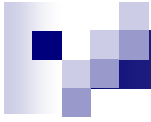




Robot Simulation

CHUI Chee Kong, PhD
Control & Mechatronics Group
Mechanical Engineering, NUS

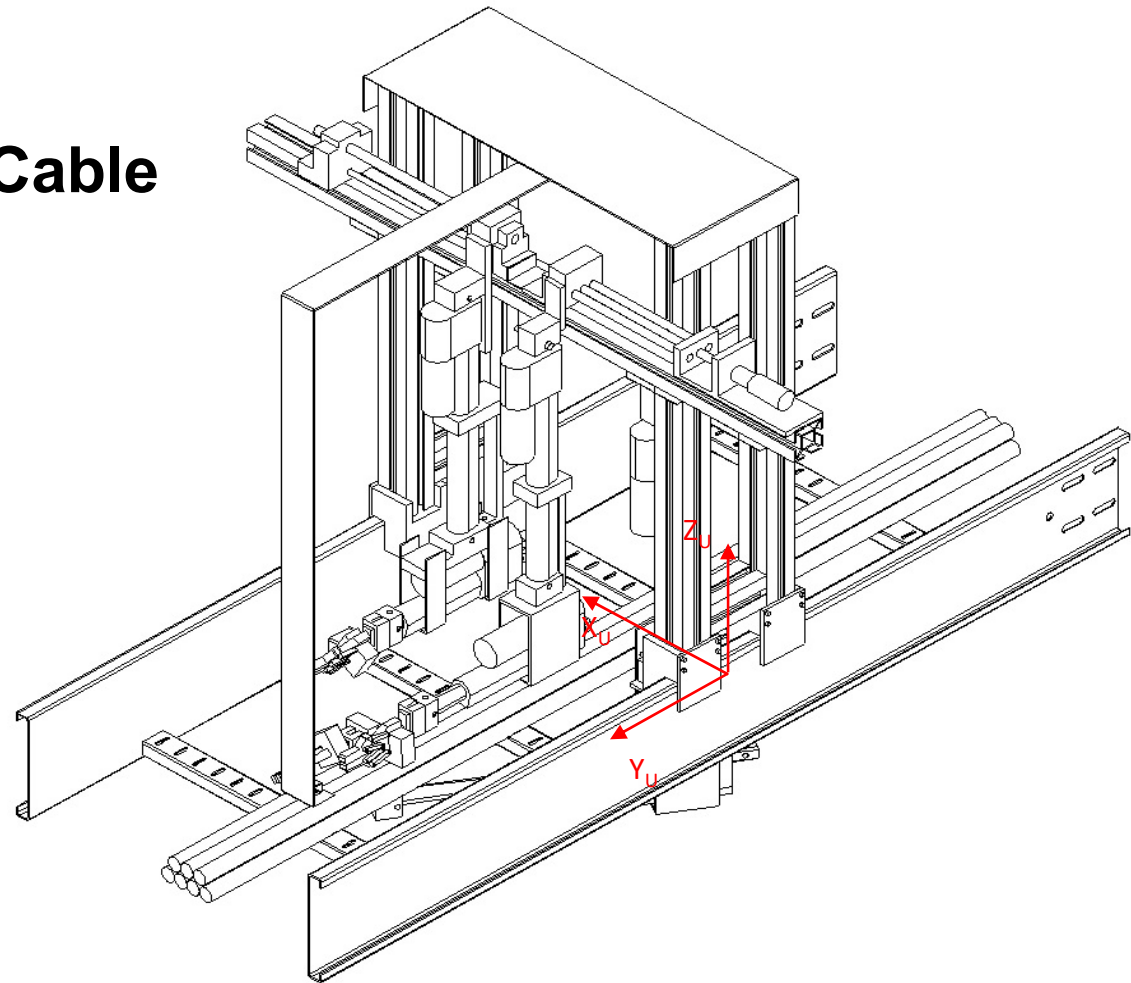


Perspective

- A robotics simulator help creates application for a physical robot without depending on actual machine.
- 1990s: Robot models were not precise; cycle times and robot paths did not match the real world; significant rework to create the actual system
- Need to enhance robot simulation accuracy, robot off-line programming methodology
- Replication of physical environments virtually, digital twins

