CHAPTER 13

Programming

In this chapter we come to the finale of the robot laboratory exercises. In this laboratory exercise, you will attempt to program your robot to navigate a "maze." The course your robot must travel is shown below in Fig. 13.1. Using the dimensions given, you must develop a program - a sequence of instructions entered through the teach pendant - that will allow your robot to navigate the passage.

Programming the Robot

We suggest the following procedure for programming the robots.

1. Turn the robot off.

   Nothing should happen

2. Plug in the teach pendant.

   Nothing should happen

3. Turn the robot on.

   Nothing should happen

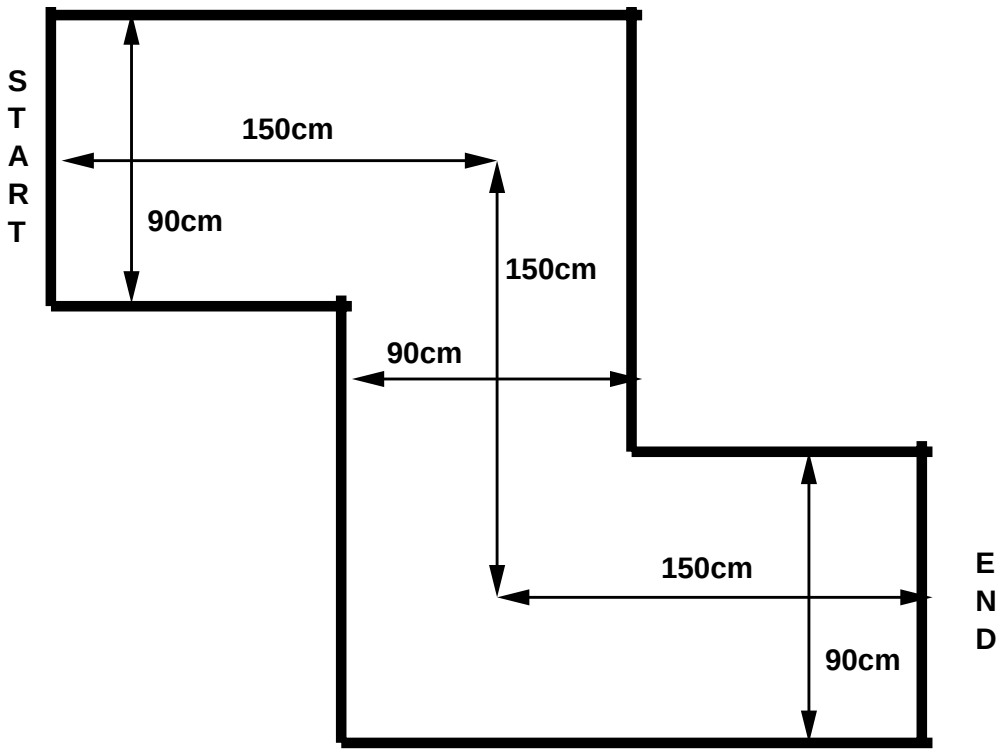

Figure 13.1 Dimensions of the Maze

4. Press the reset switch located on the robot.

   This resets the counter to zero

   Nothing physical should happen

5. Press and hold the buttons corresponding to the FIRST action you wish the robot to perform (i.e. turn left = left button; go straight = left and right button)

   Nothing should happen - yet

6. With those buttons pressed, press and hold the enter button until the robot performs the action

   The robot should perform that command

   It may be a split second or so until the robot responds

As the robot performs the action it is saving that command into memory and incrementing the counter

7. After the robot performs the action, release the enter button and repeat steps 5 & 6, entering the SECOND command, then THIRD command and so forth.

   The robot will perform each command as the enter button is pressed

8. When all the commands are entered a reset counter command needs to be programmed. To do this, follow steps 5 & 6 with all four command buttons pressed.

   The robot should move straight with the light and buzzer on

   This puts into memory a reset counter command

9. Now press and hold the RESET push-button switch on the robot.

   This manually keeps the counter at zero

   Nothing should happen

10. With the RESET switch pressed, disconnect the teach pendant.

    Nothing should happen

11. As soon as you let go of the RESET switch the robot will begin to execute the commands as they were entered. It will repeat itself as soon as it reaches the last command that was entered (which was the reset counter command).

    At any time you can press the RESET switch which will reset the counter to zero

    Nothing will happen until you release the RESET switch, then it will go to the first command

Additional Tips

You can program pauses by simply pressing the enter button. You must hold it down long enough to make sure it has been entered. It is a good idea to do this as the first few commands, so that you have time to pull your hand away after you let go of the RESET switch. Remember that the robot will not move in quite the same path when it is running independently as it did when you programmed it. This is because the drag of the electrical cable and the pauses between each instruction both change the path. In the next section we will discuss how to characterize your robot.

Characterizing The Robot

In order to create a program that will correctly guide your robot through the maze you cannot simply guide it through with the teach pendant and then expect it to behave in the same manner when it is executing the instructions in rapid sequence. You are going to have to characterize your robot's behavior so that you can develop a winning program. After all, how are you going to get the robot to run through the course if you don't know how far your robot will move forward or how quickly it will turn?

We suggest using the following steps in order to characterize your robot.

1. How far does my robot go in one step? Suggested procedure: Program your robot to go forward for ten steps. Disconnect the teach pendant and let the robot go. Measure how far it went. Did it go straight, or did it veer to

the right or left? Let the robot go again. Did it do exactly the same thing? What is the robot's average behavior? Now, take the average behavior and divide that by ten. This is your robot's average single step behavior.

2. How far does my robot turn in step? Suggested procedure: Program your robot to turn left ten times. Disconnect the teach pendant and let the robot go. Measure how far it turned. No protractor? Think about trigonometry - sines, cosines, tangents - calculate how far the robot turned. Let the robot go again. Did it do exactly the same thing? Does this sound really familiar? What is the robot's average single turn to the left behavior? Now, take the average behavior and divide that by ten. This is your robot's single turn to the left behavior. Finally, repeat the process for turns to the right. Do the left and right turns match?

3. What about the potentiometer? Remember that the potentiometer changes the duration of each instruction. You should adjust the potentiometer and see how that affects your robot's behavior.

Now you are all set to program your robot based on the maze dimensions and your knowledge of how your robot performs, right? Perhaps you are, but you considered how your robot's turning behavior might change if you are moving forward and then go right into a turn? Is your program going to require too many steps? What kind of surface did you run your tests on? Is that the same as the floor in the lab? Maybe you need to run a few more tests...

To give you an example of the calibration procedure, we have built a robot and run it through the calibration process. The sample robot was tested at two different settings of the clock potentiometer. In the initial test, the clock was running at an intermediate setting (about 2Hz.) In the second test, the clock was running as fast as possible (about 4Hz.) For both tests, three experiments were performed: the robot was commanded to run forwards ten steps, the robot was commanded to turn left ten times, and the robot was commanded to turn right ten times. Each experiment was performed ten times. After each experiment, the results of the robot's motion were recorded. The ten results for each experiment were then averaged, and that result was divided by ten to produce the average motion for one robot step. The robot produced the following results:

Test 1 (2Hz clock)

Forward	14.5 cm forward	3.0 cm right	-11.5˚ turn
Left turn	60.5˚ turn		
Right turn	-60.75˚ turn		

Test 2 (4Hz clock)

Forward	7.1 cm forward	0.5 cm right	-5.0˚ turn
Left turn	30.75˚ turn		
Right turn	-29.0˚ turn		