National University of Singapore
Department of Electrical Engineering
EE4304/ME4245_Robotics

Experiment I

1. Objectives:
(I) Robot operations, moving the various degrees of freedom;
(II) Teaching positions in space ("Teach-in"), returning to position taught, listing and deleting of positions in the position table in the memory;
(III) Transferring a block from Position A to position B

2. Equipment:
PERFORMER-MK2, ER14 and CONTROLLER-B
Computer (PC)
TEACH PENDANT
SCORBASE level 5 software

3. Procedure:
I. (a) System Connection: Ensure that POWER ON/OFF, MOTOR ON/OFF switches are set to **OFF** and emergency buttons both on the Controller Box and teach pendant are pressed **down**.

Strictly operate according to the following order:

1. connect the system to 220V AC supply;
2. set POWER ON/OFF switch to **ON**;
3. set MOTOR ON/OFF switch (on the Controller Box) to **ON**;
4. pull both emergency buttons out.

When you want to turn off the system, please follow the order as:

1. set MOTOR ON/OFF switch (on the Controller Box) to **OFF**;
2. push both emergency buttons down;
3. set POWER ON/OFF switch to **OFF**;
4. disconnect the system from 220V AC supply.
(b) Enter the directory “C:\scorbase” in the hard diskette. Typing “rob”, and <CR>, SCORE BASE Main Menu is displayed in Figure 1:

![SCORE BASE Main Menu](image1)

Figure 1

(c) **Homing the Robot**

Select the HOME MENU from the MAIN MENU by typing the function key “F5”. Figure 2 will be shown. Then press “G” key to home the robot. Be sure that there is sufficient space for the homing of the robot. You can always use the key “Esc” to return to the preceding menu or stop the current operation.

![HOME menu](image2)

Figure 2
(d) **Moving the Robot Motors**

Select the TEACH POSITIONS MENU from the MAIN MENU by typing the function key “F1”. The TEACH POSITIONS MENU will be displayed as shown in the Figure 3

![TEACH POSITIONS Menu]

Figure 3

(Note: figure 3 is for MK2 only. For ER14, Base denotes Axis 1, Shoulder denotes Axis 2, Wrist-pitch denotes Axis Z, and Wrist-roll denotes Roll.)

This experiment will use the first five lines in the block on the left hand side of the TEACH POSITIONS MENU (not counting the heading). There are three columns in the block:

* Left: indicates key to be pressed in order to move a robot joint.
* Centre: indicates the joint to be moved.
* Right: indicates direction of movement.

For example, consider the 2nd line:

```
2/W MOVE SHOULDER UP/DOWN
```

Pressing "2" will move the robot shoulder up.

Pressing "w" will move the robot shoulder down.

Complete the table:
### II (a) Teaching positions in space ("Teach-In")

You can use arrow key or space key to alternate between the two blocks of the TEACH POSITIONS MENU. This experiment is related to the following lines in the block on the right side of TEACH POSITIONS MENU:

- **RP** Record Position #.
- **GP** Go To Position #.
- **GH** Go Home

For example, by typing in “RP”, the following message will appear at the bottom of the screen:

```
RECORD POSITION (1-400)...
```

The computer is now waiting to receive a number from 1 to 400 inclusive (to be typed in on the keyboard). This number will identify a position in space equivalent to the position of the robot joints at the time the RECORD POSITION key is typed in.

The task of this experiment is to record six positions of the robot. When recording positions, you do not have to maintain strict numerical order.

1. Typing in “GH” will bring the robot arm to the home position.
   The corresponding message will display on the screen to tell
you the procedure of the homing. After homing is done, type in “RP”, the following message will appear on screen:

```
RECORD POSITION ( 1-400 )
```

Type in "1" and press <CR>. You have recorded position #1.

2. turn the base 45° left and record the position as position #2.

3. move the shoulder 45° down (for MK2) / left (for ER14) and record the position as #3.

4. move the elbow 45° down and record it as #4 (for MK2 only).

5. turn the wrist-pitch 45° (for MK2) / 10 cm (for ER14) down and record it as position #5.

6. turn the wrist-roll 45° left and record the position as #6.

