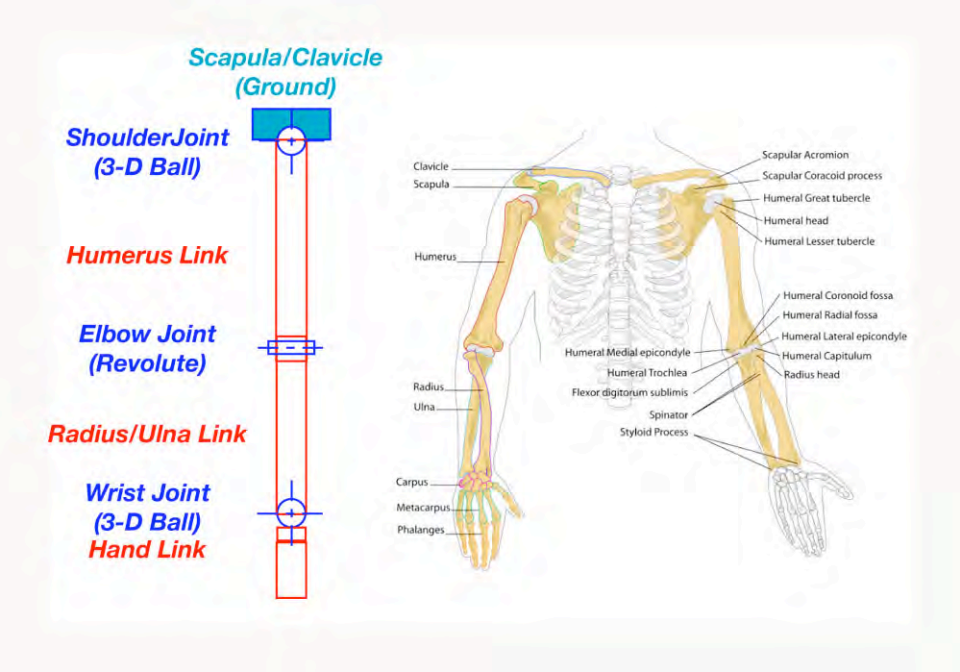
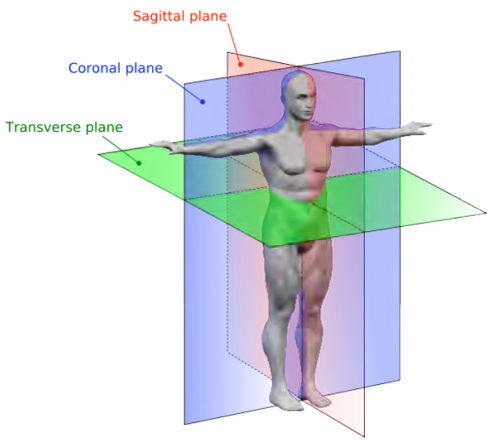
MAE 345
Robotics and Intelligent Systems

Assignment #2
due: September 29, 2011



The assignment is to characterize the workspace and motions of a human arm and hand as an articulated robot. The original reference frame is established by the scapula and clavicle, which are assumed to be fixed. Simplifying assumptions are made about the representation of the humerus, radius, ulna, and carpus by links and joints, with the metacarpus and phalanges each modeled as objects. We want to identify the homogeneous coordinates and the coordinate transformations that allow position vectors expressed in the hand frame to be expressed in a coordinate frame that is fixed to the reference frame, and vice versa.

First, however, the arm-hand model must be designed. The model's principal joints are the shoulder, the elbow, and the wrist. There are three links: humerus (length = 25 cm), combined radius/ulna (length = 25 cm), and hand (length = 18 cm). You may substitute your own arm and hand dimensions if you wish. In the reference position, the humerus and



radius/ulna, are in the coronal plane, and the hand is parallel to the transverse plane.

Human joints are quite complex, and so they are simplified for this exercise. The shoulder joint is characterized as a three degree-of-freedom ball joint, which is free to yaw, pitch, and roll. The elbow's action is modeled by a revolute joint that is free to pitch. The wrist allows pitching, yawing, and rolling, modeled by a ball joint with three degrees of freedom.

1) Determine the maximum and minimum joint deflections for your model by moving your own joints to their limits. Do not overdo it; you must do no damage to yourself to complete this assignment!

2) Identify the four link parameters and the joint variable for each element of your model.

3) Formulate the Denavit-Hartenberg transformation matrices for each element of your model.

4) Write a MATLAB script that executes the transformation of a vector from the hand frame to the origin (scapula/clavicle) frame of reference.

5) Determine the workspace of your model, assuming that the origin (reference) frame is fixed with one axis aligned to the vertical, another parallel to the sagittal plane, and the third parallel to the coronal plane. How does it compare to the workspace for your own hand?

6) Transform a position vector that represents the center of mass of the hand from the hand frame to the scapula/clavicle frame for five typical *T'ai Chi Chih* poses of the arm-hand model, as described in the four pictures. Numerically present the joint deflections and the net homogeneous transformation matrices for each case using your MATLAB code to generate the results.

a) Right arm-hand

b) Left arm-hand

c) Right arm-hand

d) Right and left arm-hand

References

http://en.wikipedia.org/wiki/Tai_chi_chih

http://www.youtube.com/watch?v=qi8oT0aG2Fk