

CSE4421: Lab 2

Burton Ma

Wed 23 Jan, 2013

1 Preliminaries

This lab teaches you the basics of operating the CRS A150 robotic arm, an industrial robot manufactured in the early 1990s.

1.1 Safety

The A150 and A255 robotic arms can seriously injure you if you do not follow reasonable safety precautions:

- Always be ready to press the big red kill switch! Do not let the robot crash into someone, something, or the table!
- Keep the tables the robots are mounted on clear of extraneous objects (coats, books, binders, etc.).
- Do not put your head (especially if you have long hair) within the range of any of the robots.
- Never use a speed of higher than 30% of the maximum (in fact during the debugging use much less than 30%)
- Do not power on a robot unless you are logged in to the workstation connected to the robot. If you are not logged in, it is possible for someone else to remotely log in and control the robot!
- Do not remotely log in to the workstations connected to the robots.
- Avoid working in the lab alone.
- If a robot malfunctions, turn off the power and immediately inform the technical staff (`tech` at `cse.yorku.ca`) and the instructor (`burton` at `cse.yorku.ca`) in person during working hours and by email otherwise.

2 Instructions to Power the A150 Arm

1. Log in to the workstation connected to the arm.
2. Start a console; in the console start the minicom program by entering the command `minicom`.
3. Power on the robot by turning the clear power switch in the upper-right corner of the control panel clockwise. The switch should turn orange, the control panel should hum, and minicom should display some information.
4. Check the big red kill switch (kills power to the arm motors). If it is pressed in, unlock it by turning it counterclockwise.
5. Manually align the robot. There are 5 sets of markers that you must align by moving the robot by hand (there is no power to the arm motors yet). The robot will be limp, so you will need to support the links of the robot by hand. All 5 sets of markers must remain aligned before you proceed to the next step.
6. Have someone else press the arm power button (located beside the big red kill switch). The button should turn orange and the robot should support itself. There is now power to the robot motors.
7. Tell the robot to home itself by entering the command `HO` in minicom. The message `LOCATED IN ITS HOME BOUNDS?` will appear. Type `y` followed by enter. The system shell has the annoying feature of auto-completing typed commands; the actual command name is `HOME`.
8. The robot will now try to set each of its 5 axes into a pre-calibrated home position. A message will appear for each axis in minicom; the message `TEST PASSED` should appear for each axis (even if you did a poor job in the previous step!); make sure the robot is in the correct home position.
9. If the robot is not correctly homed, support the robot by hand and press the kill switch. Repeat steps 3–7 to re-home the robot.
10. Once the robot is correctly homed it is ready for use. Enter the command `READ` in minicom and quit minicom using `Ctrl-A X`.

Note that the Matlab controller code has a home function; thus, you can avoid the use of minicom. However, minicom is very useful for trying out the many commands supported by the robot (and documented in the large black binder).

3 Instructions to Turn Off the A150 Arm

1. Support the robot by hand and turn the main power switch to the off position. Gently allow the arm to come to rest on the foam.
2. Log out of the workstation.

