**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.

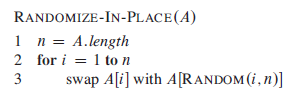
You can use the code templates in permute.java in this lab.

**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.

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(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.

array:

[61, 79, 71, 2, 91, 82, 1, 68, 7, 58]

randomize sample1:

[79, 7, 61, 58, 71, 1, 82, 91, 68, 2]

randomize sample2:

[91, 68, 7, 71, 61, 1, 82, 79, 2, 58]

randomize sample3:

[68, 79, 61, 58, 91, 1, 7, 2, 71, 82]

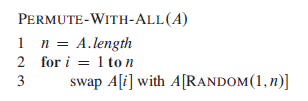
randomize sample4:

[68, 79, 2, 71, 91, 61, 1, 58, 82, 7]

randomize sample5:

[1, 68, 61, 82, 71, 58, 2, 91, 79, 7]

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

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(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.

permute sample1:

[2, 68, 82, 71, 91, 61, 1, 7, 58, 79]

permute sample2:

[82, 61, 58, 7, 68, 1, 79, 2, 91, 71]

permute sample3:

[7, 2, 82, 79, 61, 71, 58, 91, 1, 68]

permute sample4:

[91, 2, 58, 1, 7, 61, 82, 79, 68, 71]

permute sample5:

[82, 71, 61, 2, 7, 58, 1, 79, 68, 91]

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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 | 1029 | 940 |
| 1 | 1243 | 1015 | 934 |
| 2 | 1324 | 1003 | 931 |
| 3 | 1342 | 977 | 1316 |
| 4 | 1423 | 1043 | 1071 |
| 5 | 1432 | 1012 | 781 |
| 6 | 2134 | 995 | 956 |
| 7 | 2143 | 999 | 1443 |
| 8 | 2314 | 1005 | 1320 |
| 9 | 2341 | 923 | 1349 |
| 10 | 2413 | 962 | 1060 |
| 11 | 2431 | 992 | 1055 |
| 12 | 3124 | 1041 | 1025 |
| 13 | 3142 | 997 | 993 |
| 14 | 3214 | 1006 | 909 |
| 15 | 3241 | 972 | 974 |
| 16 | 3412 | 1020 | 1013 |
| 17 | 3421 | 1000 | 956 |
| 18 | 4123 | 1013 | 792 |
| 19 | 4132 | 987 | 845 |
| 20 | 4213 | 997 | 810 |
| 21 | 4231 | 1009 | 769 |
| 22 | 4312 | 1009 | 874 |
| 23 | 4321 | 994 | 884 |

(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?

Yes. Yes, for the RANDOMIZE-IN-PLACE they are around 1000.

(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?

Yes. Yes, for the PERMUTE-WITH-ALL they are around 1000 but far then RANDOMIZE-IN-PLACE results.