Programming Principles in Python (CSCI 503/490)

Control Statements

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(some slides adapted from Dr. Reva Freedman)
Assignment 1

• Due Friday
• Get acquainted with Python using notebooks
• Make sure to follow instructions
  - Name the submitted file a1.ipynb
  - Put your name and z-id in the first cell
  - Label each part of the assignment using markdown
  - Make sure to produce output according to specifications
• ipynb files are in a JSON format. Please maintain the .ipynb extension!
• Questions?
Assignment 2

• Out soon
Quiz
Question 1

• Which is not a valid python identifier?
  (a) señor
  (b) anotherVar
  (c) else
  (d) int
Question 2

• What does "Repeat " + 2 evaluate to?
  (a) "Repeat Repeat "
  (b) "Repeat 2"
  (c) 9
  (d) There is an error
Question 3

- What is the programming environment we are using in this course?
  - (a) Observable
  - (b) Jupyter
  - (c) Mars
  - (d) Zen
Question 4

• Which is a programming principle?
  (a) Use Loops Sparingly
  (b) Duplicate Code Often
  (c) Don’t Repeat Yourself
  (d) Make Code Complex
Question 5

• What does $3 + 9 \, \div \, 2$ evaluate to?
  (a) 8
  (b) 7.5
  (c) 7
  (d) 8.
Questions?
Identifiers

• A sequence of letters, digits, or underscores, but…
• Also includes unicode "letters", spacing marks, and decimals (e.g. \( \Sigma \))
• Must begin with a letter or underscore (_)
• Why not a number?
• Case sensitive (a is different from A)
• Conventions:
  - Identifiers beginning with an underscore (_) are reserved for system use
  - Use underscores (a_long_variable), not camel-case (aLongVariable)
  - Keep identifier names less than 80 characters
• Cannot be reserved words
Types

• Don't worry about types, but think about types
• Variables can "change types"
  
  - a = 0
  - a = "abc"
  - a = 3.14159

• Actually, the name is being moved to a different value
• You can find out the type of the value stored at a variable v using type(v)
• Some literal types are determined by subtle differences
  
  - 1 vs 1. (integer vs. float)
  - 1.43 vs 1.43j (float vs. imaginary)

• Can do explicit type conversion (int, str, float)
Assignment

- The = operator: \( a = 34; c = (a + b)^2 \)
- Python variables are actually **pointers** to objects
- Also, augmented assignment: +=, -=, *=, /=, //=, **=**

\[
\begin{align*}
x &= 42 \\
x &= x + 1 \\
y &= x
\end{align*}
\]
Simultaneous Assignment & Assignment Expressions

• Simultaneous assignment leaves less room for error:
  - \( x, y = y, x \)

• Assignment expressions use the walrus operator :=
  - \( (\text{my}_\pi := 3.14159) \times r^{2} + a^{0.5}/\text{my}_\pi \)
  - Use cases: if/while statement check than use, comprehensions
Control Statements
Boolean Expressions

- Type `bool`: True or False
- Note **capitalization**!
- Comparison Operators: `<`, `<=`, `>`, `>=`, `==`, `!=`
  - Double equals (`==`) checks for equal values,
  - Assignment (`=`) assigns values to variables
- Boolean operators: `not`, `and`, `or`
  - Different from many other languages (`!`, `&&`, `||`)
- More:
  - `is`: exact same object (usually `a_variable` is `None`)
  - `in`: checks if a value is in a collection (`34 in my_list`)
if and else

• Blocks (suites) only executed if the condition is satisfied
  
• if <boolean expression>:
    <then-block>

• if <boolean expression>:
  <then-block>
  else:
  <else-block>

• Remember **colon (:)**

• Remember **indentation**

**Example:**

```python
if a < 34:
    b = 5
else:
    b = a - 34
```
elif is a shortcut

- if $a < 10$:
  print("Small")
else:
  if $a < 100$:
    print("Medium")
  else:
    if $a < 1000$:
      print("Large")
    else:
      print("X-Large")

- if $a < 10$:
  print("Small")
elif $a < 100$:
  print("Medium")
elif $a < 1000$:
  print("Large")
else:
  print("X-Large")

- Indentation is critical so else-if branches can become unwieldy (elif helps)
pass

• pass is a no-op
• Python doesn't allow an empty block so pass helps with this
• Used when commenting out code blocks
• if a < 10:
    print("Small")
elif a < 100:
    print("Medium")
elif a < 1000:
    # print("Large") <- block would be empty (comments don't count)
    pass
else:
    print("X-Large")
while

• while repeats the execution of the block
• while <boolean expression>:
  <loop-block>

• Condition is checked at the beginning and before each repeat
• If condition is False, loop will never execute
• Don't use a while loop to iterate (use for loop instead)
• Example:
  - d = 100
    while d > 0:
      a = get_next_input()
      d -= a
break and continue

• **break**: immediately exit the current loop

• **continue**: stop loop execution and go back to the top of the loop, checking the condition again

• while d > 0:
  
  a = get_next_input()
  
  if a > 100:
    break
  
  if a < 10:
    continue
  
  d -= a

• These are similar to goto statements in that they can jump from one statement to another part of the code but scoped to the current loop
The Go To Statement Debate

Go To Statement Considered Harmful

Key Words and Phrases: go to statement, jump instruction, branch instruction, conditional clause, alternative clause, repetitive clause, program intelligibility, program sequencing

CR Categories: 4.22, 5.23, 5.24

Editor:
For a number of years I have been familiar with the observation that dynamic progress is only characterized when we also give to which call of the procedure we refer. With the inclusion of procedures we can characterize the progress of the process via a sequence of textual indices, the length of this sequence being equal to the dynamic depth of procedure calling.

Let us now consider repetition clauses (like, while B repeat A or repeat A until B). Logically speaking, such clauses are now superfluous, because we can express repetition with the aid of

"...I became convinced that the go to statement should be abolished from all 'higher level' programming languages... The go to statement as it stands is just too primitive; it is too much an invitation to make a mess of one's program."

[Dijkstra, 1968]
The Go To Statement Debate

```
for i := 1 to n
   do begin
      for j := 1 to n do
         if x[i, j] <> 0
            then goto reject;
         writeln
            ('The first all-zero row is ', i);
      break;
   reject: end;
```

```
i := 1;
repeat
   j := 1;
   allzero := true;
   while (j <= n) and allzero
      do begin
         if x[i, j] <> 0
            then allzero := false;
         j := j + 1;
      end;
i := i + 1;
until (i > n) or allzero;
i := 1;
repeat
   j := 1;
   while (j <= n)
      do (x[i, j] = 0) do
         j := j + 1;
i := i + 1;
until (i > n) or (j > n);
if j > n
   then writeln
         ('The first all-zero row is ', i - 1);
```

"All of my experiences compel me to conclude that it is time to part from the dogma of GOTO-less programming. It has failed to prove its merit"

[Rubin, 1987]
Programming Principles: break, continue, goto

• ACM the published a number of critiques of Rubin's letter, Dijkstra also wrote some notes on this: bugs, maybe the language is bad…

• Most computer scientists agree that the problem was over-use, not that the statement is never useful

• Break and continue are more structured gotos because they apply only to the current block

• Breaks and continues at the top of a loop are better

• Multi-level breaks are annoying (compare with return statements in functions)
Continue at the beginning of a loop

• Like `elif`, can help with indentation

```python
while x >= 0:
    d = get_data()
    if d is not None:
        # do stuff
```

```python
while x >= 0:
    d = get_data()
    if d is None:
        continue
        # do stuff
```
Loop Styles

- Loop-and-a-Half
  
  ```python
  d = get_data()  # priming rd
  while check(d):
      # do stuff
      d = get_data()
  ```

- Infinite-Loop-Break
  
  ```python
  while True:
      d = get_data()
      if not check(d):
          break
      # do stuff
  ```

- Better way?
Loop Styles

• Loop-and-a-Half

```python
d = get_data()  # priming rd
while check(d):
    # do stuff
    d = get_data()
```

• Infinite-Loop-Break

```python
while True:
    d = get_data()
    if check(d):
        break
    # do stuff
```

• Assignment Expression (Walrus)

```python
while check(d := get_data()):
    # do stuff
```
do-while

- do-while loops always execute at least once
- There is no do-while loop construct in Python
- Can set the condition so that it is always True first time through the loop
- ...or move the break to the end of the loop
Looping Errors

- # while loop - summing the numbers 1 to 10
  
  ```python
  n = 10
  cur_sum = 0
  # sum of n numbers
  i = 0
  while i <= n:
      i = i + 1
      cur_sum = cur_sum + i

  print("The sum of the numbers from 1 to", n, "is ", cur_sum)
  ```

[The Carpentries, CC-BY 4.0]
Looping Errors

- # while loop - summing the numbers 1 to 10
  n = 10
  cur_sum = 0
  # sum of n numbers
  i = 0
  while i <= n:
    cur_sum = cur_sum + i
    i = i + 1

  print("The sum of the numbers from 1 to", n, "is ", cur_sum)
Looping Errors

• # while loop - summing the numbers 1 to 10
  n = 10
  cur_sum = 0
  # sum of n numbers
  i = 0
  while i != n:
      cur_sum = cur_sum + i
      i = i + 1

  print("The sum of the numbers from 1 to", n, "is ", cur_sum)
For Loop

• for loops in Python are really **for-each** loops
• Always an element that is the current element
  - Can be used to iterate through iterables (containers, generators, strings)
  - Can be used for counting
• ```
  for i in range(5):
      print(i) # 0 1 2 3 4
```  
• `range(5)` **generates** the numbers 0,1,2,3,4
Range

- Python has lists which allow enumeration of all possibilities: [0,1,2,3,4]
- Can use these in for loops
  
  ```python
  for i in [0,1,2,3,4]:
      print(i) # 0 1 2 3 4
  ```
- **but** this is less efficient than range (which is a generator)
  
  ```python
  for i in range(5):
      print(i) # 0 1 2 3 4
  ```
- List must be stored, range doesn't require storage
- Printing a range doesn't work as expected:
  - `print(range(5))` # prints "range(0, 5)"
  - `print(list(range(5)))` # prints "[0, 1, 2, 3, 4]"
Range

- Different method signatures
  - `range(n)` → 0, 1, ..., n-1
  - `range(start, end)` → start, start + 1, ..., end - 1
  - `range(start, end, step)` → start, start + step, ... < end

- Negative steps:
  - `range(0,4,-1)` # <nothing>
  - `range(4,0,-1)` # 4 3 2 1

- Floating-point arguments are not allowed
Looping Errors

• # for loop - summing the numbers 1 to 10
  n = 10
  cur_sum = 0
  for i in range(n):
    cur_sum += i

  print("The sum of the numbers from 1 to", n, "is ", cur_sum)
Looping Errors

• # for loop - summing the numbers 1 to 10
  n = 10
  cur_sum = 0
  for i in range(n+1):
    cur_sum += i

  print("The sum of the numbers from 1 to", n, "is ", cur_sum)
Looping Errors

- # for loop - summing the numbers 1 to 10
  
  ```python
  n = 10
  cur_sum = 0
  for i in range(1, n+1):
    cur_sum += i

  print("The sum of the numbers from 1 to", n, "is ", cur_sum)
  ```