Project 10: Real Time Motion Reflexes for Robotic Hip Surgery

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Team Members and Mentors

Team Members:

Kangsan Kim

Kevin Yee

Mentors:

Andrew Hundt

Dr. Peter Kazanzides

Background

Robone is a next-generation orthopedic surgical system.

The Kuka robotic arm that cuts the femur has torque sensors. These torque sensors are not currently utilized.

Project Goal

- Integrate torque sensor data from Robone femur cutting robot
  - Develop and implement a force controlled velocity (FCV) algorithm to change the cutting speed of the robot in response to the force on the cutting tool
  - Develop functionality that allows robot joints to be physically manipulated without altering cut path (null-space compliance)


KUKA

Project Relevance

By modifying velocity profile of tool trajectory using force controlled velocity, it will allow a safe, accurate, and efficient milling operation.

Allowing the surgeon to move the joints of the robot without affecting the cutting trajectory or velocity will give the surgeon better visibility and comfort without negatively affecting the surgery.

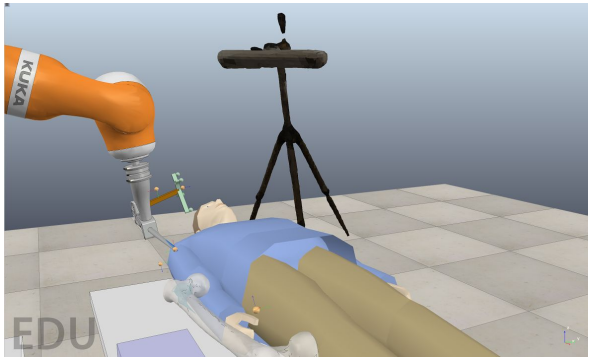
Deliverables

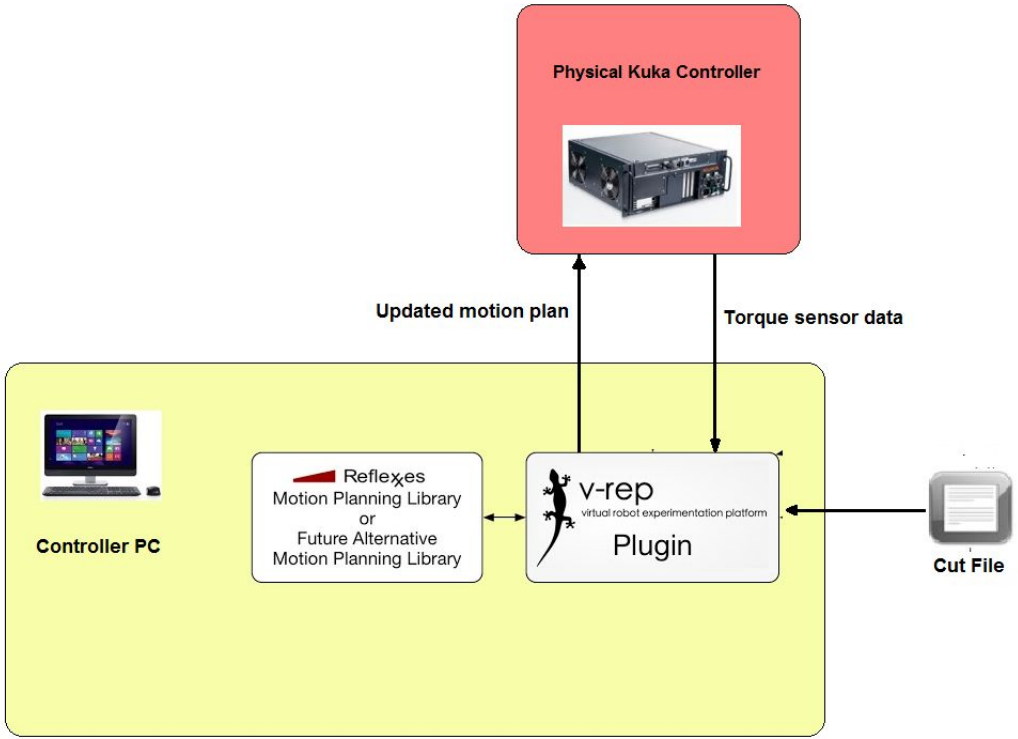
Minimum
- Implement an algorithm to traverse cutting path at varying speeds
- Position control force controlled velocity implementation in software
- Demonstrate position control on hardware (robot)

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

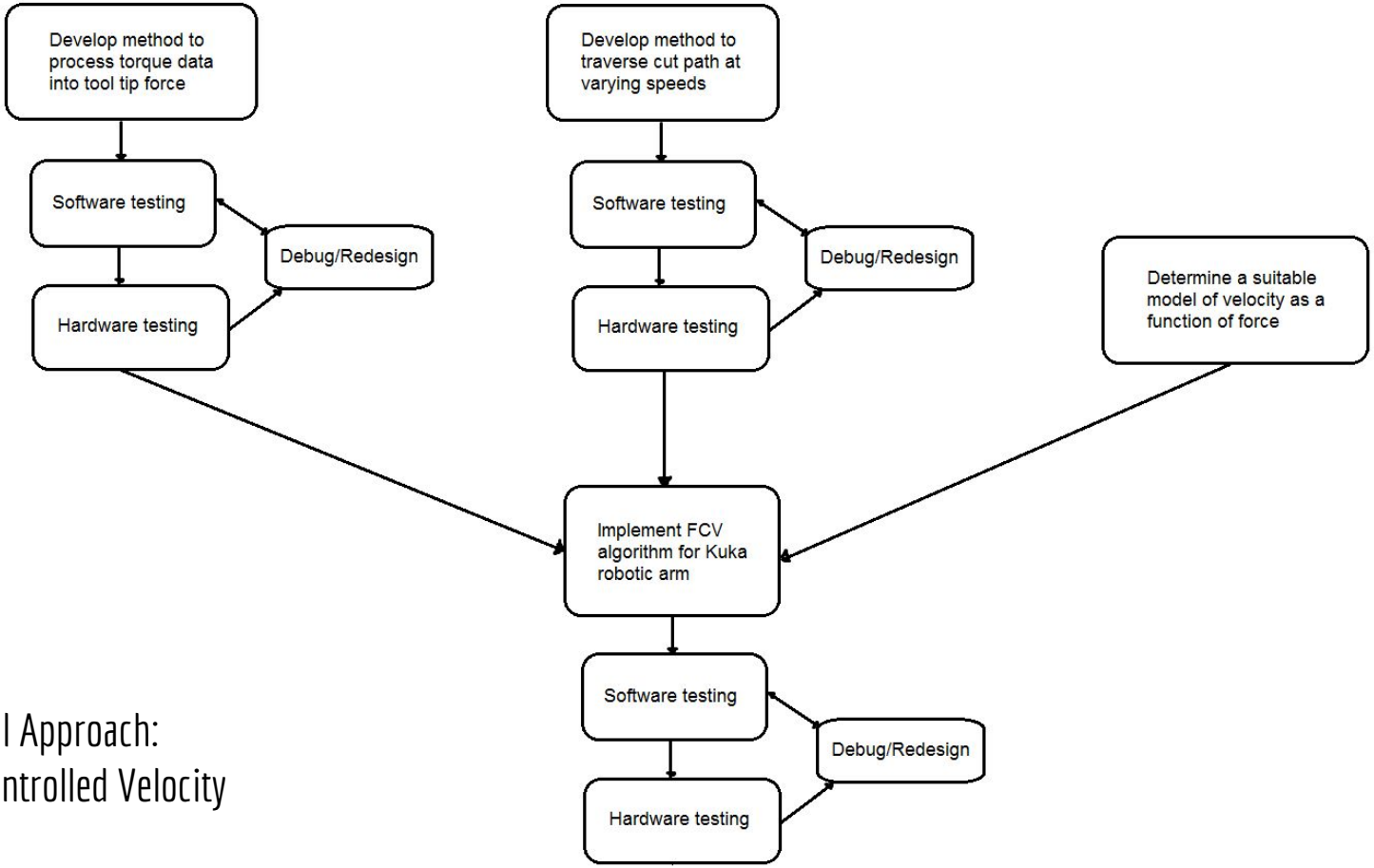
System Overview

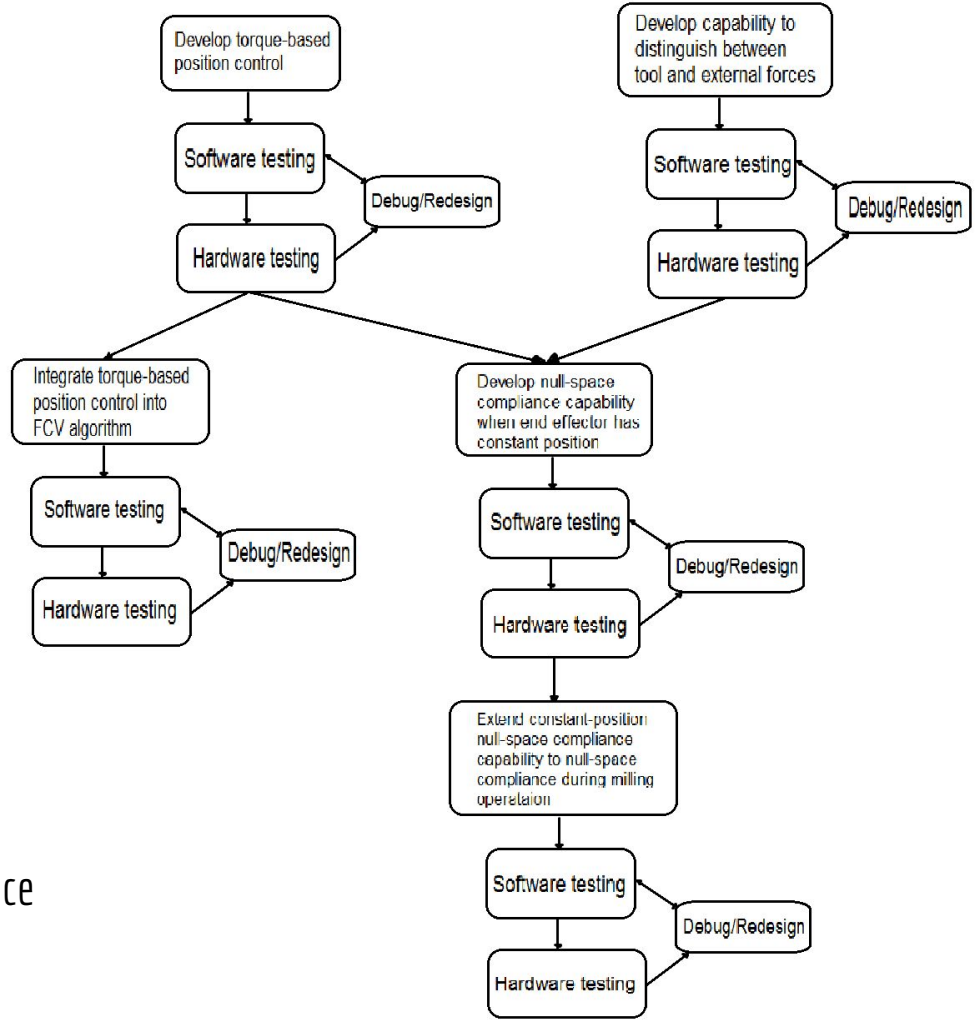




Adapted from Andrew Hundt's slides

Technical Approach:
Force Controlled Velocity

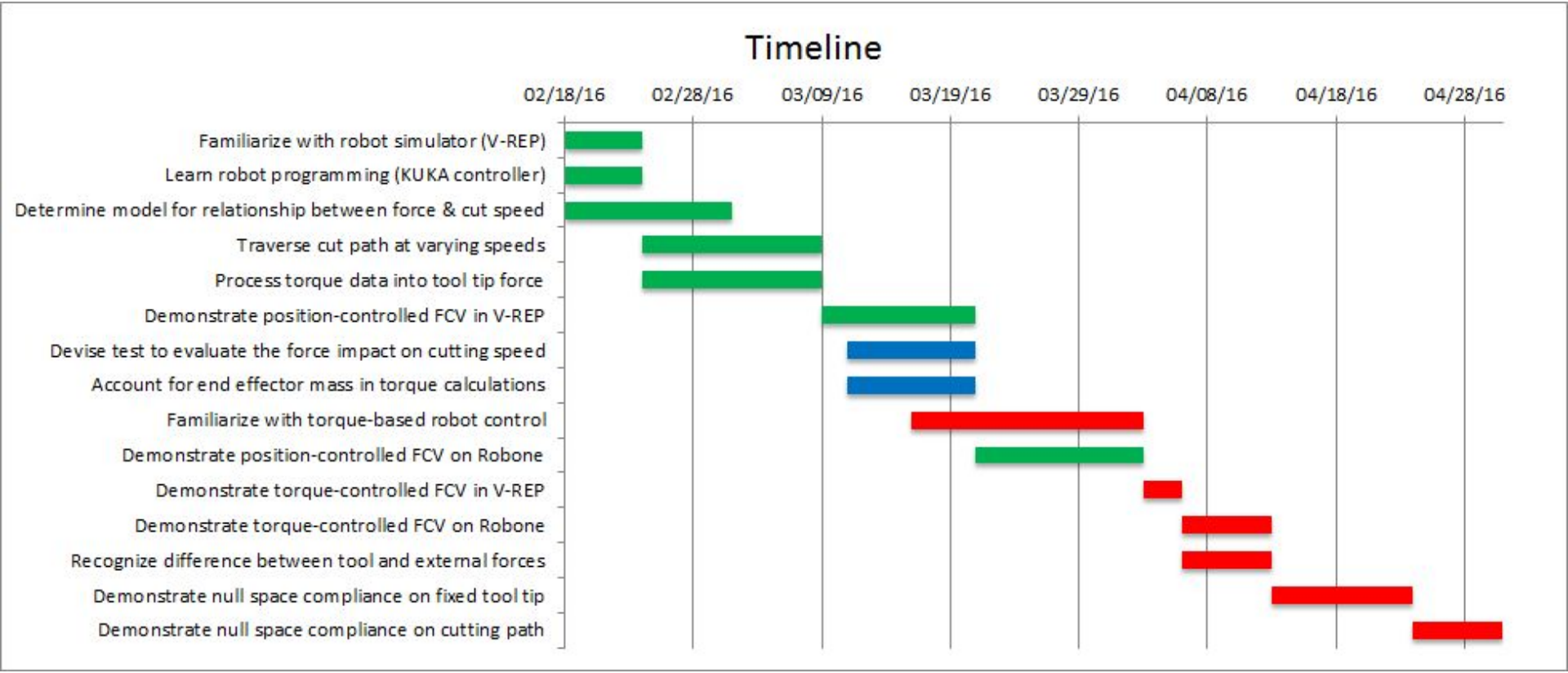




Technical Approach:
Null-Space Compliance

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


Timeline
02/18/16
02/28/16
03/09/16
03/19/16
03/29/16
04/08/16
04/18/16
04/28/16
Familiarize with robot simulator (V-REP)
Learn robot programming (KUKA controller)
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

Management Plan

Weekly mentor meetings scheduled on Wednesday

Team meetings on Sunday and Tuesdays

Kangsan	Kevin
Develop force vs. cut speed model	Variable cut speed method
Process torque data	Devise test for evaluation
Learn development tools, Collaborate on V-REP simulations and V-REP-to-Kuka interaction	

Reading List

Zuhars, J.; Hsia, T.C., "Nonhomogeneous material milling using a robot manipulator with force controlled velocity," in *Robotics and Automation, 1995. Proceedings., 1995 IEEE International Conference on* , vol.2, no., pp.1461-1467 vol.2, 21-27 May 1995

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Questions?