# Co-robotic Ultrasound Imaging System


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## Introduction

- Integrate UR5 robot arm with ultrasound imaging system
- Implement admittance robot control and virtual fixtures to assist user's motion
- Combine Synthetic Tracked Aperture algorithm to increase the US resolution and imaging field
- Improve the existing system to higher dexterity by replacing the 1 DOF load cell to 3-axis force sensor.

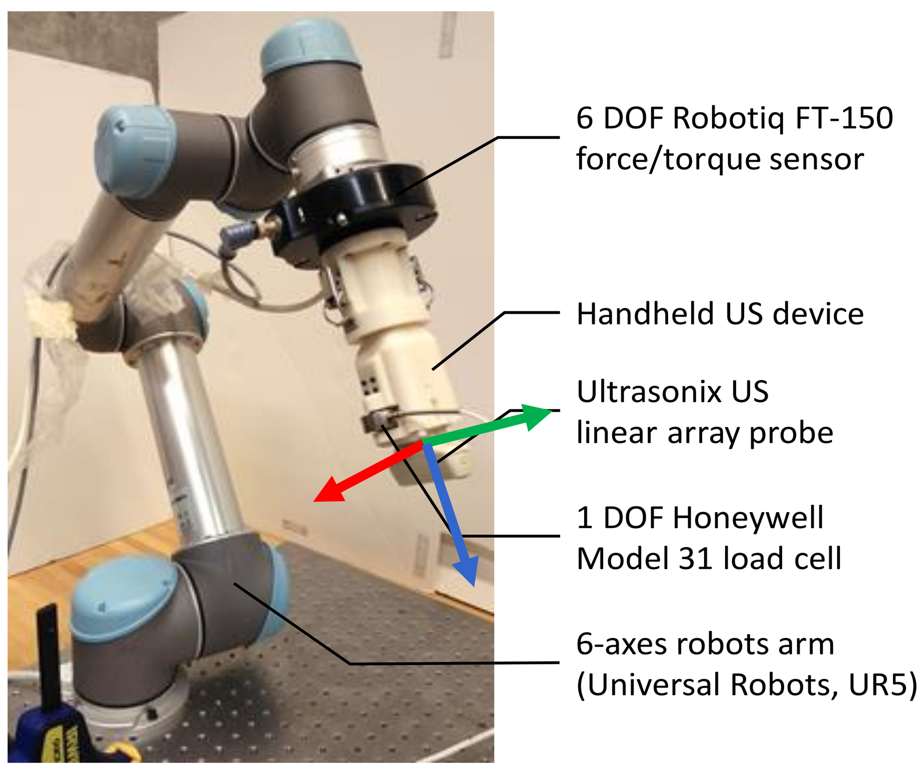


**Figure 1. Dual force sensing co-robotic ultrasound system**

## The Problem

- Ultrasound image quality is limited to the aperture size of the transducer, especially for deep tissue and it highly depends on operator's skill
- STRATUS algorithm aims to solve this problem but it takes time to process before getting the result
- Virtual fixture stay on line is not enough
- The US attachment only has 1-DOF sensing feature which is not enough for general clinical use.
- The system lacks of in-vivo studies

## The Solution

- Combine UR5 and dual force sensors with US system
- Implement admittance control and virtual fixtures which enable real-time STRATUS

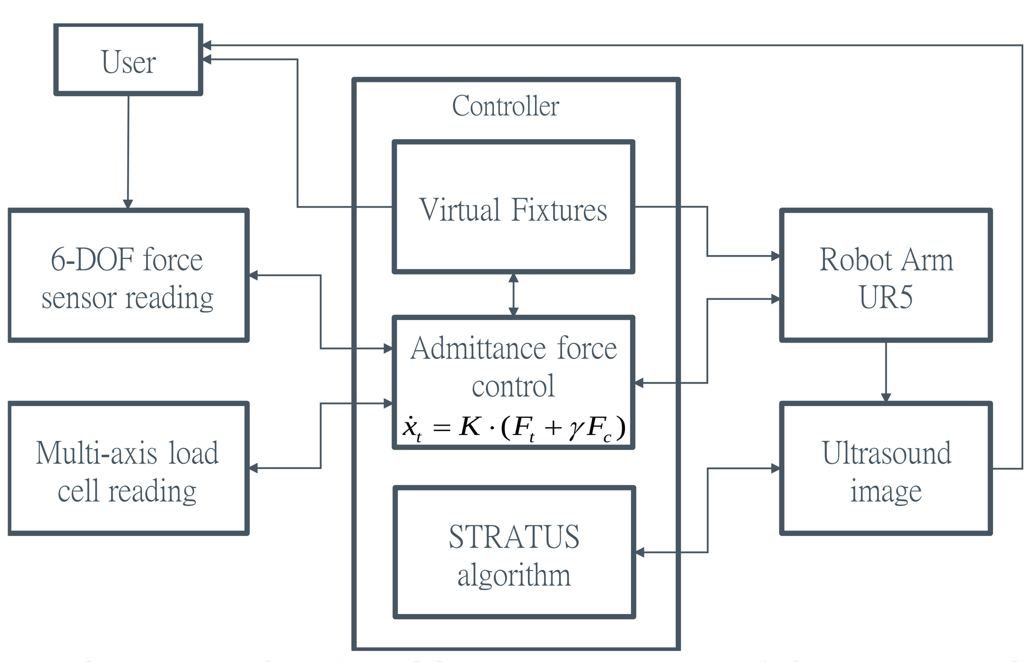


**Figure 3. The algorithm control loop of the proposed robotic US system**

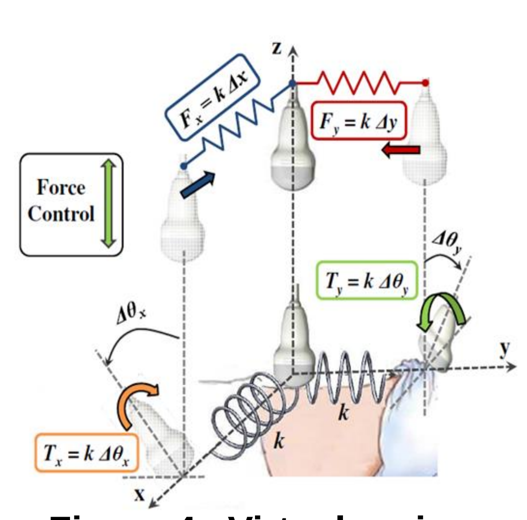


**Figure 4. Virtual spring method for haptic guidance**

- Improve the algorithm time efficie… visualization
- Develop virtual spring method for VF: follow trajectory
- Performed phantom studies, animal and human experiments

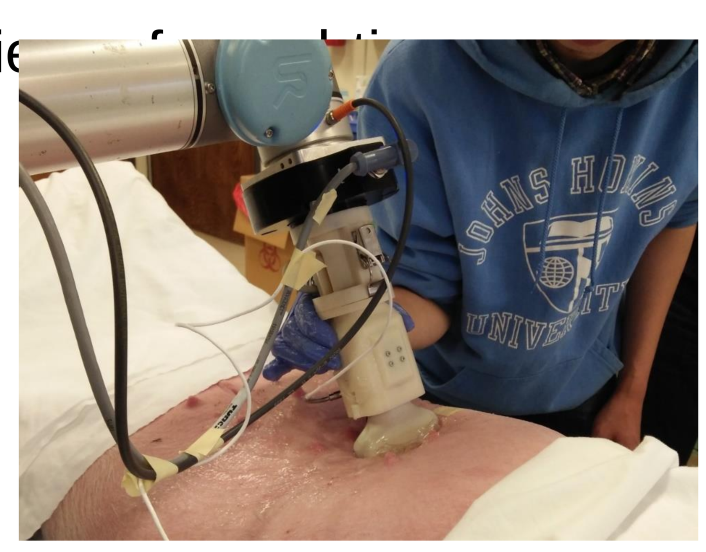

**Figure 5. In-vivo study: animal experiment**

## Outcomes and Results

- Developed several virtual fixtures to constraint the user's motion and provide haptic guidance
- Improved the efficiency of 2D and 3D STRATUS algorithm
- Built real-time STRATUS GUI visualization
- Designed new US attachment for higher dexterity
- Conducted phantom study, animal and human experiments for system validation

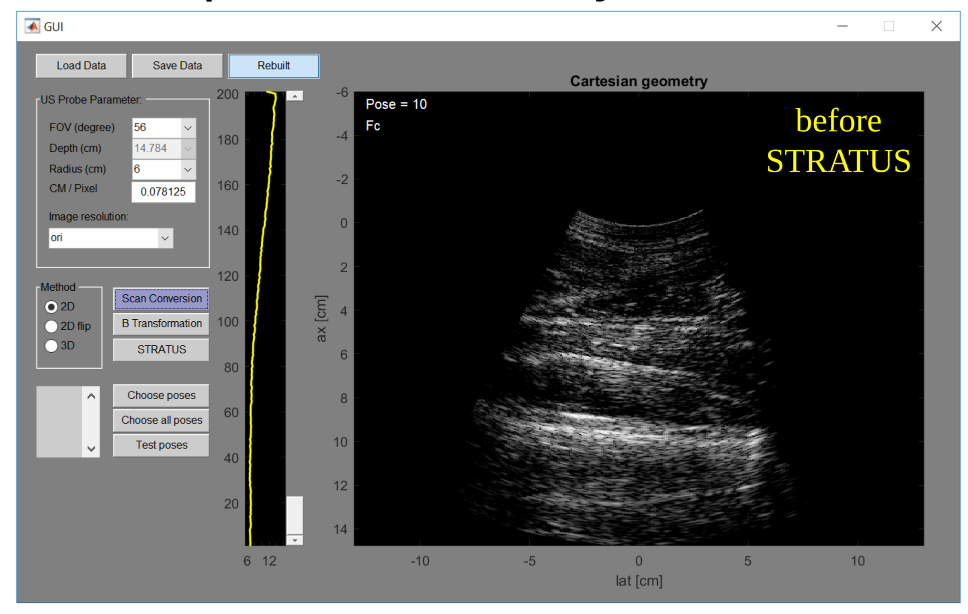


**Figure 6. STRATUS visualization GUI and human tight US image before STRATUS**

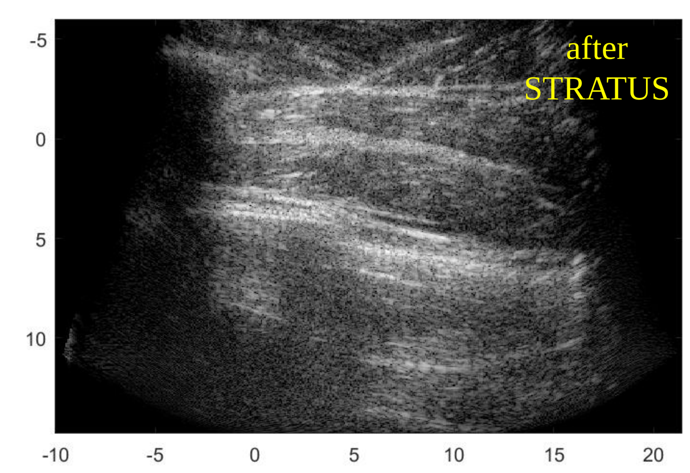


**Figure 7. STRATUS result of human tight US image**

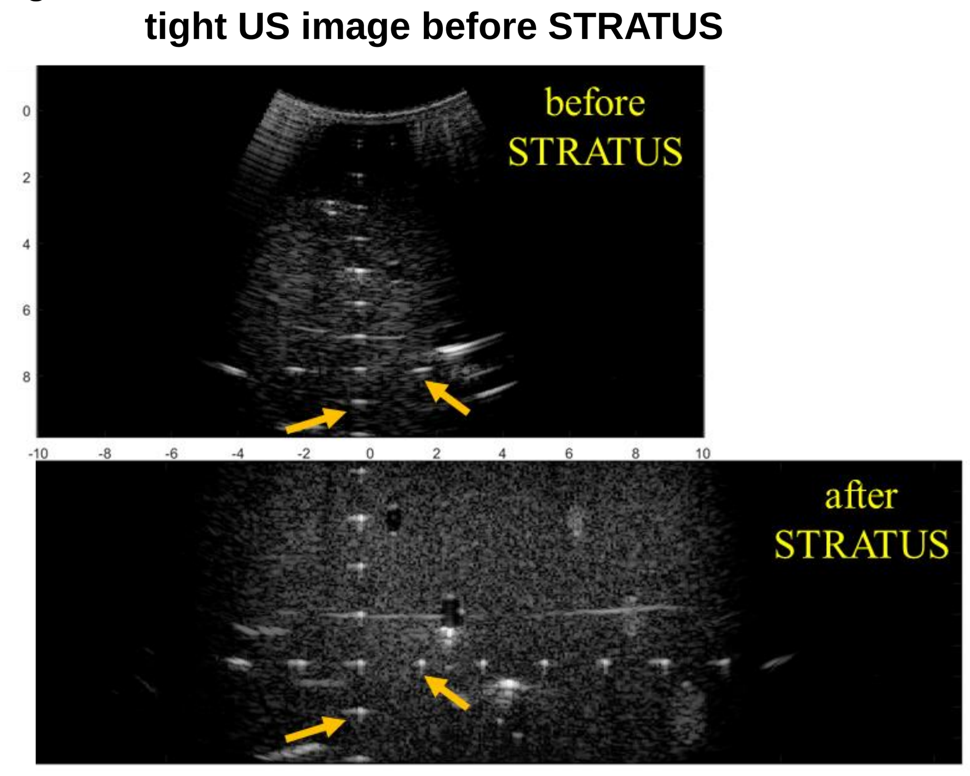


**Figure 8. The result of phantom study**

**Figure 9. US attachment with 3-axis load cell**

## Future Work

- Upgrade the system with 3-DOF US attachment
- Validation of the system with more human experiments
- Include tissue motion compensation into the algorithm

## Lessons Learned

- We acquired experience in CAD design, prototyping, Matlab GUI design, TCP/IP connection, and algorithm implementation
- It is really important and beneficial to continuously write laboratory reports

## Credits

- Ting-Yun Fang – Design US attachments, real time STRATUS implementation, system validation
- Weiqi Wang – Virtual fixtures development, error compensation, system validation


## Support by and Acknowledgements

- Thanks to our mentors for giving us advises and helping us identified problems
- Thanks to Rodolfo Finocchi and Haichong K. Zhang allowing us to use their initial work on this project