Synthetic Tracked Aperture Ultrasound Imaging:
Virtual Fixtures and Force Control

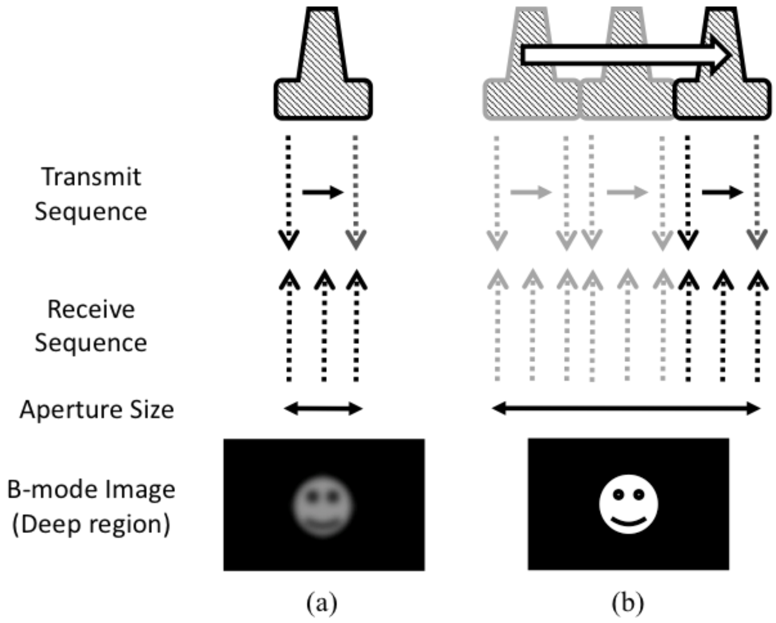
Kalyna Apkarian and Rodolfo Finocchi

Mentors: Kai Zhang, Dr. Emad Boctor

MUSiiC Research Laboratory

Motivation

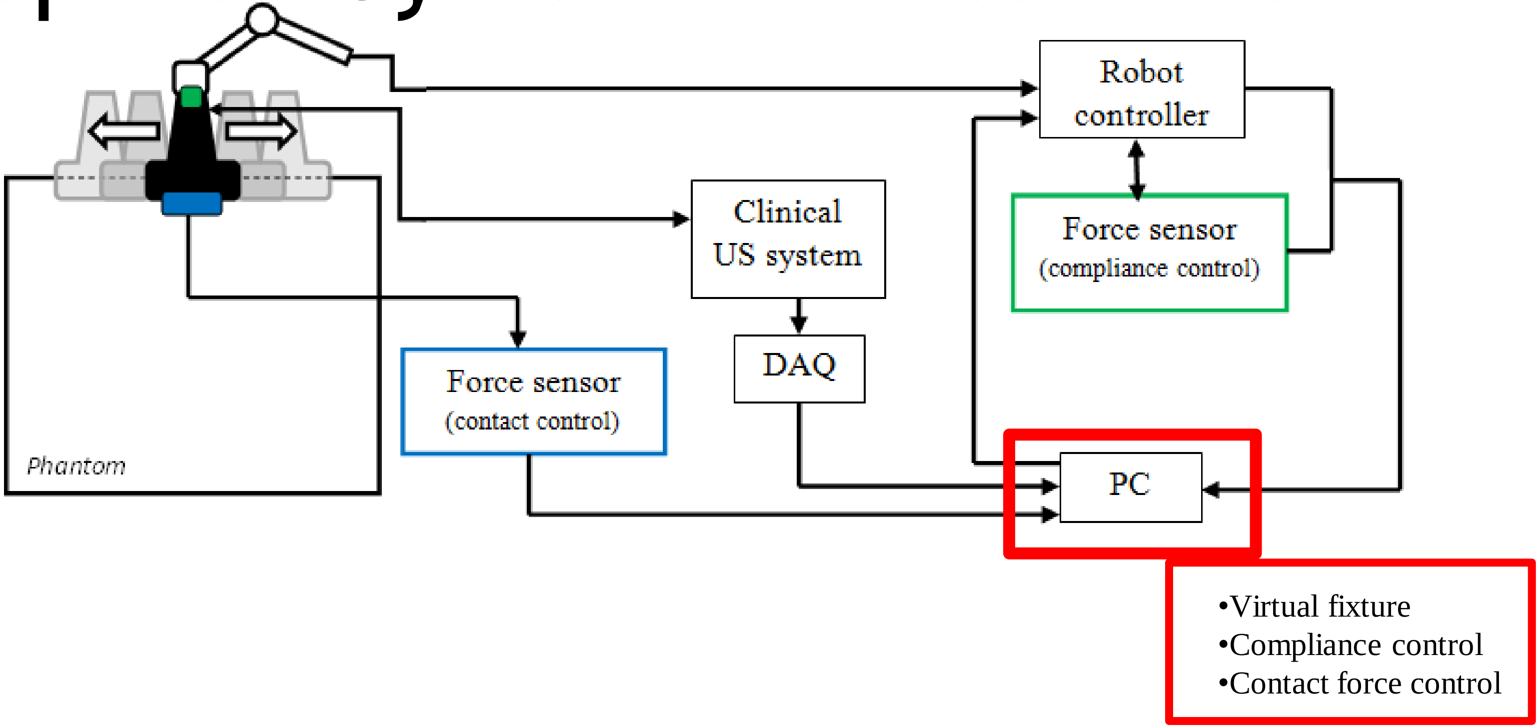
- Aperture size of the ultrasound transducer limits image quality
- Synthetic tracked aperture imaging shows improvement
    - Current system is autonomous by robot
        - Difficulty in clinical translation
        - Force control required for anatomy specific imaging and patient safety



