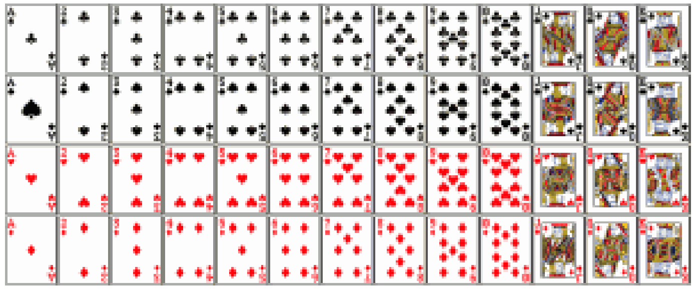
Shuffle a given array

Given an array, write a program to generate a random permutation of array elements. This question is also asked as “shuffle a deck of cards” or “randomize a given array”.



Let the given array be *arr[]*. A simple solution is to create an auxiliary array *temp[]* which is initially a copy of *arr[]*. Randomly select an element from *temp[]*, copy the randomly selected element to *arr[0]* and remove the selected element from *temp[]*. Repeat the same process n times and keep copying elements to *arr[1], arr[2], … .* The time complexity of this solution will be O(n^2).

Fisher–Yates shuffle Algorithm works in O(n) time complexity. The assumption here is, we are given a function rand() that generates random number in O(1) time.
The idea is to start from the last element, swap it with a randomly selected element from the whole array (including last). Now consider the array from 0 to n-2 (size reduced by 1), and repeat the process till we hit the first element.

Following is the detailed algorithm

```
To shuffle an array a of n elements (indices 0..n-1):
  for i from n - 1 downto 1 do
```

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```
        j = random integer with 0 <= j <= i
        exchange a[j] and a[i]
```

Following is C++ implementation of this algorithm.

```
// C Program to shuffle a given array

#include <stdio.h>
#include <stdlib.h>
#include <time.h>

// A utility function to swap to integers
void swap (int *a, int *b)
{
    int temp = *a;
    *a = *b;
    *b = temp;
}

// A utility function to print an array
void printArray (int arr[], int n)
{
    for (int i = 0; i < n; i++)
        printf("%d ", arr[i]);
    printf("\n");
}

// A function to generate a random permutation of arr[]
void randomize ( int arr[], int n )
{
    // Use a different seed value so that we don't get same
    // result each time we run this program
    srand ( time(NULL) );

    // Start from the last element and swap one by one. We don't
    // need to run for the first element that's why i > 0
    for (int i = n-1; i > 0; i--)
    {
        // Pick a random index from 0 to i
        int j = rand() % (i+1);

        // Swap arr[i] with the element at random index
        swap(&arr[i], &arr[j]);
    }
}
```

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```
// Driver program to test above function.
int main()
{
    int arr[] = {1, 2, 3, 4, 5, 6, 7, 8};
    int n = sizeof(arr)/ sizeof(arr[0]);
    randomize (arr, n);
    printArray(arr, n);

    return 0;
}
```

Output:

```
7 8 4 6 3 1 2 5
```

The above function assumes that rand() generates a random number.

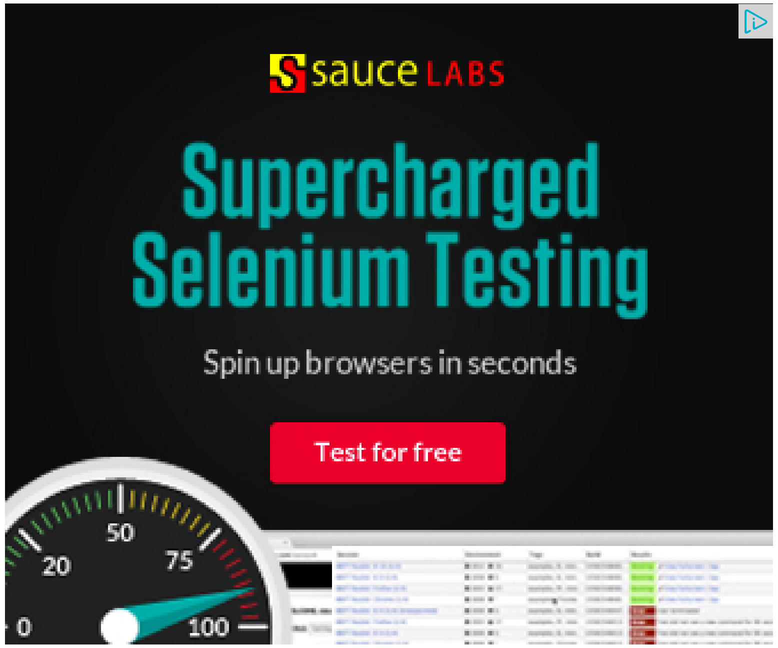
Time Complexity: O(n), assuming that the function rand() takes O(1) time.

How does this work?
The probability that ith element (including the last one) goes to last position is 1/n, because we randomly pick an element in first iteration.

The probability that ith element goes to second last position can be proved to be 1/n by dividing it in two cases.
Case 1: i = n-1 (index of last element):
The probability of last element going to second last position is = (probability that last element doesn't stay at its original position) x (probability that the index picked in previous step is picked again so that the last element is swapped)
So the probability = ((n-1)/n) x (1/(n-1)) = 1/n
Case 2: 0 < i < n-1 (index of non-last):
The probability of ith element going to second position = (probability that ith element is not picked in previous iteration) x (probability that ith element is picked in this iteration)
So the probability = ((n-1)/n) x (1/(n-1)) = 1/n

We can easily generalize above proof for any other position.

Please write comments if you find anything incorrect, or you want to share more information about the topic discussed above.



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Manni • 2 months ago

Manni's probabilistic approach:

Select 2 random number between 0-n, swap the two elements at the the inde
Repeat the step n/2 times atleast. Contact Manpreet Singh, NIT Durgapur for r

https://www.facebook.com/manpr...

1

Ankur Jain • 3 months ago

Q1 why mod we take mod rand() % (i+1);and not like rand() % (n) ?
Q2 and why didn't take the element at zeroth index ?

alien ➦ Ankur Jain • a month ago

A1: because once you have shuffled nth element, dont replace it again
A2: with what will you replace 0th element with?

Ankur Jain ➦ alien • a month ago

Q1 comment : in the above solution you are swapping with its l
position is only replace with 0,1,2,3,4 and why cant 6 th ,7th , th

Q2 comment : as 0th element is only replace when rand fun gi
for i 0 to n
j=rand()%n;
shuffle the whole array in equal proportion

Sumit Gera • 11 months ago

How did we arrive at the probability for I = n - 1 case?

K.kaushik • 11 months ago

A simple java implementation of the above program with O(n) time complexity

```
public class Shuffle {

        public static int randomize(int min, int max)
        {
                        return (int) (Math.random() * (max-min+1) + m:
        }

        public static void shuffleCards(int cards[],  int n)
        {
                        int i;

                        for(i = 0; i < n; i++)
                        {
                                int j = randomize(i, n-1-i);
```

see more

Poorvank Bhatia • a year ago

why don&#039t we need to run it for the first element?

Poorvank Bhatia • a year ago

why don&#039t we need to run it for the first element?

Praveen · 2 years ago

Also a better explanation is here - http://bost.ocks.org/mike/shuf...

Mahesh · 2 years ago

Can you explain how the first case is order n^2 ?

Kartik ➦ Mahesh · 2 years ago

In first method, we need to remove the selected element from temp. R
c(m-1) time where m is the number of elements in temp[] and c is a cc
2 + ... 1)c = O(n^2)

Ishant Gaurav ➦ Kartik · a year ago

```
class Main
{
public static void main (String[] args) throws java.lang.Exceptio
{
int a[]={0,1,2,3,4,5,6,7,8,9};
int randarray[]=new int[10];
int flag[] = new int[10];
for(int i=0;i<10;i++)
{
randarray[i]=a[i];
}
SecureRandom rand = new SecureRandom();

int i=0;
while(i<=9)
```

{
int num = rand.nextInt(10);
if(i<=9 && flag[num]==0)

see more

Ishant Gaurav Ishant Gaurav • a year ago

I have wrritten acc to first method suggested by geeks f
complexity is o(n*2). Can u plz suggest if m wrong som

raj Ishant Gaurav • a year ago

In First method..
instead of removing selected element and then moving
to left by 1...we can just simply swap it with the last eler
As a result first algorithm will also be 0(n) time..

GeeksforGeeks • 2 years ago

@V: Thanks for the suggestion. We have added srand(time(NULL)) to the orig

@Apeirogon: Thanks for the inputs. We have added a comment before 'for' lo
last only as it makes the program more readable and matches with the standa

V • 2 years ago

You need to call srand(time(NULL)) before your call to randomize() otherwise
on each program execution.

```
/* Paste your code here (You may delete these lines if not writing co
```

Aish • 2 years ago

Hi,

It appears like the same output is generated each time when I try executing the

Output:
3 6 4 7 1 5 8 2

Is there any way by which we can get differnet set of array output each time?

```
/* Paste your code here (You may delete these lines if not writing c
```

adarsh Aish • 2 years ago

```
you must have forgot to write srand() function
```

Apeirogon • 2 years ago

It is a C implementation and not C++ implementation as stated in the post.

The loop iteration in randomize function need not be in reverse order, it is bett

When the code leaves out one iteration, write a comment about the same.

```
void randomize (int *a, int n) {
  for (int i = 0; i < n - 1; i++) { // off-by-one intentional, we do
  swap  (&a[i], &a[i + rand()%(n - i)];
}
```

Rajeev · 2 years ago

Nice

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