TaSSAT: Transfer and Share SAT

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Local Search and DDFW Overview

Dozens of local search algorithms for SAT
- On various problems much faster than CDCL
- Most algorithms use local flips (to be prob. complete)
- We studied weight transfer algorithms (with global flips)
Local Search and DDFW Overview

Dozens of local search algorithms for SAT
▶ On various problems much faster than CDCL
▶ Most algorithms use local flips (to be prob. complete)
▶ We studied weight transfer algorithms (with global flips)

Arguably the best weight transfer algorithm is DDFW
▶ Divide and Distribute Fixed Weights
▶ Original solver by Ishtaiwi et al. (2005) was never released
▶ Tompkins reverse engineered the details for UBCSAT
▶ Various papers mention effectiveness of DDFW in UBCSAT
Weight Transfer Heuristics

Key heuristic: transfer weight from neighboring clauses

- Clauses are neighboring if they share a literal
- Transfer weight from satisfied to falsified clauses
- Transfer from highest weight satisfied neighboring clause

Divide and Distribute Fixed Weights (DDFW) heuristics

- Weight initialization
  \[ W(C) = w_0 = 8 \]
- Transfer weights if no weight-reducing variable to flip
  - Transfer a weight of 1 if \( W(C_{satisfied}) = w_0 \)
  - Transfer a weight of 2 if \( W(C_{satisfied}) > w_0 \)
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Divide and Distribute Fixed Weights (DDFW) heuristics

- Weight initialization $W(C) = w_0 = 8$
- Transfer weights if no weight-reducing variable to flip
- Transfer a weight of 1 if $W(C_{satisfied}) = w_0$
- Transfer a weight of 2 if $W(C_{satisfied}) > w_0$
New Weight Transfer Heuristics

Divide and Distribute Fixed Weights (DDFW) heuristics

- Weight initialization \( W(C) = w_0 = 8 \) (int)
- Transfer weights if no weight-reducing variable to flip
- Transfer a weight of 1 if \( W(C_{\text{satisfied}}) = w_0 \)
- Transfer a weight of 2 if \( W(C_{\text{satisfied}}) > w_0 \)

Linear Weight Transfer heuristics [NFM 2023]

- Weight initialization \( W(C) = w_0 \) (float)
- Transfer weights if no weight-reducing variable to flip
- Transfer a weight of \( p_{\text{init}} \times w_0 \) if \( W(C_{\text{satisfied}}) = w_0 \)
- Otherwise a weight of \( p_{\text{base}} \times w_0 + p_{\text{curr}} \times W(C_{\text{satisfied}}) \)
Optimizing the Parameters

PAR-2: average runtime with timeout counted as $2 \times$ timeout

Observations:
- Combining $p_{base}$ (basepct) and $p_{curr}$ (currpct) is best
- Max $p_{init}$ (initpct), i.e., taking all weight, is best
Solver Comparison

Solvers used for runtime comparison

- TaSSAT: The solver presented in this talk/paper
- YalSAT-Lin: Weight transfer with NFM’23 paper heuristics
- YalSAT-DDFW: Weight transfer with DDFW heuristics
- YalSAT-ProbSAT: Default YalSAT
- UBCSAT-DDFW: Only public implementation of DDFW
Results on SAT Competition Benchmarks

![Graph showing solved anniversary track instances over runtime (secs) for TaSSAT, YalSAT-Lin, UBCSAT-DDFW, YalSAT-DDFW, and YalSAT-Prob.]
Data-Structure Sharing

PaISAT:
- Each thread reads / stores / preprocesses formula
- Redundant computation
- Large memory footprint

PaSSAT:
- Master thread reads / stores / preprocesses formula
- Shared clause database and lookup table
- Large memory reduction when using many cores
Results on van der Waerden Numbers

Color the numbers 1 to n \textcolor{red}{red} and \textcolor{blue}{blue} without
\begin{itemize}
\item arithmetic progress of length 3 in \textcolor{red}{red}
\item arithmetic progress of length k in \textcolor{blue}{blue}
\end{itemize}

Best known results by Ahmed et al. using parallel SAT
\begin{itemize}
\item used DDFW in UBCSAT
\item some bounds obtained by enforcing symmetries
\end{itemize}

\begin{tabular}{l|cccccccccc}
result \k & 31 & 32 & 33 & 34 & 35 & 36 & 37 & 38 & 39 \\
\hline
Known & 930 & 1006 & 1063 & 1143 & 1204 & 1257 & 1338 & 1378 & 1418 \\
PaSSAT & 953 & 1011 & 1071 & 1145 & 1208 & 1260 & 1341 & 1380 & 1419 \\
\end{tabular}
Conclusions

TaSSAT: Arguably the best SAT-based local search solver
- open source: https://github.com/solimul/tassat
- best SLS performance on SAT Competition benchmarks
- improved many van der Waerden lower bounds
- PaSSAT has reduced memory footprint

Future work
- Communication between threads (e.g. sharing assignments)
- Combining TaSSAT with CDCL
- Further improve heuristics