Introduction to:  
Computers & Programming:  
Sequences in Python  
Part 2

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Outline

• Lists: Reviewing and Elaborating
• Lists for different types of problems
• Ordering Sequences
• Summary
• Homework
Lists: Overview

- Sequence of elements of any type (called arrays in other languages)
- Python Syntax: elements in square brackets separated by commas
- Indexes and Slices – like all sequences
  - `my_list = ['the','big','cheese','sandwich']`
  - `my_list[0] → 'the'`
  - `my_list [-1] → 'sandwich'`
  - `my_list [2:] → ['cheese','sandwich']`
  - `my_list[2:] → ['the','big']`
  - `my_list[1:3] → ['big','cheese']`
- Mutable (unlike previous data types we discussed)
  - `my_list.append('is')`
  - `my_list.extend(['on','the','plate'])`
  - `my_list[0]='The'`
  - `my_list → ['The','big','cheese','sandwich','is','on','the','plate']`
- To produce a copy of a list (not a pointer to the same list)
  - `copy_list = my_list[:]  ## a slice that goes from the beginning to the end`
Mutability: Test Lists to Predict Behavior

- Two variables can point to the same list (changing the list will change both values)
  - Abc = [1]
  - Abd = Abc
  - Abc.append(1)
  - Abd → [1,1]

- Functions can change lists
  - def add_2(inlist):
    
    ## the variable inlist is local, but the list it points to is not
    inlist.append(2)

    add_2(Abd)
    Abd → [1,1,2]

- Be careful of the repetition operators repeat lists, they don't copy them
  - Abc = [1]*3
    - Abc → [1, 1, 1] ## 3 copies of the integer 1
  - efg = [[1,2,3]]*3
    - Efg → [[1,2,3],[1,2,3],[1,2,3]] # 3 pointers to the same exact list
    - Efg[2][0] = 'banana'
    - Efg → [['banana', 2, 3], ['banana', 2, 3], ['banana', 2, 3]]
Program File: dog_instructions.py

- https://cs.nyu.edu/courses/spring18/CSCI-UA.0002-004/dog_instructions.py
- Imports functions & variables from
  - https://cs.nyu.edu/courses/spring18/CSCI-UA.0002-004/turtle_dog.py
  - Put in same directory
- Var1, var2, var3, … = list_or_tuple
- 2 kinds of lists used for drawing dogs:
  - List of different variable values – a record of a sort
  - List of lists = sets of instructions
Comparing Objects

- Operators $<$, $>$, $<=$, $=>$ are defined for numbers, strings and some lists (or tuples)
- For numbers, they have the expected interpretations
- Characters ordered based on unicode numbers:
  - $\text{[ord('1'),ord('A'),ord('a')]} \rightarrow [49, 65, 97]$
  - '1'<'A' $\rightarrow$ True
  - 'A' < 'a' $\rightarrow$ True
  - 'a' < '1' $\rightarrow$ False
- True $>$ False
- Orders of Sequences based on the order of their parts
Sequences Ordered Lexographically

• The > operator is defined approximately as follows:
  
  ```python
  def seq_greater_than(seq1, seq2):
      length = min(len(seq1), len(seq2))
      for index in range(length):
          if seq1[index] > seq2[index]:
              return(True)
          elif seq2[index] > seq1[index]:
              return(False)
      if len(seq1) > len(seq2):
          return(True)
      else:
          return(False)
  ```

• Compares sequences one item at a time from the beginning

• Alphabetic order is a type of lexicographic order
Comparing Sequences

- '456' > '1234' → True
  - '4' (52) comes after '1' (49) in the unicode table
- 'Zebra' < 'ant' → True
  - 'Z' (90) comes before 'a' (97) in the unicode table
- 'ch ick' < 'chick' → True
  - ' ' (32) comes before 'i' (105) in the unicode table
- [1,3,4] < [1,5,6] → True
  - Based on the first different item
- [55, 'chicken', 'blah', 'blah', 'blah'] > [55,'chicken','blah'] → True
  - Sequential elements are the same, but first is longer
- [True,True,False] < [True,True,True] → True
  - The left list has the first False matching a True
- [55, 'chicken'] > [55, 45] → Error
  - First items are the same, second items are not compatible
Sorting lists

• Sorting implies comparison using <=

• List1 = [-20, 45, 13, 1, 25.1]
  – List1.sort()
  – List1 → [-20, 1, 13, 25.1, 45]
  – Numbers sorted from lowest to highest number (integers and floats can be compared)

• List2 = ['abc', '123', 'efg', 'ABC', 'EFG']
  – List2.sort()
  – ['123', 'ABC', 'EFG', 'abc', 'efg']

• List3 = [[2, 'chicken'], [45, 'duck'], [-50, 'ox'], [150, 'emu'], [50, 'calf']]
  – List3.sort()
  – Lists of lists are sorted by first elements, than second elements, etc.

• List4 = [1, 'chicken', 'abc', 5]
  – List4.sort() ## causes an error because string 'chicken' cannot be compared to number 1
Max and Min

- Like sort, they use the $<=$ and $>$=
- Like sort, they use lexicographic order for sequences
- $\text{max('abcd Ghhau &')} \rightarrow 'u'$
- $\text{min('012345')} \rightarrow '0'$
- $\text{max(['$%'^&*^&%^%$','abc','XYZ'])} \rightarrow 'abc'$
- $\text{max([True,True,False,True,True])} \rightarrow \text{True}$
- $\text{min(['abc',99,True])} \rightarrow \text{error}$
Examples with Lists as Records

• Functions that take list of lists as argument. Each list is a record.
  – FunctionX([record1, record2, record3, …])
  – record1 = ['Sally', '004_37B', 4, 3, 3.3, 4]
  – record2 = ['Ben', '004_38B', 4, 4, 2.3, 3.3]
  – Examples below

• [name, id_number, hw_grade, test1_grade, test2_grade, test3_grade]
  – Program assumes that positions in a list have defined purposes:
    1\textsuperscript{st} position is name, 2\textsuperscript{nd} is id_number, 3\textsuperscript{rd} is hw_grade, etc.
  – Program prints a statement including: the name, student_number and an average based on record[2:]

• [team_name, wins, losses, ties]
  – Program prints each team name followed by a score equal to
    (wins+1/2 ties)/total_number_of_games
Controlling Sequence Comparisons by Using a Score

• You classified homework as follows:
  – [SUBJECT,Days_until_due,Maj_Min_Elect,hours]

• Now you want to order it favoring
  – Major < Minor < Elective
  – Fewer hours < More hours
  – Fewer Days_until_due < More Days_until_due

• You can make up a score based on these attributes and sort according to that score, as in the file:
  – homework_sort.py
2 Ways to Use Your Score for Sort

1 – Put your score first in the lists to be sorted
   - list_to_sort.append([score_homework(homework), homework])
     • [[0.75, ['ArtHist', 1, 'Min', 1]], [3.0, ['IntroCS', 2, 'Maj', 3]], ...]
     • sort puts the lowest score first

2 – Use lambda notation (more compact)
   - homework_list.sort(key=lambda homework: score_homework(homework))
     • The term after lambda is a variable representing each item in the list
     • A function is listed after the colon
     • The sort compares values of the function for purposes of sorting
     • The output is the sorted list
     • The output of each call to score_homework is not saved as part of the list as in the other version
Text Version of Tic Tac Toe: Slide 1

• The file: tic_tac_toe.py

• Initialize list of rows to represent board
  
  for num in range(3):
    row = ['_','_','_'] creates a new list each iteration
    rows.append(row)

  for row in rows:  ##
    [['_', '_', '_'], ['_', '_', '_'], ['_', '_', '_']]
    print(row)  ## looks like a tic tac toe board
      ['_', '_', '_']
      ['_', '_', '_']
      ['_', '_', '_']

• Game: Take turns filling in X or O, trying to get 3 in a row

• Each position can be identified by indexes,
  – Rows[0][1] → 1st row, 2nd position (or 2nd column)
Text Version of Tic Tac Toe – Slide 2

• 'X' and 'Y' take turns
  – Each turn results in filling in one position
  – A turn can result in X or O winning
  – If 9 turns pass and nobody won, it is a draw

• go_tic_tac_toe_turn(player, rows)
  – Player is X or O
  – Player is queried about where he/she wants to go
  – The list of lists that row points to is modified
    • The variable rows is local, but the list it points to can be changed because lists are mutable
Text Version of Tic Tac Toe – Slide 3

**go_tic_tac_toe**

- **Player Input**
  - Player provides row and column (1, 2 or 3)
  - '1', '2','3' are the only permitted answers
  - A player cannot chose a position already occupied by 'X' or 'O'
- **Program prints the board after player goes**
- **Checks for winning condition and returns 'X' or 'O' if the player wins**
  - All items in row match 'X' (or 'O')
  - The same index in each row match 'X' or 'O' (a column)
  - A diagonal: the middle plus opposing corners (2 cases)
In-Class Problem

• Let's write a computerized version of a memory game called *Concentration*

• The board consists of 5 rows and 4 columns, randomly filled with 20 items: 2 As, 2 Bs, 2 Cs, 2 Ds, 2 Es.

• These items are initially hidden from the user. The user sees a grid filled with Xs—representing that the items are “covered.”

• User can ask to uncover 2 positions in the grid at a time. If they match, they stay uncovered (non X). If they don't match, they are printed for a few seconds and then “covered” again by an X.

• User tries to permanently uncover all squares in the grid in as few turns as possible.
The Turtle Version of Tic Tac Toe

- **Skip Slide if no Time**
- The text version plus additional elements
- Draws the board on turtle.Screen and records in a list the X,Y coordinates of the centers of each of the 9 board positions on the board
- `go_turtle_tic_tac_toe_turn`
  - Like `go_tic_tac_toe_turn`, except also moves turtle to center of position on board and draws X or O
- Writes win or draw message on turtle.Screen
List of Lists Representing Structure (AKA 2 dimensional Lists)

- Tic Tac Toe rows[row_num][col_num]
  - A way of representing X and Y in a grid
  - Could also be used to represent X and Ys for turtle programs
- NYCStreets[X,Y] – for numbered Streets and Avenues in NYC (simplified)
  - Streets[4][6] → 'Waverly Theater'
- Wins = [['Mets','win','lose','win','win'],
   ['lose','Yankees','win','win','win'],
   ['win','lose','Bears','lose','lose'],
   ['lose','lose','win','Senators','win'],
   ['lose','lose','win','lose','Clowns']]  
  - Wins[X][X] – team name of X
  - Wins[X][Y] – did team X win or lose against Y
More 2-D Lists

• Paragraph1 = [['John','saw','Mary','.'],['Mary','saw','John','.']] ...
  - Paragraph1[0][2] → 'Mary'
• The first sentence, second word
• Playing_Cards = [[[A', C'], [A', D'], [A' H'], [A', S']].
  [[2', C'], [2', D'], [2', H'], [2', S']]
  [[3', C'], [3', D'], [3', H'], [3', S']]
  ...
  [[K', C'], [K', D'], [K', H'], [K', S']]}
  - Playing_Cards[1][3] → [2', 'S']
Summary

• Python's List Data structure
  – Is mutable
  – list any kind of element in a sequence
• Lists are used to represent records, tables of data, and other multi-
dimensional objects
• Python defines <, >, <=, >= for many data types.
• Sequences use these definitions lexicographically
• Sort, max, min and other functions assume these orderings as well
• A Score Function provides 1 means to sort data according to your
  own definition.
• 2-D (or multi-dimensional lists) provide ways to represent
  structured information including maps of streets and avenues
Homework

- https://cs.nyu.edu/courses/spring18/CSCI-UA.0002-004/hw7.html