4 Robot Geometry

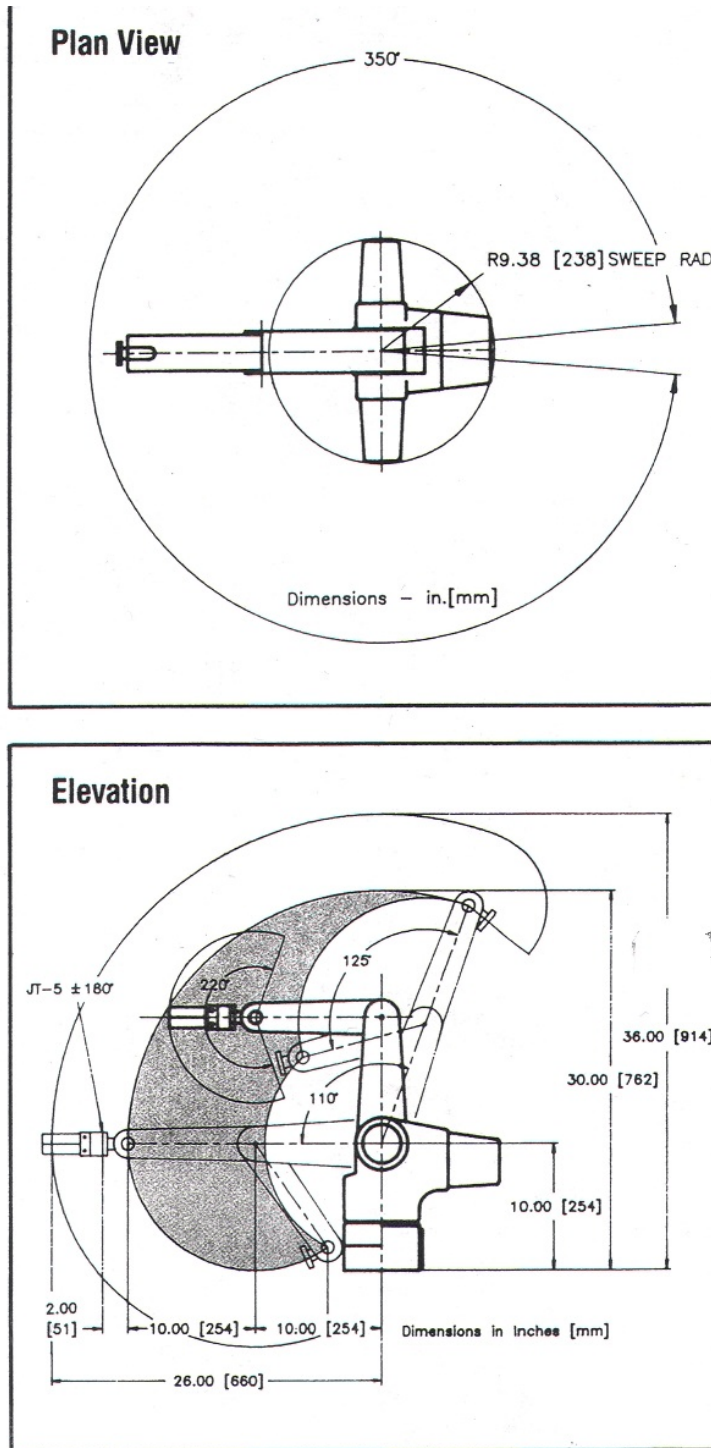


Figure 1: Dimensions of the A150 robotic arm *in inches and [mm]*.

