



November 21, 2022

HIPSTER

# Autonomous Reaming for Total Hip Replacement

Team C

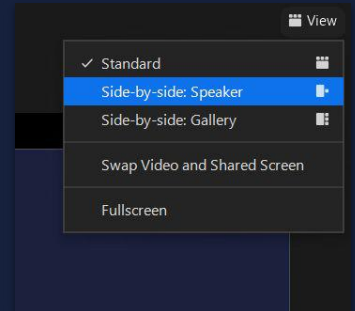
## Fall Validation Demonstration

Zoom Viewers please **mute your microphone** and **turn off your video!** Thank you!

### Zoom Viewing Info:

- Presentation Cam - screenshare of slide presentation
- System Cam - video which highlights system
- Room Cam - video which provides overview of room

Recommended Zoom Settings:





# The Team



**Kaushik Balasundar**

Perception and  
Sensing Lead



**Parker Hill**

Mechanical  
Systems  
Engineering Lead



**Anthony Kyu**

Controls and  
Actuation Lead



**Gunjan Sethi**

Software  
Engineering Lead



**Sundaram Seivur**

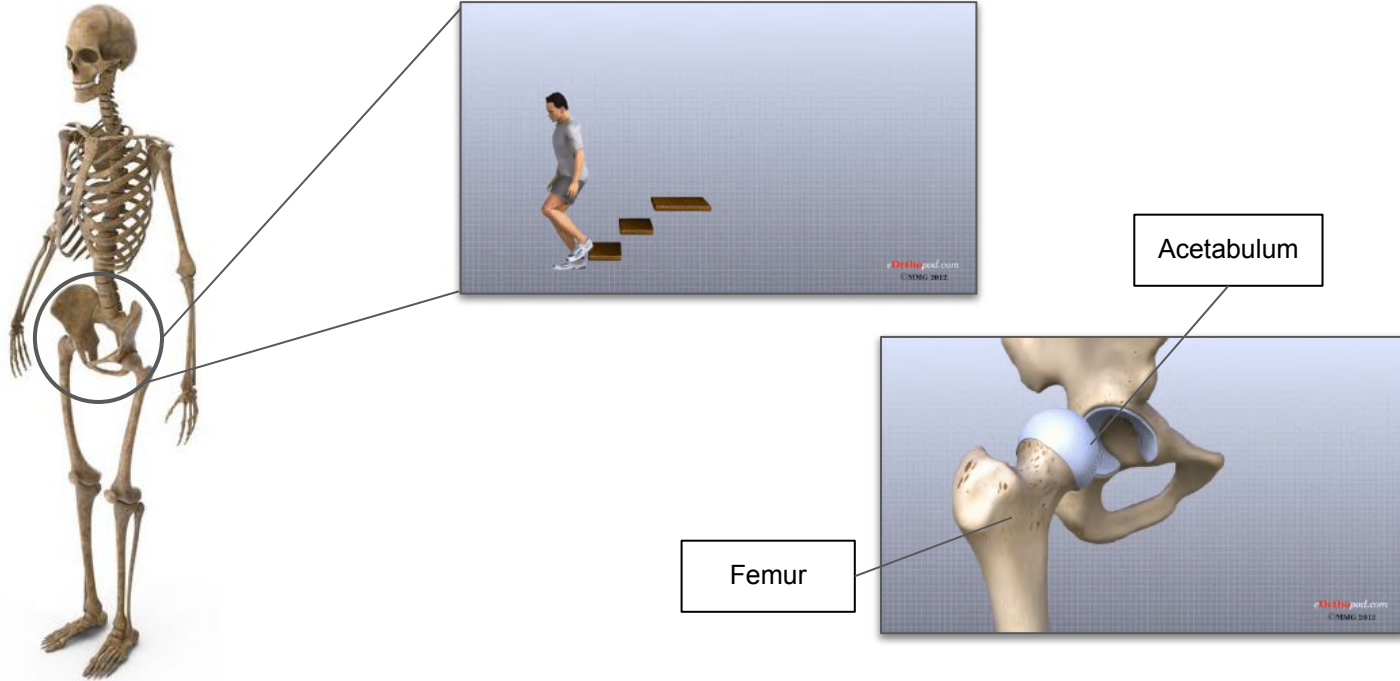
System Validation  
Lead

# Total Hip Replacement

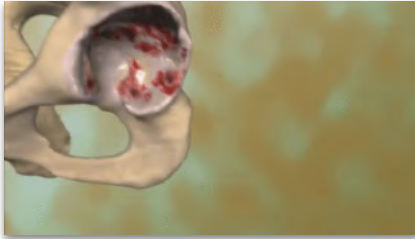
"You have been diagnosed with **arthritis** in your hip. You need **hip replacement surgery!**"



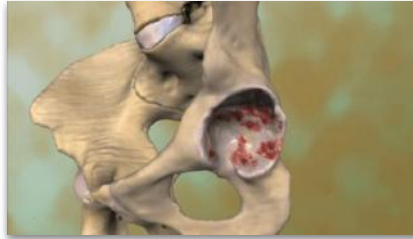
# Total Hip Replacement



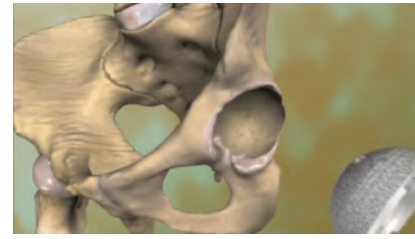
# Total Hip Replacement



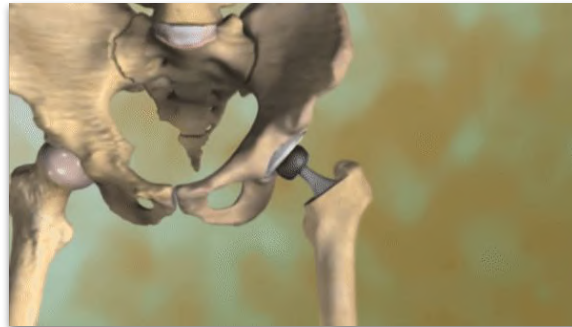
Bone within acetabulum is damaged and must be removed



