

# Robone: Next Generation Orthopedic Surgical Device

## Alex Strickland Seminar Presentation

Team 1:

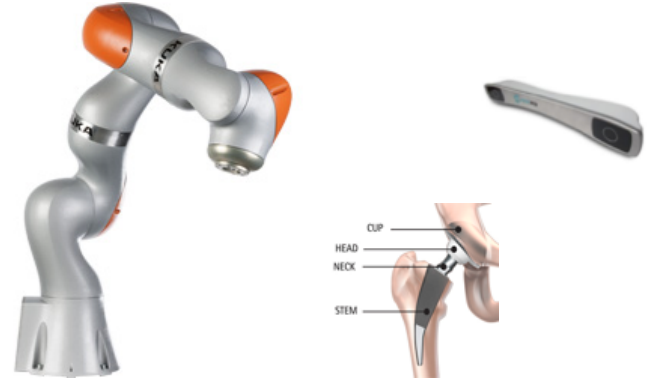
Alex Strickland

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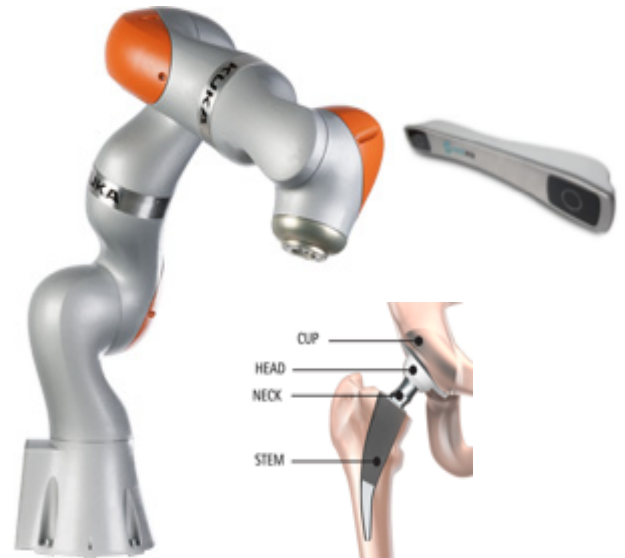
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# Project Background

- 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



# Paper Selection

Taylor, Russell H., Brent D. Mittelstadt, Howard A. Paul, William Hanson, Peter Kazanzides, Joel F. Zuhars, Bill Williamson, Bela L. Musits, Edward Glassman, and William L. Bargar. "An image-directed robotic system for precise orthopaedic surgery." *Robotics and Automation, IEEE Transactions on* 10, no. 3 (1994): 261-275.

# Summary of Problem

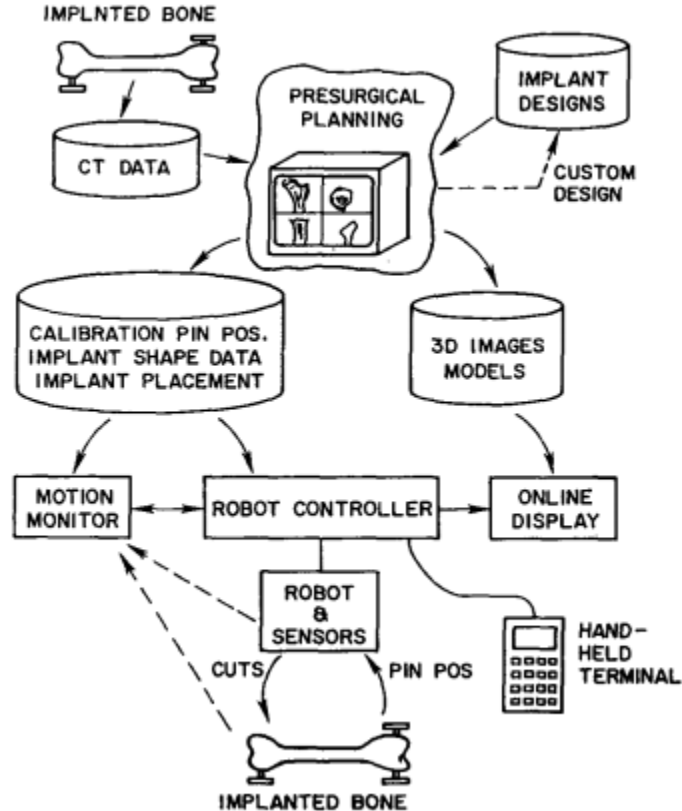
- Problems can arise during traditional hip replacement surgery
  - Gaps between implant and bone can get infected
  - Inserting implant can cause cracking or fracturing of bone
  - Misalignment of implant

