Project 10: Real Time Motion Reflexes for Robotic Hip Surgery

Kangsan Kim & Kevin Yee

Checkpoint Presentation

Team Members and Mentors

Team Members:

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Mentors:

Andrew Hundt

Dr. Peter Kazanzides

Project Summary

- Integrate torque sensor data from Robone femur cutting robot
  - Force controlled velocity (FCV) algorithm to change the cutting speed of the robot in response to the force on the cutting tool
  - *Null space compliance* to allow robot joints to be manipulated without altering cut path

physically

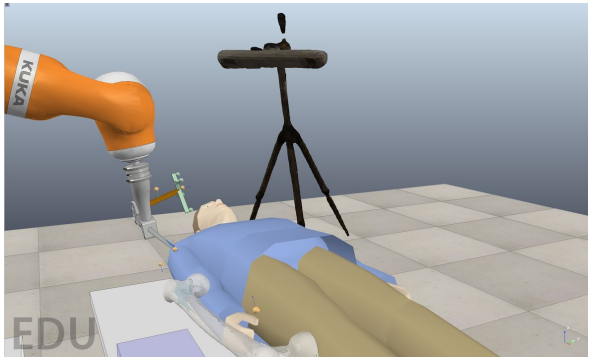
Deliverables

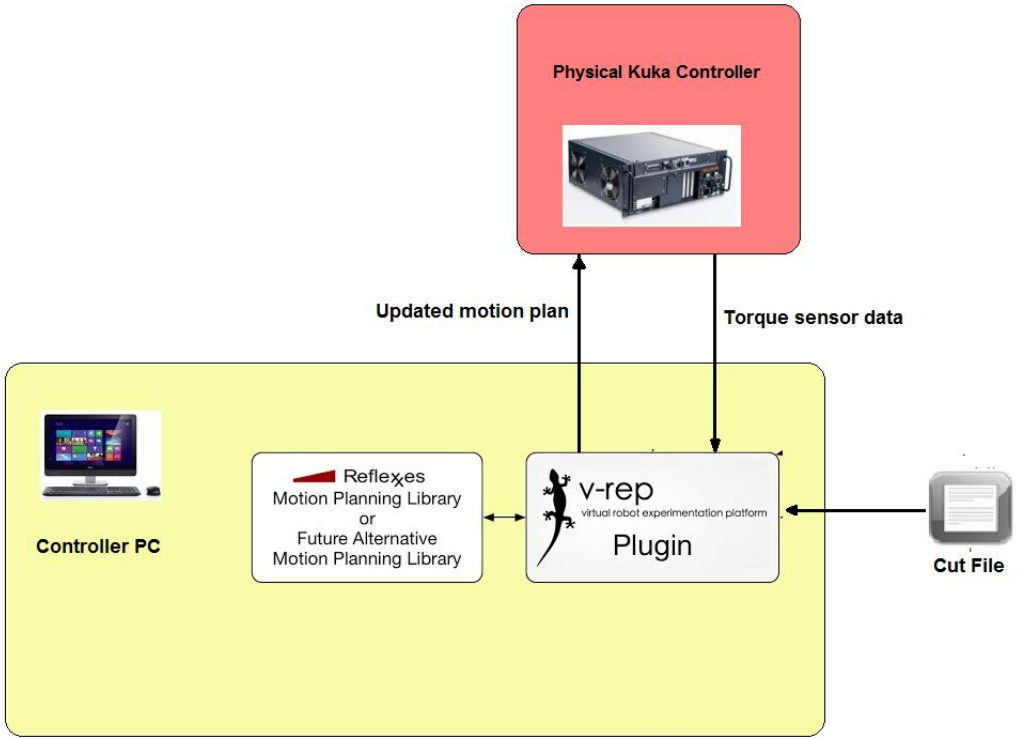
Minimum
- Implement an algorithm to traverse cutting path at varying speeds ✓
- Position control force controlled velocity implementation in software ✓
- Demonstrate position controlled velocity on hardware (robot) ✓

Expected
- Factor in end effector mass into calculations ➤
- Test force control based on known resistance ➤

Maximum
- Demonstrate torque control in software
- Demonstrate torque control on hardware
- Human force null space compliance (fixed and cut path)
- Quantify accuracy of robot arm torque sensors

System Overview

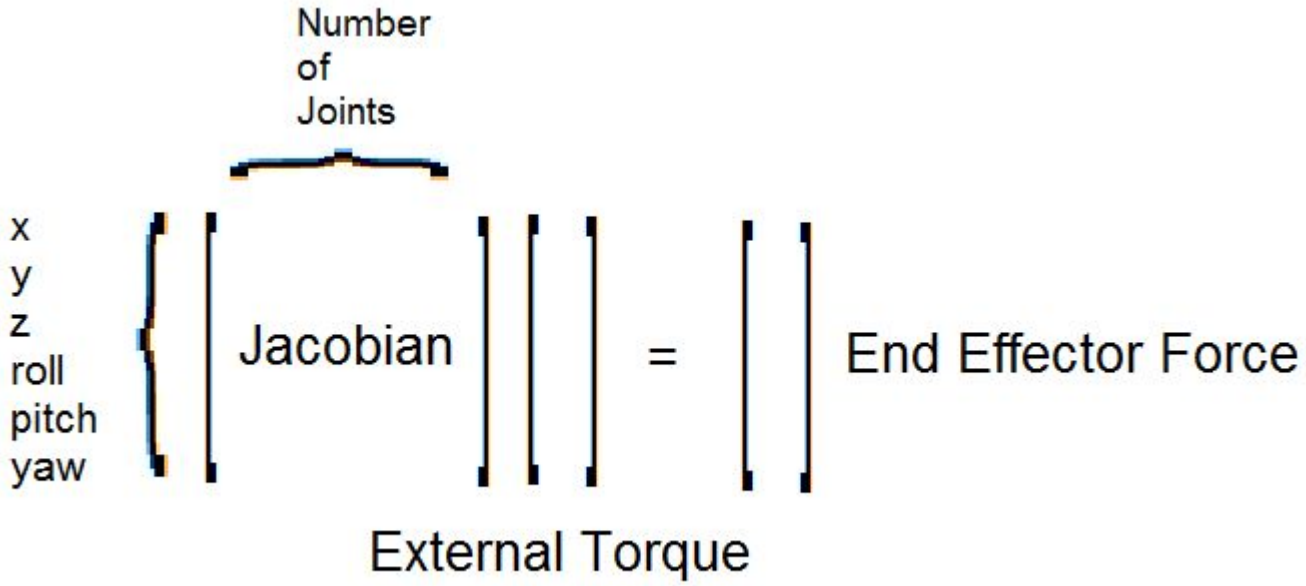




Passing Data

- Created duplicate arm to reflect measured data in V-REP
- Pass data from KUKA controller to V-REP plug-in
- Convert external torque data to bytes and pass to V-REP duplicate arm
- Convert byte data back to numbers to calculate tool-tip force

Tool-Tip Force



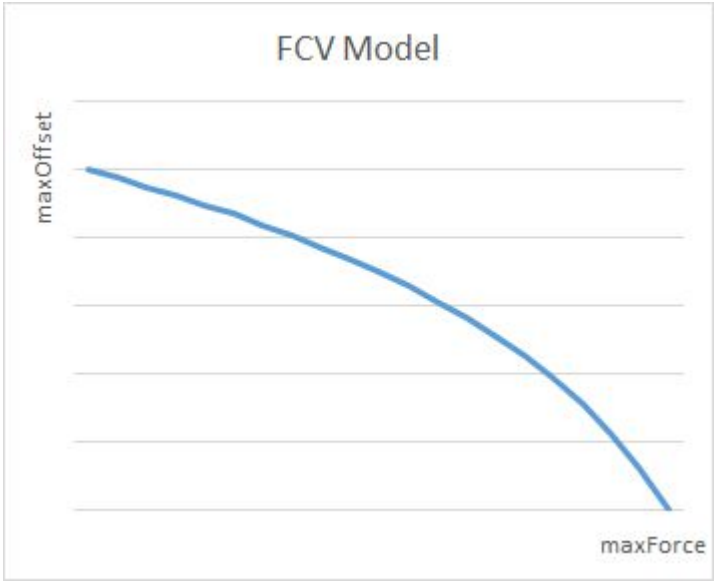
Variable Velocity Algorithm

- Old constant velocity implementation
- Two representation of path position:
  - Absolute path position (measured in meters)
  - Relative path position (mapped from 0 to 1)