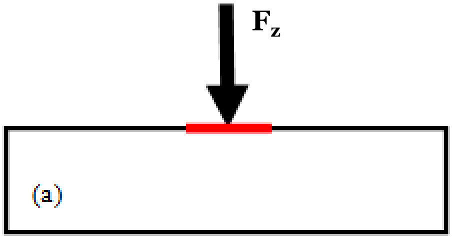
Goals

- Bring system from autopilot to co-robotic freehand using a guidance virtual fixture
- Implement compliance force control for ease of use by the physician
- Ensure patient safety using virtual fixtures

Proposed System Architecture



Main Constraints



(a) Phantom: Front view

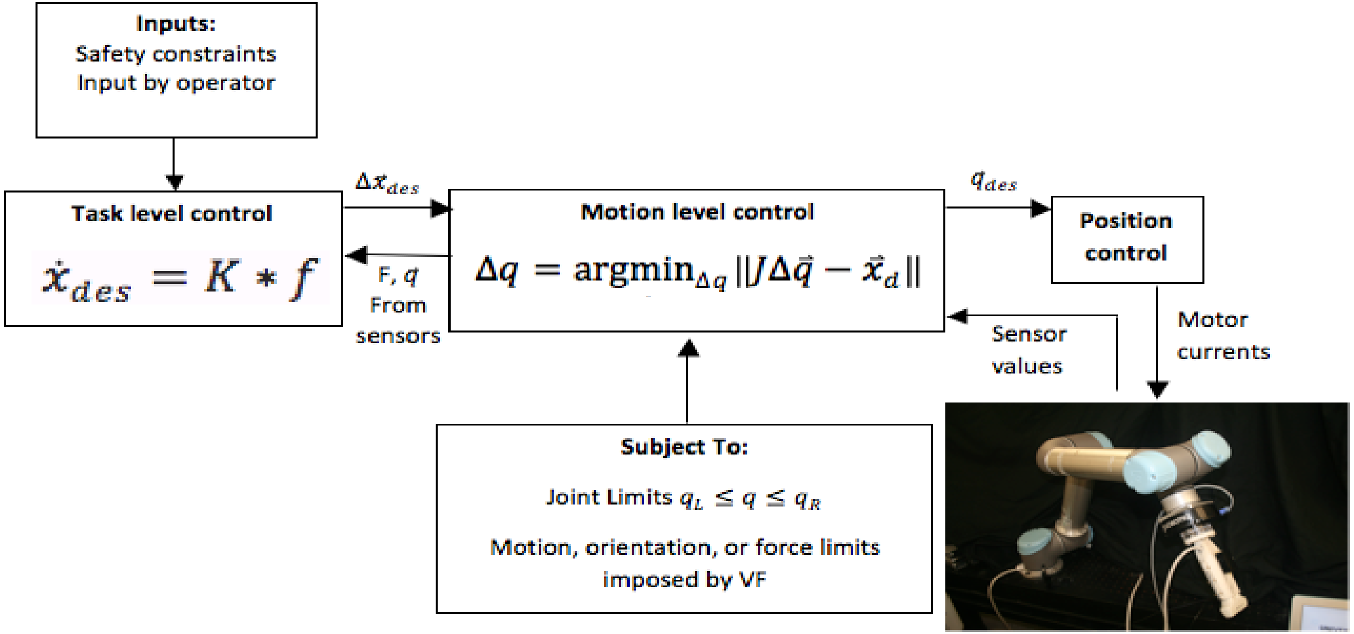
Forbidden region virtual fixture

(b) Phantom: Top view

Forbidden region virtual fixture
(out of plane)

Guidance virtual fixture

Technical Approach: compliance control



Deliverables: Summary

Minimum

- Code implementing virtual fixtures
- Code implementing compliance force control
- Comparison of actual trajectory of robot with planned trajectory
- Demonstration of translational path in water tank using co-robotic control

Expected

- Demonstration of rotational path in water tank using co-robotic control
- Demonstration of translational path on general US phantom

Maximum

- Demonstrate control on more anatomically accurate path using rotation and force control on abdominal phantom