A reamer is used to remove bad bone

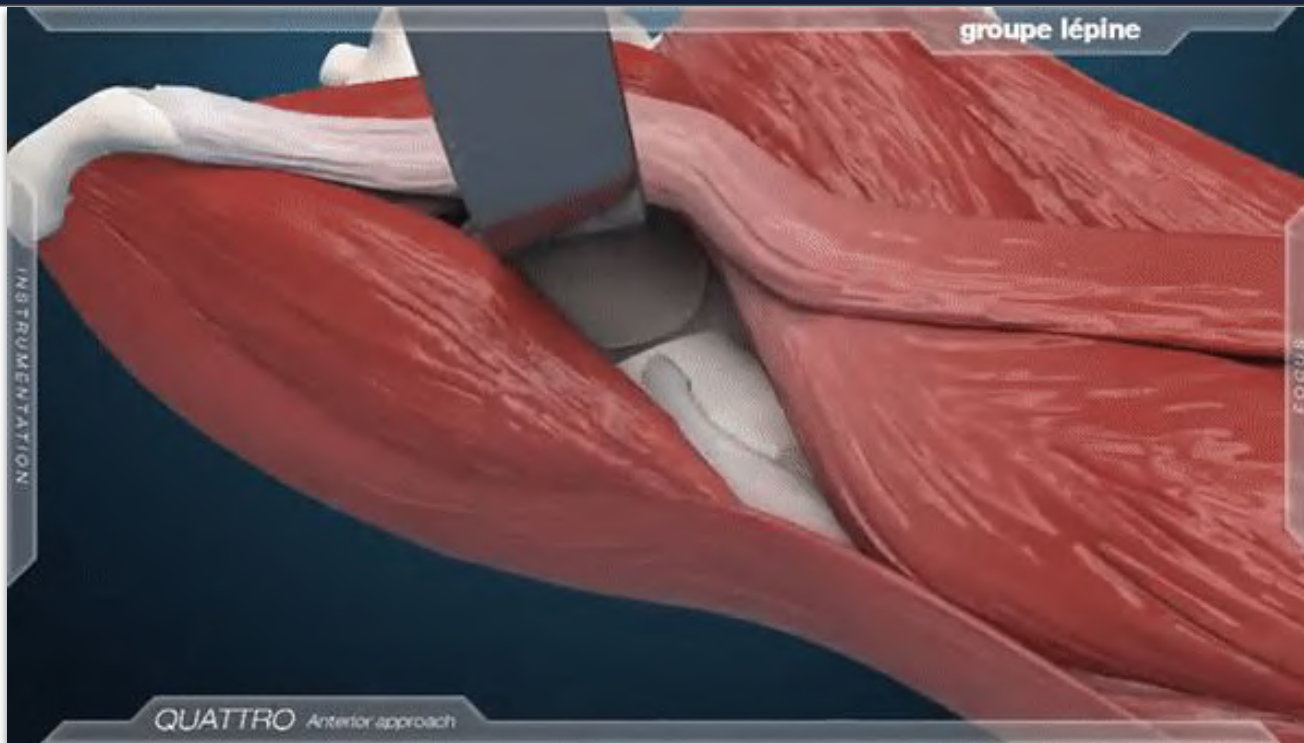


Acetabular implant is fitted



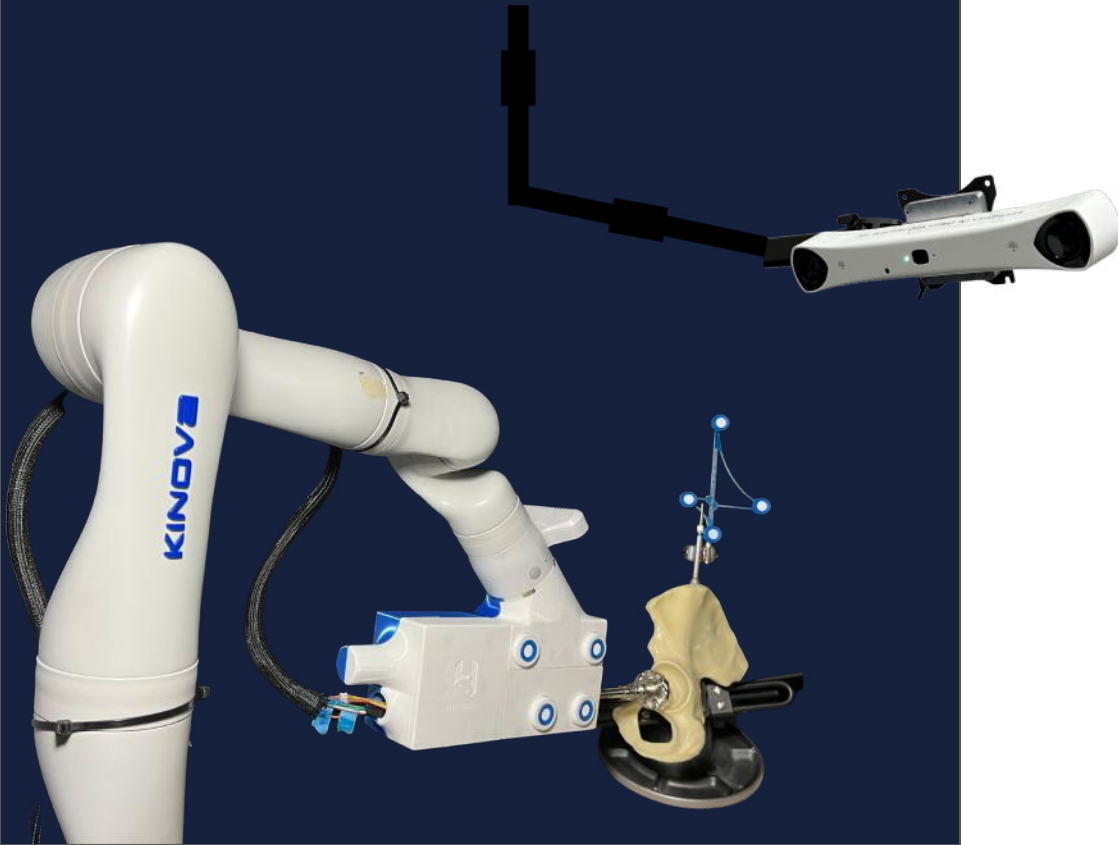
Femur implant fitted, surgery complete!

# Total Hip Replacement



**But surgeons can hardly see the acetabulum and a lot of forces are involved in reaming!**

# Our Solution



A fully autonomous robotic arm aimed at performing acetabular reaming with high accuracy, eliminating the need of surgeons to use intuition to correctly position/angle the reamer.

