**What are parallel manipulators?**

More than one branch of links and joints connecting its end effectors to its base.

**Advantages**
- Multiple Degrees Of Freedom.
- High Stiffness,
- Compactness ,
- Low Inertia.
- Gravitational Counterbalancing.

**Challenges**
- Limited Workspace
- Forward Kinematics...!
  Highly nonlinear and often not in closed form.

**Problem Overview**

- 3 RRR Manipulator:
  - Combination of three serial RRR manipulators
  3RRR robot – 3 virtual serial robots

**Approach to solve forward kinematics**

- Given the desired End-Effector position (i.e. given x, y, φ)
- Decompose to three RRR manipulator
- For each use Inverse Kinematics
  Evaluate \( \theta \)
  - Plot the resulting pose back feeding the evaluated angles in forward kinematics

**Inverse Kinematics**

\[
\theta_i = \cos^{-1}\left(\frac{x^2 + y^2 - L_i^2 - L_{i+1}^2}{2 L_i L_{i+1}}\right)
\]

\[
\theta_2 = \cos^{-1}\left(\frac{-L_2 \sin \phi \cdot x + (L_1 + L_2 \cos \theta_1) \cdot y}{L_1 \sin \phi + (L_1 + L_2 \cos \theta_1) \cdot x}\right)
\]

**Forward Kinematics**

\[
x = L_1 \cos \theta_1 + L_2 \cos (\theta_1 + \theta_2)
\]

\[
y = L_1 \sin \theta_1 + L_2 \sin (\theta_1 + \theta_2)
\]

**GUI Capabilities:**

- Adjustable link lengths, & elbow configurations
- Allowable workspace.
- Trace user defined path

**GUI Applications:**

- Interactive introductory teaching device for robotic.
- Simulate a real time inverse kinematics of 3RRR parallel manipulator