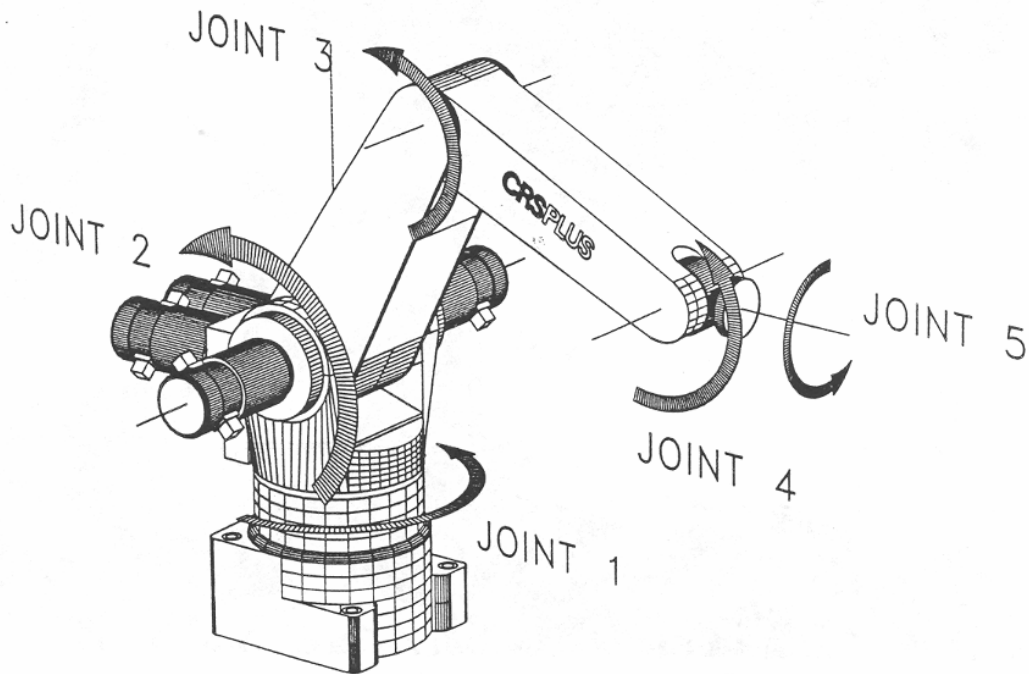


Figure 2: The five revolute joints of the A150 robotic arm.

Note that the Java simulator and controller classes refer to the joints the waist, shoulder, elbow, wrist, and twist. Their range of legal angles and the angles in the ready position are shown in the table below.

Joint	Java parameter name	min value	max value	value in ready position
1	waist	-175	175	0
2	shoulder	0	110	90
3	elbow	-125	0	-90
4	wrist	-110	110	0
5	twist	180	180	0

The shoulder angle is specified relative to horizontal. The elbow angle is specified relative to link 2 (the link starting with the shoulder); the robot is currently configured in the “elbow down” configuration, so the valid angles are all less than or equal to zero. The wrist angle is specified relative the link 3 (the link starting with the elbow).

5 Matlab Source Code

Both a Matlab simulator and Matlab controller are available for the A150 arm. Retrieve the Matlab sources from the "Source Code" section of the course web site.

5.1 Using the Simulator Code

Unzip the Matlab source file into a directory somewhere under your CSE account. The Matlab simulator is similar to the controller except that you use the class name `sim150` instead of `a150` to create a simulated instance of the robot. You can run the simulator on any workstation in the labs.

There is a small demonstration program `demoSim150.m` that uses the simulator.

5.2 Using the Matlab Controller Code

To use the controller, you must be logged into the workstation attached to the A150 robot (remote login is not sufficient to access the robot). Start Matlab in the directory (or in Matlab navigate to the source directory).

There is a small demonstration program `demo150.m` that uses the controller.

6 The Task

First, carefully read this document. Next, study the APIs of the simulator classes and run the `demoSim150.m` script; this script uses the Matlab A150 simulator to move the arm through a variety of poses.

Create a new simulator demonstration that moves the simulated arm in the following manner (starting from the home position):

1. Opens the gripper as wide as possible (2 inches).
2. Points the arm approximately straight up.
3. Rotates the wrist (joint 4) through its full range of motion (± 90 degrees) and back to 0 degrees.
4. Rotates the waist (joint 1) 90 degrees clockwise (when looking down on the robot).
5. Rotates the elbow (joint 3) so that the end of the arm is pointing through the glass into CSEB1006.
6. Rotates the shoulder (joint 2) so that arm is pointing down towards the table at 45 degrees.
7. Rotates the twist (joint 5) 90 degrees.
8. Closes the gripper.
9. Rotates the shoulder (joint 2) so that the end of the arm is pointing through the glass into CSEB1006.
10. Rotates the waist so that the end of the arm is pointing in the opposite direction from Step 9.
11. Rotates the shoulder (joint 2) so that arm is pointing down towards the table at 45 degrees.
12. Opens the gripper as wide as possible (2 inches).
13. Return the robot to the home position.

You can run the example solution script `solutionlab2.p`

Show me your simulation once you have it working.

Now create a controller demonstration program in Matlab that reproduces your simulation. When you are ready, test your program using the actual robot.

Submit your simulator and controller scripts:

```
submit 4421 L2 <your 2 matlab scripts here>
```