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

Adam Meyers
New York University
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

- http://cs.nyu.edu/courses/fall17/CSCI-UA.0002-007/dog_instructions.py
- Imports functions & variables from
  - http://cs.nyu.edu/courses/fall17/CSCI-UA.0002-007/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
Examples with Lists as Records

- [name, id_number, hw_grade, test1_grade, test2_grade, test3_grade]
  - For each student, printout a statement including: their name, student_number and average (weighted average)

- [team_name, wins, losses, ties]
  - Print each team name followed by a score equal to (wins+1/2 ties)/total_number_of_games

- [item_number, description, price, net_weight, review_score]
  - Sort list of lists in 2 ways – list.sort() sorts the list
  - Sort by products by review_scores – put review_score first in list before sorting
  - Sort by price – put price first before sorting

- In order to use a list in this way, your programs must be consistent with certain positions in the list having certain purposes, as suggested by the variable names
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:
  - `[ord('1'), ord('A'), ord('a')]) → [49, 65, 97]
  - '1'<'A' → True
  - 'A' < 'a' → True
  - 'a' < '1' → 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 $\leq$
- List1 = [-20, 45, 13, 1, 25.1]
  - List1.sort()
  - List1 $\rightarrow$ [-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()
  - [[-50, 'ox'], [2, 'chicken'], [45, 'duck'], [50, 'calf'], [50, 'emu']]
  - 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
• max('abcd Ghhau &') → 'u'
• min('012345') → '0'
• max(['$%^&*&&^%$','abc','XYZ']) → 'abc'
• max([True,True,False,True,True]) → True
• min(['abc',99,True]) → error
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
  
  ```python
  for num in range(3):
      row = ['_', '_', '_']  # creates a new list each iteration
      rows.append(row)
  ```

  ```python
  # print each row
  for row in rows:
      print(row)  # looks like a tic tac toe board
  ```

  ```python
  ['#', '#', '#', '#', '#', '#', '#', '#', '#', '#']
  ```

- 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 choose 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, 2Ds, 2Es.

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

• The 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.

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

- 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

- [McFarland, 2019](http://cs.nyu.edu/courses/fall17/CSCI-UA.0002-007/hw7.html)