4

Sensing From Within

I see dead people.
Cole Sear (played by Haley Joel Osment) in *Sixth Sense*,
M. Night Shyamalan, 1999.

Opposite page: Candle Flame
Photo courtesy of Jon Sullivan (www.pdphoto.org)

Cole Sear in Shyamalan's *Sixth Sense* is not referring to dead bodies lying in front of him (for those who have not seen the movie). The five senses that most humans relate to are: touch, vision, balance, hearing, and taste or smell. In all cases our bodies have special sensory receptors that are placed on various parts of the body to enable sensing. For example the taste receptors are concentrated mostly on the tongue; the touch receptors are most sensitive on hands and the face and least on the back and on limbs although they are present all over the body, etc. Besides the difference in the physiology of each kind of receptors there are also different neuronal pathways and thereby sensing mechanisms built into our bodies. Functionally, we can say that each type of sensory system starts with the receptors which convert the thing they sense into electrochemical signals that are transmitted over neurons. Many of these pathways lead to the cerebral cortex in the brain where they are further *processed* (like, "Whoa, that jalapeno is hot!!"). The perceptual system of an organism refers to the set of sensory receptors, the neuronal pathways, and the processing of perceptual information in the brain. The brain is capable of combining sensory information from different receptors to create richer experiences than those facilitated by the individual receptors.

Proprioception
Sensing from within

Get something really delicious to eat, like a cookie, or a piece of chocolate, or candy (whatever you fancy!). Hold it in your right hand, and let your right arm hang naturally on your side. Now close your eyes, real tight, and try to eat the thing you are holding. Piece of cake! (well, whatever you picked to eat :-)

Without fail, you were able to pick it up and bring it to your mouth, right?

Give yourself a *Snickers moment* and enjoy the treat.

The perceptual system of any organism includes a set of *external* sensors (also called exteroceptors) and some *internal* sensing mechanisms (*interoceptors* or *proprioception*). Can you touch your belly button in the dark? This is because of proprioception. Your body's sensory system also keeps track of the internal state of your body parts, how they are oriented, etc.

Sensing is an essential component of being a robot and every robot comes built with internal as well as external sensors. It is not uncommon, for example, to find sensors that are capable of sensing light, temperature, touch, distance to another object, etc. An example of internal sensing in robots is the measurement of movement relative to the robot's internal frame of reference. Sometimes also called *dead reckoning*, it can be a useful sensing mechanism that you can use to design robot behaviors.

Robots employ electromechanical sensors and there are different types of devices available for sensing the same physical quantity. For example, one common sensor found on many robots is a *proximity* sensor. It detects the distance to an object or an obstacle. Proximity sensors can be made using different technologies: infrared light, sonar, or even laser. Depending upon the type of technology used, their accuracy, performance, as well as cost vary: infrared (IR) is the cheapest, and laser is on the expensive side. Lets us take a look at the perceptual system of your Scribbler robot starting with internal sensors.

Proprioception in the Scribbler

The Scribbler has three useful internal sensory mechanisms: *stall*, *time*, and *battery level*. When your program asks the robot to move it doesn't always imply that the robot is actually physically moving. It could be stuck against a wall, for example. The stall sensor in the Scribbler enables you to detect this. You have already seen how you can use time to control behaviors using the `timeRemaining` and `wait` functions. Also, for most movement commands, you can specify how long you want that movement to take place (for example `forward(1, 2.5)` means full-speed forward for 2.5 seconds). Finally, it is also possible to detect battery power level so that you can detect when it is time to change batteries in the robot.

Time

All computers come built-in with an internal clock. In fact, clocks are so essential to the computers we use today that without them we would not have computers at all! Your Scribbler robot can use the computer's clock to sense time. It is with the help of this clock that we are able to use time in functions like `timeRemaining`, `wait`, and other movement commands. Just with these facilities it is possible to define interesting automated behaviors.

Do This: Design a robot program for the Scribbler to draw a square (say with sides of 6 inches). To accomplish this, you will have to experiment with the movements of the robot and correlate them with time. The two movements you have to pay attention to are the rate at which the robot moves, when it moves in a straight line; and the degree of turn with respect to time. You can write a function for each of these:

```
def travelStraight(distance):
    # Travel in a straight line for distance inches

def degreeTurn(angle):
    # Spin a total of angle degrees
```

That is, figure out by experimentation on your own robot (the results will vary from robot to robot) as to what the correlation is between the distance and the time for a given type of movement above and then use that to define the two functions above. For example, if a robot (hypothetical case) seems to travel at the rate of 25 inches/minute when you issue the command `translate(1.0)`, then to travel 6 inches you will have to translate for a total of (6*60)/25 seconds. Try moving your robot forward for varying amounts for time at the same fixed speed. For example try moving the robot forward at speed 0.5 for 3, 4, 5, 6 seconds. Record the distance travelled by the robot for each of those times. You will notice a lot of variation in the distance even for the same set of commands. You may want to average those. Given this data, you can estimate the average amount of time it takes to travel an inch. You can then define `travelStraight` as follows:

```
def travelStraight(distance):
    # set up your robot's speed
    inchesPerSec = <Insert your robot's value here>

    # Travel in a straight line for distance inches
    forward(1, distance/inchesPerSec)
```

Similarly you can also determine the time required for turning a given number of degrees. Try turning the robot at the same speed for varying amounts of time. Experiment how long it takes the robot to turn 360 degrees, 720 degrees, etc. Again, average the data you collect to get the number of degrees per second. Once you have figured out the details use them to write the `degreeTurn` function. Then use the following main program:

```
def main():
   # Transcribe a square of sides = 6 inches

   for side in range(4):
       travelStraight(6.0)
       degreeTurn(90.0)

   speak("Look at the beautiful square I made.")

main()
```

Run this program several times. It is unlikely that you will get a perfect square each time. This has to do with the calculations you performed as well with the variation in the robot's motors. They are not precise. Also, it generally takes more power to move from a still stop than to keep moving. Since you have no way of controlling this, at best you can only approximate this type of behavior.

Over time, you will also notice that the error will aggregate. This will become evident in doing the exercise below.

Do This: Building on the ideas from the previous exercise, we could further abstract the robot's drawing behavior so that we can ask it to draw any regular polygon (given the number of sides and length of each side). Write the function:

```
def drawPolygon(SIDES, LENGTH):
    # Draw a regular polygon with SIDES number of sides
    # and each side of length LENGTH.
```

Then, we can write a regular polygon drawing robot program as follows:

```
def main():
    # Given the number of sides and the length of each side,
    # draw a regular polygon

    # First, ask the user for the number of sides and
    # side length
    print "Given # of sides and side length I will draw"
    print "a polygon for you. Specify side length in inches."

    nSides = input("Enter # of sides in the polygon: ")
    sideLength = input("Enter the length of each side: ")

    # Draw the polygon
    drawPolygon(nSides, sidelength)

    speak("Look! I can draw.")

main()
```

To test the program, first try drawing a square of sides 6 inches as in the previous exercise. Then try a triangle, a pentagon, hexagon, etc. Try a polygon with 30 sides of length 0.5 inches. What happens when you give 1 as the number of sides? What happens when you give zero (0) as the number of sides?

A Slight Detour: Random Walks

One way you can do interesting things with robot drawings is to inject some randomness in how long the robot does something. Python, and most programming languages, typically provide a library for generating random numbers. Generating random numbers is an interesting process in itself but we will save that discussion for a later time. Random numbers are very useful in all kinds of computer applications, especially games and in simulating real life phenomena. For example, in estimating how many cars might be entering an

already crowded highway in the peak of rush hour? Etc. In order to access the random number generating functions in Python you have to import the `random` library:

```
from random import *
```

There are lots of features available in this library but we will restrict ourselves with just two functions for now: `random` and `randint`. These are described below:

`random()` Returns a random number between 0.0 and 1.0.

`randint(A, B)` Returns a random number in the range `[A…B]`.

Here is a sample interaction with these two functions:

```
>>> from random import *
>>> randint(1,10)
7
>>> randint(1,10)
7
>>> randint(1,10)
7
>>> randint(1,10)
10
>>> randint(1,10)
5
>>> randint(1,10)
2
>>> random()
0.44634304047922957
>>> random()
0.19755181190206628
>>> random()
0.90671189955264253
>>> random()
0.3057456532664905
>>>
```

As you can see, using the random number library is easy enough, and similar to using the Myro library for robot commands. Given the two functions, it is entirely up to you how you use them. Look at the program below:

```
def main():
    # generate 10 random polygons
    for poly in range(10):
        # generate a random polygon and draw it
        Print "Place a new color in the pen port and then…"
        userInput = input("Enter any number: ")
        sides = randint(3, 8)
        size = randint(2, 6)
        drawPolygon(sides, size)

    # generate a random walk of 20 steps
    for step in range(20):
        travelStraight(random())
        degreeTurn(randrange(0, 360))
```

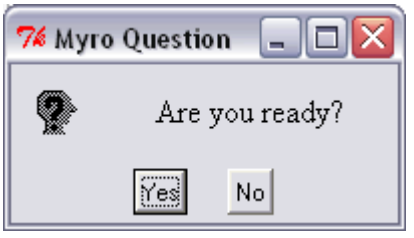
The first loop in the program draws 10 random polygons of sizes ranging from 3 to 8 sides and each side in the range 2 to 6 inches. The second loop carries out a random walk of 20 steps.

Asking Questions?

As you can see from above, it is easy to program various kinds of movements into the Scribbler. If there is a pen in the pen port, the Scribbler draws a path. Also in the example above, you can see that we can stop the program temporarily, pretend that we are taking some input and use that as an opportunity to change the pen and then go on. Above, we used the Python `input` command to accomplish this. There is a better way to do this and it uses a function provided in the Myro library:

```
>>> askQuestion("Are you ready?")
```

When this function is executed, a dialog window pops up as shown below:



When you press your mouse on any of the choices (`Yes/No`), the window disappears and the function returns the name of the key selected by the user as a string. That is, if in the above window you pressed the `Yes` key, the function will return the value:

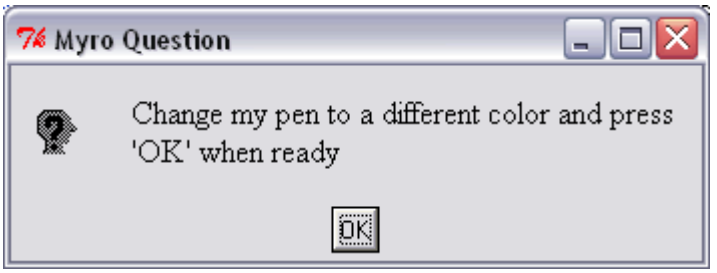
```
>>> askQuestion("Are you ready?")
'Yes'
```

The `askQuestion` command can be used in the program above as follows:

```
askQuestion("Change my pen to a different color and press 'Yes'
when ready.")
```

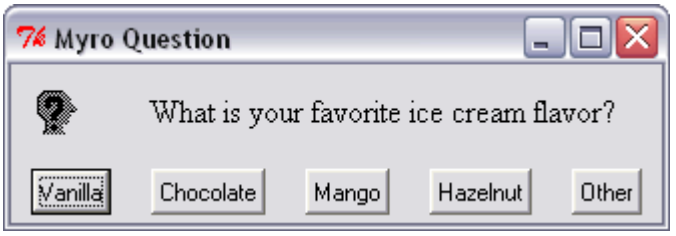
While this is definitely more functional than our previous solution, we can actually do better. For example, what happens when the user presses the `No` button in the above interaction? One thing you know for sure is that the function will return the string `'No'`. However, the way we are using this function, it really does not matter which key the user presses. `askQuestion` is designed so it can be customized by you so that you can specify how many button choices you want to have in the dialog window as well as what the names of those buttons would be. Here is an illustration of how you would write a better version of the above command:

```
askQuestion("Change my pen to a different color and press 'OK'
when ready", ["OK"])
```



Now this is certainly better. Notice that the function `askQuestion` can be used with either one parameter or two. If only one parameter is specified, then the default behavior of the function is to offer two button choices: `'Yes'` and `'No'`. However, using the second parameter you can specify, in a list, any number of strings that will become the choice buttons. For example,

```
askQuestion("What is your favorite ice cream flavor?",
["Vanilla", "Chocolate", "Mango", "Hazelnut", "Other"])
```



This will be a very handy function to use in many different situations. In the next exercise, try and use this function to become familiar with it.

Do This: Write a Scribbler program of your own that exploits the Scribbler's movements to make random drawings. Make sure you generate drawings with at least three or more colors. Because of random movements, your robot is likely to run into things and get stuck. Help your robot out by picking it up and placing it elsewhere when this happens.

Back to time…

Most programming languages also allow you to access the internal clock to keep track of time, or time elapsed (as in a stop watch), or in any other way you may want to make use of time (as in the case of the `wait`) function. The Myro library provides a simple function that can be used to retrieve the current time:

```
>>> currentTime()
1169237231.836
```

The value returned by `currentTime` is a number that represents the seconds elapsed since some earlier time, whatever that is. Try issuing the command several times and you will notice that the difference in the values returned by the function represents the real time in seconds. For example:

```
>>> currentTime()
1169237351.5580001
>>> 1169237351.5580001 - 1169237231.836
119.72200012207031
```

That is, 119.722 seconds had elapsed between the two commands above. This provides another way for us to write robot behaviors. So far, we have learned that if you wanted your robot to go forward for 3 seconds, you could either do:

```
forward(1.0, 3.0)
```

or

```
forward(1.0)
wait(3.0)
stop()
```

or

```
while timeRemaining(3.0):
    forward(1.0)
stop()
```

Using the `currentTime` function, there is yet another way to do the same thing:

```
startTime = currentTime()     # record start time
while (currentTime() - startTime) < 3.0:
   forward(1.0)
stop()
```

The above solution uses the internal clock. First, it records the start time. Next it enters the loop which first gets the current time and then checks to see if the difference between the current time and start time is less than 3.0 seconds. If so, the `forward` command is repeated. As soon as the elapsed time gets over 3.0 seconds, the loop terminates. This is another way of using the `while`-loop that you learned in the previous chapter. In the last chapter, you learned that you could write a loop that executed forever as shown below:

```
while True:
   <do something>
```

The more general form of the `while`-loop is:

```
while <some condition is true>:
   <do something>
```

That is, you can specify any condition in `<some condition is true>`. The condition is *tested* and if it results in a `True` value, the step(s) specified in `<do something>` is/are performed. The condition is tested again, and so on. In the example above, we use the expression:

```
(currentTime() - startTime) < 3.0
```

If this condition is true, it implies that the elapsed time since the start is less than 3.0 seconds. If it is false, it implies that more than 3.0 seconds have elapsed and it results in a `False` value, and the loop stops. Learning about writing such conditions is essential to writing smarter robot programs.

While it may appear that the solution that specified time in the `forward` command itself seemed simple enough (and it is!), you will soon discover that being able to use the internal clock as shown above provides more versatility and functionality in designing robot behaviors. This, for example is how one could program a vacuum cleaning robot to clean a room for 60 minutes:

```
startTime = currentTime()
while (currentTime() - startTime)/60.0 < 60.0:
  cleanRoom()
```

You have now seen how to write robot programs that have behaviors or commands that can be repeated a fixed number of times, or forever, or for a certain duration:

```
# do something N times
for step in range(N):
  do something...

# do something forever
while True:
  do something...

# do something for some duration
while timeRemaining(duration):
  do something...

# do something for some duration
duration = <some time in seconds>
startTime = currentTime()
while (currentTime() - startTime) < duration:
  do something...
```

All of the above are useful in different situations. Sometimes it becomes a matter of personal preference.

Writing Conditions

Let us spend some time here to learn about conditions you can write in `while`-loops. The first thing to realize is that all conditions result in either of two values: `True` or `False` (or, alternately a 1 or a 0). These are Python values, just like numbers. You can use them in many ways. Simple conditions can be written using comparison (or relational) operations: < (less than), <= (less than or equal to), > (greater than), >= (greater than or equal to), == (equal to), and != (not

equal to). These operations can be used to compare all kinds of values. Here are some examples:

```
>>> 42 > 23
True
>>> 42 < 23
False
>>> 42 == 23
False
>>> 42 != 23
True
>>> (42 + 23) < 100
True
>>> a, b, c = 10, 20, 10
>>> a == b
False
>>> a == c
True
>>> a == a
True
>>> True == 1
True
>>> False == 1
False
```

Unicode

Text characters have an internal computer coding or representation that enforces lexicographic ordering. This internal encoding is very important in the design of computers and this is what enables all computers and devices like iPhones etc. to exchange information consistently. All language characters in the world have been assigned a standard computer encoding. This is called *Unicode*.

The last two examples above also show how the values `True` and `False` are related to 1 and 0. `True` is the same as 1 and 0 is the same as `False`. You can form many useful conditions using the comparison operations and all conditions result in either `True` (or 1) or `False` (or 0). You can also compare other values, like strings, using these operations:

```
>>> "Hello" == "Good Bye"
False
>>> "Hello" != "Good Bye"
True
>>> "Elmore" < "Elvis"
True
>>> "New York" < "Paris"
True
>>> "A" < "B"
True
>>> "a" < "A"
False
```

Study the above examples carefully. Two important things to notice are: strings are compared using alphabetical ordering (i.e. lexicographically). Thus `"Elmore"` is less than `"Elvis"` since `"m"` is less than `"v"` in those strings `("El"` being equal

in both). That is also why `"New York"` is less than `"Paris"` (since `"N"` is less than `"P"`). The second important thing to note is that uppercase letters are less than their equivalent lowercase counterparts (`"A"` is less than `"a"`). This is by design (see box on right).

Besides relational operations you can build more complex conditional expressions using the *logical operations* (also called *Boolean operations*): `and`, `or`, and `not`. Here are some examples:

```
>>> (5 < 7) and (8 > 3)
True
>>> not ( (5 < 7) and (8 > 3))
False
>>> (6 > 7) or (3 > 4)
False
>>> (6 > 7) or (3 > 2)
True
```

We can define the meaning of logical operators as follows:

- **`<expression-1> and <expression-2>`:** Such an expression will result in a value `True` only if both `<expression-1>` and `<expression-2>` are `True`. In all other cases (i.e. if either one or both of `<expression-1>` and `<expression-2>` are `False`) it results in a `False`.

- **`<expression-1> or <expression-2>`:** Such an expression will result in a value `True` if either `<expression-1>` or `<expression-2>` are `True` or if both are `True`. In all other cases (i.e. if both of `<expression-1>` and `<expression-2>` are `False`) it results in a `False`.

- **`not <expression>`:** Such an expression will result in a value `True` if `<expression>` is `False` or `False` if `<expression>` is `True`). I.e., it flips or complements the value of expression.

These operators can be combined with relational expressions to form arbitrarily complex conditional expressions. In fact, any decision making in your programs boils down to forming the appropriate conditional expressions. The logical operators were invented by the logician George Boole in the mid 19th century. Boolean algebra, named after Boole, defines some simple, yet important laws that govern the behavior of logical operators. Here are some useful ones:

- `(A or True)` is always True.
- `(not (not A))` is just `A`
- `(A or (B and C))` is the same as `((A or B) and (A or C))`
- `(A and (B or C))` is the same as `((A and B) or (A and C))`
- `(not (A or B))` is the same as `((not A) and (not B))`
- `(not (A and B))` is the same as `((not A) or (not B))`

These identities or properties can help you in simplifying conditional expressions. The conditional expressions can be used to write several useful conditions to control the execution of some program statements. These allow you to write conditional repetitions as:

```
while <some condition is true>:
   <do something>
```

Now you can see why the following is a way of saying, "do something forever":

```
while True:
   <do something>
```

Since the condition is always `True` the statements will be repeated forever. Similarly, in the loop below:

```
while timeRemaining(duration):
   <do something>
```

As soon as the `duration` is up, the value of the `timeRemaining(duration)` expression will become `False` and the repetition will stop. Controlling the repetitions based on conditions is a powerful idea in computing. We will be using these extensively to control the behaviors of robots.

Sensing Stall

We mentioned in the beginning of this chapter that the Scribbler also has a way of sensing that it is stalled when trying to move. This is done by using the Myro function `getStall`:

`getStall()` Returns `True` if the robot has stalled, `False` otherwise.

You can use this to detect that the robot has stalled and even use it as a condition in a loop to control behavior. For example:

```
while not getStall():
   <do something>
```

That is, keep doing `<do something>` until the robot has stalled. Thus, you could write a robot behavior that goes forward until it bumps into something, say a wall, and then stops.

```
while not getStall():
    forward(1.0)
stop()
speak("Ouch! I think I bumped into something! ")
```

In the above example, as long as the robot is not stalled, `getStall()` will return `False` and hence the robot will keep going forward (since `not False` is `True`). Once it does bump into something, `getStall()` will return `True` and then the robot will stop and speak.

Do This: Write a complete program for the Scribbler to implement the above behavior and then observe the behavior. Show this to some friends who are not in your course. Ask them for their reactions. You will notice that people will tend to ascribe some form of *intelligence* to the robot. That is, your robot is sensing that it is stuck, and when it is, it stops trying to move and even announces that it is stuck by speaking. We will return to this idea of *artificial intelligence* in a later chapter.

Sensing Battery Power Levels

Your Scribbler robot runs on 6 AA batteries. As with any other electronic device, with use, the batteries will ultimately drain and you will need to replace with fresh ones. Myro provides an internal battery-level sensing function, called `getBattery` that returns the current voltage being supplied by the battery. When the battery levels go down, you will get lower and lower voltages causing erratic behavior. The battery voltage levels of your Scribbler will vary between 0 and 9 volts (0 being totally drained). What low means is something you will have to experiment and find out. The best way to do this is to record the battery level when you insert a fresh set of batteries. Then, over time, keep recording the battery levels as you go.

Disposing Batteries

Make sure that you dispose used batteries properly and responsibly. Batteries may contain hazardous materials like cadmium, mercury, lead, lithium, etc. which can be deadly pollutants if disposed in landfills. Find out your nearest battery recycling or disposal option to ensure proper disposal.

The Scribbler also has some built-in battery-level indicator lights. The red LED on the robot remains lit when the power levels are high (or in the good range). It

starts to flash when the battery level runs low. There is also a similar LED on the Fluke dongle. Can you find it? Just wait until the battery levels run low and you will see it flashing.

You can use battery-level sensing to define behaviors for robots so that they are carried out only when there is sufficient power available. For example:

```
while (getBattery() >= 5.0) and timeRemaining(duration):
   <do something>
```

That is, as long as battery power is above 5.0 and the time limit has not exceeded `duration`, `<do something>`.

World Population, revisited

The ability to write conditional expressions also enables us to define more sophisticated computations. Recall the world population projection example from previous chapter. Given the population growth rate and the current population, you can now write a program to predict the year when the world's population will increase to beyond a given number, say 9 billion. All you have to do is write a condition-driven repetition that has the following structure:

```
year = <current year>
population = <current population>
growthRate = <rate of growth>

# repeat as long as the population stays below 9000000000
while population < 9000000000:
    # compute the population for the next year
    year = year + 1
    population = population * (1+growthRate)

print "By the year", year, "the world's population"
print "will have exceeded 9 billion."
```

That is, add population growth in the next year if the population is below 9 billion. Keep repeating this until it exceeds 9 billion.

Do This: Complete the program above and compute the year when the world's population will exceed 9 billion. To make your program more useful make sure you ask the user to input the values of the year, population, growth rate, etc. In fact, you can even ask the user to enter the population limit so you make use the program for any kinds of predictions (8 billion? 10 billion?). How would you

change the program so it prints the population projection for a given year, say 2100?

Summary

In this chapter you have learned about proprioception or internal sensory mechanisms. The Scribbler robot has three internal sensory mechanisms: time, stall, and battery-level. You have learned how to sense these quantities and also how to use them in defining automated robot behaviors. You also learned about random number generation and used it to define unpredictable robot behaviors. Later, we will also learn how to use random numbers to write games and to simulate natural phenomena. Sensing can also be used to define conditional repetitive behaviors using conditional expressions in `while`-loops. You learned how to construct and write different kinds of conditions using *relational* and *logical* operations. These will also become valuable in defining behaviors that use external sensory mechanisms and also enable us to write more explicit decision-making behaviors. We will learn about these in the next chapter.

Myro Review

`randomNumber()`
Returns a random number in the range 0.0 and 1.0. This is an alternative Myro function that works just like the `random` function from the Python `random` library (see below).

`askQuestion(MESSAGE-STRING)`
A dialog window with `MESSAGE-STRING` is displayed with choices: `'Yes'` and `'No'`. Returns `'Yes'` or `'No'` depending on what the user selects.

`askQuestion(MESSAGE-STRING, LIST-OF-OPTIONS)`
A dialog window with `MESSAGE-STRING` is displayed with choices indicated in `LIST-OF-OPTIONS`. Returns option string depending on what the user selects.

`currentTime()`
The current time, in seconds from an arbitrary starting point in time, many years ago.

`getStall()`
Returns `True` if the robot is stalled when trying to move, `False` otherwise.

`getBattery()`
Returns the current battery power level (in volts). It can be a number between 0 and 9 with 0 indication no power and 9 being the highest. There are also LED

power indicators present on the robot. The robot behavior becomes erratic when batteries run low. It is then time to replace all batteries.

Python Review

`True, False`
These are Boolean or logical values in Python. Python also defines `True` as 1 and `False` as 0 and they can be used interchangeably.

`<, <=, >, >=, ==, !=`
These are relational operations in Python. They can be used to compare values. See text for details on these operations.

`and, or, not`
These are logical operations. They can be used to combine any expression that yields Boolean values.

`random()`
Returns a random number between 0.0 and 1.0. This function is a part of the `random` library in Python.

`randint(A, B)`
Returns a random number in the range A (inclusive) and B (exclusive). This function is a part of the `random` library in Python.

Exercises

1. Write a robot program to make your Scribbler draw a five point star. [Hint: Each vertex in the star has an interior angle of 36 degrees.]

2. Experiment with Scribbler movement commands and learn how to make it transcribe a path of any given radius. Write a program to draw a circle of any input diameter.

3. Write a program to draw other shapes: the outline of a house, a stadium, or create art by inserting pens of different colors. Write the program so that the robot stops and asks you for a new color.

4. If you had an open rectangular lawn (with no trees or obstructions in it) you could use a Zanboni like strategy to mow the lawn. Start at one end of the lawn, mow the entire length of it along the longest side, turn around and mow the entire length again, next to the previously mowed area, etc. until you are done.

Write a program for your Scribbler to implement this strategy (make the Scribbler draw its path as it goes).

5. Enhance the random drawing program from this chapter to make use of speech. Make the robot, as it is carrying out random movements, to speak out what it is doing. As a result you will have a robot artist that you have created!

6. Rewrite your program from the previous exercise so that the random behavior using each different pen is carried out for 30 seconds.

7. The Myro library also provides a function called, `randomNumber()` that returns a random number in the range 0.0 and 1.0. This is similar to the function `random()` from the Python library `random` that was introduced in this chapter. You can use either based on your own preference. You will have to import the appropriate library depending on the function you choose to use. Experiment with both to convince yourself that these two are equivalent.

8. In reality, you only need the function `random()` to generate random numbers in any range. For example, you can get a random number between 1 and 6 with `randRange(1,6)` or as shown below:

```
randomValue = 1 + int(random()*6)
```

The function `int()` takes any number as its parameter, truncates it to a whole number and returns an *integer*. Given that `random()` returns values between 0.0 (inclusive) and 1.0 (exclusive), the above expression will assign a random value between 1..5 (inclusive) to `randomValue`. Given this example, write a new function called `myRandRange()` that works just like `randrange()`:

```
def myRandRange(A, B):

    # generate a random number between A..B
    # (just like as defined for randrange)
```

9. What kinds of things can your robot talk about? You have already seen how to make the robot/computer speak a given sentence or phrase. But the robot can also "talk" about other things, like the time or the weather.

One way to get the current time and date is to import another Python library called `time`:

```
>>> from time import *
```

The time module provides a function called `localtime` that works as follows:

```
>>> localtime()
(2007, 5, 29, 12, 15, 49, 1, 149, 1)
```

`localtime` returns all of the following in order:

1. year
2. month
3. day
4. hour
5. minute
6. seconds
7. weekday
8. day of the year
9. whether it is using daylight savings time, or not

In the example above, it is May 29, 2007 at 12:15pm and 49 seconds. It is also the 1st day of the week, 149 day of the year, and we are using daylight savings time. You can assign each of the values to named variables as shown below:

```
year, month, day,…, dayOfWeek = localtime()
```

Then, for the example above, the variable year will have the value 2007; month will have the value 5, etc. Write a Python program that speaks out the current date and time.