Python, PyGame and Raspberry Pi Game Development

—

Sloan Kelly

Apress®

Python, PyGame and Raspberry Pi Game Development

Sloan Kelly

Apress®

Python, PyGame and Raspberry Pi Game Development

Sloan Kelly
Niagara Falls, Ontario, Canada

ISBN-13 (pbk): 978-1-4842-2516-5 ISBN-13 (electronic): 978-1-4842-2517-2
DOI 10.1007/978-1-4842-2517-2

Library of Congress Control Number: 2016961244

Distributed to the book trade worldwide by Springer Science+Business Media New York, 233 Spring Street, 6th Floor, New York, NY 10013. Phone 1-800-SPRINGER, fax (201) 348-4505, e-mail orders-ny@springer-sbm.com, or visit www.springeronline.com. Apress Media, LLC is a California LLC and the sole member (owner) is Springer Science + Business Media Finance Inc (SSBM Finance Inc). SSBM Finance Inc is a **Delaware** corporation.

For information on translations, please e-mail rights@apress.com, or visit www.apress.com.

Apress and friends of ED books may be purchased in bulk for academic, corporate, or promotional use. eBook versions and licenses are also available for most titles. For more information, reference our Special Bulk Sales–eBook Licensing web page at www.apress.com/bulk-sales.

Any source code or other supplementary materials referenced by the author in this text are available to readers at www.apress.com. For detailed information about how to locate your book's source code, go to www.apress.com/source-code/. Readers can also access source code at SpringerLink in the Supplementary Material section for each chapter.

Printed on acid-free paper

Contents at a Glance

Contents

About the Author

Sloan Kelly has been programming computers since 1982. His first computer was a ZX Spectrum 16K where he learned Sinclair BASIC and moved onto Z80 machine code. At the end of the 8-bit era he progressed to the Commodore Amiga where he coded some small games in a language called Blitz.

After nine years in traditional IT working in senior or lead positions, Sloan went back to school and was awarded a Masters in Informatics (Game Technology) to allow him to pursue a career in the games industry where he has remained for almost ten years. He is currently working for PixelNAUTS Games in the beautiful Niagara Region of Canada as senior programmer. Their debut game, LOST ORBIT, was released in 2015 to critical acclaim.

About the Technical Reviewer

Chaim Krause presently lives in Leavenworth, Kansas, where the U.S. Army employs him as a Simulation Specialist. In his spare time he likes to play PC games and occasionally develops his own. He has recently taken up the sport of golf to spend more time with his significant other, Ivana. Although he holds a BA in Political Science from the University of Chicago, Chaim is an autodidact when it comes to computers, programming, and electronics. He wrote his first computer game in BASIC on a Tandy Model I Level I and stored the program on a cassette tape. Amateur radio introduced him to electronics while the Arduino and the Raspberry Pi provided a medium to combine computing, programming, and electronics into one hobby.

Introduction

This book is intended for anyone who wants to learn how to program games. It is ideally suited to students who want to learn Python and PyGame on their Raspberry Pi. While not necessary, this book has been oriented toward the Raspberry Pi computer.

The Python programming language is ideally suited to beginners and experts alike. The skills you will learn in this book are easily transferable to other computer languages too.

This book assumes that you are familiar with the Raspberry Pi computer and that you have the Raspberry Pi Foundation's recommended OS installed: Raspbian "Jessie," a distribution of the Debian Linux operating system built specifically for the Raspberry Pi. This distribution contains all the Software Development Kits (SDKs) including one for Python that includes PyGame. If you don't have "Jessie" installed, you will have to ensure that you have Python and PyGame installed on your system.

Don't have a Raspberry Pi? Not to worry, you can still learn Python and PyGame. The code in this book will work on other OSes with Python and PyGame installed; Python is a platform independent language.

You can obtain more information and download versions of Python from `http://www.python.org`. PyGame can be obtained from `http://www.pygame.org/`.

Sprites from Ari Feldman's SpriteLib have been used for the projects contained in this book.

How This Book Is Organized

The book is organized into chapters covering the following:

- Introduction to the Python language
- Containers in Python
- The IDLE IDE
- Introduction to PyGame library
- Designing your game
- User-defined functions
- File input/output
- Object oriented design and programming
- Model View Controller design pattern
- Finite state machines

There are three projects that produce complete games, all the code and resources for which are on the web site `http://www.sloankelly.net/`. The three games are:

- Bricks
- Snake
- Invaders

Throughout the book are lines of code that you can type in to tell the computer to perform actions, or to add text to a file. In the book, these lines will appear like this:

```
print 'hello world'
```

Python uses white space characters, notably tabs, to denote blocks of code. Because this is an eBook and it is not possible to know how tabs will be rendered on your device, white space is very important to Python, so remember to use the 'tab' key to indent the lines exactly as written like so:

```
name='Sloan'
if (name=='Sloan'):
	print 'Hello ', name
```

The line that starts with 'print' has been indented using the 'tab' key. If you are using spaces instead of tabs, make sure you are consistent. Each time you indent, always use the same number of spaces.

OS commands that are to be typed into a command window like Terminal or a Windows Command Prompt will be preceded with a '$' sign:

```
$ ls -al
```

There are screen shots and other graphics throughout the text to illustrate output, but when it is just text it will appear in a box like this:

```
This is output from a command.
It can appear on one or more lines.
```

Finally, anything important will appear in a note formatted like this:

TAKE NOTE OF THIS MESSAGE.

CHAPTER 1

What Is a Programming Language?

A computer program is a list of statements that a computer must carry out in order to complete a task. A computer language describes the arrangement or syntax of those statements. There are various computer languages out there, each suitable to one or more tasks.

Each language has its own syntax, but they all have commands that perform roughly the same types of actions:

- Input
- Output
- Decision-Making
- Loops

A command or keyword is a special phrase that is used by the language to perform an action whether it is to get input from the user, or display text on the screen. These commands are reserved words that cannot be used for any other purpose in your program.

The old definition of a computer program was a basic mathematical formula:

Program = Algorithm + Data

An algorithm is a step-by-step procedure for processing data. The algorithm solves a problem with the data that it has been supplied. What kind of problem? It could be anything from calculating the area of a rectangle or the volume of a room to deciding how an enemy should react to a player who just obtained a power up.

Electronic supplementary material The online version of this chapter (doi: 10.1007/978-1-4842-2517-2_1) contains supplementary material, which is available to authorized users.

S. Kelly, *Python, PyGame and Raspberry Pi Game Development*,
DOI 10.1007/978-1-4842-2517-2_1

Are all computer programs written the same way? Is there a standard way to approach a given problem? Well, no. Not really. There are many ways to achieve the same result in computer programming! There is no correct way of solving a problem. So long as your program does what it is supposed to, that's just fine! You may want to 'tweak' your code later to speed it up, but any optimization happens once you have the algorithm right. Your program must function as expected. This is of paramount importance.

It is not advisable to stick to one language, but rather experience as many languages as you can. This will enable you, the programmer, to decide which language is best for a given situation.

Your first language is a great choice. Python is a very powerful language that can be used for a variety of purposes and is perfect for the first-time programmer.

CHAPTER 2

What Is Python?

Python is a modern programming language that supports object-oriented, functional, and imperative programming styles. It is ideal for the beginner because of its readability and ease of use. Python is first and foremost a scripting language, but can be compiled into computer-readable binary. The upside to all of this is that you can write programs in less lines of code than an equivalent C/C++ or Java program.

What on earth did I just say? Let's break that last paragraph down and make it a little more readable.

Programming Styles

Python is suitable for programming in the following styles:

- Imperative
- Object-Oriented
- Functional

Imperative

Imperative programming was for the longest time the most common way to write computer code. It describes step by step how to perform changes to the data in a very linear manner.

For example, we have the following items:

- Tea
- Bag
- Milk
- Cup
- Spoon
- Kettle
- Water

S. Kelly, *Python, PyGame and Raspberry Pi Game Development*,
DOI 10.1007/978-1-4842-2517-2_2

This is our data. We want to change this data to a different state. What state? Well, we want a cup of milky tea. How do we do that? We prescribe a series of operations that will transform this data into some other data. Like so:

- Place tea bag in cup
- Pour water into kettle
- Boil the kettle
- While the kettle is boiling, watch TV
- Pour the water from the kettle to the cup
- Pour milk into the cup
- Stir the tea with the spoon
- Serve

In code (not specifically Python code), this could be written as:

```
addTo(cup, tea_bag)
addTo(kettle, watter)
boil(kettle)
while isBoiling(kettle):
        watchTV()
addTo(cup, getWaterFrom(kettle))
addTo(cup, milk)
stir(cup)
serve(cup)
```

These are the prescribed steps (process) to change our initial data (our input) and transform it into our output. See Figure 2-1.

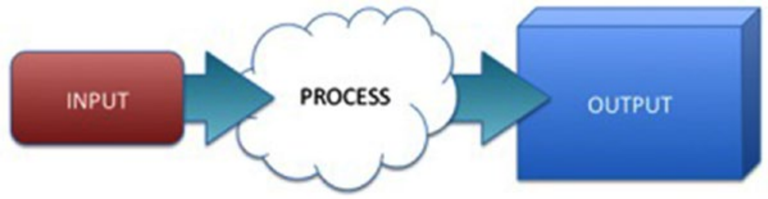


Figure 2-1. *Input, process, output block diagram*

Object-Oriented

Imperative programs separate the functionality (the algorithm) from the data. Object-oriented languages keep the functionality with the data. Objects contain the data and the instructions used to manipulate that data in one place.

There is an advantage to this; algorithms stored with it process your data. Let's take a pencil as an example. It has certain attributes that describe it:

- Color
- Hardness
- Nib Size
- Length

It also has certain actions or methods that can be applied to it:

- Write
- Erase
- Sharpen

These methods change the state of the object; remember that state is determined by the data. For example, when you write using a pencil, the nib length gets smaller and smaller. When you sharpen the pencil, its overall length gets shorter, but the nib size is reset to its maximum.

Functional

Functional programming is not new and was first developed in the 1930s. It has its roots in lambda calculus. Functional programming uses mathematical functions to perform calculations. No data is changed in these calculations; instead new values are calculated. This means that functional programs have no state.

Functional programming tends to be used for recursion (calling the same function from itself) and iteration through items.

In Python, Fibonacci numbers can be calculated with the following one line:

```
fib = lambda n: n if n < 2 else fib(n-1) + fib(n-2)
```

This was taken from a discussion on StackOverflow (http://bit.ly/FibonacciPython). To calculate a value, the programmer simply passes in an integer value:

```
fib(5)
```

Conclusion

Python is a modern, multi-paradigm programming language. It can be used for imperative, object-oriented, and functional programming. So, now that we know what Python is capable of, it's time we took a look at the language itself.

CHAPTER 3

Introducing Python

In this section we will introduce the Python language. At this stage we're only interested in understanding the format or syntax of the Python language and its keywords. Python is an interpreted language, meaning that it requires another program called an interpreter to run any code that we write.

The Python interpreter program is called Python and is an executable program. When you run Python from the command line by itself then you will see the following:

```
pi@raspberrypi ~ $ python
Python 2.7.9 (default, Jan 13 2013, 11:20:46)
[GCC 4.9.2] on linux2
Type "help", "copyright", "credits" or "license" for more info

>>>
```

This is the Python interpreter and will run each command block as you type it in. To start the Python interpreter, type the following at a command prompt or terminal window:

```
$ python
```

A command block in Python is a list of commands at least one line long. Let's try one now:

```
print 'Hello, world!'
```

This will instruct Python to display the phrase 'Hello, world!' onscreen. Notice that Python doesn't display the quotation marks:

```
Hello, world!
```

This is because 'Hello, world!' is a string literal. A string is any phrase containing alphanumeric or symbol characters that is enclosed between 'and' or "and". You can't mix and match the quotes. Being able to use both becomes quite handy at times. Let's try this:

```
print "It's going to rain on Saturday."
```

S. Kelly, *Python, PyGame and Raspberry Pi Game Development*,
DOI 10.1007/978-1-4842-2517-2_3

With double quotes used to mark where our string literal starts and ends, we can use the single quote as an apostrophe:

```
It's going to rain on Saturday.
```

If we used single quotes, we would have had to add a special escape character to the line:

```
print 'It\'s going to rain on Saturday.'
```

We'll get to escape characters later, but that's a little messy for just wanting to put an apostrophe in a sentence!

Let's break down the print statement that we've just used. print is a keyword used by Python to output information to the screen. The second part, the string literal, is a parameter of the print command. Parameters are also called arguments.

Python Is Interpreted

Every line of Python is interpreted. This means that the computer takes each line of code that you type and converts it one at a time to code that the computer can understand. The other type of language is compiled. When a language requires compilation to translate your source code into a language the computer can understand, that processing is done by another program called a compiler. This is a separate program that you run after you have written all your code.

Because the Python language is interpreted, you only need one program to run it: Python. When we are in the interactive Python shell, anything we type is immediately interpreted by the program and the result displayed onscreen, if there is a result.

Python as a Calculator

Say we want to add two numbers together, for argument's sake, 2 and 2. Type the following into the Python interpreter and press return:

```
2+2
```

What you will see onscreen is what you were (hopefully) expecting to see:

```
4
```

We will see later that all the arithmetic operations (add, subtract, multiply and divide) are available as well as others that you might not have seen before. They'll be introduced as you go through the text.

Examples:

```
5 * 4
10 / 2
7 + 2
9 - 4
```

What about something more complex like:

```
2 + 2 * 6
```

What did you expect to see? 24? Why is it 14? That's because arithmetic operators work on an order of precedence or put another way, some operators are more important than other operators. The operators '*' for multiplication and '/' for divide are more important than + and - used for addition and subtraction respectively.

If you want to ensure the order of operation, you can use parenthesis marks '(' and ')' like so:

```
 (2 + 2) * 6
```

Which will now give 24 because the addition of 2 and 2 will be performed first, then its product will be multiplied by 6. Watch your brackets! Ensure that they match up. If you don't you'll get a continuation marker '...') as shown in the following:

```
>>> (2 + 2 * 6
...
```

Let's say you want to calculate the area of a floor (width * length) in meters and convert that value to square feet. Assume that the room is 2 meters by 4 meters. You could use something like:

```
 ((2 * 4) * (3.28 * 3.28)
```

This is because there are 3.28 feet in a meter; to get a square meter in feet, we multiply the 3.28 feet value by itself. This is called the square value:

```
26.246719160104988
```

Or 26 square feet. Of course, we know that a square meter is actually 10.76 square feet, so we can make this problem shorter by doing this:

```
((2 * 4) * 10.76
```

We'll go into this next bit in depth later, but for now we should take a moment to discuss what we've been doing so far.

The numeric values that you have entered are called constants. They can never change. 1 will always be 1 and 24.234 will always be 24.234. We can store constants in memory for safekeeping and refer to them later on in our program. These slots in the computer's memory are called variables. They are called this because the value that we store can vary over the course of the program. Let's say we wanted to store the 10.76 constant. We have to assign it a name. This action is called variable assignment and looks like this:

```
squareFeet = 10.76
```

You can read that as ‘assign the value 10.76 to squareFeet’ or ‘give squareFeet the value 10.76’, or (as I like to call it) ‘squareFeet equals 10.76’. That’s more of a “say what you see mentality” though!

Any time we want to use this variable, we use it in much the same way as we’d use a constant. To calculate the area of that 2 x 4 meter room:

```
(2 * 4) * squareFeet
```

Python is cAsE sEnsItIve! Note that the name of the variable is ‘squareFeet’ and not ‘squarefeet’ or ‘Squarefeet’.

Keywords

Python has a very small number of built-in keywords, 31 in total. From these though we can make any program you want to make from a simple bat and ball game to a spreadsheet application, if you fancy making one of them. Python's keywords are the following:

- and
- as
- assert
- break
- class
- continue
- def
- del
- elif
- else
- except
- exec
- finally
- for
- from
- global
- if

- import
- in
- is
- lambda
- not
- or
- pass
- print
- raise
- return
- try
- while
- with
- yield

These are the building blocks of the language, the Lego® bricks if you like. From all of these words you can create anything from simple calculations to games to application software. Sometimes, most of the really hard work is done for you and is supplied as a Python module. This is a library of commands, routines, and objects that are packaged together to provide a common functionality. PyGame is an example of a module.

Printing

We've seen how to print simple messages on the screen, but you can get much fancier with how those messages are formatted (how they look). For example, you can use escape sequences to add white space characters like tabs and returns to the text. For example:

```
print "these\nare\non\nseparate\nlines"
print "tab over\tto here"
```

The backslash character '\' is used to generate an 'escape' code for the next character. Escape characters or control sequences date back to the teletype days and are used to control the output to the device we're printing to: in this case the screen.

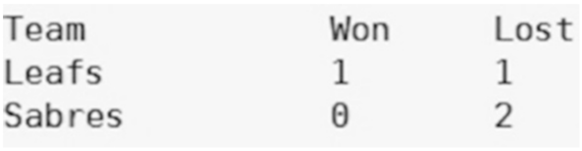
There are various control sequences and these are listed below with their descriptions.

Escape Sequence	Description
\\	Outputs a backslash
\’	Outputs a single quote mark(‘)
\”	Outputs a double quote mark (“)
\a	Bell
\b	Performs a backspace
\f	Performs a form feed
\n	Performs a line feed
\N(name)	Character named name in the UNICODE database
\r	Performs a carriage return
\t	Performs a horizontal tab
\uxxxx	Character with 16-bit hex value xxxx
\Uxxxxxxxx	Character with 32-bit hex value xxxxxxxx
\v	Performs a vertical tab
\ooo	Character with the octal value ooo
\xhh	Character with the hex value hh

From these escape characters you can create complex output. This can be used to display tabular information, for example:

```
print "Team\t\tWon\tLost\nLeafs\t\t1\t1\nSabres\t\t0\t2"
```

Will display the following table.



```
Team            Won     Lost
Leafs           1       1
Sabres          0       2
```

Figure 3-1. *Output from the team table's print statement*

Which is pretty, but what if we want to do a better job? Say we wanted to align the numbers to the right instead of to the left? That means moving the numbers to the same column as the last character of “won” and “lost.” This is where string formatting comes into play.

String Formatting

String formatting allows you to decide how information will be displayed to the user as text. We've already seen how we can manipulate the visual portion of the text by deciding where the text will be placed; we'll now examine at how the data can look to the user. We don't need to change the data: we're just altering how the user sees the data.

Formatting is achieved by using placeholders in the text for information you want to insert. These are shown in the next table.

Placeholder	Description
%s	String
%d	Whole number
%f	Floating point number
%r	Raw value

The raw value isn't particularly helpful for end users of your program, but it can be handy when you are debugging the code trying to find out what went wrong. More of that later in the debugging chapter.

If we want to display three numbers, for example, the x-, y-, and z- coordinates of an object then we could use something like:

```
print "{%d, %d, %d}" % (1,2,3)
```

The '%' inside the string literal denotes that the following item is a placeholder and it is of type 'd' for a whole number. The '%' outside the string literal is used to say 'fill in those placeholders with' and then the last bit in parentheses '(' and ')' is called a tuple. Those are the values that are placed in the string in the order that they appear. The text that appears when you enter that line is:

```
{1, 2, 3}
```

Let's try it again, but this time with the player's name, their score, and percentage completed:

```
print "%s scored %d and completed %f of the quest" % ('Sloan', 15, 55)
```

You'll notice that the output is a little over the top; the floating point number is showing a lot of zeros. We can minimize this by specifying how many points there should be to the right of the decimal point. At the moment we have:

```
Sloan scored 15 and completed 55.000000 of the quest
```

Let's change the line to show only two decimal points:

```
print "%s scored %d and completed %.2f of the quest" % ('Sloan', 15, 55)
```

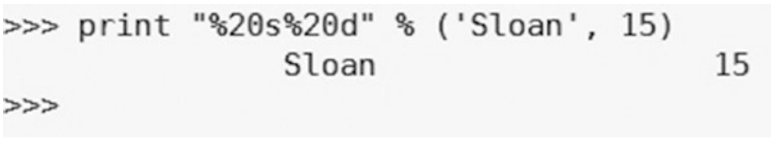
Now the output of the statement is:

```
Sloan scored 15 and completed 55.00 of the quest
```

We can also use the numbers after the '%' symbol to space out the values. For example:

```
print "%20s%20d" % ('Sloan', 15)
```

This displays what is shown in Figure 3-2.



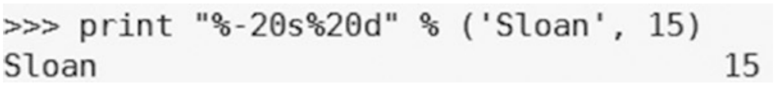
```
>>> print "%20s%20d" % ('Sloan', 15)
               Sloan                  15
>>>
```

Figure 3-2. *Showing the result of prefixing placeholders with numeric values*

The values are right-aligned to their positions and they both take up 20 columns. What if we wanted to left-align the name of the player though? We would use a negative value:

```
print "%-20s%20d" % ('Sloan', 15)
```

By using the negative value, you are specifying that you want 20 spaces but the text must be aligned to the left:



```
>>> print "%-20s%20d" % ('Sloan', 15)
Sloan                                 15
```

Figure 3-3. *Formatting text with negative numbers aligns the value to the left*

Going back to our hockey team example, we can now use this information to better place the text and data. Rather than relying on tabs that can vary depending on the size of the text, we can make the table use fixed values like so:

```
print "%s%s%s\n%s%d%d\n%s%d%d" % ('Team', 'Won', 'Lost',
'Leafs',1,1,'Sabres',0,2)
```

This shows how it appears without the values before the placeholder. And now with the column width of each item:

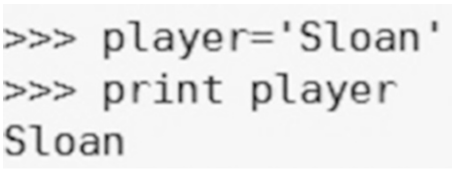
```
print "%-10s%10s%10s\n%-10s%10d%10d\n%-10s%10d%10d" % ('Team', 'Won',
'Lost', 'Leafs',1,1,'Sabres',0,2)
```

That's a lot of '%' symbols, isn't it! This is a rather severe case, and not one that would be particularly common. In fact, you would use something called variable assignment to make this a lot easier to read. We will now look at that in detail now.

Variables

Variables are used to store the data in memory while we are processing it. We access the data using names. Each variable can be assigned a value. This value represents our data that we want processed. Let's say we want to store the player's name so that we could retrieve it at a later time.

This is called variable assignment. When we assign a value to a name, we are saying that that name now contains the assigned value:



```
>>> player='Sloan'
>>> print player
Sloan
```

Figure 3-4. *The name player is assigned the value 'Sloan'*

Our variable assignment is:

```
player='Sloan'
```

The left-hand side of the equals sign (=) is the name and the right-hand side of the equals sign is the value. The value can be anything from a string literal, a whole or floating point number, to a complex mathematical formula.

Naming Variables

You can call variables whatever you want, but I would suggest that they reflect the data that you are expecting to store in them. There are a couple of caveats to the characters you can use for a name:

- Alphanumeric characters, but the name can't start with a number
- The underscore '_' character

These are valid variable names:

- playerName
- player1
- numOfLives
- _arg1
- this_is_a_long_name_hope_its_worth_it_555

These are invalid variable names. The reasons given are shown to the right of the '#'. The '#' is used as a comment character in Python. Everything after the '#' is ignored on a line:

- 123Fred # starts with a number
- Fr*d # contains an illegal character
- character '*' player$ # contains an illegal character '$'

Python variable names are case sensitive! Be careful:

```
thisVariable
```

is not the same as:

```
Thisvariable
```

You have been warned! Watch your cases!

PYTHON IS CASE SENSITIVE!

Python as a Calculator, Part II

Remember that a computer program takes information from the user, processes it, and gives feedback to the user as output. We are going to turn Python into a calculator for this section. Say we have the price of a can of soda as 55 cents, let's remember that:

```
canOfSoda = .55
```

Now, suppose we have been told to buy 12 cans of soda, let's remember that too:

```
numCans = 12
```

We can now print out the value of 12 cans of soda using a simple formula:

```
canOfSoda * numCans
```

But wait! What is this?! You don't get 6.6, you actually get this:

```
6.6000000000000005
```

This seems a little strange, doesn't it? Why should this happen? This is all to do with precision. When computers calculate a fractional number, they have to use binary numbers (base 2, 0, or 1) to calculate those fractions. When translating them back into decimal values, it doesn't quite add up. We can tidy it up ourselves using string formatting:

```
"%2.2f" % (canOfSoda * numCans)
```

That's better! And we can further tidy it up to show the dollar (or local currency symbol) amount:

```
"$%2.2f" % (canOfSoda * numCans)
```

Which will display:

```
'$6.60'
```

Notice that our values have '' around them; that's because we're doing raw output to the Python terminal, so anything we type in immediately gets processed and output. If we want to print out the string without the quotes, we need to add the print command:

```
print "$%2.2f" % (canOfSoda * numCans)
```

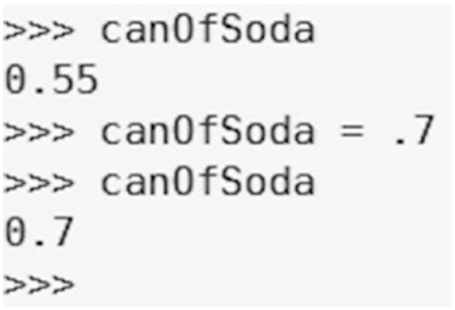
Outputs:

```
$6.60
```

Bad news though, the price of a can of soda has now risen to 70 cents. No problem though, because we can just tell Python to remember the new value:

```
canOfSoda = .7
```

This session shows the previous value, the assignment and the new value:



```
>>> canOfSoda
0.55
>>> canOfSoda = .7
>>> canOfSoda
0.7
>>>
```

Figure 3-5. *Changing the price of a can of soda*

If we want to see how much a dozen cans costs, we use the same line as before:

```
print "$%2.2f" % (canOfSoda * numCans)
```

Did you know that you can use the up and down cursor keys to move through the history of the Python statements you typed in the interactive Python program? When you step through your statements, you can use the left and right cursor keys to move along the line and the delete / backspace keys to remove unwanted characters. Could save you some typing time!

Figure 3-6. *Use the up/down cursor keys to recall previously typed lines and the left-right keys to edit*

Arithmetic Operators

Arithmetic operators are short form symbols used to perform arithmetic on numbers. You will have used the majority of them at school; Python uses some different symbols compared to the ones used in school.

Operator	Description	Example
+	Addition; the two values either side of the operator are added together	4 + 5 will give 9
-	Subtraction; the value on the right-hand side of the operator is subtracted from the value on the left-hand side	5 - 4 will give 1
*	Multiplication; the two values on either side of the operator are multiplied together	2 * 3 will give 6

(*continued*)

Operator	Description	Example
/	Division; divides the value on the left-hand side of the operator with the value on the right-hand side	10 / 5 will give 2
%	Modulus; divides the value on the left-hand side of the operator with the value on the right-hand side to produce the remainder	5 / 2 will give 1
**	Exponent; raises the value on the left-hand side by the power supplied on the right-hand side	2 ** 4 will give 16. This is written in mathematics as 2^4 or 2 * 2 * 2 * 2
//	Floor division; divides the value on the left-hand side of the operator with the value on the right-hand side to produce the integer lower value	5 / 2 will give 2.0

Data Types

Python uses something called duck typing. Duck typing ensures that as long as a method or functionality exists for a particular named value (a variable), then Python will perform that action upon it. The poet James Whitcomb Riley came up with this phrase to describe inductive reasoning:

> *If it looks like a duck, swims like a duck, and quacks like a duck, then it probably is a duck.*

Python does have specific data types as well, and these are used to describe the contents of a variable. Python has the following built-in data types:

- Numerics
- Sequences
- Mappings
- Files
- Classes
- Instances
- Exceptions

Numeric types

Numeric Type	Description
int	Integers are at least 32 bits in size (4 bytes), which means you can store any whole number up to and including 4,294,967,295. However, this is usually a signed value, which means that the range of values actually goes from -2,147,483,648 to +2,147,483,647
float	A floating point number is a number with a fractional component like 2.4 or 1.49387
long	Long integers have an unlimited precision and therefore no upper limit on the number of bits that can be used to store them.
complex	Complex numbers have real and imaginary parts. These parts are floating point numbers.

Arithmetic operations will work on all the numeric types without issue. In addition, the following operators might come in handy. These aren't used in normal everyday arithmetic, but for Python they come in very handy:

Operator	Description	Example
-x	Negate the value 'x'	-2 gives -2
+x	Leave the value 'x' unchanged	+2 gives 2
abs(x)	Absolute value of 'x'	abs(-5) gives 5
int(x)	Convert 'x' to an integer	int(5.44) gives 5
long(x)	Convert 'x' to an integer	long(5) gives 5
float(x)	Convert 'x' to an integer	float(5) gives 5.0
complex (real, imaginary)	Creates a complex number with the real part 'real' and the imaginary part 'imaginary'	complex(1,5) gives (1+5j)

For example, to calculate the area of the side of a building that is 5 meters along, by 10 meters high:

```
width = 5
height = 10
area = width * height
```

To display the value, type in:

```
area
```

This will display the answer to 5 * 10:

```
50
```

String Formatting Again

Let's go back to our hockey score table:

```
print "%-10s%10s%10s\n%-10s%10d%10d\n%-10s%10d%10d" % ('Team', 'Won',
'Lost', 'Leafs',1,1,'Sabres',0,2)
```

We can break this down into smaller, more readable chunks of data. Don't be afraid to do just that; making your program readable is preferable over speed. You should strive to get the code right rather than fast. Optimization can come later.

MAKE YOUR CODE READABLE! WHEN YOU RETURN TO IT AT A LATER DATE, YOU WILL STILL BE ABLE TO MAKE SENSE OF IT!

There is common formatting used throughout the table; each team is allotted 10 characters for their name, and won and lost numbers. At the end of each is a new line character. We can set a variable up to remember this format:

```
formatter="%-10s%10s%10s\n"
```

Then it's a simple matter of assigning variables that use this format for each header and team:

```
header=formatter % ('Team', 'Won', 'Lost')
leafs=formatter % ('Leafs', 1, 1)
sabres=formatter % ('Sabres', 0, 2)
```

Now that we have our header and team data stored in variables, we can combine them all in one line to draw our table:

```
print "%s%s%s" % (header, leafs, sabres)
```

If we wanted we could assign this to a variable and print that out later. Our variable assignment would look like this:

```
table = "%s%s%s" % (header, leafs, sabres)
```

If we just type in the table in the Python interpreter program we get this displayed:

```
'Team Won Lost\nLeafs 1 1\nSabres 0 2\n'
```

This is the raw output of the contents of the name table. This shows us what the name table contains, but not how it will be displayed. To display the table correctly:

```
print table
```

CHAPTER 4

Breaking Free from the Interpreter

Up until now we have used the interpreter to write our code. As each line is entered, the Python program interprets it and the processed line's output is displayed onscreen. From now on we will use the 'nano' editor from the command line.

To quit the interpreter, if you haven't already done so, press Ctrl+D.

Starting a New File

To start a new file, or edit an existing file, you type:

```
$ nano {filename}
```

Where {filename} is the name of the file you want to create / edit. It's important that you know where you are when you create the file because with just the file name, the file will be created in the current directory. Let's move to the home directory and create a folder called pygamebook. We'll do all our work inside there.

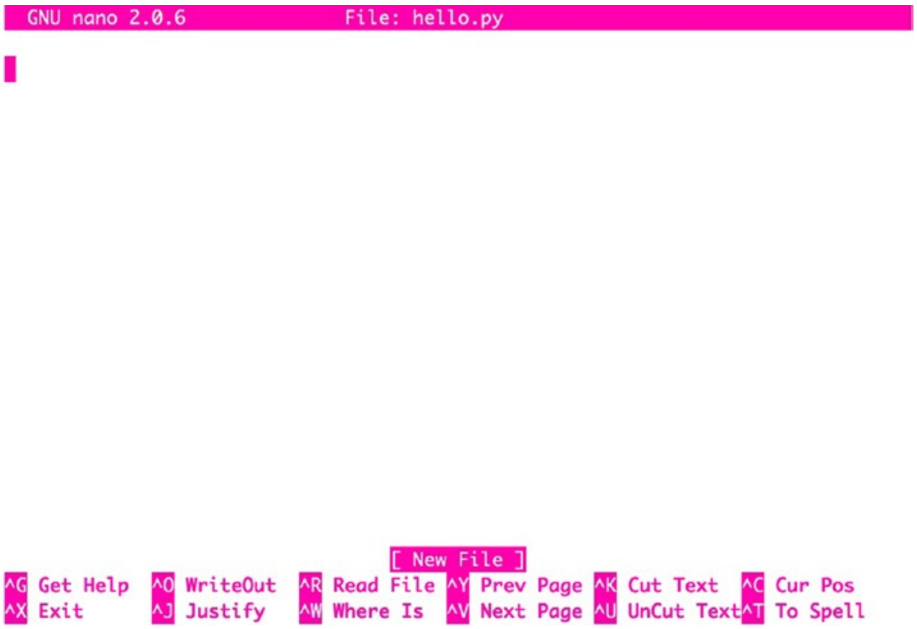
```
$ cd
$ mkdir pygamebook
$ cd pygamebook
```

To open up nano and create the file (which we will call 'hello.py'):

```
$ nano hello.py
```

This will start the nano text editor as shown in Figure 4-1.

© Sloan Kelly 2016
S. Kelly, *Python, PyGame and Raspberry Pi Game Development*,
DOI 10.1007/978-1-4842-2517-2_4



```
GNU nano 2.0.6                File: hello.py

                              [ New File ]
^G Get Help  ^O WriteOut  ^R Read File ^Y Prev Page ^K Cut Text  ^C Cur Pos
^X Exit      ^J Justify   ^W Where Is  ^V Next Page ^U UnCut Text^T To Spell
```

Figure 4-1. *The blank nano editor with 'hello.py' as the opened file*

The first line of any Python script file is the location of the Python interpreter. This is called a hash-bang and looks like this:

```
#!/usr/bin/python
```

This tells the shell which program to call when this file is executed. Now that we have that in place, we can start our program. In this case, it's super simple; our standard "Hello World!" program:

```
print "Hello, World!"
```

You should now have the following lines in the nano editor:

```
#!/usr/bin/python print "Hello, World!"
```

Save the file by pressing Ctrl+O. Press return to confirm the name. Then press Ctrl+X to exit nano. There is one final piece to the puzzle. By default, Linux (Raspbian) does not make files executable; we have to do that. At the command prompt, type:

```
$ chmod +x hello.py
```

This adds the executable flag to the file's attributes. To run the file we type:

```
$ ./hello.py
```

Why do we add the './'? It is because in Linux executable files are searched through a series of paths. Our new folder isn't part of the system path, so we have to tell it where it is. Luckily there's a shortcut for this; the current directory is called '.'

When the program runs you should see the now familiar message:

```
Hello, World!
```

Remember, from now on, we're going to be writing script files for our Python programs.

WHEN CREATING A PYTHON SCRIPT FILE ALWAYS PLACE

THE PATH TO THE INTERPRETER AS THE FIRST LINE IN A HASH-BANG:

#/usr/bin/python

For the sake of brevity, I will not be including this line in each program, unless the program is sufficiently large, like our game listing walk-throughs.

CHAPTER 5

Making Decisions

Up until now we have seen very linear programs. These programs follow from one statement to the next, never deviating. In essence, they're just a shopping list; you get the vegetables first, then bread, then canned vegetables, and finally cat food. Why? Because that's the order that those items typically appear in a supermarket.

But what if you wanted to make simple changes? What if your program could decide what to do, based upon the input it was given?

In computer science this is called branching. Essentially, a decision is made based upon the given data, and one block of code is executed over another block of code. Let's look at a diagram in Figure 5-1.

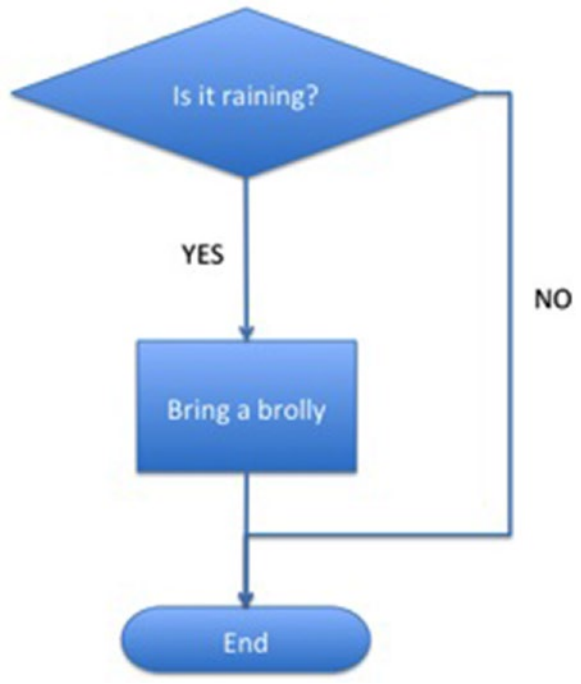


Figure 5-1. *Flowchart showing a simple 'if' statement*

© Sloan Kelly 2016
S. Kelly, *Python, PyGame and Raspberry Pi Game Development*,
DOI 10.1007/978-1-4842-2517-2_5

This is called a flowchart and shows the route taken (process) through a series of decisions based on our input that we use to generate our output. In the diagram, we're asking a question: "Is it raining?" Our data is either a "YES" or a "NO." If the answer to the question is "YES" then we bring a brolly (umbrella). Otherwise? We do nothing.

Computers are excellent at these types of decisions; it's either YES or NO; on or off; true or false.

In fact, computers only really understand these binary decisions.

BINARY MEANS THAT SOMETHING IS EITHER OFF OR ON, TRUE OR FALSE.

In Python, we don't have "YES" or "NO" values, but we do have similar values; 'True' and 'False'. That's the 'On' and 'Off' values respectively. So how do we write this in Python? We use the 'if' keyword. In English, we'd say, "If it's raining, I'll bring my brolly," in Python that's written as:

```
isRaining = True
if isRaining:
        print "I will take my umbrella to work today"
```

The first line assigns the 'True' constant to 'isRaining'. True is a special keyword (along with False) that is used in Python to denote the result of a Boolean test.

The second line checks the value contained within 'isRaining' and if it is set to True (which it is), it will print out the string of text. Notice that you will have to tab in the print statement. This is because it forms part of the 'if' block.

IF conditions always equate to one of two values: TRUE or FALSE.

We could also have written that 'if' statement as:

```
if isRaining == True:
```

This is much more explicit, but is not the preferred use. When you have a variable that begins with 'is' or 'has', the assumption is that it contains a Boolean value. ALWAYS! ALWAYS! – check that this is the case before you use the variable.

The format of the 'if' statement is:

```
if condition: {statement}
```

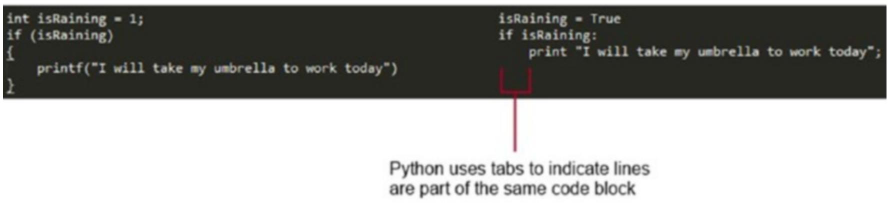
or

```
if condition:
{block}
```

The second method is preferred because you may want to go back and add more lines to the code that is to execute inside the 'if' block. Not that for each line in the block, you will have to indent that line the same amount each time.

A Note about Blocks

A block of code is one or more lines of Python code. When contained within a controlling statement like an 'if', 'for', or a 'while', for example, the statements that make up the block MUST be shifted one tab across. This is because Python does not use syntactic sugar or extra characters to denote the start and end of a block. Languages based upon the C language use '{' and '}' to indicate blocks. Python does not. For example, see Figure 5-2; this is the C language-style equivalent beside the Python version.



```
int isRaining = 1;
if (isRaining)
{
    printf("I will take my umbrella to work today")
}
```

```
isRaining = True
if isRaining:
    print "I will take my umbrella to work today";
```

Python uses tabs to indicate lines
are part of the same code block

Figure 5-2. *Showing the difference between explicit block characters and Python's implicit indentation method*

We can also place more than one line after the ':' as shown in the example below:

```
isSunny = True
if isSunny:
        print "It is sunny outside"
        print "I won't need my umbrella"
```

Both lines inside the 'if' block are executed only if 'isSunny' is 'True'. What if we wanted to display something if isRaining wasn't true? Could we do this:

```
isRaining = True


if isRaining:
        print "I will take my umbrella to work today"
print "It is nice and sunny"
```

The program displays the following output when it is run:

```
I will take my umbrella to work today.
It is nice and sunny
```

This is not an ideal situation because we were only looking for one line to be output. The second line is always going to be executed because as we know, programs run blindly step by step through a program until they get to the end and there are no more lines to process. What we need to do is this:

```
isRaining = True
if isRaining:
        print "I will take my umbrella to work today"
else:
        print "It is nice and sunny"
```

Notice the extra keyword 'else'. This allows us to better control what we expect to do if 'isRaining' turns out to be false. You don't have to put in an 'else' for each 'if'. Sometimes there will be no alternatives and you only want to run a particular set of statements for a particular condition.

Testing for Equality

Python allows the programmer to test for equality - we have seen this in so far as we were testing that a particular variable is equal to true. We know that IF conditions have to equate to one of two values: TRUE or FALSE, so how can we test for (in)equality? We use one of the following *range operators*:

- Equals (==)
- Less than (<)
- Greater than (>)
- Less than or equal to (<=)
- Greater than or equal to (>=)
- Not equal to (!=)

These are mathematical symbols. For those of you unfamiliar with them, especially the less-than and greater-than symbols, the small pointy end points to the lesser value. You cannot use these operators against variables that contain Boolean True or False; equality operators can only work against numbers or character strings.

The following program prompts the user to enter two string values and then checks which string is greater. We'll cover the finer details in just a second, but the program does have some shortcomings. Can you see what they are?

```
print "This program will take two strings and decide which one is greater"
first = raw_input("First string: ")
second = raw_input("Second string: ")

if first > second:
        tup = (first, second)
```

```
else:
        tup = (second, first)

print "%s is greater than %s" % tup
```

The first line displays a message indicating what the program will do. The next two lines prompt the user to enter two separate string values and place them in 'first' and 'second' variables. The 'if' statement condition is:

```
if first > second:
```

This checks to see if the first string is greater than the second. If it is, a tuple called 'tup' is created and first and second are stored. Note the order; first is before second.

If the second string is greater than the first, then the tup variable is also created, but the order is reversed; 'second' appears before 'first'.

Type in the program above and run it. Enter the following values.

Run#ofprogram	'first'	'second'
1	Lowercase a	Uppercase A
2	Aaa	Zzz
3	9	100

What do you notice about the results? Were you expecting that?

The problem with our little example is that unless 'first' is absolutely greater than 'second', the 'else' block is executed. We can remedy this by changing the program to:

```
print "This program will take two strings and decide which one is greater"
tup = None
first = raw_input("First string: ")
second = raw_input("Second string: ")

if first > second:
        tup = (first, second)
elif second > first:
        tup = (second, first)

if tup != None:
        print "%s is greater than %s" % tup
else:
        print "The strings were equal"
```

Change the above program to use an equality sign (==) in the second 'if'. Will you need to change the text of the 'print' statements? If so, what would you change them to?

More common than text equality is numeric equality. Equality tests for numbers are used for collision detection, deciding if a player or enemy is dead, and how much fuel is remaining, etc.

Say, for example, we wanted to check and see if the player's character was within a certain boundary on the screen. This involves checking both the x- and y- coordinate of the player. We can combine our conditions in one statement using Boolean logic:

```
x = 50
y = 50
if x > 0 and x < 100 and y > 25 and y < 250:
        print "Player hit something"
else:
        print "Player missed it"
```

Using Boolean Logic

As we saw in the previous chapter, computers use Boolean logic: any question so long as it results in a TRUE or FALSE answer. The following Boolean keywords can be used to make more complex If conditions:

- And
- Or
- Not

And

And in an 'if' statement will equate to true, only if both conditions are true:

```
isRaining = True isSunny = True
if isRaining and isSunny:
        print "Sun showers"
```

In the context of a game you might have a condition to test that if the player has a key and he or she hits a door, and then opens the door:

```
if playerHasKey and playerHitDoor:
        OpenTheDoor()
        RemoveKeyFromInventory()
```

The two methods OpenTheDoor() and RemoveKeyFromInventory() are programmer made; they're not part of Python. We'll learn about how to make user-defined functions in a later chapter.

In Boolean logic, truth tables are used to show the result of an operation ('and', 'or' or 'not'). Typically, this shows the values for two inputs called 'A' and 'B' and a result.

The truth table for 'and' is follows.

A	B	Result
False	False	False
False	True	False
True	False	False
True	True	True

This shows that for 'and', the combined result of 'A' and 'B' can only be true when both 'A' and 'B' are true.

Or

Or in an 'if' statement will equate to true if either one or the other condition is true:

```
isRaining = True
isSunny = False

if isRaining or isSunny:
        print "Some kind of weather out there"
else:
        print "No weather!"
```

The truth table for 'or' follows.

A	B	Result
False	False	False
False	True	True
True	False	True
True	True	True

This shows that 'or' is only false when both 'A' and 'B' are false.

Not

Not is used to negate a condition: turn it from a true to a false and vice versa. This is a unary operator and only works on a single condition:

```
isRaining = True
isSunny = False
```

```
if isRaining and not isSunny:
        print "It's raining and not sunny"
else:
        print "Sun showers"
```

The truth table for 'not' is different in that it only has one input because it is a unary operator. The truth table therefore only has the 'A' input.

A	Result
False	True
True	False

You can see that whatever the input is, the 'not' keyword negates it.

Nesting Ifs

When we need to make complex decisions based on a number of facts, we can do what is called "nesting." This means placing an 'if' block of code inside another 'if' block of code, for example:

```
isRaining = True
isCloudy = True

if isRaining:
        print "I will take my umbrella to work today"
elif isCloudy:
        print "It looks like it will rain. I'll take my umbre
else:
        print "It is sunny. I'll not bother with the brolly"
```

The truth table for this is shown below to make the above example clearer:

IsRaining	IsCloudy	Output
True	True	I will take my umbrella to work today
True	False	I will take my umbrella to work today
False	True	It looks like it will rain, I'll take my umbrella in case
False	False	It is sunny. I'll not bother with the brolly

The format of an IF statement is therefore:

```
if condition:
        Action(s)
[else:
        Action(s)]
[elif condition:
        Action(s)]
```

A Note on Switch

For users of other languages, you should note that there is no "switch" statement in Python. It was proposed for the language, but ultimately rejected. In an OO (object oriented) language like Python, "switch" can be replaced by polymorphic (we'll get to this later!) calls. Stack Overflow (a great web site, and one you should bookmark) has a great article on how to get around "switch."

See http://stackoverflow.com/questions/126409/ways-to-eliminate-switch-in-code for details. The switch keyword can be easily implemented using ifs like so:

```
character = raw_input("Enter command (help, list): ")
if character == "help":
        print "The help screen goes here"
elif character == "list":
        print "List the items here"
else:
        print "Invalid command!"
```

CHAPTER 6

Making the Raspberry Pi Repeat Itself

A video game repeats the action until all the players' lives have gone, or the end of the game has been reached. So far we have only written programs that run through a sequence of commands and then terminate. With the use of certain Python keywords, we can get the computer to repeat a block of code when required, either using conditions or for a set number of times.

The for Loop

The 'for loop' in Python takes a list, and for each item in the list it performs a series of action. These actions are contained within the block of code that appears after the ':' character and are shifted to the right by one tab. The flowchart in Figure 6-1 below shows what happens inside a 'for' loop.

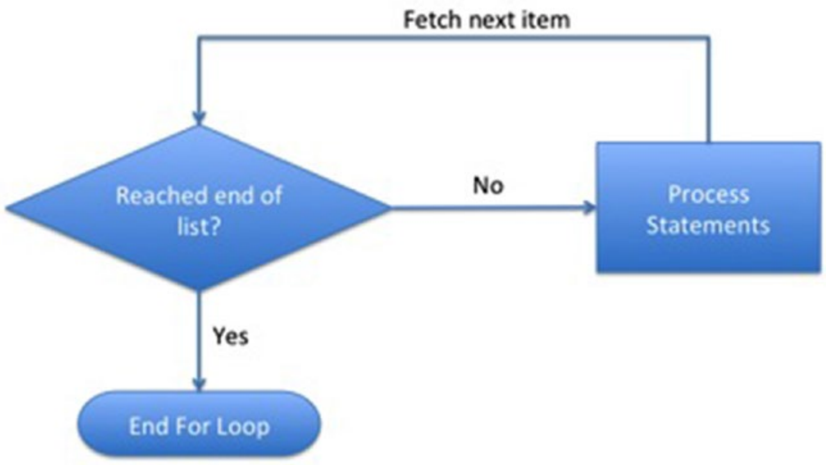


Figure 6-1. *Flowchart diagram showing a for loop*

© Sloan Kelly 2016
S. Kelly, *Python, PyGame and Raspberry Pi Game Development*,
DOI 10.1007/978-1-4842-2517-2_6

As an example, the following program will print the numbers 1 through 5 inclusive. We'll talk about some of the quirks of the range() function in a moment.

Don't forget the hash-bang at the top of the script! Remember that you need the hash-ban to run script files from the command prompt. And you'll also need to change the file mode (chmod) and add the executable flag. See the "Breaking Free From the Interpreter" chapter if you can't quite remember how to do it.

```
for i in range(1, 6):
        print i
```

The 'i' variable here has special meaning. It is acting as a control for the loop. In fact, we give any variable that controls flow the name control variable. Again, this is just a name I've given the variable. I could have called in 'n' or 'j' or 'fred'. Control variables tend to have short names. I chose this one because we're iterating through integers or whole numbers and 'i' seemed appropriate for the task.

The format of a 'for' loop is:

```
for condition:
        Action(s)
```

Where 'condition' is any statement that generates a list.

The range() function

The range() function is provided by Python and as such is referred to as an intrinsic function. It generates a list of numbers from the start value to 1-n where n is the last value in the range. The following examples are taken from statements typed into the Python interpreter:

```
>>> range(1,6)
[1, 2, 3, 4, 5]
>>> range(2,4)
[2, 3]
```

You can also specify a third parameter. This parameter indicates the count that is added to each number after each iteration of the 'for' loop. The default value is 1 (one), which is why you don't need to provide it:

```
 >>> range(10, 255, 10)
[10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 110, 120, 130, 140, 150, 160, 170,
180, 190, 200, 210, 220, 230, 240, 250]
>>> range (10, 0, -1)
[10, 9, 8, 7, 6, 5, 4, 3, 2, 1]
```

That's right, you can even use negative values to iterate from a larger number to a smaller number.

We'll talk about lists and dictionaries in the next chapter, but we've already established that the 'for' loop iterates through lists. So, what if we didn't have numbers? What if we had the names of characters from TV:

```
names = ['Fred', 'Wilma', 'Barney', 'Betty']
for name in names:
        print name
```

The 'names' name is assigned the value of a list that contains the names of characters from a popular TV show. The 'for' loop iterates through each of the names and prints them on the screen. The control variable in this example is 'name'. At each iteration of the loop, the next name from the list will be pulled out and processed.

While Loops

For loops are great for iterating through a fixed list, but what if we don't know how many items we have? For example, reading the contents of a file, or getting data from a web site. This is where the 'while' keyword comes in.

Sure, you can use it for a substitute for the 'for' keyword, but it doesn't look as elegant. For example:

```
#!/usr/bin/python i = 1
while i < 6:
        print i
        i = i + 1
```

In this example I've kept in the hash-bang.

Whereas in the 'for' loop the control variable is contained within the 'for' statement, a 'while' loop has the control variable defined out-with the loop. The programmer also has to manually update the control variable the required step each time.

Notice that the format of a 'while' statement is:

```
while condition:
        Action(s)
```

The 'where condition' is a statement that equates to 'True' or 'False': a Boolean. This is similar then to the 'if' keyword in that it too takes a Boolean condition as its argument. The flowchart for this 'while' loop is shown below in Figure 6-2.

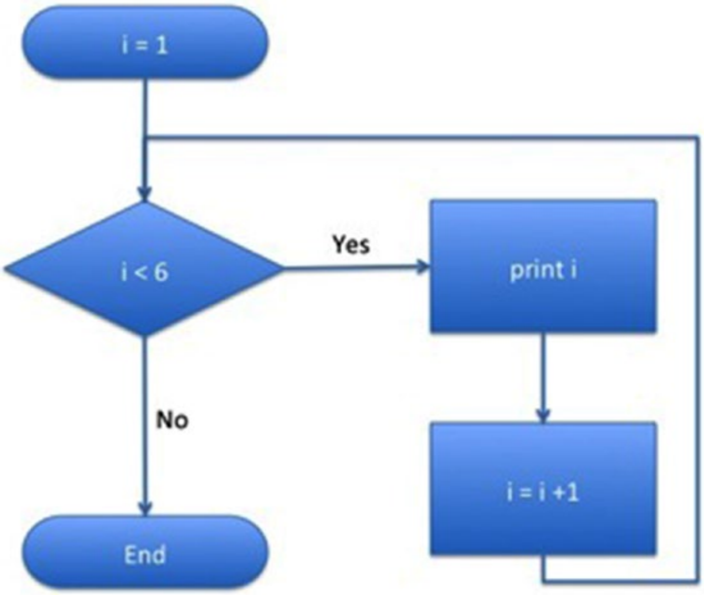


Figure 6-2. *The sample 'while' loop's flowchart*

From the flowchart we can see that the statements in the 'while' block is only executed while the Boolean condition is 'True.'

This means that the 'while' loop's condition acts as a gatekeeper to the lines inside the block. If that condition is not true, don't execute the lines within. Change the initialization of 'i' to 6:

```
#!/usr/bin/python i = 6
while i < 6:
        print i
        i = i + 1
```

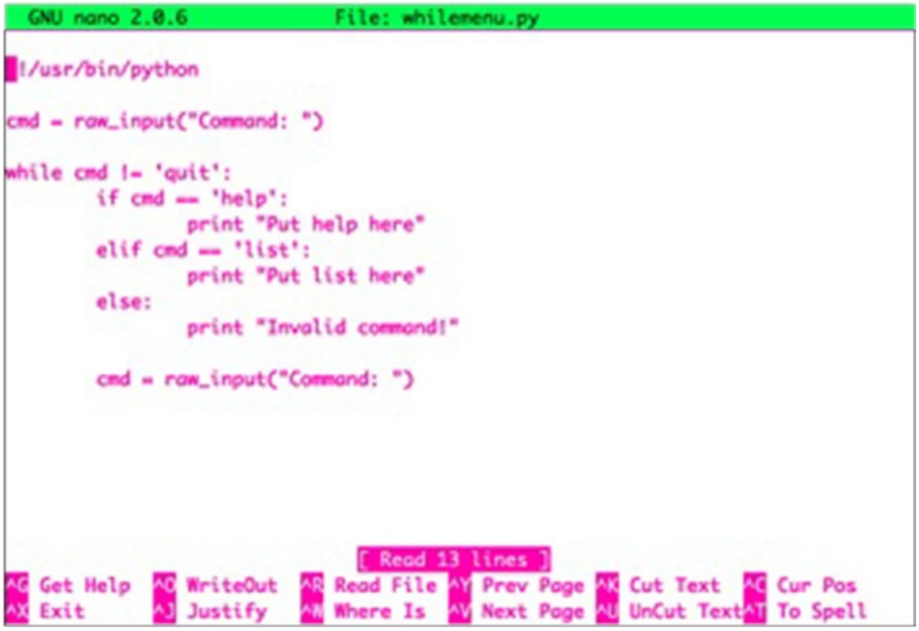
Run the script. What happens? Nothing. No output at all. This is because i< 6, when i = 6 returns 'False.' Let's return to our menu example from earlier. We have three commands now: list, help, and quit. When the user selects quit, the program ends.

We have no idea how many commands the user will start, and we have no idea how many times they will use the same command. This is an idea use case for the 'while' loop because it's perfect for not knowing when something is going to end:

```
cmd = raw_input("Command: ")
while cmd != 'quit':
        if cmd == 'help':
                print "Put help here"
        elif cmd == 'list':
                print "Put list here"
                else:
                        print "Invalid command!"

                cmd = raw_input("Command: ")
```

When we start getting into multiple tabs, you really have to keep the correct spacing. In your editor you should see a program similar to what is shown in Figure 6-3.



```
  GNU nano 2.0.6                File: whilemenu.py

#!/usr/bin/python

cmd = raw_input("Command: ")

while cmd != 'quit':
        if cmd == 'help':
                print "Put help here"
        elif cmd == 'list':
                print "Put list here"
        else:
                print "Invalid command!"

        cmd = raw_input("Command: ")




                                [ Read 13 lines ]
^G Get Help   ^O WriteOut   ^R Read File  ^Y Prev Page  ^K Cut Text   ^C Cur Pos
^X Exit       ^J Justify    ^W Where Is   ^V Next Page  ^U UnCut Text ^T To Spell
```

Figure 6-3. *The menu program showing the indented lines of code*

Here is a typical output from running the program:

```
Command: help
Put help here
Command: list
Put list here
Command: badcommand
Invalid command!
Command: quit
```

CHAPTER 7

Containers

Up until now, we've mostly stored a single value in a variable like this:

```
playerName = 'Sloan'
```

Python allows you to store multiple values in the same variable. In this, you are assigning a container object a name. There are three different types of containers:

- Tuple
- List
- Dictionary

There are cases when you will use one over the other, and we'll discuss the pros and cons of each use.

Container Nomenclature

Container subparts are called elements. Each element can be indexed using the '['and']' characters and specifying a number between 0 and n-1 where 'n' is the number of items in the container between them. We'll see how this works in the Tuples part.

Tuples

Tuples are immutable collections of objects. Neither the elements in the collection nor the container itself can be modified. This means that you can't add and remove elements from a tuple.

A tuple is a list of objects, either literals or variable names, separated by a comma and enclosed in parentheses characters '(' and ')'. For example:

```
('sloan', 'robert')
```

To access an element in the tuple, use the '[' and ']' characters and place the index value between them. Say you want the first element in the array,

© Sloan Kelly 2016
S. Kelly, *Python, PyGame and Raspberry Pi Game Development*,
DOI 10.1007/978-1-4842-2517-2_7

then you would specify ‘0’ like so:

```
('sloan', 'robert')[0]
```

This will display:

```
'sloan'
```

Removing Elements from a Tuple

If you want to remove items from a tuple (you can't) but there is a way around it. Create a new tuple! Let’s say you have a tuple that contains five elements but you don’t want the third element:

```
numbers = (1, 2, 3, 4, 5)
tuple(x for x in range(0, 5) if x != 3)
```

Woah! That looks needlessly complex! That’s because tuples are immutable and that means they can’t change. Let’s break down the complexity a little. The tuple() function returns a tuple from whatever sequence it is given. For example:

```
>>> tuple('abcdef')
('a', 'b', 'c', 'd', 'e', 'f')
>>> tuple(['sloan', 'robert'])
('sloan', 'robert')
```

In the former example, the character string is split into separate characters. The last latter contains a list of names and a tuple is created from that list.

The part that does all the magic is called ‘list comprehension.’ It is used to create a list based upon existing lists.

```
x for x in range(0, 5) if x != 3
```

List comprehension takes in a list, processes each element in the list, and produces another list. As we’ve seen, the tuple() keyword makes a tuple out of any sequence. A string is a sequence of characters, a tuple is a (immutable) sequence of objects, and lists are also a sequence of objects.

Don’t get too bogged down in the format of that statement; it is merely an example of how one would go about removing an item from a tuple.

Changing Element Values

Another ‘can’t do’ for tuples. However, there is also a way around that too. Tuples are immutable, and so are their elements. The only alternative is to create another tuple.

In this example we have a tuple that represents the x- and y- coordinate of the player ('playPos') and another tuple that represents the speed ('speed') of the player. To get the next position of the player, we add the speed to the current position. Remember, we can't change the tuple or its elements. We must create a new tuple and assign that value to 'playPos':

```
playPos = (5, 4)
print "playPos = %d, %d" % playPos
speed = (2, 1)

playPos = (playPos[0] + speed[0], playPos[1] + speed[1]) print "playPos =
%d, %d" % playPos
```

The line:

```
playPos = (playPos[0] + speed[0], playPos[1] + speed[1])
```

On the right-hand side of the equals sign, the new tuple is created. This is then assigned to the name 'playPos'. The tuple that 'playPos' was assigned is overwritten by this new value. This is the equivalent of the simple assignments shown below:

```
>>> num = 5
>>> print num
5
>>> num = 10
>>> print num
10
```

In this example, the value 'num' is initially assigned the value 5. It is then assigned the value 10. This overwrites the value initial stored in 'num'.

Tuples in Printing

We have used tuples before with respect to displaying formatted strings. For example:

```
>>> numbers = (1, 2, 3, 4, 5)
>>> print "%d %d %d %d %d" % numbers
1 2 3 4 5
```

Deconstructing Tuples

Another common action is to deconstruct the tuple into its component parts and assign them to separate variables. This is achieved by placing the variables that are to be assigned values on the left-hand side of the equals sign and the tuple on the other. In the following example we have a vector 'vec' that contains two elements: one for the x- and another for the y- co-ordinate:

```
>>> vec = (2, 3)
>>> x, y = vec
>>> x
2

>>> y
3
>>>
```

Similarly, you can construct a tuple by specifying comma-separated values too. I don‘t recommend this; I prefer to use the explicit parenthesized syntax, but this works just as well:

```
>>> vec2 = x, y
>>> vec2
(2, 3)
>>>
```

Lists

Lists are mutable containers. This means that both the elements and the list itself can be altered. In the case of the list, this means that we can add and remove elements to the list after we create it. Items are added to the list using the append() method, and removal is through the remove() method. A method is an action that an object can perform. We will see more of methods in the object-oriented section of this text.

List Creation

You can create a blank list or one that is initially populated with values:

```
blankList = []
populatedList = [1, 2, 3, 4, 5]
```

The output of which, if we were to run these commands in the Python interpreter would be:

```
>>> blankList = []
>>> populatedList = [1, 2, 3, 4, 5]
>>> blankList
[]
>>> populatedList
[1, 2, 3, 4, 5]
>>>
```

Adding Values to the List

If we want to add values to the 'blankList' we simply use the append() method and place whatever we want to add within the parentheses:

```
>>> blankList.append("Python")
>>> blankList
['Python']
>>>
```

Adding another computer language name (Lua this time) would mean that our blankList would contain:

```
>>> blankList.append("Lua")
>>> blankList
['Python', 'Lua']
>>>
```

Removing Values from a List

To remove an item from the list, the remove() method is used like so:

```
>>> populatedList [1, 2, 3, 4, 5]
>>> populatedList.remove(3)
>>> populatedList
[1, 2, 4, 5]
>>>
```

You can also remove items from the list by their index value. There is no built-in method to do this in a list; instead we use the 'del' keyword. For example, to remove the first element, or index 0 (zero), we would use:

```
>>> populatedList [1, 2, 4, 5]
>>> del populatedList[0]
>>> populatedList
[2, 4, 5]
>>>
```

This means that we can remove more than one item as well; say we want to remove all the items from the list? We would do this:

```
>>> populatedList [2, 4, 5]
>>> del populatedList[:]
>>> populatedList
[]
>>>
```

ahead and populated the list again:

```
populatedList = [1, 2, 3, 4, 5]
```

Let’s say we want to delete 2 and 3 from the list. We could issue this line twice:

```
del populatedList[1]
```

Why twice? Well, index 1 of the list is the ‘2’ element. When we delete something in a list, everything after that moves up one slot. So, the array now contains:

```
 [1, 3, 4, 5]
```

Which means that index 1 now contains ‘3’.

Typing the same command twice is a little wasteful when we can do it all at once. We can use the colon (‘:’) to specify a range of values to remove. So now, to delete 2 and 3 at the same time we would use:

```
del populatedList[1:3]
```

The number before the colon is the starting index for the deletion. The number after the column is one plus the number of elements you want to remove. If you wanted to remove everything from the first element onward, you could use:

```
del populatedList[1:]
```

Doctor’s Waiting Room Program

I've created a simple program to demonstrate lists using the example of a doctor's waiting room. The user has the ability to add patients, remove them from the list as they are called, and quit the program. All actions are done through a menu.

```
#!/usr/bin/python
#
# This program keeps a list of names for a doctor's
# office. It uses a menu to control the list.

names = [] # an empty list of names
```

We start off with a blank list each morning.

```
cmd = ""
while cmd != '4':
```

There are four commands; 1- list names, 2- add name, 3- call patient, and 4 to quit. The user's commands will be stored in the 'cmd' variable. Note that we have a 'while' loop to keep the user inside the program until they choose to quit.

```
print."1. Listnames"
print."2. Addname"
print."3. Call.next.patient"
print."\n4. Quit"
```

The menu is displayed to let the user know the options that they can choose.

```
cmd = raw_input("\rCommand : ")
```

The user is now prompted for a command. We'll now use a series of nested-ifs to perform the command chosen by the user.

```
if cmd == '1':
    for name in names:
        print name
    print "\n"
```

If the user enters '1' then we use a 'for' loop to go through all the names in the 'names' list. In each iteration, we print the patient's name. Finally we end it with a newline character ('\n') to give us some white space onscreen.

```
elif cmd == '2':
    newName = raw_input("Name : ")
    names.append(newName)
```

If the user enters '2' then we prompt them for the newly arrived patient's name. We then add that new name to the list of names using the append() method.

```
elif cmd == '3':
    if len(names) == 0:
        print "There are no more patients!"
    else:
        nextPatient = names[0]
        names.remove(nextPatient)
        print "Calling %s" % nextPatient
```

For the third and final command, but not quite the end of our program, the user has opted to call the next patient to be seen. The practice offers a strict first-come-first-served policy. This means that the first item in the list is removed. However, if we have no items in the list, then a warning message is displayed. You can determine the length of a list of items using the 'len' keyword.

```
elif cmd != '4':
    print "Invalid command!"
```

The final lines in the program are used to let the user know that they have typed in an invalid command: something other than 1, 2, 3, or 4.

Save the program as 'patients.py' (without the quotes) and don't forget to change the program's attributes to allow it to be executed. Remember! You only have to change this once:

```
$ chmod +x patients.py
```

To run the program:

```
$ ./patients.py
```

When you are in the same directory as the program.

Dictionaries

Dictionaries are a set of key/value pairs. This means that instead of an indexing number, you can use a user-defined key to access the information. For example, we'll define a dictionary that contains telephone numbers for various people. A person's telephone number can be obtained by using their name:

```
>>> numbers = {'Sloan':'416-555-1234', 'Kevin':'212-555-4321'}
>>> numbers['Sloan']
'416-555-1234'
>>>
```

The first line defines the dictionary 'numbers' containing two entries. Each entry is a separate key/value pair. Each key/value is separated using a colon ':' and each pair is separated using a comma ','.

Iterating Through Dictionaries

We can iterate through each item using the iteritems() method for the dictionary:

```
>>> for k,v in numbers.iteritems():
...  print "%s = %s" % (k ,v )
...
Sloan = 416-555-1234
Kevin = 212-555-4321
>>>
```

Adding New Items to Dictionaries

Dictionaries have a simpler way of adding new items: if a key doesn't exist, that value is added to the dictionary. If a key already exists then the new value is assigned to that key.

```
>>> numbers['Frank'] = '216-555-1234'
>>> numbers
{'Sloan': '416-555-1234', 'Frank': '216-555-1234', 'Kevin': '2
>>>
```

Removing Entries from a Dictionary

To remove an entry from a dictionary, we use our old friend 'del'. To remove 'Sloan' from the dictionary 'numbers':

```
>>> del numbers['Sloan']
>>> numbers
{'Frank': '216-555-1234', 'Kevin': '212-555-4321'}
>>>
```

Conclusion

We've seen that Python offers us three different types of containers that provide options for our programs. The tuple can be used to group together like items that are immutable (cannot be changed). Use a tuple to define a structure line a point in space. The properties of a point in space are its x and y coordinates. These two elements don't change and you very rarely iterate (loop) through them. The list container can be used to store a collection of items that can be added and removed. Finally, the dictionary allows items to be added and removed as well as altered.

We're going to take a break from the Python language just now to take a look at how to go about designing a game and taking the leap to the windowed system called LXDE that the Raspberry Pi uses. This is because we're going to start looking at PyGame in the next few sections and we can't do that from the command line.

