**ME192 Lab Project 1**

**Manual Robot Motion Control and Joint Frame Description**

**8/27/2014**

**Robots:**

*Used:* Adept 550 (SCARA), Adept Linear Modules (Cartesian), two AdeptSix 300 (6 axis)

*Future Use*: Denso 6-axis. Puma 560 6-axis.

**Preparation:**

1. *Learn to use the Adept’s user documentation library. Start with V+ Quick Command Summary.*
2. *Download the MCP user guide and motion control commands from the Adept website.*
3. *Know the robot work envelopes (the arm’s reach) and the E-stop buttons.*
4. *Divide into teams of four and sign the safety agreement sheet individually.*

**Learning Objectives:**

*Be able to*

* + Manipulate robot arm using a MCP control pendant or executing monitor commands.
  + Perform pick and drop operation using a handful of Adept V+ location and program commands.
* Correctly set up Cartesian coordinates at each revolute and prismatic joint of the assigned robots in preparation for developing homogenous joint transformation matrices for robot kinematics.

**Lab Exercises:**

**Part A – Hands-on exercise**

* *Practice controller power up, energizing robot arm, calibration, E-stop, and joint brake release.*
* *Switch between World (Cartesian), Joint (angular), & Tool (yaw, pitch, roll) coordinate systems.*
* *Identify the joint types (Torso, shoulder, elbow, wrist, tool frame – yaw, pitch, roll) of the robots.*
* *Manipulate robot arm and gripper using Motion Control Pendant.*
* *Do the same using various “do” commands on the monitor screen.*
* *Define locations using HERE for monitor command or SET..TRANS(,,,,,) for program command.*
* *Find the relationship between the Cartesian roll angle and the joint angles on the SCARA robot.*
* *Set up a pick-up/drop-off sequence using a handful of V+ commands.*

**Part B - Report**

Set up a Cartesian coordinate system at each joint of three types of robot – Cartesian, SCARA and one of 6-axis articulating arm robots. Show the unit vector frame with valid positioning of the origin and XYZ axes orientation. Identify the link lengths and the link offsets. Follow the convention and the assignment rules used in the text book. Use the robot frame drawings or pictures provided, or download more detailed drawings with dimensions from the website.

**Robot arm and controller setup**

*No. 1 and 2 (AdeptSix 300)* – The two robots are controlled by a shared CS (smart) controller and a separate motor controller and power amplifier. Adept ACE software on PC controls the operation. ACE is installed in most of the PC’s in the lab.

*No. 4 (SCARA) and 5 (Cartesian)* – These two robots share a common MV controller and a PA4 amplifier chassis. AdeptWindows on a PC executes program and monitor instructions.

*No. 3 (Denso 6-axis)* – The robot has a dedicated controller and a PC and is set up for a special development project. This set up should not be disturbed.

*For configuration study (Part B), the Staubli RX60 6-axis robot in Eng. 194 will be a good model along with the AdeptSix 300’s. The robot schematics and dimensions are found in Staubli’s website. Also, specialized RRR(or RRRR) wafer handling robots such as Brooks Automation’s or Motoman-Yaskawa’s will be good study subjects. The PUMA 560 robot in the lab will be of special interest as its kinematics is analyzed in the textbook (Ch. 3).*

**Robot manipulation using MCP and Monitor commands**

* Power up/calibration sequence (**en**able **po**wer and **ca**librate) and turn on the air supply.
* Manipulate the robot joint arm under World and Joint coordinate systems.
* Perform manual pick-up/drop-off sequence using MCP and “**do** ...” monitor command.
* Define locations and read the (X, Y, Z, y, p, r) coordinates with **here** or **where** command.
* Move a peg from P1 to P2 using monitor commands. Do the same using program commands.

The locations are defined using**:**

**set p\_ = trans (**x, y, z, y, p, r**)** in Cartesian coordinate system.

**set #p\_ = #ppoint (**θ1, θ2, θ3, y, p, r**)** in angular coordinate system.

* Use “**openi / appro** p\_, x **/ move** p\_ **/ closei / delay** t **/ depart** x” for pick up sequence.

**File Handling**

* Use **store** to save your work to a USB memory (**storep** for program or **storel** for locations).
* Use **lo**ad to load a program from USB and transfer to the controller memory.
* Use **fdi**r to see file directory, **fdel**ete to delete a file, and **fren**ame to rename a file.

**Program Edit**

* The Adept text editor or any other text editor may be used.
* Each program starts with **.program** *progname***( )** and ends with **.end**. An invisible carriage return character must be inserted after **.end**.

**Program Execution**

* **execute** *progname* to run the program
* **xstep** *progname* to step execute the program lines

**Part B Joint Frame Assignment**

Learn to use the right hand rule in assigning XYZ frames to robot joints.

For joint I, set the thumb up or down for Zi axis on a rotational axis with the index finger for X i axis generally pointing in the direction of the next joint i+1. On a prismatic (orthogonal-linear) joint, the thumb is the pointer for the direction of move as in hitch hiking. Allow the joint axis Z i to rotate to the next higher joint axis along the Z i’s companion Xi axis. Restated, the two adjacent axes of motion set the Zi and Zi+1 axes which together determines the orientation of Xi as Zi is allowed to rotate toward Zi+1 only about Xi.

The angle between Zi and Zi+1 defines link twist αi. The distance between Zi and Zi+1 measured along the common perpendicular Xi defines link length ai. The distance between Xi and Xi+1 measured alongZi+1 defines link offset d i+1. In prismatic joints, d i is variable. In revolute joints, the rotation angle θ i is variable.

For more details including graphics, review the pre-posted lecture notes for Chapter 3.

Turn in a team report 5-6 page long, containing

**Lab Report** *(Due in instructor’s mail box one week from the completion of the lab).*

* A cover page with the project name, and the team member identification.
* A brief description of Part A activities with comments.
* Part B drawings. Indicate the link lengths and any offset distance between two adjacent X axes.

Use the tabular format in Fig. 3.8, Pg. 71 to summarize

* A project log sheet with team member initials collected weekly.

*Updated 9-3-14*

**Work Sheet 1/2 for Part B**





**Work Sheet 2/2 for Part B**



