# Force-Controlled Velocity for Robotic Hip Surgery

Kevin Yee

Project #10: Seminar Presentation

March 1st, 2016

# Project Background

- Robone: robotic hip surgery robot for bone milling
- Utilize Kuka robot arm's torque sensors for 2 applica
  - Vary cutting speed based on force on tool tip
  - Null space compliance


Team Members:

Kevin Yee

Kangsan Kim

Mentors:

Andrew Hundt

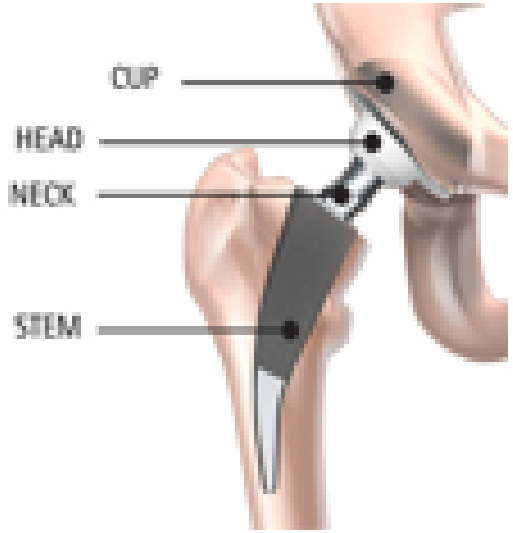
Dr. Peter Kazanzides

# Paper Selection

J. Zuhars and T. C. Hsia, "Nonhomogeneous material milling using a robot manipulator with force controlled velocity," *Robotics and Automation, 1995. Proceedings., 1995 IEEE International Conference on*, Nagoya, 1995, pp. 1461-1467 vol.2.

# Summary of Problem

- Bone density nonhomogeneous
- Effects of tool chattering
- Surgery duration



# Goals

- Develop suitable model for tool force to cutting speed
- System verification
  - Uncuttable object
  - Variable drag profile

# Implementation

- Manipulation time and position in classical kinematics equations

$$P(t) = P_O + V_O(t - t_i) + \frac{1}{2} A (t - t_i)^2$$

- Adjusted time using delay function

$$T = t - D(t, F(t))$$

# Delay Function Constraints

$$0 < \frac{d}{dt} D\big(t, F(t)\big) < 1$$

$$\frac{d}{dt} D\big(t, F(t)\big) = e^{-R\left(MaxForce - F(t)\right)}$$

# Position Model Function

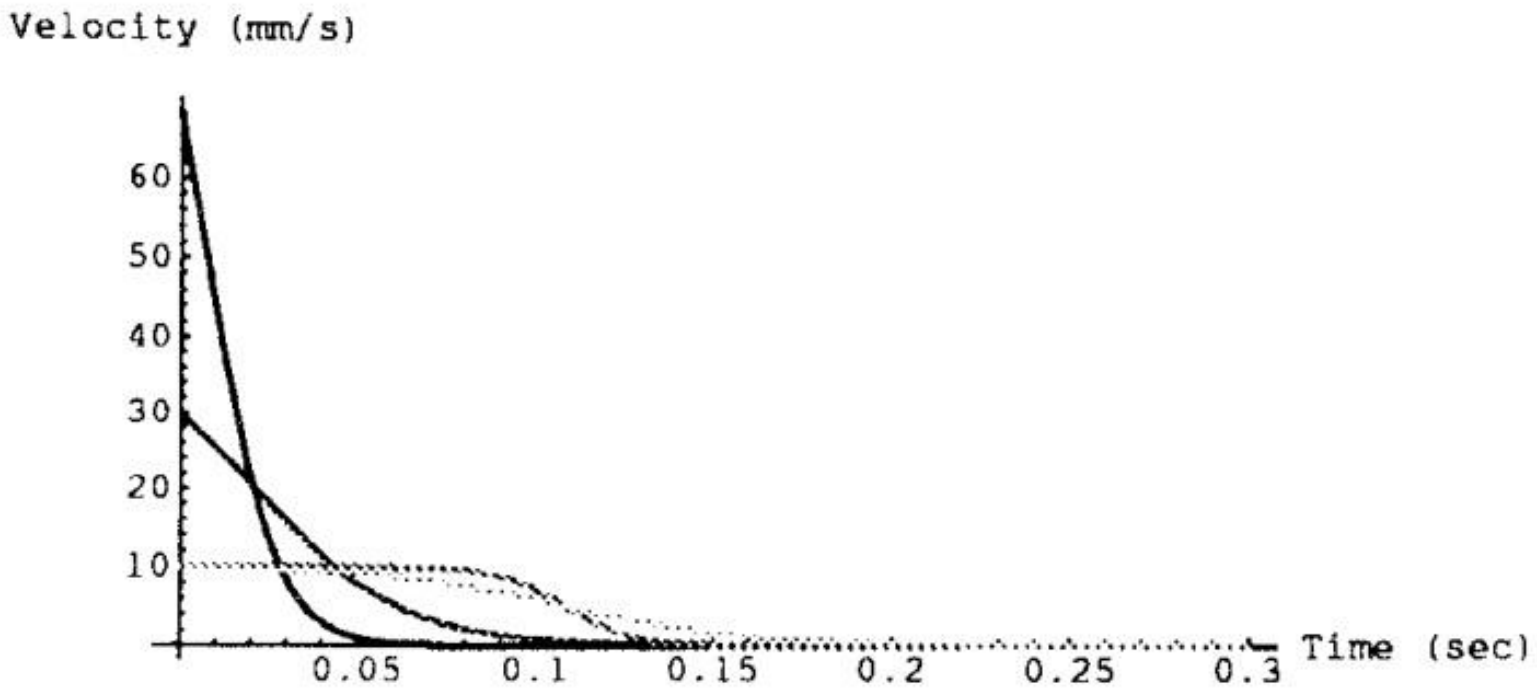
**D(t, F(t)) =**

$$\int e^{-R(MaxForce - Ke^{-K\int \sigma(t)^{-1}\,dt} \int e^{K\int \sigma(t)^{-1}\,dt} V(t)dt)}\,dt$$

**Position:**

$$P(T) = V_0 (t - D(t, F(t)))$$

# Results: Uncuttable Object



# Results: Variable Drag Profile

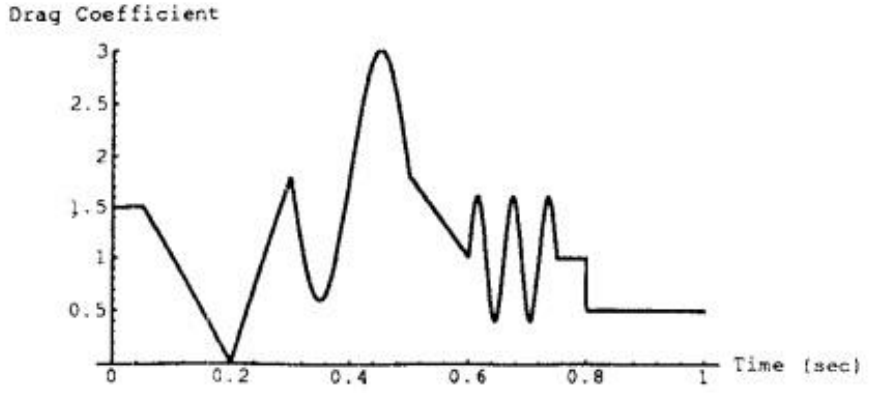
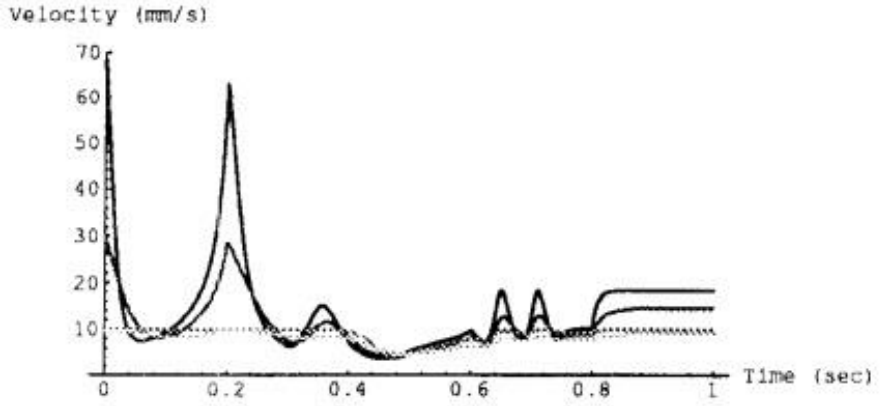



Figure 2: Variable drag profile



# Paper Assessment

Pros

- Clear and detailed explanation of how mathematical model was reached

Cons

- Perhaps too dense mathematical explanation
- Poor documentation of test conditions

# Questions?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