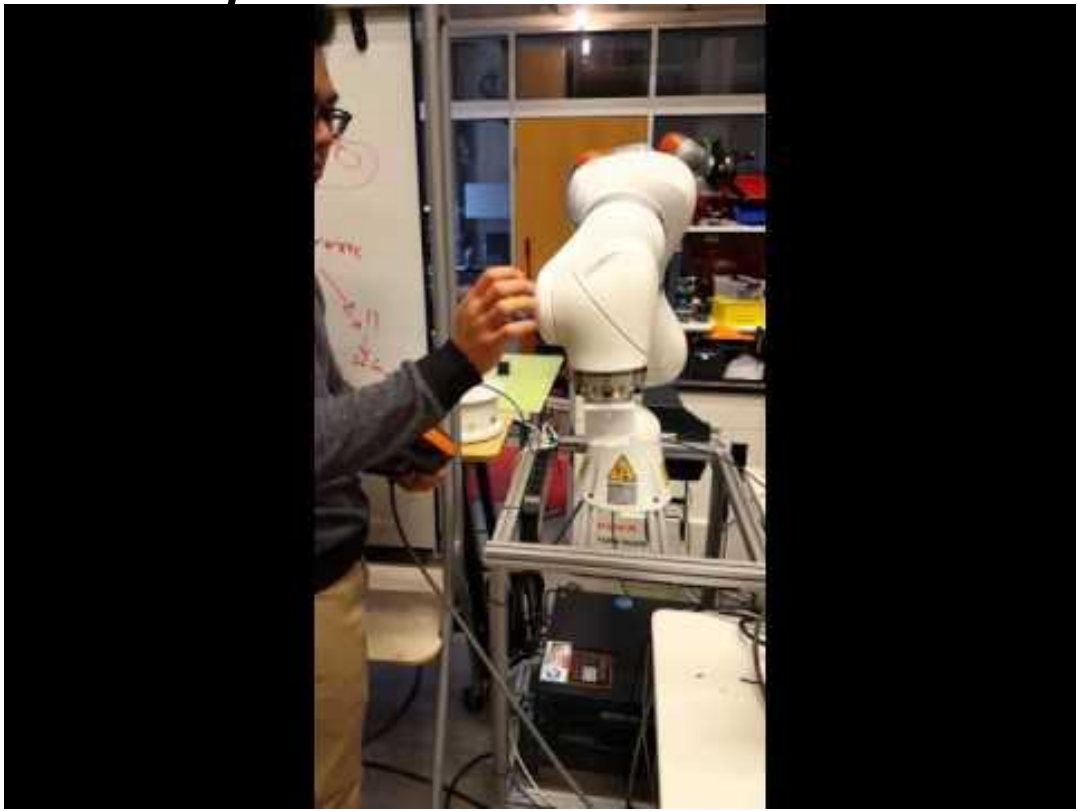
1. Offset determined by FCV Model
2. Add absolute path position to offset
3. Convert new absolute path position to (x, y, z) coordinates
4. Set robot position to coordinates

FCV Model

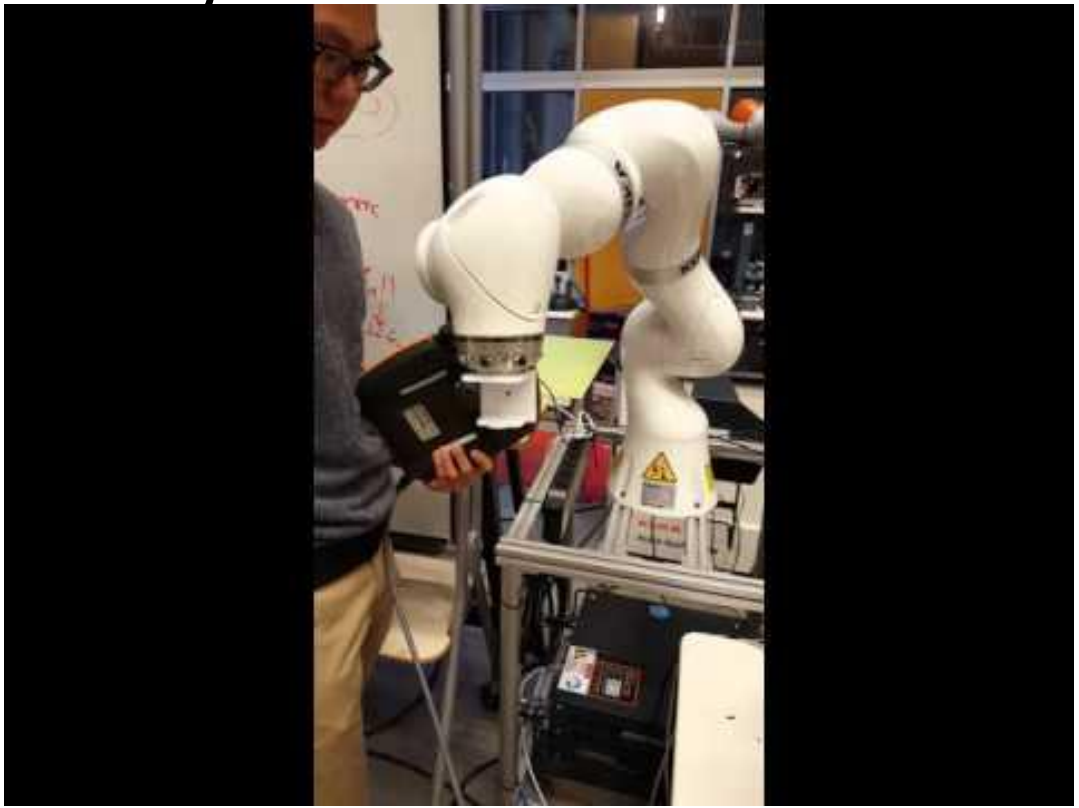
- Goal: more sensitivity at higher forces to dampen effect of noise
- General shape: concave down with axes intersections at maxForce and maxOffset
- Possible models
  - Natural log
  - Square root