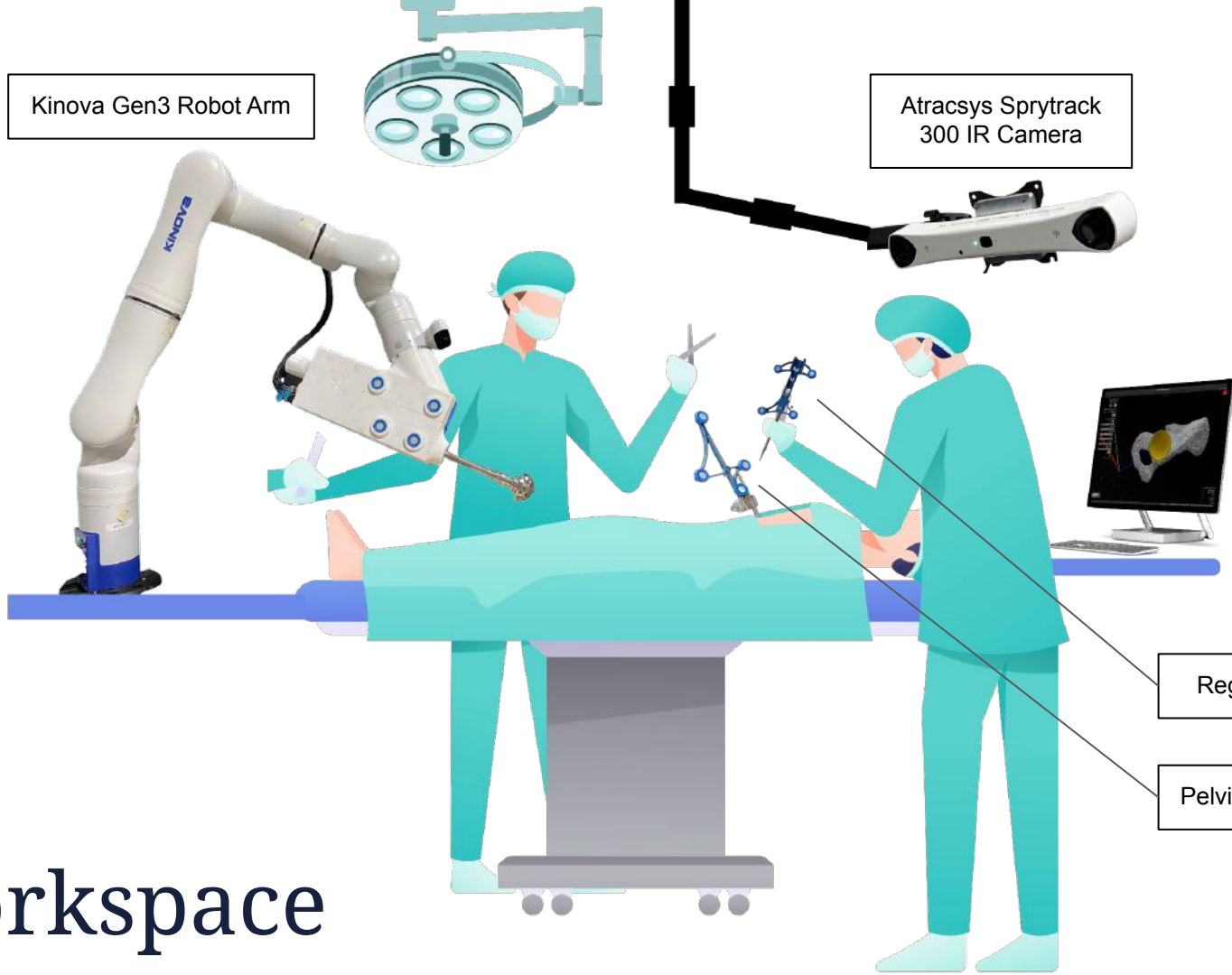
Kinova Gen3 Robot Arm

Atracsys Sprytrack  
300 IR Camera

Surgeon Interface

Registration Probe

Pelvis Marker



# Workspace





Ballistics gel  
simulates how bone  
moves within soft  
tissue

# Why is the pelvis in that? Why are there sandbags?

We want to replicate pelvis motion  
within a human body as accurately  
as possible!

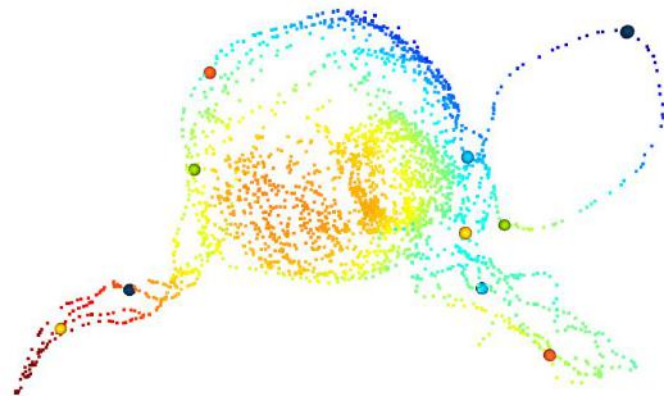


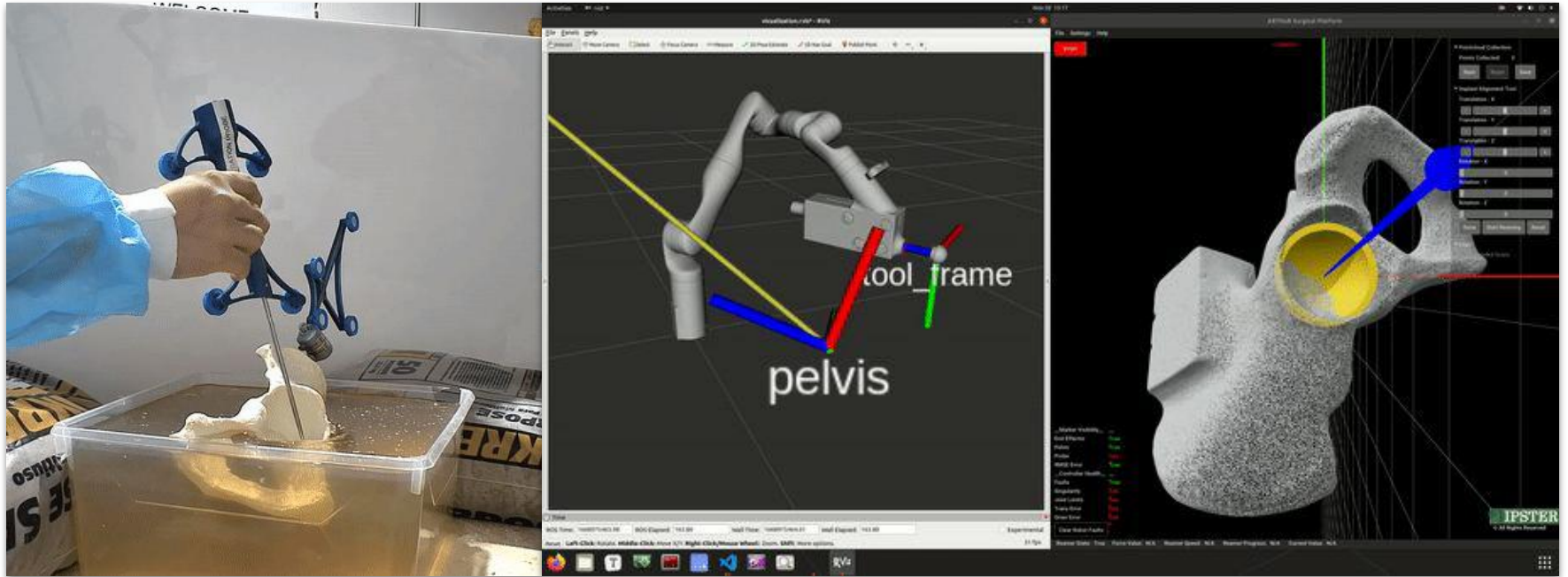
Sandbags simulate  
how the patient body  
moves during surgery

# Pointcloud Collection



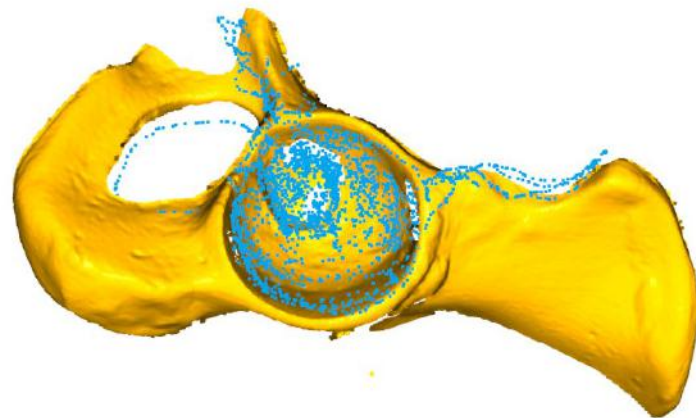
*registration probe  
(for pointcloud collection)*

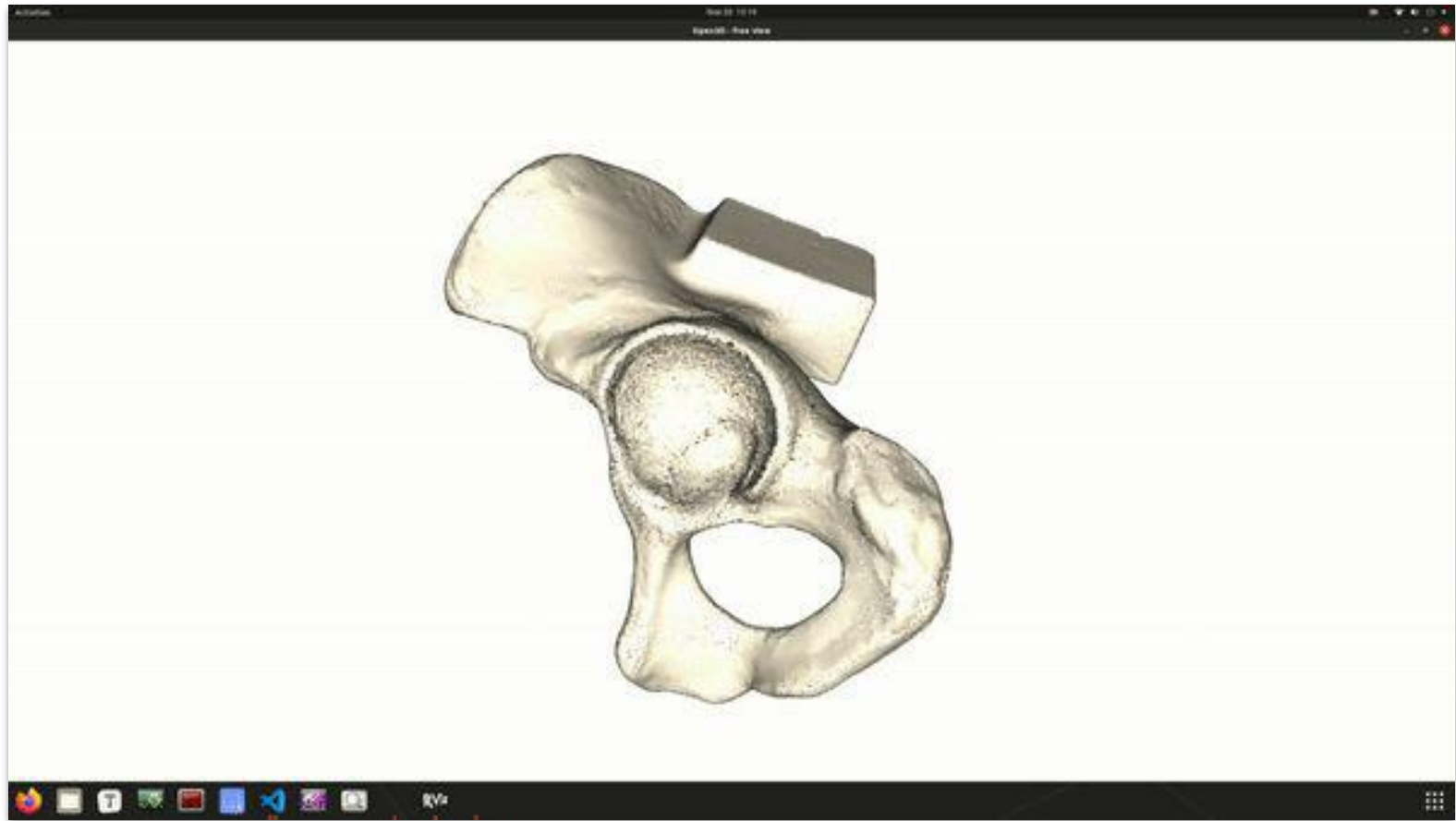




Zoom viewers watch System Cam

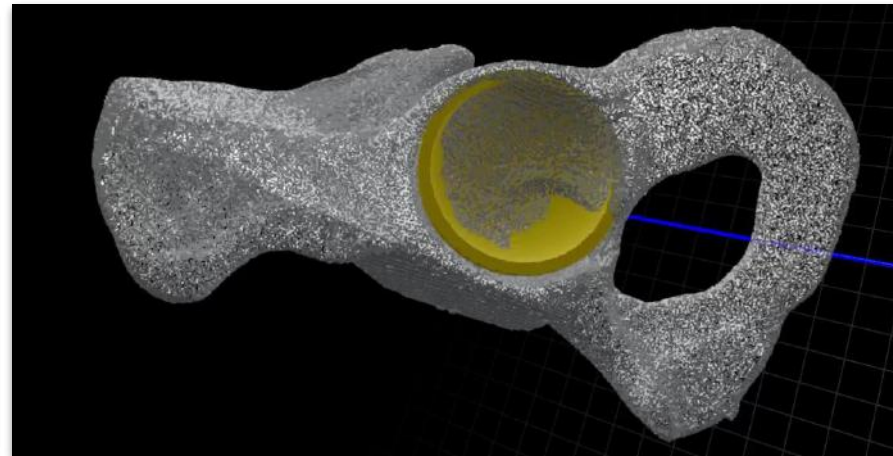
# Landmark Selection + Registration

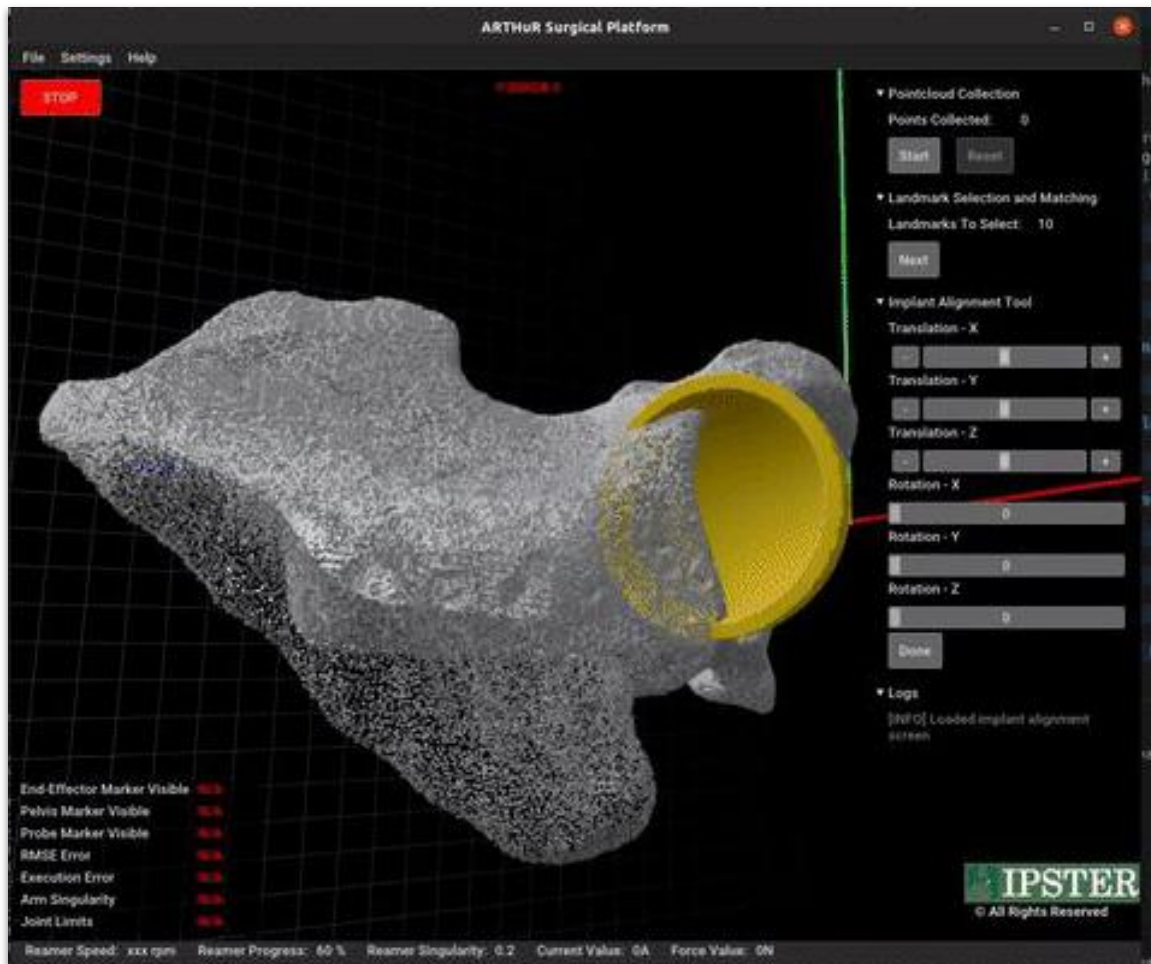




Zoom viewers watch here

# Implant Alignment Tool (Surgeon UI)





Zoom viewers watch here

# Task Prioritization Controls



Most Critical

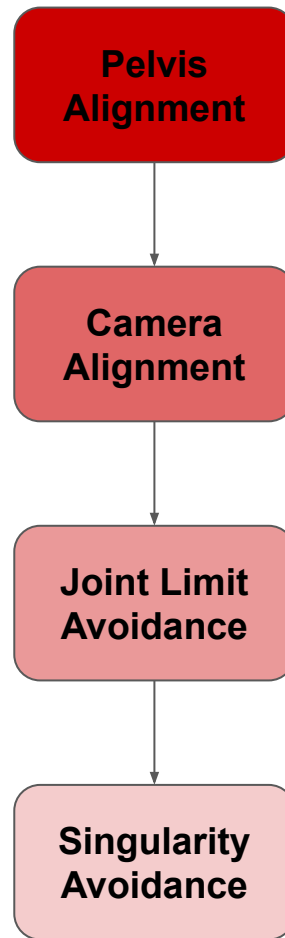
**Pelvis  
Alignment**

**Camera  
Alignment**

**Joint Limit  
Avoidance**

Least Critical

**Singularity  
Avoidance**







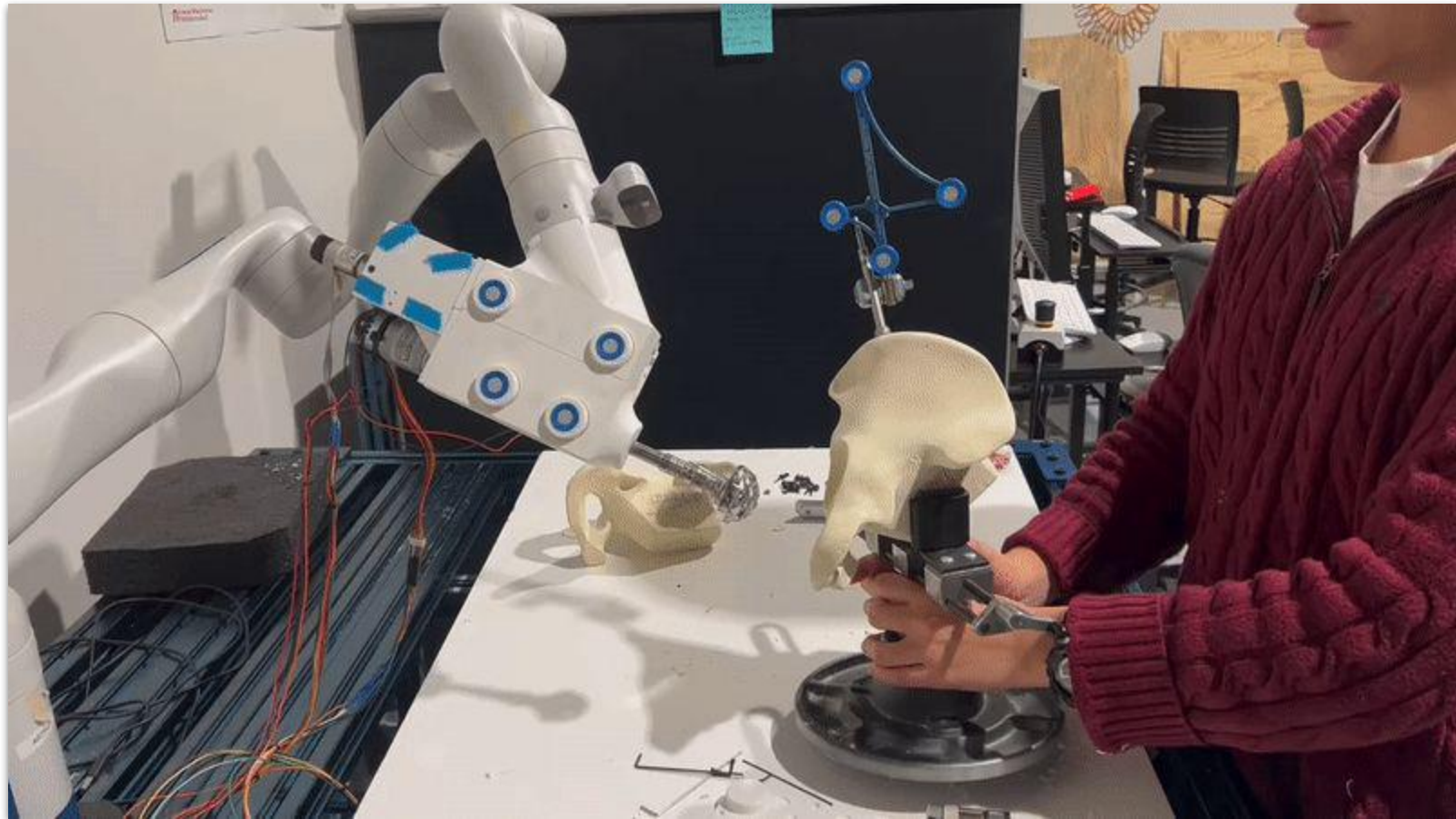
Zoom viewers watch System Cam

# Dynamic Compensation



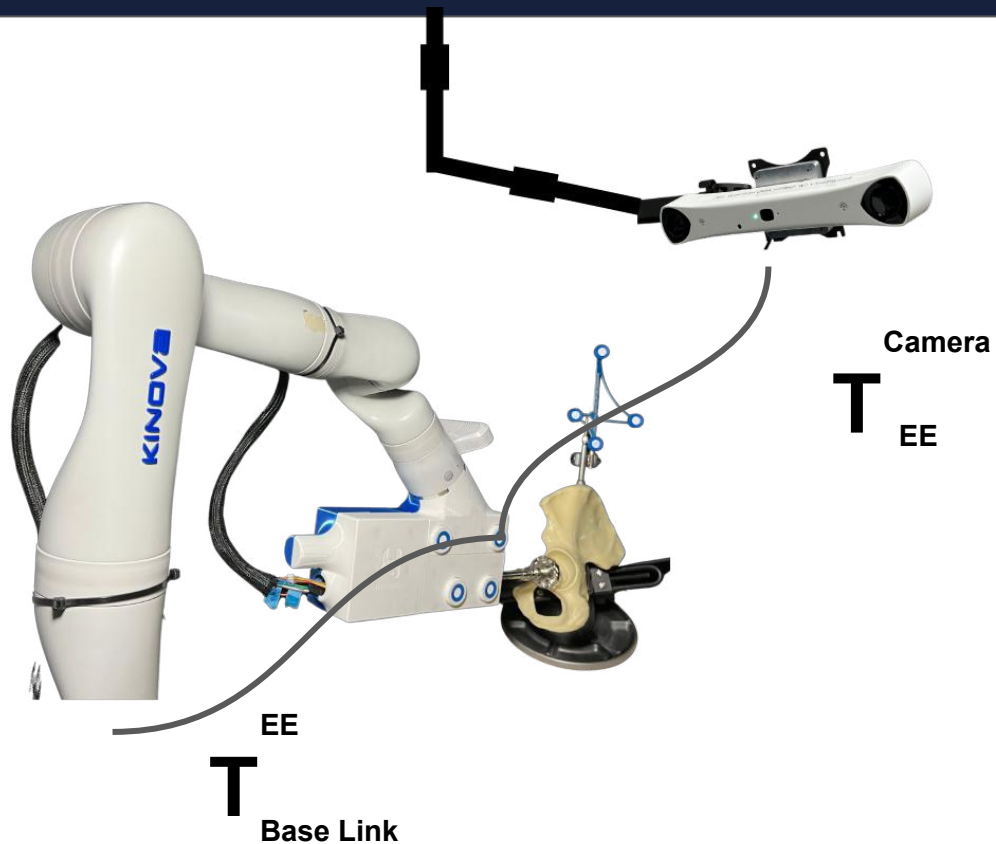
During total hip replacement surgery, the forces acting on the patient while reaming are high due to which the patient moves.

ARTHuR constantly checks for any movement of the patient above a certain threshold and