

# Transparency Optimization of the Galen Robot

Computer Integrated Surgery II

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## Introduction

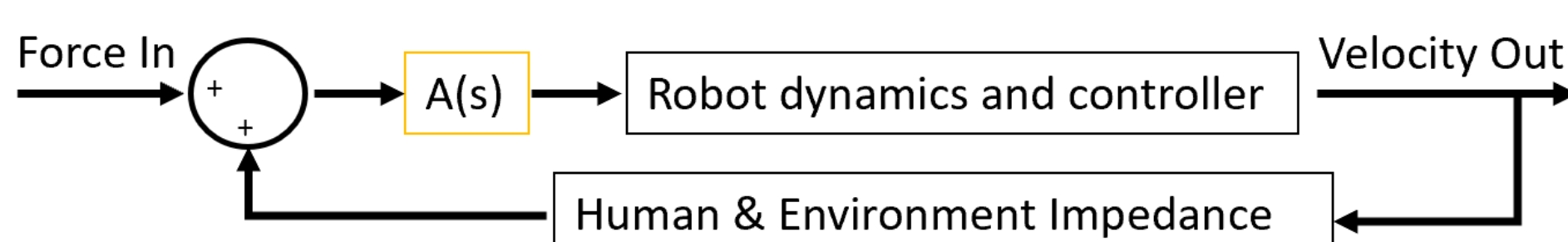
- The Galen Robot is a hand over hand guidance cobot used to assist surgeons in ENT microsurgery.
- The robot features an on-board controller that tries to help the surgeon easily move the robot while keep the movement steady and controlled.
- This controller feels very heavy and clunky and diminishes 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

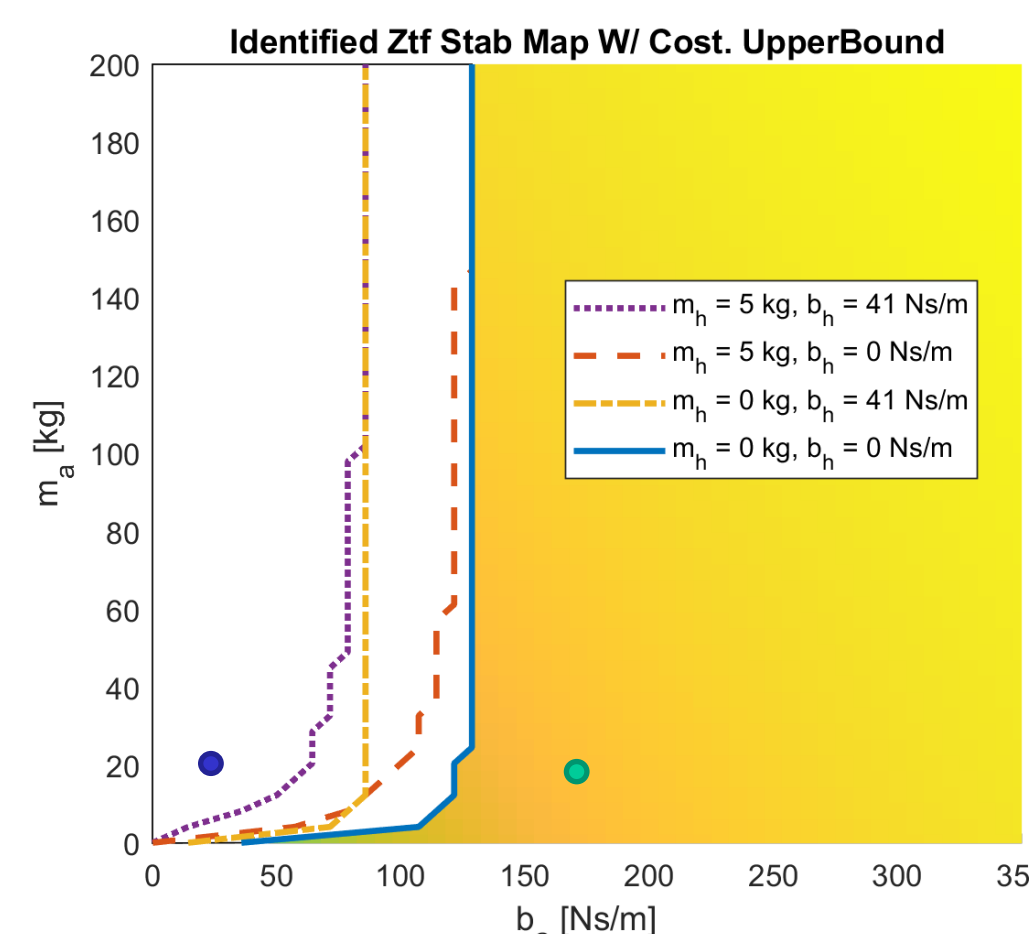


Figure 2. Stable  $m_{ad}$  and  $b_{ad}$  values in colored area

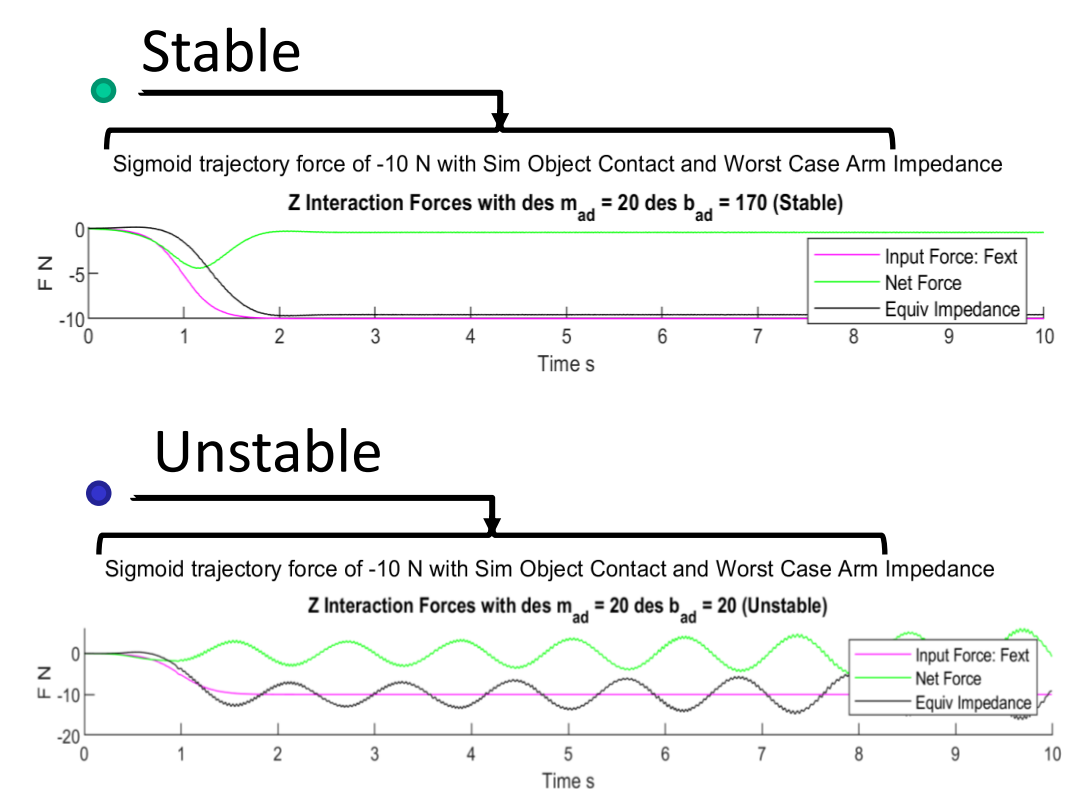


Figure 3. AMBF performance with selected admittance values

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

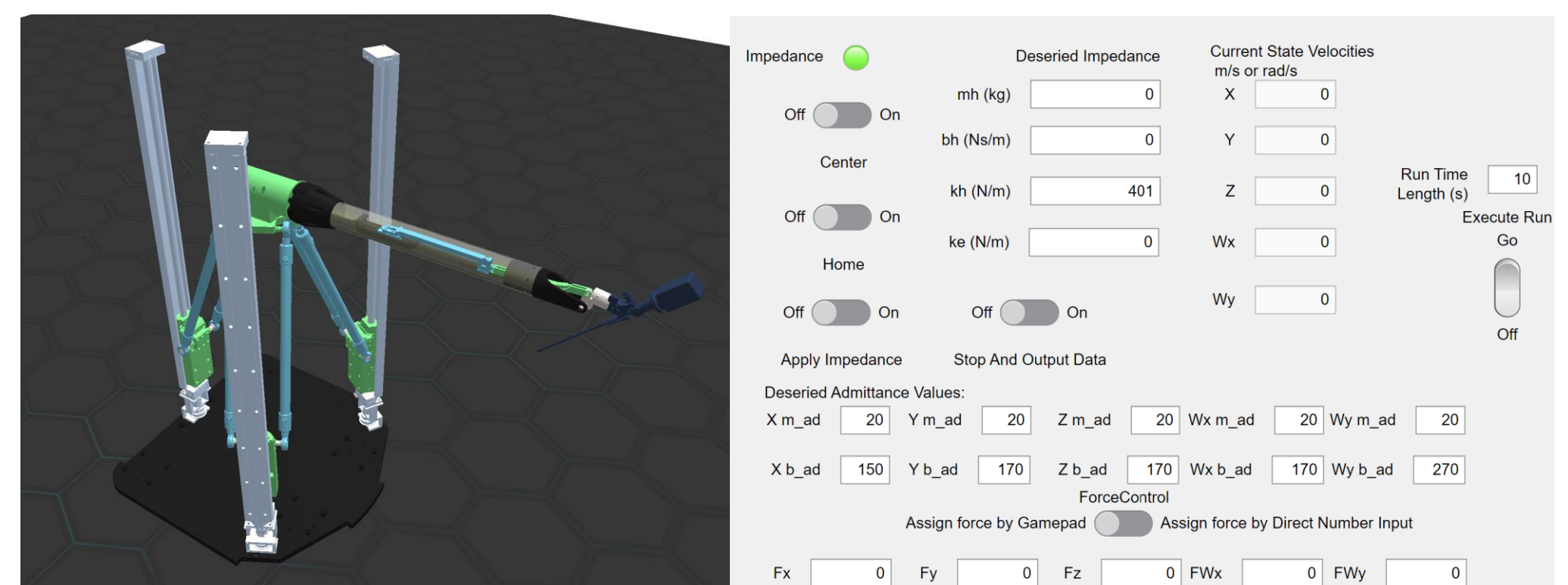


Figure 4. Teleoperation of the Galen Robot in AMBF

## 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>

## Support by and Acknowledgements

- Thank you to Galen Robotics