Robotic System

- **Robot-assisted Cable Binding**



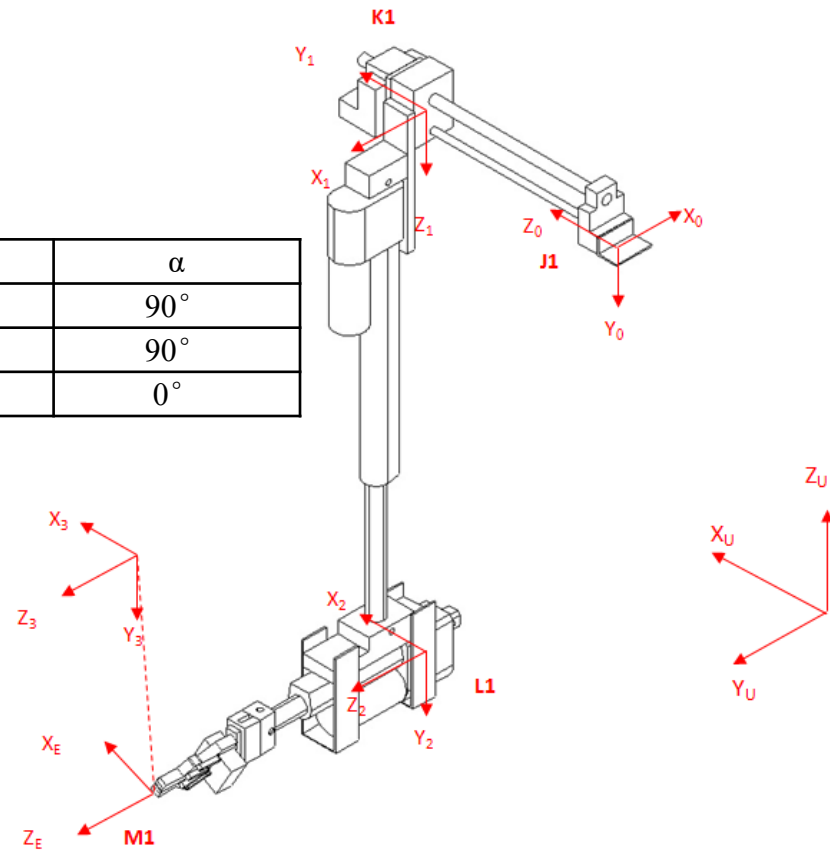
Forward Kinematics (Right Arm)

- DH parameters

	θ	r	d	α
Link 1	180°	r_6	0	90°
Link 2	90°	r_7	0	90°
Link 3	0	r_8	0	0°

- Link transformation matrix

$${}^{i-1}T_i = \begin{bmatrix} \cos \theta_i & -\cos \alpha_i \sin \theta_i & \sin \alpha_i \sin \theta_i & d_i \cos \theta_i \\ \sin \theta_i & \cos \alpha_i \cos \theta_i & -\sin \alpha_i \cos \theta_i & d_i \sin \theta_i \\ 0 & 0 & \cos \alpha_i & r_i \\ 0 & 0 & 0 & 1 \end{bmatrix}$$