Detailed Summary of Approach

Minimum deliverable

- Code implementing virtual fixtures
  - Finding correct CISST libraries and gaining a deeper understanding of algorithm
  - Implement virtual fixture algorithm
    - Guidance type and forbidden region type
- Code implementing compliance force control
  - Implement compliance force control algorithm
- Comparison of actual trajectory of robot with planned trajectory
  - Calculate forward kinematics of desired trajectory
  - Collect end effector pose data of the robot using commands from UR5 library
  - Compare actual end effector pose data with desired
- Demonstration of translational path in water tank using co-robotic control
  - Compare with image generated on autopilot using FWHM

Detailed Summary of Approach

Expected deliverable

- Demonstration of rotational path in water tank using co-robotic control
  - Compare with image generated on autopilot using FWHM
  - Ensure better quality than translational path

- Demonstration of translational path on general US phantom
  - Implement contact force control algorithm
  - Compare actual force exerted with desired force exerted

Detailed Summary of Approach

Maximum deliverable

- Demonstrate control on more anatomically accurate path using rotation and force control on abdominal phantom
  - Demonstrate integration of virtual fixtures with compliance force control and contact force control
  - Compare actual force exerted with desired force exerted over a varying path

Dependencies

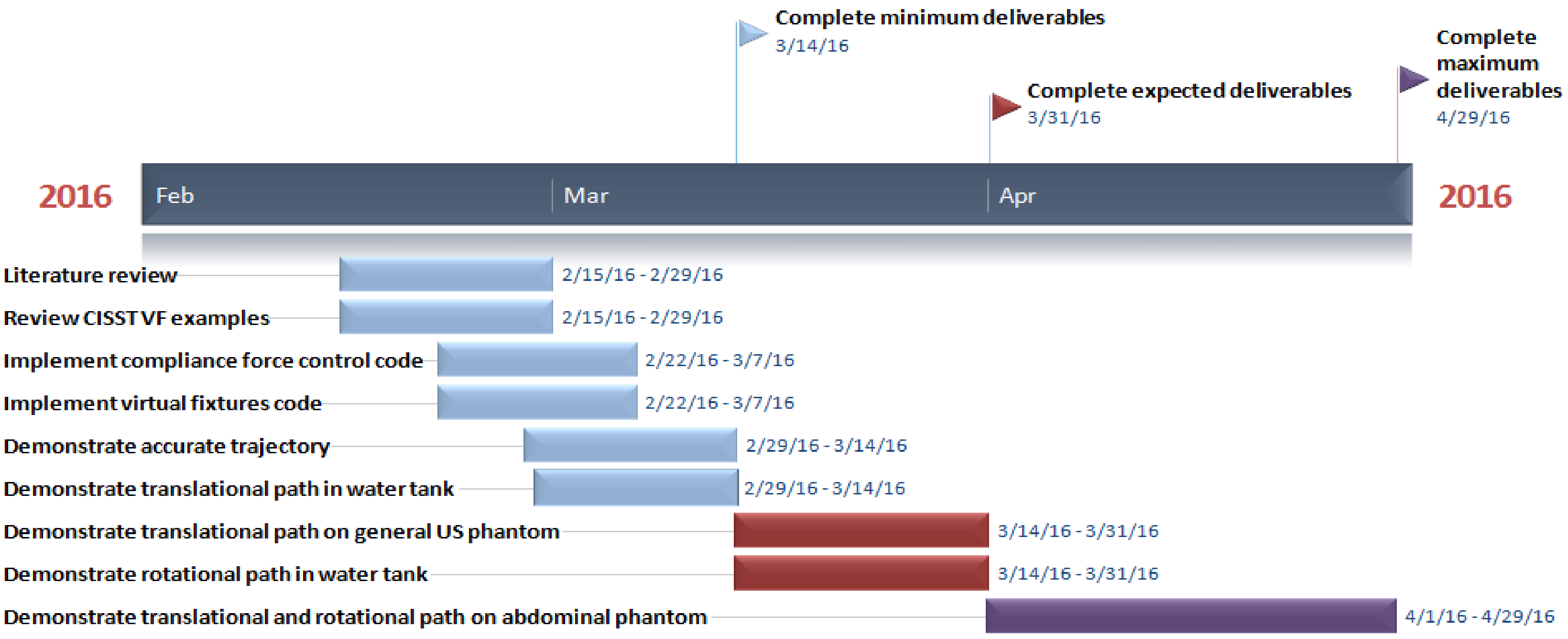
- Access to UR5 robot and force sensors - **MUSiiC Lab Google Calendar**
- Access to Sonix Touch ultrasound system – **Done**
- Access to STrAtUS real-time visualization system - **Done**
- Access to mentors - **Weekly meeting with Kai**
- Access to water tank & phantoms - **Available in lab space**
- Deeper understanding of virtual fixtures and implementation- Ongoing
- Familiarity with CISST libraries- Ongoing

Management Plan

- Bi-weekly team meetings: Mondays and Thursdays
- Weekly meetings with Kai: Mondays
- Use Git for version control

Kalyna	**Rodolfo**
Virtual fixtures	Compliant force control
Image analysis	Contact force control
Phantom experiments, data collection & analysis	

Project Timeline



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