CHAPTER 8

Introduction to IDLE under LXDE

In the second half of the book we will concentrate on creating games using the PyGame framework. This is installed by default on the Raspbian "Jessie" distribution located on the Raspberry Pi web site. Like Python it is free to use and distribute programs written using it.

Starting Pixel

PyGame does not work in the command line because it requires that OpenGL be initialized before use. So, in order to utilize PyGame we have to load up the window environment on the Raspberry Pi. The window environment is called Pixel and is started by executing the following at a command prompt:

```
$ startx
```

If you have already started Pixel, it's an option in the settings to boot to Pixel, then you won't have to issue that command.

When Pixel boots, you will be presented with the desktop looking something like what you see in Figure 8-1.

S. Kelly, *Python, PyGame and Raspberry Pi Game Development*,
DOI 10.1007/978-1-4842-2517-2_8

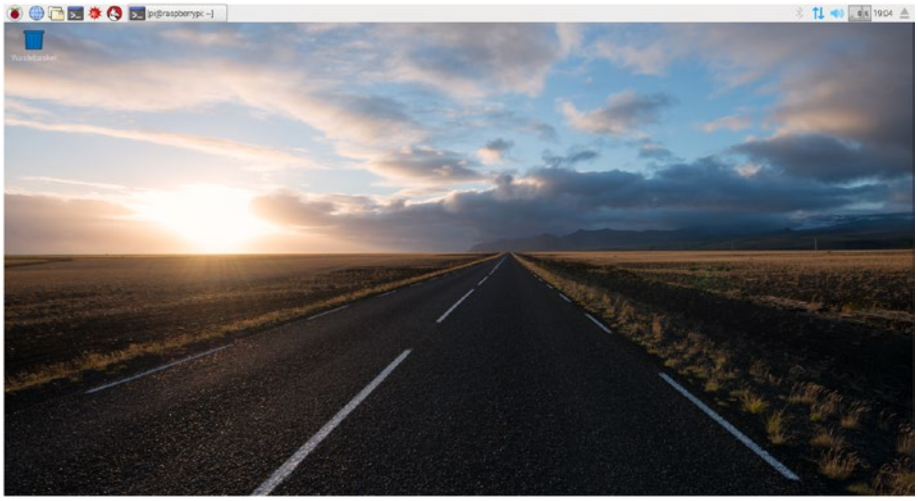


Figure 8-1. *The Pixel desktop*

Your desktop might not look exactly like this, but it will have similar elements.

Along the top of the screen runs that taskbar. This shows the active applications, shortcuts to most-commonly used applications, and system status as well as access to the other applications through the Pixel menu on the left-hand side. See Figure 8-2.

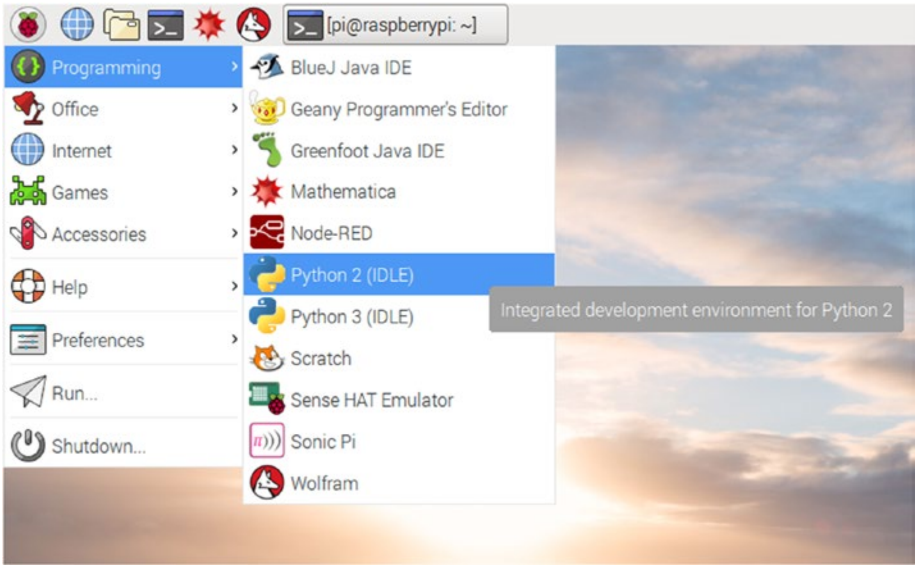
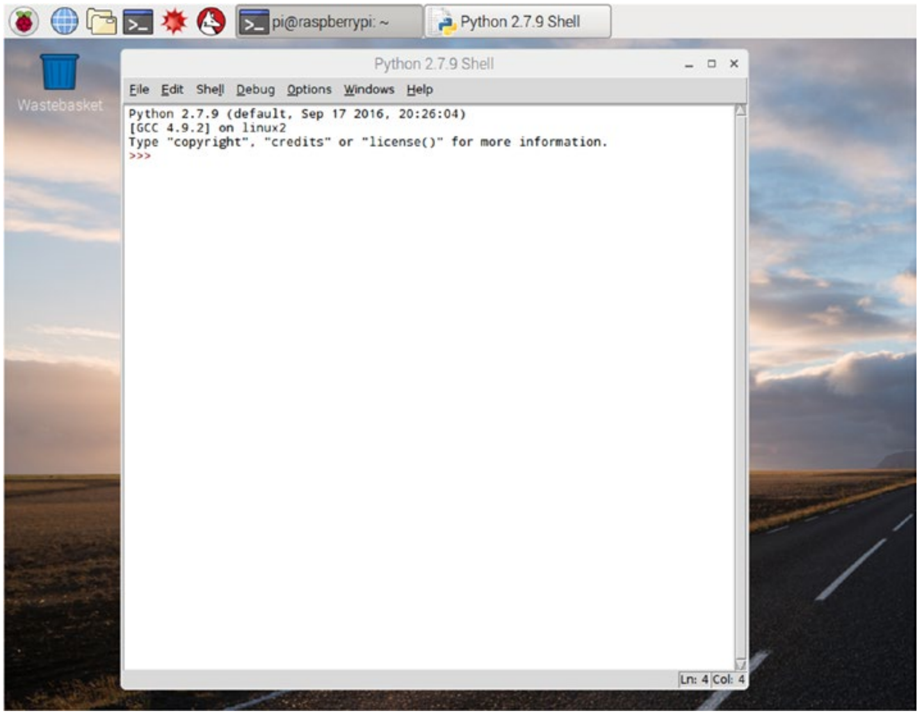


Figure 8-2. *The Pixel menu open with the IDLE option highlighted*

As can be seen in the figure above, the Pixel menu is open and the IDLE entry has been highlighted.

Starting IDLE

To start IDLE, you can double-click the application's icon on the desktop or select the IDLE entry in Programming as shown in the figure above. On starting, the program will launch the interactive shell as shown in Figure 8-3.



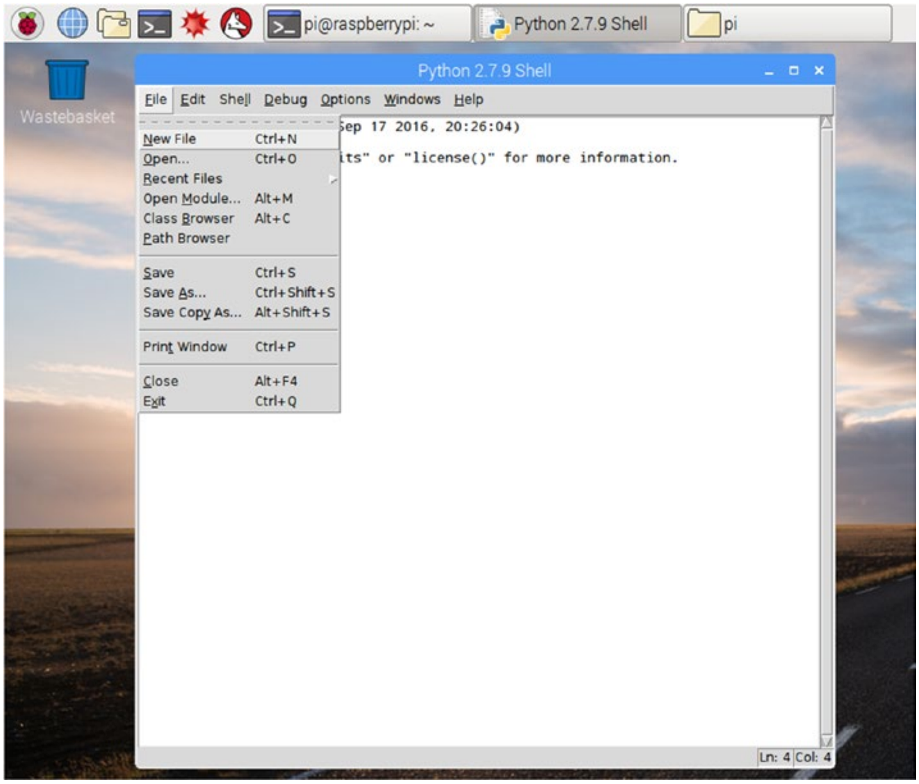
```
Python 2.7.9 (default, Sep 17 2016, 20:26:04)
[GCC 4.9.2] on linux2
Type "copyright", "credits" or "license()" for more information.
>>>
```

Figure 8-3. *The Python interactive shell running in a window*

As you'd expect, everything you can do in the Python interactive shell on the command line you can do in this window environment.

Creating a New File to Edit a Program

What if you want to create a script though? Well, all you need to do is press Ctrl + N or choose File | New File from the menu bar as shown in Figure 8-4.



```
ep 17 2016, 20:26:04)

its" or "license()" for more information.
```

Figure 8-4. *The New File menu option in IDLE*

You can then use it as you would any text editor. The added bonus is, now that we're in a windowed environment, you can use the mouse to highlight and move text and navigate around the document.

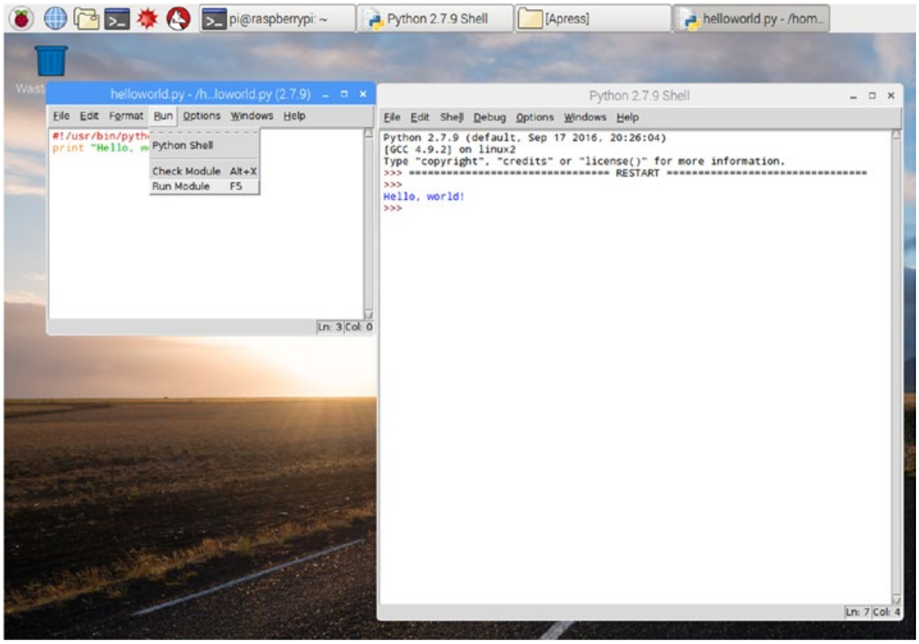
To open an existing file, Press Ctrl + O or choose File | Open from the menu bar.

For our example, we'll use the traditional "Hello, world!" program:

```
#!/usr/bin/python
print "Hello, world!"
```

Running Your Program

To run your program, press F5 or choose Run | Run Module as shown in Figure 8-5.



```
#!/usr/bin/pyth
print "Hello, w
```

```
Python 2.7.9 (default, Sep 17 2016, 20:26:04)
[GCC 4.9.2] on linux2
Type "copyright", "credits" or "license()" for more information.
>>> ================================ RESTART ================================
>>>
Hello, world!
>>>
```

Figure 8-5. *Running the program in IDLE*

Conclusion

These are the basic operations of the Python IDLE. We'll cover the other features, such as debugging, in depth in later sections. For now though you should be able to the following:

- Create a new window
- Open an existing document
- Run a program
- Use the interactive shell

CHAPTER 9

Basic Introduction to PyGame

PyGame is a free framework for Python that provides modules designed to write video games. It is built on top of the Simple DirectMedia Layer Library (SDL) that provides easy access to sound and visual elements.

In this section we will see how to set up PyGame and look at some of the elements that will be used in our future programs. The Python language does not include PyGame, and as such the framework must be imported before it can be used.

Importing the PyGame Framework

Importing a module in Python is through the 'import' keyword. To import PyGame you would add the following line to the top of the script, after the hash-bang:

```
import pygame, os, sys
from pygame.locals import *
```

The first line imports the PyGame module and its objects as well as the OS and system modules. The import keyword does not enter the names of the objects defined in pygame, os and sys directly in the current symbol table. It only enters the module names. To access the elements of each module we have to use the module name. Which is why we have to write pygame.locals. The second line says that we're going to import the constants from the PyGame framework as if they were defined locally. In this case we won't have to prefix each constant with 'pygame'. The 'from' keyword is a variant of the import keyword that allows us to import module elements as if they were defined in our (local) code base.

Initializing PyGame

Before using any of the objects in the framework, you must initialize it first. We also want to clamp the updates to 30 frames per second, so we add an fpsClock variable that we initialize to 30 frames per second.

S. Kelly, *Python, PyGame and Raspberry Pi Game Development*,
DOI 10.1007/978-1-4842-2517-2_9

```
pygame.init()
fpsClock = pygame.time.Clock()
surface = pygame.display.set_mode((800, 600))
```

The first line initializes PyGame. The second line creates an instance of an object and stores this value in 'fpsClock'. An object is an instance of a user-defined class. We'll cover this in detail in the object-oriented section. Everything in Python is an object, and that's part of the beauty of the language; so for now let's just say that you can create your own data types. These user-defined data types are called 'classes'.

The third line creates a surface that we can draw our images (background and sprites) upon. The set_mode() method takes two parameters that specify the width and the height of the surface in pixels. In this example, we're creating an 800 x 600 pixel surface.

It's good practice to clear the screen before we draw on it. So, rather than plucking numbers out of thin air, we're going to create a tuple that contains the Red, Green, and Blue components of the background. A pixel onscreen is made up of combinations of red, green, and blue. These ratios determine what color is displayed. For example (0, 0, 0) is black and (255, 255, 255) is white. The tuple represents, in order, the red, green, and blue combination that makes up the color. So, (255, 0, 0) is red and (0, 0, 255) is blue.

```
background = pygame.Color(100, 149, 237) # cornflower blue
```

In this example I've chosen cornflower blue because it's not a color you see very often, so when the window appears you'll know the program has worked.

The Main Loop

Some programs, notably those run from the command line, tend to perform a series of tasks and exit. This is not true with the majority of windowed environment programs and games. These programs stay active until the user explicitly quits. During the execution they perform what is called the main loop. This contains the series of statements that are executed over and over again until the program ends. The main loop is:

```
while True:
```

This keeps the program in memory because it executes the loop while the condition is 'True'. Because the condition actually is 'True', the loop will always execute.

```
surface.fill(background)
```

First we clear the surface before drawing anything onscreen. This erases what was there before and allows us to start fresh.

```
for event in pygame.event.get():
    if event.type == QUIT:
        pygame.quit()
        sys.exit()
```

PyGame provides us with events from the window manager: keypresses, button clicks, and window close requests. When we get a window close request ('QUIT') we will stop PyGame and quit the application. There are a number of events that can occur during the loop, and these are held in a list that we can iterate through. So, we have to check each event to see what type it is and then act upon it. In our basic framework we're only checking for the 'QUIT' event.

```
pygame.display.update()
fpsClock.tick(30)
```

The pygame.display.update() method redraws the screen. When you place objects on the screen it is drawn to an area of memory called the back buffer. When update is called, this back buffer is made visible, and the buffer that is currently displaying data (front buffer) becomes the back buffer. This allows for smooth movement and reduces flickering.

Most modern video cards have two areas of memory; both are used to display images to the user, but only one is shown at a time. This technique is called double buffering and is shown in Figure 9-1 below.

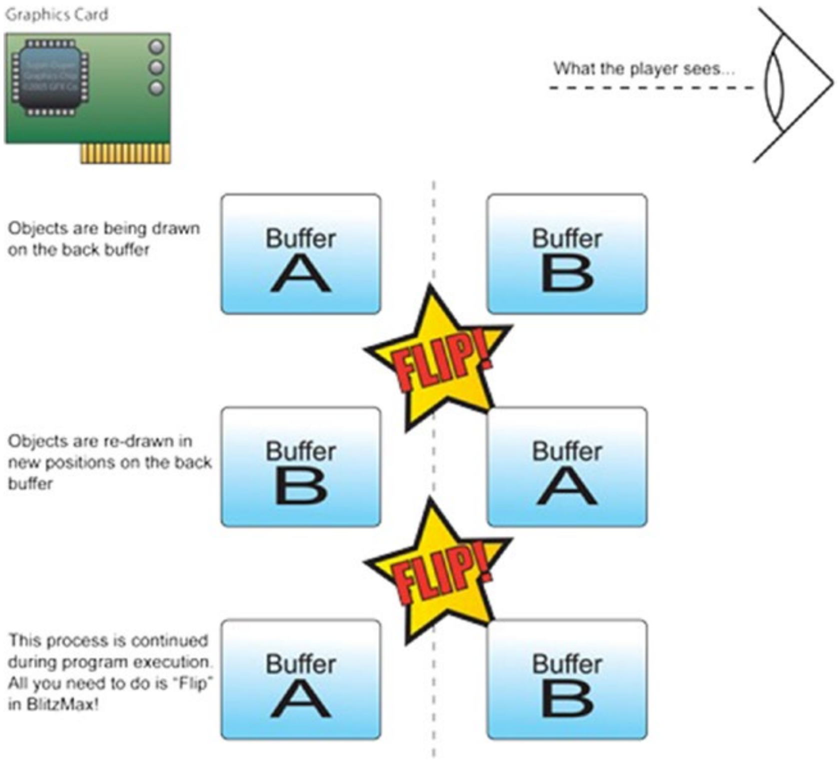

Graphics Card
What the player sees...
Objects are being drawn on the back buffer
Buffer A
Buffer B
FLIP!
Objects are re-drawn in new positions on the back buffer
Buffer B
Buffer A
FLIP!
This process is continued during program execution. All you need to do is "Flip" in BlitzMax!
Buffer A
Buffer B

Figure 9-1. *Double buffering in a modern graphics adapter*

From the user's viewpoint, they see the items visible on the monitor. But behind the scenes, the program is drawing to the back buffer. With the flick of an electronic finger, the user is shown the images on the back buffer. Figure 9-2 below shows what happens.

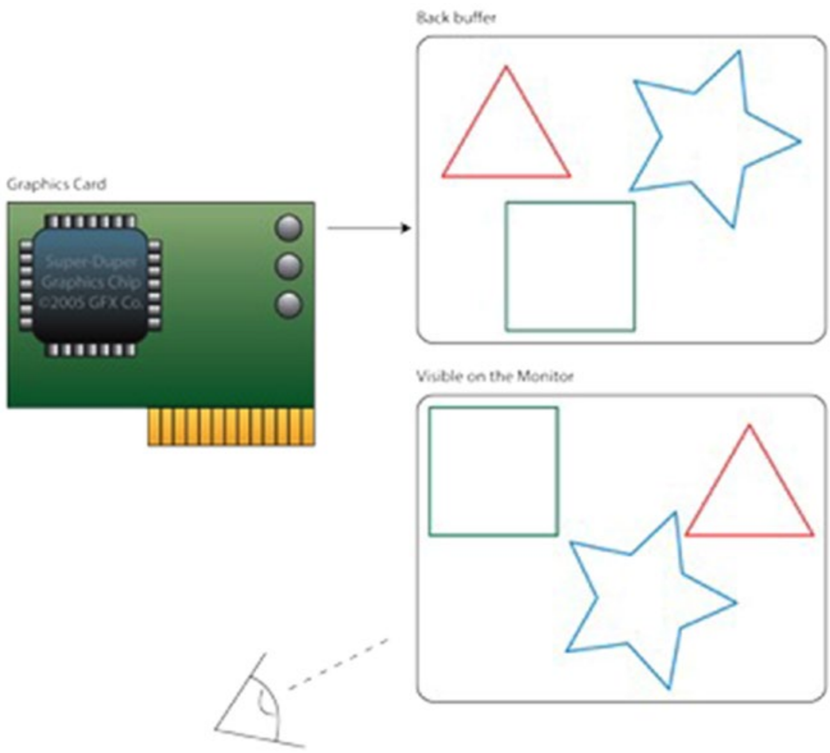


Figure 9-2. *The contents of the front and back buffers.*

Theaters have used this technique to hide set changes. While the actors are out on stage, behind the curtain a new scene is being dressed. When the actor's scene is finished, the curtain opens and the new scene is revealed.

Finally, we want to clamp the updates to 30 frames per second. To do that we call fpsClock.tick(30). This ensures that we get consistent timing in our game. This is the maximum that the clock can run at, but not the minimum. You may perform complex calculations during your game that could drop the frame rate. You will need to be aware of that when you start to write more complex games than the ones presented in this text.

Images and Surfaces

PyGame uses surfaces to draw images onto the screen. It uses the image module to load image files from disk. These are then converted to an internal format and stored in a surface object until later use. You will create at least one surface object, for your main screen. This will be the object that you will draw your sprites and other images on.

Creating Images

For the most part, you will want to create images in a third-party product, such as the Open Source GIMP (GNU Image Manipulation Program) at `www.gimp.org`. GIMP is a professional-level graphics program on par with Photoshop. If, like me, you have spent most of your professional life using Photoshop, you might find GIMP a bit frustrating to use at first – this is no fault of the application! Just relax and you'll be creating images like you did in Photoshop! Any image creation program that allows you to generate BMP, PNG, and JPG images is fine. There is a list of these in the appendices. If you are stuck with images, there are some (badly) drawn images located on this book's web site (`http://sloankelly.net`) to help you. Some of the images are part of SpriteLib through the GPL (GNU Public License); this means that the images are free to use for commercial and noncommercial works.

Loading Images

Python uses surfaces to draw images onscreen. When you load an image into memory, it is put in a special surface. For example, load an image called 'bloke.png':

```
image = pygame.image.load('bloke.png')
```

This will load the image into memory and place a reference to the newly loaded object in 'image'. The name 'image'

Drawing Images

Images are drawn on a PyGame Surface. Remember from our skeleton game that we created a surface that we use to draw images on the screen. To draw an image:

```
surface.blit(image, (0, 0))
```

Where 'surface' is the Surface instance and 'image' is the image you want to draw onscreen. The second parameter is the location onscreen you want the image drawn.

Screen Coordinates and Resolution

The screen or monitor is the primary output device for the computer system. There are two different types of screen: Cathode Ray Tube (CRT) and Liquid Crystal Display (LCD). The latter is becoming cheaper and therefore more popular, or is that cheaper because it is popular? The computer outputs images to the monitor at a given resolution. Resolution means "How many pixels along? How many pixels down?" Physical screen resolution is measured in pixels. The word pixel is shortened form of Picture Element. There are a variety of resolutions available on your PC from 320x240 pixels to 2560x1600 and beyond.

A graphics card inside the computer works with the CPU to produce images on the monitor. With newer graphic cards, a Graphic Processor Unit (GPU) is placed on the card to improve the 3D capabilities of the system — to make games more realistic by providing higher resolutions, special effects, and better frame rate.

Resolution defines how detailed your images will look onscreen. The number of columns — the horizontal axis and the number of rows — the vertical axis define the number of pixels available to the application. In the following example a 640x480 resolution screen map is shown. No matter what resolution your monitor is running at the top-left corner, it always has the coordinate (0,0). See Figure 9-3.

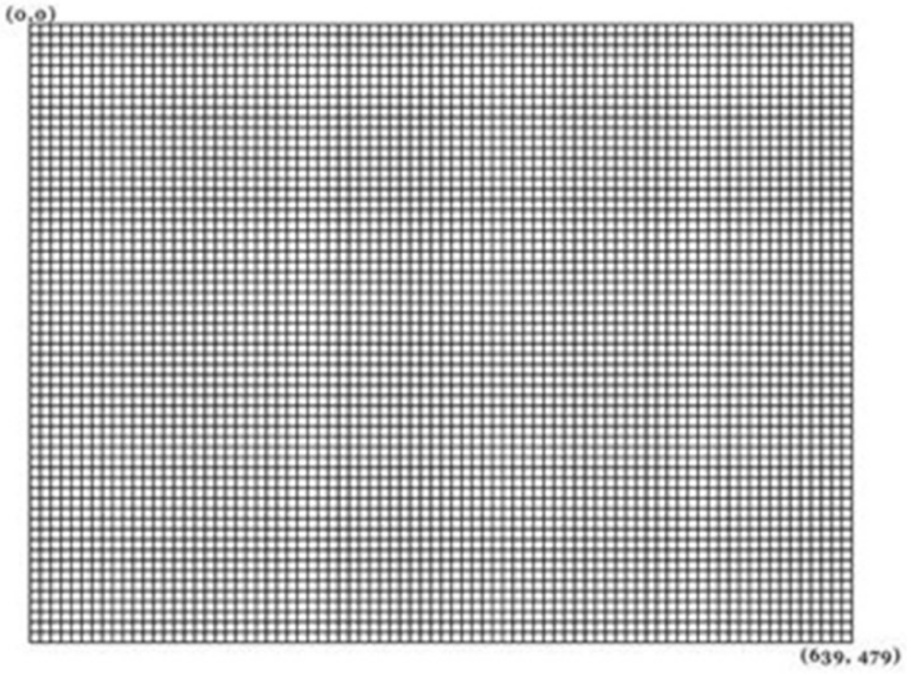


Figure 9-3. *Screen coordinates of a 640x480 monitor*

Coordinate numbers start from 0 (zero). Resolution works independently of the physical size of your monitor. So if you have a large monitor and a low-resolution screen, you will easily see pixels and the screen image will appear blocky:

Sprite Sheets

Sprite sheets are commonly used to keep all frames of a character's animation on one image. The name comes from a sprite, which, in computer terms, is a small image used as an avatar in games. An example sprite sheet is shown in Figure 9-4.

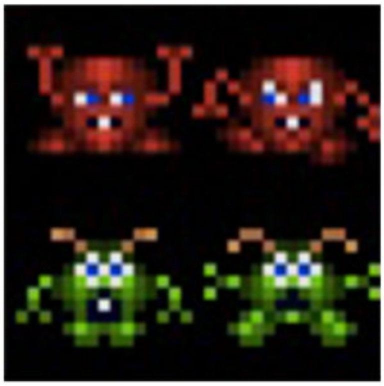


Figure 9-4. *Four-image sprite sheet*

This sprite sheet contains four images: two frames of animation for two Space Invaders characters. When we want to draw the character onscreen, we choose what cell of the sprite sheet to use. Cells are determined by the height and width of the sprite. In this case, we have 32x32 pixel sprites, so that means our sprite sheet is 64x64 pixels because we have 2x2 sprites.

PyGame allows us to display a piece of the image we want to display. So, for example, if we only wanted to show the second frame of the first invader (top right of the image) we would use a line like this:

```
surface.blit(image, (0, 0), (32, 0, 32, 32))
```

The third parameter, the tuple containing four values, is the area of the image we want to display at (0, 0). The tuple represents (x, y, width, height) of the image to display.

CHAPTER 10

Designing Your Game

Before we launch into programming our first game, we're going to slow things down a little. Before starting any project, whether it is home improvement, taking a trip, or programming a game, you should sit down and plan what you want to do.

This usually involves taking the following steps:

- Requirement gathering
- Functional specification
- Program design
- Coding
- Test

The latter two items tend to go hand in hand, and if you use test-driven development, then they are actually one and the same.

Requirement Gathering

We're concerning ourselves with small projects here. In a more formal setting, this would entail going around all the people involved (stakeholders) and asking them what they want from the program. In our case, it's a video game. You'll probably be working with two or three people, and this part tends to be brainstorming ideas:

It's gonna be a racing game

With weapons

And traps! You can set traps!

These ideas are all stored in a single document; Google Drive is excellent for this type of work because it allows for collaboration between developers.

Once you have all your requirements, you then move onto functional requirements. Remember though that all of these documents are "living" in that they can change. Subsequent documents / code need to be updated to reflect those changes.

S. Kelly, *Python, PyGame and Raspberry Pi Game Development*,
DOI 10.1007/978-1-4842-2517-2_10

Functional Specification

Functional specification takes the requirements gathered in the first stage and removes all the "fluff" language around them. They set out a series of rules about the game that can be passed on to a coder to implement. For example, our racing game has the ability to fire weapons, so our functional requirements might have a "Weapons" section and a "Traps" section.

These sections further split down the requirements into bite-sized chunks that a programmer can take away and implement. See the following examples.

Weapon Firing

> *The player can fire a machine gun at another player. There should be a maximum of 10 shots per second allowed per player. If the gun is held down for more than two seconds, it will start to heat up. This will start a 'heat' counter. After the heat counter reaches 5 seconds, the gun will no longer be fireable. It takes a further five seconds for the gun to cool down once the player has released the fire button.*

This also gives the artist some cues as well; they will have to show the gun heating up and cooling down.

Program Design

As you can see, each step refines the previous step's information. The program design takes the functional requirements and breaks them down into modules that a programmer can take and implement. The programmer may take those modules and refine them further, making smaller modules.

The overall goal here is to take a problem and break it down until you have lots and lots of smaller, more easily solved problems. This sounds counterintuitive: take one problem and make it many. "Make a cup of tea" is a larger problem. This can be broken down into smaller problems like this:

- Boil kettle
- Place tea bag in cup
- Place boiled water in cup
- Etc., etc.

From a programming perspective, you are taking requirements (the basic idea for the game) through functional requirements (how the player interacts with the game – how the game environment works) to the program design where you take these functional requirements and figure out what needs to be done from a programming perspective.

Now, this is somewhat of a Catch-22 situation. You need to have experience to know how to take these requirements and figure out how they become program design.

Coding

Sometimes called the fun part of the process. This is where the ideas start to take form; graphics are added and code is used to move them across the screen. The program itself, if you remember from the opening chapters, is this:

Program = Data + Algorithms

The data is called the model and is manipulated by the algorithm. Algorithms that are used to manipulate the data are called controllers and the ones that are used to render items to the display are part of the view. In object-oriented programming, this paradigm (idea) is called Model View Controller.

Throughout this text, we will try and keep the model, view, and controller as separate as we can with communication going through the controller, as shown in Figure 10-1.

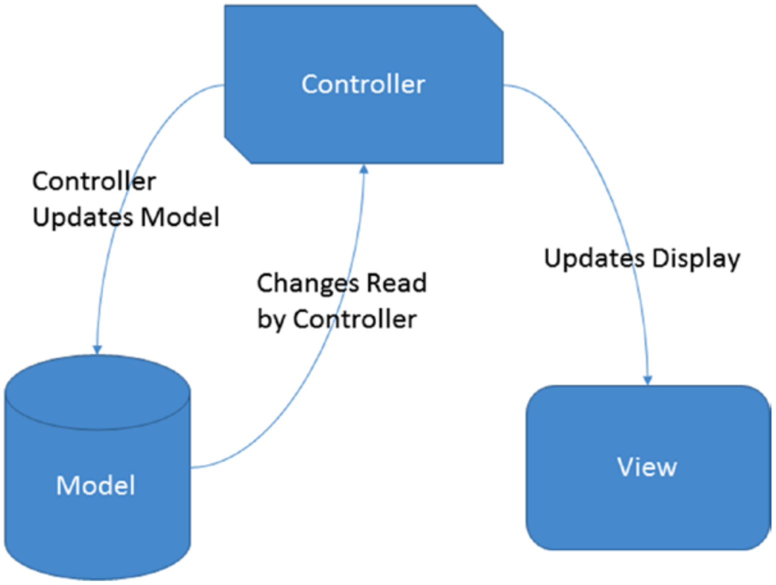


Figure 10-1. *The Model View Controller pattern*

The MVC pattern fits in nicely with our "Programs = Data + Algorithms" statement. The controller manipulates the model in code. In turn, the model's data is read by the view to render data. There can be many different views all rendering different data. For example, in William's® Defender®, the player and the aliens are displayed onscreen using the main play-field view and also in the radar, as shown in Figure 10-2.

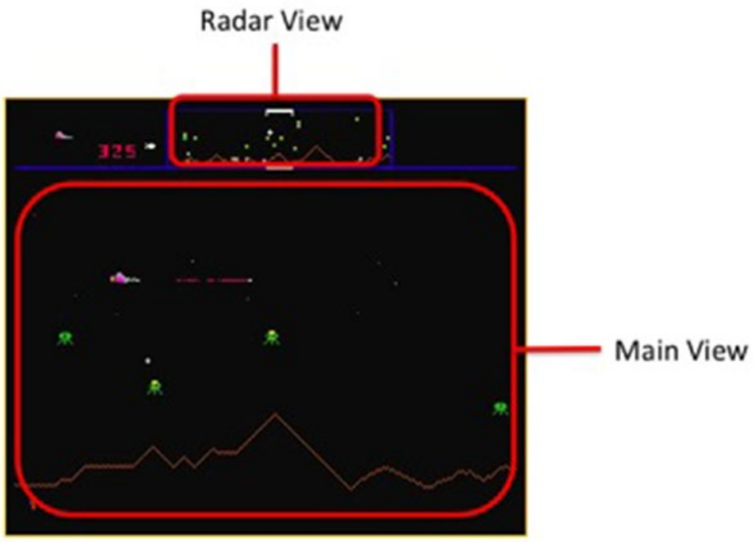


Figure 10-2. *Williams Defender showing the two views*

The code to show the aliens and the player ship in the main playing field is different to how they are displayed in the radar view. They do share one thing in common though; they use the same data. The player's model is also used to display (in yet another view) the number of lives left, the score, and the number of smart bombs at the player's disposal.

Although we won't be formally introduced to the MVC pattern until the object-oriented chapters, we will be using the spirit of this pattern in the games (Bricks and Snake) that precede that section.

