Title: Rational meta-reasoning in Problem solving Search.

I have read the dissertation of Mr. David Tolpin and my opinion is that the thesis should be ACCEPTED in its current form.

This thesis is rather unique in the areas of Search and problem solving. Many of the dissertations in this area include new algorithms/new enhanced variants to old problems, or introduce new problems and engineer existing algorithms to the new problem.

By contrast, the current thesis takes a general direction which is orthogonal to the algorithms in the area of meta-reasoning for search. A search algorithm usually has many inside decisions to make but usually, these decisions are selected arbitrarily or better yet by the algorithms designer. The current dissertation is a significant breakthrough in this area as it suggests a meta-reasoning level that makes rational decisions. This is the core idea of the general Artificial Intelligence fields (i.e., to make ration decisions) and implying this to Search is a tremendous contribution as this area usually lacks those insights.

The author presents a methodology to guide search algorithms in their decision making based on the general principle of Value Of Information (VOI). For each possible decision, the VOI is calculated/approximated and the algorithm chooses to take the direction with the highest VOI. The author presents a number of non trivial, yet easy to calculate (from the complexity point of view) formulas for effective VOI approximations for a number of different scenarios, e.g., Constraint satisfaction problems, Monte-Carlo tree Search and the standard well-known A* algorithm. Each of these directions makes its own chapter in the thesis as specific formulas need to be developed for each of these unique circumstances. Nevertheless, there is a single thread which ties all these chapters together, that is - the meta-reasoning formula to make the best rational choice. This makes the thesis very broad as the main idea of the thesis is demonstrated on three rather different scenarios, each with its own definitions, structure of problem and the resulting search tree and limitations.

The first chapter on CSP and the third chapter on Rational Lazy-A* are very important and the author posses state-of-the art results for such scenarios. This is a remarkable achievement. In particular, a program based on Rational-Lazy A* spawned an entry to the International Planning Competition to take place in summer

But, I think the greatest contribution of this thesis the chapter on Monte-Carlo Tree Search. The UCT algorithm is rather new, but attracted tremendous number of researchers in the past few years due to its great success in many domains. On the other hand its logical structure and mathematical foundations are not deeply clear to researchers. The author, in the MCTS chapter, reveals a major flow in that algorithm and introduces his own method that remedies this issue together with a new theoretical understanding on the relation between the different "regent" attributes. This is a lasting contribution and will see broad applications in many years.

This thesis spawned a large number of scientific publications in the highest tier of international conferences in th field of Artificial Intelligence such as AAAI, IJCAI, EACI and UAI. The thesis is very well structured: an introduction and background section which nicely covers the related directions followed by a single chapter for each of the scenario and a summary chapter. While the main contribution of the thesis is theoretical, the author systematically provides experimental results that support his claims. This deeply strengthen the merit of the thesis. The thesis is well written and proofread. I did not spot any misktakes/typos and this is rather unusual.

Perhaps my only concern is the following. In the mathematical sections the guidance of the author in English words around the mathematical formulas is on the minimal side. In general, this is a matter of personal taste; different authors have different writing styles. Nevertheless, I encourage the author to widen the English sentences around his formulas to make them better accessible. But, whether to do it or not is completely up to the author.

To summarize, I herby recommend to ACCEPT this Ph.D dissertation in its current form without any comments.

In addition, I think that this thesis should be considered to be awarded "WITH EXCELLENCE". This thesis re-vitalized the field of meta-reasoning in search. There was an early theory on this matter from decades ago but it was impractical. The current thesis brought this area into life and made it accessible to real-world domains and scenarios. The richness and depth of his contributions is exceptional for a researcher at this level

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