
Subject: Re: Randomize array order

Posted by [Vince Hradil](#) on Wed, 25 Jul 2007 19:59:14 GMT

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On Jul 25, 2:17 pm, Conor <cmanc...@gmail.com> wrote:

> Hi everyone!

>

> Anyone know an efficient way to randomize an array (I have a
> sorted array that I want unsorted). Initially, I tried something like
> this:

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> array = findgen(1000000)

> unsort = array[sort(randomu(seed,1000000))]

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> It works, but sorting on a million elements is rather slow. Anyone
> know a faster way?

Takes about 0.87 seconds on my machine? Is this too long?

Of course, if you want "with replacement" you could do:

unsort = array[long(1000000*randomu(seed,1000000))]

But you probably want a permutation, right? That'll be more difficult.

Subject: Re: Randomize array order

Posted by [Conor](#) on Thu, 26 Jul 2007 12:24:55 GMT

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On Jul 25, 3:59 pm, hradilv <hrad...@yahoo.com> wrote:

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> Of course, if you want "with replacement" you could do:

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> But you probably want a permutation, right? That'll be more difficult.

It takes about 3 seconds on my machine (really crappy machine). The whole program takes about 6 seconds, so about half the program execution comes from the one sort statement. This is going to execute somewhere between 1000 and 10,000 times, so losing three seconds will save me between 50 minutes and 8 hours. Yeah, I need a permutation. Losing or repeating elements would be bad. It's always got to be the hard way, doesn't it :)

Subject: Re: Randomize array order
Posted by [Conor](#) on Thu, 26 Jul 2007 12:28:46 GMT
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On Jul 25, 3:59 pm, hradilv <hrad...@yahoo.com> wrote:
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> Of course, if you want "with replacement" you could do:
> unsort = array[long(1000000*randomu(seed,1000000))]
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> But you probably want a permutation, right? That'll be more difficult.

You know, it's a shame that sort and histogram don't make use of the thread pool. If there were any algorithms that need to be multi-threaded, those would be it. Oh well :(

Subject: Re: Randomize array order
Posted by [mattf](#) on Thu, 26 Jul 2007 12:50:25 GMT
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On Jul 25, 3:17 pm, Conor <cmanc...@gmail.com> wrote:

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> know a faster way?

I think this is one of those vectorization cases where you have a trade-off between processor time and memory-- the one 'obvious' faster way that occurs to me is to pre-compute a sequence of a few billion random integers-- and then just select sub-sequences as needed. It's possible that there's some intermediate strategy that's not quite so extravagantly wasteful of memory.

Subject: Re: Randomize array order

Posted by [Brian Larsen](#) on Thu, 26 Jul 2007 13:04:19 GMT

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for the without replacement see http://www.dfanning.com/code_tips/randomindex.html
I have written a resample with and without replacement routine based on this and it works fine.

Cheers,

Brian

Brian Larsen
Boston University
Center for Space Physics

Subject: Re: Randomize array order

Posted by [Brian Larsen](#) on Thu, 26 Jul 2007 13:06:21 GMT

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Brian Larsen
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Subject: Re: Randomize array order
Posted by [Allan Whiteford](#) on Thu, 26 Jul 2007 13:30:00 GMT
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Conor,

Is it a million elements you want to do?

The following scales better:

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pro shuffle,in  
  b=long(n_elements(in)*randomu(seed,n_elements(in)))  
  for i=0l,n_elements(in)-1 do begin  
    tmp=in[i]  
    in[i]=in[b[i]]  
    in[b[i]]=tmp  
  end  
end
```

but on my machine, a million elements is around about where it starts to become as efficient as yours. For 10 million elements the above is a bit (17.05 seconds vs 12.92 seconds) but for 1 million elements they both come in at around 1.2 seconds (1.15 seconds vs 1.26 seconds). The above will scale as pretty much $O(n)$ since it doesn't do any sorting but it

takes a hit in the practical implementation because of the loop in IDL-space. Your suggestion will scale worse than $O(n)$ but it seems the overlap in the two methods is exactly where you want to work.

Maybe my loop can be made more efficient in practical terms but I don't think this is any better algorithm in terms of scaling (hard to imagine anything that could go faster than $O(n)$ to randomise n things).

Probably not helpful but I thought it was interesting that the cross-over is exactly where you want to work. But, maybe I should get out more if I think that's especially interesting.

Thanks,

Allan

Subject: Re: Randomize array order
Posted by [Conor](#) on Thu, 26 Jul 2007 13:40:56 GMT
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On Jul 26, 9:30 am, Allan Whiteford
<allan.rem...@phys.remove.strath.ac.remove.uk> wrote:
> Conor wrote:
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> out more if I think that's especially interesting.
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> Thanks,
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> Allan

Thanks for the suggestions guys! I'll have to play around and see what works best.

Subject: Re: Randomize array order
Posted by [Vince Hradil](#) on Thu, 26 Jul 2007 14:58:19 GMT
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On Jul 26, 8:40 am, Conor <cmanc...@gmail.com> wrote:

> On Jul 26, 9:30 am, Allan Whiteford
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> <allan.rem...@phys.remove.strath.ac.remove.uk> wrote:
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Here's a table of results from my machine. All times are in seconds.
PC single processor, WinXP, IDL6.4

i	Niter	Rand-meth	Loop-meth
0	100000	0.0929999	0.110000
1	166810	0.0779998	0.0940001

2	278256	0.140000	0.157000
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7	3593812	3.84400	2.56300
8	5994841	7.09400	4.31300
9	10000000	13.0470	7.29800

Here's my code:

```

function runsort, array
  na = n_elements(array)
  return, array[sort(randomu(seed,na))]
end

function lunsort, array
  na = n_elements(array)
  rarray = array

  b = long(na*randomu(seed,na))
  for i=0l, na-1 do begin
    tmp = rarray[i]
    rarray[i] = rarray[b[i]]
    rarray[b[i]] = tmp
  endfor

  return, rarray
end

pro test_unsort, randi=randi, loopi=loopi, nel=nel

  n = 10l
  nlo = 5l
  nhi = 7l
  fndx = findgen(n)/float(n-1)
  nel = long(10^( (nhi-nlo)*fndx + nlo ) )

  randi = fltarr(n)
  loopi = fltarr(n)
  for i=0l, n-1 do begin
    array = findgen(nel[i])
    t = systime(1)
    unsort = runsort(array)
    randi[i] = systime(1)-t

    t = systime(1)
    unsort = lunsort(array)
  endfor

```

```
loopi[i] = systime(1)-t

print, i, nel[i], randi[i], loopi[i]
endfor

return
end
```

Subject: Re: Randomize array order
Posted by [Vince Hradil](#) on Thu, 26 Jul 2007 15:13:36 GMT
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```

More details: Single Intel 1.86GHz, 2Gb RAM

Other machine: Sun Blade 2500 - Solaris 9, IDL 6.3 - Dual processor,
2Gb RAM

i	Niter	Rand-meth	Loop-meth
0	100000	0.112775	0.218330
1	166810	0.194601	0.370555

2	278256	0.369679	0.621675
3	464158	0.700207	1.05355
4	774263	1.32646	1.74441
5	1291549	2.42519	2.95356
6	2154435	4.38822	4.91093
7	3593812	8.63800	8.35843
8	5994841	15.6409	13.9243
9	10000000	28.9150	23.6173

Interesting, there's a crossover at ~ 3,000,000 where the loop method starts to win.

Subject: Re: Randomize array order

Posted by [Allan Whiteford](#) on Thu, 26 Jul 2007 15:49:13 GMT

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> Interesting, there's a crossover at ~ 3,000,000 where the loop method
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```

Here's what I get on a dual core 3GHz Pentium 4 with 2GB of RAM running Linux (FC4) using IDL6.2:

i	Niter	Rand-meth	Loop-meth
0	100000	0.0818000	0.120713
1	166810	0.140054	0.205111
2	278256	0.255531	0.340111
3	464158	0.462941	0.572567
4	774263	0.835279	0.973762
5	1291549	1.53649	1.71803
6	2154435	3.08281	2.83829
7	3593812	5.27431	4.71084
8	5994841	10.6316	7.85549
9	10000000	17.4706	13.6622

kind of annoying that your 1.8GHz machine running windows goes faster than my 3GHz running Linux. Not as bad as how slow the Sun goes though.

Incidentally, previously I was quoting raw CPU times rather than the wall clock times which your routine prints out.

Thanks,

Allan

Subject: Re: Randomize array order

Posted by [Conor](#) on Thu, 26 Jul 2007 16:22:27 GMT

[View Forum Message](#) <> [Reply to Message](#)

On Jul 26, 11:49 am, Allan Whiteford

<allan.rem...@phys.remove.strath.ac.remove.uk> wrote:

> hradilv wrote:

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>      i      Niter  Rand-meth  Loop-meth
>      0    100000  0.0818000  0.120713
>      1    166810  0.140054  0.205111
>      2    278256  0.255531  0.340111
>      3    464158  0.462941  0.572567
>      4    774263  0.835279  0.973762
>      5   1291549  1.53649   1.71803
>      6   2154435  3.08281   2.83829
>      7   3593812  5.27431   4.71084
>      8   5994841 10.6316   7.85549
>      9 10000000 17.4706  13.6622
>
> kind of annoying that your 1.8GHz machine running windows goes faster
> than my 3GHz running Linux. Not as bad as how slow the Sun goes though.
>
> Incidentally, previously I was quoting raw CPU times rather than the
> wall clock times which your routine prints out.
>
> Thanks,
>
> Allan

```

Here's what I get running it on my super old computer:

0	100000	0.231639	0.266472
1	166810	0.429814	0.450388
2	278256	0.768671	0.777250
3	464158	1.40014	1.29011
4	774263	2.55367	2.15114
5	1291549	4.66570	3.60980
6	2154435	8.48878	6.04430
7	3593812	15.3753	10.1437
8	5994841	29.2131	20.1072
9	10000000	52.2718	29.7969

Subject: Re: Randomize array order
 Posted by [David Streutker](#) on Thu, 26 Jul 2007 16:57:31 GMT

How about a Knuth shuffle?

