Sudoku Players' Forums

THE REAL DISTRIBUTION OF MINIMAL PUZZLES

Goto page Previous **1**, **2**, **3** … , **11**, **12**, **13** **Next**

new topic   post reply   **Sudoku Players' Forums Forum Index** -> **General/puzzle**

View previous topic :: View next topic

Author	Message
coloin Joined: 06 May 2005 Posts: 1052 Location: Devon UK	Posted: Sat Jul 18, 2009 10:57 pm Post subject: quote

denis_berthier wrote:

> P41 = P40
> P39 = 42/40 * P40
> P38 = 43/39 * P39

Thank-you **denis** now I understand what the formula means [obvious but not to everyone] The P41=P40 is very nice.

The hike up from 25.39 to~26.5 is because of

Code:
```
unbiased-mean(X) = sum[E(X, n) * on(n) * cf(n)] /
sum[on(n) * cf(n)].
```

except I dont get this bit apart from I think it is related to the statistical bias introduced by the original bias.

Allan Barker wrote:

> 39 ?????? Were they using specially selected grids or random ones?

Initially I started out trying to find large puzzles in specific grids - but the 37s came out of neighbouring grids. The 38s and 39s were found probably by processing power [with the help of IBM and 16-core super machines I believe !]

An analytical approach such as yours to reproduce this work would be commendable. Analysis on the individual essential clues and non essential clues in a subgrid might point the way to go in achieving the progresivly harder step-up in clues. It might indicate which puzzle is more likely to have a bigger brother. I wish you luck !

C

Back to top   profile   pm

| **Red Ed**

Joined: 06 Jun 2005
Posts: 616 | Posted: Sun Jul 19, 2009 6:45 am   Post subject: quote

Coloin, with regard to the bit you didn't get ... if E(X,n) is the average value of X (*any* thing "X") over n-clue minimals, and P(n) is the probability that a random minimal has n clues, then sum_{n}(E(X,n) * P(n)) is the average value of X |

over all minimals. Just a weighted average, right?

Reproduced below in small font is how P(n) is derived. This has been said many times before, but it wasn't clear to me if you understood or not.

Quote:

I think about it this way:

1. The modified generator finds on(n) n-clue minimals in t trials: so estimated probability on(n)/t that a random n-clue subgrid is a proper minimal puzzle.
2. There are choose(81,n) n-clue subgrids in any solution grid.
3. 1&2 => estimated nr n-clue minimals per grid, call it EM(n), equals on(n)/t * choose(81,n).
4. Therefore the estimated total number of minimals per grid, call it EM(*), equals EM(0)+EM(1)+...+EM(81)
5. ... and the estimated proportion of n-clue minimals, call it P(n), equals EM(n)/EM(*).

If we write out P(n) in full we get:

P(n) = on(n)/t * choose(81,n) / sum_{c=0...81}(on(c)/t * choose(81,c))

You can multiply top and bottom by the same number and the formula will remain true, obviously. Denis chooses to multiply by t/choose(81,24) and he uses the name cf(n) to mean choose(81,n)/choose(81,24). So, in Denis' terms:

P(n) = on(n)*cf(n) / sum_{c=0...81}(on(c)*cf(c))

Back to top   [🔲 profile] [🔲 pm]

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m_b_metcalf   🗋 Posted: Sun Jul 19, 2009 9:50 am   Post subject: [🔲 quote]

I'm back for a few hours and see much has taken place. This is just to point out that I have a 24MB zipped file of 1 million random grids that I'd be happy to make available if anyone wants them and can tell me how to transmit them.

Joined: 15 May 2006
Posts: 2218
Location: Berlin

Regards,

Mike Metcalf

Back to top   [🔲 profile] [🔲 pm]

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denis_berthier   🗋 Posted: Mon Jul 20, 2009 7:20 am   Post subject: [🔲 quote] [🔲 edit]

denis_berthier wrote:

> **Allan Barker wrote:**
>
> > **denis_berthier wrote:**
> >
> > > **Allan Barker wrote:**
> > >
> > > > If anyone is interested, I can put the first batch of 30s on my website.
> > >
> > > I'm interested. Large samples of 30s, 31s, 32s ... are not so frequent.
> >
> > **http://sudokuone.com/xsudo1/puzzle33.txt**. These are

Joined: 19 Jun 2007
Posts: 752
Location: Paris, France

> not compressed, a bit over 20000.

> Thanks, I don't know when I can study them (all my computing resources are currently centered on the controlled-bias generator), but I'll do it.
> BTW, the url is: http://sudokuone.com/xsudo1/puzzle30.txt

I found a little time to run SudokuExplainer on your collection of 20,000 30s. The mean value and standard deviation for the SER are:
E(SER) = 6.255
sd(SER) = 2.124

This is fully consistent with the results obtained previously on 2 much smaller samples:
- the 10 30-clue puzzles included in sudogen0_1M
E(SER) = 6.46
sd(SER) = 1.74

- the 8 30-clue puzzles included in rabrnd_1M
E(SER) = 5.69
sd(SER) = 2.02

and with their weighted average:
E(SER) = 6.07
sd(SER) = 1.96

This result was uncertain due to the small sample size.
Now, with your large sample, it is confirmed that the mean SER increases with the number of clues in a range that includes the 30s.

Did you say you have large samples of 31s, 32s and 33s?

Back to top   profile   pm   www

Allan Barker   Posted: Mon Jul 20, 2009 11:50 am   Post subject: quote

Joined: 21 Feb 2008
Posts: 295
Location: Bangkok

> **denis_berthier wrote:**
> Did you say you have large samples of 31s, 32s and 33s?

Some but not much yet as I have spent more time tinkering with the code. I do have about **850** size 33s, which would be interesting to test. These were generated without the constraint of 1 minimal per grid, i.e., the grid is free to change during the search. I do plan to make more including 32s and 31s soon.

From now on, I will paste data files on a separate webpage for data
http://sudokuone.com/xsudo1/data.htm. The files are there now.

BTW: Thanks, I corrected the erroneous file name.

Back to top   profile   pm   www

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denis_berthier   Posted: Mon Jul 20, 2009 12:15 pm   Post subject: quote   edit

Joined: 19 Jun 2007
Posts: 752

> **Allan Barker wrote:**
> I do have about **850** size 33s, which would be interesting to test.

Posts: 752
Location: Paris, France

Thanks. I'll try to test them today.

> **Allan Barker wrote:**
>
> These were generated without the constraint of 1 minimal per grid, i.e., the grid is free to change during the search.

Does it mean anything special wrt to the problem of bias? Did you implement some form of the controlled bias?

> **Allan Barker wrote:**
>
> I do plan to make more including 32s and 31s soon.

Even only ~ 1000 of each would be enough to check whether the trend extends to the whole range 20-33.

Back to top   ⎇ profile   ⎇ pm   ⎇ www

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denis_berthier   ▯ Posted: Mon Jul 20, 2009 1:16 pm   Post subject: ⎇ quote   ⎇ edit

Allan,

Joined: 19 Jun 2007
Posts: 752
Location: Paris, France

For the 850 33s:

mean SER = 7.14
standard deviation = 1.47

Here again, the trend is confirmed.

Back to top   ⎇ profile   ⎇ pm   ⎇ www

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denis_berthier   ▯ Posted: Tue Jul 21, 2009 4:53 am   Post subject: ⎇ quote   ⎇ edit

Joined: 19 Jun 2007
Posts: 752
Location: Paris, France

NEW RESULTS WITH THE CONTROLLED-BIAS GENERATOR

The controlled-bias generator is slow but it works fine.
I've now generated 10,000 minimal puzzles.

As suexg was free software, the same is true of its controlled-bias modification (implemented by eleven): suexg-cb; it can be downloaded from my web page on classification: http://www.carva.org/denis.berthier/HLS/Classification.
I've also improved the redaction of section 3 on the controlled-bias generator and its application to the unbiased classification of minimal puzzles.

Here are the mean and standard deviations obtained from these 10,000 puzzles for a few variables of interest. These results are very stable (almost unchanged when the sample passed from 1,000 to 10,000 puzzles).

Number of clues of minimal puzzles:
unbiased-mean = 26.568

SER
unbiased-mean = 4.484 unbiased-sd = 2.53

NRCZT
unbiased-mean = 2.31 unbiased-sd = 1.38

As could be expected, there are more fluctuations in the distribution of clues, especially in the tail, but it is nevertheless reasonably stable.
For comparison with the standard, non-controlled, top-down generator, the second column ("top-down") recalls the results obtained from the 1,000,000 puzzles generated with suexg-x.x; the third column ("controlled") gives the direct result for the sample of 10,000 puzzles from the controlled-bias generator; the fourth column ("unbiased") gives the unbiased results, obtained by using the correction factors, it is scaled to 1,000,000 puzzles.
The mean values for each case are also recalled.
Of course, "top-down" appears to be much more biased in favour of fewer clues than "controlled".

Code:

```
#clues  top-down    controlled    unbiased
19      0           0             0.0 (*)
20      44          0             0.0 (*)
21      2428        1             1.14 (*)
22      34548       11            34.34 (*)
23      172512      188           1505.35
24      342335      1211          23433.75
25      297838      3066          135270.99
26      122116      3372          320431.17
27      25315       1676          324429.35
28      2686        423           157914.58
29      168         49            33431.50
30      10          3             3547.83 (*)
31      0           0             0.0 (*)

mean    24.38       25.658        26.568

* values relying on a small sample should be taken
with caution.
```

Last edited by denis_berthier on Tue Jul 21, 2009 3:03 pm; edited 1 time in total
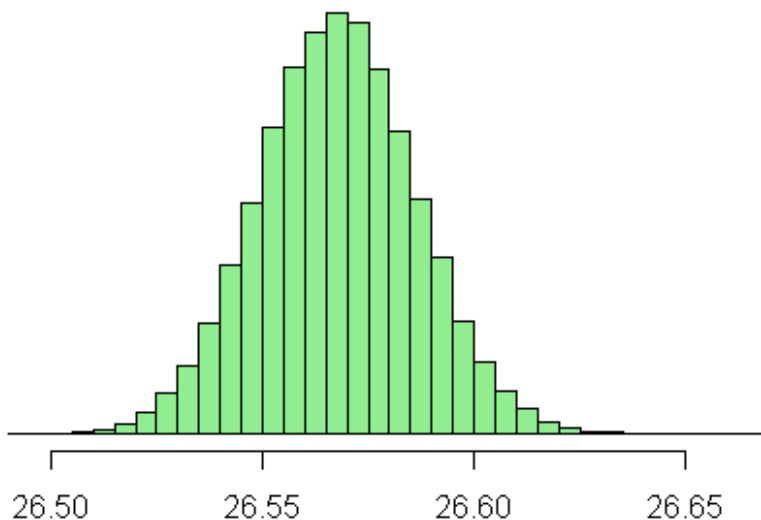
Back to top   profile   pm   www

Red Ed

Joined: 06 Jun 2005
Posts: 616

Posted: Tue Jul 21, 2009 2:19 pm   Post subject: quote

Three 30s, purely at random! Impressive amount of compute time required for that, I should think.

Bootstrap resampling of those counts gives the following probability distribution for the average-number-of-clues value that you'd get if you ran your experiment for an enormously long time:

Of course the true average-number-of-clues might be outside of that range (after all, we already have strong evidence that the *suexg* solution grid generator produces biased number-of-minimals estimates). I ought to burn some CPU to see if I can come up with enough data to produce a similar graph, so that we can compare.

Back to top   [profile] [pm]

Red Ed

Joined: 06 Jun 2005
Posts: 616

Posted: Tue Jul 21, 2009 2:23 pm   Post subject: [quote]

PS: this is a typo -

> **denis_berthier wrote:**
> Number of clues of minimal puzzles:
> unbiased-mean = 26.658

You mean 26.568.

Back to top   [profile] [pm]

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denis_berthier

Joined: 19 Jun 2007
Posts: 752
Location: Paris, France

Posted: Tue Jul 21, 2009 3:03 pm   Post subject: [quote] [edit]

> **Red Ed wrote:**
> after all, we already have strong evidence that the *suexg* solution grid generator produces biased number-of-minimals estimates

Obviously, we don't have the same notion of "evidence".
The only evidence we have is that the suexg generator of minimal puzzles is biased - that's not a scoop. We have no evidence that its complete grids generator part is biased.

When asked why this imagined bias in the complete grids would lead to the same results for minimal puzzles generated by suexg and by Allan's generator (based on completely different principles), as described on my website, your only answer was that you had overlooked this.

Much of what is in the complete grids is irrelevant for the minimal puzzles, as I've already shown for your 3322 tests, which you once pushed forward as an argument against the sudogen0_1M collection.

Moreover, the controlled-bias version of suexg, suexg-cb, uses so many more complete grids before it gets a minimal puzzle that any bias in the complete grids is very unlikely to have any effect on the minimal puzzles.

Back to top   [profile] [pm] [www]

coloin

Joined: 06 May 2005
Posts: 1052
Location: Devon UK

Posted: Tue Jul 21, 2009 4:05 pm   Post subject: [quote]

Well, suexg tends to produce puzzles->grids with less U4s [10.67] as opposed to the expected 11.58.

As we know the grid does make a difference - here is data from the past with 1M puzzles per grid with suexg:

Code:

```
Ran6            Coloin37        Havard37        MC
  PT              SF [2-U4s]
24.5            24.83           24.80           25.71
   25.56           24.10


18 0            18  0           18  0           18 0
   18   0           18  0
19 0            19  0           19  0           19 0
   19   0           19  4.3
20 53           20  8           20  8           20 5
   20   0           20  182
21 2281         21  409         21  489         21 56
   21  9            21  6051
22 33020        22  11093       22  12231       22 1797
   22  1051          22   61826
23 169240       23  93587       23  97379       23 21631
   23  22174         23   227480
24 340913       24  281228      24  284695      24 116439
   24  137344        24   352289
25 299993       25  351640      25  348769      25 287167
   25  323361        25   248568
26 124899       26  198947      26  195332      26 330392
   26  324568        26   86061
27 26439        27  54898       27  53222       27 184541
   27  152286        27   15908
28 2966         28  7571        28  7338        28 50751
   28  35032          28   1547
29 190          29  587         29  518         39 6735
   29  3931           29  74
30 6            30  31          30  19          30 466
   30   239           30  8.6
31 0            31  0           31  0           31 20
   31   5             31   0
32 0            32  1           32  0           32 0
   32   0             32   0
```

From a few random grids from suexg......

Code:

```
24.35
24.51
24.56
24.41
24.31
24.40
24.42
24.55
24.42
24.30
24.38
```

```
24.51
24.38
24.50
24.49
24.44
24.38
24.33
24.47
24.51.....

24.43 average
```

One thing I have learnt from you **denis** is that a random sample from a biased sample is still biased - however thin the sampling 😃

C

Back to top   [profile] [pm]

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denis_berthier   ⬜ Posted: Tue Jul 21, 2009 4:55 pm   Post subject: [quote] [edit]

Joined: 19 Jun 2007
Posts: 752
Location: Paris, France

> **coloin wrote:**
> Well, suexg tends to produce puzzles->grids with less U4s [10.67] as opposed to the expected 11.58.

1) where does the "expected" 11.58 come from? Red Ed? But what guarantee do you have that his generator of grids is unbiased? He keeps claiming it? But who has ever proven it? Worse, who has ever seen this generator or any collection of puzzles produced by it?

2) who said that solution grids of unbiased collections of puzzles should be unbiased?

3) as I said in my previous post, I have shown that the U4 count (as well as all the 3322 tests defined by Red Ed) is totally irrelevant wrt to the complexity of puzzles (my main interest here): the correlation coefficients are almost null. Some people may "earn their living" by finding bias everywhere, that doesn't make the bias exist for good in the puzzles. 😃

4) the experience gained from a detailed study of a few complete grids and their minimal sub-puzzles can be very misleading. I'd never care to generate 1,000,000 minimals from a single grid.

5) I'm still expecting explanations why suexg and Allan's generator (which differ only by the way they generate complete grids) give the same classification results for puzzles. As long as there's no answer to this question, all the claims about bias in the puzzles due to bias in the complete grids are vacuous words. The example of these two generators is strong evidence that the way the complete grids are generated, provided that it is sufficiently random, is irrelevant to the puzzles. And this is easily understandable, as 2 thirds of the complete grid has to be eliminated to get a puzzle.

6) finally, all this is nitpicking. The important thing here is the new notion of a controlled-bias generator. When we use it, we know where the source of bias is and we know how to correct it.

Back to top   [profile] [pm] [www]

Red Ed

Joined: 06 Jun 2005
Posts: 616

□ Posted: Tue Jul 21, 2009 5:26 pm   Post subject: [quote]

Denis, Denis. What *are* we going to do with you? 😃

I'm not going to get into an argument about the effect of generator "bias" (of any form) on puzzle "complexity" (in any sense). I really don't care.

My only interest is in making sure that our analysis of the number-of-clues-in-minimals distribution (and related problems) is accurate. When you give estimates to 5 significant figures without quantifying the variance then you being either lazy or deliberately misleading. My beautiful -- even if I do say so myself -- graph above was an attempt to *help you* quantify the variance. I thought maybe you might be grateful. Ah, well, you do like to play hard to get, don't you Denis. 😃

And as for this:

> **denis_berthier wrote:**
>> **Red Ed wrote:**
>> after all, we already have strong evidence that the *suexg* solution grid generator produces biased number-of-minimals estimates
>
> Obviously, we don't have the same notion of "evidence". The only evidence we have is that the suexg generator of minimal puzzles is biased - that's not a scoop. We have no evidence that its complete grids generator part is biased.

Yes, we have evidence. Why don't we take a vote? **Hey everyone, vote here:** do you think that the complete grids generator part of suexg is biased or unbiased? If the consensus is with unbiased then I will endeavour to explain myself better so that you can see where you're wrong! 😃

Back to top   [profile] [pm]

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denis_berthier

Joined: 19 Jun 2007
Posts: 752
Location: Paris, France

□ Posted: Tue Jul 21, 2009 5:36 pm   Post subject: [quote] [edit]

> **Red Ed wrote:**
> Why don't we take a vote? **Hey everyone, vote here:** do you think that the complete grids generator part of suexg is biased or unbiased? If the consensus is with unbiased then I will endeavour to explain myself better so that you can see where you're wrong! 😃

Red Ed, is that your notion of mathematical truth? Hey everyone, vote here: do you think that 2+2= 4 or 5?

As usual, you are not at all trying to help, as you keep repeating, but to generate confusion.
I don't care about the bias of complete grids. I care only about a possible (and anyway small) bias in the complexity of puzzles.

Be serious and answer my question about suexg and Allan's generator.

BTW, thanks for your graph illustrating my results.

Back to top   [profile] [pm] [www]

Display posts from previous: [All Posts ▲▼] [Oldest First ▲▼] [Go]

[new topic] [post reply]

Sudoku Players' Forums Forum Index -> General/puzzle

All times are GMT

Goto page **Previous** **1**, **2**, **3** ... , **11**, 12, **13** **Next**

Page 12 of 13

[Stop watching this topic](#)

Jump to: [General/puzzle ▲▼] [Go]

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