You have just recorded six different positions in the computer memory.

(b) Return to Positions Taught

The robot is now in the position previously recorded as position #6.

Make sure that the block on the right hand side is highlighted and type in "GP". The following message will appear on screen:

```
GO POSITION ...... 
```

Type in "5" and press <CR>. The robot will go to the position recorded as position #5, rotating the wrist (roll) joint only.

Now type in "GP" again, type in "4" and press <CR>. Which joint moved? (for MK2 only)

Now type in "GP" again, type in "3" and press <CR>. Which joint moved?

Now type in "GP" again, type in "2" and press <CR>. Which joint moved?

Now type in "GP" again, type in "1" and press <CR>. Which joint moved?
The above commands resulted in the motion of only one axis at a time. Now type in "GP" again and press <CR>. Describe the response, including the number and names of axes (joints) moved.

(c) **List/delete Positions**

Type in "L". The List/delete Position will be displayed as shown:

![List/delete Position](image)

Figure 4

Typing in “LP”, the following message will be displayed on the screen:

LIST POSITION......

To display the coordinates of position #1 as recorded in memory, type in "1" and press <CR>. Fill in the coordinates displayed for position #2:

<table>
<thead>
<tr>
<th>#</th>
<th>X</th>
<th>Y</th>
<th>Z</th>
<th>PITCH</th>
<th>ROLL</th>
</tr>
</thead>
<tbody>
<tr>
<td>2:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(MK2 only)

To display the coordinates of all positions starting from position #1, as recorded in memory, type in “LF”. The following message will appear on screen:

LIST FROM POSITION......

Type in “1” and press <CR> for details.

To delete a position from the table, say position #2, type in “DP”. The following will appear on the screen:

DELETE POSITION......
Type in “2” and <CR>. After a moment, the computer will ask for you confirmation. After you type "Y", the "delete" command will be executed and the following message is displayed:

-DONE-

III Transfer a block from Position A to position B

You will begin with a relatively short exercise, demonstrating the operation of the robot.

(a) Operational Procedure

The robot is required to transfer the block from position A to position B by two intermediate positions (dummy points) as shown in Figure 5.

1. The robot will go to position A from its home position, pick up the block.
2. The robot will go to position B via two dummy points, release it from the gripper, and leave position B.
3. The robot will return to position B, pick up the block, and transfer it to position A via two dummy points, leave position A.

![Figure 5](image)

(b) Writing the program:

1. Select the EDIT PROGRAM from the MAIN MENU by typing in “F2”, the EDIT PROGRAM will be displayed as Figure 6
2. The sequence of operations described above is broken down into individual operations which may be defined to the robot, such as “open gripper” and “go to position ……”. Each operation is listed on a separate line. Now translate each operation written above into a command appearing on the EDIT Program Menu. Type in the following program:

1. OPEN GRIPPER
2. GO POSITION #1 SPEED #2
3. CLOSE GRIPPER
4. GO POSITION #3 SPEED #3
5. GO POSITION #4 SPEED #3
6. GO POSITION #2 SPEED #2
7. OPEN GRIPPER
8. GO POSITION #4 SPEED #3
9. GO POSITION #2 SPEED #2
10. CLOSE GRIPPER
11. GO POSITION #4 SPEED #3
12. GO POSITION #3 SPEED #3
13. GO POSITION #1 SPEED #2
14. OPEN GRIPPER

where “#1”, “#2”, “#3”, and “#4” denote position “A”, “B”, “C”, and “D” in Figure 5, respectively.

3. Teach the robot the required points. Motion should begin from the home position.
4. Store the program under the PROGRAM HANDLING, which can be entered by press “F3” from the MAIN MENU.

(c) Running the program

Press the functional key “F4” from the MAIN MENU to run the program under the RUN PROGRAM MENU, which is shown in Figure 7.

![Figure 7](image)

1. Run the program in RUN Single Line mode by press “F1”;
2. Run the same program in RUN Cycle mode by press “F3”;
3. Run the same one in RUN Continuously mode by press “F5”;
4. Record the design procedure and experiment result, explain the observation.

--------End--------