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Author

Message

PIsaacson

Posted: Thu Apr 23, 2009 9:05 pm Post subject:



Denis,

Joined: 02 Jul 2008

Posts: 183

Location: Campbell, CA

I became involved in studying ALSs and Allan's set/link-set logic to the point that I neglected to complete my promised statistics for the sudogen0 collection. Mea culpa. I need to re-trace my steps and re-read this thread to get back in sync...

Cheers,
Paul

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Allan Barker

Posted: Fri Apr 24, 2009 6:47 am Post subject:



StrmCkr wrote:

nice to see you back at it again denis

Joined: 21 Feb 2008

Posts: 279

Location: Bangkok

Ditto. Hi Denis, welcome back.

Allan

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denis_berthier

Posted: Fri Apr 24, 2009 8:49 am Post subject:



Hi **Paul, Allan, StrmCkr**

Joined: 19 Jun 2007

Posts: 631

Location: Paris, France

Glad to see you're still here.

As for me, I've been (and still am) completely involved in other topics and out of the sudoku world for several months - except for the brief incursion in the above posts.

StrmCkr, as I still have no time for Sudoku, I think you should open a thread to

discuss your new ideas instead of sending them to me alone ; you'd certainly get much more interesting comments.

Paul, if you complete your computations for whips/braids with ALS inserts on sudogen0, I'm still interested. Given my above results, it doesn't matter much if you do them with braids or whips. I'm not sure : does your solver have "pure" ALS-chains (with no z- or t- candidates) ? Does it have their supersymmetric counterpart (i.e. with AHS and super-hidden-ALS or "A-fish" - whatever you call them)?

Allan, as I'ven't been reading what has been published in the last few months, you may have already answered these old questions of mine : have you defined any measure of complexity for your patterns? If so, can your algorithm be tuned to provide resolution paths that grant the "simplest" solution according to this measure?

Indeed, I'm still interested in anything that deals with principled measures of complexity for well defined families of patterns and in any comparison between such measures - the topic of this thread. I'm aware of nothing of this sort for pure ALS-chains.

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ttt

📅 Posted: Fri Apr 24, 2009 3:25 pm Post subject:

 [quote](#)

Me too, nice to see you back after around half year 😊

Joined: 20 Oct 2006
Posts: 173
Location: vietnam

ttt

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denis_berthier

📅 Posted: Sun Apr 26, 2009 8:01 am Post subject:

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ttt wrote:

Me too, nice to see you back after around half year 😊

ttt

Joined: 19 Jun 2007
Posts: 631
Location: Paris, France

Hi, **ttt**, nice to see you.

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Pisaacson

📅 Posted: Mon Apr 27, 2009 3:07 am Post subject:

 [quote](#)

Denis,

Joined: 02 Jul 2008
Posts: 183
Location: Campbell, CA

I don't have braids with ALS/AHS group extensions, so I can only execute using nrczt chains/whips.

Your question on "pure" ALS chains raises a point that I've been considering lately

from a programming perspective. Currently, I have a separate engine for ALS chaining and a separate engine for nrczt chaining. They both use a common ALS generator that builds the map of all possible ALS/AHS pairs within RC/RN/CN spaces, so: Yes, both engines have all the supersymmetrics available for use.

However, they build chains with ALSs using very different algorithms. In the nrczt engine, preference is (usually) given to linking 3d nrc candidates and attempting z/t promotion when possible. ALS/AHS nodes are (usually) only considered after exhausting all other possible nrc children of a given parent node. The ALS engine always attempts to chain ALS/AHS nodes directly via RCC peer linkage first, and then attempts to chain via a limited number of techniques such as using bi-value/local cells, ERs, GSLs, AURs and X-cycles to "bridge" RCCs from a parent ALS to a potential child ALS. At some point, I would like to have these two techniques "merge" into a super-engine.

I qualified the nrczt engine with the phrase "usually" because for these tests, I opted to have the nrczt engine select an ALS whenever possible instead of as a last resort. It made the results for short chains entirely different and came close to emulating the ALS engine restricted to linking no more than 2 or 3 ALSs.

So with that out of the way, here are the results from running nrczt-whips with ALS/AHS group extensions:

pNRCZT1_0: 4247
pNRCZT1: 1135
pNRCZT2: 3899
pNRCZT3: 525
pNRCZT4: 109
pNRCZT5: 45
pNRCZT6: 25
pNRCZT7: 6
pNRCZT8: 5
pNRCZT9: 3
pNRCZT10: 1

This demonstrates that ALSs lead to somewhat shorter solution paths. I believe this is simply because an ALS typically includes more weak link paths than a standard nrc candidate. Also, given the resolution power of braids and with the advent of whips, I am uncertain that ALS groups offer additional solutions.

Cheers,
Paul

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denis_berthier

Posted: Mon Apr 27, 2009 7:41 am Post subject:



Joined: 19 Jun 2007
Posts: 631
Location: Paris, France

PIsaacson wrote:

This demonstrates that ALSs lead to somewhat shorter solution paths. I believe this is simply because an ALS typically includes more weak link paths than a standard nrc candidate.

Maybe, the length of a chain should be increased by 2/3/4 instead of 1 when a Pair/Triplet/Quad is inserted? That'd be consistent with the fact that Pairs are chains of length 2 and (most) Triplets/Quads are chains of length 3/4.

Anyway, I think it's worth giving a full example of a "zt promoted" naked, hidden or super-hidden subset within a whip.

Pisaacson wrote:

Also, given the resolution power of braids and with the advent of whips, I am uncertain that ALS groups offer additional solutions.

It is interesting that nrczt-whips and supersymmetric ALS-chains have separately almost the same solving power (see my work with Mike, here <http://www.sudoku.com/boards/viewtopic.php?t=5591&postdays=0&postorder=asc&start=90> and next page) but their combination through the zt-ing principle (z/t promotion in your vocabulary) is much stronger, as shown by the tables at the end of this page : <http://www.sudoku.com/boards/viewtopic.php?t=6390&postdays=0&postorder=asc&start=30>. And your super-engine would be able to solve very hard puzzles.

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denis_berthier

Posted: Sat Jun 20, 2009 5:40 am Post subject:



Joined: 19 Jun 2007
Posts: 631
Location: Paris, France

NEW STATISTICAL RESULTS

sudogen0_1M is a random sample of 1,000,000 different independent minimal puzzles generated with the suexg program (with seed 0). More on it in the next post.

Using this extended sudogen0_1M collection, I computed the following variables for all the puzzles in it: the NRCZT-ratings, the SER ratings, the number of clues, the number of partial nrczt-chains.

The longest part was the computation of the NRCZT-ratings, which took 5 weeks.

1) Here are first the correlation coefficients:

NRCZT vs SER : 0.895

This confirms what I had already shown with the first 10,000 puzzles in the collection: although the two ratings are based on very different sets of rules, they are very strongly correlated.

NRCZT vs log(#chains) : 0.946

This confirms that the length of chains is statistically a good indicator for the complexity of a puzzle: the more useless partial chains there are, the harder it is to find the useful ones. The number of useless partial chains increases exponentially with the length of the longer chain necessary to solve the puzzle (in the range of validity of these results : 1 to 10).

NRCZT vs #clues : 0.116**SER vs #clues : 0.121**

This gives a precise meaning to what was already intuitively known concerning the number of clues: it has no impact on the complexity of minimal puzzles.

2) Here is now the number of puzzles per number of clues: (all the puzzles in the collection have between 20 and 30 clues).

Code:

```
nb-clues    nb-puzzles
20          44
21          2,428
22          34,548
23          172,512
24          342,335
25          297,838
26          122,116
27          25,315
28          2,686
29          168
30          10
```

This shows that puzzles with less than 20 or more than 30 clues are extremely rare - in frequency. (Notice however that, in numbers, as there are billions of billions of minimal puzzles, "extremely rare" may still mean thousands or millions - we already know more than 64,000 17-clue puzzles).
Most of the puzzles have between 23 and 26 clues.

3) The SER in the collection varies upto 9.2

4) Here is finally the number of puzzles per NRCZT-level (already posted in the "supersymmetric chains" thread)

Code:

```
Level      Number      Total
1_0        417,624      417,624
1          120,618      538,242
2          138,371      676,613
3          168,355      844,968
4          123,153      968,121
5          24,187       992,308
6          5,511       997,819
7          1,514       999,333
8          473       999,806
9          130       999,936
10         38       999,974
11         15       999,989
12         9       999,998
13         2       1,000,000
14         0
```

This confirms that:

- **more than 99% of the minimal puzzles can be solved with whips of length 5 or less;**
- **more than 99.9% of the minimal puzzles can be solved with whips of length 7 or less;**
- **"almost all" the puzzles can be solved with nrczt-whips of length 13 or less.**

Of course, such statistical results can't say anything about extreme cases with very low probability (e.g. cases with very special symmetries, such as the EasterMonster family).

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denis_berthier

Posted: Sat Jun 20, 2009 7:08 am Post subject:



Joined: 19 Jun 2007
Posts: 631
Location: Paris, France

THE SUDOGEN0_1M COLLECTION

sudogen0_1M is a random sample of 1,000,000 different independent minimal puzzles generated with the suexg program (with seed 0).

suexg is a free program developed by Guenter Stertinbrink..... aka dukuso at Magictour (thanks **Coloin** for the exact name). It produces about 20 minimal puzzles per minute even on an old cheap micro-computer (1 GHz).

There are several versions of it. For definiteness, a copy of the exact version I use is available on my web pages: http://www.carva.org/denis.berthier/HLS/Results-Classif/sudoku_gen.c

Ever since I started being interested in Sudoku, I've used the "small" sudogen0 collection with 10,000 puzzles, but I've now extended it to 1,000,000. The reason is that hard puzzles are very rare (in frequency) and the higher we want to go into the complexity hierarchy (as reflected, say, by the NRCZT-level) the more puzzles we need to analyse.

Now, the question that naturally arises is: how random is the "large" sudogen0_1M collection? This is a major question, because randomness is what allows to extend the results in the above posts from the sudogen0_1M collection to the full set of minimal puzzles.

"Real randomness" can rarely be fully proven, but good indicators of randomness can be checked.

The first thing that can be checked is that all the puzzles are different. Another thing one might want to check is that no two of them are essentially equivalent. I'ven't done this, first because it would have been one more long computation and secondly because it isn't really relevant here: we are dealing with minimal puzzles and not with equivalence classes of such puzzles. Anyway, in terms of proportions, even if a few puzzles were essentially equivalent, this wouldn't change the results. If anyone has a fast checker of essential-equivalence,

he can do it. Also, as **Coloin** pointed out in a PM after this post, the probability of two puzzles being essentially equivalent in a 1,000,000 random sequence is very low).

The second thing one is expecting from a random collection is the independence of the puzzles in it. As usual, independence of a sequence of non-numerical variables (the puzzles) is tested indirectly through the (normalised) auto-correlation function of one (or more) numerical function(s) of this variable.

The numerical functions of the puzzles I'll consider here are:

- the number of clues
- the NRCZT rating
- the SER (Sudoku Explainer Rating)

What is the (normalised) auto-correlation function? Its k-th value (which is a number between -1 and +1) measures the degree of correlation between any element in the sequence and the element k places after it. (Look any textbook on statistics of sequences for a precise definition).

How did I compute it? I used Matlab, with the exact function: `xcorr(x, maxlag,'unbiased')`; here "maxlag" is a parameter allowing to specify that we don't take into account values of k (beyond maxlag) that would rely on too few puzzles; I choose maxlag = 990,000.

Now for the results:

the maximum absolute values for the correlation function were:

- for the number of clues: 0,041
- for the SER: 0,037
- for the NRCZT: 0,039

All these values are very small. All these sequences of variables are white noise.

Conclusion: wrt to all the above criteria, the sudogen0_1M sequence has null auto-correlation.

Soon, I'll put the whole series of results (lists of puzzles, SER, NRCZT, #clues) on my web pages, so that anyone can check these results and add his own.

Edited 06/23/2009 to take into account two remarks from **Coloin**.

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denis_berthier

Posted: Tue Jun 23, 2009 6:38 am Post subject:



Joined: 19 Jun 2007
Posts: 631
Location: Paris, France

The average number of clues in a minimal puzzle

One result I had forgotten to give is the average number of clues in a minimal puzzle (it can easily be computed from the distribution of clues though).

As **Coloin** evoked this number in a PM, here is the result for the sudogen0_1M collection:

mean number = 24.38

standard deviation = 1.120

For all the results reported in the above posts, what is important is that the

sudogen0_1M collection is unbiased. This is enough to extend these results to the full set of minimal puzzles.

But another interesting point is that suexg itself is unbiased, whatever the seed we use. This can be inferred from the algorithm or this can be checked experimentally on several seeds. I therefore tried another seed, 173, on a smaller sequence of 100,000 puzzles, and I checked only the number of clues.

max number = 29

min number = 20

mean number = 24.387

standard deviation = 1.125

This is fully compatible with the results for the sudogen0_1M collection.

Anyone can do these elementary computations starting with different seeds. In order to avoid random fluctuations of the mean, a minimum of 100,000 puzzles seems reasonable.

Last edited by denis_berthier on Fri Jul 03, 2009 5:28 am; edited 1 time in total

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denis_berthier

📅 Posted: Wed Jun 24, 2009 8:08 am Post subject:

 [quote](#)  [edit](#)

Joined: 19 Jun 2007
Posts: 631
Location: Paris, France

As I announced in a previous post, I've now put all the above rating results online on the following Web page:

<http://www.carva.org/denis.berthier/HLS/Ratings.html>

From the middle of this page, you can download the sudogen0_1M collection, the ratings (SER, NRCZT) used above, the numbers of clues and the solution grids. These are all simple .txt files, with 1 puzzle or value per line.

Also, I have updated some of my Web pages related to Sudoku <http://www.carva.org/denis.berthier/HLS-Supplements>. These are mainly a synthetic compilation of my posts in this forum.

Last edited by denis_berthier on Sat Jul 04, 2009 5:16 pm; edited 1 time in total

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m_b_metcalf

📅 Posted: Wed Jun 24, 2009 11:29 am Post subject:

 [quote](#)

Joined: 15 May 2006
Posts: 2150
Location: Berlin

denis_berthier wrote:

suexg is a free program developed by Guenter Stertinbrink..... aka dukuso at Magictour (thanks **Coloin** for the exact name). It produces about 20 minimal puzzles per minute even on an old cheap micro-computer (1 GHz).

I was sufficiently intrigued by this result that I fired up my own program and let it run for one hour real time (@ 2GHz). The summary is:

Code:

Number: 51492 (~860/min)
 Average # of clues: 24.36532

20	2
21	142
22	1853
23	8996
24	17656
25	15306
26	6127
27	1257
28	149
29	4

Looks comparable. The zipped file is 1.3MB and I'd be happy to send it anyone who'd like it. Whether I'd want to go for another 19 hours to reach the million is another question.

Regards,

Mike Metcalf

P.S. As an exercise, I once generated 1 million solution grids (in 100secs). The zipped file is 24.8MB.

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denis_berthier

Posted: Wed Jun 24, 2009 12:56 pm Post subject:



m_b_metcalf wrote:

I was sufficiently intrigued by this result that ...

Joined: 19 Jun 2007
 Posts: 631
 Location: Paris, France

Which result exactly did intrigue you? Do you know why you were intrigued by it?

BTW, which seed did you use in suexg?

Yes, your findings are comparable. Minor discrepancies can be explained by normal random fluctuations due to sample size.

Average # of clues: 24.36532 vs 24,38

Code:

#Clues results	#Puzzles	#Puzzles*1,000,000/51492 vs my results
20	2	39 vs 44
21	142	2,470 vs 2,428
22	1853	35,986 vs 34,548
23	8996	174,797 vs 172,512
24	17656	342,888 vs 342,335
25	15306	297,250 vs 297,838

```

26   6127
27   1257
28   149
29    4
30    0

```

```

118,989 vs 122,116
24,412 vs 25,315
2,894 vs 2,686
78 vs 168
0 vs 10

```

Regards

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m_b_metcalf

Posted: Wed Jun 24, 2009 1:17 pm Post subject:

[quote](#)

Joined: 15 May 2006
Posts: 2150
Location: Berlin

denis_berthier wrote:

Which result exactly did intrigue you? Do you know why you were intrigued by it?

BTW, which seed did you use in suexg?

I was intrigued to know whether my *own* program (*not* suexg) would yield the same results, and by what factor my program might be faster (~ 20 , as it turned out).

Regards,

Mike Metcalf

P.S. I doubled the sample, yielding:

Code:

```

Number:      110840
Average:     24.36463

```

```

20    10
21   324
22  4081
23 19378
24 37965
25 32685
26 13271
27  2778
28   333
29    15
30     0

```

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denis_berthier

Posted: Wed Jun 24, 2009 1:40 pm Post subject:

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m_b_metcalf wrote:

I was intrigued to know whether my *own* program (*not* suexg) would yield the same results, and by what factor my program might be faster (~ 20 , as it turned out).

Joined: 19 Jun 2007
Posts: 631
Location: Paris, France

As your results are based on a different generator, they are still more interesting, especially if the generation algorithm is significantly different from suexg.

Is your generator available? Or is there any place where the basic principles it uses are defined? Or can you state them in a few words?

In any case, I'm interested by your file of 110840 puzzles. It'd be a good way to check my results about the nrczt and SER ratings and to confirm that they don't depend on the generator.

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