ENPM 808M - Project Pre-Proposal

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Major: Professional Masters in Robotics

Proposed Topic: We propose to create a model of an anthropomorphic gripper, with four fingers and a thumb. This model could be used for dexterous gripping actions that most industrial grippers are not capable of currently.

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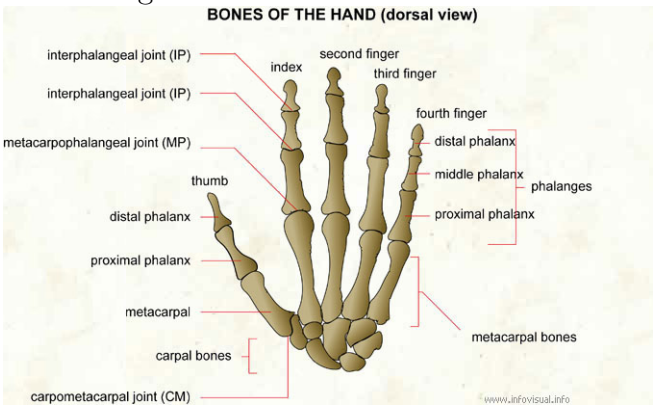
Proposal

In this project, we aim to model and simulate a basic anthropomorphic gripper, based on four fingers and a thumb. Note that we do not attempt to model the gripper biomimetically. Most common industrial grippers have two or three gripping surfaces which are useful when 'top-down' gripping is required. However, for a more dexterous approach at gripping objects, a more natural gripping solution is required.
The human hand is capable of 27 degrees of freedom, including the rotation and translation of the wrist.[1] Here we aim to model only the 19 degrees of freedom provided by the fingers and thumb only.

Figure 1: Bones in Human Hand



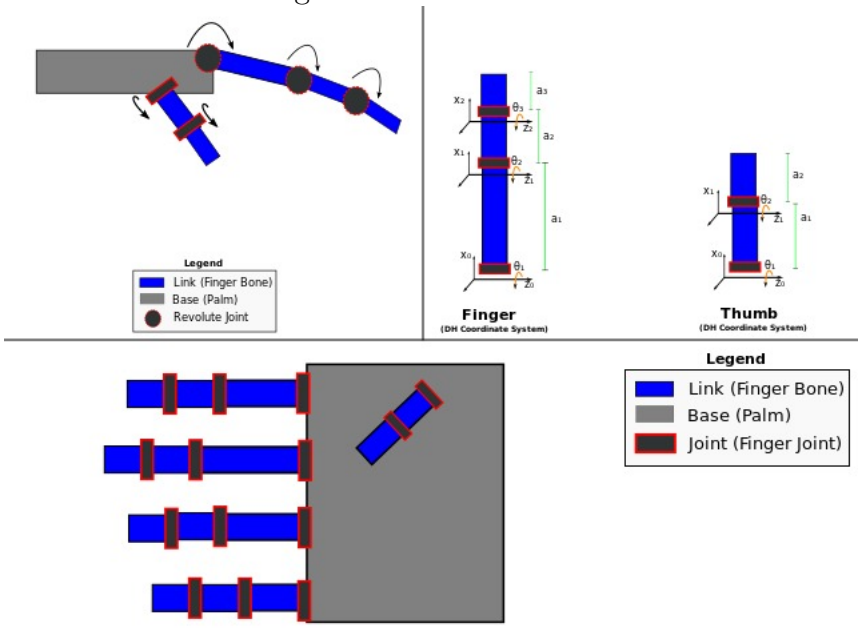
- Fingers (4 DOF each)
  As seen in figure 1, each finger has a joint between the distal and the middle phalange and a joint between the middle and the proximal phalange. These allow extension/flexion (2 DOF).

There is also a joint between the proximal phalange and the metacarpal that allows for abduction/adduction along with the standard flexion/extension (2 DOF).

- Thumbs (5 DOF)
  The thumb has an interphalangeal joint between the distal and proximal phalanges allowing flexion/extension (1 DOF); a metacarpophalangeal joint between the proximal phalanx and metacarpal allowing flexion/extension and abduction/adduction (2 DOF); a carpometacarpal joint between the metacarpal and trapezium allowing flexion/extension and abduction/adduction (2 DOF).
  Out of these 5 degrees of freedom, we aim to model only 3, namely the joints between distal and proximal phalanges and the joint between proximal phalanx and metacarpal.

Now, consider the following diagram for a model of the anthropomorphic gripper.[2]

Figure 2: Model of Hand

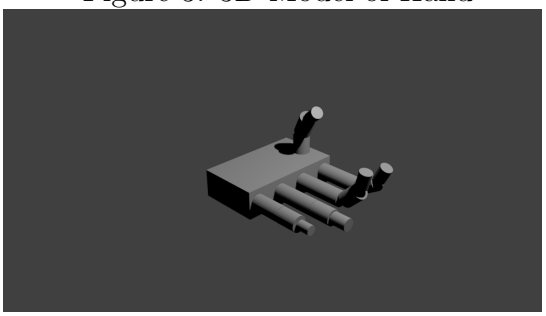


From Figure 2, we propose the following DH parameters for the anthropomorphic gripper:

- Fingers

Link (i)	a_i	α_i	d_i	θ_i
1	a_1	0	0	θ_1
2	a_2	0	0	θ_2
3	a_3	0	0	θ_3

Figure 3: 3D Model of Hand



- Thumb

Link (i)	a_i	α_i	d_i	θ_i
1	a_1	0	0	θ_1
2	a_2	0	0	θ_2

Given these parameters, we can aim to find the forward kinematic equations for each of the finger tips. Also, since we are assuming each finger to be its own kinematic chain, we can get precise control over the motion of each finger, independent of each other.

Further Scope

At a later stage in the project, we aim to add a 'sideways' motion to the base of each finger as well, as can be seen in a human hand.
Also, we can attach the gripper to the end of a generic Stanford Arm to fully realize the range of motion provided by an actual human hand.

Tentative Timeline

Goal I (Minimum Objective)
Modelling of basic 14 DOF hand, including IK calculations for the same.

- *Nov. 1, 2015 - Nov. 15, 2015*
  CAD Model and 3D Animation
- *Nov. 16, 2015 - Nov. 30, 2015*
  Inverse kinematics calculations
  SimMechanics Simulation

Goal II (Intermediate Objective)

Adding remaining 5 degrees of freedom, through 'sideways' motion of thumb and fingers

- *Dec. 1, 2015 - Dec. 10, 2015*
  Inverse kinematics calculations
  SimMechanics Simulation

Goal III (Final Objective)

Integration with Stanford Arm

- *Dec. 11, 2015 - Dec. 19, 2015*
  CAD Modelling
  Inverse kinematics calculations
  SimMechanics Simulation

Note

Considering the complexity of this project and the ambitious but achievable target, we hope to finish the entire project by the 19^{th} of December, 2015.
However, we are setting the final goal on standby, to be attempted if time permits us and the other two goals are completed satisfactorily.
The main reason for this being that the aim of this project is to model and simulate the motion of the human fingers as a gripper and not the entire arm itself.

References

[1] StackOverflow. `http://biology.stackexchange.com/questions/30857/does-the-human-hand-have-27-degrees-of-freedom`

[2] Modelling and Control for Soft Finger Manipulation and Human-Robot Interaction. *Fanny Ficuciello*, `http://wpage.unina.it/fanny.ficuciello/files/Thesis_ficuciello.pdf`