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

# Goals of System

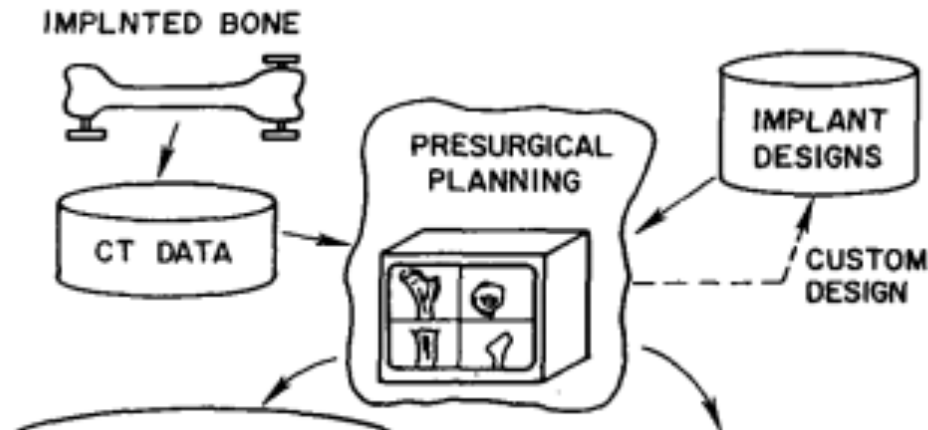
- Human-Machine Interaction in a Surgical Situation
- Registration of Plan Data with Intraoperative Reality
- Verification
- Operating Room Compatibility and Sterility

# 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

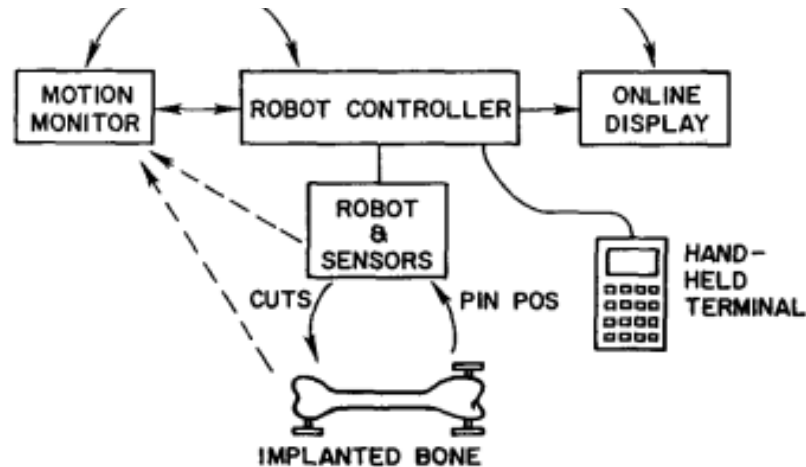


- Pivot Calibration for Robot Tip Calibration

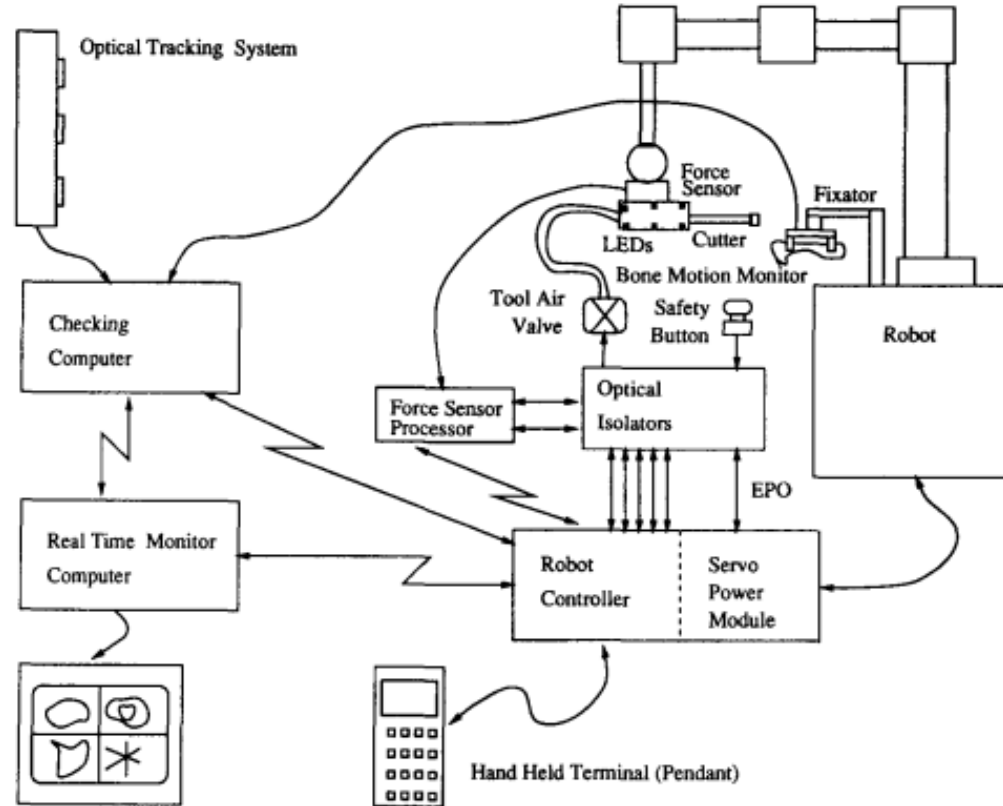


# Surgical Procedure: Drilling

- 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?**