adjusts for that movement, allowing for a consistent axis to be maintained with the acetabulum.



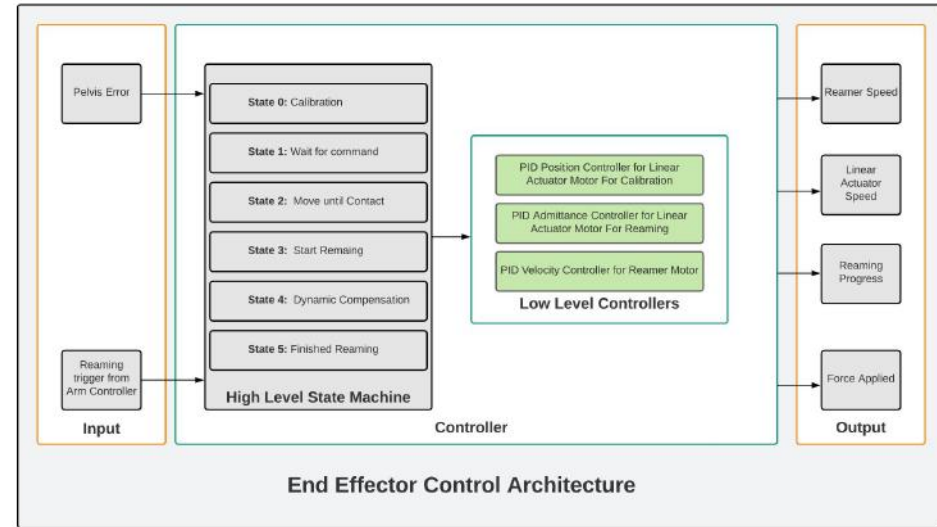
Zoom viewers watch System Cam

# Online Calibration



- **SVD: Offline Calibration**
  - Tsai-Lenz algorithm
  - Needs to be repeated if camera position changes
  - Time consuming
- Robust to changes in camera position
- Arm controls ensures markers are continuously visible to the camera

