

Team B: Spring Validation Demonstration

Location	Newell-Simon Hall B512
Subsystems	Hardware, Perception, Real-Time Tracking, Error Reporting
Equipment	KUKA LBR MED 7 with custom end-effector, Apple Vision Pro, Intel RealSense D405 camera, Sawbones model of Femur and Tibia, IR-marked fiducial points
Personnel	Aayush Agrawal, Shreenabh Agrawal, Shubh Jain, Gabriel Zaragoza
Duration	~20 minutes

Objectives:

- Detect and track IR-marked fiducial points on bone models in real time
- Reconstruct 3D point clouds of bone and markers and register with global reference frame
- Create a real-time synced digital twin in Apple Vision Pro
- Track and stream the digital twin to Apple Vision Pro at ≥ 10 Hz
- Validate accuracy against ground truth using pre-marked positions

Procedure:

Setup:

- Assemble workspace with Sawbones model mounted on surgical table with IR fiducials
- Calibrate sensors: intrinsic/extrinsic calibration of Intel RealSense relative to KUKA base frame
- Verify hardware and software E-stop functionality

Demonstration:

- Launch perception pipeline to detect IR markers and establish initial point cloud with arm trajectory
- Execute point cloud registration to align with precomputed bone geometry
- Display the synchronized digital twin of arm and real-time bones tracking in Apple Vision Pro
- Verify localization of tracked points against pre-marked ground truth positions
- Repeat steps 4–7 for 3 distinct fiducial point locations and bone orientations without manual recalibration

Verification:

- Apple Vision Pro updates tracked point overlay with latency ≤ 500 ms
- IR fiducials are continuously tracked $\geq 95\%$ of total run time
- At least **2 of 3** tracked points are localized within ± 5 mm of ground truth (measured via pre-marked positions)
- Digital twin is tracked and streamed at a rate of ≥ 10 Hz
- System Tracking drift ≤ 2 mm over 5-minute continuous monitoring window

Notes:

- SVD Encore: Document all tracking errors and deliver system refinements based on feedback from primary demonstration