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CS 151

Handout #4
September 14, 2022

Project #1: Wordle

Due: 5:00 P.M., Friday, September 16

This project is designed to help you practice working with strings in the context of an engaging application: the Wordle game initially developed by Josh Wardle, now available on the *New York Times* web site. Given Wordle's enormous popularity, we thought it would be fun to give you the chance to implement the game.

The starter folder

The good news is that you don't have to implement the Wordle project entirely from scratch. The `Project1Starter.zip` file includes the following files:

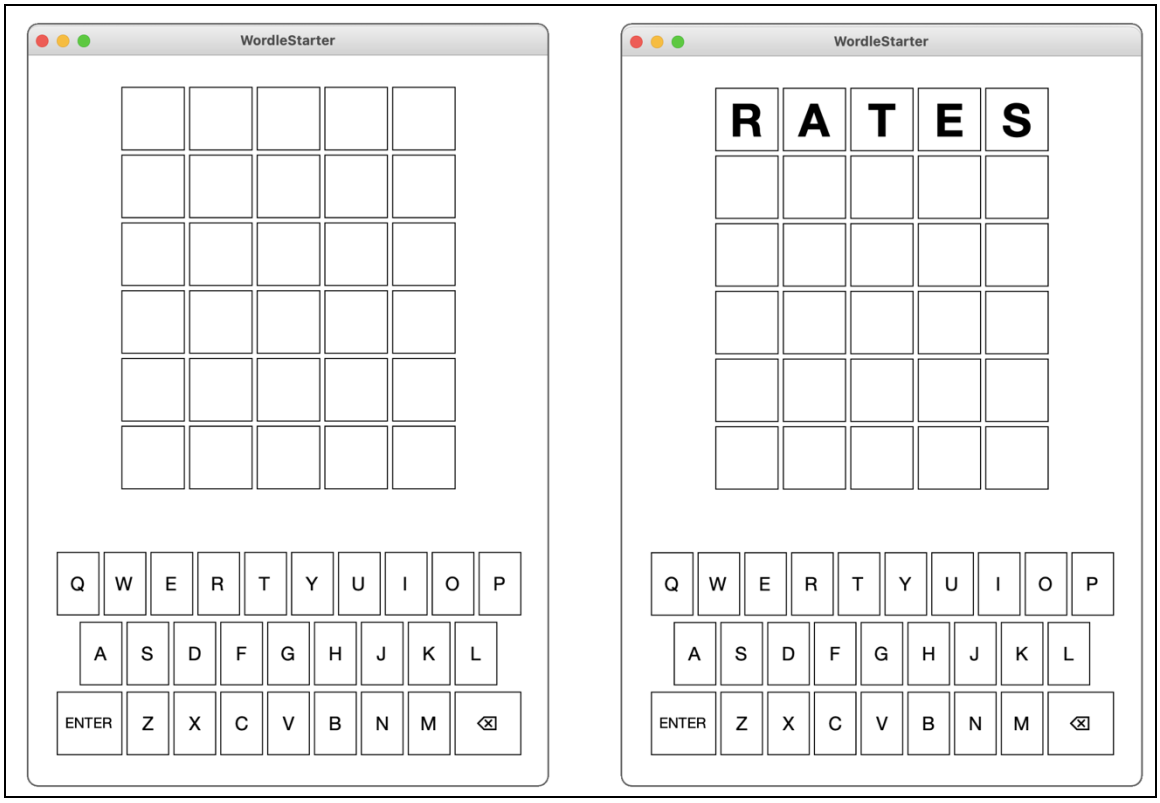
`Wordle.py`	The starter file for the project, which uses the `WordleGraphics` module to display the board.
`WordleGraphics.py`	This module exports the `WordleGWindow` class, which is responsible for the graphics, along with several useful constants.
`WordleDictionary.py`	This module exports the constant `FIVE_LETTER_WORDS`, which contains a list of the five-letter words that Wordle allows.

Unless you are implementing extensions, the only file you need to change is `Wordle.py`, which imports the resources it needs from the other modules. The starter version of `Wordle.py` appears in Figure 1.

