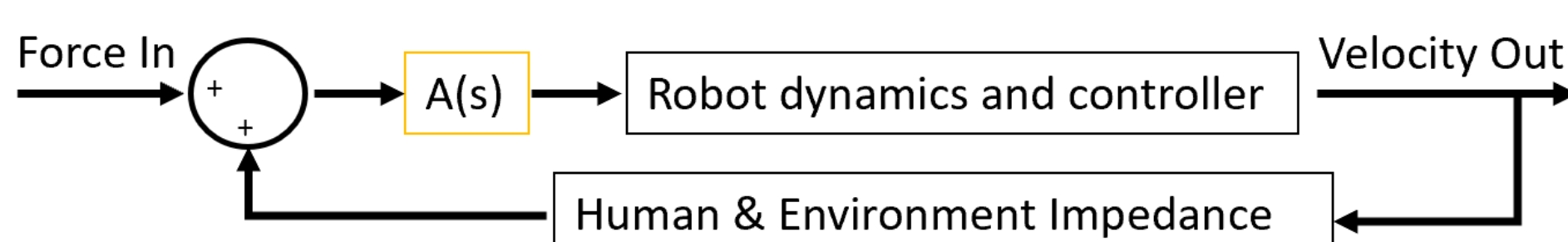
- The Galen Robot is a hand over hand guidance cobot used to assist surgeons in ENT microsurgery.
- The robot features an on-board controller that tries to help the surgeon easily move the robot while keep the movement steady and controlled.
- This controller feels very heavy and clunky and diminishes the user experience and offers limited added value to the surgeon.
- We developed and tested a new controller that optimizes for transparency to improve the quality, feel, and performance of the controller.

The Problem

- The robot feels heavy and difficult to move leading to less desirable control and poor user experience.
- The current controller displayed noticeable jittering during drilling and surface contact.
- There are several industry methods of applying an 'Admittance Controller' that could be implemented in the controller design.
- The controller could be better optimized for stability and transparency together to improve the fidelity of the cobot experience.

The Solution

- Our project was to create this controller using an Admittance controller design scheme similar to the work of Aydin et. al. (2020).
- This work attempts to superimpose a virtual mass gain, m_{ad} , and damping gain, b_{ad} , we want the user to feel.



Admittance

$$A(s) = \frac{1}{m_{ad}s + b_{ad}}$$

Figure 1. Admittance controller design.

- We designed this controller, tested the range of possible mass and damping values that could be used on the robot without driving it unstable.
- The mass and damping values were then tested on an AMBF simulated version of the Galen Robot and now work is being done for the real Galen Robot.

Outcomes and Results

- The stability analysis of closed loop poles gave a range of acceptable m_{ad} and b_{ad} values

