Visualizing Dynamic Programming On Tree Decompositions

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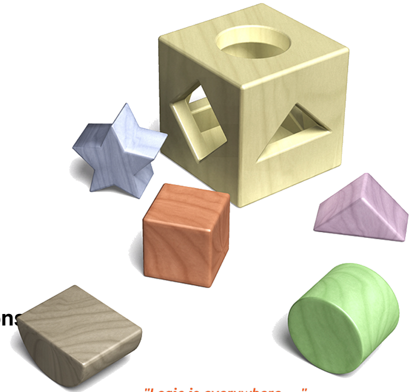
- **REWORK AFTER CHAPTERS**
- WHAT **was the motivation**
- WHAT **could be used otherwise?**
- WHO **benefits from visualization?**
- METHODOLOGY **challenges and solutions**
- WHAT **could be developed next?**



"Logic is everywhere ..."

Motivation

- **DP-on-TD-algorithms can solve Model Counting and various combinatorial problems**
- **Implementations of those are competing with modern solvers**
- **But: those are fairly hard to implement efficiently**
- **Practical debug output quickly becomes very large (GB)**
- **Finding the cause of the problem is a time consuming challenge**

Background

The algorithms of interest solve problems of:

- **combinatorics (NP-problems)**
- **model-counting (#P-problems)**

Recent promising results for Projected Model Counting by Markus Hecher[1].

[1] Hecher M., Thier P., Woltran S. (2020) Taming High Treewidth with Abstraction, Nested Dynamic Programming, and Database Technology. In: Pulina L., Seidl M. (eds) Theory and Applications of Satisfiability Testing - SAT 2020. SAT 2020. Lecture Notes in Computer Science, vol 12178. Springer, Cham. https://doi.org/10.1007/978-3-030-51825-7_25

Tree Decompositions

A tree decomposition is a tree obtained from an arbitrary graph s.t.

1. **Each vertex must occur in some bag**
2. **For each edge, there is a bag containing both endpoints**
3. **Connected: Subgraph “restricted” to any vertex must be connected**

Graphic

Graphs for Boolean Formulas

- **Example set of CNF-clauses:**

  $\{c1 = \{v1, v3, \neg v4\}, c2 = \{\neg v1, v6\}, c3 = \{\neg v2, \neg v3, \neg v4\}, c4 = \{\neg v2, v6\}, c5 = \{\neg v3, \neg v4\}, c6 = \{\neg v3, v5\}, c7 = \{\neg v5, \neg v6\}, c8 = \{v5, v7\}\}$

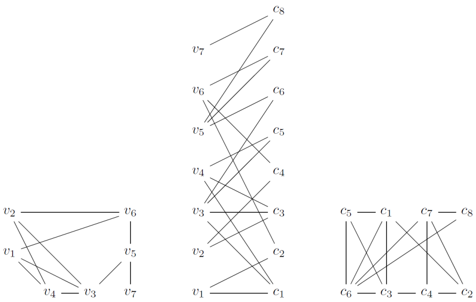
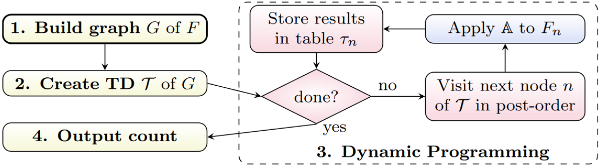
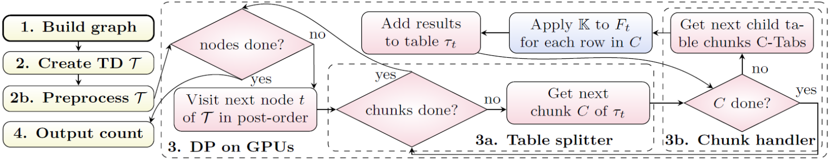


Figure: The primal (left), incidence (middle) and dual (right) graph

gpusat2 - Solving on GPU



- **Customized tree decompositions**
- **Adapted memory-management**
- **Improved precision handling**



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[1] text

dpdb

Using databases for intermediate results

1. **Create graph representation**
2. **Decompose graph**
3. **Solve sub-problems**
4. **Combine rows**

Generator SQL Qs =¿ Datenbank Templating in Python

- **SAT**
- **#SAT**
- **Vertex cover**

– #εTab#: `SELECT 1 AS cnt`
– #intrTab#: `SELECT 1 AS val UNION ALL 0`
– #localProbFilter#: $(l_{1,1}$ `OR` … `OR` $l_{1,k_1})$ `AND` … `AND` $(l_{n,1}$ `OR` … `OR` $l_{n,k_n})$
– #aggrExp#: `SUM(cnt) AS cnt`
– #extProj#: τ_1`.cnt *` … `*` τ_ℓ`.cnt AS cnt`

(a) Problem #SAT

– #εTab#: `SELECT 1 AS cnt`
– #intrTab#: `SELECT 1 AS val UNION ALL` … `UNION ALL` o
– #localProbFilter#: `NOT` $([\![u_1]\!] = [\![v_1]\!])$ `AND` … `AND NOT` $([\![u_n]\!] = [\![v_n]\!])$
– #aggrExp#: `SUM(cnt) AS cnt`
– #extProj#: τ_1`.cnt *` … `*` τ_ℓ`.cnt AS cnt`

(b) Problem #o-Col

– #εTab#: `SELECT 0 AS card`
– #intrTab#: `SELECT 1 AS val UNION ALL 0`
– #localProbFilter#: $([\![u_1]\!]$ `OR` $[\![v_1]\!])$ `AND` … `AND` $([\![u_n]\!]$ `OR` $[\![v_n]\!])$
– #aggrExp#: `MIN(card) AS card`
– #extProj#: τ_1`.card +` … `+` τ_ℓ`.card -` $(\Sigma_{i=1}^{\ell}|\chi(t_i) \cap \{a_1\}|$ `- 1) *` $\tau_1.[\![a_1]\!]$ `-` … `-` $(\Sigma_{i=1}^{\ell}|\chi(t_i) \cap \{a_k\}|$ `- 1) *` $\tau_1.[\![a_k]\!]$

(c) Problem MinVC

github: `https://github.com/hmarkus/dp_on_dbs`

Challenge1

Generisches Datenformat /Strings Visu
=¿ Anwendungen

Challenge2

=¿ Wie robust ist die Datenverarbeitung in der Visu =¿ Was Gedanken bei der Visu waren

Challenge3

Gephi makes graphs handy

© Gephi.org - a tool for data analysts and scientists keen to explore and understand graphs.[2]

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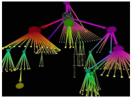
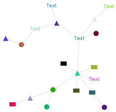


Tulip - Better Visualization Through Research. [3]



[4] Vis.js   Sigma.js   vasturiano/3d-force-graph [5]

=¿ Related Work Schluss / Wiss Arbeiten -¿ Nicht speziell Angeschaut / Format aus Solvern extrahiert - kann trotzdem sehr generisch sein (dpdb speziell)

[2] https://gephi.org/

[3] https://tulip.labri.fr/TulipDrupal/

[4] https://neo4j.com/developer/tools-graph-visualization/

Visualization

Manually for gpusat

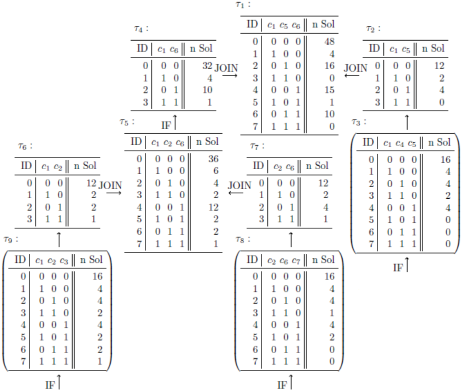


Figure: Handcrafted #SAT example-run from Markus Zisser[6]

=¿ Dynamic programming Grafiken / Verlaufsschema Kurz erklären -¿ Beweise dazu sind aufwändig und recht speziell /

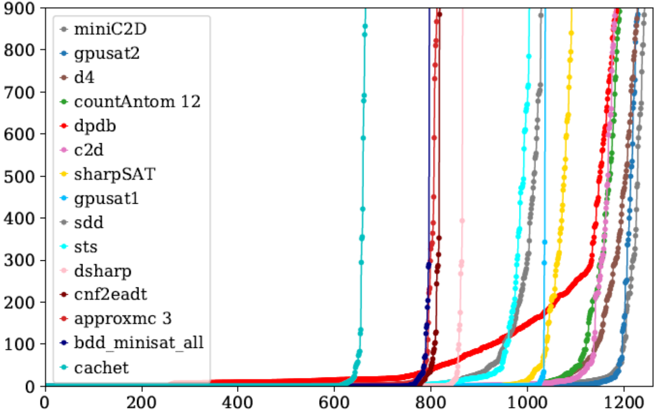
[6] "Solving #SAT on the GPU with Dynamic Programming and OpenCL".

Outlook

for relevant problems the static graph visualization will become to complicated.
https://data-science-blog.com/blog/2015/07/20/3d-visualisierung-von-graphen/
=¿ Automatische Methoden werden häufig schwerer als gedacht.
Für tiefere Debugging Tasks müsste evtl auch der Ansatz erneuert werden
=¿ Was wären weitere Fragestellungen was man ansehen möchte

Benchmark

Performance of all three programs on #SAT instances:



Visualization

Manually for dpdb

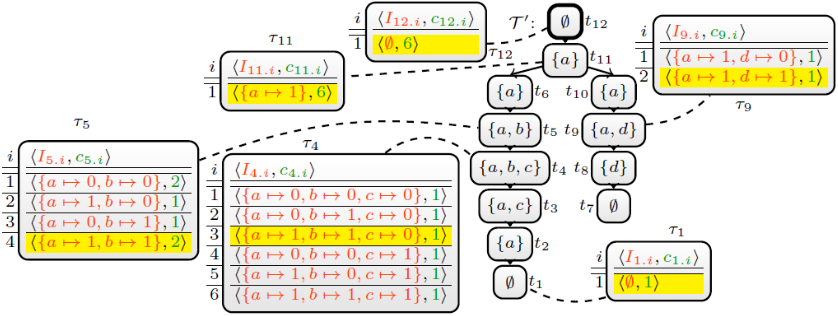


Figure: Handcrafted #SAT example-run from dpdb[7]

[7] "Exploiting Database Management Systems and Treewidth for Counting", Fichte, Hecher, Thier, Woltran

Bibliography