Constant Velocity

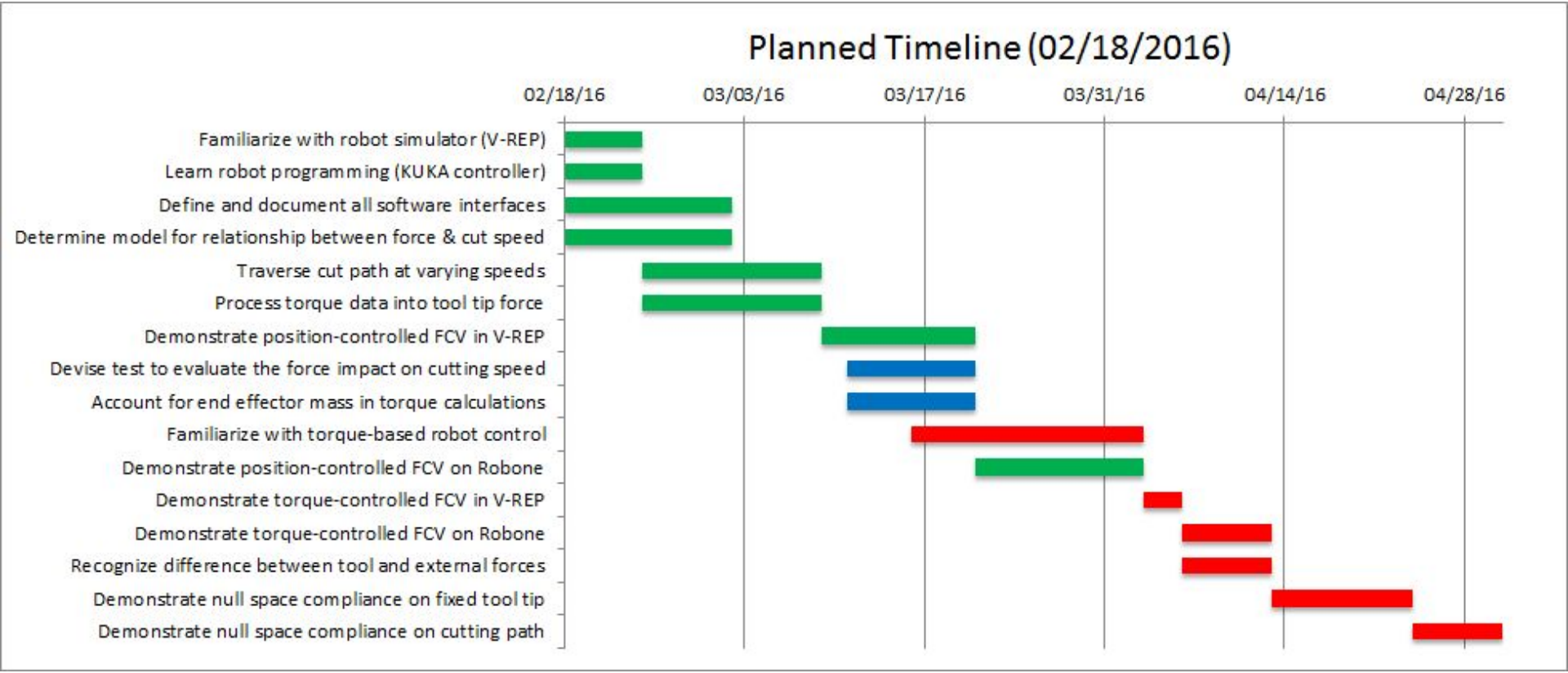


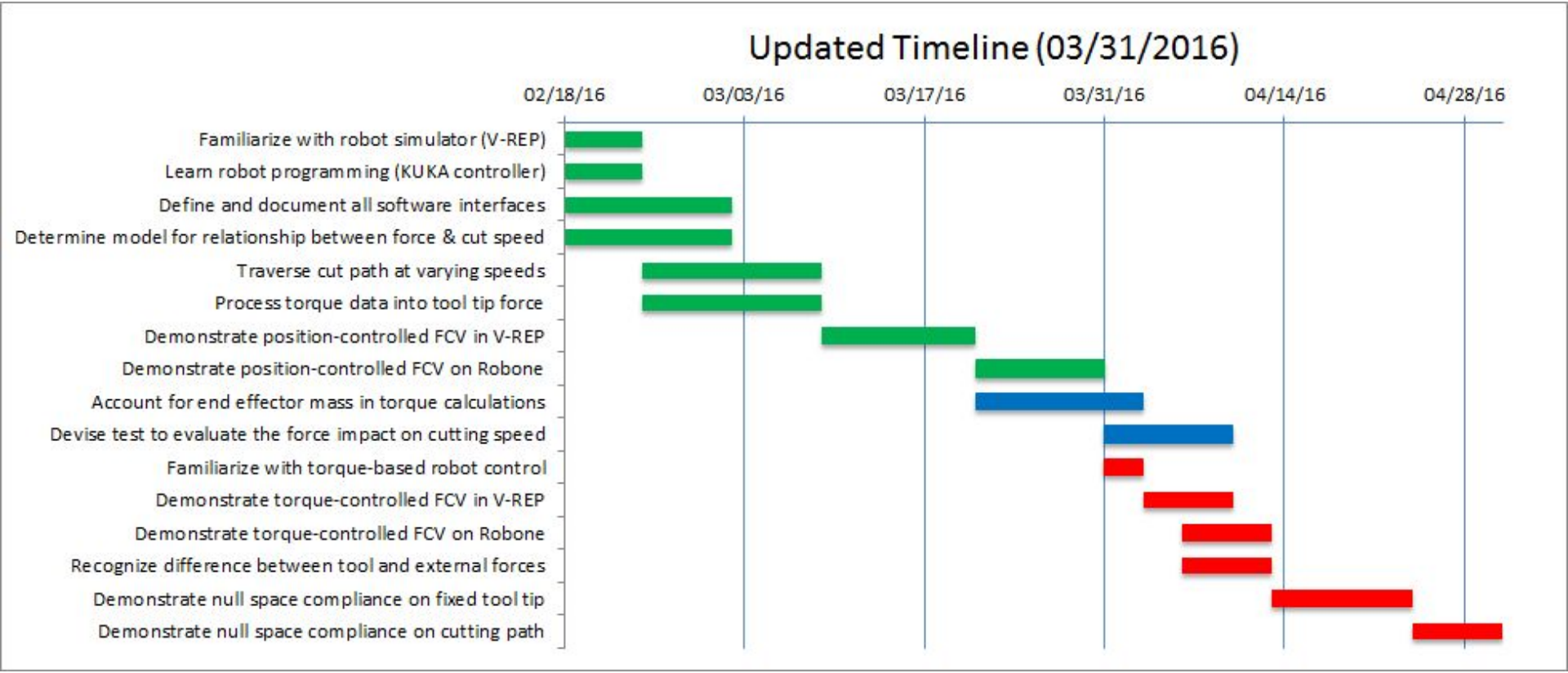
Variable Velocity



Dependencies

- Access to lab
- Access to robot arm & mentors
- Access to Robone Git repository
- Access to Linux machine to drive robot
- API access to force data
- Funding for experiment


Planned Timeline (02/18/2016)
02/18/16
03/03/16
03/17/16
03/31/16
04/14/16
04/28/16
Familiarize with robot simulator (V-REP)
Learn robot programming (KUKA controller)
Define and document all software interfaces
Determine model for relationship between force & cut speed
Traverse cut path at varying speeds
Process torque data into tool tip force
Demonstrate position-controlled FCV in V-REP
Devise test to evaluate the force impact on cutting speed
Account for end effector mass in torque calculations
Familiarize with torque-based robot control
Demonstrate position-controlled FCV on Robone
Demonstrate torque-controlled FCV in V-REP
Demonstrate torque-controlled FCV on Robone
Recognize difference between tool and external forces
Demonstrate null space compliance on fixed tool tip
Demonstrate null space compliance on cutting path


Updated Timeline (03/31/2016)
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Questions?