Master Thesis Report

Faculty of Mathematics and Physics, Charles University

Thesis author	Jelena Glišić
Thesis title	Non-standard representations of Boolean functions for knowledge compilation
Submitted	2024
Program	Computer Science **Specialization** Theoretical Computer Science

Review author	prof. RNDr. Ondřej Čepek, Ph.D. **Role** advisor
Position	Department of Theoretical Computer Science and Mathematical Logic

Review text:

The main aim of the thesis was to place the Boolean Nearest Neighbor (BNN) language into the Knowledge Compilation Map (KCM) introduced in 2002 by Adnan Darwiche and Pierre Marquis. BNN was introduced quite recently (2022) by Hajnal, Liu, and Turán. It is a knowledge representation language which belongs to the family of vector-list representations of Boolean functions (other such languages include the full truth table, list of models, list of non-models, interval representations, and switch list representations). In the BNN language a boolean function $f(x_1, \ldots, x_n)$ is represented by a set of positive and negative prototypes (n dimensional boolean vectors) and the function value $f(x_1, \ldots, x_n)$ is determined by the fact whether the (Hamming distance) closest prototype to $(x_1, \ldots, x_n)$ is positive or negative (the definition of BNN does not allow ties). Placing a knowledge representation language into a KCM means achieving three goals:

1. Deriving relative succinctness results comparing the new language with as many languages already in KCM as possible.

2. Establishing the complexity status of as many standard queries as possible (for the new language).

3. Establishing the complexity status of as many standard transformations as possible (for the new language).

In the ideal case (exact placement) the phrase "as many as possible" is replaced by "all" in the above three goals. However, it is realistic to expect that when a new language is being studied in the context of KCM, not all questions are answered instantly and some open ends remain for future research.

Jelena's thesis contains new non-trivial results towards all three goals. In particular:

1. The thesis fully establishes relative succinctness relations to languages MODS, CNF, DNF, IP, PI, and BDD and partially also to OBDD. Some results are trivial (relation to MODS), some required finding appropriate functions as counterexamples (incomparability with CNF, DNF, IP, and PI), some are quite non-trivial (BNN is strictly less succinct than the language BDD of Binary Decision Diagrams). Succinctness relations with many more languages are implied by the transitivity of this relation (and already known results in KCM), so there are not many open ends left in this area (establishing fully the relation to the OBDD language is perhaps the most interesting open question).

2. The thesis shows that the BNN language supports consistency and validity checks (which is more or less obvious from the definition of BNN) and that it also supports implicant check and clausal entailment (which is not obvious at all and requires an algorithm and a proof). The complexity status of other queries (in particular of model counting, equivalency check and sentential entailment) remains open.

3. The thesis shows that the BNN language supports negation (which is an easy result) and that it does not support conditioning and forgetting. The complexity status of singleton forgetting, conjunction, and disjunction remains open.

Since the thesis contains several new non-trivial results which place the BNN language quite precisely (although not fully) into KCM, I conclude that the main aim of the thesis was in my opinion fulfilled and the thesis can be (hopefully) successfully defended.

I recommend the thesis for defense.

I suggest to not consider the thesis for the annual award.

August 23, 2024

Signature: