More Variable Strangeness, 2D lists, and design processes

October 22

Administrative notes

#Any administrative notes go here

More Python variable strangeness

Let’s look at some code snippets. This will work like you expect it to:

```
a = 1
b = a
b += 1
print(a)
```

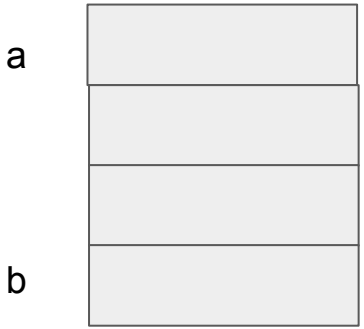
But this might produce some surprising output:

```
c = [1, 2, 3, 4]
d = c
d.append(5)
print(c)
```

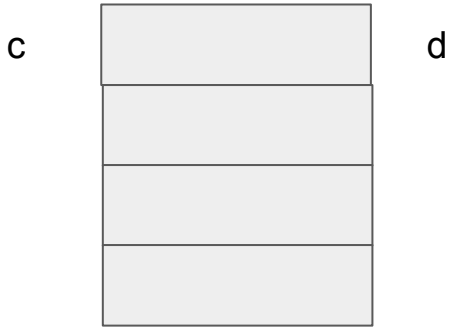
So why did that happen?

Python handles assignment different for different types of variables

For simple types like int, float, str, Python just copies the value: b=a copies the value of a into a new location, labeled b. a and b point to different locations in memory. “Immutable”



For types built of other types, Python handles assignment by passing a reference to the original variable. c and d now point to the same locations in memory. “Mutable”



How can you tell which is which?

Immutable objects: int, float, bool, str, tuple, unicode (don't worry about those last two yet)

- Assignment works like the left side of the previous slide: b = a means copy the value stored in a into b.

Mutable objects: list, set, and dict. (We're going to get to "dict" on Thursday)

- Assignment works like the right side of the previous slide: d = c means that d gets the *address in memory* of c and thus they point to the same locations

"Mutable" means "can be changed"; "immutable" means "can't be changed."

If that’s not strange enough - passing a list to a function

```
def strange_stuff (a_list):
    a_list.append(5)
    return

# This function doesn't return any value
# that's usable by the main program. So
# what will happen?
```

```
# a calling program
if __name__ == "__main__":
    main_list = [1, 2, 3, 4]
    strange_stuff(main_list)
    print(main_list)
```

WHY??!!!!

It works that way because Python declares basic types to be immutable, while constructed types are mutable

So what do you do if you want to just work with a copy of the original list?

```
list_copy = list(main_list)
```

Or use a splice:

```
list _copy = main_list[:]
```

Lists of lists

Now, back to lists. This material is in Section 6.7 of the textbook if you have it.

You can create a list of pretty much anything.

- A list of ints - a=[1,2,3,4]
- A list of floats - b = [1.0, 2.354, 3.67, -9.14]
- A list of strings - c = [“Verlander”, “Scherzer”, “Sanchez”, “Price”]
- A list of booleans - d = [True, False, True, True]

Can you create a list of lists?

Yes, you certainly can

2D List - aka, Matrix; aka, Table

Medal Table from the recent 2019 IAAF World Championships

RANK	COUNTRY				TOTAL
1	UNITED STATES	14	11	4	29
2	KENYA	5	2	4	11
3	JAMAICA	3	5	4	12
4	PR OF CHINA	3	3	3	9
5	ETHIOPIA	2	5	1	8
6	GREAT BRITAIN & N.I.	2	3	0	5
7	GERMANY	2	0	4	6

How do we recreate that in python?

Each row will be a list with five entries: rank, gold medals won, silver medals won, bronze medals won, total medals won.

(We could have country name as a list element, too, but we'll leave that out for now.)

Then we'll create a list where each element is one of those lists

Creating a medal table

```
medal_table = [
   [1, 14, 11,4,29],
   [2,5,2,4,11],
   [3,3,5,4,12],
   [4,3,3,3,9],
   [5,2,5,1,8],
   [6,2,3,0,5],
   [7,2,0,4,6],
]
```

Some notes on this:

- Each row has the same number of elements, and they are all the same type. That is not required
  - Rows don't have to have the same number of elements, elements can be of different type - we could have made the second row be [2, "Kenya", 5,2,4,11] and it would be legal
  - But you're getting into really bad coding habits if you do that.
- Separate each list by a comma!!!

Accessing list elements

Treat this as a table or matrix. Rows are the outer elements; columns are inside. Row and column indices both start at 0!!

len(medal_table) tells you how many ROWS are in the 2D-list

medal_table[0] is the list [1, 14, 11,4,29],

medal_table[3][2] is 3 - the number of silver medals won by China

Using constants can help us keep track of which column means what

Constants to use with the medal_table

RANK = 0 #the first column is the country's rank

GOLDS = 1 # column 1 tells us how many gold medals the country won

SILVERS = 2 # column 2 tells us how many silver medals the country won

BRONZES = 3 # column 3 tells us how many bronze medals the country won

TOTAL = 4 # the last column tells us how many total medals the country won

medal_table [3][SILVERS] tells us how many silver medals the 4th place country won

So how many Gold medals did the top 7 countries win, combined?

```
golds_won = 0

for i in range(len(medal_table)):

   golds_won += medal_table[i][GOLDS]

print(golds_won)
```

The answer is 31.

- If you allow rows to have different numbers of elements, with different meanings, this type of calculation becomes meaningless.

Make sure you understand the table structure

```
medal_table = [
   [1, 14, 11,4,29],
  [2,"Kenya",5,2,4,11],
   [3,3,5,4,12],
   [4,3,3,3,9],
   [5,2,5,1,8],
   [6,2,3,0,5],
   [7,2,0,4,6],
]
```

```
golds_won = 0
for i in range(len(medal_table)):
   golds_won += medal_table[i][GOLDS]
print(golds_won)
```

Will fail, because the element in medal_table[1][GOLDS] isn't an integer

```
silvers_won = 0
for i in range(len(medal_table)):
      Silvers_won += medal_table[i][SILVERS]
print(silvers_won)
```

Won't fail, but it will give you the wrong answer

Creating a 2D list without entering the data

```
#write a routine that fills a 2D table with the
#successive squares - 1, 4, 9, 16, 25,...
ROWS = 5
COLUMNS = 10
square_table = []  #create the initial blank table
num_to_be_squared = 1
for i in range(ROWS):
   row = []
   for j in range(COLUMNS):
      row.append(num_to_be_squared**2)
      num_to_be_squared += 1
   square_table.append(row)
print(square_table)
```

Improving your output

```
# How do I make that output look prettier?
# print out each row on a separate line
for k in range(ROWS):
    print(square_table[k])
```

How do you add a column to a 2D list?

- Adding a row is easy - either “insert” or “append” a list
- Adding a row must be done one element at a time
- *# adding a column to our medal_table*
- *# to put the "country" in*
- countries =[**"United States"**, **"Kenya"**, **"Jamaica"**, **"China"**, **"Ethiopia"**, **"Great Britain"**, **"Germany"**]
- **for** i **in** range(len(medal_table)):
- medal_table[i].insert(1, countries[i])
-
- **for** k **in** range(len(medal_table)):
- print(medal_table[k])
-

```
# Now we need to update the constant
definitions
# so that our previous code will still work
RANK = 0
COUNTRY = 1
GOLDS = 2
SILVERS = 3
BRONZES = 4
TOTALS = 5
```

```
golds_won = 0
for i in range(len(medal_table)):
    golds_won += medal_table[i][GOLDS]
print(golds_won)
```

Presuming there’s time: a design example

Your assignment is to “design an autonomous vehicle” - presume it’s a car

What are the major components you have to do?

1 - get a car that works - it can be driven safely by a human

- Teach a computer to drive it

2 - understand traffic signs and signals, and what you have to do

3 - (the hard part) react to traffic, pedestrians and other objects you might encounter

Now, how do you break down each of those functions?

- Is there any commonality? Any shared sub-functions?
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