Comp 555 Problem Set 4

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Question 1

a

While both Hash-table and Suffix trees would correctly solve this problem, they may be preferred over one another depending on the circumstances. Suffix trees have a run time of $O(m)$, making them preferable *ceteris paribus.* But there is computational and engineering overhead to generate the suffix tree. Hash tables are implemented natively in many programming languages (such as Python's dict structure), making them easier to implement in some situations.

That said, for our purposes computational and engineering overhead are negligible when compared to runtime savings, especially given that n is likely to be very long. So, the suffix tree structure is most appropriate for our purposes here.

b

Assuming the suffix table for m is already constructed as a graph, an algorithm to find the number of occurrences of m in n is

```
Preprocess n into suffix tree s_n in O(n).

SuffixSearch(m, s_n)
position = 0
for edge in childEdge(s_n) == m[position:len(edge_label)]
    if descendent vertex has child edge == m[position +1:len(
        child_edge_label)]
        SuffixSearch(m[position+1:len(m)], descendants(edge)
    else
```

```
matches = count(descendants(edge))
return matches
```

c

The time complexity is $O(m)$.

Question 2

A hash table scheme for providing the student id, given a score x, is to sort student IDs into a Hash table based on some feature of the scores themselves. For this problem, we've been told that the scores can range from -10 to 20 and that the hash table should have at most 5 rows. There are many solutions to this, but an optimal solution would divide both possible and actual values as evenly as possible amongst the 5 rows to reduce collisions. The best solution I've found is to separate scores based on the sum of their digits. Table 2 illustrates where each possible score would be stored. This scheme achieves the goal of equally distributing possible values of scores across the rows. In addition, as shown below in b, the actual values of scores are distributed evenly, $+/-1$ score. Within rows, values should be ordered by ascending score.-

Digit sums	Corresponding scores
$1, 2$	$-2, -1, 1, 2, 10, 11$
$3, 4$	$-4, -3, 3, 4, 12, 13$
$5, 6$	$-6, -5, 5, 6, 14, 15$
$7, 8$	$-8, -7, 7, 8, 16, 17$
$9, 10, 0$	$-9, 0, 9, 10, 18, 19$

Table 1: A hash table scheme for storing student IDs and scores based on the sum of the digits of the score. Each row has six possible scores.

a

```
MakeTable(min,max)
hash_table, 2 columns x 5 rows

for row, count in hash_table, range(1,9,2)
  row[0] ← [count, count+1]
```

```
for number in range(min,max)
    for digit in number
        sum += abs(digit)
    for sum in row in hash_table
        row[1] gets \{number\}

DigitHash(student,x)
for digit in x
    sum += abs(digit)

add sum, student to row[1] in hash_table where sum in row[0]
```

b

The actual hash table for this question is shown in Table 2. As noted above, the scheme achieves a relatively even distribution of scores, minimizing collisions. Even though Row 2 has three students in it, and Row 1 only has one, there is no way to reduce collisions further in a hash table this small.

Digit sums	Corresponding scores
1, 2	{-1,A4}
3, 4	{4,A1,A2},{12,A8}
5, 6	{14,A5},{15,AA}
7, 8	{7,A9},{17,A7}
9,10,0	{9,A3},{19,A6}

Table 2: The actual hash table for Question 2.

c

```
index = DigitHash(4)    # 4

find index in row[0] in hash_table
    Find 4 in entry in row[1]
    return entry[1::]
```

	x	y
p1	2.2	3.3
p2	1.6	4.5
p3	6.7	3.3
p4	4.7	1.2
p5	8.6	7.5
p6	5.3	5.6
p7	7.6	6.5
p8	2.5	4.6
p9	5.5	4.5
p10	1.1	3.8

	p1	p2	p3	p4	p5	p6	p7	p8	p9	p10
p1	0.0	1.3	4.5	3.3	7.7	3.9	6.3	1.3	3.5	1.2
p2	1.3	0.0	5.2	4.5	7.6	3.9	6.3	0.9	3.9	0.9
p3	4.5	5.2	0.0	2.9	4.6	2.7	3.3	4.4	1.7	5.6
p4	3.3	4.5	2.9	0.0	7.4	4.4	6.0	4.0	3.4	4.4
p5	7.7	7.6	4.6	7.4	0.0	3.8	1.4	6.8	4.3	8.4
p6	3.9	3.9	2.7	4.4	3.8	0.0	2.5	3.0	1.1	4.6
p7	6.3	6.3	3.3	6.0	1.4	2.5	0.0	5.4	2.9	7.0
p8	1.3	0.9	4.4	4.0	6.8	3.0	5.4	0.0	3.0	1.6
p9	3.5	3.9	1.7	3.4	4.3	1.1	2.9	3.0	0.0	4.5
p10	1.2	0.9	5.6	4.4	8.4	4.6	7.0	1.6	4.5	0.0

Table 3: A Euclidean distance matrix.

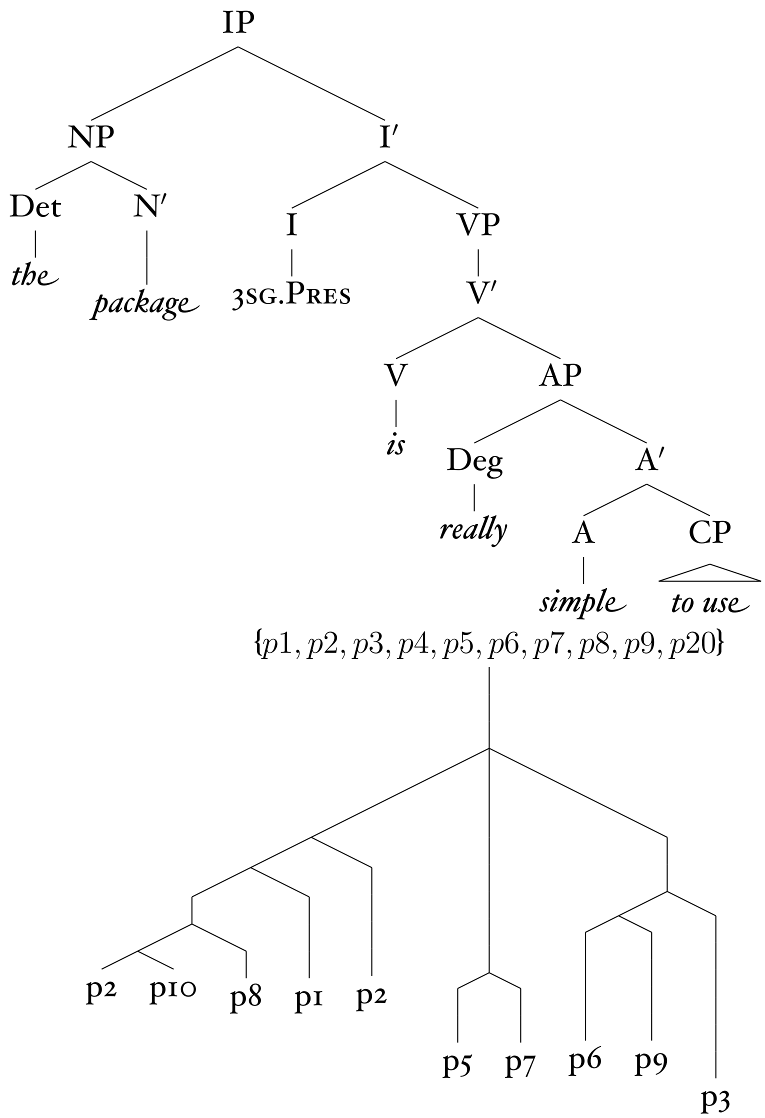
Question 3

Question 4

a

A distance matrix is given in Table 3

b


IP
NP
I′
Det
N′
I
VP
the
package
3sg.Pres
V′
V
AP
is
Deg
A′
really
A
CP
simple
to use
{p1, p2, p3, p4, p5, p6, p7, p8, p9, p20}
p2
p10
p8
p1
p2
p5
p7
p6
p9
p3

c

d

e

Question 5

1

The substrings were taken from crYsubset.fa. I generated random 'slices' of this text of length 100 characters 500 times to generate the data below.

2

3

Question 6: Programming exercise

```
PalindromeSearch(text)
"""Find & return all palindrome strings in a text"""

palindromes = [ ]

for n in len(text)
   if nth char in text equals (n+1)^{th} char
      palindromes ← PalindromeBuild(n, n+1, text)
   if nth char in text equals (n+2)^{th} char
      palindromes ← PalindromeBuild(n, n+2, text)

return palindromes


PalindromeBuild(start, stop, text)
"""Takes the start and stop positions of a palindrome in a text.
   Extends palindrome found between start and stop, if possible, and
   returns longest palindrome found"""
if text[start-1] == text[stop+1]
   PalindromeBuild(start-1,stop-1)
else
   return text[start:stop]
```

Figure 1: An algorthm to find all palindromes in a text in O(n) on the length of the text.

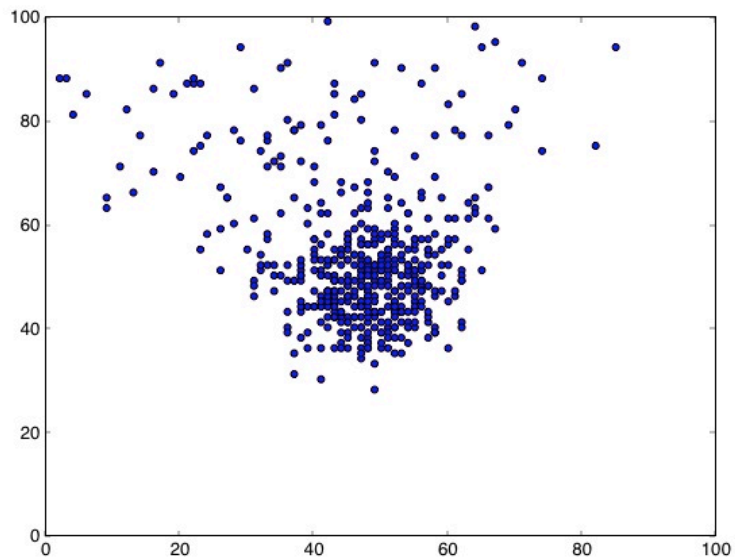


Figure 2: A scatter plot of runs in random 100 character subsequences, untransformed (x axis) and BW Transformed (y axis).