Compsci 101
Recursion and Beyond

Lasst Lecture

Susan Rodger
December 8, 2022

Y is for …

• YAML and YACC
  • Yet Another …
• Y2K: https://www.youtube.com/watch?v=rblt2EtFfC4
  • How many bits are enough bits?
• YouTube
  • Connected to computing …

Z is for …

• Zero
  • There are two, or 10 bits in the universe
• Zip
  • Compressed file archive format
• Zork
  • Text-based adventure game
  • https://www.youtube.com/watch?v=TN4VPIRBj8

Raja Kushalnagar

• Professor Gallaudet University
• PhD CS and MS of Laws (LLM) in Intellectual Property and Information Law from Univ Houston
• Juris Doctor (JD) Texas Southern University
• As a Deaf professor, he advocates in bringing consumers, industry, and policymakers together on accessibility issues, advocating for a deaf/hard of hearing perspective, as well as developing prototype technologies for improving the accessibility of such systems.
Announcements

• APT-7 due today
  • Today is last day for Office Hours
  • One grace day, NO LATE DAYS!
  • MUST TURN in BY tomorrow
• Lab 11 Friday – do prelab!
• Assign 7 Create due, tomorrow
  • Grace period is through Tuesday, Dec 13
  • No turnin’s after that.

• Exam 3 …. Coming back soon

Assignment 7:
More samples from previous semesters
A Story – One Eternity Later

Haiku – From Previous Semester

Turtles and Pythons
But We Are Not at the Zoo
We Are in CompSci

Haiku – From Previous Semester

Ugh Syntax Error
Did I Forget a Colon?
Nope. Parentheses.
Final Exam

• Study like you studied for Exam 3
  • Use Exam 3 handout
• We only have a little material since then
  • Recommender
    • this is all about stuff we did before
  • Modules
    • Exceptions
  • Recursion – reading only, no writing
• Not on the exam
  • Images, turtles, exceptions

Calculate Your Grade

• From “About” tab on course web page

<table>
<thead>
<tr>
<th>Component</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labs</td>
<td>10%</td>
</tr>
<tr>
<td>Sakai Quizzes</td>
<td>5%</td>
</tr>
<tr>
<td>Class Participation (WOTOs)</td>
<td>5%</td>
</tr>
<tr>
<td>Apts</td>
<td>10%</td>
</tr>
<tr>
<td>Programming Assignments</td>
<td>10%</td>
</tr>
<tr>
<td>APT Quizzes</td>
<td>10%</td>
</tr>
<tr>
<td>Three Exams(12% each) and Final(14%)</td>
<td>50%</td>
</tr>
</tbody>
</table>
More on Grades

• Class Participation-WOTOs – **ignore** the first two weeks (drop/add period), plus drop 10 **points**
• Sakai Quizzes 299 points– will drop **39** points
  • Your points/260, can’t get more than 100
• Lab – drop **15** points (each lab is 5 pts)
• That is all we drop

Two extra credit opportunities!

• Fill out survey/consent for study (emailed last night)
  • 70% fill out by Friday – 1 extra point on Exam 3

• **CompSci 101 course evaluation!**
  • 70% fill out by Friday – 1 extra point on final exam
  • 80% fill out by Friday – a second extra point on final exam

Time for CompSci 101 Course Eval

1. Please fill out Duke Course Eval on DukeHub now

Only 47% have filled it in as of last night

<table>
<thead>
<tr>
<th>Courses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Code</td>
</tr>
<tr>
<td>---------</td>
</tr>
<tr>
<td>COMPSCI-101L-001</td>
</tr>
</tbody>
</table>

Review: Recursion Summary

• **Make Simpler or smaller calls**
  • Call a clone of itself with different input

• **Must have a base case when no recursive call can be made**
  • Example - The last folder in the folder hierarchy will not have any subfolders. It can only have files. That forms the base case
  • This is the way out of recursion!
Problem: is a number in a list?

• Is 5 in [7, 5, 6, 8]?

• Is 8 in [5, [7,4], 9, [3, 4]], [4, [5, [2, [8, 1], 4, ]], 5]]?

Possible solution

```python
def isItInList(alist, num):
    for item in alist:
        if type(item) == type([]):  # is a list
            return isItInList(item, num)
        else:  # type is number
            if item == num:
                return 'yes'
    return 'no'
```

• Doesn't work! Consider 2 and [3, [6,7], 8, [2, 7]]
Possible solution

```
18 def isItInList(alist, num):
19     for item in alist:
20         if type(item) == type([]): # is a list
21             return isItInList(item, num)
22     else: # type is number
23         if item == num:
24             return 'yes'
25         return 'no'
```

- Doesn't work! Consider 2 and [3, [6,7], 8, [2, 7] ]

Possible Solution 2

```
8 def isItInList2(alist, num):
9     for item in alist:
10         if type(item) == type([]): # is a list
11             if isItInList2(item, num) == 'yes':
12                 return 'yes'
13         else: # type is number
14             if item == num:
15                 return 'yes'
16             return 'no'
```

- Line 21 returns “no”, doesn’t check rest of list

- Works! Consider 2 and [3, [6,7], 8, [2, 7] ]

Possible Solution 2

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8 def isItInList2(alist, num):
9     for item in alist:
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```

- Works! Consider 2 and [3, [6,7], 8, [2, 7] ]
Possible Solution 2

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    return 'no'
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- Works! Consider 2 and [3, [6,7], 8, [2, 7] ]

Problem: is a number in a list?

- Is 5 in [7, 5, 6, 8] ?
- Is 8 in [5, [7,4], 9, [3, 4]], [4, [5, [2, [8, 1], 4, ]], 5] ] ?
Revisit the APT Bagels Recursively

```python
filename: Bagels.py

def bagelCount(orders):
    """
    return number of bagels needed to fulfill
    the orders in integer list parameter orders
    """

1. orders = [1, 3, 5, 7]
   Returns: 16
   No order is for more than a dozen, return the total of all orders.

2. orders = [11, 22, 33, 44, 55]
   Returns: 175 since 11 + (22+1) + (33+2) + (44+3) + (55+4) = 175
```

APT Bagels Recursively

A) `def bagelCount(orders):
   if len(orders) > 0:
       return orders[0]/12 + orders[0] + bagelCount(orders[1:])
   else:
       return 0
B) `def bagelCount(orders):
   if len(orders) > 0:
       return orders[-1]/12 + orders[-1] + bagelCount(orders[::-1])
   else:
       return 0
C) `def bagelCount(orders):
   return orders[0] + orders[0]/12 + bagelCount(orders[1:])
D) `def bagelCount(orders):
   if len(orders)>1:
       return orders[1] + orders[1]/12 + bagelCount(orders[2:])
   else:
       return bagelCount(orders[0])`

A peek into CompSci 201

- Sorting list of numbers
- Quicksort algorithm
  - Uses recursion
**Quicksort - Idea**

- Pivot – select and adjust the list
  - Select one of the elements
  - Put it where it belongs in sorted order
  - Put elements less than it, to its left
  - Put elements greater than it, to its right
- Recursively sort the elements to its left
- Recursively sort the elements to its right
- Done!

5 9 1 4 3 6 2 7

**Select pivot**

**Adjust**

**Recurse left**

**Result**

**Recurse right**

**Result**
Quicksort: fast in practice

```python
def doQuick(list, first, last):
    if (first >= last):
        return

    piv = pivot(list, first, last)
    doQuick(list, first, piv-1)
    doQuick(list, piv+1, last)
```

Sir Anthony (Tony) Hoare

Invented Quicksort in 1962
- he didn't get recursion

Turing Award winner
- programming language design
- Algol 60

“There are two ways of constructing a software design. One way is to make it so simple that there are obviously no deficiencies. And the other way is to make it so complicated that there are no obvious deficiencies.”

“What is computer science, what is its potential?
- What can we do with computers in our lives?
- What can we do with computing for society?
- Will networks transform thinking/knowing/doing?
- Society affecting and affected by computing?
- Changes in science: biology, physics, chemistry, …
- Changes in humanity: access, revolution (?), …

“Inside every large program is a small program struggling to get out.”

Privileges and opportunities available if you know code
- Writing and reading code, understanding algorithms
- Majestic, magical, mathematical, mysterious, …
Computing - solve all problems?

- Some problems can be solved 'efficiently'
  - Run large versions fast on modern computers
  - What is 'efficient'? It depends
- Some cannot be solved by computer.
  - Provable! We can't wait for smarter algorithms
- Some problems have no efficient solution
  - Provably exponential $2^n$ so for "small" $n$ …
- Some have no known efficient solution, but
  - If one does they all do!

Problem: Traveling Band

- Band wants you to schedule their concerts.
- They don’t like to travel. Minimize the time they are on the bus!
- Given N cities, what is the best schedule (shortest distance) to visit all N cities once?

How do you calculate the best path?

- Try all paths
  - Atlanta, Raleigh, Dallas, Reno, Chicago
    - Add up the distance in this order
  - Dallas, Atlanta, Raleigh, Reno, Chicago
    - Add up the distance in this order
  - Etc.
- Would you agree to code this up?

Traveling Band questions
### How long?

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<thead>
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</tr>
<tr>
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</tr>
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<td>11 days</td>
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<tr>
<td>20</td>
<td>$10^{18}$</td>
<td>31 years</td>
</tr>
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<td>25</td>
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How is Python like all other programming languages, how is it different?

Find all unique/different words in a file, in sorted order
Unique Words in Python

def main():
    f = open('/data/melville.txt', 'r')
    words = f.read().strip().split()
    allWords = set(words)
    for word in sorted(allWords):
        print(word)

if __name__ == '__main__':
    main()
What is next?

• CompSci 201
  • Java, efficiency, other ways to organize data
• CompSci 230 – can take concurrently with 201
  • Discrete Mathematics
    • Course substitutions if you take a lot of math/stats
• CompSci 260 Computational Biology
• CompSci 216 Everything Data
• CompSci 240 Race, Gender, Class and Computing

What to do over Winter Break?
Take a Duke Coursera course Free

• Course on Java

Duke Coursera course on Java

• Coursera for Duke
  • https://online.duke.edu/coursera-for-duke/
• Java Programming/Soft Eng Fund
  • 5 courses
    • HTML/CSS/JavaScript
    • 4 courses on Java
• Course is FREE for Duke students
  • Go through link above

End with A CS Story
bit.ly/101f22-1208-3