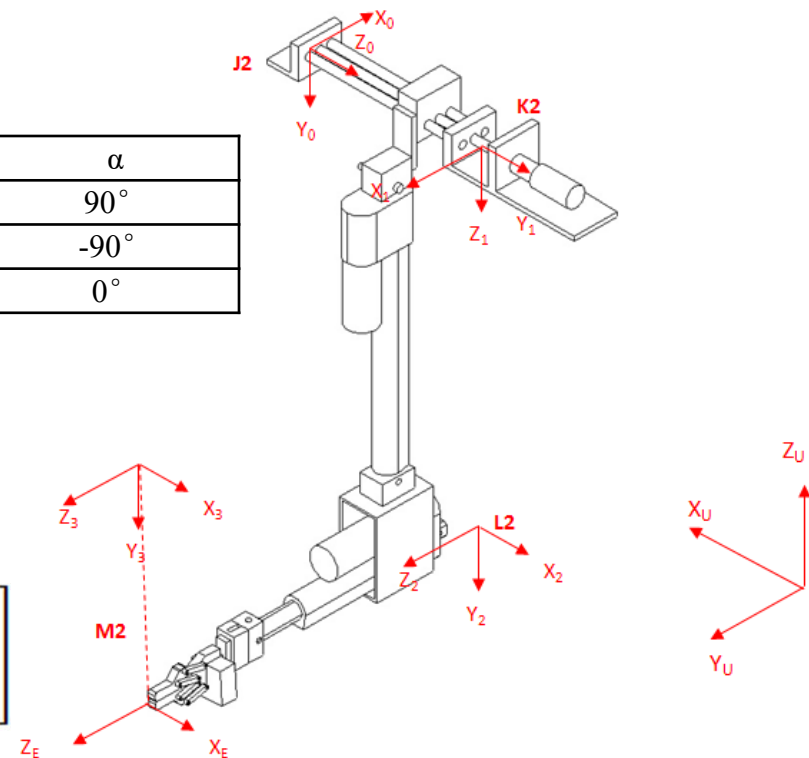
Forward Kinematics (Left Arm)

- DH parameters

	θ	r	d	α
Link 1	180°	r_{11}	0	90°
Link 2	-90°	r_{12}	0	-90°
Link 3	0	r_{13}	0	0°

- Link transformation matrix

$${}^{i-1}T_i = \begin{bmatrix} \cos \theta_i & -\cos \alpha_i \sin \theta_i & \sin \alpha_i \sin \theta_i & d_i \cos \theta_i \\ \sin \theta_i & \cos \alpha_i \cos \theta_i & -\sin \alpha_i \cos \theta_i & d_i \sin \theta_i \\ 0 & 0 & \cos \alpha_i & r_i \\ 0 & 0 & 0 & 1 \end{bmatrix}$$



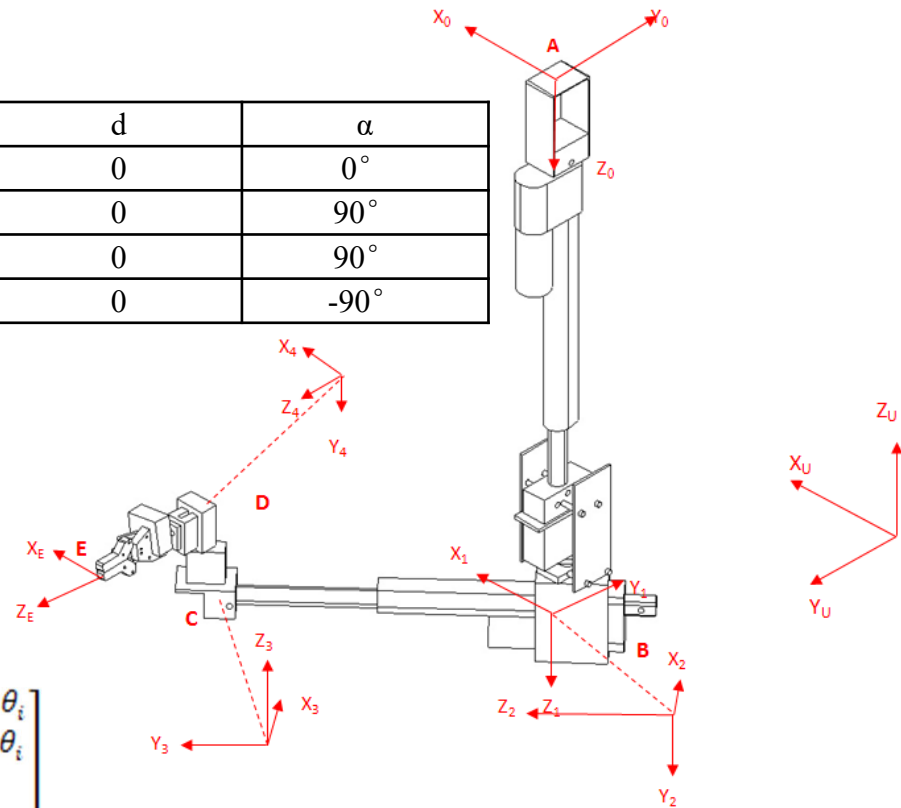
Forward Kinematics (Tail Arm)

