COMP 301 Analysis of Algorithms
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Lab Assignment 9

Introduction

In this lab you will compare two permutation algorithms and analyze whether the distribution of the permutations produced is uniform or not. Submit your answers to the questions below in a text file (e.g. Word document). Name your file in name_surname.docx format. Submit your solution document and Java codes as a compressed folder (.zip, .rar) in name_surname format to Canvas.

You can use the code templates in `permute.java` in this lab.

Problem Statement

Given an array of integers permute the numbers in this array. Analyze the output distribution of permutation algorithms.

Assignment

1. (a) Implement a Java method for the RANDOMIZE-IN-PLACE algorithm given below.

RANDOMIZE-IN-PLACE(A)
1   $n = A.length$
2   for $i = 1$ to n
3   swap $A[i]$ with $A[\text{RANDOM}(i, n)]$

(b) Test your algorithm by choosing an array of size 10. Initialize your array by random numbers from 0 to 99. Make sure your program permutes the numbers. Include a sample of 5 output permutations produced by this method in your report.

2. (a) Implement a Java method for the PERMUTE-WITH-ALL algorithm given below.

PERMUTE-WITH-ALL(A)
1   $n = A.length$
2   for $i = 1$ to n
3   swap $A[i]$ with $A[\text{RANDOM}(1, n)]$

(b) Test your algorithm by choosing an array of size 10. Initialize your array by random numbers from 0 to 99. Make sure your program permutes the numbers. Include a sample of 5 output permutations produced by this method in your report.

3. Choose the input array size as 4. Initialize your array to include numbers 1,2,3,4 in this order.

(a) Repeatedly call RANDOMIZE-IN-PLACE 24000 times and include the number of times you receive each permutation to the table below. Write a code that performs these computations automatically.

(b) Repeatedly call PERMUTE-WITH-ALL 24000 times and include the number of times you receive each permutation to the table below. Write a code that performs these computations automatically.

Permutation index	Permutation	RANDOMIZE-IN-PLACE	PERMUTE-WITH-ALL
0	1234	1015	1020
1	1243	1027	1068
2	1324	953	999
3	1342	974	945
4	1423	1060	968
5	1432	1013	1019
6	2134	1021	1029
7	2143	1020	995
8	2314	1008	966
9	2341	1037	968
10	2413	968	1018
11	2431	1038	976
12	3124	952	1047
13	3142	937	1021

14	3214	1021	988
15	3241	999	936
16	3412	963	987
17	3421	980	1018
18	4123	998	1025
19	4132	907	977
20	4213	1023	948
21	4231	1015	1017
22	4312	1041	1063
23	4321	1030	1002

(c) Can you see approximately equal frequencies for RANDOMIZE-IN-PLACE (i.e. are they all around 1000)? Can you say that the distribution of permutations produced by RANDOMIZE-IN-PLACE is close to uniform?

(d) Do you see different frequencies for PERMUTE-WITH-ALL? Can you say that the distribution of permutations produced by PERMUTE-WITH-ALL is not close to uniform?

c) If we look at the results, we can see that numbers are close to 1000 and we can conclude as RANDOMIZE-IN-PLACE makes permutations which are close to uniform.

d) If we look at the results , we can see that PERMUTE-WITH-ALL permutations close to uniform but in theory, it shouldn't be like that. In this example, we can see that sometimes experiment creates a result which is the opposite of the theory. Maybe if we change the size of array PERMUTE-WITH-ALL would not close to uniform but in this question array size was 4 and I used that information.

1.(b)
Original array:
[82, 96, 65, 36, 18, 68, 33, 70, 26, 49]
Permutation 1
[82, 65, 18, 68, 70, 33, 36, 26, 49, 96]
Permutation 2
[36, 96, 82, 65, 33, 70, 49, 26, 68, 18]
Permutation 3
[82, 96, 33, 18, 36, 26, 70, 65, 68, 49]
Permutation 4
[70, 68, 18, 82, 96, 49, 33, 65, 36, 26]
Permutation 5
[68, 65, 49, 82, 70, 36, 18, 33, 26, 96]

2.(b)
Original array:
[95, 0, 49, 0, 2, 14, 18, 76, 77, 29]
Permutation 1
[77, 0, 49, 0, 14, 76, 2, 18, 29, 95]
Permutation 2
[0, 2, 18, 76, 0, 77, 14, 29, 95, 49]
Permutation 3
[18, 76, 49, 0, 14, 77, 95, 29, 0, 2]
Permutation 4
[14, 0, 29, 0, 2, 49, 18, 76, 95, 77]
Permutation 5
[0, 77, 0, 95, 76, 14, 29, 18, 49, 2]