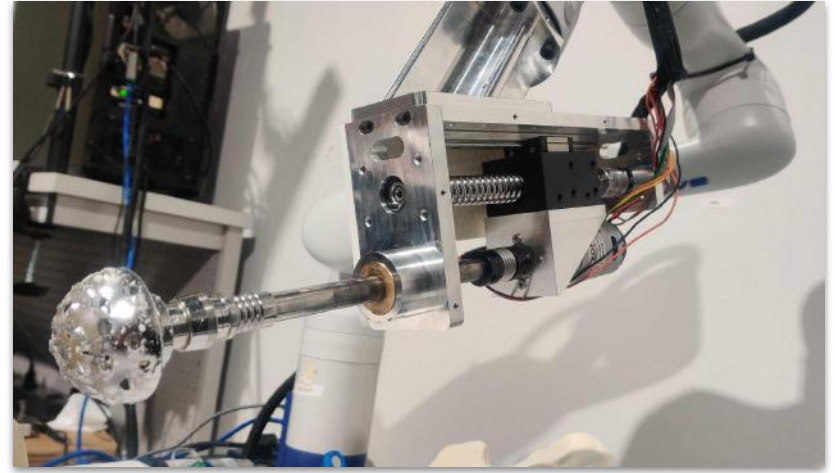
# Reaming Controls

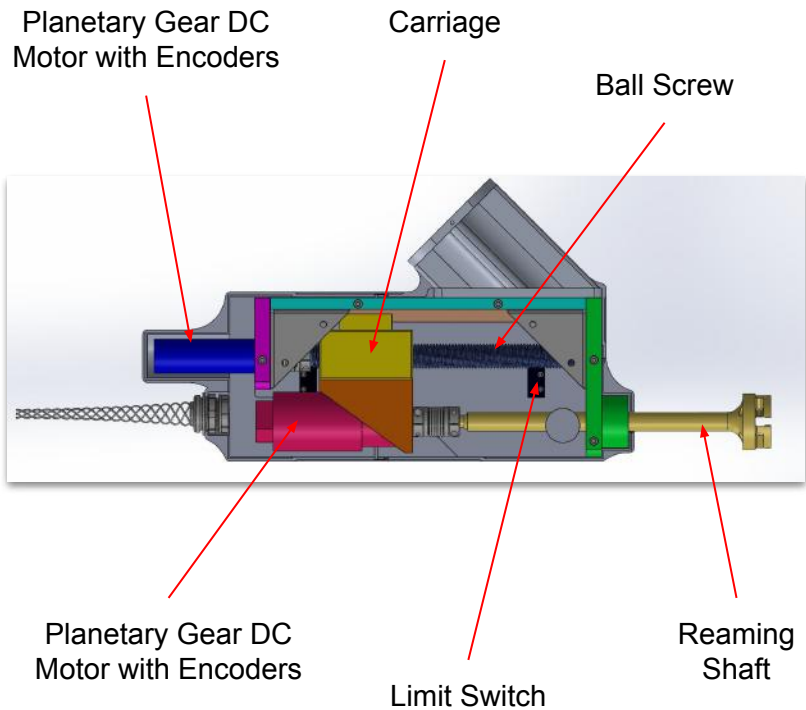




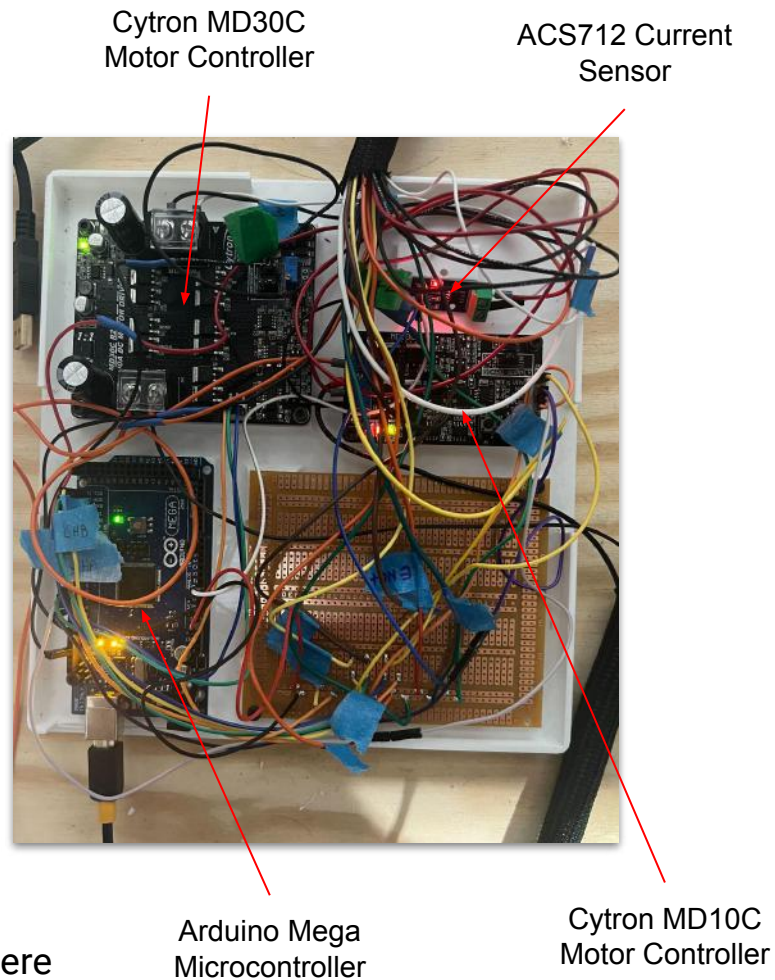
Zoom viewers watch System Cam

# Hardware and Electrical



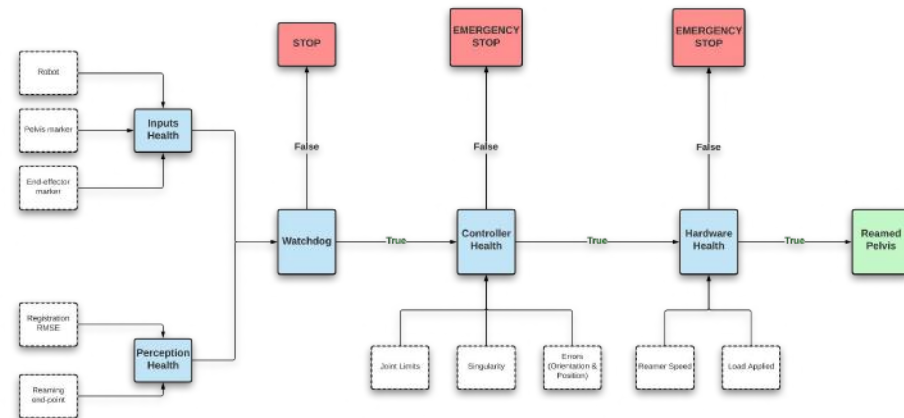


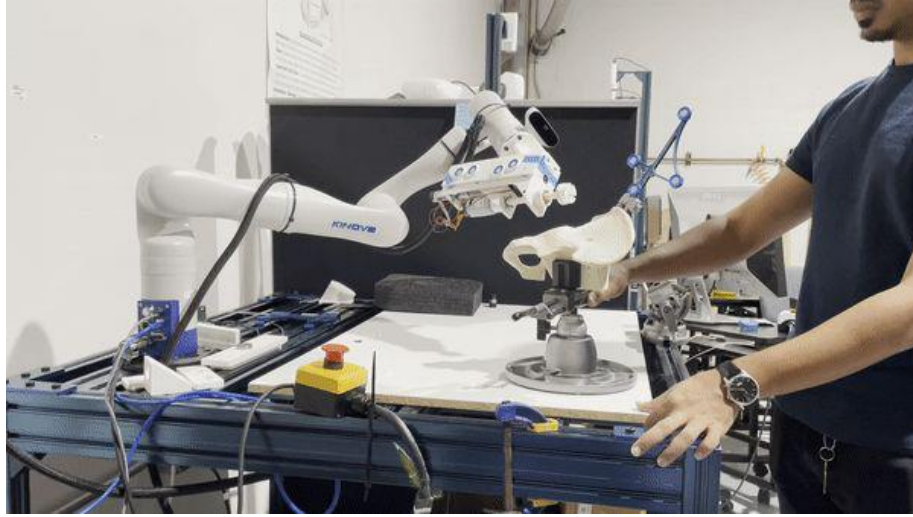
Zoom viewers watch here





# WatchDog





Pelvis not visible  
(patient decides to run away)



Stops controller at any fault

Zoom viewers watch here

# System Validation



Distance computation

Compared: "Test7\_final".part.part

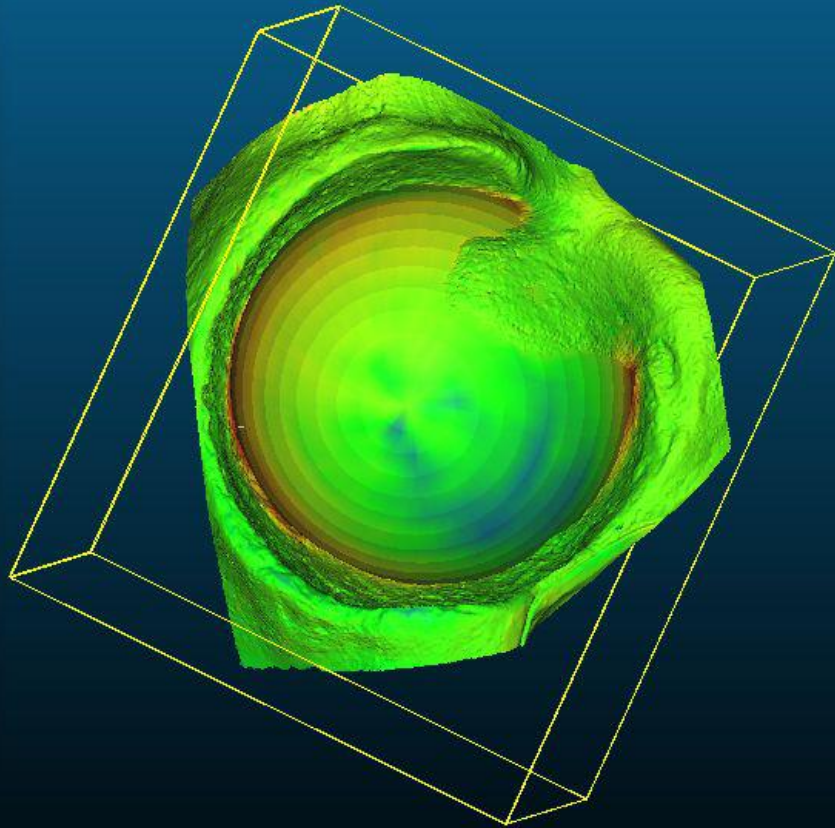
Reference: ASCII STL file generated with VxScan by Creafom..part.part

General parameters | Local modeling | Approximate distances

Warning: approximate distances are only provided to help advanced users setting the general parameters

1	Min dist.	0
2	Max dist.	1.25659
3	Avg dist.	0.0418584
4	Sigma	0.157372
5	Max error	0.280983

Compute Ok Cancel



Zoom viewers watch here

Distance computation

Compared "Test2\_final".part

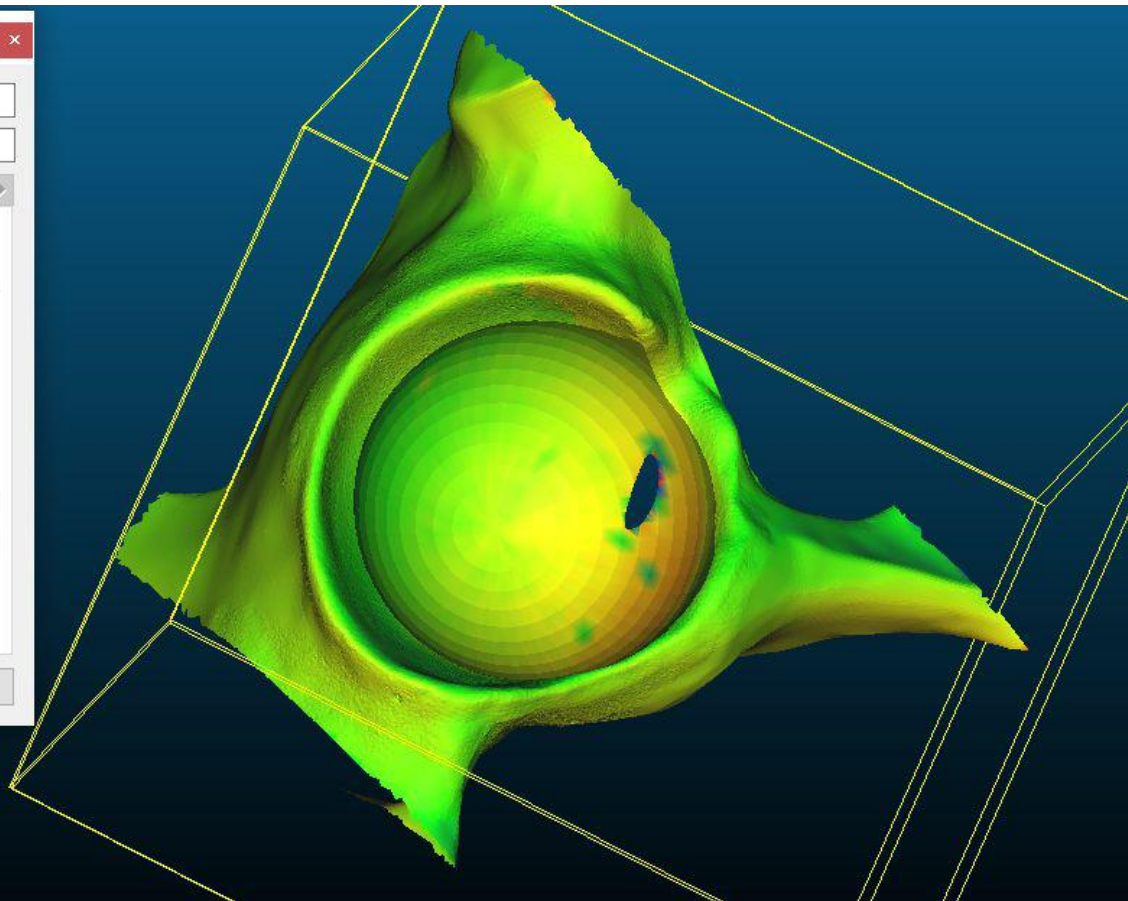
Reference ASCII STL file generated with VxScan by Creaform..part

General parameters Local modeling Approximate distances

Warning: approximate distances are only provided to help advanced users setting the general parameters

1	Min dist.	0
2	Max dist.	2.11534
3	Avg dist.	0.188335
4	Sigma	0.360326
5	Max error	0.431791

Compute Ok Cancel



Zoom viewers watch here

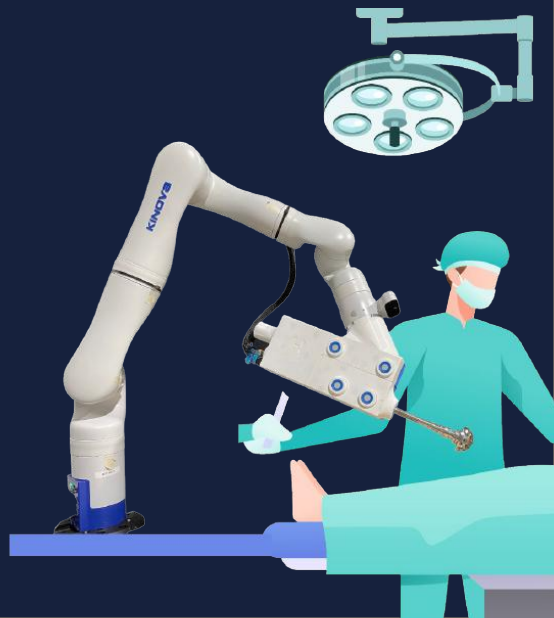
## All Test Results

Test No.	Max. Error
Test 1	1.25659 mm
Test 2	2.115354 mm
Test 3	3.56207 mm
Test 4	2.95984 mm



Zoom viewers watch here

# What you saw today



A robot arm for total hip replacement surgery

that dynamically compensates for patient movement

and improves patient outcomes!

Thank you for  
your support!



### MRSD Advisors:

- John Dolan
- Dimi Apostolopoulos





November 21, 2022



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# Questions and Discussion

Autonomous Reaming for Total Hip  
Replacement (ARTHUR)