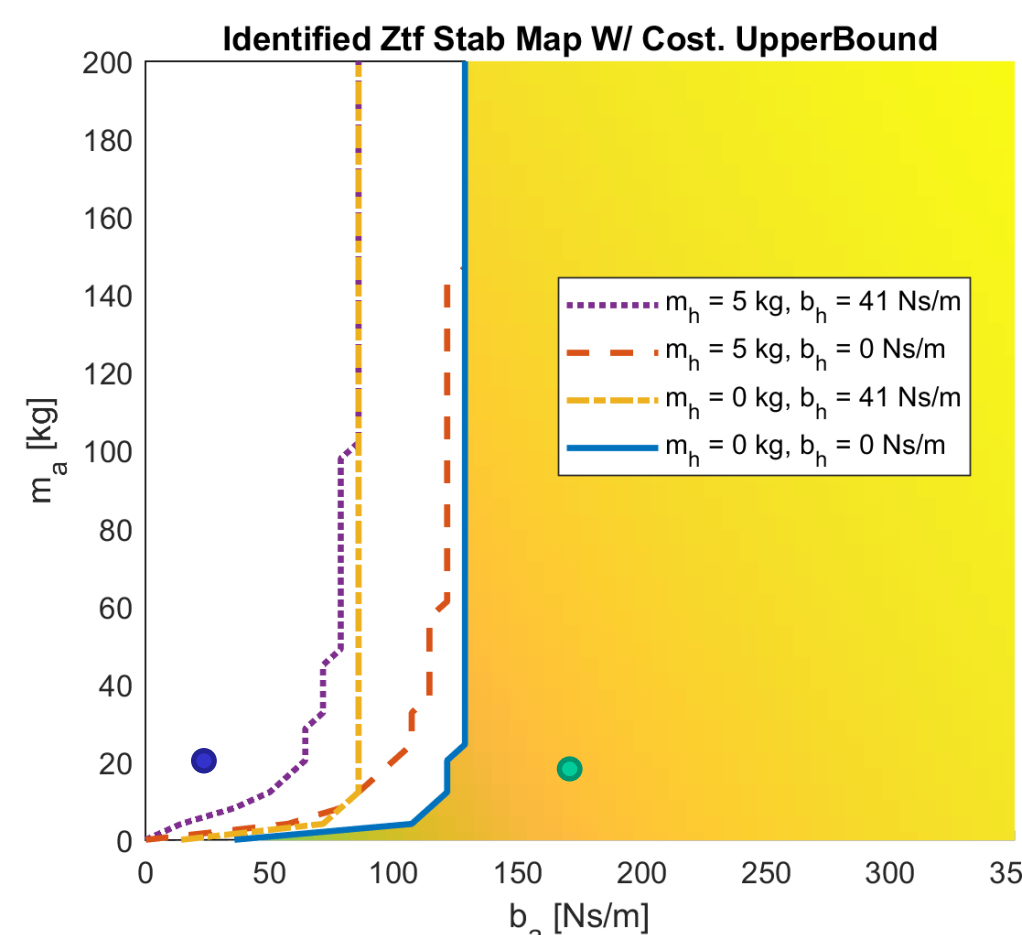


Figure 2. Stable m_{ad} and b_{ad} values in colored area

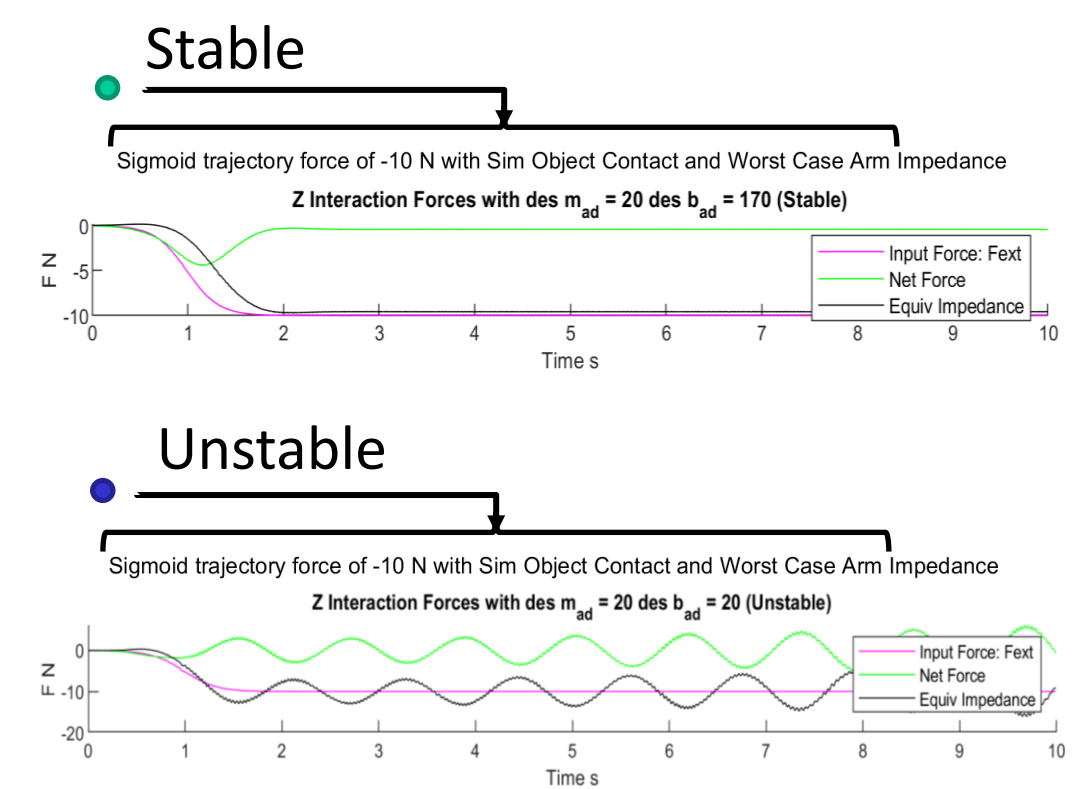


Figure 3. AMBF performance with selected admittance values

- The performance of stable and unstable values was verified in the AMBF simulation with teleoperation implementation.

