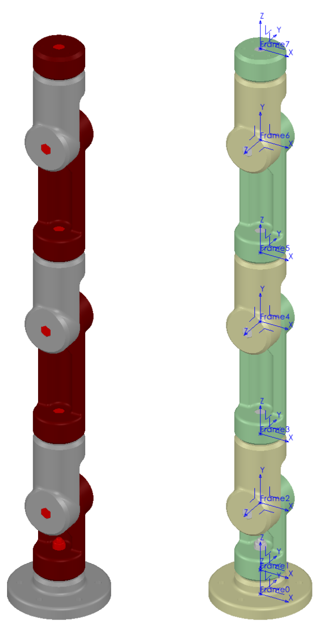
1 Mechanical Design

- Design commentary
  - ⋆ 7R spatial
- Selfies

Physical manipulator

2 Kinematics

- Frame definitions
- D-H parameters
- Forward kinematics



Frame definitions

Joint i	α_{i-1}	a_{i-1}	d_i	θ_i
1	$0°$	0	$l_1 + b$	q_1
2	$90°$	l_2	0	q_2
3	$-90°$	0	$l_2 + b$	q_3
4	$90°$	l_3	0	q_4
5	$-90°$	0	$l_2 + b$	q_5
6	$90°$	l_3	0	q_6
7	$-90°$	0	$l_1 + l_2 + b$	q_7

where $b = \frac{1}{16}$" is the plain bearing flange thickness, $l_1 = 1$", $l_2 = 3$", and $l_3 = 5$".

$$
\begin{aligned}
{}^0_1T &= \begin{bmatrix} cq_1 & -sq_1 & 0 & 0 \\ sq_1 & cq_1 & 0 & 0 \\ 0 & 0 & 1 & l_1+b \\ 0 & 0 & 0 & 1 \end{bmatrix} = \begin{bmatrix} cq_1 & -sq_1 & 0 & 0 \\ sq_1 & cq_1 & 0 & 0 \\ 0 & 0 & 1 & 1.0625 \\ 0 & 0 & 0 & 1 \end{bmatrix} \\
{}^1_2T &= \begin{bmatrix} cq_2 & -sq_2 & 0 & l_2 \\ 0 & 0 & -1 & 0 \\ sq_2 & cq_2 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} = \begin{bmatrix} cq_2 & -sq_2 & 0 & 3 \\ 0 & 0 & -1 & 0 \\ sq_2 & cq_2 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \\
{}^2_3T = {}^4_5T &= \begin{bmatrix} cq & -sq & 0 & 0 \\ 0 & 0 & 1 & l_2+b \\ -sq & -cq & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} = \begin{bmatrix} cq & -sq & 0 & 0 \\ 0 & 0 & 1 & 3.0625 \\ -sq & -cq & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \\
{}^3_4T = {}^5_6T &= \begin{bmatrix} cq & -sq & 0 & l_3 \\ 0 & 0 & -1 & 0 \\ sq & cq & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} = \begin{bmatrix} cq & -sq & 0 & 5 \\ 0 & 0 & -1 & 0 \\ sq & cq & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \\
{}^6_7T &= \begin{bmatrix} cq_7 & -sq_7 & 0 & 0 \\ 0 & 0 & 1 & l_1+l_2+b \\ -sq_7 & -cq_7 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} = \begin{bmatrix} cq_7 & -sq_7 & 0 & 0 \\ 0 & 0 & 1 & 4.0625 \\ -sq_7 & -cq_7 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}
\end{aligned}
$$

where $q = q_i$ for ${}^{i-1}_{\ \ i}T$.

3 Control

- Description
- Lyapunov stability proof
- Impluse respose plots

downflop_bullet.mp4
upflop_bullet.mp4