

Master Thesis Proposal

Certified Circuit Reconstruction for QBF

Student: Mihai-Alexandru Weng

Advisor: Dr. Friedrich Slivovsky

March 18, 2024

Contents

1	Motivation & Problem Statement	2
2	Aim of the Work	3
3	Methodological Approach	4
4	Structure of the Work	5
5	State-of-the-Art	6
6	Relevance to the Curricula of Logic and Computation	7

1 Motivation & Problem Statement

2 Aim of the Work

The objective of the thesis is to introduce an additional way of generating a QRAT proof for a given QBF in QDIMACS format, using its circuit translation.

In this way, we can achieve extra assurance for the circuit translation by checking the produce proof can also solve the input before translation. And also, utilize the favorable input for the QBF solver, based on empirical result [1], a circuit based format.

3 Methodological Approach

1. Better understanding of the tools involved in the process.
2. Devise test samples for checking various edge cases.
3. Automate the workflow.
4. Modify a QCIR QBF (QCDCL) solver to output the CNF encoding.
5. Implement conversion from Q-resolution proof to QRAT.
6. Implement a program for getting a (Q)RAT derivation of the CNF encoding using a SAT solver.
7. Verify against the test sample.
8. Using common benchmarks for testing.

4 Structure of the Work

1. Introduction
2. Preliminaries
 - (a) Q-resolution proof
 - (b) QRAT proof
 - (c) QBF input formats (CNF / non-CNF)
3. Extension of circuit based solver
4. QRAT proof for QDIMACS from QCIR
5. Testing
6. Conclusion

5 State-of-the-Art

In [2], it is raised the problem that simple Tseitin translation can be harmful to the QBF, a CNF QBF solver could take exponential time for a trivial input before the translation. Thus, in the previous work, a tool for transforming a QDIMACS into circuit form is developed. Also, in [1] testing the circuit format, QCIR [3], is noted the direction of the ongoing research for non-CNF solvers in improving the translation and certification. In plus, we can see an interest in developing those solvers for circuits format for competition. This way, it can open the possibility for combining the best of both worlds solvers, CNF and non-CNF, [4].

6 Relevance to the Curricula of Logic and Computation

The topic of certifying proof, in development of validation tools for boolean formulas, touches many areas covered in the Logic and Computation syllabus. Those branches are: algorithms and data structures, logic, formal verification, complexity. Courses relevant to the thesis' content are:

- 186.814 Algorithmics
- 186.182 Seminar on Algorithms
- 184.090 SAT Solving
- 181.145 Computer Aided Verification
- 185.291 Formal Methods in Computer Science
- 185.A45 Logic and Computability
- 184.068 Artificial Intelligence Seminar

References

- [1] C. Jordan, W. Klieber, and M. Seidl, “Non-CNF QBF Solving with QCIR,”
- [2] W. Klieber, “Formal Verification Using Quantified Boolean Formulas (QBF),”
- [3] “QCIR-G14: A Non-Prenex Non-CNF Format for Quantified Boolean Formulas,” *QBF Gallery 2014*.
- [4] M. Janota, “Circuit-Based Search Space Pruning in QBF,” in *Theory and Applications of Satisfiability Testing – SAT 2018* (O. Beyersdorff and C. M. Wintersteiger, eds.), vol. 10929, pp. 187–198, Cham: Springer International Publishing, 2018. Series Title: Lecture Notes in Computer Science.