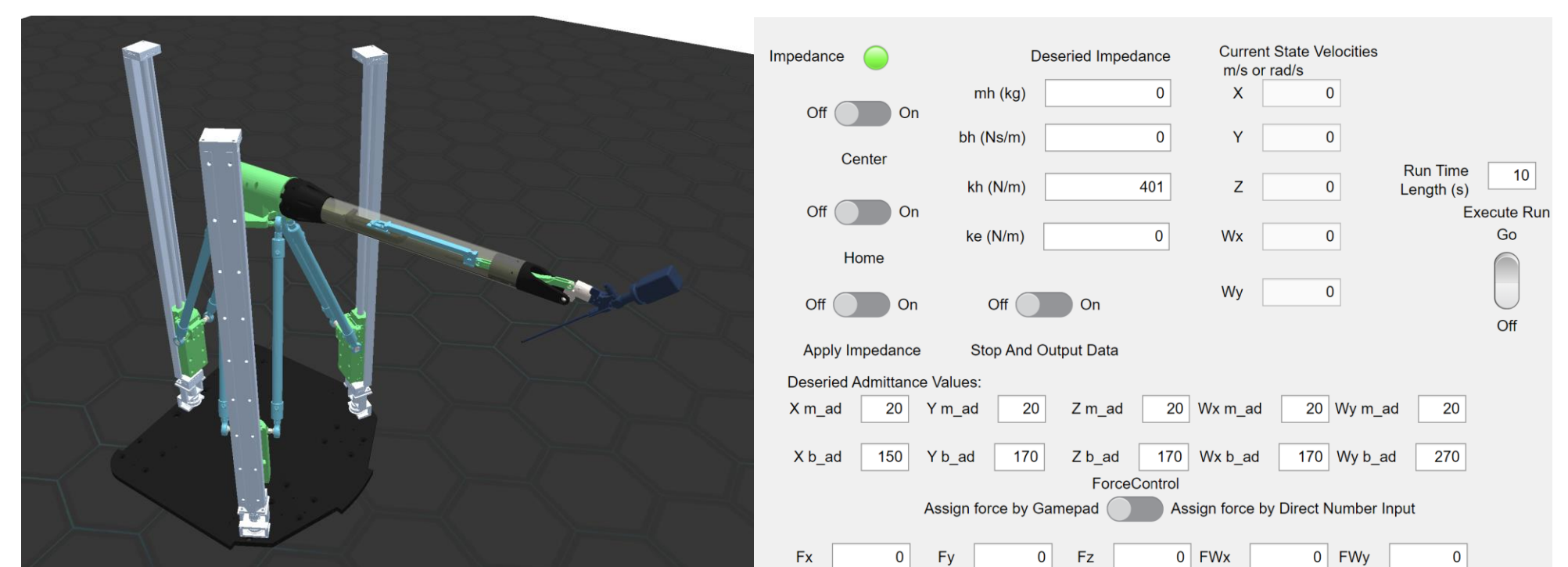


Figure 4. Teleoperation of the Galen Robot in AMBF

- The admittance control has been partially implemented on the real Galen robot for the Z axis.

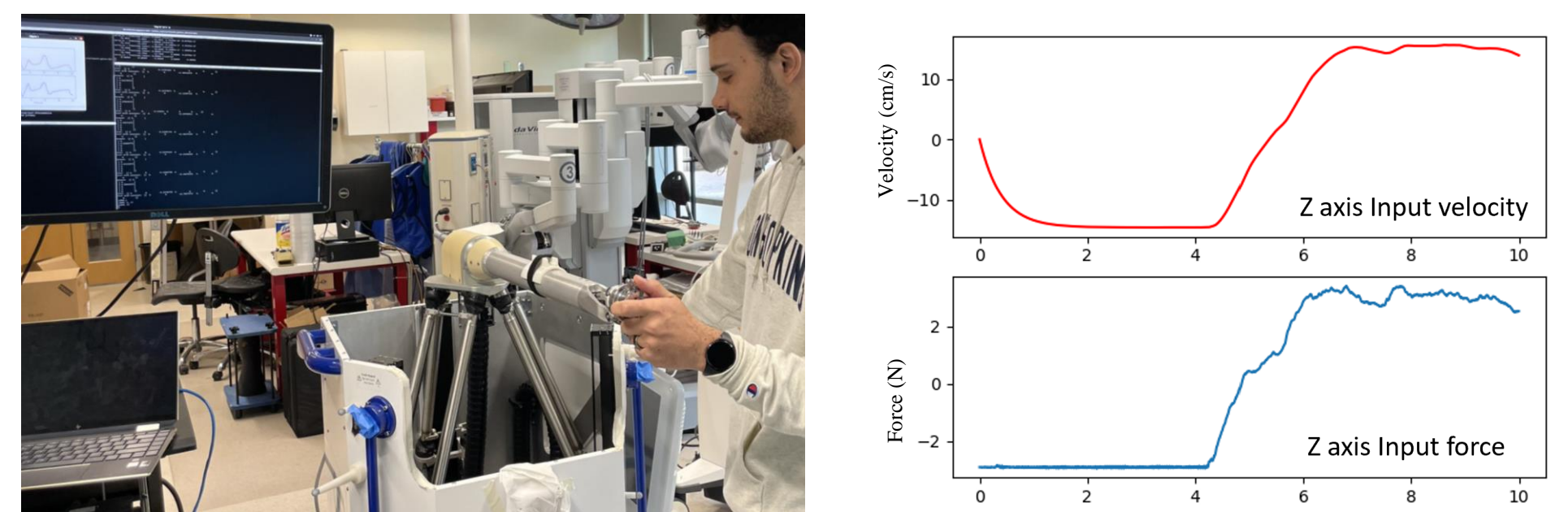


Figure 5. Z axis Admittance control on the real Galen Robot

Future Work

- Efforts on the real robot integration will continue until the start of summer
- Robust stability testing of the controller
- Virtual Fixture implementation
- User studies

Lessons Learned

- The variability in stability due to changing masses and damping
- Implementation of accurate system identification
- The difficulty of translating simulation to hardware

Credits

- Brevin Banks – Control scheme design, implementation, and testing

Publications

Aydin, Y., Sirintuna, D., & Basdogan, C. (2020). Towards collaborative drilling with a Cobot using admittance controller. *Transactions of the Institute of Measurement and Control*, 43(8), 1760–1773. <https://doi.org/10.1177/0142331220934643>

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