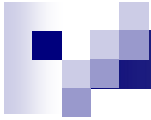
- DH parameters

	θ	r	d	α
Link 1	0°	r_1	0	0°
Link 2	θ_2	0	0	90°
Link 3	0°	r_3	0	90°
Link 4	θ_4	86	0	-90°

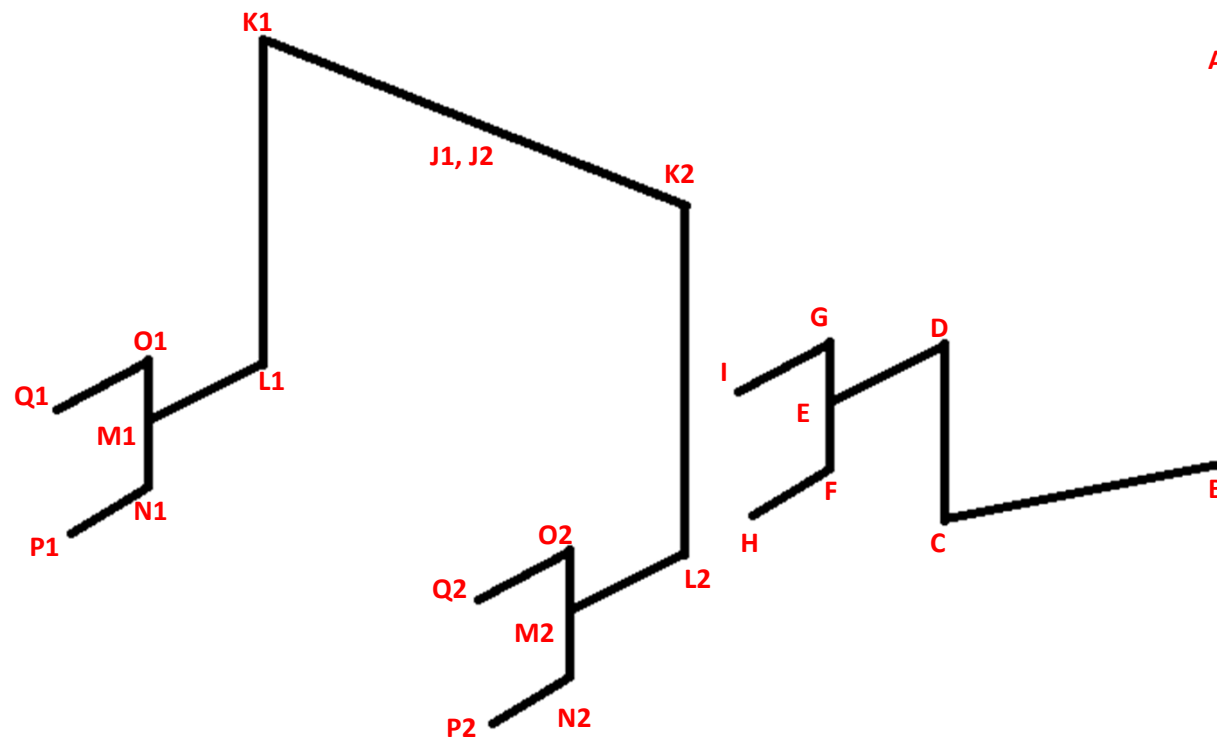
- Link transformation matrix

$${}^{i-1}T_i = \begin{bmatrix} \cos \theta_i & -\cos \alpha_i \sin \theta_i & \sin \alpha_i \sin \theta_i & d_i \cos \theta_i \\ \sin \theta_i & \cos \alpha_i \cos \theta_i & -\sin \alpha_i \cos \theta_i & d_i \sin \theta_i \\ 0 & 0 & \cos \alpha_i & r_i \\ 0 & 0 & 0 & 1 \end{bmatrix}$$



