Chapter 15

GUI Programming with Tkinter

Up until now, the only way our programs have been able to interact with the user is through keyboard input via the **input** statement. But most real programs use windows, buttons, scrollbars, and various other things. These *widgets* are part of what is called a *Graphical User Interface* or GUI. This chapter is about GUI programming in Python with Tkinter.

All of the widgets we will be looking at have far more options than we could possibly cover here. An excellent reference is Fredrik Lundh's *Introduction to Tkinter* [2].

15.1 Basics

Nearly every GUI program we will write will contain the following three lines:

```
from tkinter import *
root = Tk()
mainloop()
```

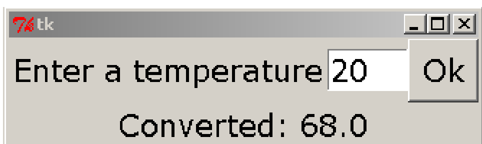
The first line imports all of the GUI stuff from the `tkinter` module. The second line creates a window on the screen, which we call `root`. The third line puts the program into what is essentially a long-running while loop called the *event loop*. This loop runs, waiting for keypresses, button clicks, etc., and it exits when the user closes the window.

Here is a working GUI program that converts temperatures from Fahrenheit to Celsius.

```
from tkinter import *

def calculate():
    temp = int(entry.get())
    temp = 9/5*temp+32
    output_label.configure(text = 'Converted: {:.1f}'.format(temp))
    entry.delete(0,END)
```

```
root = Tk()
message_label = Label(text='Enter a temperature',
                      font=('Verdana', 16))
output_label = Label(font=('Verdana', 16))
entry = Entry(font=('Verdana', 16), width=4)
calc_button = Button(text='Ok', font=('Verdana', 16),
                     command=calculate)

message_label.grid(row=0, column=0)
entry.grid(row=0, column=1)
calc_button.grid(row=0, column=2)
output_label.grid(row=1, column=0, columnspan=3)

mainloop()
```

Here is what the program looks like:



We now will examine the components of the program separately.

15.2 Labels

A label is a place for your program to place some text on the screen. The following code creates a label and places it on the screen.

```
hello_label = Label(text='hello')
hello_label.grid(row=0, column=0)
```

We call `Label` to create a new label. The capital `L` is required. Our label's name is `hello_label`. Once created, use the `grid` method to place the label on the screen. We will explain `grid` in the next section.

Options There are a number of options you can change including font size and color. Here are some examples:

```
hello_label = Label(text='hello', font=('Verdana', 24, 'bold'),
                    bg='blue', fg='white')
```

Note the use of keyword arguments. Here are a few common options:

- `font` — The basic structure is `font=` (*font name, font size, style*). You can leave out the font size or the style. The choices for style are `'bold'`, `'italic'`, `'underline'`, `'overstrike'`, `'roman'`, and `'normal'` (which is the default). You can combine multiple styles like this: `'bold italic'`.

- `fg` and `bg` — These stand for `foreground` and `background`. Many common color names can be used, like `'blue'`, `'green'`, etc. Section 16.2 describes how to get essentially any color.

- `width` — This is how many characters long the label should be. If you leave this out, Tkinter will base the width off of the text you put in the label. This can make for unpredictable results, so it is good to decide ahead of time how long you want your label to be and set the `width` accordingly.

- `height` — This is how many rows high the label should be. You can use this for multi-line labels. Use newline characters in the text to get it to span multiple lines. For example, `text='hi\nthere'`.

There are dozens more options. The aforementioned *Introduction to Tkinter* [2] has a nice list of the others and what they do.

Changing label properties Later in your program, after you've created a label, you may want to change something about it. To do that, use its `configure` method. Here are two examples that change the properties of a label called `label`:

```
label.configure(text='Bye')
label.configure(bg='white', fg='black')
```

Setting `text` to something using the `configure` method is kind of like the GUI equivalent of a **`print`** statement. However, in calls to `configure` we cannot use commas to separate multiple things to print. We instead need to use string formatting. Here is a **`print`** statement and its equivalent using the `configure` method.

```
print('a =', a, 'and b =', b)
label.configure(text='a = {}, and b = {}'.format(a,b))
```

The `configure` method works with most of the other widgets we will see.

15.3 `grid`

The `grid` method is used to place things on the screen. It lays out the screen as a rectangular grid of rows and columns. The first few rows and columns are shown below.

(row=0, column=0)	(row=0, column=1)	(row=0, column=2)
(row=1, column=0)	(row=1, column=1)	(row=1, column=2)
(row=2, column=0)	(row=2, column=1)	(row=2, column=2)

Spanning multiple rows or columns There are optional arguments, `rowspan` and `columnspan`, that allow a widget to take up more than one row or column. Here is an example of several grid statements followed by what the layout will look like:

```
label1.grid(row=0, column=0)
label2.grid(row=0, column=1)
label3.grid(row=1, column=0, columnspan=2)
label4.grid(row=1, column=2)
label5.grid(row=2, column=2)
```

<table>
<tr><td>label1</td><td>label2</td><td></td></tr>
<tr><td colspan="2">label 3</td><td>label4</td></tr>
<tr><td></td><td></td><td>label5</td></tr>
</table>

Spacing To add extra space between widgets, there are optional arguments `padx` and `pady`.

Important note Any time you create a widget, to place it on the screen you need to use `grid` (or one of its cousins, like `pack`, which we will talk about later). Otherwise it will not be visible.

15.4 Entry boxes

Entry boxes are a way for your GUI to get text input. The following example creates a simple entry box and places it on the screen.

```
entry = Entry()
entry.grid(row=0, column=0)
```

Most of the same options that work with labels work with entry boxes (and most of the other widgets we will talk about). The `width` option is particularly helpful because the entry box will often be wider than you need.

- **Getting text** To get the text from an entry box, use its `get` method. This will return a string. If you need numerical data, use **`eval`** (or **`int`** or **`float`**) on the string. Here is a simple example that gets text from an entry box named `entry`.

  ```
  string_value = entry.get()
  num_value = eval(entry.get())
  ```

- **Deleting text** To clear an entry box, use the following:

  ```
  entry.delete(0,END)
  ```

- **Inserting text** To insert text into an entry box, use the following:

  ```
  entry.insert(0, 'hello')
  ```

15.5 Buttons

The following example creates a simple button:

```
ok_button = Button(text='Ok')
```

To get the button to do something when clicked, use the `command` argument. It is set to the name of a function, called a *callback function*. When the button is clicked, the callback function is called. Here is an example:

```
from tkinter import *

def callback():
    label.configure(text='Button clicked')

root = Tk()
label = Label(text='Not clicked')
button = Button(text='Click me', command=callback)

label.grid(row=0, column=0)
button.grid(row=1, column=0)

mainloop()
```

When the program starts, the label says `Click me`. When the button is clicked, the callback function `callback` is called, which changes the label to say `Button clicked`.

`lambda` trick Sometimes we will want to pass information to the callback function, like if we have several buttons that use the same callback function and we want to give the function information about which button is being clicked. Here is an example where we create 26 buttons, one for each letter of the alphabet. Rather than use 26 separate `Button()` statements and 26 different functions, we use a list and one function.

```
from tkinter import *
alphabet = 'ABCDEFGHIJKLMNOPQRSTUVWXYZ'

def callback(x):
    label.configure(text='Button {} clicked'.format(alphabet[x]))

root = Tk()

label = Label()
label.grid(row=1, column=0, columnspan=26)

buttons = [0]*26 # create a list to hold 26 buttons
for i in range(26):
    buttons[i] = Button(text=alphabet[i],
                        command = lambda x=i: callback(x))
```

```
    buttons[i].grid(row=0, column=i)

mainloop()
```

We note a few things about this program. First, we set `buttons=[0]*26`. This creates a list with 26 things in it. We don't really care what thoset things are because they will be replaced with buttons. An alternate way to create the list would be to set `buttons=[]` and use the `append` method.