Testing

During development, you will be constantly testing your code. Each time you implement (code) a new routine, you will test it to make sure that it does what you set out for it to do. How do you know that it's doing the right thing? You have documentation in the form of the "Requirements" and "Functional Specification" to ensure that what you expect to happen does happen.

There are two types of testing done at the coding level: white-box and black-box testing. The former examines each code step in turn and ensures that they perform as expected. The latter takes each separate module and treats them as a black box. Data goes in, results come out.

Conclusion

Although you won't always create separate documents for the requirements and functional specifications, it is still a good idea to jot your thoughts down. Even if it's just a reminder as to what needs programming and what art needs creating. If you're still not keen on writing, don't forget that a drawing is worth a thousand words.

When it comes to programming, think before you put your hands on the keyboard to start typing. The biggest question you have to ask yourself is, "What do I hope to achieve with the code I'm about to write?" You should have a clear idea of the goal that you're aiming for before you start typing.

Last, but certainly not least, is testing. Always, always, always test your code!

CHAPTER 11

Game Project: Bricks

Our first game project is called Bricks. For those of you who haven't played this game before, you control a bat at the bottom of the screen. There is a collection of bricks above you, and using the ball you must destroy all the bricks by hitting them with the ball.

Sounds simple enough, but in this project we'll learn about:

- Player movement
- Automatic (non-player) movement
- Collision detection
- Image display

See Figure 11-1.

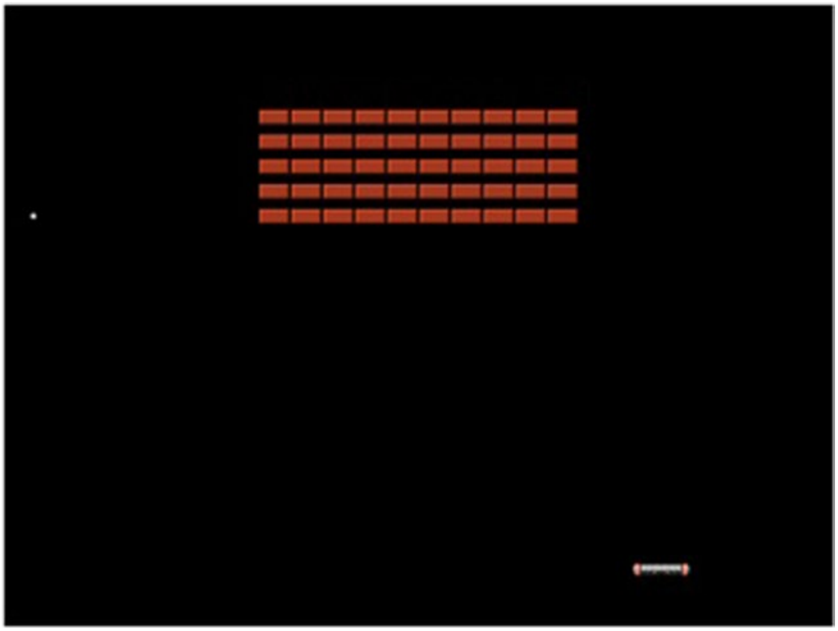


Figure 11-1. *The main brick play screen*

© Sloan Kelly 2016
S. Kelly, *Python, PyGame and Raspberry Pi Game Development*,
DOI 10.1007/978-1-4842-2517-2_11

The Main Framework

We will lay down the main framework in this section to give you an overview of the structure of the entire game. To keep things simple for our first game, there won't be any interstitial screens such as splash screens, menus, or pause screens, etc.

There will be placeholder comments through the framework indicating points where new lines will be added throughout the course of this project.

```
import pygame, os, sys
from pygame.locals import *

pygame.init()
fpsClock = pygame.time.Clock()

mainSurface = pygame.display.set_mode((800, 600))
pygame.display.set_caption('Bricks')
black = pygame.Color(0, 0, 0)

# bat init

# ball init

# brick init

while True:
    mainSurface.fill(black)

    # brick draw

    # bat and ball draw

    # events

    for event in pygame.event.get():
        if event.type == QUIT:
            pygame.quit()
            sys.exit()

    # main game logic

    # collision detection
    pygame.display.update()
    fpsClock.tick(30)
```

Save the file in your Python folder inside your home directory. Call the file 'bricks.py'.

Images

There are three images used in the game, all of which are downloadable from the Resources section on the book's web site (`http://sloankelly.net`). If you don't want to use those images, you can create your own. The game, however, assumes the following dimensions for each of the images. See Figures 11-2, 11-3, and 11-4 below.

Figure 11-2. *Ball.png 8x8 pixels*

Figure 11-3. *Bat.png 55x11 pixels*

Figure 11-4. *Brick.png 31x16 pixels*

Moving the Bat

The user controls the bat using their mouse. We clamp the movement to the x-axis by ignoring the y-axis changes on the mouse. The bat is also restricted to allow movement within the confines of the screen only. The bat must remain within the play field (the screen) during the game.

Bat Initialization

Locate the following line in the framework:

```
# bat init
```

Underneath that line, add a couple of blank lines to give you some space. Type the following:

```
bat = pygame.image.load('bat.png')
```

Our bat is loaded into memory as a surface called 'bat.' It doesn't need to be called this, but it makes sense to call your variables something meaningful. You could also have called it 'batImage' or 'batSprite,' for example.

```
playerY = 540
```

Our player's movement is restricted to the x-axis, so they will always be at a height of 540 pixels on the screen. This is quite near the bottom; remember that as you increase in value on the y-axis, you move further down the screen.

```
batRect = bat.get_rect()
```

The bat's rectangle will be used in our collision detection calculations later.

```
mousex, mousey = (0, playerY)
```

We give the mouse coordinates a default value. Notice that we use a tuple here? We could have also written that single line as two like this:

```
mousex = 0
mouseY = playerY
```

Which would take up two lines and wouldn't imply what our values are for; they represent the coordinates of the bat in 2D space on the screen.

Drawing the Bat

Each time the main loop is executed, we clear the main surface in one line:

```
mainSurface.fill(black)
```

This fills the main surface with black, fresh so that we can draw other things on top of it! Scroll down to this line:

```
# bat and ball draw
```

And add the following line after that:

```
mainSurface.blit(bat, batRect)
```

Save and run the game. What do you see? The bat should be at the top left of the screen. But why is that the case? The answer lies in 'batRect'. Take another look at the initialization of 'batRect':

```
batRect = bat.get_rect()
```

This will contain the dimensions of the bat:

(0, 0, 55, 11)

Which means that the image will be drawn at (0, 0). It's time to move the bat.

Moving the Bat

Moving the bat is achieved in two steps:

- Capturing the mouse input
- Changing the location where the bat image is to be drawn

Scroll down to the section marked:

```
# events
```

Change the code underneath to read:

```
for event in pygame.event.get():
if event.type == QUIT:
    pygame.quit()
    sys.exit()
elif event.type == MOUSEMOTION:
    mousex, mousey = event.pos
    if ( mousex < 800 - 55):
        batRect.topleft = (mousex, playerY)
    else:
        batRect.topleft = (800 - 55, playerY)
```

That's a lot of tabs! Careful with the tab placement or your code won't work.

Events

Events are generated by the Windows manager, whether that's under Microsoft Windows, Mac OS, or an X-Windows manager under a Linux operating system like the one running on your Raspberry Pi. Events that apply to the currently active window are passed to it by the system for processing. You only need to check for events that you want to perform actions for. In this game, we're only interested in checking for this:

- The user closing the window
- The user moving the mouse
- The user clicking the mouse button (later)

Quit Event

Each event is passed through as an event type with additional parameters, as required. For the QUIT event, there are no additional parameters. QUIT is just a signal to the application to shut down. Which we do by exiting PyGame and the program itself.

Mouse Move Event

When the user moves the mouse, the information is passed from the hardware (the mouse, the physical interface, some controller chips), through some low-level OS drivers to the currently active application. In this case, our game. With it comes the position of the mouse as well as any buttons that were pressed. Like all events, this message is only passed if the event occurs (mouse is moved in this case).

The event type for mouse movement is 'MOUSEMOTION' and has a parameter called 'pos' that contains the location of the mouse. 'pos' is a tuple that contains the x- and y- coordinate of the mouse position.

The new x-co-ordinate is clamped within the confines of the screen and then assigned to the 'topleft' property of the 'batRect' variable.

Save and run the program. The bat will now move with the mouse movement. If it doesn't, or you get errors, check your code. It could be a stray or missing 'tab'.

Moving the Ball

Moving the ball is done entirely in code and does not require input from the user, save from the initial tap of the mouse button to get things rolling, if you pardon the pun.

Ball Initialization

Ball initialization looks very similar to the bat initialization. Locate this line in code:

```
# ball init
```

Add the following lines underneath:

```
ball = pygame.image.load('ball.png')
ballRect = ball.get_rect()
ballStartY = 200
ballSpeed = 3
ballServed = False

bx, by = (24, ballStartY)
sx, sy = (ballSpeed, ballSpeed)
ballRect.topleft = (bx, by)
```

The first two lines load the image and capture its rectangle. The next two lines set up the default values for the starting y-coordinate and speed. The 'ballServed' variable is used to determine, in the code later, if the ball has or has not been served. The remaining lines set up the initial position of the ball and its speed.

Scroll down the code to:

```
# bat and ball draw
```

Add the following line to draw the ball on screen:

```
mainSurface.blit(ball, ballRect)
```

Save and run the game. You will now see the ball in the top left of the screen. If you don't, check your code against the lines written above. Typing mistakes or typos are common, even among seasoned programmers!

Ball Movement

Ball movement is achieved by adding the speed of the ball to the current position. This is from the Physics equation:

Speed = Distance / Time

How do we do this in code? Scroll down to the line that reads:

```
# main game logic
```

The formula to calculate distance is:

*Distance = Speed * Time*

Because our rate is fixed to 30 frames per second, we will be adding our speed to the current position once every 1/30th of a second. This means that after one second our ball will have traveled:

*30 * 3 = 90 pixels*

So, the actual velocity of our ball is 90 pixels per second.

Just after the 'main game logic' comment line, add the following code and run the game:

```
bx += sx
by += sy
ballRect.topleft = (bx, by)
```

A new symbol has been introduced here. The += operator is used to add the value on the left of the operator to the value on the right and place the sum in the variable on the left of the operator. It's a short form of bx = bx + sx. There are other short form operators like -= (minus), *= (multiply) and /= (divide) that follow the same rule we outlined for +=. The ball will now move slowly and diagonally from the top left of the screen to the bottom right. What happens if it hits the bat? What happens when it reaches the end of the screen? Nothing; the ball just passes right through the bat and sails past the edge of the screen.

Let's remedy this situation. First, we'll clamp the ball within the confines of the screen area. Our screen is 800x600 pixels in size. Our ball is 8x8 pixels in size. We'll use some Boolean logic to determine, from the ball's position, if it hits the edges. If so, we'll reverse the speed. This means that the next loop the ball will move in the opposite direction as shown in Figure 11-5.

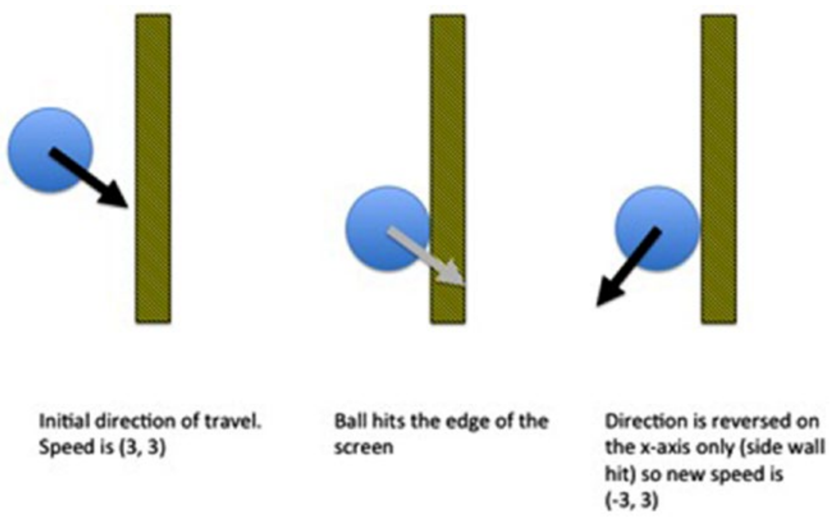

Initial direction of travel. Speed is (3, 3)
Ball hits the edge of the screen
Direction is reversed on the x-axis only (side wall hit) so new speed is (-3, 3)

Figure 11-5. *Ball hitting a side wall showing reversal of direction along the x-axis*

Add a couple of extra lines after the ball position update code and add the following text:

```
if (by <= 0):
    by = 0
    sy *= -1
```

The ball's y-co-ordinate is checked against 0, which is the topmost row of pixels on the display. Remember that the top left of the screen is (0, 0) and the bottommost is the maximum size; in our case, that's (800, 600). This code will ensure that the topmost boundary of the screen reflects the ball. The ball is only reflected on the y-axis because we have hit a vertical boundary of the screen, in this case the top edge.

Do the same for the bottom of the screen. In this case, we have to subtract the size of the image from the bottommost number. Remember that when we draw an image on screen, we're drawing it from the top left of the image:

```
if (by >= 600 - 8):
  by = 600 - 8
  sy *= -1
```

The sides of the screen will reflect on the x-axis instead of the y-axis:

```
if (bx <= 0):
    bx = 0
    sx *= -1
```

This will reflect the ball on the left-hand edge (when x is 0). Finally, we'll reflect when we're on the right-hand edge (when x is 800 - 8 or 792):

```
if (bx >=800 - 8):
    bx = 800 - 8
    sx *= -1
```

Save and run the game. You'll now see the ball bounces around the screen. But it still goes through the bat. We need to add more code to the game to get it to collide with the bat so that it reflects back up the screen.

Bat and Ball Collision

The bat and ball collision works in a similar way to checking a collision against the bottom of the screen. We will use the colliderect method of the Rect class to determine if a collision has occurred.

Add a couple of blank lines after the last code you typed and add:

```
if ballRect.colliderect(batRect):
    by = playerY - 8
    sy *= -1
```

The colliderect takes a single parameter that represents the rectangle we want to the check collision against. The colliderect method returns a Boolean 'True' or 'False' depending on whether the rectangles intersect each other. See Figure 11-6.

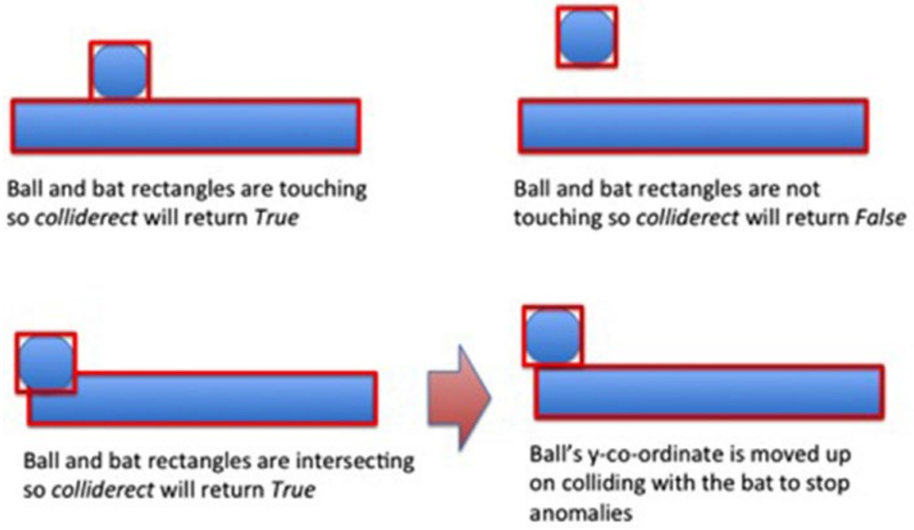

Ball and bat rectangles are touching so *colliderect* will return *True*
Ball and bat rectangles are not touching so *colliderect* will return *False*
Ball and bat rectangles are intersecting so *colliderect* will return *True*
Ball's y-co-ordinate is moved up on colliding with the bat to stop anomalies

Figure 11-6. *Collision rectangles showing touching, not touching, and intersection*

The top-left image shows that when the two rectangles are touching, colliderect will return 'True'. The top-right image shows that when the two rectangles are not touching, colliderect will return 'False'.

The bottom two images show what happens when the bat and ball intersect. Colliderect will return 'True' because the two rectangles are touching, but in code, we have to move the ball's position up so that they're not touching. This stops any anomalies from occurring; if you hit the ball from the side it travels inside the bat! By replacing the ball to touch the top of the bat, we get around this problem, and this line:

```
by = playerY - 8
```

Is the one that solves the issue. Save and run the code and you'll be able to knock the ball back up the screen using the bat.

Serving the Ball

Up until this point we've just served the ball as the game starts. We want to restrict the ball serve to when the user clicks the left mouse button. Firstly, we'll stop the ball movement if it hasn't been served. Locate the line:

```
# main game logic
```

You should see these lines underneath:

```
bx += sx
by += sy
ballRect.topleft = (bx, by)
```

Change these lines to read:

```
if ballServed:
    bx += sx
    by += sy
    ballRect.topleft = (bx, by)
```

Saving and running the game will show that the ball stays in the top left.

To get it to move, we have to change 'ballServed' to 'True'. In order to do that, we have to respond to the player pressing the left mouse button. That's in the events section of the code. Scroll up to the events section and add these lines after the last 'elif' block:

```
elif event.type == MOUSEBUTTONUP:
    if not ballServed:
        ballServed = True
```

The MOUSEBUTTONUP tests for any button on the mouse being 'up'. So, really, right-clicking will work too. We also test for the case where ballServed is already 'True'. If the ball is already served, we don't need to serve it again.

Brick Wall

We're almost there! The last piece of this puzzle is the wall of bricks that the player must destroy. Like the screenshot at the start of this section shows, we're going to arrange the bricks in the center of the screen.

Locate the following line in the code:

```
# brick init
```

Add the following lines:

```
brick = pygame.image.load('brick.png')
bricks = []
```

Once again, we load in an image that we're going to use for our bricks. We then create an empty list where we will store the positions of each of the bricks.

```
for y in range(5):
    brickY = (y * 24) + 100
    for x in range(10):
        brickX = (x * 31) + 245
        bricks.append(Rect(brickX, brickY, brick.get_width(),
        brick.get_height()))
```

Our bricks are arranged in five rows of ten bricks. We store the brick locations in the 'bricks' list. Our brick positions are actually stored as Rect instances because it will make collision detection easier later.

Scroll down to find this line of code:

```
# brick draw
```

Add the following lines just after:

```
for b in bricks:
    mainSurface.blit(brick, b)
```

Save and run the game. You'll now see the wall of bricks. Once again, you'll notice that the collision doesn't work, so the ball just sails through the wall. We'll fix that in our last section.

Brick and Ball Collision

Our bat and ball move and our brick wall displays. Our penultimate task in this project is to destroy the bricks as the ball hits them. This is similar to when the ball hits the bat except we will remove the brick that was hit. Luckily, PyGame provides a method on the Rect class called collidelist().

Scroll down the source code and locate:

```
# collision detection
```

You will remember that our bricks are just a list of rectangles. The collidelist() method takes a list of rectangles and returns the index of the two rectangles that were hit. We will use the rectangle of the ball as the left-hand side of the test and the bricks variable as the parameter to the function:

```
brickHitIndex = ballRect.collidelist(bricks)
if brickHitIndex >= 0:
    hb = bricks[brickHitIndex]
```

Capture the index of the brick rectangle contained in bricks that intersects with the ballRect rectangle. In layman's terms, find out which brick the ball touched. If no brick was hit, this method returns a -1. So, we're only interested in values greater than or equal to zero. Remember that lists start at element zero (0), not 1 in Python.

```
mx = bx + 4
my = by + 4
if mx > hb.x + hb.width or mx < hb.x:
    sx *= -1
else:
    sy *= -1
```

We then calculate the midpoint of the ball's rectangle, which is 4 pixels in and 4 pixels down because the ball is an 8x8 image. We then test this against the width of the brick that was hit. If it is outside the width then the ball was hit from the side. Otherwise, the ball hit the brick on the top or bottom. We deflect the ball accordingly by changing its speed.

```
del (bricks[brickHitIndex])
```

Because we hit the brick, we remove it from the list.

Save and run the game. When the ball hits the bricks, they will be removed and the ball will rebound from the hit. Now, what about hitting the bottom of the screen?

Out of Bounds

When the ball hits the bottom of the screen it should be marked as out of bounds. As it stands, we haven't done that and the ball simply bounces off the bottom.

Scroll down the source code to find the line that reads:

```
# main game logic
```

You will see this block of code:

```
if (by >= 600 - 8):
    by = 600 - 8
    sy *= -1
```

Replace it with:

```
if (by >= 600 - 8):
    ballServed = False
    bx, by = (24, ballStartY)
    ballRect.topleft = (bx, by)
```

When the ball hits the bottom of the screen, the ‘ballServed’ flag is reset to ‘False’ meaning that the ball has not been served. Because the ball hasn’t been served, it will not be updated. The code also resets the balls position to the default starting position.

Save and run the complete game, pressing any mouse button to serve the ball and using the mouse to move.

Conclusion

You have written your first game! This game really shows the power of Python and PyGame because a game like this contains the following:

- Mouse movement
- Automatic ball movement
- Collision
- Brick destruction
- Boundary checking

And it can all be achieved in around 120 lines of code.

Now that we have the first game under our belt, we’ll spend some time learning more about the Python language.

CHAPTER 12

User-Defined Functions

A user-defined function allows you to package and name several lines of code and reuse those lines of code throughout your program. All you have to do is call the name you've given your function.

What Is a Function?

A function in Python can be used to perform a simple task, and as such is just a mnemonic or special name given to a collection of lines. You can also optionally send values into a function as parameters or return a value from a function. Only one value can be returned from a function, but that value can be a tuple.

Format of a Function

The following simple function displays "Hello world" when it is called:

```
def sayHello():
     print "Hello, world!"

sayHello()
```

Use the def keyword to define the function. The function consists of its name and optional parameters inside parentheses '(' and ')'.

Because it is a Python block, the first line ends in a colon and the lines that form the block are indented one tab.

Functions as a Menial Task / Mnemonic Device

At the trivial end, functions can be used as a mnemonic or replacement for multiple lines of code that you will use over and over again. For example, if you want to display a box you might want to use something like this:

```
def drawBox():
    print "+--------+"
```

© Sloan Kelly 2016
S. Kelly, *Python, PyGame and Raspberry Pi Game Development*,
DOI 10.1007/978-1-4842-2517-2_12

```
    print "| |"
    print "+--------+"

drawBox()
print "Between two boxes"
drawBox()
```

The output of this code is:

```
+--------+
| |
+--------+
Between two boxes
+--------+
| |
+--------+
```

We now have consistency when we want to draw a box. Each box will look like every other box when we call drawBox().

FUNCTIONS ALLOW YOU TO REUSE CODE.

This is the power of functions: they allow for something called code reuse. Code reuse means that you can use the same single block of code multiple times in your application. If you need to change that function for any reason, any code that calls it will get the changed version.

The other goal of functions is to make the place where you call it easier to read. A block of code should perform a single task rather than multiple tasks. When writing a program, consider where these breaks should occur. These should be your functions.

For example, you have been asked to read in the temperatures from the keyboard and write them to a file and calculate the average, maximum, and minimum values and store them in a separate file. You might write functions called:

- getTemperatures()
- writeTemperatures()
- calcAverage()
- calcMinimum()
- calcMaximum()
- writeStats()

These would then be called from the main program in the correct sequence.

Sending Parameters

Having a block of code that you can execute over and over again from multiple places is all well and good, but it's a bit restricting. What if you wanted to change some values each time you call it? Parameters (or arguments) can be used to provide your function with more information. For example, the width and height of the box you want to draw. Consider the following code:

```
def drawBox(width, height):
```

The drawBox() method now takes two parameters: one is named width and the other height. These parameters are passed into the function from the calling line (seen later). These are just names that we use so that we can refer to the parameters in a meaningful way in the body of the function.

```
if width < 0:
    width = 3
```

The boxes are drawn on a character-based display, and as such, the minimum width that we can have is three characters; this is because we use '+' characters at each of the corners and '-' to denote the horizontal line.

```
if height < 3:
    height = 3
```

We have a similar restriction with height. Our minimum height is three because we have to have two horizontal lines and at least one line containing '|', some spaces and then '|' to represent the vertical lines of the box.

```
width = width - 2
```

Whatever our width is, it's two characters too long! This is because each row starts and ends with '|'. The number of characters is therefore width - 2 (two '|' characters).

```
print "+" + "-" * width + "+"
```

Our top line is fixed because it contains the corner pieces represented by '+'. We also use Python's handy string arithmetic to generate the string line; '+' is used to concatenate (add) two strings together, and '*' is used to multiply a string with a number to repeat a character a certain number of times.

```
for y in range(3, height + 1):
    print "|" + " " * width + "|"
```

The for loop goes through each value from '3' to the height plus one. Remember that the range goes from a starting value to one less than the number you want. Again, we use string arithmetic to generate our line.

```
print "+" + "-" * width + "+"
```

We close off the function by drawing the bottom of the box.

```
drawBox(5, 4)
```

To call the function, you use the function's name and then pass in the parameters that we want to use. You have to know what each parameter is used for, so that's why it's a good idea to name the parameters to something recognizable. In this example, if the width of the box is 5 and the height is 4, its output will be:

```
+---+
|   |
|   |
+---+
```

Default Argument Values

Default values for each parameter can be specified. This means that if the user doesn't want to specify the value of an argument, they don't have to. Let's say we want to default width and height to 3. Change the function definition to:

```
def drawBox(width = 3, height = 3):
```

If we just want a 3x3 box we can do this:

```
drawBox()
```

That will assign the default values to both width and height. Let's say we want to specify width without height. Let's create a 5x3 rectangle:

```
drawBox(5)
```

Named Parameters

What about if we just want a default width, but we want to specify a height? That's easy enough; just pass in the name of the parameter you want to specify a value for:

```
drawBox(height = 10)
```

This will draw a 3x10 box. Width will default to 3 because it has not been assigned a value. This technique is called *named parameters* and allows you to specify the parameter by name. In other languages optional parameters - those with a default value - must be placed at the end of the parameter list. In Python, you can use named parameters to specify all or just some of the optional arguments.

Returning Values

One of the primary uses for functions is to generate a new value from the supplied arguments. Let's take a look at a trivial example first, adding two numbers together:

```
def add(num1, num2):
    return num1 + num2

print add(10, 5)
```

The function is defined as usual with the 'def' keyword and a name for the function. The function takes two parameters num1 and num2.

The only line that makes up the body of the function is:

```
return num1 + num2
```

The 'return' keyword takes whatever value is on the right-hand side of it and passes it back to the calling line. In our example, the calling line is this print statement:

```
print add(10, 5)
```

'num1' is assigned the value 10 and 'num2' is assigned the value 5. The two are added together and returned. The 'print' keyword then displays the value returned. Because it's an integer value, this is a fairly trivial undertaking and it just displays the result.

But we can add so much more than integer values:

```
print add('sloan ', 'kelly')
print add(3.14, 1.61)
print add((1,2,3), (4,5,6))
```

Anything we can add together can use this function. We've seen that Python will return anything we want from a function, and it could depend on the arguments that are passed how that value is determined.

Accessing Global Variables

Global variables are generally thought to be bad programming practice.

They can lead to mistakes, or bugs, in code because it will take time to track down when each global variable is accessed (the value is read) and each time it is changed (a value is written to it).

Functions can read global variables with no problem, like in this example:

```
num = 5

def printNum():
    print num

printNum()
```

What if we change the value inside the function? What happens to it then?

```
num = 5

def printNum():
    num = 10
    print num

printNum()
print num
```

Now, the output is:

```
10
5
```

Why is this the case? Well, in order to prevent bad things from happening in your program, Python has a fail-safe technique to prevent global values being written to unless you explicitly say they can be written to. To mark the variable as being 'write-enabled' in your function, add global and the name of the global variable, like so:

```
num = 5
def printNum():

    global num
    num = 10
print num

printNum()
print num
```

With the addition of the global keyword and the name of the global variable, any changes to the 'num' global in printNum will be applied. The output of the program will now be:

```
10
10
```

Real-World Example of a Function

Functions can contain their own variables. These variables are said to be local to the function. They cannot be seen or manipulated by anything outside of the function. This hiding of variables is called variable scope. We have seen that global variables can be accessed anywhere. With local variables they are visible only to that function and only exist as long as the function is executing.

We can rewrite some of the code for our Bricks game to use functions. I'll leave it as an exercise for the reader to convert other areas of the code to functions. We'll create a function to load the brick image and set up the brick positions.

Open up the Python file that contains the code for the 'Bricks' game. Right now, the code you have should have an area that looks like this:

```
# brick init
brick = pygame.image.load('brick.png')
bricks = []

for y in range(5):
    brickY = (y * 24) + 100
    for x in range(10):
        brickX = (x * 31) + 245
        bricks.append((brickX, brickY))
```

Remove the line:

```
brick = pygame.image.load('brick.png')
```

Change the remaining lines to read:

```
def createBricks(pathToImg, rows, cols):
    global brick
```

The function will take in three parameters. The first is the path of the image file that we will use to draw the bricks. The second and third parameters are the number of rows and columns of bricks we want. Our brick positions are stored in a list called 'bricks' and the image is called 'brick.' We are going to create a global variable at the top of the file called brick. This holds our image of a brick.

```
brick = pygame.image.load(pathToImg)
bricks = []

for y in range(rows):
    brickY = (y * 24) + 100
    for x in range(cols):
        brickX = (x * 31) + 245
        bricks.append(Rect(brickX, brickY, brick.get_width(),
        brick.get_height()))
```

At the top of the file add:

```
brick = None
```

This line should be added just after:

```
pygame.init()
fpsClock = pygame.time.Clock()
```

Now, scroll back down to just before this line at the start of the main loop:

```
while True:
```

Now add this line just above:

```
bricks = createBricks('brick.png', 5, 10)
```

We return the list of brick data directly into our ‘bricks’ variable. This means that we don’t need to create a variable earlier and add a global line in our function.

YOU SHOULD KEEP GLOBAL VARIABLES TO A MINIMUM.

Globals can be avoided, and we’ll see how throughout this book. Rather than teaching those techniques now and muddying the waters, it’s best to let this infraction slip and enjoy our first game!

Save and run the game. It should work as before, but the cool thing is that now you can easily change the number of rows and columns of bricks just by changing the parameters passed to 'createBricks'.

CHAPTER 13

File Input and Output

File input and output allows you to store and read back data from your programs. For example, level data like maps, user save data, or high score tables. Take this program as an example; it reads in itself from disk and displays the contents to the screen:

```
import os
f = open('readmyself.py', 'r')
for line in f:
        print line

f.close()
```

The open keyword's first argument is the file that we want to access. The second argument is the mode that we want to access the file:

- 'r' - Read the contents of the file
- 'w' - Write data to the file
- 'a' - Append (add on to the end of an existing file) data to the file

The default is 'r' for read, so we could omit this argument in this instance. Finally, this is for text mode only. This means that if we pass a '\n' it will be converted to the platform-specific line ending. On UNIX and Raspbian this is '\n' but on Windows it's '\r\n'.

You can add 'b' to the access mode parameter (e.g., 'rb' or 'wb') to specify binary mode. This mode is commonly used for things like images or complex save data.

The open keyword returns a File object. We can use this to read information from the file, or write out data, depending on what we want to do.

The output of this program is:

```
import os

f = open('readmyself.py', 'r')
for line in f:
    print line
f.close()
```

© Sloan Kelly 2016
S. Kelly, *Python, PyGame and Raspberry Pi Game Development*,
DOI 10.1007/978-1-4842-2517-2_13

You'll notice that it seems to put in blank lines where there are none in the file. You'll see in just a moment how to get rid of those blanks.

Reading Data from a File

Save the program as readmyself.py and run it. The program will display the content, but it adds blank lines between each line of the code. They are not there in the file, so where do they come from? Well, on disk, each line is terminated with a '\n' which is a newline, and the print keyword adds its own newline making those empty lines.

To get around this, you can do one of two things:

- Add .rstrip('\n') to each print
- Or add ',' to each print

Like so:

```
print line,
print line.rstrip('\n')
```

The rstrip() function returns a copy of the string where all the specified characters have been removed (stripped) from the end of the string. By default this is all whitespace characters, but in this case we only want to strip out the 'newline' character. Choose one; they both work, and the output will show the contents of the file.

Writing Data to a File

Writing text to a file uses the write method of the file object. This next program takes a list of high scores and writes it out to a text file.

```
players = ['Fred,10000', 'Barney,15000', 'Derek,12000', 'Janet,17000']
```

The list contains the names of the players and their scores separated by a comma.

```
f = open('highscores.txt', 'w')
```

The file is opened in 'write' mode because we are sending data to the file. The file's name can be whatever you want it to be, but it should be something that makes sense.
It doesn't even have to end in .txt.

```
for p in players:
    f.write(p + '\n')
```

All the values in the list are cycled through and the write method of the File object is called with the list item followed by a '\n'. If we didn't include that, the file would have all the names and scores mashed together on a single line.

```
f.close()
```

You must always remember to close the file when you're finished with it. When I'm writing a file read/write, I always write the open and close lines first, then code what I want to do with the file. This means that I never forget to close the file.

Conclusion

You should now understand how to read from and write to a file. Remember to close the file when you are done. Don't keep the file open for longer than you have to; just open it, do what you need to do, and close it as quickly as possible.

CHAPTER 14

Introducing Object-Oriented Programming

Object-Oriented Programming is a programming paradigm where items are abstracted down to their basic elements:

- What you can do with them
- Attributes that describe them

Object-oriented programming (OOP) allows you to chop your program into discrete bundles, like we did with functions, where all the data and the code associated with a particular object are stored together. These models are referred to as classes, and copies of these classes in memory are called instances. In some languages, classes are called User-Defined Types.

A 'class' is a definition of an abstract thing. The ‘class’ defines methods (actions) that can be taken on the data (attributes) of the ‘instance’. An ‘instance’ of a class is called an ‘object’. An ‘instance’ of a user-defined class is much like ‘5’ is an instance of an integer, or "Hello, World" is an instance of a string. Both ‘integer’ and ‘string’ are abstractions, and ‘5’ and "Hello, World" are instances of each respectively.

Let’s take an example of an object we’ve seen before: a ball. A ball can be described by its size, shape, and color. These are its attributes. In a game world, we can’t do much with a ball, but what we can do is update its position, check for collisions, and draw it onscreen. These actions are called methods.

