21/1/2014

**Review of David Tulpin Thesis:**
**""Rational Metareasoning in Problem-Solving Search**

The thesis considers some of the theoretical difficulties as well as advantages that arise when applying methods of rational metareasoning (RM) to solve search problems. In particular, it focuses on rational metareasoning version of algorithms for Monte Carlo tree search, optimal planning and constraint satisfaction. It considers the tradeoff between the accuracy of estimating the value of information (VOI) vs. the computational efforts that are required for such a task and propose a practical working scheme to address it.

Overall the work is well organized and well written in terms of language and scientific style. It addresses a problem that is well motivated by many real world examples. For example, the work provide concrete examples of applying the proposed approach to state-of-the art algorithms, such as the TSP, Multi-armed bandit and A*, that are used to tackle real-world problems, as well as improvements to widely applied optimization algorithms. The proposed approach seems to be competitive and efficient although its optimality has not been proven for the general case.

Chapters 1&2 present very well the research gap and the work motivation. However I think that the introduction on metareasoning dual process could be explained better – to differentiate it from many greedy search algorithms approaches that do not belong to that class, but use VOI-like procedures. Chapter 2 provides good background on problem-solving search and maps it well, although some newer publications in the field could be added (eg Bulitko's later publications, Kagan et al. etc).

I am not sure that the presented work should consider also games – as these are based on fundamentals that are often different than those related to conventional search problems (eg in TSP, planning and routing) and it might have been better to keep the discussion on games to another framework.

Chapter 3 provides background on Rational Metareasoning. Yet, some details on actual implementation remain unclear, for example how to set the value of alpha – the amortization factor and how to practically apply the general framework of RM in real world problems with specific set of assumptions.

A better distinction should be made to distinguish between the work own contribution and other contributions in the field.

Chapter 4 addresses very important and popular class of problems. It is shown how the propose approach can reduce computation of VOI estimates by focusing and recalculating the estimates only for measurements for which a change in VOI is likely to affect the choice of the next measurements. However, I do feel that the analysis and benchmark sections could be extended here to include more numerical results. For example when considering parameter optimization problems, it could be interesting to

evaluate the proposed scheme against other approaches such as *importance sampling* and *cross entropy* that follow the same rational in selecting the next computations. Chapter 5 is well written and contains nice analyses. The advantage of the proposed scheme is well illustrated and an improvement in the overall algorithmic performance is achieved – yet, again with respect to simple deployment tactics, such as computing always the estimates. Here as well a benchmark vs more sophisticated methods could have been beneficial.

Chapters 6 &7& 8 are well written (see below remark on potentially small addendum to chapter 8)

To summarize, this work provides both theoretical background and shows in a series of case studies how an improvement of state-of the art search algorithms is obtained due to the implementation of the rational metareasoning concepts. Applications from different domains emphasize the effectiveness of the proposed method in a variety of domain properties and different objectives. Nonetheless, since a general conclusion cannot be inferred by examples, even if they are good ones as in this case, it might be justified to try and propose a general observation at the last chapter to support a more general conclusion when the proposed approach might work well.

Finally, let me note that the challenge of implementing RM framework to search problems is not always trivial and requires both wide and deep understanding from the student, and I congratulate him for this achievement.

This work is accepted as a PhD thesis subject to the proposed corrections that will be controlled and supervised by the student advisor.