We only use one callback function and it has one argument, which indicates which button was clicked. As far as the **`lambda`** trick goes, without getting into the details, `command=callback(i)` does not work, and that is why we resort to the **`lambda`** trick. You can read more about **`lambda`** in Section 23.2. An alternate approach is to use classes.

15.6 Global variables

Let's say we want to keep track of how many times a button is clicked. An easy way to do this is to use a global variable as shown below.

```
from tkinter import *

def callback():
    global num_clicks
    num_clicks = num_clicks + 1
    label.configure(text='Clicked {} times.'.format(num_clicks))

num_clicks = 0
root = Tk()

label = Label(text='Not clicked')
button = Button(text='Click me', command=callback)

label.grid(row=0, column=0)
button.grid(row=1, column=0)

mainloop()
```

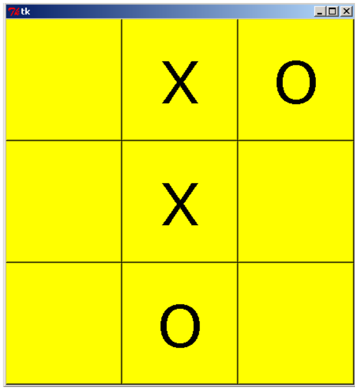
We will be using a few global variables in our GUI programs. Using global variables unnecessarily, especially in long programs, can cause difficult to find errors that make programs hard to maintain, but in the short programs that we will be writing, we should be okay. Object-oriented programming provides an alternative to global variables.

15.7 Tic-tac-toe

Using Tkinter, in only about 20 lines we can make a working tic-tac-toe program:

```
from tkinter import *

def callback(r,c):
    global player
    if player == 'X':
        b[r][c].configure(text = 'X')
        player = 'O'
    else:
        b[r][c].configure(text = 'O')
        player = 'X'

root = Tk()

b = [[0,0,0],
     [0,0,0],
     [0,0,0]]

for i in range(3):
    for j in range(3):
        b[i][j] = Button(font=('Verdana', 56), width=3, bg='yellow',
                         command = lambda r=i,c=j: callback(r,c))
        b[i][j].grid(row = i, column = j)

player = 'X'

mainloop()
```

The program works, though it does have a few problems, like letting you change a cell that already has something in it. We will fix this shortly. First, let's look at how the program does what it does. Starting at the bottom, we have a variable `player` that keeps track of whose turn it is. Above that we create the board, which consists of nine buttons stored in a two-dimensional list. We use the **`lambda`** trick to pass the row and column of the clicked button to the callback function. In the callback function we write an *X* or an *O* into the button that was clicked and change the value of the global variable `player`.



Correcting the problems To correct the problem about being able to change a cell that already has something in it, we need to have a way of knowing which cells have *X*'s, which have *O*'s, and which are empty. One way is to use a `Button` method to ask the button what its text is. Another way, which we will do here is to create a new two-dimensional list, which we will call `states`, that will keep track of things. Here is the code.

```
from tkinter import *

def callback(r,c):
    global player

    if player == 'X' and states[r][c] == 0:
        b[r][c].configure(text='X')
        states[r][c] = 'X'
        player = 'O'

    if player == 'O' and states[r][c] == 0:
        b[r][c].configure(text='O')
        states[r][c] = 'O'
        player = 'X'


root = Tk()

states = [[0,0,0],
          [0,0,0],
          [0,0,0]]

b = [[0,0,0],
     [0,0,0],
     [0,0,0]]

for i in range(3):
    for j in range(3):
        b[i][j] = Button(font=('Verdana', 56), width=3, bg='yellow',
                         command = lambda r=i,c=j: callback(r,c))
        b[i][j].grid(row = i, column = j)
```

```
player = 'X'

mainloop()
```

We have not added much to the program. Most of the new action happens in the callback function. Every time someone clicks on a cell, we first check to see if it is empty (that the corresponding index in `states` is 0), and if it is, we display an *X* or *O* on the screen and record the new value in `states`. Many games have a variable like `states` that keeps track of what is on the board.

Checking for a winner We have a winner when there are three *X*'s or three *O*'s in a row, either vertically, horizontally, or diagonally. To check if there are three in a row across the top row, we can use the following if statement:

```
if states[0][0]==states[0][1]==states[0][2]!=0:
    stop_game=True
    b[0][0].configure(bg='grey')
    b[0][1].configure(bg='grey')
    b[0][2].configure(bg='grey')
```

This checks to see if each of the cells has the same nonzero entry. We are using the shortcut from Section 10.3 here in the if statement. There are more verbose if statements that would work. If we do find a winner, we highlight the winning cells and then set a global variable `stop_game` equal to **`True`**. This variable will be used in the callback function. Whenever the variable is **`True`** we should not allow any moves to take place.

Next, to check if there are three in a row across the middle row, change the first coordinate from 0 to 1 in all three references, and to check if there are three in a row across the bottom, change the 0's to 2's. Since we will have three very similar if statements that only differ in one location, a for loop can be used to keep the code short:

```
for i in range(3):
    if states[i][0]==states[i][1]==states[i][2]!=0:
        b[i][0].configure(bg='grey')
        b[i][1].configure(bg='grey')
        b[i][2].configure(bg='grey')
        stop_game = True
```

Next, checking for vertical winners is pretty much the same except we vary the second coordinate instead of the first. Finally, we have two further if statements to take care of the diagonals. The full program is at the end of this chapter. We have also added a few color options to the `configure` statements to make the game look a little nicer.

Further improvements From here it would be easy to add a restart button. The callback function for that variable should set `stop_game` back to false, it should set `states` back to all zeroes, and it should configure all the buttons back to `text=''` and `bg='yellow'`.

To add a computer player would also not be too difficult, if you don't mind it being a simple computer player that moves randomly. That would take about 10 lines of code. To make an intelligent computer player is not too difficult. Such a computer player should look for two *O*'s or *X*'s in a row in order to try to win or block, as well avoid getting put into a no-win situation.

```
from tkinter import *

def callback(r,c):
    global player

    if player == 'X' and states[x][y] == 0 and stop_game==False:
        b[r][c].configure(text='X', fg='blue', bg='white')
        states[r][c] = 'X'
        player = 'O'

    if player == 'O' and states[r][c] == 0 and stop_game==False:
        b[r][c].configure(text='O', fg='orange', bg='black')
        states[r][c] = 'O'
        player = 'X'

    check_for_winner()

def check_for_winner():
    global stop_game
    for i in range(3):
        if states[i][0]==states[i][1]==states[i][2]!=0:
            b[i][0].configure(bg='grey')
            b[i][1].configure(bg='grey')
            b[i][2].configure(bg='grey')
            stop_game = True

    for i in range(3):
        if states[0][i]==states[1][i]==states[2][i]!=0:
            b[0][i].configure(bg='grey')
            b[1][i].configure(bg='grey')
            b[2][i].configure(bg='grey')
            stop_game = True

    if states[0][0]==states[1][1]==states[2][2]!=0:
        b[0][0].configure(bg='grey')
        b[1][1].configure(bg='grey')
        b[2][2].configure(bg='grey')
        stop_game = True

    if states[2][0]==states[1][1]==states[0][2]!=0:
        b[2][0].configure(bg='grey')
        b[1][1].configure(bg='grey')
        b[0][2].configure(bg='grey')
        stop_game = True

root = Tk()

b = [[0,0,0],
     [0,0,0],
```

```
     [0,0,0]]


states = [[0,0,0],
          [0,0,0],
          [0,0,0]]

for i in range(3):
    for j in range(3):
        b[i][j] = Button(font=('Verdana', 56), width=3, bg='yellow',
                         command = lambda r=i,c=j: callback(r,c))
        b[i][j].grid(row = i, column = j)

player = 'X'
stop_game = False

mainloop()
```