



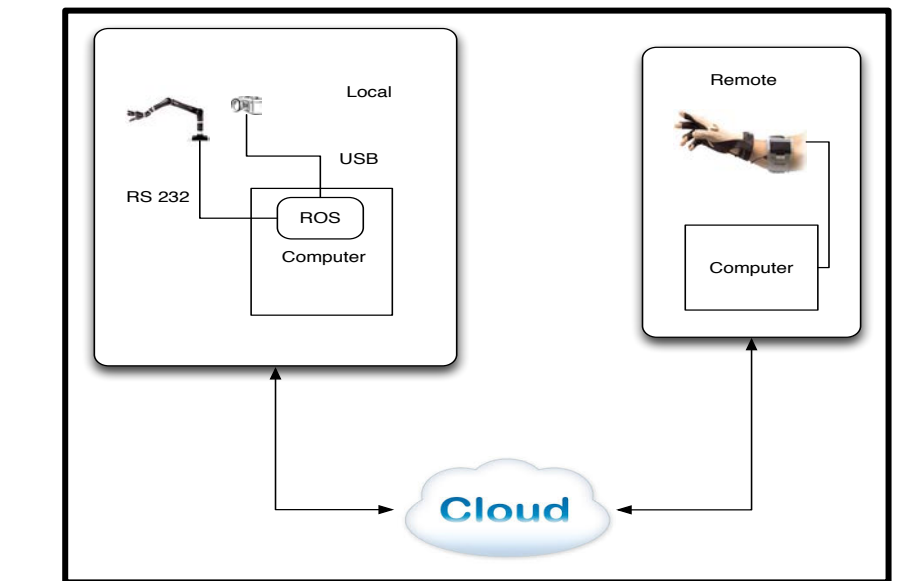
Kinova JACO Manipulator and the NPS Arm Interaction Robot (NPSAir)

Sensors, Algorithms and Architecture

$$A_i = Rot_{z,\theta_i} Trans_{z,d_i} Trans_{x,a_i} Rot_{x,\alpha_i}$$

$$= \begin{bmatrix} \cos\theta_i & -\sin\theta_i & 0 & 0 \\ \sin\theta_i & \cos\theta_i & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & d_i \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 & a_i \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos\alpha_i & -\sin\alpha_i & 0 \\ 0 & \sin\alpha_i & \cos\alpha_i & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$= \begin{bmatrix} \cos\theta_i & -\sin\theta_i \cos\alpha_i & \sin\theta_i \sin\alpha_i & a_i \cos\theta_i \\ \sin\theta_i & \cos\theta_i \cos\alpha_i & -\cos\theta_i \sin\alpha_i & a_i \sin\theta_i \\ 0 & \sin\alpha_i & \cos\alpha_i & d_i \\ 0 & 0 & 0 & 1 \end{bmatrix}$$



Robotic Arm Manipulation Laboratory

- Teach Students control for a **6 Degree-of-Freedom (DOF)** manipulator
- Work out the **Kinematic and Dynamic** Equations of motion
- Expose Students to **Feedback and Control** Theory with Applications
- Hands-on Lab interaction with **Tactile** and **Visual** Sensors
- Local and Remote **Tele-Manipulation**
- Virtual Reality with **Biomechanical Sensors**
- Remote **Multiple Autonomous** robot interactions, **NPSAir**

Motivation

- This project falls under the **Naval Science and Technology focus area** for autonomy and unmanned Systems
- Helps students think about how to **mitigate** exposure of personnel to **tedious, difficult and dangerous tasks** with the use of autonomy.
- Teaches students, in a lab environment, the **difficulty** of implementing an autonomous system by **exposing the theory-to-system gap** for autonomous systems.