Figure 1. Starter file for Wordle

```
# File: Wordle.py
# Name: your name

"""This module is the starter file for the Wordle assignment."""

import random

from WordleDictionary import FIVE_LETTER_WORDS
from WordleGraphics import WordleGWindow

def wordle():

    def enter_action():
        gw.show_message("You have to implement this method.")

    gw = WordleGWindow()
    gw.add_enter_listener(enter_action)

# Startup code

if __name__ == "__main__":
    wordle()
```

Figure 2. Running the starter program



When you download the starter folder, a lot of the code is already running because we've implemented the graphics for you. Running the starter program creates a window, draws the letter boxes, and creates the keyboard at the bottom of the window. You can even type in letters either by hitting keys on the keyboard or clicking the keys on the screen, just as you can when you are playing the online version. Figure 2, for example, shows both the initial screen and the screen you get after typing in the five letters in the useful starting word RATES, which includes five of the most common letters.

Unfortunately, that's all the program does at this point. It doesn't actually let you play the Wordle game. That's your job. But first, it is worth spending a bit of time reviewing the rules for Wordle, in case you've somehow managed to miss this craze.

Playing Wordle

The object of the Wordle puzzle is to figure out the hidden word for the day using no more than six guesses. When you type in a word and then hit the RETURN or ENTER key, the website gives you information about how close your guess is by coloring the background of the letters. For every letter in your guess that is in its correct position, Wordle colors the background a light shade of green, indicated by the constant `CORRECT_COLOR`. For every letter that appears in the word but is not in the correct position, Wordle colors the background a brownish yellow (`PRESENT_COLOR`). All letters in the guess that don't appear in the word are colored a medium gray (`MISSING_COLOR`).

For example, suppose that the hidden word for the day was RELIC, and your first guess was RATES as in the Figure 2 example. The R is in the correct position, and the word

contains an E, but not in the position you guessed. The hidden word does not contain any of the letters T, E, and S. Wordle reports that information by changing the background colors of the squares like this:

Even though you know the position of the R, it doesn't make sense to guess more words beginning with R at this point because doing so gives you no new information. Suppose that you tried guessing the word LINGO, which contains five new letters, two of which appear in the word, but none of which are correctly positioned. Wordle responds by coloring the letter squares in your second guess as follows:

Putting these two clues together means that you know that the word begins with an R, contains the letters E, L, and I in some order other than the one you guessed, and that the letters A, T, S, N, G, and O do not appear anywhere in the word. These answers give you an enormous amount of information. If you think carefully about it, you might find the word RELIC, which is in fact the only English word that meets these conditions:

Done in three!

It is worth noting a few other rules and special cases. The hidden word and each of your guesses must be a real English word that is five letters long. The file `WordleDictionary.py` included with the starter package defines the constant `FIVE_LETTER_WORDS as`

```
FIVE_LETTER_WORDS = [ "aahed", "aalii",. . ., "zoril", "zowie" ]
```

where the three dots are placeholders for more than 5000 other five-letter words. If you guess a word that it not in the word list, Wordle displays a message to that effect, at which point you can delete the letters you've entered and try again. Another rule is that you only get six guesses. If all the letters don't match by then, Wordle gives up on you and tells you what the hidden word was.

The most interesting special cases arise when the hidden word and the guesses contain multiple copies of the same letter. Suppose, for example, that the hidden word is GLASS and you for some reason guess SASSY. Wordle responds with the following colors:

The green S shows that there is an S in the fourth position, and the yellow S shows that a second S appears somewhere else in the hidden word. The S in the middle of SASSY, however, remains gray because the hidden word does not contain three instances of the letter S.

The `WordleGraphics` module

Even though you don't have to make any changes to it or understand the details of its operation, you need to know what capabilities the `WordleGraphics` module has on offer so that you can use those facilities in your code. The most important thing to know is that this library module exports a class called `WordleGWindow`, which implements all the graphical capabilities. The methods exported by the `WordleGWindow` class are outlined in Figure 3. The right column of the table gives only a brief description of what these methods do. More complete descriptions appear later in this handout in the description of the milestone that requires them.

Planning the implementation as a sequence of milestones

Whenever you are working on a programming project of any significant size, you should never try to get the entire project running all at once. A much more effective strategy is to define a series of milestones that allow you to complete the project in stages. Ideally, each milestone you choose should be a program that you can test and debug independently, even if the code you write to test a particular milestone doesn't make its way into the finished project. The advantage you get from making it possible to test each stage more than compensates for having to write a little extra code along the way. Similarly, it often makes sense to defer more the more complex aspects of a project until after you have gotten the basic foundation working. The next few sections outline four milestones for the Wordle project that walk you through different stages of the implementation. You should get each one working before moving on to the next one.

Figure 3. Methods exported by `WordleGWindow` class

`WordleGWindow()`	Creates and displays the graphics window.
`set_square_letter(`*row*`, `*col*`, `*letter*`)`	Sets the letter in the specified row and column.
`get_square_letter(`*row*`, `*col*`)`	Returns the letter in the specified row and column.
`add_enter_listener(`*fn*`)`	Specifies a callback function for the ENTER key.
`show_message(`*msg*`)`	Shows a message below the squares.
`set_square_color(`*row*`, `*col*`, `*color*`)`	Sets the color of the specified square.
`get_square_color(`*row*`, `*col*`)`	Returns the color of the specified square.
`set_current_row(`*row*`)`	Sets the row in which typed characters appear.
`get_current_row()`	Gets the current row.
`set_key_color(`*letter*`, `*color*`)`	Sets the color of the specified key letter.
`get_key_color(`*letter*`)`	Returns the color of the specified key letter.

Milestone #1: Pick a random word and display it in the first row of boxes

For your first milestone, all you have to do is choose a random word from the list provided in the `WordleDictionary.py` module and then have that word appear in the five boxes across the first row of the window. This milestone requires only a few lines of code, but requires you to understand what tools you have and start putting them to use. For example, the `WordleGWindow` class does not export any method for displaying an entire word. All you have is a method `set_square_letter` that puts one letter in a box identified by its row and column numbers.

As with everything in Python, rows and columns are numbered beginning with 0, so that the top row of the window is row 0, and its column number range from 0 to 4. To avoid cluttering up your code with numbers that don't tell you much about what they mean (where does 4 come from in the previous sentence, for example?), it is best to import the constants `N_ROWS` and `N_COLS` from `WordleGraphics` and use those constants whenever your code needs to know how many rows and columns exist. Not only does `N_COLS - 1` provide more insight than the number 4, but this strategy also makes it easier to implement a SuperWordle program with longer words or a different number of guesses.

Milestone #2: Check whether the letters entered by the user form a word

Although the starter program lets the user type letters into the Wordle game, nothing happens when you hit the RETURN key or click the ENTER button. The `WordleGWindow` class lets you respond to that event through the `add_enter_listener` method that works in much the same way that `add_event_listener` does in the `GWindow` class. If you call

```
gw.add_enter_listener(enter_action)
```

typing RETURN or ENTER in the window will trigger a call to the function `enter_action`, which you get to write.

For Milestone #2, your job is to write a version of `enter_action` that checks to see whether the string it has been given is a legitimate English word. If it isn't, your implementation of `enter_action` should call the `show_message` method with the string `"Not in word list"`, which is what the *Times* website says. If it is a word, you should display some more positive message that shows that you got this milestone running.

