Master Thesis

Modeling selected computational problems as SAT-CNF and analyzing structural properties of obtained formulas

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"Let your plans be dark and impenetrable as night, and when you move, fall like a thunderbolt." — Sun Tzu, The Art of War

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Abstract

The boolean satisfiability was the first computational problem to be proven NP complete.

The proof of this fact was established independently by Stephen Cook and Leonid Levin over 40 years ago.

Since then numerous problems were shown to be NP complete.

Nevertheless, boolean satisfiability (SAT) arguably still has remained the most fundamental NP complete problem out there.

It is possible to convert all problems in NP to SAT by using polynomial time reductions.

In this thesis I provide step by step description of reduction from OWA-Winner problem (to be precise it's decision version) to SAT-CNF.

In order to do this I investigate known techniques of reducing Integer Factorization to SAT-CNF and encoding boolean cardinality constraints.

Having reduced both Integer Factorization and OWA-Winner problems to SAT-CNF I consider experimental ways of exploring the structure of obtained boolean formulae instances.

1. The boolean satisfiability problem

1.1. Overview

bla bla bla bla bla bla bla bla bla bla bla, see **??**. Bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla DLC-coatings bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla bla, see [FN28]. (1.1) is the definition of the integral sine function.

$$\int \frac{\sin(x)}{x} \, \mathrm{d}x = \mathrm{Si}(x) \tag{1.1}$$

1.2. Applications

2. Reducing selected computational problems to SAT-CNF

2.1. Reducing Integer Factorization to SAT-CNF

bla bla bla bla bla bla bla bla bla bla bla bla bla PPS bla, see [Ric21, Mar63].

2.2. Reducing OWA-Winner to SAT-CNF

3. Experimental analysis of structure of obtained formulas

3.1. Structure of Integer Factorization formulas

3.2. Structure of OWA-Winner formulas

3.3. Structure of randomly-generated hard formulas

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A. Appendix

A.1. Overview

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A.2. The next section

Bibliography

[FN28] R.H. Fowler and L. Nordheim. Electron emission in intense electric fields. *Proceedings of the Royal Society of London. Series A, Containing Papers of a Mathematical and Physical Character*, 119(781): 173 – 181, May 1928, http://www.jstor.org/pss/95023.

[ISO] ISO 10780:1994, stationary source emissions – measurement of velocity and volume flowrate of gas streams in ducts, ISO. http://www.iso.org/iso/catalogue_detail.htm?csnumber=18855.

[Mar63] Donald W. Marquardt. An algorithm for least-squares estimation of nonlinear parameters. *SIAM Journal on Applied Mathematics*, 11(2): 431 – 441, 1963, http://dx.doi.org/10.1137%2F0111030.

[Ric21] O.W. Richardson. *The Emission of Electricity from Hot Bodies.* Longmans, Green and co., 1921.

Nomenclature

R_a	arithmetic average roughness
DLC	diamond-like carbon
PPS	Polyphenylene sulfide