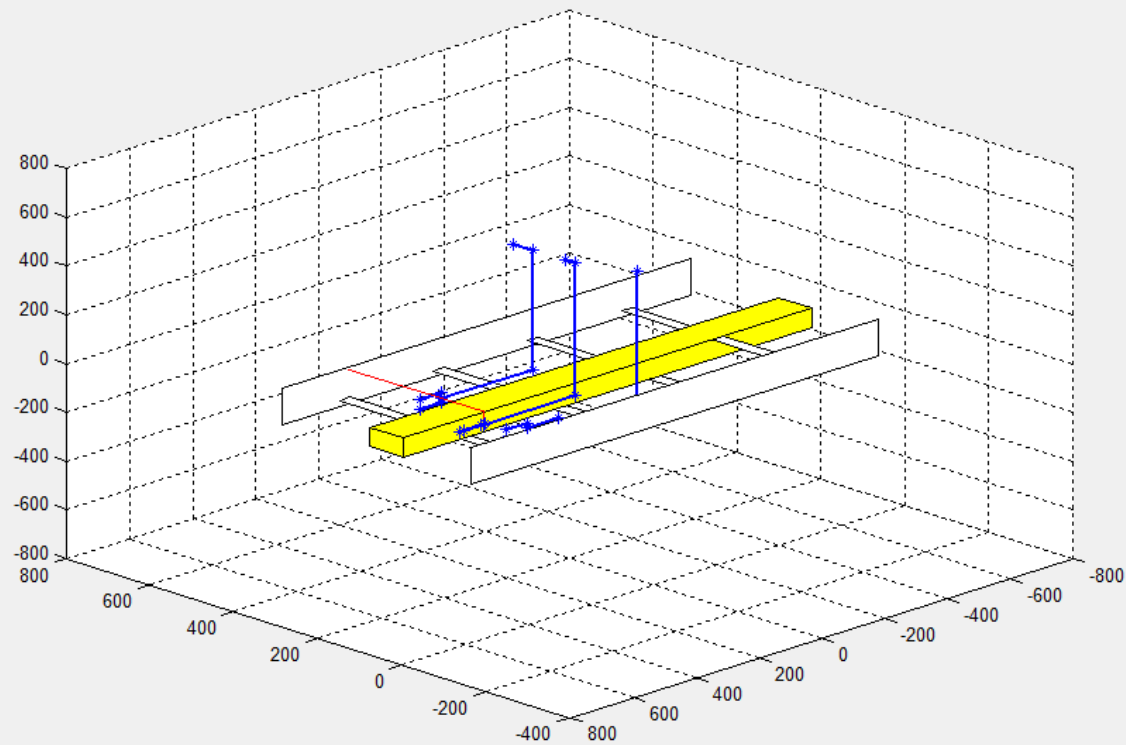


MATLAB Simulation





MATLAB Simulation



Bundle Height

80

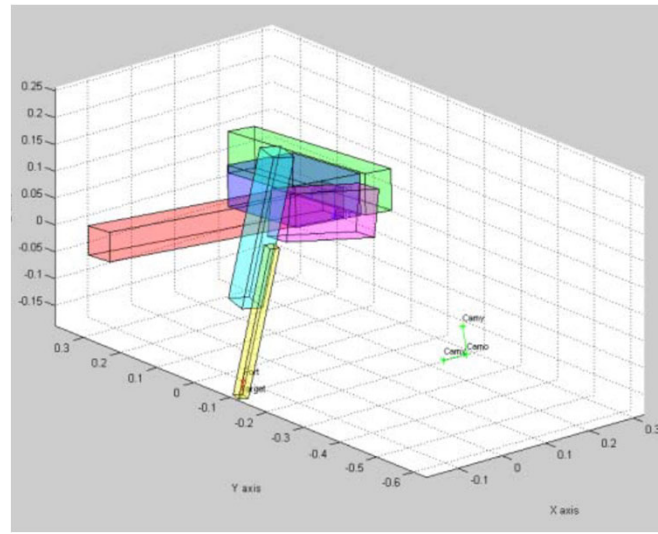
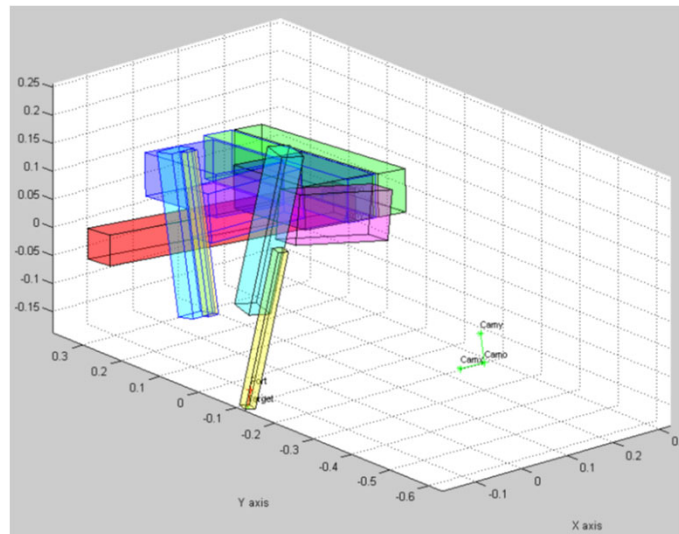
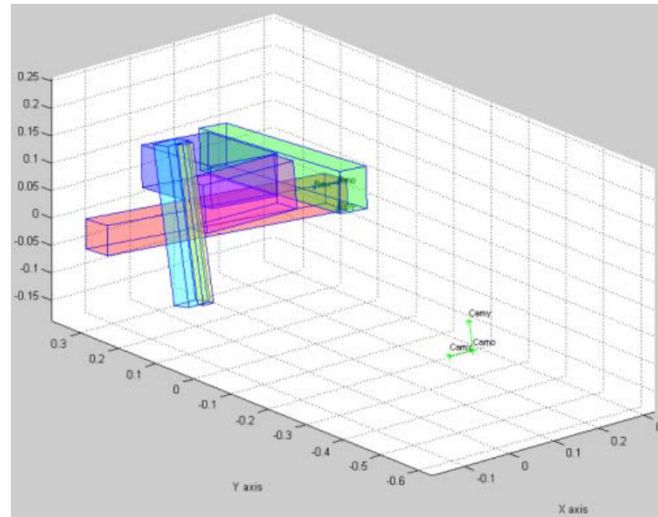
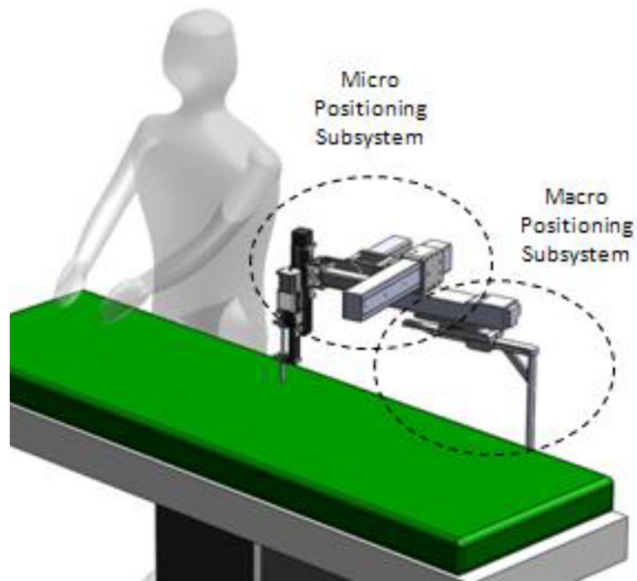
Bundle Width

80

Bundle Position

200

Run



C. Chui, Chin-Boon Chng and D. P. Lau, "Parallel processing for object oriented robotic simulation of tracheal-oesophageal puncture," 2011 IEEE/SICE International Symposium on System Integration (SII), Kyoto, 2011, pp. 144-149, doi: 10.1109/SII.2011.6147435.



CA for Part 1: Robot Simulation and Analysis

A group of 2 – 3 students

Due on Week 13: 13 April 2021 (Wednesday) 2359 Hours

Grading: 25% of the course grade

Correctness, quality of solutions and effort

Should not use Matlab Robotic Toolbox

You may want to use Matlab Symbolic Math Toolbox (when appropriate)