Milestone #3: Color the boxes

For this milestone, you need to add code to `enter_action` that, after checking to make sure it is a legal word, goes through and colors the boxes to show the user which letters in the guess match the word. The method you need to accomplish this task is

```
gw.set_square_color(row, col, color)
```

The row and column arguments are the same as the ones you used to set or get the letters from the boxes, and *color* is the color you want to use for the background, which will typically be one of the constants `CORRECT_COLOR`, `PRESENT_COLOR`, and `MISSING_COLOR` you can import from `WordleGraphics`, which have the following values, each of which is defined in terms of a six-digit hexadecimal number that gives the red, green, and blue intensities:

```
CORRECT_COLOR = "#66BB66"          # A shade of green
PRESENT_COLOR = "#CCBB66"          # A shade of brownish yellow
MISSING_COLOR = "#999999"          # A shade of gray
```

The hard part of this milestone is figuring out the color for each square, which is not as easy as it might at first appear, particularly when the hidden word contains multiple copies of the same letter. You need to keep track of which letters in the guess have been used and cross them off as you assign colors. You also need to find the correct colors first so that you don't end up coloring a letter yellow that will later turn out to be in the correct position.

Whenever the user enters a guess that appears in the word list, your program must do a few things. First, it must check to see whether the user has correctly guessed all five letters, in case you want to have your program display some properly congratulatory message. If not, your program must move on to the next row. This information is maintained inside the `WordleGraphics.py` module (which needs this information to know where typed letters should appear) using the `set_current_row` and `get_current_row` methods.

Milestone #4: Color the keys

Your last milestone implements a very helpful feature from the *New York Times* website in which it updates the colors of the keys on the virtual keyboard, making it easy to see what letters you've already positioned, found, or determined not to be there. The `WordleGWindow` class exports the methods `set_key_color` and `get_key_color` to accomplish this task. These methods use the same string codes as the corresponding methods for squares.

In solving this milestone, it is important to remember that once you have set the color of a key, it won't change back. If, for example, you've colored the S key green, it will never get set to yellow or gray even though you may end up using those colors for squares that contain an S.

Thoughts to keep in mind

- As with any large program, it is essential to get each milestone working before moving on to the next. It almost never works to write a large program all at once without testing the pieces as you go.
- You have to remember that uppercase and lowercase letters are different in Python. The letters displayed in the window are all uppercase but the `FIVE_LETTER_WORDS` constant is an array of lowercase words. At some point, your code will have to apply the necessary case conversions.

Possible extensions

There are many extensions you could add to the Wordle game. Here are a few that might be fun:

- *Create a more balanced dictionary*. If you simply choose a word at random from the dictionary, some letters will appear more frequently than others in specific positions. Josh Wardle's original implementation solved this problem by keeping two sets of words: a smaller one used to select the secret word in which frequencies are more

balanced and a larger one for determining whether a guess is legal. Devise a strategy for implementing this two-tiered dictionary without having to choose words by hand.

- *Make more balanced choices from the dictionary.* There are other strategies you can use to improve the distribution of letters in the hidden words that don't require creating a separate dictionary. For example, you could make a significant improvement simply by choosing fewer hidden words that end with the letter `"s"`, as almost 30% of the five-letter words do. To implement this strategy, you could define the constant

```
FINAL_S_FRACTION = 1 / 3
```

  and then use that constant to accept words ending in `"s"` only ⅓ of the time, going back and choosing a different word the other ⅔ of the time.

- *Enhance the graphics when the user wins the game.* The `set_square_color` method allows you to change the background color of a square to any color you choose. If you want to make victories more exciting, you could animate the square colors so that the letters in the correct entry cycled through the colors of the rainbow before settling to all green.

- *Create an option that lists all possible words that are legal given the previous guesses.* Even though doing so is clearly cheating, some players would like to see a list of all the words remaining in the dictionary that would be acceptable given the previous set of guesses. You can trigger this option by having the user hit the RETURN key or click the ENTER button when the line is not yet finished, in which case some of the squares will contain the empty string. When this occurs, you can have your program go through all the words, check whether they conform to all the previous clues, and print those words out on the console.

- *Keep score in a file.* The *New York Times* Wordle site keeps track of the number of games you've played and presents a graph of the number of guesses you needed. To implement this feature, you would need to maintain a file that kept track of this information from game to game and then display it at the end. Although you could print this information to the console, you could also display the counts in the Wordle grid, so that each row shows the number of times you needed that many guesses. Thus, if you had solved four Wordle problems in three guesses, eleven in four guesses, and six in five guesses, your Wordle program might show the following display at the end: