Coordinate Transformation Descriptions

Upper Leg:

Relevant Coordinate Systems:

1. OPT_World Optotrak world coordinate system
2. FEM Femur bone coordinate system
3. FEM_OS Femur Optotrak sensor coordinate system
4. US Ultrasound (tip) coordinate system
5. US_OS Probe housing Optotrak sensor coordinate system
6. HC Housing assembly coordinate system (CAD model)
7. HP Probe housing coordinate system
8. VN VectorNav coordinate system
9. LC Load Cell coordinate system
10. FEM_M Femur registration marker coordinate system
11. FEM_I Femur imaging coordinate system (MRI)

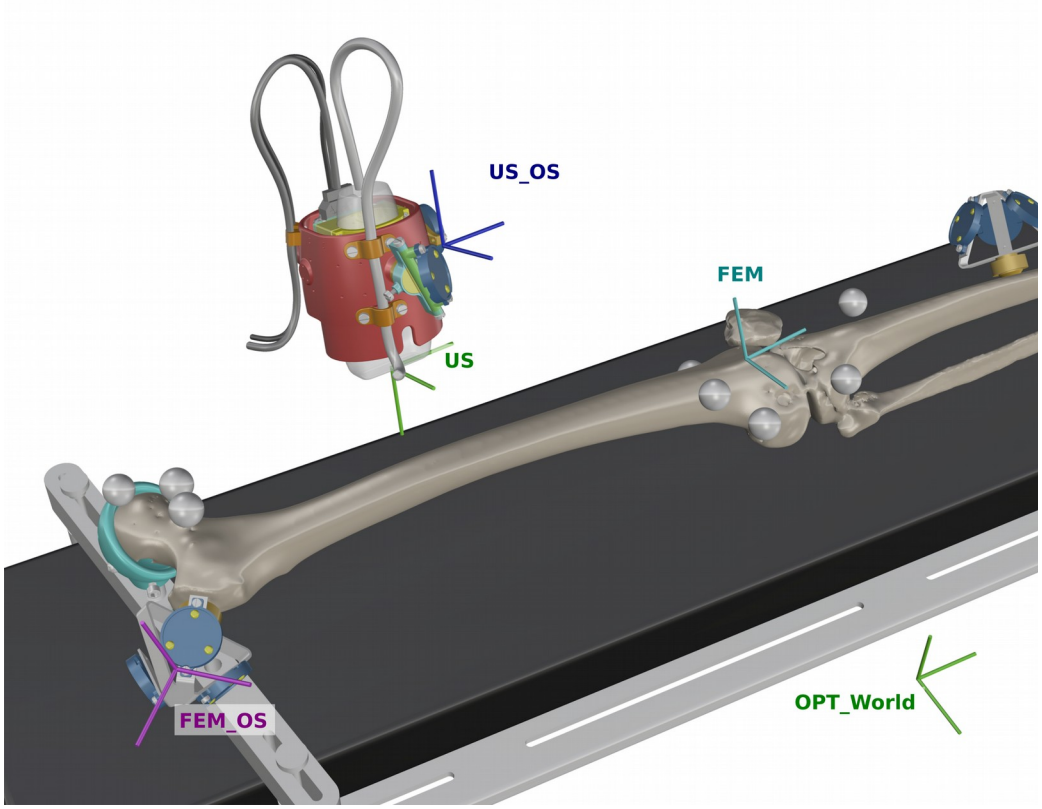

Figure 1: Coordinate systems for the upper leg segment ultrasound data collection. The leg is positioned in the fixture for image collection of the anterior, medial and lateral sides and is flipped over and removed from the fixture to collect the posterior locations.

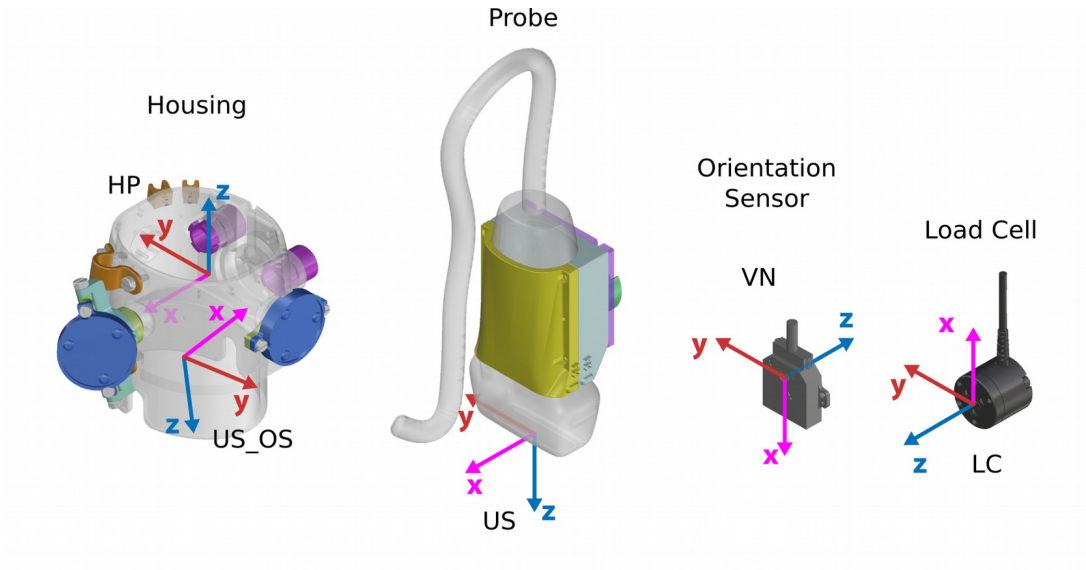

Figure 2: Probe assembly coordinate definitions.

Transformations:

1. Transformation from FEM_OS to FEM ($T_{FEM\_OS,\ FEM}$)
    - [Probe-Femur Position] T_Sensor1_RB1
2. Transformation from US_OS to US (tip) ($T_{US\_OS,\ US}$)
    - [Probe-Femur Position] T_Sensor2_RB2
3. Transformation of load cell to US tip ($T_{LC,\ US}$)
    - [6-DOF Load] T_REF_LOAD
    - Uses CAD model and digitization of points on probe housing to get this relationship
4. Transformation of Ultrasound Position (x,y,z) to Bone Optotrak Coordinate System

    $T_{FEM\_OS,\ US} = (T_{OPT\_WORLD,\ FEM\_OS})^{-1}\ T_{OPT\_WORLD,\ US}$

    where $T_{OPT\_WORLD,\ US}$ comes from the ultrasound sensor data [US Probe_smart_02] and $T_{OPT\_WORLD,\ FEM\_OS}$ is built from the x,y,z,r,p,w of the femur sensor. $T_{FEM\_OS,\ US}$ gives the position and orientation data of the ultrasound (tip) in the femur Optotrak coordinate system.

    OR

    $T_{FEM\_OS,\ US} = T_{FEM\_OS,\ FEM}\ T_{FEM,\ US}$

    where $T_{FEM,\ US}$ comes from the Probe-Femur State [Probe-Femur Position] and $T_{FEM\_OS,\ FEM}$ is described above.

As expected, these two methods result in the same positions and orientations: