Review of: "Exploiting Structure: A Survey and Analysis of Structures and Hardness Measures for Propositional Formulas"

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Potential competing interests: No potential competing interests to declare.

Short summary: The topics discussed in this paper closely relate to the Boolean Satisfiability problem (SAT) and methods that can be used to solve this problem effectively and efficiently. More specifically, a detailed overview of some notable structures and properties of SAT instances, which can easily be exploited by state-of-the-art SAT solvers, is given. Besides that, several measures that can be used to indicate the hardness of solving a SAT instance are listed and discussed as well. In order to clarify the interactions that exist between the structures, properties and measures that are discussed in this paper, several (important) relationships, which can be exploited by state-of-the-art SAT solvers as well, are identified and explained in detail.

General comments: The paper is well-written and most of the topics that are elaborated on are described in a clear way. Moreover, the content is organized very logically. This ensures that, for a broad audience, the paper is quite accessible, and easy to follow and read. However, I miss some justification on how and why this paper contributes to the field of SAT problems. More specifically, I wonder whether you can elaborate in more detail on the goal and the contributions of this paper, as well as on why you decided on giving an overview of these selected structures, properties and hardness measures (and not other the ones, e.g., discussed in the related work section). Because of this, I recommend this paper for publication after some minor modifications. More detailed comments are listed, per section, below.

Full manuscript:

- There are some references to state-of-art-work that can (or even should) be added. Especially to state-of-the-art work describing foundational concepts (such as SAT, VIGs…) are important to add in this sense. I miss, for example, references to some state-of-the-art naive/backtracking methods (in Section 2.2), to variable incidence graphs, etc.
- The language that is used is quite good. However, I have the feeling that it can still be improved slightly. Especially the usage of the articles ‘a’ and ‘the’ should be reviewed. Besides that, I encountered some linguistic (grammar) errors (e.g., ‘**an** autark assignment**s**’ in Section 4). Also, splitting up long sentences (e.g., ‘While efficiently solving arbitrary instances … for certain types of formulas’ on p. 1) would improve the readability of the paper.

Section 1:

- In the introduction, can you elaborate in more detail on the research questions answered in this paper, the

contributions of this paper and the main goal of this paper? Moreover, in my area, it is custom to add an outline of the paper (i.e., a short overview of the topics discussed in the following sections) at the end of this section. Also, can you argue why you chose to discuss the 5 five structures and hardness measures, and, for example, not the ones discussed in the related word section? Are they more commonly used in state-of-the-art work?

- Try to use either the term ‘hardness indicators’, ‘hardness indicating measure’ or ‘difficulty indicating measure’ consistently throughout the paper, to avoid any misunderstanding or confusion.

Section 2:

- Try to use either the term ‘symbol' or ‘variable' consistently throughout the paper.
- The notation *n* is used to indicate both the number of variables in the definition of a fitting assignment and the number of clauses in a formula. It would be less confusing if one of the two notations is modified. Moreover, the same comment applies to the symbol S, which is used to indicate both a box of size s and a set of variables.
- The definition of the term ‘contradiction’ should be added as a new definition (e.g., Definition 2.5) or it should be added to Definition 2.4.
- Definition 2.5 is a bit confusing. You state that the SAT problem is defined as the set of all satisfiable formulas in CNF, but, as far as I recall, the SAT problem is the problem of finding out whether a formula in CNF is satisfiable or not (which is more in line with the what is stated in Section 1). Is it possible to review/clarify this definition?
- It would help to restate (or redefine) shortly what the meaning of NP-problem and/or NP-hardness is.
- For clarity reasons and in order to improve readability, I suggest to use the example stated in Section 2.2 or the example formula introduced in Section 3 throughout Section 2.1 in order to explain the stated concepts and clarify the stated definitions.
- Can you shortly elaborate on how DPLL and CDCL compare to each other in terms of performance/scalability? Are there any results that are stated in the corresponding papers that can be used to do this?
- A clear explanation, together with an example, is stated that shows how an answer to the SAT problem can be given by means of the model finding technique. However, you elaborated only very shortly on answering the SAT problem by means of finding a refutation proof. Can you give more details on this technique and/or a clarifying example?

Section 3:

- Reorder the columns of the table listed in Figure 4, such that they feature the same order as they are discussed in the corresponding (sub)sections of Section 3.1.
- In Section 3.2, hardness is defined as referring to the difficulty of a given instance compared to other instances of the same problem. I think, however, that this definition/statement is quite abstract and difficult to understand. Can you define this more formally, or maybe add an example in order to clarify this?
- Can you give more details on ‘the amount of steps that a solving algorithm has to take’? What do you mean exactly with ‘steps’?
- In Figure 5, the symbol N is used to indicate the number of variables of an instance. Either you should define this symbol in Section 2.1 or use symbol S, which is more in line with the explanation given in this section.

- It is not clear to me why the example formula is not comparable to the instances generated and examined in the work of Achlioptas et al. [1]. Can you elaborate shortly on this?
- For the centrality, modularity and self-similarity measures, it is not clear to me how you can determine the hardness of a formula based on these measures. Can you explain this in a bit more detail and/or add a clarifying example?

Section 4:

- Try to use either the term ‘relation' or ‘relationship', ‘arrow' or ‘arrowhread' and ‘self-similarity’ or ‘self similarity’ consistently throughout the paper.
- Add the dotted line, solid line and normal arrowhead to the legend in Figure 7.