ATTRIBUTES DESCRIBE THE OBJECT METHODS AND ARE WHAT WE CAN MAKE THE OBJECT DO.

© Sloan Kelly 2016
S. Kelly, *Python, PyGame and Raspberry Pi Game Development*,
DOI 10.1007/978-1-4842-2517-2_14

The Ball Class

Create a new file called BallClass.py and save it to your working directory. Add the following lines to the top of the file to tell the shell where to find the Python executable and what modules we will require:

```
#!/usr/bin/python
import pygame, os, sys
from pygame.locals import *
```

In Python we would describe the ball class like this:

```
class Ball:
```

A class is defined using the class keyword. You must give your class a name. Something short and meaningful is perfect, but avoid plurals. If you have a collection of items (like balls) use BallCollection rather than Balls for the name of the class.

```
x = 0
y = 24
speed = (4, 4)
img = pygame.image.load('ball.png')
```

These variables are called 'member fields' and they are stored on a per-object basis. This means that each object gets a separate bit of memory for each field. In our Ball class, we have four such member fields: one each for the coordinates on the x- and y- plane, the ball speed, and one for the ball's image.

```
def update(self, gameTime):
    pass
```

Methods are defined as you would a function with the def keyword, the method/function name, and the parameter list. The major difference is the use of the 'self' keyword as the first entry of the parameter list.

Earlier I mentioned that the member fields are per object. The 'self' keyword is used because Python passes in a reference to the object being used for that operation. Whereas the data is different for each object, the code is not. It is shared between all instances of the class. This means that the same piece of code that updates a ball is used by all instances of the Ball class.

You must always put a 'self' keyword as the first argument in your method's list, even if you have no other parameters.

THE FIRST ARGUMENT IN A METHOD DEFINITION IS ALWAYS 'self'.

There's a new keyword in there, and this isn't part of OOP but it's vital in this example. We've produced what is effectively a stub. This means that our class doesn't do much. None of the methods perform any reasonable operation either, but because Python can't have an empty block we must use the 'pass' keyword instead. This would be the equivalent in a C-style language of doing '{ }'.

```
def hasHitBrick(self, bricks):
    return False
```

This method will return true if the ball has hit a brick. In our stub-code, we always return False.

```
def hasHitBat(self, bat):
    return False
```

Our stub method for testing whether the ball has hit the bat:

```
def draw(self, gameTime, surface):
    surface.blit(self.img, (self.x, self.y))
```

This isn't a stub because we know exactly how this will be achieved. We use the main surface to blit our image to the screen at the correct x- and y- coordinates. To access the object's member field, we have to use the 'self' keyword. Attributes and methods belonging to the current object are accessed through self followed by a dot ('.') followed by the attribute or method. When calling the method, you don't have to pass in 'self', Python will handle that for you. Self is only placed in the parameter list at the method declaration.

```
if __name__ == '__main__':
```

Python knows the name of each module, or program, that it is running. If the file doesn't have a specific name then it is assigned the value '__main__'. We can use this to our advantage because it means that we can put our classes in separate files; import them as required; and more importantly, test them in isolation.

This is the beauty of OOP: the fact that you can take small objects, test them in isolation, and then combine them into a much larger program.

In simplest terms, this 'if' statement checks to see if this is the main entry point into our program, and if it is it will run the code block underneath. If it is not, the code block underneath will be ignored. We don't have to remove this code when we use the 'Ball' class in other programs because it will be ignored.

```
pygame.init()
fpsClock = pygame.time.Clock()
surface = pygame.display.set_mode((800, 600))
```

Creating an Instance of the Class

This is our almost-standard initialization code for PyGame. We initialize PyGame and create a clock to clamp our game to 30 frames per second. We create a surface that is 800x600 pixels.

```
ball = Ball()
```

To create an instance of a class, this is all that is required: you assign a new instance of the class to a name, just as you would when you assign a number to a name. The major difference are the parentheses at the end of the assignment. This allows for parameters to be passed to a special method called a constructor. We'll see what a constructor in Python looks like later.

```
while True:
    for event in pygame.event.get():
        if event.type == QUIT:
            pygame.quit()
            sys.exit()
```

We've employed the same code as in the Bricks program to ensure that we listen for system events, especially when those events tell us to close the window.

```
surface.fill((0, 0, 0))
```

Clear the screen for drawing. We don't bother with creating colors here, just passing in a tuple representing the Red, Green, and Blue components (all zero is black) is good enough for our test code.

```
ball.draw(fpsClock, surface)
```

In this line we call the draw() method on the ball object we created a few lines earlier. Although the method signature has three arguments (self, gameTime, and surface) we don't explicitly pass in 'self'. This is passed in my Python itself as the 'ball' instance of the Ball class.

```
pygame.display.update()
fpsClock.tick(30)
```

Finally, we update the display to flip the back buffer to the front buffer and vice versa. We also tick the clock to ensure a steady 30 frames per second.

The ball update() method

When we run the program it won't do much; it will in fact just draw the ball in the top left-hand corner of the playing screen. Go back up to the ball's update() method and change it to look like this:

```
def update(self, gameTime):
    sx = self.speed[0]
    sy = self.speed[1]
```

We can't assign values directly to tuples so we'll copy the values into local variables; it saves us typing as well. We can reassign the tuple later.

```
self.x += sx
self.y += sy
if (self.y <= 0):
    self.y = 0
    sy = sy * -1

if (self.y >= 600 - 8):
    self.y = 600 - 8
    sy = sy * -1

if (self.x <= 0):
    self.x = 0
    sx = sx * -1

if (self.x >=800 - 8):
    self.x = 800 - 8
    sx = sx * -1
self.speed = (sx, sy)
```

Any changes to 'sx' and 'sy' will be reassigned to the 'speed' member field. Now, scroll down to the part of the program where we draw the ball and add this line above the draw call in the main 'while' loop:

```
ball.update(fpsClock)
```

This calls the update() method of the 'ball' instance. Save and run the program. You should see the ball bouncing around the screen.

Constructors

A constructor is a special method that is called when an object is instantiated. The method isn't called using the conventional calling method with the object, a dot, and the method name. You've actually been calling the constructor when you created the ball:

```
ball = Ball()
```

Although you didn't explicitly create a constructor, Python creates one for you. It doesn't contain any code and it would look something like this (don't ever do this, it's really not worth it; just let Python create one for you behind the scenes):

```
def __init__(self):
    pass
```

The double underscores before and after a name, like __init__ are special method names used by Python. When you want to do something different from the default behaviour you will override the default method with your own. Python describes these names as 'magic' and as such you should never invent your own and only use them as documented. Like when we want to create our own constructors.

In Python the constructor method is called init . It takes at least one parameter, the 'self' keyword. In our Ball class, we'll create our own constructor. Remove all these lines from the class:

```
x = 0
y = 24
speed = (4, 4)
img = pygame.image.load('ball.png')
```

Replace them with:

```
def __init__(self, x, y, speed, imgPath):
    self.x = x
    self.y = y
    self.speed = speed
    self.img = pygame.image.load(imgPath)
```

Notice that we have to add 'self.' to the name of the member field when we read or write values to it. This is the same when we're in the constructor. Scroll down the source code to the ball initialization line and change that to:

```
ball = Ball(0, 24, (4, 4), 'ball.png')
```

We can now pass in values when we construct an instance of the class.

SOLID

What does all this mean? Well, in an OOP language we have created a class to represent our Ball. We don't care what happens inside that class so long as it does what we expect it to do. Although we will be writing the classes in this book ourselves, we could farm out the work to other developers and give them a specification or interface to code to. So for example, all action objects must have an update() method that takes in an FPS clock.

Classes describe attributes and methods that describe and perform actions, respectively, of an abstract data structure. There is an acronym that describes five principles of object design. For our games, we will try to adhere to these principles:

- Single responsibility
- Open-closed principle
- Liskov substitution
- Interface segregation
- Dependency inversion

The initials of which spell out SOLID. While it is not important to use these techniques in all your games, you should strive to make your classes in such a way that they try to adhere to the principles laid out below. You may skip this and move onto the conclusion if you wish.

Single Responsibility

Each class should have a single responsibility and that responsibility should be contained within the class. In other words, you have a ball class and its functionality should be wrapped within that class. You should not implement additional functionality, like a Bat inside that same class. Create a separate class for each item. If you have lots of space invaders, you only need to create one Invader class, but you can create an InvaderCollection class to contain all your invaders.

Open-Closed Principle

Your class should be thoroughly tested (hint: name ==' main ') and should be closed from further expansion. It's OK to go in and fix bugs, but your existing classes shouldn't have additional functionality added to them because that will introduce new bugs. You can achieve this in one of two ways: extension or composition.

With extension, you are extending the base class and changing the existing functionality of a method. With composition, you encapsulate the old class inside a new class and use the same interface to change how the caller interacts with the internal class. A class' interface is just the list of methods (the actions) that can be performed on the class.

Liskov Substitution

This is by far the trickiest of all the SOLID principles. The idea behind this principle is that when extending a class the subclass should act no different than the class it extends. This is also known as the substitutability of a class.

Interface Segregation

Interface segregation means that you should code to the interface, rather than the implementation. There are other ways to achieve this in other OOP languages, but Python uses something called Duck Typing. This means that Python will try and call a method on an object with the same name and parameters even if they're not the same object. Take this example program. We create two classes: Duck and Person. Each class has a method called Quack(). Watch what happens in the makeItQuack() function. The parameter that is passed gets its Quack() method called:

```
class Duck:
    def Quack(self):
        print "Duck quack!"
```

```
class Person:
    def Quack(self):
        print "Person quack!"

def makeItQuack(duck):
    duck.Quack()

duck = Duck()
person = Person()

makeItQuack(duck)
makeItQuack(person)
```

We have sort of seen Duck Typing before when we created the add() function to add two things together; integers, real numbers, strings, and tuples all worked because they can all be added together using the plus ('+') operator.

Dependency Inversion

Last is dependency inversion. Dependency inversion is a form of decoupling where higher-level modules (classes) should not depend on lower-level modules (classes). They should instead both depend on abstractions. Second, abstractions should not depend on details. Details should depend on abstractions. Let's create an example to better illustrate this.

```
class Item:
    vat_rate = .2

    def __init__(self, price):
        self.price = price
    def calcVAT(self):
        return self.price * self.vat_rate
item = Item(2.99)
print item.calcVAT()
```

The Item class breaks the Open/Closed principle because it is closed for extension; we'd have to create a separate Item for each country. What if we wanted to allow for discounts too? Not to mention that the VAT rate is included in the Item class. What we need is another class to calculate the VAT rate. Like this:

```
class UkVat:
    vat_rate = .2

    def calcVAT(self, item):
        return item.price * self.vat_rate
```

We have a separate class to represent the VAT rate for each region we are operating. This class can then be decided upon based upon the user's address information.

```
class OntarioVat:
    vat_rate = .13

    def calcVAT(self, item):
        return item.price * self.vat_rate
```

This also satisfies the single-use principle; an item is an item, it shouldn't need to know its VAT rate because that is separate from the item's price. Similarly, because it shouldn't need to know its VAT rate it shouldn't need to know how to calculate the value. This fits in quite nicely with interface segregation (duck typing). We don't need to know what's happening in that calcVAT() method only that it should take an item and produce a value.

```
class Item:

    def __init__(self, price):
        self.price = price

    def calcVAT(self, rate):
        return rate.calcVAT(self)

item = Item(2.99)
uk = UkVat()
ontario = OntarioVat()

print item.calcVAT(uk)
print item.calcVAT(ontario)
```

It seems a little over the top to create separate classes for each VAT rate, but it does mean that in this example, you won't have to add all the VAT rates to the Item class for each territory. You would then have to pass in the customer's country details to the calcVAT() method on the object.

Conclusion

This has been a short introduction to OOP. By this point you should understand the following:

- Attributes are member fields and contain data that describes the class.
- Methods are functions that belong to a class that perform actions on the class.
- Self is used to reference.

- A constructor can be used to initialize member fields when the object instance is created.
- Python uses Duck Typing; when you see a bird that walks like a duck, swims like a duck, and quacks like a duck … it's a duck.

As an exercise, create a new blank file called BatClass and implement a class called 'Bat'. You can use the code from the Brick game as a starting point.

CHAPTER 15

Inheritance, Composition, and Aggregation

When most people learn about object-oriented programming, they learn three things:

- Objects have attributes (data) that contain the object's state.
- Methods that control access (change or view) the object's state.
- Objects can be extended using a technique called inheritance.

There are others, but those are the three main things that people remember about their first introduction to object-oriented programming.

Most people fixate on that last one: object extension by inheritance. That's true in a lot of cases, but there are ways that objects can be extended using techniques called composition and aggregation. This section will provide an introduction to the three methods of object extension.

Inheritance

Inheritance occurs at the very base level of the Python language. When you create a new class, you are actually extending a base class called 'object'. This simple object:

```
class Foo:

    def bar(self):
        print "bar"

foo = Foo()
foo.bar()
```

S. Kelly, *Python, PyGame and Raspberry Pi Game Development*,
DOI 10.1007/978-1-4842-2517-2_15

Can be rewritten explicitly as:

```
class Foo(object):

    def bar(self):
        print "bar"
foo = Foo()
foo.bar()
```

Indeed, if you are using the newer Python syntax you are encouraged to use this syntax. You will see it used in the 'Invaders' game later on in this very text. For more information regarding the old way vs. the new way, please visit https://wiki.python.org/moin/NewClassVsClassicClass.

USE THE NEWER MyClass(object) SYNTAX WHEN DEFINING CLASSES.

Taking this a step further, let's create two classes. The first is a base class.

A base class contains the basic level of functionality that is required to perform a given set of actions. It can contain methods that are placeholders for actions that will be implemented by a child class.

A child class is any class that derives from another class. In actuality, every class you create is a child class of the Python base 'object' class.

Base and Child Classes

Create a new file and enter the code below:

```
class MyBaseClass(object):

    def methodOne(self):
        print "MyBaseClass::methodOne()"

class MyChildClass(MyBaseClass):
```

When a class derives from another class, remember to put the base class' name in parentheses after your new class' name:

```
def methodOne(self):
    print "MyChildClass::methodOne()"
```

We'll create a function to call the methodOne() method of each class:

```
def callMethodOne(obj):
    obj.methodOne()
```

This method takes in a single parameter 'obj' and calls the methodOne() method of that object.

```
instanceOne = MyBaseClass()
instanceTwo = MyChildClass()
```

It then creates an instance of the 'MyBaseClass' and 'MyChildClass' classes.

```
callMethodOne(instanceOne)
callMethodOne(instanceTwo)
```

Using the function, we pass in our instances of the base and child classes. Save and run the program. You should see:

```
MyBaseClass::methodOne()
MyChildClass::methodOne()
```

The function is called and it, in turn, takes the parameter and calls the methodOne() method of the object that it receives. Add another line after the last callMethodOne() line:

```
callMethodOne(5)
```

Run the program. You should see output similar to the one below:

```
MyBaseClass::methodOne()MyChildClass::methodOne()
Traceback (most recent call last):
    File "basechildclass.py", line 26, in <module>
        callMethodOne(5)
    File "basechildclass.py", line 17, in callMethodOne
        obj.methodOne()
AttributeError: 'int' object has no attribute 'methodOne'
```

This is because the 'int' object that is built into Python does not contain a method called 'methodOne'.

Python uses a technique called *duck typing*.

When I see a bird that walks like a duck and swims like a duck and quacks like a duck, I call that bird a duck.

This means that when Python sees a method call on an object, it assumes that that message can be passed to it. The benefit of this technique is that inheritance has been almost superseded by a technique called *programming to the interface*.

Programming to the interface means that you don't need to worry about the internal workings of the object; you just need to know what methods are available.

There is still an applicable use for inheritance though. For example, you may have a base class that provides much of the functionality required. Subclasses would then implement their specific methods.

Programming to the Interface

Let's take a look at another example. Rather than using inheritance, we'll use the same method for two different objects:

```
class Dog(object):

    def makeNoise(self):
        print "Bark!"

class Duck(object):

    def makeNoise(self):
        print "Quack!"

animals = [ Dog(), Duck() ]

for a in animals:
    a.makeNoise()
```

Our two classes - Dog and Duck - both contain a method called 'makeNoise'. A list of animals is created that contains an instance of Dog and Duck classes. Iteration through the list is then used to call the 'makeNoise' method for each object.

A Note about Constructors and Base Classes

To round off inheritance, we need to mention the recommended steps in calling the base class of an object's constructor. Take the following two classes as an example:

```
class Foo(object):

    x = 0

    def __init__(self):
        print "Foo constructor"
        self.x = 10

    def printNumber(self):
        print self.x
        class Bar(Foo):
```

```
    def __init__(self):
        print "Bar constructor"

b = Bar()
b.printNumber()
```

When you run this code you will get the following output:

```
Bar constructor
0
```

Even though 'Bar' extends 'Foo', it hasn't initialized the 'x' field because the init () method of the parent class was not called. To properly do that, change the constructor of 'Bar' to:

```
def __init__(self):
    super(Bar, self).__init__()
    print "Bar constructor"
```

What is going here? The super() method allows us to reference the base class; however, the base class needs to know two things: the derived class type and the instance. We achieve this by passing in the type of our derived class - 'Bar' in this case and 'self'. We can then call the method __init__() to set up our fields correctly. When you run the program, you should see:

```
Foo constructor
Bar constructor
10
```

You must always call your base class's constructor before you write any other code in your derived class's constructor. This is especially true if you are creating a base class with lots of functionality and inheriting from it. Make sure you call the base class's constructor!

Composition

Composition is the containment of one or more objects inside another. With composition, the contained objects' creation and destruction are controlled by the container object. The container object generally acts as a controller for the contained objects. For example:

```
class Alien:


    def __init__(self, x, y):
        self.x = x
        self.y = y

    def draw(self):
        pass
```

The ‘Alien’ class contains just the x- and y- coordinate that would be used to display an alien at a particular point onscreen. Other attributes that you might want to add would be the type of alien or its shield strength.

```
class AlienSwarm:

    def __init__(self, numAliens):
        self.swarm = []

        y = 0
        x = 24

        for n in range(numAliens):
            alien = Alien(x, y)
            self.swarm.append(alien)

            x += 24
            if x > 640:
                x = 0
                y += 24
```

The __init__() method takes a single parameter that represents the number of aliens in the swarm. The logic in the method ensures that the swarm is evenly distributed across the screen. Each alien is separated by 24 pixels across and 24 pixels down.

```
    def debugPrint(self):
        for a in self.swarm:
            print "x=%d, y=%d" % (a.x, a.y)

    def isHit(self, x, y):
        alienToRemove = None
        for a in self.swarm:
            if x>=a.x and x <= a.x + 24 and y >= a.y and y <= a.y + 24:
            alienToRemove = a
                break

        if alienToRemove != None:
            self.swarm.remove(alienToRemove)
            return True

        return False

swarm = AlienSwarm(5)
swarm.debugPrint()
```

The 'break' keyword is used to exit from the enclosed loop. When the 'break' keyword is executed the control of the program jumps to the line immediately after the loop statements. A related keyword is 'continue'. Continue stops processing the remaining statements in the current iteration of the loop and move control back to the top of the loop. Both 'break' and 'continue' work with any loop structure.

The Alien class is never called outside the AlienSwarm. It is created by the AlienSwarm class, and any interaction with the outside world is also done through this class.

Aggregation

Aggregation is, conceptually, much like composition. A container object has a link to other objects and it manipulates them in some form, through a method or methods. However, the big difference is that the creation and destruction of the objects are handled elsewhere. With aggregation, the container class *must not* delete objects that it uses.

Say we have a Collision class and we want to check if any of the player's bullets have hit an alien, we could implement something like this - assuming Alien and AlienSwarm remain unchanged:

```
class Player:

    def __init__(self):
        self.bullets = []

    def getBullets(self):
        return self.bullets

    def removeBullet(self, bullet):
        self.bullets.remove(bullet)

class Collision:

    def __init__(self, player, swarm):
        self.player = player
        self.swarm = swarm

    def checkCollisions(self):
        bulletKill = []

        for b in player.getBullets():
            if swarm.isHit(b.x, b.y):
                bulletKill.append(b)
                continue
        for b in bulletKill:
            self.player.score += 10
            self.player.removeBullet(b)
swarm = AlienSwarm(5)
player = Player()

collision = Collision(player, swarm)

collision.checkCollisions()
```

The Collision class is an aggregation, that is, it contains a reference to two other classes: Player and AlienSwarm. It does not control the creation and deletion of those classes.

This ties in with our SOLID principal: each class should have a single purpose and should be independent of each other. In this case, our Player class does not need to know about aliens, and likewise the AlienSwarm class doesn't need to know about players. We can use our interfaces to create a class that sits in between the two to allow us (the programmer) to determine if a collision has occurred.

Conclusion

Python allows for standard OOP techniques but offers its own unique twist: duck typing. By programming to the interface, we can ensure that our classes can be written independently of each other.

PROGRAM TO THE INTERFACE TO KEEP YOUR CLASSES SMALL AND NIMBLE.

CHAPTER 16

Game Project: Snake

For our second game we are going to re-create the classic Snake game. Snake has been with us since the late 1970s and, if you had a Nokia phone, you probably had a version of the game on it. You control a snake, and you move around the screen using the cursor keys. You have to eat fruit to grow. You are not allowed to touch the outside walls or yourself. Did I mention that you are growing? See Figure 16-1.

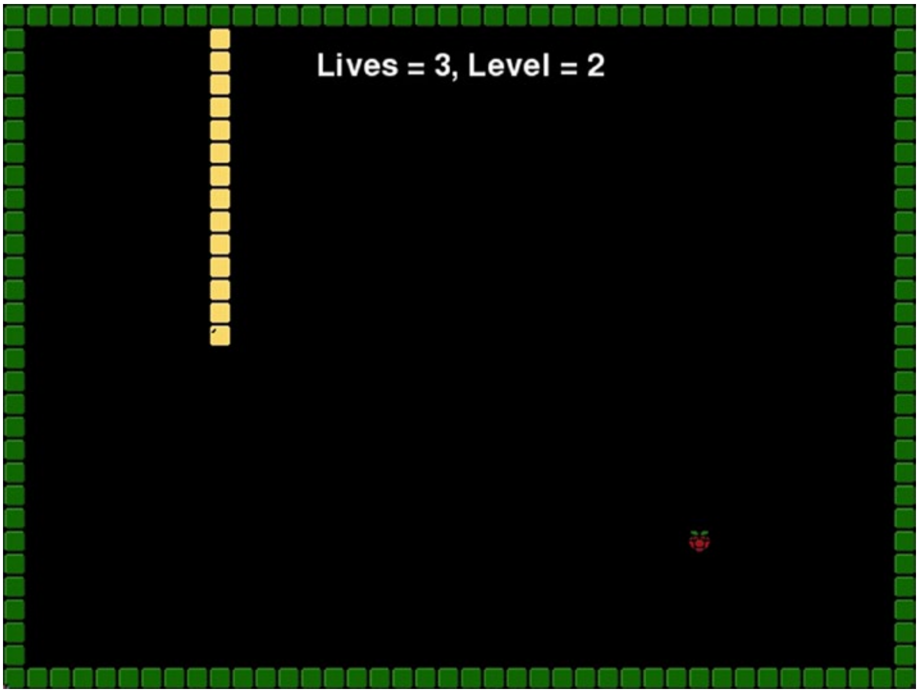


Figure 16-1. *Snake game running*

© Sloan Kelly 2016
S. Kelly, *Python, PyGame and Raspberry Pi Game Development*,
DOI 10.1007/978-1-4842-2517-2_16

In this game we are going to introduce the following:

- Class declarations and instances (objects)
- File input
- Cell-based collision detection
- Functions
- Text fonts

Snake will use more functions than object-oriented techniques. For the most part, our objects in this game will be for organizational purposes only. There will be very little OOP involved.

Functions

The following functions are defined:

- drawData
- drawGameOver
- drawSnake
- drawWalls
- headHitBody
- headHitWall
- loadImages
- loadMapFile
- loseLife
- positionBerry
- updateGame

We can create a structured diagram in Figure 16-2 showing how these functions all work together.

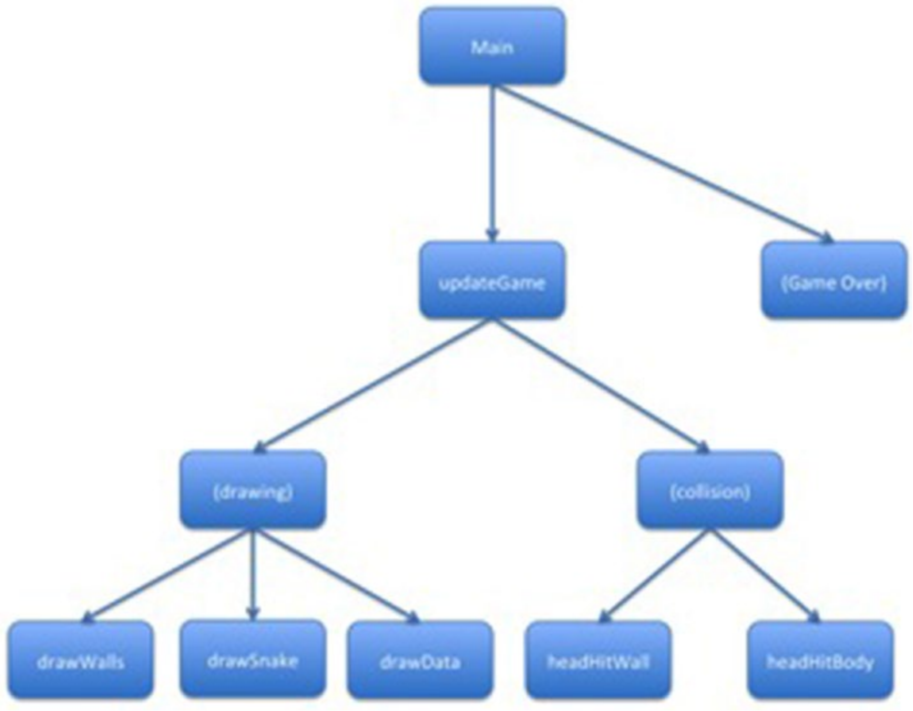


Figure 16-2. *Structured diagram for the Snake game*

The structured diagram shows how each function interacts with each other. The functions enclosed in parentheses don't actually exist. They are used to group together like functions. For example, drawing the game actually calls three separate functions. We could create another function - I will leave that to the reader's discretion.

Snake Framework

The basic outline for the Snake game is shown below. Create a new file in your working folder and call it snake.py. Type the code in exactly as written below. Don't forget to read the comments as you go to help you understand what's going on and what the intent of the author (me) was. We'll replace some of the comments with code later on in this section. You should include the comments in your own listings as you type the code. This will act as placeholders for the later code.

```
#!/usr/bin/python
import pygame, os, sys
import random
from pygame.locals import *
```

By now you should recognize the familiar start to our programs! The hash-bang and the import of the Python modules we need: PyGame, OS, and System. We're also importing a new one for this game: Random. This module will allow us to generate a random starting position for the berry.

```
pygame.init()
fpsClock = pygame.time.Clock()
surface = pygame.display.set_mode((640, 480))
font = pygame.font.Font(None, 32)
```

To keep the map size down, the game will run in a 640x480 window. We'll see in a second how to create the map. Our PyGame initialization and clock to keep everything at 30 frames per second are also initialized here. Our last bit of initialization is to create a font object using the default font with a size of 32 pixels.

```
class Position:
    def __init__(self, x, y):
        self.x = x
        self.y = y
```

Our first class is a simple one: Position. This holds the position of a map block. We use the constructor (in Python, that's the init () method) to pass in the x- and y-coordinates.

```
class GameData:
    def __init__(self):
        self.lives = 3
        self.isDead = False
        self.blocks = []
        self.tick = 250
        self.speed = 250
        self.level = 1
        self.berrycount = 0
        self.segments = 1

        self.frame = 0

        bx = random.randint(1, 38)
        by = random.randint(1, 28)

        self.berry = Position(bx, by)
        self.blocks.append(Position(20,15))
        self.blocks.append(Position(19,15))

        self.direction = 0 # 0 = right, 1 = left, 2 = up, 3 = down
```

The GameData holds just about everything we need to store about the game. The majority of this data is for the player's snake.

- lives - the number of lives the player has left
- isDead - is set to true when the snake's head touches a piece of the tail or a wall
- blocks - the list of blocks that make up the tail of the snake
- tick - the running total used to count down to the next animation frame. In milliseconds
- speed - the default tick speed. Also in milliseconds
- level - the current level of difficulty
- berrycount - the number of berries consumed by the snake in this level
- segments - the number of segments added when a berry is consumed. This value changes each level
- frame - the current animation frame used to draw the snake's head. The snake has two frames of animation, not unlike Pacman
- direction - The current traveling direction of the snake. 0 is right, 1 is left, 2 is up, and 3 is down. The snake can only move in one of those four directions. They also cannot reverse direction. For example, if the snake is traveling right, the player cannot move to the left. They can move either up or down, or continue going right

The snake starts out with two blocks that are represented by two instances of the 'Position' class; that means that it has one head segment and one tail segment. The number of segments grows every time a berry is consumed.

Berry positions, bx and by are used to position a berry at a location on the game screen. These are stored in the 'berry' attribute of the GameData class.

```
def loseLife(gamedata):
    pass

def positionBerry(gamedata):
    pass

def loadMapFile(fileName):
    return None

def headHitBody(gamedata):
    return False

def headHitWall(map, gamedata):
    return False
```

```
def drawData(surface, gamedata):
    pass

def drawGameOver(surface):
    pass

def drawWalls(surface, img, map):
    pass

def drawSnake(surface, img, gamedata):
    pass

def updateGame(gamedata, gameTime):
    pass

def loadImages():
    return {}
```

These are all the functions that were drawn on the structured diagram.

They will be discussed in detail when we start implementing the functionality for the game.

```
images = loadImages()
images['berry'].set_colorkey((255, 0, 255))
```

Our images are loaded in using the loadImages() function. The images are stored in a dictionary. The key is a string value, and the example given shows that we are setting the color key of the 'berry' image to purple (Red = 255, Green = 0 and Blue = 255). PyGame will not draw any pixel of that image that matches the supplied color. This means that you can have transparent pixels in your image. This is handy for windows or complex shapes like a berry.

```
snakemap = loadMapFile('map.txt')
data = GameData()
quitGame = False
isPlaying = False
```

These local (to the main game loop) variables are used to store the map, create an instance of the GameData class, a control variable to determine if the user quits the game, and finally one to determine if the user is playing the game. The default value is 'False' because we want to start the game in "Game Over" mode to allow the user to choose whether to play the game or exit the application.

```
while not quitGame:
    if isPlaying:
        x = random.randint(1, 38)
        y = random.randint(1, 28)
```

Our screen size is 40 blocks along by 30 blocks down. For a 640x480 screen that means that we have a block size of 16x16 pixels. The random value that is generated here will be used to place the berry that will be consumed by the player-controlled snake.

Our random values are between 1 and 38 because we want to produce a value in the range 1 to 38 inclusive. Our map is going to be a solid block that makes up the border of the playing area. We'll discuss this in detail in a section below.

```
rrect = images['berry'].get_rect()
rrect.left = data.berry.x * 16
rrect.top = data.berry.y * 16
```

Now that we have our random values for the x- and y- coordinates we will assign them to the left and top fields of the berry image rectangle.

The coordinates are multiplied by 16 because each cell is 16x16 in size.

```
for event in pygame.event.get():
    if event.type == QUIT:
        pygame.quit()
        sys.exit()
```

In a real game you probably wouldn't want to quit the game if the user closed the window. Or, at the very least you would want to prompt them to confirm the action. In this simple game, however, we just close the game and quit to the desktop.

```
# Do update stuff here
```

Our update routines will go here. This is just a placeholder comment. This type of comment will be used throughout the book. If you see comments as part of the 'type in' code, please include it with your own source code. We will return to this point later on in the text, and if you don't have it, it could lead to confusion.

```
isPlaying = (data.lives > 0)
```

This is a nice short form way to set the isPlaying variable to false if the player has no lives left. You could easily rewrite this as an 'if' statement. How would you go about that?

```
if (isPlaying):
```

The value to isPlaying could have changed after the previous line. This is why we do another if-check of this variable here.

```
    surface.fill((0, 0, 0))
    # Do drawing stuff here
else:
```

If the game is not playing then it's in the "Game Over" mode. The "Game Over" mode displays a message to the user. If they want to play the game again, the user must press 'space' on the keyboard.

```
keys = pygame.key.get_pressed()
for event in pygame.event.get():
    if event.type == QUIT:
        pygame.quit()
        sys.exit()
```

The event trap that we have is here. This is the second time this has appeared in the code. That means that it's an ideal candidate for creating a function. How would you go about doing it? Do you have to pass in any parameters?

```
if (keys[K_SPACE]):
    isPlaying = True
    data = None
    data = GameData()
```

If the user presses the spacebar, we set the isPlaying flag to true and reset the data to a new instance of GameData. It is good practice when you have finished with an object to set the variable that points to it to 'None'.

```
drawGameOver(surface)
```

The "Game Over" screen is drawn by calling the drawGameOver() function.

```
pygame.display.update()
fpsClock.tick(30)
```

Our last lines flip the screen (double-buffered display) and clamp the frame rate to a maximum of 30 frames per second. Save the program. The program won't run just now; we need to load the images and the map data first before we can see anything onscreen.

Images

The game needs the following images:

- berry.png - The berry that the snake eats
- snake.png - A multiframe image that contains all the images used by the snake
- wall.png - A block that the snake cannot travel through

Our images are 16x16 except for snake.png, which is 144x16 pixels. The reason for this is that all the images that we want for the snake are included in the same file. See Figure 16-3.

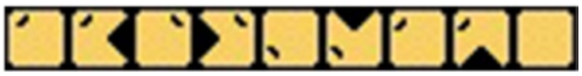


Figure 16-3. *The frames of the snake*

These images, as with all the examples in this book, can be downloaded from http://sloankelly.net.

Loading the Images

Copy or make the images and put them in the same directory as the snake.py file. Locate the loadImages() function and change it to look like this:

```
def loadImages():
    wall = pygame.image.load('wall.png')
    raspberry = pygame.image.load('berry.png')
    snake = pygame.image.load('snake.png')
```

The images are loaded in separately, but we're going to put them in a dictionary to keep all the images together.

```
return {'wall':wall, 'berry':raspberry, 'snake':snake}
```

The next step is to create and load the map that makes up the game screen.

The Game Map

The map for the game is held in a text file called map.txt. In this file enter the following text:

```
1111111111111111111111111111111111111111
1000000000000000000000000000000000000001
1000000000000000000000000000000000000001
1000000000000000000000000000000000000001
1000000000000000000000000000000000000001
1000000000000000000000000000000000000001
1000000000000000000000000000000000000001
1000000000000000000000000000000000000001
1000000000000000000000000000000000000001
1000000000000000000000000000000000000001
1000000000000000000000000000000000000001
1000000000000000000000000000000000000001
1000000000000000000000000000000000000001
1000000000000000000000000000000000000001
1000000000000000000000000000000000000001
1000000000000000000000000000000000000001
1000000000000000000000000000000000000001
1000000000000000000000000000000000000001
1000000000000000000000000000000000000001
1000000000000000000000000000000000000001
1000000000000000000000000000000000000001
```

```
1000000000000000000000000000000000000001
1000000000000000000000000000000000000001
1000000000000000000000000000000000000001
1000000000000000000000000000000000000001
1000000000000000000000000000000000000001
1000000000000000000000000000000000000001
1000000000000000000000000000000000000001
1000000000000000000000000000000000000001
1111111111111111111111111111111111111111
```

That's 30 lines of text. The top and bottom lines are:

```
1111111111111111111111111111111111111111
```

And the rest of the lines are:

```
1000000000000000000000000000000000000001
```

You can experiment with different patterns of 0s and 1s if you like. Each '0' represents an open space that the snake can travel through. Each '1' represents a wall block that will kill the snake if it is touched. Save this file and open snake.py. Locate the loadMapFile() function and change it to:

```
def loadMapFile(fileName):
    f = open(fileName, 'r')
    content = f.readlines()
    f.close()

    return content
```

The readlines() method reads each line of text in a file into a list. Save the snake.py file.

Drawing the 'Game Over' Screen

If we run the game now we will see nothing because we have not implemented any of the drawing methods. Let's start by showing the "Game Over" screen. Locate the drawGameOver() function and change it to:

```
def drawGameOver(surface):
    text1 = font.render("Game Over", 1, (255, 255, 255))
    text2 = font.render("Space to play or close the window",
```

Font's render() method creates a PyGame surface that will fit the text exactly. The parameters that the render() method takes is the string that is to be displayed, the anti-aliasing level, and the color.

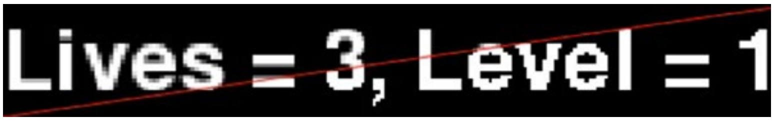


Figure 16-4. *The anti-aliased version of the image is shown to the left of the red line*

Anti-aliasing means that the text won't appear with jaggy edges. In Figure 16-4 below you can see the effects of anti-aliasing versus having no aliasing:

The image has been split down the middle and shows the anti-aliased text to the left of the red line and the aliased version to the right.

```
textpos1 = text1.get_rect(centerx=surface.get_width()/2,
top=surface.get_height()/2 - 48)
textpos2 = text2.get_rect(centerx=surface.get_width()/2,
top=surface.get_height()/2)
```

We're using named arguments here because we don't need to specify all the values for the text positions. These two lines create the rectangles that are used to place the text in the middle of the screen.

```
surface.blit(text1, textpos1)
surface.blit(text2, textpos2)
```

The blit() method of the surface instance passed to the function is used to draw the text on the surface. Save and run the game. You should now see the following screen (as shown in Figure 16-5) appear when you run the game:

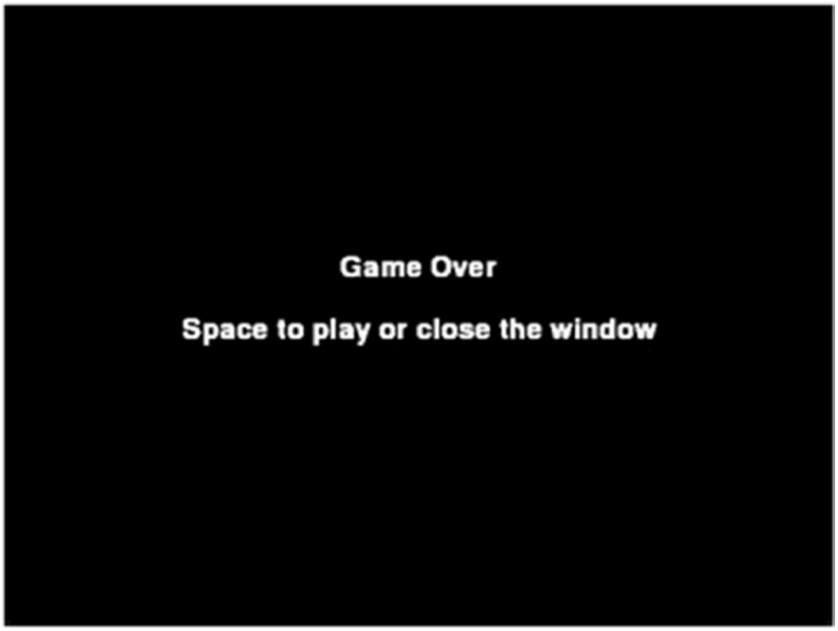


Figure 16-5. *The "Game Over" screen, as it appears when the game starts*

Close the window when you've finished. If you press 'space' the screen will go blank and nothing will happen because we haven't added the functions to update or draw the screen. Let's add the drawing functions now.

Drawing the Game

The drawing of the snake, the playing area, and the game data (player's lives, score, and level text) are performed by three functions:

- drawWalls
- DrawSnake
- drawData

In snake.py, scroll down in the source code to the line that reads:

```
# Do drawing stuff here
```

Add the following lines just underneath that comment. Be sure that you get the right number of tabs per line. The left column of each line should start directly under the '#' of the comment:

```
drawWalls(surface, images['wall'], snakemap)
surface.blit(images['berry'], rrect)
```

```
drawSnake(surface, images['snake'], data)
drawData(surface, data)
```

There isn't a specific routine for drawing the berry, so we just call the main surface's blit() method directly. There is an order to how we draw things on screen. Images drawn on the screen after other images will appear on top. So, the walls appear behind the snake, and the snake appears behind the lives / score display.

Drawing the Walls

The walls are drawn in the drawWalls() function. Locate this function in the source code and change it to read:

```
def drawWalls(surface, img, map):
```

The function takes three parameters. The first argument is the main surface that we will draw our wall blocks on. The second is the image we will use to represent a brick in the wall, and finally the third argument is the map data. This is the data we loaded from the file earlier on.

```
row = 0
for line in map:
    col = 0
    for char in line:
        if ( char == '1'):
```

For each character in the line we examine it. If the character is '1' we put down a block. Because we are keeping count of the row (variable 'row') and column (variable 'col'), calculating the onscreen position is just a matter of multiplying each by 16. Why? Because our block image is 16x16 pixels and our file is not mapped per pixel. Instead, each character in the map file represents a 16x16 block.

It is an array of characters arranged from zero to the maximum row and column we have given. In this game's case, that maximum is 40 blocks by 30 blocks. For a 640x480 screen, that's 16x16 pixels per block.

```
imgRect = img.get_rect()
imgRect.left = col * 16
imgRect.top = row * 16
surface.blit(img, imgRect)
```

The image rectangle's left and top values are changed each time a block is drawn to ensure the image is drawn to the surface at the right position.

```
    col += 1
row += 1
```

Save and run the game. When you press the spacebar to start the game, you will see the wall around the playing field and the berry. Close the game when you are ready and let's start adding the lives, level, and score display. See Figure 16-6.

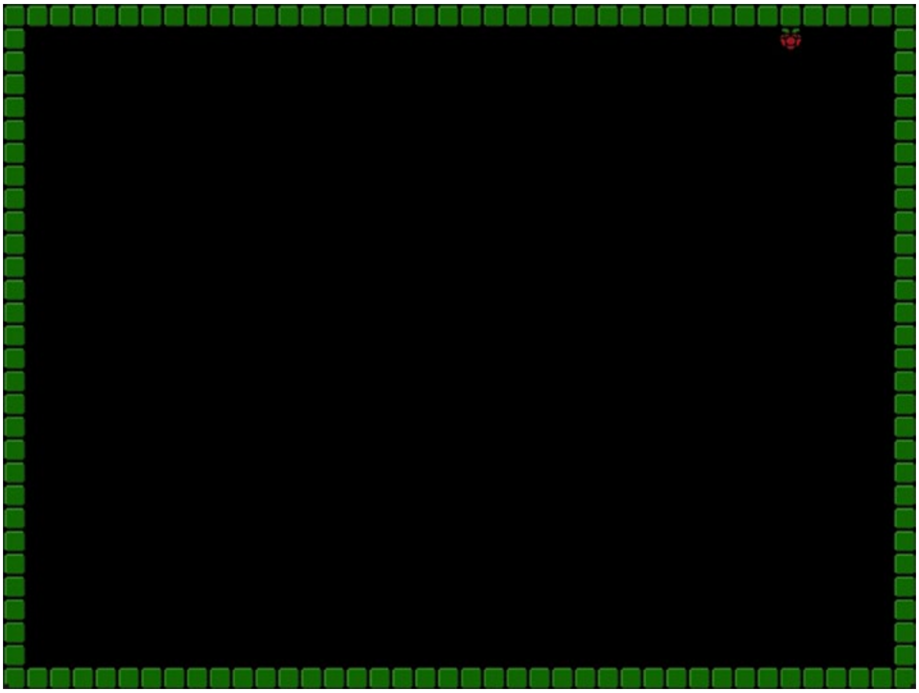


Figure 16-6. *The wall and berry displayed when the game is run with the code up to this point*

Drawing the Player Data

The player needs some feedback on how well they are doing. This is usually an indicator of their score, the number of lives left, and usually the current level. We will add code to the drawData() function to give our player's feedback. Locate the drawData() function in code and change it to this:

```
def drawData(surface, gamedata):
```

The function takes in two parameters. The first is the surface we will draw the data on. The second is the actual game data itself.

```
text = font.render("Lives = %d, Level = %d" % ( gamedata.lives, gamedata.
level ), 0, (255, 255, 255))
textpos = text.get_rect(centerx=surface.get_width()/2, top=32)
surface.blit(text, textpos)
```

The data is rendered as text using a tuple to inject the data into a string. This is called string formatting and we saw this kind of code when we looked at tuples in the previous sections.

Save the program at this point. You can run it if you wish. This time, when the game starts you will see the player's lives and current level at the top of the screen.

Drawing the Snake

Drawing the snake is a little more complex than our previous drawing functions - that's why I left it for last! Our snake image (the actual .png file) is 144 pixels by 16, which means that it contains nine 16x16 images. We need to somehow slice them up into individual images.

Locate the drawSnake() function in the code and change it to read:

```
def drawSnake(surface, img, gamedata):
```

The function takes in three parameters. The first is the surface that the snake is to be drawn on. The second is the snake image, and last the third parameter is the GameData instance. This holds all the information about our snake. Specifically, the blocks attribute of the GameData class contains a list of coordinates in the range 0..39 for the column and 0..29 for the row. The coordinates are stored as instances of the 'Position' class.

These coordinates are instances of the Position class. The blocks attribute is a list and as the snake grows, the number of items in this list grows.

```
first = True
```

This is set to true because the first block drawn is special. It is the head of the snake. The image that we draw here depends on:

- The direction the snake is facing
- Whether its mouth is open or not

Take a look at the snake image again in Figure 16-7.

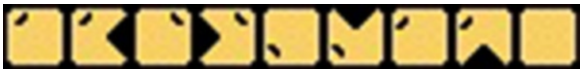


Figure 16-7. *The snake image contains coded data for the snake's head and its tail section*

There is actually a pattern to the sub images. The last cell is the normal tail block. The remaining eight blocks represent the head of the snake. Their position in the array corresponds to the direction of the snake:

- 0 - Right
- 1 - Left
- 2 - Up
- 3 - Down

If we multiply the direction number – which is stored in GameData's direction attribute – by two we get the starting cell number for the image we want. The snake's head is animated, too - it opens and closes. All we have to do is add the current frame (GameData's frame attribute) to get the required image.

```
for b in gamedata.blocks:
    dest = (b.x * 16, b.y * 16, 16, 16)
```

We cycle through all the blocks (positions) of the snake in the list. The destination is a simple calculation: the position multiplied by the dimensions of a single cell (16x16 pixels) to give the screen coordinate.

```
if ( first ):
    first = False
    src = (((gamedata.direction * 2) + gamedata.frame)
```

If we are at the head of the list, we draw the head of the snake. Remember that we can draw a part of an image by specifying a tuple that represents the x- and y- starting pixel of the sub image and its width and height.

For our snake, our sub image's x- coordinate is calculated using this formula:

*((direction * 2) + animation_frame) * 16*

Our image is taken from the top of the sprite sheet, the top is where the y- coordinate is 0 (zero). Our dimensions of width and height are also fixed at 16x16 pixels.

```
else:
    src = (8 * 16, 0, 16, 16)
```

For normal blocks, we just want to draw the last image in the snake.png file. This is the right-most 16x16 square, which happens to be the eighth frame of the image. We could have hard-wired the value, but 8 * 16 makes for a little more descriptive code in this case.

```
surface.blit(img, dest, src)
```

Save and run the game and you will see the snake, the wall and, the player data, as shown in Figure 16-8.

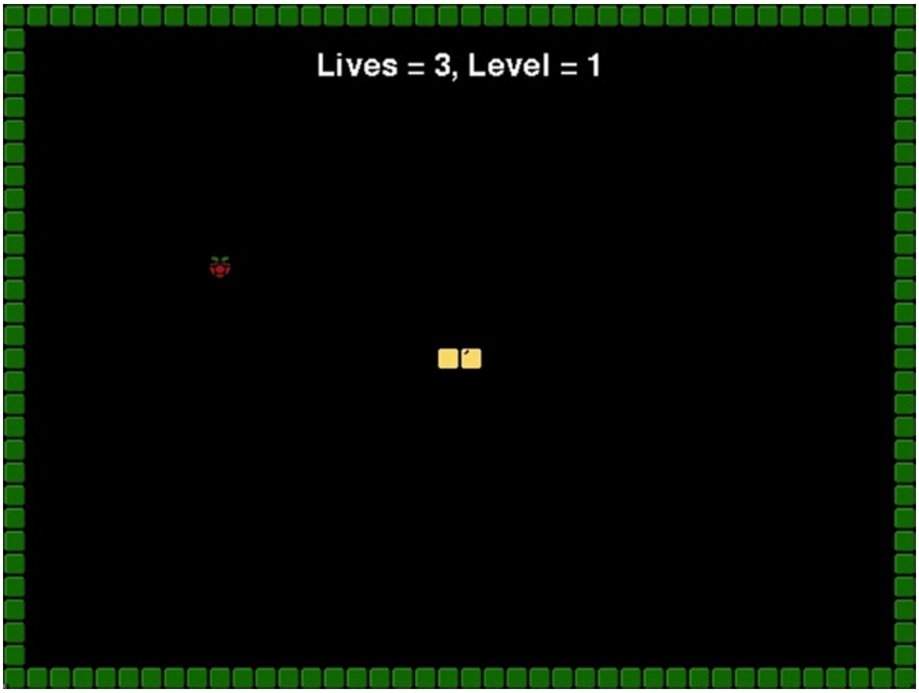


Figure 16-8. *Snake, berry, and walls*

Updating the Game

Static screens, as fun as they are, are no substitute for actually playing the game! However, we haven't implemented any routines to get player input, check for collisions, or update the player's data. Locate the following line:

```
# Do update stuff here
```

Just after the line, add the following code:

```
updateGame(data, fpsClock.get_time())
```

The majority of the update code resides in the updateGame() function. We'll examine that in detail in a moment.

```
crashed = headHitWall(snakemap, data) or headHitBody(data)
if (crashed):
    loseLife(data)
    positionBerry(data)
```

We now test to see if the snake's head has hit a wall (headHitWall() function) or its own body (headHitBody() function). If that's the case, the player loses a life and the berry is repositioned.

The updateGame() method

This is the largest method in the game and it does the most work. Its purpose is to:

- Update the snake's head and tail
- Get input from the player
- Check to see if the snake's head hit the berry

Browse to the part of the code that looks like this:

```
def updateGame(gamedata, gameTime):
    pass
```

Change this function to:

```
def updateGame(gamedata, gameTime):
    gamedata.tick -= gameTime
    head = gamedata.blocks[0]
```

Each part of your game can update at a different rate. For example, you may only want to update certain parts of your game once per second, and others you might want to update thirty times a second. This can be achieved by reading the system clock and determining the number of milliseconds since the code was last called. In this method, we are passing in the difference (in milliseconds) since the last call as 'gameTime.'

The gamedata's tick is decremented by the current game time. When this counter hits zero, we update the snake's head to show it closed (if it's currently open) or open if it's currently closed. We also take note of the current position of the head of the snake. This is always' the 0th element of the blocks attribute of the 'gamedata.'

```
if (gamedata.tick < 0):
    gamedata.tick += gamedata.speed
    gamedata.frame += 1
    gamedata.frame %= 2
```

If the tick attribute is less than zero, we add the speed to it to start the timer all over again. We then add one to the current frame count. We use the modulo calculation to clamp the value to 0 or 1 because we only have two frames of animation. In other languages there is a 'switch' or 'case' statement. This isn't the case (sorry) in Python, but it's easily achievable using nested if/elif statements.

```
if (gamedata.direction == 0):
    move = (1, 0)
    elif (gamedata.direction == 1):
        move = (-1, 0)
    elif (gamedata.direction == 2):
        move = (0, -1)
    else:
        move = (0, 1)
```

In the game of Snake, the snake is always moving; the player only controls direction. Based upon the direction the player wants the snake to move, the appropriate tuple is created.

```
newpos = Position(head.x + move[0], head.y + move[1])
```

This tuple is then used to generate and store the new position for the head of the snake.

```
first = True
for b in gamedata.blocks:
    temp = Position(b.x, b.y)
    b.x = newpos.x
    b.y = newpos.y
    newpos = Position(temp.x, temp.y)
```

The tail of the snake moves up to follow the head. This of course is just an illusion; what we actually do is move the segments of the snake to the previous segment's position.

Snake Movement

Snake movement is clamped to one of four directions: left, right, up, and down. The player can only really suggest the movement: the snake itself moves under its own steam. The snake's direction is chosen by the player by pressing one of the arrow keys on the keyboard.

To get the keyboard input we fetch the list of keys that are currently pressed:

```
keys = pygame.key.get_pressed()
```

The get_pressed() method returns a dictionary of Boolean values. Now that we have the keys pressed, we can test each of the arrow keys to see if the player has depressed it. We also have to make sure that they are not trying to go in the opposite direction. The player can't turn right if they are already heading left, and they can't turn up if they are already heading down, etc.

```
if (keys[K_RIGHT] and gamedata.direction != 1):
    gamedata.direction = 0
elif (keys[K_LEFT] and gamedata.direction != 0):
    gamedata.direction = 1
elif(keys[K_UP] and gamedata.direction != 3):
    gamedata.direction = 2
elif(keys[K_DOWN] and gamedata.direction != 2):
    gamedata.direction = 3
```

We store the current direction in the direction field of the 'gamedata' instance.

Touching a Berry

To progress through the game, the player must get the snake to 'eat' the berries that appear on the playing field. To 'eat' the berries, the player has to steer the head of the snake over the cell that the berry appears. Once the berry has been 'devoured,' a new berry is positioned at another random position on screen and the snake grows by a certain number of segments. The number of segments depends on what level the player is on. The higher the level, the more segments are added to the snake.

```
if (head.x == gamedata.berry.x and head.y == gamedata.berry.y):
    lastIdx = len(gamedata.blocks) - 1
    for i in range(gamedata.segments):
        gamedata.blocks.append( Position( gamedata.blocks[ lastIdx ].x,
        gamedata.blocks[ lastIdx ].y ) )
```

If the head of the snake is in the same cell as the berry, then we append the appropriate number of segments to the end of the snake. The number of segments we add to the end depends on the level in the game. The higher the level, the more segments are added. This makes that game more difficult in later levels because the snake will have more segments for each berry that is consumed.

```
bx = random.randint(1, 38)
by = random.randint(1, 28)
gamedata.berry = Position(bx, by)
gamedata.berrycount += 1
```

Next we generate a new position and set that as the location of the berry. We also increment a counter holding the number of berries that our snake has consumed.

If our snake has consumed 10 berries, we move up to the next level. This has the added effect of increasing the speed of the snake (adding a little extra excitement!), and the number of segments added to the player each time the snake eats a berry.

We clamp the number of segments to 64 and the update speed (in milliseconds) to 100:

```
if (gamedata.berrycount == 10):
    gamedata.berrycount = 0
    gamedata.speed -= 25
    gamedata.level += 1
    gamedata.segments *= 2

    if (gamedata.segments > 64):
        gamedata.segments = 64
    if (gamedata.speed < 100):
        gamedata.speed = 100
```

Collision Detection

As we have seen, collision detection in this game is done on a per-cell basis rather than per pixel. In some ways, this makes our job easier because all we need to do is determine when one block overlaps another, in other words, they occupy the same cell.

Helper Functions

There are four functions that we haven't filled in, but without them we won't be able to detect whether the player has hit a wall or whether the snake has touched itself. Our missing implementations are for:

- loseLife()
- positionBerry()
- headHitBody()
- headHitWall()

Losing a Life

When the snake's head hits its own tail or a wall, the player loses a life. When this happens, we removed all the current blocks that make up the tail of the snake and subtract one from the number of lives. We then add two blocks to the snake to start the player off again. Find 'loseLife' in the code and change it to look like this:

```
def loseLife(gamedata):
    gamedata.lives -= 1
    gamedata.direction = 0
```

Mark the number of lives down by one and reset the direction to the right.

```
gamedata.blocks[:] = []
```

This line removes all the items in the list.

```
gamedata.blocks.append(Position(20,15))
gamedata.blocks.append(Position(19,15))
```

Add two new blocks to the snake in the default position.

Repositioning the Berry

When the player dies, we have to find a new position for the berry. Find the 'positionBerry' function in the code and change it to look like this:

```
def positionBerry(gamedata):
    bx = random.randint(1, 38)
    by = random.randint(1, 28)
    found = True
```

First we generate a random number in our playing field. We then cycle through all the game blocks to make sure that we don't randomly generate a position within the snake itself:

```
while (found):
    found = False
    for b in gamedata.blocks:
        if (b.x == bx and b.y == by):
            found = True
```

Checking to see if the berry occupies the same position as a snake block is easy. We just have to check two values for equality: the x- and y- coordinates of the berry and each of the blocks.

```
if (found):
    bx = random.randint(1, 38)
    by = random.randint(1, 28)
```

If the berry is on a cell that contains a block, 'found' is set to True. If this happens, we assign new values to our 'bx' and 'by' variables and try again.

```
gamedata.berry = Position(bx, by)
```

Once we find a block that doesn't contain a piece of snake, we assign the position to the berry field of the game data.

Testing Snake Body Hits

The snake's head cannot 'touch' its body. Each time we update the snake, we must also check to see if the head has touched the body. Our cell-based collision detection makes this easy. We only have to check the x- and y- coordinates of the snake's head against the x- and y- coordinates of the rest of the blocks that make up the body of the snake. Locate the 'headHitBody' function and change it to look like this:

```
def headHitBody(gamedata):
    head = gamedata.blocks[0]
```

Create a variable to hold a reference to the first block in the list of blocks that make up the snake. This is the head of the snake.

```
for b in gamedata.blocks:
```

Go through each of the blocks one at a time.

```
if (b != head):
```

If the block is not the head, check to see if the head is in the same cell as the current block.

```
if(b.x == head.x and b.y == head.y):
    return True
```

If the head is in the same position as a block in the snake's body, return True to the function's caller.

```
return False
```

Otherwise, return False indicating to the caller that there has been no collision.

Testing Wall Hits

The final function we need to fill in is to test whether the snake's head hits the wall. Locate the 'headHitWall' function and change it to this:

```
def headHitWall(map, gamedata):
    row = 0

    for line in map:
        col = 0
        for char in line:
            if ( char == '1'):
```

For each character in the line we check to see if it is a wall character. Our map file contains 0's and 1's; any '1' represents a wall in the play field. Our control variables 'col' and 'row' are checked against the current position of the 0th element of the blocks. This is the head of the snake.

```
            if (gamedata.blocks[0].x == col and gamedata.blocks[
                return True
        col += 1
    row += 1
return False
```

Conclusion

Save the game and run it. You should be able to start playing Snake. If you get any errors, check the code against the text in the book and make sure you haven't transposed any letters. Remember that whitespace is important: those 'tab' characters need to be in the right place! As a final alternative, download the code from http://sloankelly.net and check yours against the code there.

CHAPTER 17

Model View Controller

Model View Controller was mentioned before in the “Designing Your Game” section to describe how the interactions between different objects can be used to simplify the problem: breaking down a bigger problem into smaller easier-to-manage chunks. See Figure 17-1.

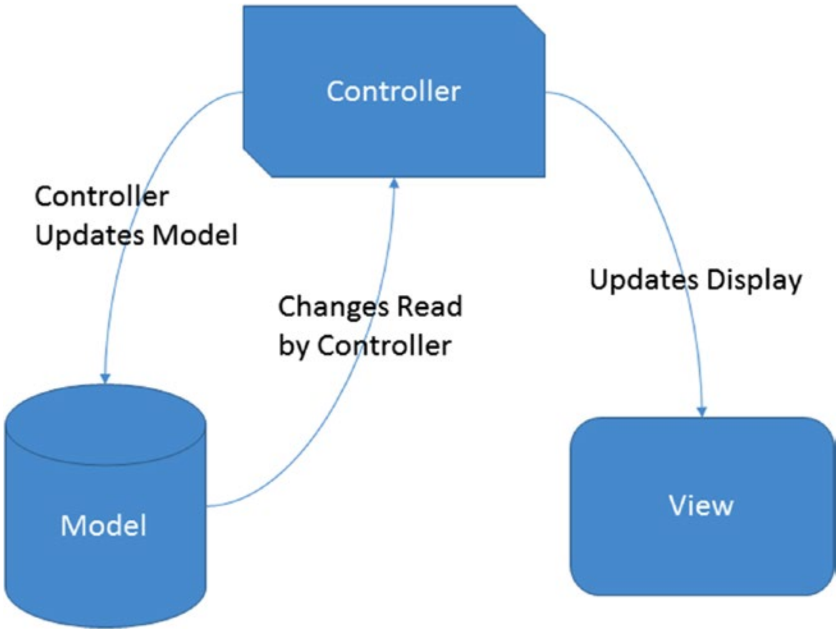


***Figure 17-1.** Model View Controller design pattern*

Model

The model represents the data or attributes associated with the object. For example, a player has a position in space, lives, shield strength, and score. The model usually has very few methods, possibly to do with saving or serializing data out to cheap storage like a disk drive. This would be used to save game data. However, it is more likely that you would have a save controller that would read the data from the models and store them.

View

The view is the visual representation of each of the models in the game. Some models don't have a direct visual representation in the game. For example, the data associated with an NPC (non-player character) in an RPG (role-playing game)

Controller

The controller is the glue that links the model to the view. The player interacts with the view (clicking a button, moving a player), and this calls a method on the controller. In turn, the controller updates the model to represent the new state.

In computing terms, state is the current value for an object or value. For example, in one state a player might be jumping, in another they could be running. In each state the internal variables (the object's fields) are set to particular values.

Why Use MVC?

MVC allows you, the programmer, to split the functionality of the object from its visual representation and data. With each responsibility handled by different classes, it's very easy to swap out different controllers and views.

As an illustrative example of MVC, let's create a little game that moves a robot around the screen using the cursor keys. We'll add a second view that contains a little blip in a radar view. We'll start by separating out the classes into separate files and then combine them into one game using another file as the 'glue code', in essence the main game loop. See Figure 17-2.

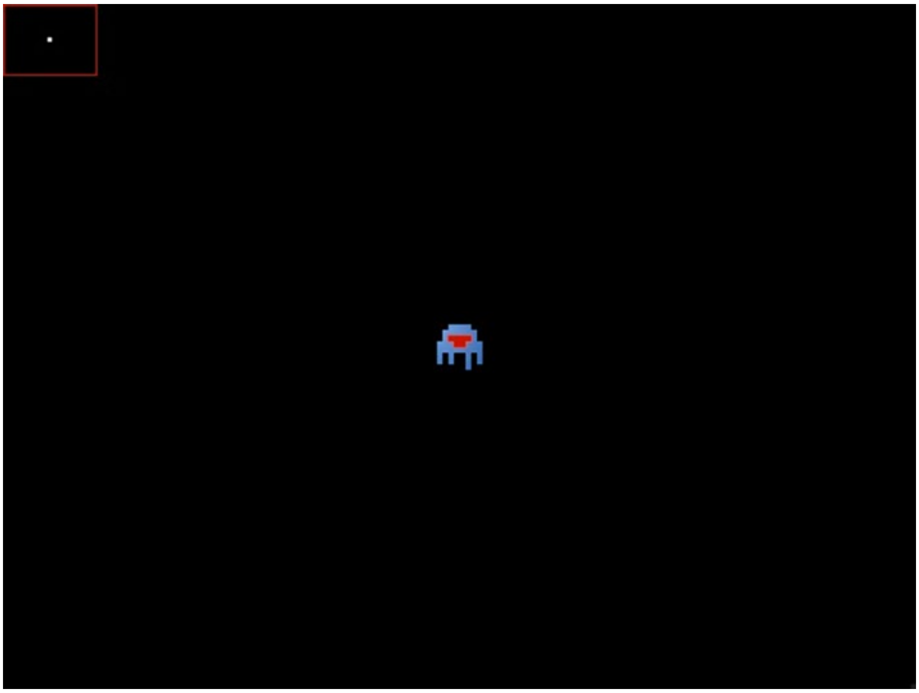


Figure 17-2. *The robot 'game' showing the robot in the middle. Radar in the top left*

The Classes

The classes we are going to create are:

- RobotModel
- RobotView
- RobotController
- RadarView

You don't need to add 'Model,' 'View,' and 'Controller' to each class that you create, but it shows us clearly in this example what class performs what purpose.

RobotModel

The robot model holds the state of the robot. It has no methods at all, just data.

RobotView

The robot view displays the robot on the screen. It does not alter the robot model; it just reads the data from the model and decides what to display based upon the state of the model.

RobotController

The robot controller alters the state of the model based upon the player's input.

RadarView

The radar view displays a small blip that represents the robot in a smaller version of the screen in the top-left corner of the window.

Folder

Create a new directory inside your scripting folder called "RobotMVC." We will create all the files inside this directory.

The Model

The model class, called RobotModel, contains just the data for the robot.

Create a new file called RobotModel.py and type in the following code. I'll be reminding you as we go about classes and methods:

```
class RobotModel(object):
```

Classes are defined with just a name. In our example, we're going to post - fix each class with its intended purpose. In reality, you might not want to do that, or it might not make sense to do so. Use your judgment on your own class names.

```
def __init__(self, x, y, speed):
```

The __init__ method (functions inside a class definition are called methods) and is a special method called a constructor. It takes three parameters for the start position of the robot and its update speed. The first parameter 'self' is required by Python and refers to the object being created.

```
self.x = x
self.y = y
self.frame = 0
self.pixelsPerSec = 200
```

As we'll see later, pixelsPerSec will be used to keep a consistent movement speed.

```
self.speed = speed
self.clock = speed
```

We'll use the 'clock' member field to update the current frame of the robot; it has a 'walking' animation.

The Robot View

The RobotView class displays the large graphic of the robot at the position in the robot's model. The graphic used by the robot contains two frames and each frame is 32x32 pixels. See Figure 17-3.

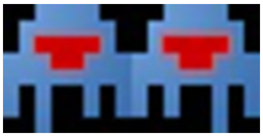


Figure 17-3. *The robot, 64x32 pixels with two 32x32 frames*

The current frame is calculated in the RobotController class, which we'll see in just a moment. In the mean time, create a new file called RobotView.py and enter the following text:

```
import pygame
from pygame.locals import *
```

We need this import for the Rect class.

```
from RobotModel import RobotModel
```

Our RobotView class uses RobotModel, so we need to import that file. However, the file name is also RobotModel.py. This causes a small issue in that we can't just do a straight import. The way around it is to use this syntax.

```
class RobotView:


    def __init__(self, imgPath):
        self.img = pygame.image.load(imgPath)

    def draw(self, surface, model):
        src = Rect(model.frame * 32, 0, 32, 32)
        surface.blit(self.img, (model.x, model.y), src)
```

We only want to show a small 32x32 portion of our image. The source area to copy to the screen is calculated using the model's frame. The model has two frames: 0 and 1. If this value is multiplied by 32, the possible rectangles are (0, 0, 32, 32) and (32, 0, 32, 32), as shown in Figure 17-4.

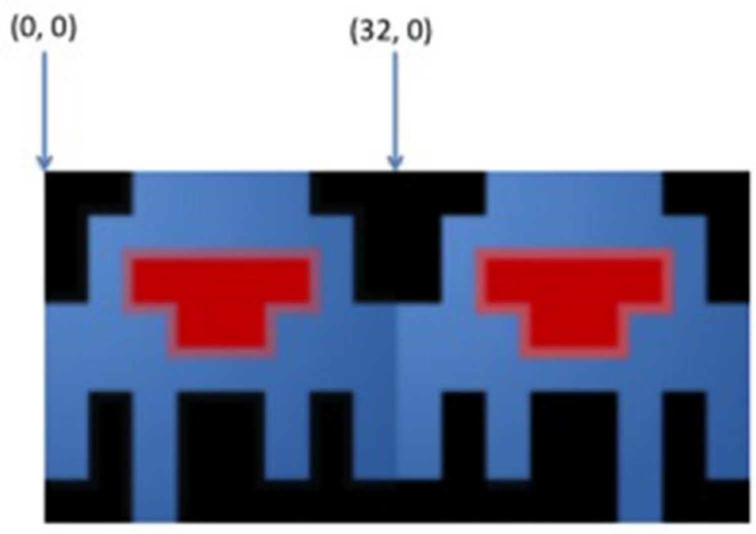


Figure 17-4. *The start coordinates of each frame of the robot's animation*

The Radar View

The radar view shows a tiny blip (3x3 pixels, white) on a radar screen. The radar screen is a 66x50 pixels image with a 1-pixel border. See Figure 17-5.

Figure 17-5. *The 66x50 radar image*

The area of the radar is actually 64x48 pixels, but it has been extended to accommodate the 1-pixel border around the outside.

Create a new file called RadarView.py and enter the following text:

```
import pygame
from pygame.locals import *
from RobotModel import RobotModel

class RadarView:

    def __init__(self, radarImagePath, blipImagePath):
        self.radarImg = pygame.image.load(radarImagePath)
        self.blipImg = pygame.image.load(blipImagePath)

    def draw(self, surface, model):
        surface.blit(self.radarImg, (0, 0))
```

The radar's border is simply copied to the screen in the top-left of the screen.

```
x = (model.x / 10.0) + 1
y = (model.y / 10.0) + 1
```

The 'blip' representing the robot is slightly trickier. We need to convert the coordinate that is a value between 0..639 on the x-axis and 0..479 on the y-axis to a value between 0..63 on the radar's x-axis and 0..47 on the radar's y-axis.

```
surface.blit(self.blipImg, (x, y))
```

The Robot Controller

The robot controller is the glue that binds the model and the view together; it uses the clock to update the current frame and it polls the keyboard to read the input from the player. It uses this input to update the player's position based upon the speed (in pixels per second) of the robot.

Create a new file called RobotController.py and type in the following code:

```
import pygame
from pygame.locals import *
from RobotModel import RobotModel
```

The robot's model RobotModel is imported from the RobotModel.py file because the controller class reads and writes values to the robot's model.

This means that the controller changes the state of the model.

```
class RobotController:
```

The RobotController doesn't require a constructor (init method) because it doesn't contain any state and therefore doesn't need to contain any attributes.

```
def update(self, deltaTime, model):
    model.clock -= deltaTime
    if (model.clock < 0):
        model.clock += model.speed
        model.frame += 1
        model.frame %= 2
```

The time difference from the last time this method was called and this time is subtracted from the 'clock' field of the model. If the 'clock' is less than zero, we switch the current frame. The frame number is clamped to a value between 0 and 1 inclusive using the modulo operator.

```
keys = pygame.key.get_pressed()
```

The currently pressed keys are read in and stored as a dictionary in the 'keys' local variable. We then use this dictionary in the 'if' statements below to determine which direction the robot is moving.

```
if (keys[K_RIGHT]):
    model.x += model.pixelsPerSec * deltaTime
elif (keys[K_LEFT]):
    model.x -= model.pixelsPerSec * deltaTime

if (keys[K_UP]):
    model.y -= model.pixelsPerSec * deltaTime
elif (keys[K_DOWN]):
    model.y += model.pixelsPerSec * deltaTime
```

The model's position is incremented by the pixels per second multiplied by the time difference from when the method was last called. This is explained in detail below.

```
if (model.x <= 0):
        model.x = 0
if (model.x >= 640 - 32):
        model.x = 640 - 32
if (model.y <= 0):
        model.y = 0
if (model.y >= 480 - 32):
        model.y = 480 - 32
```

The values on the x-axis are clamped to the screen in this series of if- statements.

Ensuring Constant Speed

We want to ensure that we have a constant speed when our objects are moving. Sometimes other routines take longer to run and we can't ensure this. For example, if we decide that our robot should move at 200 pixels per second. If we assume that our routine will get called 30 frames per second, then we should just increment the speed by 6.25 each frame. Right? Wrong!

Our robot's position should change by 200 pixels per second. If the player holds down the right cursor key, the robot should move to the right 200 pixels after one second. What happens if the update method only gets called 15 times per second? This means that our robot will only move 15 * 6.25 = 93.75 pixels in one second.

Remember in "Snake" we used the clock's tick of milliseconds to update parts of the code when we wanted them to be updated. We can use this *delta time* to calculate the distance we need to travel in a single 'tick' of the game. A tick is each time the game loops around.

This means that even with a variable frame rate, you will still have a constant speed because the *delta time* will ensure that your speed remains constant over time.

With delta time, your 15 times per second update will still result in a displacement of 200 pixels after one second of holding down the right cursor key. Why? Because with each update, we multiply the desired speed by the fraction of a second since the last call. For a 15th of a second, that's 66 milliseconds.

*0.066 * 200 = 13.2 pixels each update*

*13.2 pixels * 15 updates = 198 pixels per second*

Which is roughly the speed we want. If our frame rate increases to 60 frames per second:

60 frames per second is 16.67 milliseconds

*0.01667 * 200 = 3.333 pixels each update*

*3.333 pixels * 60 updates = 200.00 pixels per second*

You can see that with 60 frames per second, we get a much more accurate speed than at 15 frames per second. For our purposes, though, 30 frames per second is more than adequate for our needs.

The Main Robot Program

The main robot program takes all these individual classes and combines them into a single 'game' example. Create a new file called Robot.py. In this new file, add the following code:

```
import pygame, os, sys
from pygame.locals import *
```

Our more-than-familiar imports to access the PyGame library of routines and classes as well as the OS and System libraries supplied with Python.

```
from RobotModel import RobotModel
from RobotView import RobotView
from RadarView import RadarView
from RobotController import RobotController
```

These import the RobotModel, RobotView, RadarView, and RobotController from the respective files. We have to use the 'from' keyword here because the names of the classes are the same as the names of the files.

```
pygame.init()
fpsClock = pygame.time.Clock()
surface = pygame.display.set_mode((640, 480))
```

Next, we initialize PyGame and set up a clock so we can clamp our frame rate to a maximum of 30 frames per second. Our test game will be 640x480 pixels in size.

```
model = RobotModel((640 - 32) / 2, (480 - 32) / 2, .2)
view = RobotView('robotframes.png')
radarView = RadarView('radar.png', 'blip.png')
controller = RobotController()
```

This is where we create instances of our classes. The constructor arguments are passed through. We're just using hard-coded values in this example, but you could easily read in this data from a text file if you so desired.

```
while True:
    for event in pygame.event.get():
        if event.type == QUIT:
            pygame.quit()
            sys.exit()
```

Our main loop has the get-out-of-jail escape we've seen before; when the user closes the window, we quit PyGame and signal to the operating system that we're exiting the application.

```
controller.update(fpsClock.get_time() / 1000.0, model)
```

Generally, you want to update your classes before you draw their visual representations. Our controller is the only class in this example that needs an update call so that it can poll the keyboard for input and update the model appropriately.

```
surface.fill((0, 0, 0))
radarView.draw(surface, model)
view.draw(surface, model)
```

Next, the screen is cleared with black, the tuple for the fill() method is for the red, green and blue components of a color, and black is the absence of all color so all the values are zero. The radar view is drawn first and then the robot is drawn.

This is called draw order. The images that are drawn to the screen first are drawn behind images drawn later. Think of it as photographs being placed on a table. Those placed first will get obscured by those placed on top.

```
pygame.display.update()
fpsClock.tick(30)
```

Our last actions in the main game loop are to flip the front buffer to the back and vice versa and clamp the frame rate to 30 frames per second.

Save and run the game. The little robot can be moved using the cursor keys. Notice that the 'radar' view updates with the relative position of the robot.

Conclusion

The Model View Controller design pattern can be used to functionally split up an object into three separate classes. This enables you, the programmer, to decide how to combine those classes at a later date. For example, if you only want to provide keyboard support at the start of development, a new controller that allows for joystick support can be easily added at a later stage. This new addition will not impact the view or model classes.

CHAPTER 18

Sound

Sounds are played using PyGame's mixer object. Like, PyGame, you must first initialize the sound mixer before using it.

```
pygame.mixer.init()
```

Likewise, when you stop using the sound mixer, you should shut it down gracefully by calling the quit method:

```
pygame.mixer.quit()
```

The Sound class' init() method takes a single parameter, which is usually just the path to the sound file on disk. You can also pass in buffers and other things, but we'll only be passing in the path to the sound file.

```
shootSound = pygame.mixer.Sound('playershoot.wav')
```

Like every other class, calling the constructor - the init() method - passes back an instance of the class. The Sound class can load Ogg Vorbis or WAV files only. Ogg files are compressed and are therefore more suited to machines that have a tight space requirement.

Playing a Sound

Create a new Python script file called testsound.py. Enter the following code and run it to play the sound. The file playershoot.wav is available on the web site (sloankelly.net) in the Resources section. If you don't want to download that file, you can supply your own.

```
import pygame, os, sys
from pygame.locals import *
```

Import the usual modules.

```
pygame.init()
pygame.mixer.init()
```

S. Kelly, *Python, PyGame and Raspberry Pi Game Development*,
DOI 10.1007/978-1-4842-2517-2_18

Initialize PyGame and the sound mixer.

```
shootSound = pygame.mixer.Sound('playershoot.wav')
```

Load in the playershoot.wav sound file and name it shootSound.

```
shootSound.play()
```

Play the sound by calling the play() method.

```
while pygame.mixer.get_busy():
    pass
```

This is a dummy while statement to keep the program busy while the sound is playing. Remember the pass keyword? It’s like a blank statement that does nothing in Python. You can use it to create stub code for functions or, as in this case, to create blank while loops.

```
pygame.mixer.quit()
pygame.quit()
```

You must always deinitialize the mixer and PyGame. Save and run to hear the sound getting played.

CHAPTER 19

Finite State Machines

A state can be described as a particular condition of a program or entity. Finite defines that there is only a set number of states that the program or entity can be defined by.

The entity is controlled by a series of rules that determine what the next state of the program or entity is to be placed in.

Finite state machines are used in video games for Artificial Intelligence (AI) as well as menu systems and the overall game state as well.

Game State

A game is a computer program that has unique, discrete, compartmentalized states. For example: splash screen, playing the game, game over, the main menu, the options menu. Each part can be seen as a separate state.

Menu System

Menu systems used to control various aspects of the game can also be compartmentalized into separate states. For example: the main menu, display options, control options, and sound options. These are all separate states.

Non-Player Artificial Intelligence

This is the most common use of Finite State Machines (FSMs) and the one that most people associate with FSMs. At a basic level, each enemy that the player encounters has a finite state machine (FSM) attached to them. By attached, I mean that it has a reference to a Finite State Machine in the form of a member variable, like self.fsm, for example.

Enemy FSMs can run independently of each other, or there can be an overarching 'pack AI' that controls a whole series of enemies. For example, you might have ten enemies but the 'pack AI' will control how many enemies are used to attack the player, how many will 'run away', etc.

In a specific case, let's take an example of a guard. He might have two states: patrol and attack. The guard stays in the patrol state until an enemy (the player) comes within range, say 50 units, and they then move to the attack state.

FSMs are usually described using a diagram. Each block represents the state and each arrow shows the rule and the direction of transition. That is, if that rule is met, the arrow points to the state that the entity should use. See Figure 19-1.

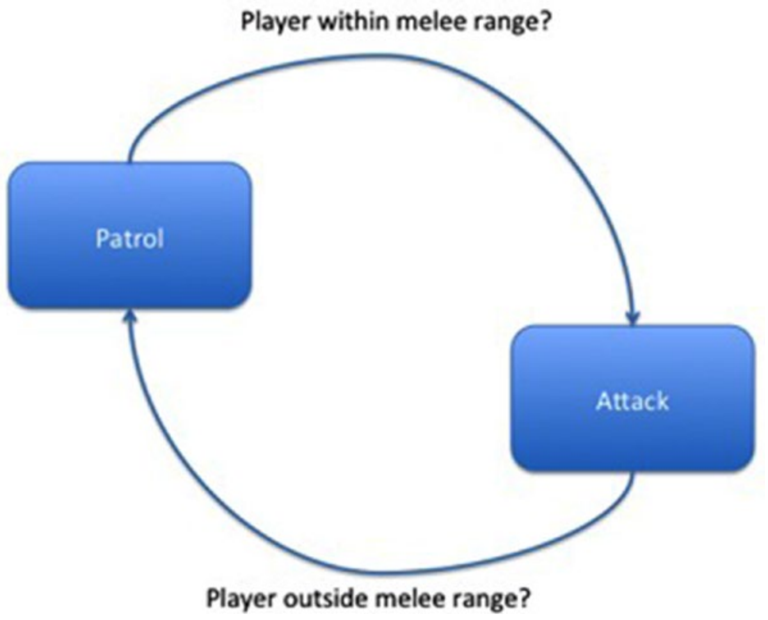


Figure 19-1. *Finite State Machine showing a simple two-state patrol / attack for an enemy AI*

If the guard is in the patrol state and the player enters the melee range, the guard will move to the attack state. This no doubt will contain code that attacks the player. Similarly, if the guard is in attack state and the player moves outside the melee range, it will transition back to the patrol state.

A Finite State Machine Example

This example shows a three-state FSM. Each state has the following methods:

- enter()
- exit()
- update()

There is a FSM manager that controls the current state of the program. This manager has two methods:

- changeState()
- update()

The changeState() method transitions the entity from one state to another, and the update() method calls the update() method of the current state.

In the following section we will create an example Finite State Machine (FSM). Create a new Python file called FSMExample.py. When it is completed you will see the following output:

```
Entering State One
Hello from StateOne!
Hello from StateOne!
Hello from StateOne!
Hello from StateOne!
Hello from StateOne!
Exiting State One
Entering State Two
Hello from StateTwo!
Hello from StateTwo!
Hello from StateTwo!
Hello from StateTwo!
Hello from StateTwo!
Exiting State Two
Entering Quit
Quitting...
```

If you don't, recheck your code.

Finite State Machine Manager

The finite machine manager class is defined below. Remember to type it (and the rest of the code!) explicitly. You can change whatever you want later, but first type in the code exactly as seen.

The FSM manager controls the current state of the entity. In our example, we're going to have three states. The first two states display "hello" messages, the latter quits the application. The transition rule is diagrammed below in Figure 19-2.

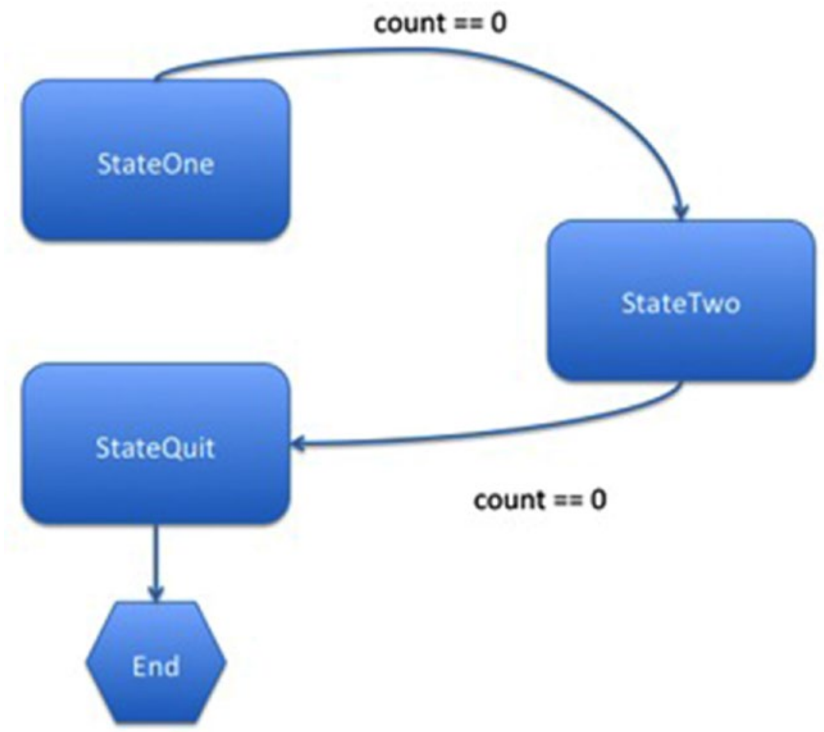


Figure 19-2. *FSM example state machine showing transitions*

StateOne transitions to StateTwo when the count reaches zero. StateTwo transitions to StateQuit when the count reaches zero. StateQuit calls Python's exit() method to quit the application.

```
class FsmManager:

    def __init__(self):
        self.currentState = None
```

The current state is set to None. We will call the changeState() method explicitly in the main part of the program below.

```
def update(self):
    if (self.currentState != None):
        self.currentState.update()
```

The update() method checks to see if we have a current state, and if so, we call the update() method of it. Notice that we're using Python's duck typing here.

```
def changeState(self, newState):
    if (self.currentState != None):
        self.currentState.exit()
```

When we change state, we want to give the current state the chance to 'shutdown' or 'clean up' before we transition to the new state. The exit() method does just that, or at least it's up to the developer who implements the state to put the code they want in the exit() method.

```
self.currentState = newState
self.currentState.enter()
```

Similarly, when we enter a new state, we need to let the state know that this event has occurred. The developer of each state will place code in the enter() method if they want to act upon that event.

```
class StateOne:
```

In general, there is very little difference between StateOne and StateTwo apart from the text messages that appear onscreen.

```
def __init__(self, fsm):
    self.count = 5
    self.fsm = fsm
    self.nextState = None
```

We will set the nextState field in the main part of the program. This is the next state that this current state will transition to. There are far more complex FSM systems that apply rules to the various states and makes for an even more flexible system. This, being a simple example, bakes the rules inside each of the states.

```
def enter(self):
    print "Entering State One"
```

The enter() method is used to set up various values for the current state. In this example, we just write a message to the screen.

```
def exit(self):
    print "Exiting State One"
```

The exit() method could be used to clean up the current state before it transitions to the new state. In this example, we show a simple message.

```
def update(self):
    print "Hello from StateOne!"
    self.count -= 1

    if (self.count == 0):
        fsm.changeState(self.nextState)
```

The update() method is called by the FSM manager. In our example, we count down until we reach zero and then transition to the next state.

```
class StateTwo:

        def __init__(self, fsm):
            self.count = 5
            self.fsm = fsm
            self.nextState = None

        def enter(self):
            print "Entering State Two"

        def exit(self):
            print "Exiting State Two"

        def update(self):
            print "Hello from StateTwo!"

            self.count -= 1
            if (self.count == 0):
                fsm.changeState(self.nextState)
class StateQuit:
```

The quit state is very simple; it just exits the application.

```
def __init__(self, fsm):
    self.fsm = fsm

def enter(self):
    print "Entering Quit"

def exit(self):
    print "Exiting Quit"

def update(self):
    print "Quitting..."
    exit()
```

We don't need to update any variables; we're just quitting the application at this point.

```
fsm = FsmManager()
stateOne = StateOne(fsm)
stateTwo = StateTwo(fsm)
quit = StateQuit(fsm)
```

Here we create our FSM manager and the states. Each state takes the FSM manager as an argument in the constructor.

```
stateOne.nextState = stateTwo
stateTwo.nextState = quit
```

The next state for stateOne and stateTwo are assigned. StateOne's next state is stateTwo and stateTwo's next state is stateQuit.

```
fsm.changeState(stateOne)
```

We set the initial state for the FSM manager to be the StateOne.

```
while True:
    fsm.update()
```

Our while loop is very simple; just call the FSM manager's update() method. That's it. Our states handle the program flow from there.

Save and run the file.

Conclusion: The Goal of FSMs

The goal of any object-oriented pattern is to make classes and main programs as small as possible. This reduces the amount of code that you have to read for a particular class, making it easier to understand. Each class should have a single purpose. Our FSM manager class has a single purpose: run the currently selected state. Each state has a single purpose too: perform certain actions until the rule changes then transition to a new state.

FSMs are perfect for Artificial Intelligence (AI) because you can design quite complex interactions based upon known criteria: Is the user within weapons range? Am I able to fire my weapon? Can the player see me? Etc., etc.

You can also use FSMs to control program state. Let's take an example of the flow of a typical game application. See Figure 19-3.

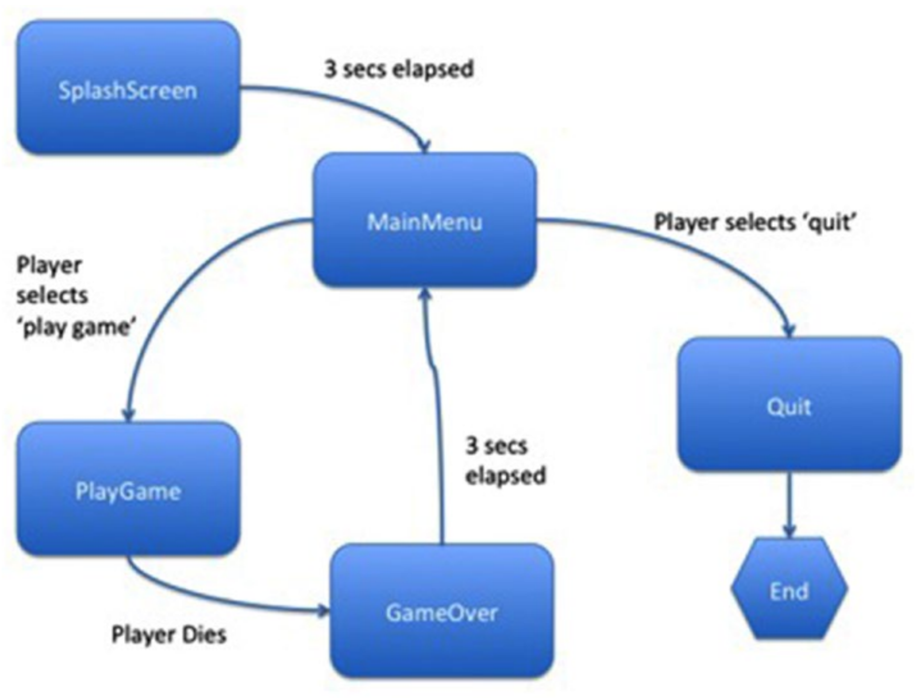


Figure 19-3. *FSM for a game*

The entry state is SplashScreen. This transitions after three seconds to the main menu. The main menu gives the user two choices: play the game or quit to the OS. If the user is playing the game and they die, the game transitions to the GameOver state. It remains in this state for three seconds and after that, the game transitions to the MainMenu state.

Our final project "Invaders" ties our Model-View-Controller (MVC) and Finite State Machine (FSM) knowledge together.

CHAPTER 20

Invaders

Our final project is Invaders and it brings together everything that we've done up until this point. We've got sounds, animation, MVC, and FSM all wrapped in one game. See Figure 20-1.

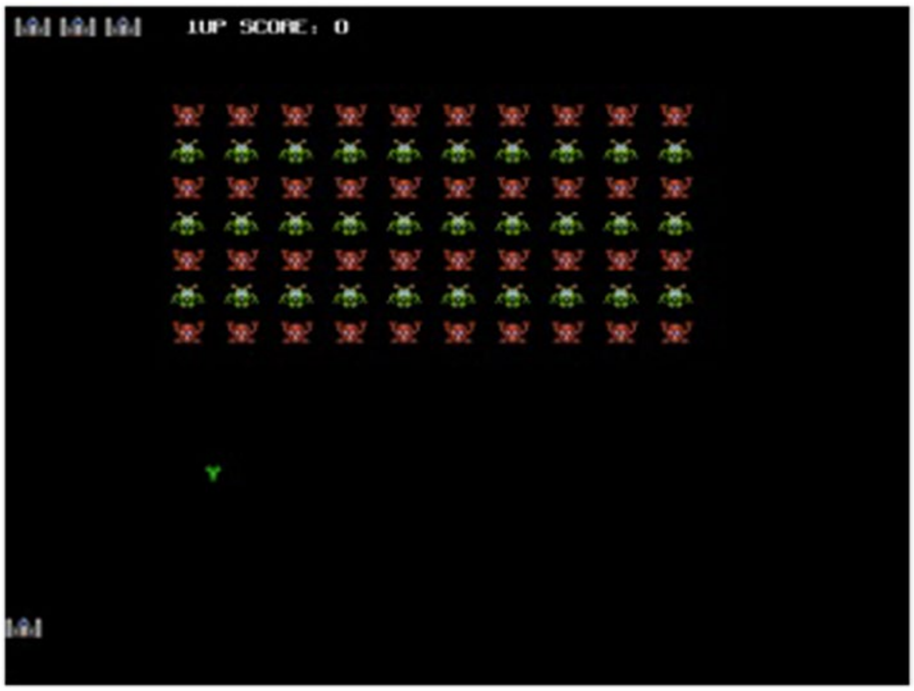


Figure 20-1. *The Invaders game in action*

Before we get started, create a new folder called Invaders. We're going to be using several files for this project, and they are:

- bitmapfont.py - for displaying a font that is actually a sprite sheet
- bullet.py - bullet classes

- collision.py - collision classes
- interstitial.py - interstitial screens. That is, the "Get Ready" and "Game Over" screens
- invaders.py - the actual runnable game. This is the ‘main’ program. It creates the framework and instantiates all the objects
- invadersgame.py - the actual ‘play game’ state class
- menu.py - menu classes player.py - player classes
- raspigame.py - base classes that you can use to extend for your own games
- swarm.py - alien swarm classes

There are three WAV files for our sound effects:

- aliendie.wav
- playerdie.wav
- playershoot.wav

We also have a number of PNG files that contain the animation frames for all the invaders, the player, the display font (we’re using a bitmap font), and the bullets:

- alienbullet.png
- bullet.png
- explosion.png
- fasttracker2-style_12x12.png
- invaders.png
- ship.png

The entire source and all the resources (the images and the sound files) can all be downloaded from sloankelly.net in the Resources section.

The Classes

The following classes will be defined as part of this project:

- BitmapFont - permits the drawing of a bitmap font on a PyGame surface.
- BulletController, BulletModel, BulletView - the MVC classes for the ‘bullet’ entities. Bullets can be ‘owned’ by a swarm of aliens or by the player.

- CollisionController - handles the collision detection for the game. This includes player / bullet and alien / bullet as well as player / alien collision detection.
- ExplosionController, ExplosionModel, ExplosionModelList, ExplosionView - the MVC classes for the 'explosion' entities. When an alien invader or the player dies, an explosion is shown in their place.
- GameState - the base class for all of the game's states.
- InterstitialState - interstitial screens are used in video games to display "Game Over" or "Get Ready" messages. This is a 'state of being' for the program; therefore InterstitialState is derived from a state base class called 'GameState'.
- InvaderModel, SwarmController, InvaderView - The alien invader swarm's MVC classes. There is no individual controller for each alien; instead the 'SwarmController' updates the position of each alien and determines which one is firing on the player.
- PlayGameState - play game state.
- MainMenuState - main menu state.
- PlayerController, PlayerLivesView, PlayerModel, PlayerView - The 'player' entity's MVC classes.
- RaspberryPiGame - contains the main update loop that we've seen in our previous programs. This is effectively the Finite State Manager.

The Finite State Machine

The game is controlled using a *finite state machine* (FSM). The diagram (Figure 20-2) below shows the distinct states and how the game transitions between them.

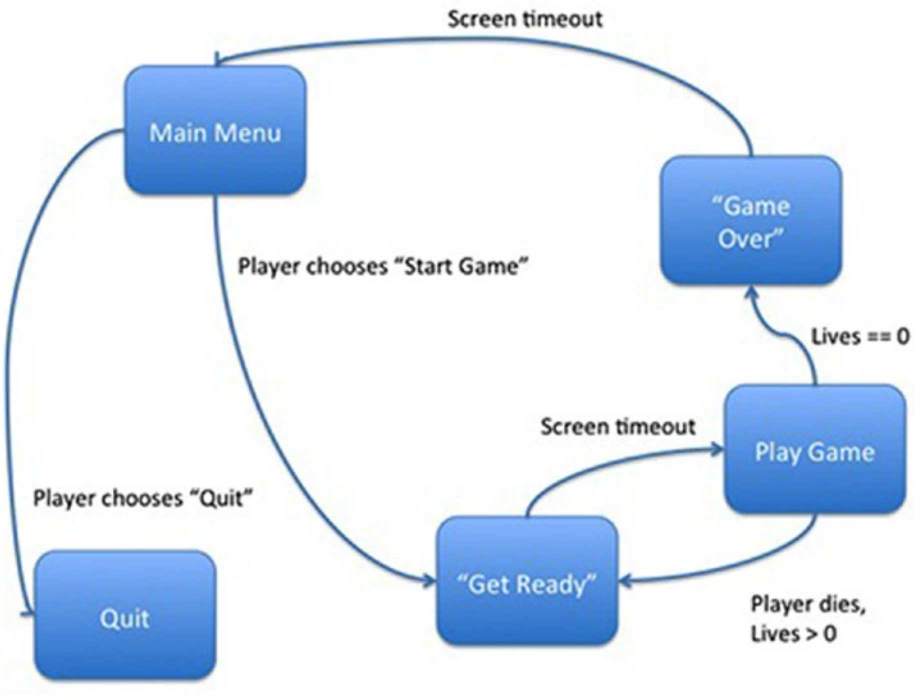


Figure 20-2. *The 'Invaders' game Finite State Machine*

The game starts with the main menu state and ends with the 'quit' game state. The 'quit' game state isn't really a state, as you will see; it's actually the *absence* of state; we set the current state of the game to 'None' and the code handles this by neatly quitting the program. In our implementation, the base class for each state is defined as 'GameState'.

MVC and 'Invaders'

Each entity (the player, alien swarm, alien) has a corresponding model, view, and controller class. For the alien invaders, the controller actually controls more than one alien entity.

The Framework

The basic state class and state machine manager are defined in a file called raspigame.py. Create this file and type in the code below:

```
import pygame, os, sys
from pygame.locals import *
class GameState(object):
```

The game state class defines an interface that is used by the RaspberryPiGame class. Each state manages a particular function of the game. For example: main menu, the actual game play, and interstitial screens. The GameState class uses the new format for class definition. Each class that uses the new format must extend from the object. In Python, extending a class means that you place the name of the base class in parentheses after the class name.

```
def __init__(self, game):
    self.game = game
```

Initialize the Game state class. Each subtype must call this method. Take one parameter, which is the game instance.

```
def onEnter(self, previousState):
    pass
```

The base class 'GameState' does not contain any code for onEnter(). Classes that extend 'GameState' are expected to provide their own definition. This method is called by the game when entering the state for the first time.

```
def onExit(self):
    pass
```

The base class 'GameState' does not contain any code for onExit(). Classes that extend 'GameState' are expected to provide their own definition. This method is called by the game when leaving the state.

```
def update(self, gameTime):
    pass
```

The base class 'GameState' does not contain any code for update(). Classes that extend 'GameState' are expected to provide their own definition. This method is called by the game allowing the state to update itself. The game time (in milliseconds) is the time since the last call to this method.

```
def draw(self, surface):
    pass
```

The base class 'GameState' does not contain any code for draw(). Classes that extend 'GameState' are expected to provide their own definition. This method is called by the game, allowing the state to draw itself. The surface that is passed is the current drawing surface.

```
class RaspberryPiGame(object):
```

Basic game object-oriented framework for the Raspberry Pi. Users create ‘states’ that alter what is being displayed onscreen / updated at any particular time. This is really just a glorified state manager.

```
def __init__(self, gameName, width, height):

    pygame.init()
    pygame.display.set_caption(gameName);

    self.fpsClock = pygame.time.Clock()
    self.mainwindow = pygame.display.set_mode((width, height))
    self.background = pygame.Color(0, 0, 0)
    self.currentState = None

def changeState(self, newState):
    if ( self.currentState != None ):
        self.currentState.onExit()
    if ( newState == None ):

        pygame.quit()
        sys.exit()
    oldState = self.currentState
    self.currentState = newState
    newState.onEnter(oldState)
```

This method transitions from one state to another. If there is an existing state, the state’s onExit() method is called. This will clean up the current state and perform any tasks that the state needs to do when exiting. The new state’s onEnter method is called unless newState is ‘None’. If the newState is ‘None’ then the game will terminate.

Our main game loop, which we’ve seen several times before, has been moved to the run() method. This handles all the event management, state update, and display.

```
def run(self, initialState):

    self.changeState( initialState )

    while True:
        for event in pygame.event.get():
            if event.type == QUIT:
                pygame.quit()
                sys.exit()

            gameTime = self.fpsClock.get_time()

            if ( self.currentState != None ):
                self.currentState.update( gameTime )
                self.mainwindow.fill(self.background)
                if ( self.currentState != None ):
                    self.currentState.draw (self.mainwindow)
                pygame.display.update()
                self.fpsClock.tick(30)
```

Save the file.

Bitmap Font

Before we can test the player's tank and bullets, we must first define the bitmap font class. A normal font contains a mathematical representation of each of the characters. A bitmap font provides a sprite sheet that contains all the individual characters that make up the font. We then use PyGame's built-in functionality to 'cut up' the sprite sheet into those individual characters. See Figure 20-3.

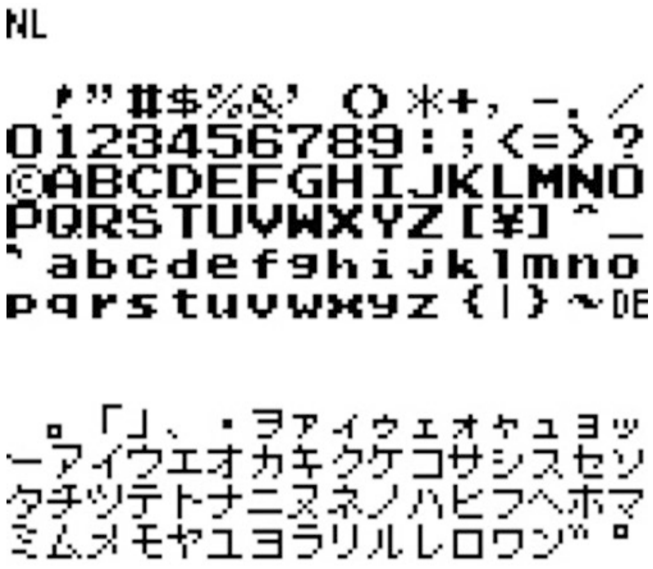


Figure 20-3. *Example of a bitmap font taken from* `http://noragames.com/free/graphics?lang=en`

Thanks to Nora Games for the sample bitmap font used in this example. As you can see from the above image, each letter of the alphabet and the symbols are displayed in a grid. They are arranged in the order that they appear in the ASCII (American Standard Code for Information Interchange) character set. The first printable character is space, which ironically prints a blank space. Space is the 33rd character in the ASCII character set, and because we start numbering at zero, this makes space ASCII 32.

Cutting Up the Image

To access the exclamation mark beside the space, ASCII 33, we use some modulo and division trickery to calculate the row and column of the character.

The row is calculated by taking the ASCII value of the character (in this case 33) and dividing it by the number of columns:

33 / 16 = 2

The column is calculated by taking the ASCII value of the character and modding it with the number of columns:

33 mod 16 = 1

So, our character (!) is located at row 2, column 1. We then multiply those values by the number of pixels in each cell. Our characters are generated from an 8x8 grid, so we multiply each value by 8:

*2 * 8 = 16*

*1 * 8 = 8*

The starting x- and y- coordinates of the start of the 8x8 grid that makes up the exclamation character is (8, 16) as shown in Figure 20-4 below.

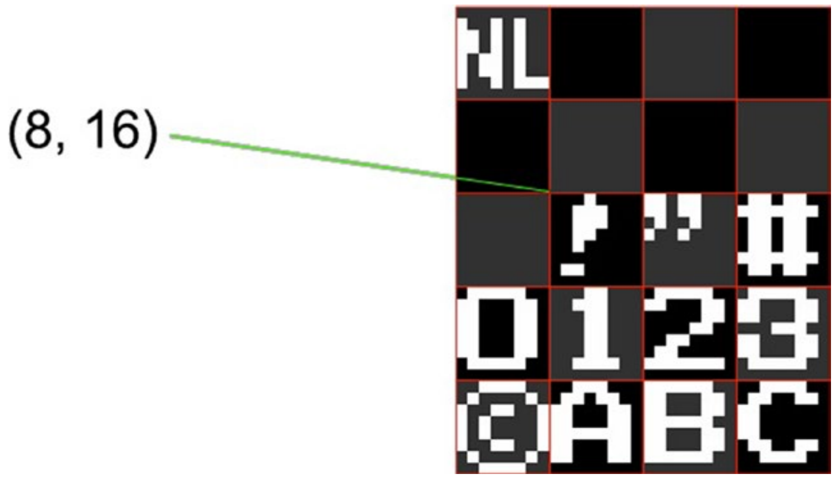


Figure 20-4. *Close-up of the bitmap font showing the pixel start position of the 8x8 grid for the exclamation mark character*

In the ‘Invaders’ game, bitmap font display is handed by the BitmapFont class. We’ll define that class now. Create a new file and call it bitmapfont.py. Enter the code below and save the file.

There is a little twist to this though. The font included with the 'Invaders' project doesn't have the first non-printable 32 characters. It starts with the space character. This is not really an issue, but it adds an extra step to move the characters down 32 positions. Take note of the toIndex() method.

```
import pygame, os, sys
from pygame.locals import *

class BitmapFont:

    def __init__(self, fontFile, width, height):
        self.image = pygame.image.load(fontFile)
        self.cellWidth = width
        self.cellHeight = height
        width = self.image.get_rect().width
        height = self.image.get_rect().height
        self.cols = width / self.cellWidth
        self.rows = height / self.cellHeight
```

The constructor loads the file and based upon the width and height of each character, it calculates the number of columns and rows for the character table.

```
def draw(self, surface, msg, x, y):
    for c in msg:
        ch = self.toIndex(c)
        ox = ( ch % self.cols ) * self.cellWidth
        oy = ( ch / self.cols ) * self.cellHeight
```

This is the part of the code that calculates the x- and y- offset into the bitmap for the current character in the message.

```
        cw = self.cellWidth
        ch = self.cellHeight
        sourceRect = (ox, oy, cw, ch)
        surface.blit(self.image, (x, y, cw, ch), sourceRect)
        x += self.cellWidth
def centre(self, surface, msg, y):
    width = len(msg) * self.cellWidth
    halfWidth = surface.get_rect().width
    x = (halfWidth - width) / 2
    self.draw(surface, msg, x, y)
```

The centre() method calculates the overall width of the message and centres it on the line.

```
def toIndex(self, char):
    return ord(char) - ord(' ')
```

The bitmap font that we use for 'Invaders' starts at space (ASCII 32). We use the ord() function that Python provides to get the ASCII value of the character. Subtracting the ASCII value for space gives us our index value into the bitmap font.

Interstitial Screens

Interstitial screens are the images that are displayed in between levels ("Get Ready!") when the pause screen is shown or when the player dies, that is, the "Game Over" screen appears. Create a new file called interstitial.py and type in the following code:

```
import pygame, os, sys
from pygame.locals import *
from bitmapfont import *
from raspigame import *

class InterstitialState(GameState):
```

Our InterstitialState class extends GameState. Remember: if we extend from a class, we place that parent (or *base*) class' name in parentheses after the name of the class.

```
def __init__(self, game, msg, waitTimeMs, nextState):
    super(InterstitialState, self).__init__(game)
```

The base class' constructor must be called. Under Python, the child class name and the child class instance 'self' must be passed to the super() method. Python 3.0 'fixes' this by way of 'syntactic sugar' and just allowing you to call super(). Not so with the version of Python that ships with the Raspberry Pi.

We must also call the constructor directly; that's why the call is to the __init__() method. The base class' constructor expects an instance of RaspiGame, so this is duly passed to the base class' constructor.

```
    self.nextState = nextState
    self.font = BitmapFont('fasttracker2-style_12x12.png', 12, 12)
    self.message = msg
    self.waitTimer = waitTimeMs
def update(self, gameTime):
    self.waitTimer -= gameTime
    if ( self.waitTimer < 0 ):
        self.game.changeState(self.nextState)
```

The update method waits until the timer runs down. When the timer reaches zero, the game is told to move to the next state.

```
def draw(self, surface):
    self.font.centre(surface, self.message, surface.get_rect().height / 2)
```

Save the file.

The Main Menu

The main menu contains two items:

- Start game
- Quit

Like the interstitial screen, the main menu is a subclass of GameState. Create a new file called menu.py and enter the following code:

```
import pygame, os, sys
from pygame.locals import *

from raspigame import *
from bitmapfont import *
```

Our main menu state uses the bitmap font class to draw the text on screen and the *raspigame* file is imported because MainMenuState is a subclass of GameState. GameState is defined in the *raspigame.py* file.

```
class MainMenuState(GameState):
    def __init__(self, game):
        super(MainMenuState, self).__init__(game)
        self.playGameState = None
        self.font = BitmapFont('fasttracker2-style_12x12.png', 12, 12)
        self.index = 0
        self.inputTick = 0
        self.menuItems = ['Start Game', 'Quit']
```

The currently selected item is stored in 'index,' and the menu items are contained in the 'menuItems' list.

```
def setPlayState(self, state):
    self.playGameState = state

def update(self, gameTime):
    keys = pygame.key.get_pressed()
    if ( (keys[K_UP] or keys[K_DOWN]) and self.inputTick == 0):
        self.inputTick = 250

        if ( keys[K_UP] ):
            self.index -= 1
            if (self.index < 0):
                self.index = len(self.menuItems) -1
        elif ( keys[K_DOWN] ):
            self.index += 1
            if (self.index == len(self.menuItems)):
                self.index = 0
```

The user presses the up and down arrow keys to select a menu item. To prevent the menu selection from spinning out of control, the updates are clamped to four per second (250 milliseconds).

```
elif ( self.inputTick >0 ):
    self.inputTick -= gameTime

if ( self.inputTick < 0 ):
    self.inputTick = 0
```

The selection is prevented from spinning by updating the inputTick control variable. Once it reaches zero, input is allowed again.

```
if ( keys[K_SPACE] ):
    if (self.index == 1):
        self.game.changeState(None) # exit the game
    elif (self.index == 0):
        self.game.changeState(self.playGameState)
```

When the user presses the spacebar, the current selected index is tested. If the user chose the zeroth element, the game changes to the playGameState. If the user chooses the first element, the game exits.

```
def draw(self, surface):
    self.font.centre(surface, "Invaders! From Space!", 48)
    count = 0
    y = surface.get_rect().height - len(self.menuItems) * 160

    for item in self.menuItems:
        itemText = " "

        if ( count == self.index ):
            itemText = "> "

        itemText += item
        self.font.draw(surface, itemText, 25, y)

        y += 24
        count += 1
```

Each menu item is drawn onscreen. The selected menu item is prefixed with a '>' character to indicate to the player that the item has been selected.

Save the file.

Player and Bullets

The bullet classes deal with the position and collection of bullets that have been fired. Like all the entities in this game, the bullets are split into separate model, view, and controller classes. MVC plays a big part in this game!

The Bullet Classes

Create a new Python file in the Invaders folder and call it bullet.py. Enter the text as shown below:

```
import pygame, os, sys
from pygame.locals import *

class BulletModel:
```

Our bullet model is super simple. It is a class that contains an x- and y- coordinate representing the bullet's position in 2D space. It has one method, and only one method called update() that takes a single delta value. This is added to the y- coordinate of the bullet's position.

```
    def __init__(self, x, y):
        self.x = x
        self.y = y

    def update(self, delta):
        self.y = self.y + delta

class BulletController:
```

The bullet controller contains a list of bullets. Each bullet is updated each time the update() method is called.

```
def __init__(self, speed):
    self.countdown = 0
    self.bullets = []
    self.speed = speed

def clear(self):
    self.bullets[:] = []

def canFire(self):
    return self.countdown == 0 and len(self.bullets) < 3
```

The player can only fire if the countdown has expired and there are less than three active bullets.

```
def addBullet(self, x, y):
    self.bullets.append(BulletModel(x, y))
    self.countdown = 1000
```

A bullet is added to the system and the countdown is reset to one second (1000 milliseconds). When the countdown reaches zero, the player can fire again. The countdown field is updated in the update() method.

```
def removeBullet(self, bullet):
    self.bullets.remove(bullet)
```

Bullets are removed from the list when they have either killed an alien or they pop off the top of the screen.

```
def update(self, gameTime):
    killList = []
```

The killList holds bullets that will be removed in this update. Bullets that pop off the top of the screen are removed from the list.

```
if (self.countdown > 0):
    self.countdown = self.countdown - gameTime
else:
    self.countdown = 0
```

The gameTime (in milliseconds) is subtracted from the countdown field.
When the countdown field reaches zero, the player can fire again.

```
for b in self.bullets:
    b.update( self.speed * ( gameTime / 1000.0 ) )

    if (b.y < 0):
        killList.append(b)
```

Each bullet is updated. If their y- coordinate is less than zero (the bullet has popped off the top of the screen), then it is marked for removal.

```
for b in killList:
    self.removeBullet(b)
```

Our final bullet class is the view. This takes all the data from the bullet controller and displays each bullet onscreen.

```
class BulletView:
    def __init__(self, bulletController, imgpath):
        self.BulletController = bulletController
        self.image = pygame.image.load(imgpath)

    def render(self, surface):
        for b in self.BulletController.bullets:
            surface.blit(self.image, (b.x, b.y, 8, 8))
```

Save the file.

The Player Classes

Create a new file called player.py and enter the following code. The MVC components of the player entity are contained in this one file.

```
import pygame, os, sys
from pygame.locals import *

from bullet import *
from bitmapfont import *

class PlayerModel:

    def __init__(self, x, y):
        self.x = x
        self.y = y
        self.lives = 3
        self.score = 0
        self.speed = 100 # pixels per second
```

The player model contains all the data for the player entity: its position onscreen in the form of x- and y- coordinates, the number of lives, the player's score, and their movement speed in pixels per second. Remember: by using pixels per second we can ensure that no matter the speed of the machine, we get a consistent movement speed.

```
class PlayerController:

    def __init__(self, x, y):
        self.model = PlayerModel(x, y)
        self.isPaused = False
        self.bullets = BulletController(-200) # pixels per sec
        self.shootSound = pygame.mixer.Sound('playershoot.wav')
```

The constructor creates an instance of the player model and a BulletController. The bullet controller takes in a single parameter representing the movement speed in pixels per second. It is a negative value because we are going ‘up’ the screen, which is tending to zero. Why? Well, remember that in computing, the top left of the screen is position (0, 0) and the bottom-right corner is the maximum value on the x- and y- axes.

```
def pause(self, isPaused):
    self.isPaused = isPaused

def update(self, gameTime):
    self.bullets.update(gameTime)

    if ( self.isPaused ):
        return

    keys = pygame.key.get_pressed()

    if (keys[K_RIGHT] and self.model.x < 800 - 32):
        self.model.x += ( gameTime/1000.0 ) * self.model.speed
    elif (keys[K_LEFT] and self.model.x > 0):
        self.model.x -= ( gameTime/1000.0 ) * self.model.speed
```

The player can move left and right using the cursor (arrow) keys on the keyboard. The position is updated by a percentage of the movement speed based upon the game time. This allows us to have smooth movement no matter the speed of the CPU or our frame rate.

```
if (keys[K_SPACE] and self.bullets.canFire()):
    x = self.model.x + 9 # bullet is 8 pixels
    y = self.model.y - 16

    self.bullets.addBullet(x, y)
    self.shootSound.play()
```

When the player hits the space bar, a bullet is added to the current list of bullets and we play the bullet shooting sound. The firing is restricted by the canFire() method of the ‘BulletController’ class.

```
def hit(self, x, y, width, height):
    return (x >= self.model.x and y >= self.model.y and x + width <= self.
    model.x + 32 and y + height <= self.model.y + 32)
```

This method allows us to test collisions against any other object by boiling the object down to its purest form: its position in space and its width and height.

There are two view classes for the player: PlayerView displays the player’s tank at the bottom of the screen, and PlayerLivesView displays the number of lives the player has left.

```
class PlayerView:
    def __init__(self, player, imgpath):
        self.player = player
        self.image = pygame.image.load(imgpath)
    def render(self, surface):
        surface.blit(self.image, (self.player.model.x, self.player.model.y,
        32, 32))
```

The PlayerView class has one main method called ‘render’. This displays the tank at the player’s position. The player model is passed into the view.

```
class PlayerLivesView:

    def __init__(self, player, imgpath):
        self.player = player
        self.image = pygame.image.load(imgpath)
        self.font = BitmapFont('fasttracker2-style_12x12.png', 12, 12)
```

The constructor takes two arguments: the player model and a string that represents the image path to a bitmap font.

```
def render(self, surface):
    x = 8

    for life in range(0, self.player.model.lives):
        surface.blit(self.image, (x, 8, 32, 32))
        x += 40
    self.font.draw(surface, '1UP SCORE: ' + str(self.player.model.score),
    160, 12)
```

The render method draws the ship image ‘lives’ number of times and then displays the player’s score as ‘1UP SCORE: 00000’.

Testing Player

We can test the Player classes by adding the following code to the player.py file. This part is optional, but it gives a clear example that classes can be tested in isolation from the main program. If you don’t want to add this, you can just save the file and move to the next section.

```
if ( __name__ == '__main__'):
```

Each Python file is given a name at runtime. If this is the main file, that is, this is the file that is run, it is given the special name ‘ main ’. If that is the case we will initialize PyGame and create our code to test our classes.

```
pygame.init()
fpsClock = pygame.time.Clock()
surface = pygame.display.set_mode((800, 600))
pygame.display.set_caption('Player Test')
black = pygame.Color(0, 0, 0)
```

```
player = PlayerController(0, 400)
playerView = PlayerView(player, 'ship.png')
playerLivesView = PlayerLivesView(player, 'ship.png')
```

Create one each of controller, view, and lives view for our Player.

```
while True:
    for event in pygame.event.get():
        if event.type == QUIT:
            pygame.quit()
            sys.exit()
    player.update(fpsClock.get_time())
    surface.fill(black)
    playerView.render(surface)
    playerLivesView.render(surface)

    pygame.display.update()
    fpsClock.tick(30)
```

Our main loop checks to see if 'QUIT' has been selected by the user (i.e., they closed the window), if not then the update() method is called and each display is rendered. Save the 'player.py' file.

The Alien Swarm Classes

Create a new Python file called 'swarm.py'. We will implement the following classes in this file:

- InvaderModel
- SwarmController
- InvaderView

```
import pygame, os, sys
from pygame.locals import *

from bullet import *
```

The PyGame libraries need to be referenced for image manipulation. The alien swarm also uses bullets, so we need to import the 'bullet.py' file too. Our InvaderModel contains minimal code; it is mostly just data that is used to describe the alien to the AlienView.

There are two frames of animation for each type of alien, and there are also two alien types.

```
class InvaderModel:

    def __init__(self, x, y, alientype):
        self.x = x
        self.y = y
        self.alientype = alientype
        self.animframe = 0
```

The constructor takes three arguments, not including 'self'. The first two are the starting coordinates of the alien, and the last one is the alien type. There are two alien types: one red and one green. They score differently when hit which is why we need to store what type of alien this model represents.

```
def flipframe(self):
    if self.animframe == 0:
        self.animframe = 1
    else:
        self.animframe = 0
```

The flipframe() method toggles the current frame of animation from 0 to 1 back to zero again. The aliens only have two frames of animation.

```
def hit(self, x, y, width, height):
    return (x >= self.x and y >= self.y and x + width <= self.x + 32 and
    y + height <= self.y + 32)
```

The last line in the hit() method is all on one line. The hit() method is used by the Collision class to determine if a hit has occurred.

The SwarmController class is actually the *controller* for the multiple aliens. It uses *composition* because each individual alien is created and destroyed by the Swarm class.

```
class SwarmController:
    def __init__(self, scrwidth, offsety, initialframeticks):
        self.currentframecount = initialframeticks
        self.framecount = initialframeticks
```

The current animation frame is controlled from here. This ensures that each alien 'marches' in time with the other aliens.

```
self.invaders = []
self.sx = -8
self.movedown = False
self.alienslanded = False
```

The current alien direction is set to a negative (left) direction. The 'movedown' flag is set when the aliens have to move down the screen when they hit a side. The final flag 'alienslanded' means that it's game over for the player when this is True.

```
self.bullets = BulletController(200) # pixels per sec
```

The BulletController class is also part of the SwarmController. The pixels per second value for bullet speed is positive because we are going down the screen. Remember that for the player, it was negative because the player's bullets go up screen.

```
self.alienShooter = 3 # each 3rd alien (to start with)
self.bulletDropTime = 2500
self.shootTimer = self.bulletDropTime # each bullet is fired in this ms
interval
self.currentShooter = 0 # current shooting alien

for y in range(7):
    for x in range(10):
        invader = InvaderModel(160 + (x * 48) + 8, (y * 32) + offsety, y % 2)
        self.invaders.append(invader)
```

The nested for-loop is used to generate the alien swarm. Each swarm member is an instance of the InvaderModel class.

```
def reset(self, offsety, ticks):
    self.currentframecount = ticks
    self.framecount = ticks

    for y in range(7):
        for x in range(10):
            invader = InvaderModel(160 + (x * 48) + 8, (y * 32) + offsety,
            y % 2)
            self.invaders.append(invader)
```

The 'reset' method is used reset the alien swarm for the next attack, speeding up their descent.

```
def update(self, gameTime):
    self.bullets.update(gameTime)
    self.framecount -= gameTime
    movesideways = True
```

The 'framecount' member field is used as a timer. The gameTime is subtracted from the current time in 'framecount', and when it reaches zero, we 'tick' the swarm. This is how we control the update speed of our objects. We can specify different 'tick' times. The smaller the 'framecount', the quicker the update occurs because we have to subtract less time.

```
if self.framecount < 0:
    if self.movedown:
        self.movedown = False
        movesideways = False

        self.sx *= -1
        self.bulletDropTime -= 250

        if ( self.bulletDropTime < 1000 ):
            self.bulletDropTime = 1000

        self.currentframecount -= 100
        if self.currentframecount < 200: #clamp the speed of the aliens to
        200ms
            self.currentframecount = 200

        for i in self.invaders:
            i.y += 32
```

If we have to move down, the section of code under 'if self.movedown' provides the steps required to move the alien swarm down the screen. When the swarm moves down screen, the 'currentframecount' is updated. This is because the aliens speed up each time they drop further toward the player.

```
self.framecount = self.currentframecount + self.framecount
for i in self.invaders:
    i.flipframe()
if movesideways:
    for i in self.invaders:
        i.x += self.sx
x, y, width, height = self.getarea()
if (x <= 0 and self.sx < 0) or (x + width >= 800 and self.sx > 0):
    self.movedown = True
```

The getarea() method determines the area used by all the aliens left on the playing field. We then use this information to determine if that area has 'hit' the sides. If the area hit the sides, we mark the swarm to move down the next tick.

```
self.shootTimer -= gameTime
if ( self.shootTimer <= 0):
    self.shootTimer += self.bulletDropTime # reset the timer
    self.currentShooter += self.alienShooter
    self.currentShooter = self.currentShooter % len(self.invaders)
    shooter = self.invaders[self.currentShooter]
    x = shooter.x + 9 # bullet is 8 pixels
    y = shooter.y + 16
    self.bullets.addBullet(x, y)
```

The shooting timer works on a different 'tick' than the frame update. When the timer reaches zero, the current shooter is incremented by 'alienShooter'; this is why it's not part of the main swarm tick.

The 'currentShooter' field is clamped to the number of aliens we have left. This ensures that we don't ever try and access an alien outside our list. The current shooter is then referenced and we add a bullet at the shooter's position. I chose 3 (three) as the incrementor because it gave a pseudo-random feel to the shooting.

```
def getarea(self):
    leftmost = 2000
    rightmost = -2000
    topmost = -2000
    bottommost = 2000
```

Setting up the maximum and minimum boundaries.

```
for i in self.invaders:
    if i.x < leftmost:
        leftmost = i.x

    if i.x > rightmost:
        rightmost = i.x

    if i.y < bottommost:
        bottommost = i.y

    if i.y > topmost:
        topmost = i.y
```

Using some simple range checking, we calculate the leftmost, rightmost, topmost, and bottommost points from all of the aliens.

```
width = ( rightmost - leftmost ) + 32
height = ( topmost - bottommost ) + 32

return (leftmost, bottommost, width, height)
```

Our final Invader class is the view class. It uses *aggregation* because it references the SwarmController class.

```
class InvaderView:

    def __init__(self, swarm, imgpath):
        self.image = pygame.image.load(imgpath)
        self.swarm = swarm
```

The constructor takes in two arguments. The first is the SwarmController instance, and the second is the path to the image file that represents our alien sprites.

```
def render(self, surface):
    for i in self.swarm.invaders:
        surface.blit(self.image, (i.x, i.y, 32, 32), (i.animframe * 32, 32 *
        i.alientype, 32, 32))
```

The ‘render’ method loops through all the invaders in SwarmController’s ‘swarm’ field and displays it onscreen. The ‘animframe’ field of the Invader model is used to control how far to the left the slice is taken of the sprite sheet. The ‘alientype’ field is how far up the slice is.

Save the file. We’re going to need this and the other files for collision detection.

Collision Detection

Our collision detection classes are stored in the ‘collision.py’ file. Create a new blank file and call it *collision.py*. This will hold the following classes:

- ExplosionModel
- ExplosionModelList
- ExplosionView
- ExplosionController
- CollisionController

We will examine each in the order that they appear in the file.

Explosions

Action games require loud noises and explosions. Our game is no different! The four explosion classes - ExplosionModel, ExplosionModelList, ExplosionView, and ExplosionController are used by the CollisionController to create and update the various explosions that occur throughout the game. Each explosion is drawn onscreen using a sprite sheet that consists of a series of animation frames.

Our file starts in the familiar way with a series of imports:

```
import pygame, os, sys
from pygame.locals import *

from player import *
from bullet import *
from swarm import *
from interstitial import *
```

Our own classes from player, bullet, swarm, and interstitial are required.

```
class ExplosionModel:

    def __init__(self, x, y, maxFrames, speed, nextState = None):
        self.x = x
        self.y = y
        self.maxFrames = maxFrames
        self.speed = speed
        self.initialSpeed = speed
        self.frame = 0
        self.nextState = nextState
```

The ‘ExplosionModel’ class contains no methods, much like all our other models. It only contains fields that describe an explosion; it’s position, the number of frames, the update speed, the current frame, and the next state.

```
class ExplosionModelList:

    def __init__(self, game):
        self.explosions = []
        self.game = game

    def add(self, explosion, nextState = None):
        x, y, frames, speed = explosion
        exp = ExplosionModel(x, y, frames, speed, nextState)
        self.explosions.append(exp)

    def cleanUp(self):
        killList = []
        for e in self.explosions:
            if ( e.frame == e.maxFrames ):
                killList.append(e)
        nextState = None

        for e in killList:
            if (nextState == None and e.nextState != None):
                nextState = e.nextState

            self.explosions.remove(e)

        if (nextState != None):
            self.game.changeState(nextState)
```

The cleanUp() method needs a little explanation. With this mechanism, we can encode in our explosion the ability to move the game to another state. For example, when the player dies and they have no more lives, we can change the state of the game to ‘Game Over.’

```
class ExplosionView:

    def __init__(self, explosions, explosionImg, width, height):
        self.image = pygame.image.load(explosionImg)
        self.image.set_colorkey((255, 0, 255))
        self.explosions = explosions
        self.width = width
        self.height = height
    def render(self, surface):
        for e in self.explosions:
            surface.blit(self.image, ( e.x, e.y, self.width, self.height ),
            (e.frame * self.width, 0, self.width, self.height) )
```

The 'ExplosionView' loops through all the explosions and displays each one of them in turn.

```
class ExplosionController:


    def __init__(self, game):
        self.list = ExplosionModelList(game)

    def update(self, gameTime):
        for e in self.list.explosions:
            e.speed -= gameTime
            if ( e.speed < 0 ):
                e.speed += e.initialSpeed
                e.frame += 1
        self.list.cleanUp()
```

The ‘ExplosionController’ is the simplest controller we’ve encountered. It has an initialization method that creates an ‘ExplosionModelList’ (an example of composition) and an update() method. The update() method only needs to increment the frame count. When the count reaches the maximum frame count, it is automatically removed in the cleanUp() method of the ‘ExplosionModelList’ class.

Collision Controller

The ‘CollisionController’ class doesn’t need a corresponding model or view because it does not require either. It does use other controllers and models to determine if a collision has occurred. If something was hit, a suitable sound is made and an action is performed.

```
class CollisionController:
    def __init__(self, game, swarm, player, explosionController, playState):
        self.swarm = swarm
        self.player = player
        self.game = game
        self.BulletController = player.bullets
        self.EnemyBullets = swarm.bullets
        self.expCtrl = explosionController
        self.playGameState = playState
        self.alienDeadSound = pygame.mixer.Sound('aliendie.wav')
        self.playerDie = pygame.mixer.Sound('playerdie.wav')
```

The constructor for 'CollisionController’ takes in the game, swarm controller, player controller, explosion controller instances, and the play game state. We also load a couple of sounds for when the player hits an alien (‘aliendie.wav’) or if an alien unfortunately hits the player (‘playerdie.wav’).

```
def update(self, gameTime):

    aliens = []
    bullets = []

    for b in self.BulletController.bullets:

        if (bullets.count(b)>0):
            continue

        for inv in self.swarm.invaders:
            if (inv.hit(b.x+3, b.y+3, 8, 12)):
                aliens.append(inv)
                bullets.append(b)
                break
```

Gather all the player's bullets and the aliens that have hit an invader.

```
for b in bullets:
    self.BulletController.removeBullet(b)
```

Remove all the bullets that were found that hit an alien

```
for inv in aliens:
    self.swarm.invaders.remove(inv)
    self.player.model.score += (10 * (inv.alientype + 1))
    self.expCtrl.list.add((inv.x, inv.y, 6, 50))
    self.alienDeadSound.play()
```

Remove all the aliens that have been hit by the player's bullets. This part also increments the player's score and plays the alien death sound.

```
playerHit = False
for b in self.EnemyBullets.bullets:
if ( self.player.hit (b.x+3, b.y+3, 8, 12 ) ):
self.player.model.lives -= 1
playerHit = True
break
```

Now we check the enemy bullets. If any one of them has hit the player, we set the 'playerHit' flag to 'True' and 'break' the for-loop. There is no need to continue searching through the bullets if we have already hit the player.

```
if ( playerHit ):
    self.EnemyBullets.clear()
    self.player.bullets.clear()

    if ( self.player.model.lives > 0 ):
    self.player.pause(True)
    getReadyState = InterstitialState( self.game, 'Get Ready!', 2000, self.
    playGameState )
    self.expCtrl.list.add((self.player.model.x, self.player.model.y, 6, 50),
    getReadyState)
    self.playerDie.play()
```

If the player has been hit, we clear all the bullets from the game. If the player still has lives left, we pause the player and change the game state to the 'get ready' screen and add an explosion to show the player's tank destroyed. Remember: we can change the state after an explosion (see the 'ExplosionController' class) and that's what we're setting up here.

We're almost done! Two more files to go. These are the main program and the main game state.

The Main Program

The main program is a single file called 'invaders.py'. Create a new file called 'invaders.py' and enter the code as shown below. The 'RaspberryPiGame' class that we created earlier is expecting an initial state. Our main program's function is to create the states used by the Finite State Machine (FSM) and set the initial state.

```
import pygame, os, sys
from pygame.locals import *

# Our imports
from raspigame import *
from interstitial import *
from menu import MainMenuState
from invadersgame import PlayGameState
```

Our usual imports for the OS and PyGame modules plus our own local modules. We're installing everything from 'raspigame.py' and 'interstitial.py' but only MainMenuState from 'menu.py' and PlayGameState from 'invadersgame.py'.

```
invadersGame = RaspberryPiGame("Invaders", 800, 600)
mainMenuState = MainMenuState( invadersGame )
gameOverState = InterstitialState( invadersGame, 'G A M E  O V E R !', 5000,
mainMenuState )
playGameState = PlayGameState( invadersGame, gameOverState )
getReadyState = InterstitialState( invadersGame, 'Get Ready!', 2000,
playGameState )
mainMenuState.setPlayState( getReadyState )
```

Create instances of the states used in the game: main menu, game over, play game, and the get ready states.

```
invadersGame.run( mainMenuState )
```

Set the initial state of the game to be the main menu. And that's it - that's the main program. Its sole purpose is to create the links between the game states and to set the initial state, and it's all achieved in six lines of code.

The last class that remains to do is the main game state. Save this file.

The Main Game State

Create a new file called 'invadersgame.py'. Enter the following code:

```
import pygame, os, sys
from pygame.locals import *

from raspigame import *
from swarm import *
from player import *
from collision import *
```

Module imports

```
class PlayGameState(GameState):

    def __init__(self, game, gameOverState):
        super(PlayGameState, self).__init__(game)
        self.controllers = None
        self.renderers = None
        self.player_controller = None
        self.swarm_controller = None
        self.swarmSpeed = 500
        self.gameOverState = gameOverState
        self.initialise()
```

Our 'PlayGameState' class derives from 'GameState' and so the constructor must call the base class' constructor. The fields for the controllers and the 'Game Over' state are initialized. To keep this method down to a bare minimum, the initialise() method is called.

```
def onEnter(self, previousState):
    self.player_controller.pause(False)
```

The onEnter() method is part of the GameState class. The only thing we need to do is tell the player controller that it is unpaused.

```
def initialise(self):
    self.swarm_controller = SwarmController(800, 48, self.swarmSpeed)
    swarm_renderer = InvaderView(self.swarm_controller, 'invaders.png')
    self.player_controller = PlayerController(0, 540)
    player_renderer = PlayerView(self.player_controller, 'ship.png')
    lives_renderer = PlayerLivesView(self.player_controller, 'ship.png')
    bullet_renderer = BulletView(self.player_controller.bullets, 'bullet.png')
    alienbullet_renderer = BulletView(self.swarm_controller.bullets,
    'alienbullet.png')
    explosion_controller = ExplosionController(self.game)
    collision_controller = CollisionController(self.game, self.swarm_
    controller, self.player_controller, explosion_controller, self)
    explosion_view = ExplosionView(explosion_controller.list.explosions,
    'explosion.png', 32, 32)
    self.renderers = [ alienbullet_renderer, swarm_renderer, bullet_
    renderer, player_renderer, lives_renderer, explosion_view ]
    self.controllers = [ self.swarm_controller, self.player_controller,
    collision_controller, explosion_controller ]
```

The initialise() method contains the code that creates the instances of each of the controllers and renderers. These are then added to the 'renderers' and 'controllers' fields. Each of these fields is a list that we can iterate through in the update() and draw() methods.

```
def update(self, gameTime):
    for ctrl in self.controllers:
        ctrl.update(gameTime)
```

Loop through all of the controllers and call the update() method on each of them. Because we have stored the controllers in a list, updating each of them is a fairly trivial piece of code

```
if ( self.player_controller.model.lives == 0 ):
    self.game.changeState( self.gameOverState )
```

If the player has no more lives left, we change the state of the game to the "Game Over" state. As it stands, it doesn't matter what lines follow, but you may want to add a 'return' here to exit from the method.

```
if ( len(self.swarm_controller.invaders) == 0 ):
    self.swarmSpeed -= 50
    if ( self.swarmSpeed < 100 ):
        self.swarmSpeed = 100
```

If there are no more aliens left onscreen then we start a new level. The speed of the aliens is decreased; this means that the delta time between updates is decreased. This also means we get faster aliens.

```
self.swarm_controller.reset(48, self.swarmSpeed)
levelUpMessage = InterstitialState( invadersGame, 'Congratulations! Level
Up!', 2000, self )
self.game.changeState ( levelUpMessage )
```

Now that we are starting a new board (swarm of aliens) we tell the swarm controller to reset to the new speed and change the state of the game to show the "Level Up" message.

Save the file. We're finished! You now have a fully working "Invaders" game.

CHAPTER 21

Conclusion

By now, you should have a good understanding of the Python language as well as the PyGame library. With the three games, Brick, Snake, and Invaders, you should have a good understanding of what goes into creating a video game. Indeed, armed with a good idea, you should have enough knowledge to make a game on your own! You certainly have the ability to display graphics, play sounds, and move characters about the screen.

In addition to the games, we also looked at Object-Oriented Programming and some associated design patterns such as Finite State Machines (FSMs) and Model View Controllers (MVCs). These will help you in the construction of your own games, and if you wanted to take it further, a possible career in the games industry.

Hopefully by this stage you should have a good understanding of the Python language itself and PyGame. Due to the three games included in this text (Bricks, Snake, and Invaders), you will also have an understanding of what goes into making a video game. With everything in here, you should have enough to create your own. All it takes is a great idea!

Where to now? Now that you have the programming bug (pardon the pun), the sky is the limit. Perhaps you want to learn C++ and do some 3D games.

If you want to read more about Python you should head over to `https://docs.python.org/2/`. PyGame has full documentation too at `http://www.pygame.org/wiki/index`.

Whatever you choose to do, the world is your oyster! Enjoy!

© Sloan Kelly 2016
S. Kelly, *Python, PyGame and Raspberry Pi Game Development*,
DOI 10.1007/978-1-4842-2517-2_21

Index