Robone: Next Generation Orthopedic Surgical Device
Alex Strickland Seminar Presentation

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Project Background

● Existing robotic hip implant surgery requires the target bone to be fixed to the operating table
  ○ Invasive and Time Consuming

● Goal: To develop a next generation system that will make real time position adjustments using newer technology
  ○ KUKA LBR iiwa Robot Arm
  ○ Optical Tracker
Summary of Problem

- Problems can arise during tradition hip replacement surgery
  - Gaps between implant and bone can get infected
  - Inserting implant can cause cracking or fracturing of bone
  - Misalignment of implant

Solution: Use a robot system to drill a more precise shape for the implant to fit in
Goals of System

- Human-Machine Interaction in a Surgical Situation
- Registration of Plan Data with Intraoperative Reality
- Verification
- Operating Room Compatibility and Sterility
Surgical Procedure: Overview
Surgical Procedure: Preoperative

- Find the position and orientation of the pins in CT coordinates
- Position the implant in the femur using a computer model to find the shape of the cut
Surgical Procedure: Calibration

- CT Coordinate System to Robot Coordinate System
  \[ f_i = K(x_i - x_0) \]
  \( f_i \): force at each step
  \( x_i \): distance at each step
  \( x_0 \): contact point

- Pivot Calibration for Robot Tip Calibration
Surgical Procedure: Drilling

- Cuts the shape of the implant parallel to the long axis of the implant
- Design of robot system allows for safety checks
Robot System: Overview
Robot System: Safety

- **Robot Controller**
  - Receive signals from sensor that could pause the motion or shut down power to system

- **Force Sensor**
  - Send signal if applied force is too great
  - Pause at 1.5 kgf, Stop at 3 kgf

- **Optical Tracking**
  - Send signal to pause the system if drill was outside the safe cutting volume
Robot System: Validation

* Cut different shapes into rigidly attached foam boxes and measure accuracy
  - Placement of Test Shape < 0.5 mm
  - Accuracy of Cut Shape < 0.05 mm
  - Forces Measured < 0.5 kgf

* Clinical trial run on 26 dog hip implants
Clinical Trial Results

- **Robot Surgery**
  - No cracks or fractures
  - Better implant fit
  - More consistent surgical times

- **Traditional Surgery**
  - 5 of 15 dogs had cracks or fractures
  - Proximal end of the implant were tilted towards the medial direction
Paper Assessment

Pros:
- Detailed description of surgical procedure and robot system developed

Cons:
- Long and dense
- Did not have the flow of a normal journal article
Conclusions

• The paper described their surgical procedure and robot system for hip replacement surgery
• Some of the system design and validation can be incorporated in our project
Questions?