

15-110 Final Exam Practice Problems

List Methods and Recursion

1. **Code Writing:** Write a recursive function that takes in a 2-D list of numbers and returns a 2-D list of all the lists that have an even sum.

For example `even2D([[1,2,3], [5,5,5], [1], [6,4]])` would return `[[1,2,3], [6,4]]`

Code:

2. **Code Writing:** Write a recursive function that takes in a list of strings and a subset phrase and returns a list of strings that contain that subset.

For example `subset(["apple", "cap", "orange", "lap"], "ap")` would return `["apple", "cap", "lap"]`

Code:

Trees and Recursion

1. **Code Writing:** You are given a tree which is **not** a binary tree, and each node can have an arbitrary number of children. Each node has a numerical value.

Your task is to find a path through the tree starting from the root to a leaf such that at every single step along the way, you are traversing down the node with the **lowest** value. For example, if a node has children with values of 1, 2, 3, 4, 5, you would choose to move down the path following the node with value 1. Assume that no node has duplicate child values, and the child values **need not be sorted**. Assume that trees are implemented as dictionaries, and that the children of each node is stored in a **list**, accessed by the key 'children'. The value for each node is accessed through the key 'value'. The function should return the list of nodes traversed in order, starting with the root node and ending with the leaf node.

Code:

2. **Code Writing:** You are given a binary tree. Your task is to reverse the binary tree, which means switching the left and right branches. Assume trees are implemented as nested dictionaries, children are stored in lists, and the value and children can be accessed using the keys 'value' and 'children' respectively. The function should return the inverted binary tree, and the inversion should occur at every level.

Code:

Simulation - Randomness & Monte Carlo

1. **Code Writing:** Write the following Monte Carlo functions:
 - a. Write a function `runTrial()` that takes in 0 inputs and simulates rolling 2 five-sided dice. The function should return True if the sum of the dice is less than 10 AND the first dice roll is strictly greater than the second dice roll. Remember to import the proper libraries when writing this function!
Code:
 - b. Now, use the function from part (a) to write the Monte Carlo function `getExpectedValue(trials)` that takes in an integer number of trials. It should return the probability that with 2 five-sided dice, the first roll is greater than the second and their sum is less than 10.
Code:
2. **Multiple Choice:** Which is false about randomness?
 - a. By the Law of large numbers, the average of the results of 1000 experiments will be the true expected value
 - b. Monte Carlo methods use repeated simulations to simulate the law of large numbers
 - c. Randomness in Python is not true randomness
 - d. The random library in Python includes functions such as `random.randint(x,y)` that can pick a number between a range.

Answer:

Simulation - Model/View/Controller

1. **Code Writing:** You are given the following starter file with a model and view built already. The size of the window is 400 and you are given a blue “balloon” with radius 20 positioned in the center of your screen.
Starter File:
https://drive.google.com/file/d/1INSmIV_rgJPysun66m748vTqP0Mi5Wm4/view?usp=sharing
 - a. Implement the `keyPressed` function so that pressing the ‘1’ key will ‘blow up’ the balloon. In other words, pressing the 1 key should increment the radius of the circle by the given `pumpValue`. Implement functionality that will allow the user to move the balloon around using the up, down, left, and right arrow keys as well (increment the position of the x and y coordinates of the circle by the `pumpValue`).
 - b. Implement the `isInBounds` function so that the balloon will ‘pop’ or reset to radius 20 as soon it circumscribes the window. Also add functionality that will prevent the user from moving any portion of the circle out of the window. Instead of allowing them to move outside of the window, have the balloon reposition itself to the middle of the window by manipulating the appropriate coordinates.

Code:

Runtime/Big O

1. **Short Answer:** Consider the following function:

```
def f(x): #assume x is a positive integer
    #section 1
    count=0
    i=1
    while i<=x:
        i *= 4
        count += 1
    #section 2
    newcount=0
    for i in range(100):
        newcount += 1
    #section 3
    newcount2 = 0
    for i in range(x):
        newcount2 += 1
    return [count, newcount, newcount2]
```

- a. Answer the following questions about the big-O runtime of this function:
- What is the runtime of section 1?
Answer:
 - What is the runtime of section 2?
Answer:
 - What is the runtime of section 3?
Answer:
 - What is the overall big-O runtime of this function?
Answer:
- b. What is the runtime if the for loops and while loop were nested?
Answer:
2. **Short Answer:** Answer the following questions about the Travelling Salesperson:
- What class of problems is this in?
Answer:
 - What is the runtime of this problem?
Answer:
 - What is the tractability of solving the problem? What is the tractability of verifying the solution?

Answer:

- d. Briefly explain how (without using code) you would solve this problem? How is this reflected in the runtime/class that the problem is in?

Answer:

- e. Now consider what happens if we modify the problem to say that we just want a solution that is under 1000 miles in total distance:

- i. How does the class of the problem change?

Answer:

- ii. Does the time that it takes to solve this problem and/or verify a solution change? Why?

Answer:

- iii. Is this problem tractable or intractable?

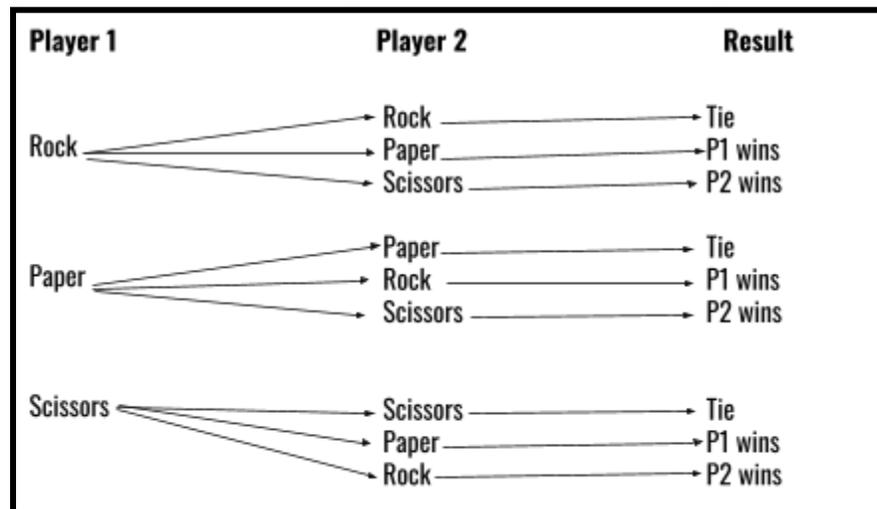
Answer:

ML and AI

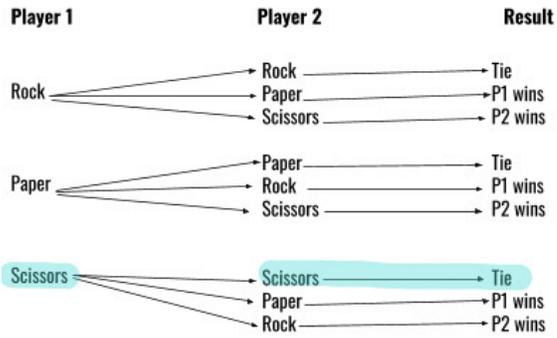
1. **Multiple Choice: True or False:** When training an algorithm, it is important to use all of the data you have at your disposal in order to make sure the algorithm can have as much practice as possible.

Answer:

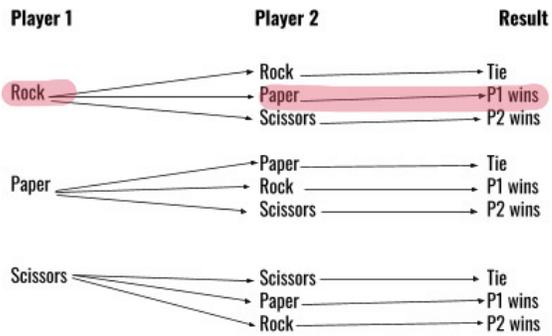
2. **MC:** Based on the game tree for rock, paper, scissors shown below, which of the following options demonstrates a game state score of 1 for Player 2?



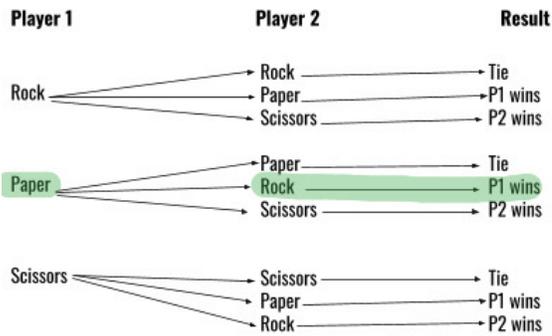
Option A:



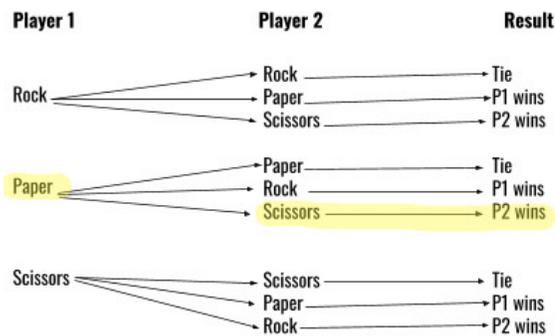
Option B:



Option C:



Option D:



Answer:

Graphs and Search

1. **Code Writing:** Write a function `findSmallConnections`, given a weighted graph like the one below, that will return all the pairs of nodes whose weights are less than 5, in a 2D list. Note that repeats do not matter.

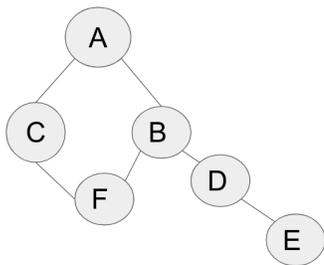
```
g = {  
  "A" : [ ["B", 5], ["E", 2] ],  
  "B" : [ ["A", 5], ["C", 3] ],  
  "C" : [ ["B", 3], ["F", 9] ],  
  "D" : [ ["E", 1], ["F", 7] ],  
  "E" : [ ["A", 2], ["D", 1], ["F", 2] ],  
  "F" : [ ["C", 9], ["D", 7], ["E", 2] ]  
}
```

Example: with the graph given above, the intended result would be:

```
[["A", "E"], ["B", "C"], ["C", "B"], ["D", "E"], ["E", "A"],  
["E", "D"], ["E", "F"], ["F", "E"]]
```

Code:

2. **Short Answer:** Consider the following graph:



- a. What nodes (in order) would the DFS algorithm visit if you started at node A and searched for node E?

Answer:

- b. What nodes (in order) would the BFS algorithm visit if you started at node A and searched for node E?

Answer:

Hashing & Search/Sort

1. **Code Tracing:** Python has a built in hash function, but recall that we can also make our own! Consider these four functions, which all take in a string and hash it.

```
def h1(s):  
    return 0
```

```
def h2(s):  
    return ord(s[0])
```

```
def h3(s):  
    x=0  
    for i in range(len(s)):  
        n=ord(s[i])  
        x+=n  
    return x
```

```
def h4(s):  
    x=0  
    for i in range(len(s)):  
        n=ord(s[i])  
        x=128*x+n  
    return x
```

- a. Which is the best to use? Why (what term do we want to avoid)? What is the runtime of good and bad hashing function situations?

Answer:

- b. Use all the functions to hash 'hi', 'bye', 'cat', 'cool', and 'act' into a hash table with 10 buckets. (You can use this ASCII table if needed <http://www.asciitable.com/>)

Answer:

2. **Short Answer:** Consider the following questions about sorting algorithms

- a. Merge sort:

- i. Draw out merge sort on the list [5,2,10,1,2,3]
Label the steps based on if its dividing, conquer/sort, or combine/merge
Label the step where the function is at its base case.

Answer:

- ii. Explain merge sort's runtime

Answer:

- b. Sort the same list using selection sort.
i. Keep count of the number of comparisons and swaps.

Answer:

[5,2,10,1,2,3]	Comparisons: 5 Swaps: 1
[1,2,10,5,2,3]	Comparisons: 4 Swaps: 0
[1,2,10,5,2,3]	Comparisons: 3 Swaps: 1
[1,2,2,5,10,3]	Comparisons: 2 Swaps: 1
[1,2,2,3,10,5]	Comparisons: 1 Swaps: 1
[1,2,2,3,5,10]	

- ii. Explain selection sort's runtime

Answer:

- iii. Is it more or less efficient than merge sort? Why?

Answer:

Authentication & Encryption

1. **Short Answer:** Answer the following questions:

- a. Describe the difference between a man-in-the-middle attack and a DDOS attack

Answer:

- b. Describe the difference between symmetric and asymmetric encryption algorithms.

Answer:

- c. What are 2 of the encryption algorithms we discussed in class, and state whether they are symmetric or asymmetric

Answer:

- d. Why is breaking RSA nearly impossible?

Answer:

2. **Multiple Choice:** Tunneling is a process used by which of the following:

- a. RSA Encryption
b. HTTP Protocol

- c. VPN
- d. Caesar Cipher
- e. Both B and C

Answer:

Parallelism, Pipelining, MapReduce

1. **Short Answer:** Consider the following lists of tasks to prepare a hamburger at a fast-food chain and how long each step takes
 - 1) Cook the patty (10 min)
 - 2) Toast the bread (3 min)
 - 3) Prepare the vegetables (3 min)
 - 4) Put it together (2 min)

These steps are currently divided among 4 employees using **pipelining** where each worker performs one step.

State whether the following are true or false for the above scenario, and explain:

- f. If a new employee is hired the total number of burgers produced will increase

Answer:

- g. If the time taken to prepare the vegetables is reduced to 1 min, the number of burgers produced in an hour will increase

Answer:

- h. If the time taken to cook the patty is reduced to 8 min, the number of burgers produced in an hour will increase

Answer:

2. **Short Answer:** You are tasked with providing some analytical information for Spotify Rewind 2020. Your goal is to find the average number of country songs across all Spotify users favorite songs list. Design a MapReduce algorithm to solve this problem. Describe at a high level what values this specific mapper function would input and output, what values this reducer would input and output, and what actions the manager function would take.

Answer:

Data Analysis/Visualization

1. **Short Answer:** For each situation, indicate what type of graph would work best
 - a. You want to compare the mean SAT scores for several different high schools in the district

Answer:

- b. You want to analyze how students did on their last exam by examining the grading distribution

Answer:

- c. You want to analyze how temperature and location affect rainfall for several places around the world

Answer:

2. **Code Writing:** A professor would like to see how the students in his class are doing with their grades. He has a CSV file that has every student's name, grade, attendance, and recitation section in each column respectively.

Here is the first 21 rows read in from his CSV file as a 2d list:

```
data = [['name', 'grade(out of 100)', 'attendance(out of 100)',  
'recitation section'],  
        ['Olivia', '83', '83', 'a'],  
        ['Emma', '83', '83', 'k'],  
        ['Ava', '81', '85', 'e'],  
        ['Sophia', '80', '78', 'j'],  
        ['Isabella', '93', '93', 'f'],  
        ['Charlotte', '84', '85', 'd'],  
        ['Amelia', '74', '76', 'c'],  
        ['Mia', '84', '86', 'j'],  
        ['Harper', '73', '73', 'c'],  
        ['Evelyn', '88', '87', 'k'],  
        ['Ezra', '91', '92', 'e'],  
        ['Hudson', '87', '86', 'g'],  
        ['Charles', '90', '87', 'k'],  
        ['Caleb', '76', '74', 'b'],  
        ['Isaiah', '83', '82', 'e'],  
        ['Ryan', '86', '84', 'd'],  
        ['Nathan', '83', '84', 'k'],  
        ['Adrian', '79', '82', 'j'],  
        ['Christian', '77', '81', 'f'],  
        ['Maverick', '82', '81', 'c']]
```

Write the function `makeDataDict(data)` that takes in the 2d list of data above and creates a dictionary that maps student names to a list where the first element is that student's grade, and the second element is that student's attendance

HINT: Remember that when you read in a CSV file, all of the fields are strings

Create a data dictionary from the 2d list of data and assign it to a variable "dataDict"

First, we want to see the overall grading distribution. Write a function `graphGrades(d)` that takes in the data dictionary `dataDict` from above and creates a histogram of all of the grades.

matplotlib functions to use:

```
(import matplotlib.pyplot as plt)
plt.hist(dataName)
plt.show() # Include this right after the above line
```

The professor would like to know if lecture attendance has any correlation with grades. Write a function `graphAttendance(d)` that takes in a dictionary `dataDict` as above and creates a scatter plot of attendance vs grades.

matplotlib functions to use:

```
(import matplotlib.pyplot as plt)
plt.scatter(xDataName, yDataName)
plt.show()
```

Code:

Concurrency, Internet

1. Short Answer:

- a. Create the concurrency tree for the equation

$$((a + b) * (c / (d + 1))) / ((e + 4 * f) * (g + h))$$

Answer:

- b. How many total steps are there?

Answer:

- c. How many time steps are there?

Answer:

2. Multiple Choice: Which of the following is NOT true?

- a. HTTP is a protocol used by browsers that describes how to request information from a website
- b. Packets are not guaranteed to reach their destination in the same order they were sent
- c. Buffering is used to show you part of a website while the rest of it loads
- d. The Cloud is not built to handle failures (i.e not fault-tolerant)

Answer:

Multiple Choice: Which of the following is true about IP addresses?

- a. Computers will maintain the same IP address for the entirety of its lifetime
- b. IP addresses are a core part of a computer, and are built into the hardware
- c. ICANN now has a new system for IP Addresses that contains 16 bytes which can handle 10^{38} addresses
- d. A request needs to pass through only one server to reach a DNS server

Answer: