

The hardest sudokus (new thread)

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Re: The hardest sudokus (new thread)

by mith » Wed Jun 29, 2022 8:06 pm

The depth 3 database is now over 400k expanded forms, and over 2mil minimals. Currently the only script running to generate new "families" is the minimal_reducer (-2+1), which has processed about 920k puzzles. Since restarting it, it's finding new expanded forms at a rate of 1.5-2% of the minimals processed, and it accounts for about 5-6% of the total expanded forms added - the rest are the result of the scripts operating on the expanded forms.

QUOTE

mith

Posts: 862
Joined: 14 July 2020

Re: The hardest sudokus (new thread)

by denis_berthier » Sun Jul 10, 2022 5:00 am

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Here are the results of quite long calculations. (I had previous results related to the much smaller 972 database, but that was too small to make any conjecture about it.)

QUOTE

denis_berthier

2010 Supporter

Posts: 3334
Joined: 19 June 2007
Location: Paris

All the known 9x9 sudoku puzzles in T&E(3) are indeed in T&E(W2, 2) or less.

All the terms are essential:
1) "sudoku puzzles" excludes sukakus
2) "9x9" excludes larger puzzles
3) "known" means both published (i.e. it refers to the last database published by mith *) and it implies that the proof relies on testing this database (not on a formal proof). Notice that (due to the consistency of the classification wrt adding candidates) testing the 375,759 minimal database has been done by testing only its 63,137 min-expands.

Considering my universal T&E(n) classification of any finite binary CSP-instance and the sub-classifications of each level:
- T&E(1) sub-classified by braids(k)
- T&E(2) sub-classified by Bk-braids or equivalently by T&E(Bk, 1)
- T&E(3) sub-classified by T&E(Bk, 2)
and applying it to 9x9 Sudoku puzzles, we have:
1) all the known puzzles in T&E(1) are in B29 or less (Mauricio's example in B29)
2) all the known puzzles in T&E(2) are in B7B = T&E(B7, 1) or less (3 examples currently known to be exactly in B7B)
3) all the known puzzles in T&E(3) are in B2BB = T&E(W2, 2)

Each of these 3 experimental results relies on a sufficiently large number of test cases to be turned into a conjecture by deleting the word "known"; Note that the resulting second conjecture is a modified version of my very old B7B conjecture, before I found that mith's puzzle Loki is not in T&E(2).

Notice however that my T&E(2) and B7B conjectures relied on a database assembled from many independent seeds. The T&E(3) mith database seems to be assembled from a much smaller number of seeds (maybe ultimately only 1: Loki). This leaves some open questions about other seeds in T&E(3).

* 375,759 minimal puzzles not in T&E(2): <http://forum.enjoysudoku.com/the-hardest-sudoku-new-thread-t6539-1299.html>
and the corresponding databases of 63,137 min-expands and 15,606 max-expands:
<http://forum.enjoysudoku.com/the-hardest-sudoku-new-thread-t6539-1304.html>

Re: The hardest sudokus (new thread)

by mith » Mon Jul 11, 2022 3:50 pm

Something I am intending to do eventually is go back to (my local version of) the ph database and try to determine the earliest T&E(3) puzzles(s) found there, as well as earlier T&E(2) puzzles which show the trivalue oddagon pattern (now that I have a reasonably quick script for determining that).

QUOTE

mith

Posts: 862
Joined: 14 July 2020

denis_berthier

2010 Supporter

Posts: 3334
Joined: 19 June 2007
Location: Paris

It's difficult to determine "seeds" precisely in the old database, given how many threads I had running at any time and the overlap between them. A newly discovered noteworthy 26c, say, could have come from a 25-27c seed, and I don't know how valuable it would have been to track that (it could have come from puzzles in all three groups, with the actual lineage just being determined by which happened to run first). Loki itself was not directly the seed for all puzzles in the current T&E(3) database - the original set of 972 puzzles was based on ~200 puzzles found with depth 3 searching the old database with SER 11.3+ - but it would not be at all surprising if they all had some common ancestor (possibly not in T&E(3) itself).

Anyway, I am stalled at the moment because I managed to blow out the PSU on the desktop (possibly from running too many sudoku scripts...) and am waiting for a replacement.

Re: The hardest sudokus (new thread)

by denis_berthier » Tue Jul 12, 2022 2:57 pm

mith wrote:

Something I am intending to do eventually is go back to (my local version of) the ph database and try to determine the earliest T&E(3) puzzles(s) found there, as well as earlier T&E(2) puzzles which show the trivalue oddagon pattern (now that I have a reasonably quick script for determining that).

QUOTE

denis_berthier

2010 Supporter

Posts: 3334
Joined: 19 June 2007
Location: Paris

Just to make it clear for those who didn't read the 89 pages of this thread: in the ph2010 database itself, there's no puzzle with T&E-depth 3.
"found there" means "found in the vicinity of hard puzzles in ph2010"

Re: The hardest sudokus (new thread)

by mith » Tue Jul 12, 2022 4:05 pm

Yes, when I say my local version, I'm not talking about ph2010 (or ph1910 before that), but rather the roughly 32 million minimals I have after running neighborhood searches on the published ph databases and a few other seeds (for low counts).

QUOTE

mith

Posts: 862
Joined: 14 July 2020

Because of the way those scripts run, this is actually split by clue count, so the best I will be able to do as a first pass is find the earliest T&E(3) puzzle at each clue count (if any - there probably aren't any at very low or very high counts).

Re: The hardest sudokus (new thread)

by mith » Thu Aug 04, 2022 6:19 pm

Five new 11.8 expanded forms today:

QUOTE

mith

Posts: 862
Joined: 14 July 2020

CODE: SELECT ALL

```
.....1.....23.....245.6.....47.....85.6.....47.28.56.86.....42.65.7..7.5.8.6..ED=11.8/2.0/2.0
.....1.....234.235.....6.....76.....56.23.8..7..8.56...56..7...3.7.28.5682.....ED=11.8/2.0/2.0
.....1.....234.235.....67...57.23.8..6..8.57...57..6...3.6.28.5782.....ED=11.8/2.0/2.0
.....1.....23.....245.6.....47.....85.6.....47.28.56.867.....42.65.7..7.5.8.6..ED=11.8/10.5/2.6
.....1.....234.235.....6..56..7...3.7.28.5682.....8..76...56.23.8..7..8.56...ED=11.8/11.8/2.6
```

Six minimals between them. All have a 1-guardian trivalue oddagon.

Re: The hardest sudokus (new thread)

by mith » Mon Aug 22, 2022 6:24 pm

Ten more 11.8s since my last update:

QUOTE

mith

Posts: 862
Joined: 14 July 2020

CODE: SELECT ALL

```
.....1.....23.4.....5..6.....576..4.814.....768.6...51...81.6...456...8..77.4.....ED=11.8/2.0/2.0
.....1.....23.4.....5..6.....576..4.814.....768.6...51...81.6...456...81.77.4.....ED=11.8/11.8/3.4
.....1.....2.3.....4.56.....17...5..84.2.87...2857...1.5.2478.74...25..ED=11.8/11.8/2.6
.....1.....2.34..4.1356...2.....3.3..56...7.8.3...1.3.542..2..64.15.4.12.3.6ED=11.8/2.0/2.0
.....1.....2.34..4.1356...2.....3.3..56...7.8.3...1..64.25.2.3.541..4.12.3.6ED=11.8/2.0/2.0
.....1.....2.34..4.1356...2.....3.3..56...7.8.3...1.32.4.6.2..64.15.4.1.532..ED=11.8/2.0/2.0
.....1.....2.34235...6...27.368..38.2.57.65.6.....53.68...6.2..7...87.52...6..ED=11.8/11.8/2.6
.....1.....2.34235...6...27.368..38.2.57.65.6.....53.68...6.2..7...87.52...6..ED=11.8/11.8/2.6
.....1.....2.34235...6...53.67...62...8...7.852..6..82.367...3.72.58.656.....ED=11.8/11.8/2.6
.....1.....2.34235...6...73.258.65.6.....82.3.67...8725..6.35.6.7...6.2..8...ED=11.8/11.8/2.6
```

Five "trees" here, and 21 minimals altogether. (All of them have single-guardian trivalue oddagons available after basics.)

The past little while I have been running the minimal_reducer script ({-2+1} on te3 minimals) along with the scripts on expanded forms. Closing in on 3 million minimals in the database, and a bit over 70% have been "reduced". I'm not sure at this point how long to expect it to run before running out of minimals (and I should mention there appears to be some bug that is causing some minimals to not be added to the database - shouldn't be too hard to track down, and I can just run the minimizer on all the min-expands once it's fixed), so depending on how I'm feeling in the next weeks I may go ahead and pause for an update of the database. My family finally got hit with COVID, and I'm definitely struggling with brain fog right now, so it may be a bit before I'm feeling up to that anyway.

When I do post an update, it will include some tools for trivalue oddagon/guardian analysis.

Re: The hardest sudokus (new thread)

by mith » Thu Aug 25, 2022 4:36 pm

Seven more:

QUOTE

mith

Posts: 862
Joined: 14 July 2020

CODE: SELECT ALL

```
.....1.....2.....3456.7.....6.....357.48..4.68..7...856..74.47.83...56.4.7..8ED=11.8/11.8/2.6
.....1.....2.....3456.7.....6.....354.78..4.68..7...856..74.47.83...56.7.4..8ED=11.8/11.8/2.6
.....1.....2.....3456.7.....6.....358.47..4.67...856..74.47.83...56.4.7..8ED=11.8/11.8/2.6
.....1.....12.....345.....36.....67.4.5847.85..6..54.638..3.7..86..68..7...ED=11.8/11.8/2.6
.....1.....12.....345.....36.....675..4857.8.4.6..45.638..3.7.8.6..68..7...ED=11.8/11.8/2.6
.....1.....12.....345.....36.....675..4857.8.4.6..45.836..3.7.6.8..68..7...ED=11.8/11.8/2.6
.....1.....12.....345.....36.....675..4857.8.4.6..45.836..3.7..8..68..7...ED=11.8/2.0/2.0
```

9 minimals from these.

Re: The hardest sudokus (new thread)

by denis_berthier » Wed Aug 31, 2022 6:52 am

Hi mith,
Best wishes with covid.

QUOTE

denis_berthier

2010 Supporter

Posts: 3334
Joined: 19 June 2007
Location: Paris

mith wrote:

The past little while I have been running the minimal_reducer script ({-2+1} on te3 minimals) along with the scripts on expanded forms.

When this is done, can we formulate any closure properties, e.g.:

- 1) all the puzzles in the min-expand database are in T&E(3) (not really a question);
- 2) any puzzle in the min-expand database has all its minimals in the minimal database (they obviously are also in T&E(3));
- 3) any T&E(3) puzzle in the minimal database has its expanded form in the min-expand database (not really a question);
- 4) any puzzle in the minimal database has all its [-2 +1] neighbours in the minimal database, provided that they are in T&E(3) and minimal; (that's were I'm the least sure about what to think; what about the T&E(2) minimals?).

Re: The hardest sudokus (new thread)

by mith » Thu Sep 01, 2022 12:32 am

I am currently running this script only on T&E(3) minimals (a separate database from the ph fork). But yes, the process currently is:

QUOTE

mith

Posts: 862
Joined: 14 July 2020

For each puzzle in the minimal_te3.db:
- Find all essentially different puzzles at {-2+1} (regardless of whether they are minimal)
- Check whether each puzzle is in T&E(3). If so:
-- Find the singles expanded form of the puzzle and check if it is new in the expanded_te3 database; if it is, add it.
-- All new puzzles in the expanded_te3.db are checked for transforms (digit cycle swaps), which are always also in T&E(3) as well as {+1} neighbors that remain in T&E(3).
-- All puzzles in the expanded_te3.db are minimized, and new minimals added to minimal_te3.

The result is stronger than property 4 - all {-2+1} neighbors which are T&E(3) and minimal will be present, but also any puzzle which is in the same "tree" as a {-2+1} neighbor (even if that neighbor isn't itself minimal).

Eventually I will also be running {-1+2} and {-2+2} neighborhoods, but this take much longer and are unlikely to ever reach a point of closure so long as I am running this on a single PC (I've given some thought to some sort of distributed computing program - sudoku@home if you will - but that's a longer term project and I have no idea how many people would be interested in contributing computing resources to something like this anyway). Even {-2+1} is quite slow - we're down to "only" 859k minimals unprocessed at the moment, out of 3.18m.

Only T&E(3) puzzles are in these databases. That said, I do intend to go back to the ph fork and run a depth check on all puzzles (or at least those not in the minimal_te3.db already), it would not be surprising to find some in different neighborhoods to add to the te3 databases.

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