(Disclaimer: I'm not a statistician; I just found it on Wikipedia.)

```
function kunsort, array
  na = n_elements(array)
  random = randomu(seed,na) * (na - array - 1) + array
  for i=0L,na-2 do array[i] = array[random[i]]
  return, array
end
```

Added to Vince's code (last column):

0	100000	0.0619998	0.0780001	0.0320001
1	166810	0.125000	0.125000	0.0780001
2	278256	0.282000	0.218000	0.141000
3	464158	0.547000	0.406000	0.235000
4	774263	1.07800	0.657000	0.390000
5	1291549	1.93700	1.09400	0.703000
6	2154435	3.51500	1.89100	1.20300
7	3593812	6.34400	3.11000	1.98400
8	5994841	11.5470	5.21800	3.36000
9	10000000	20.3750	8.67200	5.60900

Windows XP, dual 2.66 GHz, 3 GB RAM, IDL 6.3

Subject: Re: Randomize array order

Posted by [Vince Hradil](#) on Thu, 26 Jul 2007 20:32:39 GMT

[View Forum Message](#) <> [Reply to Message](#)

On Jul 26, 11:57 am, David Streutker <dstreut...@gmail.com> wrote:

> How about a Knuth shuffle?

>

> (Disclaimer: I'm not a statistician; I just found it on Wikipedia.)

>

> function kunsort, array

> na = n_elements(array)

> random = randomu(seed,na) * (na - array - 1) + array

> for i=0L,na-2 do array[i] = array[random[i]]

> return, array

> end

>

> Added to Vince's code (last column):

>

> 0 100000 0.0619998 0.0780001 0.0320001

```

>      1  166810  0.125000  0.125000  0.0780001
>      2  278256  0.282000  0.218000  0.141000
>      3  464158  0.547000  0.406000  0.235000
>      4  774263  1.07800  0.657000  0.390000
>      5 1291549  1.93700  1.09400  0.703000
>      6 2154435  3.51500  1.89100  1.20300
>      7 3593812  6.34400  3.11000  1.98400
>      8 5994841 11.5470  5.21800  3.36000
>      9 10000000 20.3750  8.67200  5.60900
>
> Windows XP, dual 2.66 GHz, 3 GB RAM, IDL 6.3

```

I'm not sure, but I think that will give you "with replacement".

Subject: Re: Randomize array order

Posted by [David Streutker](#) on Thu, 26 Jul 2007 21:27:33 GMT

[View Forum Message](#) <> [Reply to Message](#)

On Jul 26, 2:32 pm, hradilv <hrad...@yahoo.com> wrote:

> On Jul 26, 11:57 am, David Streutker <dstreut...@gmail.com> wrote:

>

>

>

>> How about a Knuth shuffle?

>

>> (Disclaimer: I'm not a statistician; I just found it on Wikipedia.)

>

>> function kunsort, array

>> na = n_elements(array)

>> random = randomu(seed,na) * (na - array - 1) + array

>> for i=0L,na-2 do array[i] = array[random[i]]

>> return, array

>> end

>

>> Added to Vince's code (last column):

>

>> 0 100000 0.0619998 0.0780001 0.0320001

>> 1 166810 0.125000 0.125000 0.0780001

>> 2 278256 0.282000 0.218000 0.141000

>> 3 464158 0.547000 0.406000 0.235000

>> 4 774263 1.07800 0.657000 0.390000

>> 5 1291549 1.93700 1.09400 0.703000

>> 6 2154435 3.51500 1.89100 1.20300

>> 7 3593812 6.34400 3.11000 1.98400

>> 8 5994841 11.5470 5.21800 3.36000

>> 9 10000000 20.3750 8.67200 5.60900

>

```
>> Windows XP, dual 2.66 GHz, 3 GB RAM, IDL 6.3
>
> I'm not sure, but I think that will give you "with replacement".
```

You're right, I wasn't swapping. Corrected, and in the form of Allan's method:

```
function kunsort, array
  na = n_elements(array)
  rarray = array

  b = randomu(seed,na-1) * (na - lindgen(na-1) - 1) + lindgen(na-1)
  for i=0L,na-2 do begin
    tmp = rarray[i]
    rarray[i] = rarray[b[i]]
    rarray[b[i]] = tmp
  endfor

  return, rarray
end
```

With the change, it's slightly slower than Allan's. However, for what it's worth, there are claims this is a less biased method. (Again, I am no expert. But the recent poker craze seems to have revived interest in the probabilities of shuffling.)

Subject: Re: Randomize array order
Posted by [Allan Whiteford](#) on Fri, 27 Jul 2007 09:33:30 GMT
[View Forum Message](#) <> [Reply to Message](#)

David Streutker wrote:

```
> On Jul 26, 2:32 pm, hradilv <hrad...@yahoo.com> wrote:
>
>> On Jul 26, 11:57 am, David Streutker <dstreut...@gmail.com> wrote:
>>
>>
>>
>>
>>> How about a Knuth shuffle?
>>
>>> (Disclaimer: I'm not a statistician; I just found it on Wikipedia.)
>>
>>> function kunsort, array
>>>   na = n_elements(array)
>>>   random = randomu(seed,na) * (na - array - 1) + array
>>>   for i=0L,na-2 do array[i] = array[random[i]]
>>>   return, array
```

```

>>> end
>>
>>> Added to Vince's code (last column):
>>
>>>      0    100000  0.0619998  0.0780001  0.0320001
>>>      1    166810  0.125000  0.125000  0.0780001
>>>      2    278256  0.282000  0.218000  0.141000
>>>      3    464158  0.547000  0.406000  0.235000
>>>      4    774263  1.07800  0.657000  0.390000
>>>      5   1291549  1.93700  1.09400  0.703000
>>>      6   2154435  3.51500  1.89100  1.20300
>>>      7   3593812  6.34400  3.11000  1.98400
>>>      8   5994841 11.5470  5.21800  3.36000
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>>
>>> Windows XP, dual 2.66 GHz, 3 GB RAM, IDL 6.3
>>
>> I'm not sure, but I think that will give you "with replacement".
>
>
> You're right, I wasn't swapping. Corrected, and in the form of
> Allan's method:
>
> function kunsort, array
>   na = n_elements(array)
>   rarray = array
>
>   b = randomu(seed,na-1) * (na - lindgen(na-1) - 1) + lindgen(na-1)
>   for i=0L,na-2 do begin
>     tmp = rarray[i]
>     rarray[i] = rarray[b[i]]
>     rarray[b[i]] = tmp
>   endfor
>
>   return, rarray
> end
>
> With the change, it's slightly slower than Allan's. However, for what
> it's worth, there are claims this is a less biased method. (Again, I
> am no expert. But the recent poker craze seems to have revived
> interest in the probabilities of shuffling.)
>

```

Yours is doing a bit more than mine was in that it's creating a copy of the original data rather than in-place swapping so that would make yours a bit slower (but probably more useful). You can probably also get a speed up by converting "b" to a long at creation time rather than implicitly every time you use it.

Looking over what a Knuth Shuffle is supposed to do, it seems that you're only supposed to swap with an element you've not already passed over; my code didn't do this but yours does. I guess Knuth is smarter than me :). Although, I tend to not believe anything which appears on Wikipedia.

However, in your code, it looks like the "na-1" in the creation of "b" and the "na-2" in the loop will mean that the last element of the array never gets swapped.

Thanks,

Allan

Subject: Re: Randomize array order

Posted by [Allan Whiteford](#) on Fri, 27 Jul 2007 12:03:34 GMT

[View Forum Message](#) <> [Reply to Message](#)

Conor wrote:

> Hi everyone!

>

> Anyone know an efficient way to randomize an array (I have a
> sorted array that I want unsorted). Initially, I tried something like
> this:

>

> array = findgen(1000000)

> unsort = array[sort(randomu(seed,1000000))]

>

> It works, but sorting on a million elements is rather slow. Anyone
> know a faster way?

>

Slightly different point and probably a bit academic:

If you have a million elements then you have 1000000! (i.e. one million factorial) different ways to re-order the data. However, your seed is a 4 byte integer which can only take 2^{32} different values.

Some messing about suggests that:

$1000000! \approx 10^{5568636}$

which means there are $\sim 10^{5568636}$ different ways to re-arrange your elements as opposed to the 4×10^9 values your seed can take.

Thus, using any of the algorithms suggested you're only going to sample

$10^{-5568625} \%$

of the possible values. This is a really small number. It means that no matter how hard you try and how many times you do things you'll never be able to access anything but a tiny number of the possibilities without doing multiple shufflings - I think it's something like 618737 sub-shufflings (i.e. $5568636 / 9$) but that could be wrong. However, that requires producing 618737 seeds per major-shuffle (and you can't use a generator based on a 4 byte seed to produce these seeds).

But, since you're only going to be running the code 1000-10,000 times (which is much smaller than $4e9$) I guess everything will be ok. I don't know if anyone has studied possible correlations of results as a function of the very small number of seeds (compared to the data), whatever random number generator is used and the shuffling method. Presumably they have and presumably everything is ok. Does anyone know?

Thanks,

Allan

Subject: Re: Randomize array order
Posted by [Paolo Grigis](#) on Fri, 27 Jul 2007 13:59:08 GMT
[View Forum Message](#) <> [Reply to Message](#)

Allan Whiteford wrote:

```
> Conor wrote:
>> Hi everyone!
>>
>>   Anyone know an efficient way to randomize an array (I have a
>> sorted array that I want unsorted). Initially, I tried something like
>> this:
>>
>> array = findgen(1000000)
>> unsort = array[sort(randomu(seed,1000000))]
>>
>> It works, but sorting on a million elements is rather slow. Anyone
>> know a faster way?
>>
>
> Slightly different point and probably a bit academic:
>
> If you have a million elements then you have 1000000! (i.e. one million
> factorial) different ways to re-order the data. However, your seed is a
> 4 byte integer which can only take  $2^{32}$  different values.
>
```

> Some messing about suggests that:
>
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>
> which means there are $\sim 10^{5568636}$ different ways to re-arrange your
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>
> Thus, using any of the algorithms suggested you're only going to sample
>
> $10^{-5568625} \%$
>
> of the possible values. This is a really small number. It means that no
> matter how hard you try and how many times you do things you'll never be
> able to access anything but a tiny number of the possibilities without
> doing multiple shufflings - I think it's something like 618737
> sub-shufflings (i.e. $5568636 / 9$) but that could be wrong. However, that
> requires producing 618737 seeds per major-shuffle (and you can't use a
> generator based on a 4 byte seed to produce these seeds).
>
> But, since you're only going to be running the code 1000-10,000 times
> (which is much smaller than $4e9$)

I am by no means an expert, but I think that in general, common sense suggests not to use more random numbers for one project than the cycle length of the generator (that is, the length at which the numbers start to repeat themselves). From the docs is hard to guess how long the cycle is, but it can be at most 2^{32} for a generator using long ints. So I wouldn't suggest doing more than $2^{32}/1d6$ runs of the code, if one is using 1d6 numbers per run.

If more random deviates are needed, it would be a good idea to use a random generator with a longer cycle.

Ciao,
Paolo

I guess everything will be ok. I don't
> know if anyone has studied possible correlations of results as a
> function of the very small number of seeds (compared to the data),
> whatever random number generator is used and the shuffling method.
> Presumably they have and presumably everything is ok. Does anyone know?

>
> Thanks,
>
> Allan

Subject: Re: Randomize array order

Posted by [David Streutker](#) on Fri, 27 Jul 2007 14:54:55 GMT

[View Forum Message](#) <> [Reply to Message](#)

On Jul 27, 6:03 am, Allan Whiteford

<allan.rem...@phys.remove.strath.ac.remove.uk> wrote:

> Conor wrote:

>> Hi everyone!

>

>> Anyone know an efficient way to randomize an array (I have a
>> sorted array that I want unsorted). Initially, I tried something like
>> this:

>

>> array = findgen(1000000)

>> unsort = array[sort(randomu(seed,1000000))]

>

>> It works, but sorting on a million elements is rather slow. Anyone
>> know a faster way?

>

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>

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> factorial) different ways to re-order the data. However, your seed is a
> 4 byte integer which can only take 2^{32} different values.

>

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>

> $1000000! \approx 10^{5568636}$

>

> which means there are $\sim 10^{5568636}$ different ways to re-arrange your
> elements as opposed to the 4×10^9 values your seed can take.

>

> Thus, using any of the algorithms suggested you're only going to sample

>

> $10^{-5568625} \%$

>

> of the possible values. This is a really small number. It means that no
> matter how hard you try and how many times you do things you'll never be
> able to access anything but a tiny number of the possibilities without
> doing multiple shufflings - I think it's something like 618737
> sub-shufflings (i.e. $5568636 / 9$) but that could be wrong. However, that
> requires producing 618737 seeds per major-shuffle (and you can't use a
> generator based on a 4 byte seed to produce these seeds).

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> But, since you're only going to be running the code 1000-10,000 times
> (which is much smaller than $4e9$) I guess everything will be ok. I don't
> know if anyone has studied possible correlations of results as a
> function of the very small number of seeds (compared to the data),
> whatever random number generator is used and the shuffling method.

> Presumably they have and presumably everything is ok. Does anyone know?
>
> Thanks,
>
> Allan

I'm not sure that I agree. Where in any of our algorithms are we unable to access a (theoretically) possible outcome? As long as we are able to randomly select any element of the array in each step, it should work, right? (I.e., as long as the input array has fewer than 2^{32} elements.) In your analysis, shouldn't we be using $(2^{32})^n$ for the maximum possible number of randomly generated combinations, where n is the number of steps/elements?

Also, in the Knuth method, the final element may or may not be swapped, depending on whether it is randomly selected for one of the previous swaps.

-David

Subject: Re: Randomize array order
Posted by [James Kuyper](#) on Fri, 27 Jul 2007 16:05:27 GMT
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David Streutker wrote:

> On Jul 27, 6:03 am, Allan Whiteford
...
>> If you have a million elements then you have 1000000! (i.e. one million
>> factorial) different ways to re-order the data. However, your seed is a
>> 4 byte integer which can only take 2^{32} different values.
>>
>> Some messing about suggests that:
>>
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>>
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>> of the possible values. This is a really small number. It means that no
>> matter how hard you try and how many times you do things you'll never be
>> able to access anything but a tiny number of the possibilities without
>> doing multiple shufflings - I think it's something like 618737
>> sub-shufflings (i.e. $5568636 / 9$) but that could be wrong. However, that

>> requires producing 618737 seeds per major-shuffle (and you can't use a
>> generator based on a 4 byte seed to produce these seeds).
>>
>> But, since you're only going to be running the code 1000-10,000 times
>> (which is much smaller than $4e9$) I guess everything will be ok. I don't
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>> function of the very small number of seeds (compared to the data),
>> whatever random number generator is used and the shuffling method.
>> Presumably they have and presumably everything is ok. Does anyone know?
>>
>> Thanks,
>>
>> Allan
>
> I'm not sure that I agree. Where in any of our algorithms are we
> unable to access a (theoretically) possible outcome? As long as we
> are able to randomly select any element of the array in each step, it
> should work, right? (I.e., as long as the input array has fewer than
> 2^{32} elements.) In your analysis, shouldn't we be using $(2^{32})^n$ for
> the maximum possible number of randomly generated combinations, where
> n is the number of steps/elements?

No, because the entire sequence of numbers is uniquely determined by initial internal state of the generator. If you knew the algorithm used, and the internal state, that's all the information you'd need to predict, precisely, the entire sequence of numbers generated, no matter how long that sequence was. If the internal state is stored in a 32 bit integer, that means there's only 2^{32} possible different sequences.

> From that fact, it can also be shown that every possible sequence must start repeating, exactly, with a period that is less than 2^{32} . If one of the possible sequences has starts repeating with a period T, then at least T-1 of the other possible sequences generate that same repeat cycle, with various shifts.

There's a reason why these things are called PSEUDO-random number generators.

Subject: Re: Randomize array order
Posted by [James Kuyper](#) on Fri, 27 Jul 2007 16:29:49 GMT
[View Forum Message](#) <> [Reply to Message](#)

Allan Whiteford wrote:

> David Streutker wrote:

>> On Jul 26, 2:32 pm, hradilv <hrad...@yahoo.com> wrote:

>>

>>> On Jul 26, 11:57 am, David Streutker <dstreut...@gmail.com> wrote:

>>>

>>>

>>>

>>>

>>>> How about a Knuth shuffle?

>>>

>>>> (Disclaimer: I'm not a statistician; I just found it on Wikipedia.)

>>>

>>>> function kunsort, array

>>>> na = n_elements(array)

>>>> random = randomu(seed,na) * (na - array - 1) + array

>>>> for i=0L,na-2 do array[i] = array[random[i]]

>>>> return, array

>>>> end

>>>

>>>> Added to Vince's code (last column):

>>>

>>>> 0 100000 0.0619998 0.0780001 0.0320001

>>>> 1 166810 0.125000 0.125000 0.0780001

>>>> 2 278256 0.282000 0.218000 0.141000

>>>> 3 464158 0.547000 0.406000 0.235000

>>>> 4 774263 1.07800 0.657000 0.390000

>>>> 5 1291549 1.93700 1.09400 0.703000

>>>> 6 2154435 3.51500 1.89100 1.20300

>>>> 7 3593812 6.34400 3.11000 1.98400

>>>> 8 5994841 11.5470 5.21800 3.36000

>>>> 9 10000000 20.3750 8.67200 5.60900

>>>

>>>> Windows XP, dual 2.66 GHz, 3 GB RAM, IDL 6.3

>>>

>>> I'm not sure, but I think that will give you "with replacement".

>>

>>

>> You're right, I wasn't swapping. Corrected, and in the form of

>> Allan's method:

>>

>> function kunsort, array

>> na = n_elements(array)

>> rarray = array

>>

>> b = randomu(seed,na-1) * (na - lindgen(na-1) - 1) + lindgen(na-1)

>> for i=0L,na-2 do begin

>> tmp = rarray[i]

>> rarray[i] = rarray[b[i]]

>> rarray[b[i]] = tmp

>> endfor

>>

```

>> return, rarray
>> end
>>
>> With the change, it's slightly slower than Allan's. However, for what
>> it's worth, there are claims this is a less biased method. (Again, I
>> am no expert. But the recent poker craze seems to have revived
>> interest in the probabilities of shuffling.)
>>
>
> Yours is doing a bit more than mine was in that it's creating a copy of
> the original data rather than in-place swapping so that would make yours
> a bit slower (but probably more useful). You can probably also get a
> speed up by converting "b" to a long at creation time rather than
> implicitly every time you use it.
>
> Looking over what a Knuth Shuffle is supposed to do, it seems that
> you're only supposed to swap with an element you've not already passed
> over; my code didn't do this but yours does. I guess Knuth is smarter
> than me :). Although, I tend to not believe anything which appears on
> Wikipedia.
>
> However, in your code, it looks like the "na-1" in the creation of "b"
> and the "na-2" in the loop will mean that the last element of the array
> never gets swapped.

```

As I understand it, I think that neither program correctly implements Knuth's algorithm. Here's my (minimally tested) attempt. I wrote it as an in-place shuffle, to save space:

```

PRO knuth_shuffle, array
  na = N_ELEMENTS(array)
  b = LONG((na+2-LINDGEN(na-1))*RANDOMU(seed, na-1))
  FOR i=na-1, 1, -1 DO BEGIN
    temp = array[b[i-1]]
    array[b[i-1]] = array[i]
    array[i] = temp
  ENDFOR
END

```

Subject: Re: Randomize array order
 Posted by [Conor](#) on Fri, 27 Jul 2007 16:44:53 GMT
[View Forum Message](#) <> [Reply to Message](#)

On Jul 27, 12:05 pm, kuyper <kuy...@wizard.net> wrote:
 > David Streutker wrote:
 >> On Jul 27, 6:03 am, Allan Whiteford
 > ...

```

>>> If you have a million elements then you have 1000000! (i.e. one million
>>> factorial) different ways to re-order the data. However, your seed is a
>>> 4 byte integer which can only take  $2^{32}$  different values.
>
>>> Some messing about suggests that:
>
>>>  $1000000! \approx 10^{5568636}$ 
>
>>> which means there are  $\sim 10^{5568636}$  different ways to re-arrange your
>>> elements as opposed to the  $4 \times 10^9$  values your seed can take.
>
>>> Thus, using any of the algorithms suggested you're only going to sample
>
>>>  $10^{-5568625} \%$ 
>
>>> of the possible values. This is a really small number. It means that no
>>> matter how hard you try and how many times you do things you'll never be
>>> able to access anything but a tiny number of the possibilities without
>>> doing multiple shufflings - I think it's something like 618737
>>> sub-shufflings (i.e.  $5568636 / 9$ ) but that could be wrong. However, that
>>> requires producing 618737 seeds per major-shuffle (and you can't use a
>>> generator based on a 4 byte seed to produce these seeds).
>
>>> But, since you're only going to be running the code 1000-10,000 times
>>> (which is much smaller than  $4e9$ ) I guess everything will be ok. I don't
>>> know if anyone has studied possible correlations of results as a
>>> function of the very small number of seeds (compared to the data),
>>> whatever random number generator is used and the shuffling method.
>>> Presumably they have and presumably everything is ok. Does anyone know?
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>>> Thanks,
>
>>> Allan
>
>> I'm not sure that I agree. Where in any of our algorithms are we
>> unable to access a (theoretically) possible outcome? As long as we
>> are able to randomly select any element of the array in each step, it
>> should work, right? (I.e., as long as the input array has fewer than
>>  $2^{32}$  elements.) In your analysis, shouldn't we be using  $(2^{32})^n$  for
>> the maximum possible number of randomly generated combinations, where
>> n is the number of steps/elements?
>
> No, because the entire sequence of numbers is uniquely determined by
> initial internal state of the generator. If you knew the algorithm
> used, and the internal state, that's all the information you'd need to
> predict, precisely, the entire sequence of numbers generated, no
> matter how long that sequence was. If the internal state is stored in
> a 32 bit integer, that means there's only  $2^{32}$  possible different

```

> sequences.
>
>> From that fact, it can also be shown that every possible sequence must
>
> start repeating, exactly, with a period that is less than 2^{32} . If one
> of the possible sequences has starts repeating with a period T, then
> at least T-1 of the other possible sequences generate that same repeat
> cycle, with various shifts.
>
> There's a reason why these things are called PSEUDO-random number
> generators.

It shouldn't really be a problem for me, fortunately. I'm running this a couple thousand times, but everytime it is on a different set of values. The only thing I would have to worry about is it repeating within one set of values, which won't happen for 1,000,000 elements.

Of course, worse comes to worse there's always a true random number generator:

www.random.org

Subject: Re: Randomize array order
Posted by [David Streutker](#) on Fri, 27 Jul 2007 17:54:07 GMT
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On Jul 27, 10:05 am, kuyper <kuy...@wizard.net> wrote:
> David Streutker wrote:
>> On Jul 27, 6:03 am, Allan Whiteford
> ...
>>> If you have a million elements then you have 1000000! (i.e. one million
>>> factorial) different ways to re-order the data. However, your seed is a
>>> 4 byte integer which can only take 2^{32} different values.
>
>>> Some messing about suggests that:
>
>>> $1000000! \approx 10^{5568636}$
>
>>> which means there are $\sim 10^{5568636}$ different ways to re-arrange your
>>> elements as opposed to the 4×10^9 values your seed can take.
>
>>> Thus, using any of the algorithms suggested you're only going to sample
>
>>> $10^{5568625} \%$
>
>>> of the possible values. This is a really small number. It means that no
>>> matter how hard you try and how many times you do things you'll never be

```

>>> able to access anything but a tiny number of the possibilities without
>>> doing multiple shufflings - I think it's something like 618737
>>> sub-shufflings (i.e. 5568636 / 9) but that could be wrong. However, that
>>> requires producing 618737 seeds per major-shuffle (and you can't use a
>>> generator based on a 4 byte seed to produce these seeds).
>
>>> But, since you're only going to be running the code 1000-10,000 times
>>> (which is much smaller than 4e9) I guess everything will be ok. I don't
>>> know if anyone has studied possible correlations of results as a
>>> function of the very small number of seeds (compared to the data),
>>> whatever random number generator is used and the shuffling method.
>>> Presumably they have and presumably everything is ok. Does anyone know?
>
>>> Thanks,
>
>>> Allan
>
>> I'm not sure that I agree. Where in any of our algorithms are we
>> unable to access a (theoretically) possible outcome? As long as we
>> are able to randomly select any element of the array in each step, it
>> should work, right? (I.e., as long as the input array has fewer than
>> 2^32 elements.) In your analysis, shouldn't we be using (2^32)^n for
>> the maximum possible number of randomly generated combinations, where
>> n is the number of steps/elements?
>
> No, because the entire sequence of numbers is uniquely determined by
> initial internal state of the generator. If you knew the algorithm
> used, and the internal state, that's all the information you'd need to
> predict, precisely, the entire sequence of numbers generated, no
> matter how long that sequence was. If the internal state is stored in
> a 32 bit integer, that means there's only 2^32 possible different
> sequences.
>
>> From that fact, it can also be shown that every possible sequence must
>
> start repeating, exactly, with a period that is less than 2^32. If one
> of the possible sequences has starts repeating with a period T, then
> at least T-1 of the other possible sequences generate that same repeat
> cycle, with various shifts.
>
> There's a reason why these things are called PSEUDO-random number
> generators.

```

Interesting. I hadn't really thought it through before.

If there are only 2^32 possible sequences, then why is the internal state characterized by a 36-element array?

```
IDL> test = randomu(seed)
IDL> help, seed
SEED      LONG      = Array[36]
```

Is it that there are only 2^{32} possible sequences available during any given session? With a new set being available in a different session?

Subject: Re: Randomize array order
Posted by [Conor](#) on Fri, 27 Jul 2007 18:09:20 GMT
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```
On Jul 27, 1:54 pm, David Streutker <dstreut...@gmail.com> wrote:
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>
>
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> IDL> test = randomu(seed)
> IDL> help, seed
> SEED      LONG      = Array[36]
>
> Is it that there are only  $2^{32}$  possible sequences available during any
> given session? With a new set being available in a different session?

```

That is a very interesting question. According to the online-manual:

The random number generator is taken from: "Random Number Generators: Good Ones are Hard to Find", Park and Miller, Communications of the

ACM, Oct 1988, Vol 31, No. 10, p. 1192. To remove low-order serial correlations, a Bays-Durham shuffle is added, resulting in a random number generator similar to ran1() in Section 7.1 of Numerical Recipes in C: The Art of Scientific Computing (Second Edition), published by Cambridge University Press.

Hmm... It turns out that randomn is completely useless. It claims to use the Box-Muller method, which I happen to know is a simple variation on a regular random number generator, but with half the possible sequences. Therefore, it has: $(2^{32})/2$ sequences = 1^{32} sequences = 1 It repeats after generating only 1 random number!!! Yikes!!!! Someone should alert RSI!!!

(okay, okay, it was a bad joke. So sue me.) Anyway, back to reality. I wonder if RSI uses an array of size 36 to institute a "virtual" increase of variable size, allowing for more precise calculations??? Is such a thing possible? I don't know why else they would need an array to hold their seed, although I'm going to guess it is for another reason.

Subject: Re: Randomize array order

Posted by [James Kuyper](#) on Fri, 27 Jul 2007 21:29:17 GMT

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David Streutker wrote:

...
> If there are only 2^{32} possible sequences, then why is the internal
> state characterized by a 36-element array?
>
> IDL> test = randomu(seed)
> IDL> help, seed
> SEED LONG = Array[36]

That is a VERY good question. I only looked at the documentation; I didn't bother to check. The documentation says:

> The state of the random number generator is contained in a long integer vector.

and also

> If the Seed argument is:
> * an undefined variable - the generic state is used and the resulting generic state array is stored in the variable.

Given that the resulting generic state appears to be a 36-element array, I don't think both statements can be true. An array of 36 longs

would be more than enough to generate all possible shuffles of a 52-card deck. More importantly, it's large enough to do large numerical simulations in quantum field theory without introducing spurious correlations. Therefore I hope that the second statement is the one that's correct.

Subject: Re: Randomize array order

Posted by [Michael Galloy](#) on Fri, 27 Jul 2007 22:35:13 GMT

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On Jul 27, 3:29 pm, kuyper <kuy...@wizard.net> wrote:

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>

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>

> and also

>

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>

> Given that the resulting generic state appears to be a 36-element

> array, I don't think both statements can be true.

I think those statements are consistent. The state is stored in a long integer vector (a 36-element long integer array to be specific).

Mike

--

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