Endomorphhic metalanguage and abstract planning for real-time recognition
by Antoine Gréa

REPORT

Summary

The work presented in this PhD manuscript revolves around knowledge representation in automated planning. The objective pursued in this work can be summarized in two points:

1) to come up with a new and expressive knowledge representation formalism for representing all types of planning domains; the knowledge description model allows incorporating semantic information and unify the representation of different kinds of planning information.
2) leveraging the knowledge description model enables to increase the speed of the search space exploration and give rise to a real-time planning setting; this new setting is the underlying formalism for the design of two planners: a heuristic-based planner for repairing plans and a HTN planner able to find intermediate (abstract) solutions.

These two contributions together are aimed to accelerate computation time in planning so that a planner be able to recognize on time the intention of an observed agent, that is, before the actual action of the observed agent is realized. Ultimately, the motivation behind this contribution is to enhance assistance to dependent people whose intentions are often needed to be inferred so that the correct decision-making is applied.

Evaluation

The thesis certainly addresses a very interesting topic that has recently become a hot research thread: model-based goal recognition as planning for human well-being. The novelty of this work lies in the incorporation of a knowledge description model for a better understanding of the observed agent behavior (the dependent person). It is stimulating that while most works that address this issue tackle the problem from an algorithmic perspective, this thesis work puts the emphasis on the knowledge representation side, an aspect that has been largely ignored. For this reason, the author contributes with a novel and innovative approach to model-based recognition.

The document is very well written and organized. English writing and style are excellent. I particularly liked the content organization in pairs of consecutive chapters where the first one exposes the theoretical concepts and the second one presents the application of the theory presented in the preceding one. This is, to my view, a different way of structuring a PhD work and I found it very refreshing.

In the following, I will present an assessment of the two main contributions of the work.

Knowledge representation formalism

The author contributes with the design of a new tool, named SELF, based on dynamic grammars and inspired in RDF format that overcomes the limitations of classical knowledge representation formalisms. By using SELF, the designer can write planning domains with a language that offers extended expressivity and higher order knowledge. The general planning formalism presented in Chapter 4 is used to formalize all planning paradigms under a unifying notation.

A practical example on the use of the SELF language for expressing planning domains is presented in Chapter 5. While the example shown in Listing 5.17 is interesting and exhibits the knowledge representation power of COLOR, a more complex example would help understand the functionalities of the planning formalism. Specifically, the *blocksworld* domain is a very simple domain from the representation point of view. The author may want to explore other domains of the International Planning Competition (IPC) benchmarks. Ideally, it would be helpful to provide answer to the following issues:

1. Type hierarchy. PDDL allows for describing hierarchies of types that encapsulate some type inheritance. The *blocksworld* domain is the simplest possible domain from this perspective because only one (implicit) type is used (the type *block*). I would like to see how the hierarchy type would be represented in COLOR (e.g. the *Driverlog* domain).
2. I miss the representation of the planning problem. Chapter 5 is devoted to explaining how to use the knowledge formalism to represent planning domains but, what about planning problems? A PDDL-based planning task consists of two files, the planning domain and the planning instance, where the initial state and goal conditions are specified. I wonder whether COLOR allows to write planning instances as well. An example of this would be very helpful.
3. It would be also interesting to see an example of the formalism on a multi-agent context.

Planners

LOLLIPOP is Partial-Order Planning (POP) algorithm to address plan repairs. I found it very interesting the design of operator graphs for the generation of valid partial plans that can be used as input to POCL algorithms as well as the negative refinement mechanism, a functionality that POCL lack as they start from an empty initial plan.

I positively value the theoretical proofs of soundness and completeness. However, I would have liked to see a more compelling experimental evaluation. Specifically, I'd suggest using a more adequate setting to test the repair planning procedure like, for instance, a domain from the IPC benchmarks.

I think that the knowledge representation formalism suits very well the hierarchical planner HEART. Advancing the state of the art with a knowledge representation formalism for the specification of decomposition hierarchies is always welcome. The research progress in this field has not shown such relevant outcomes as in other planning paradigms so any attempt to advance the representation of HTN planning is a significant step.

The section devoted to explaining HEART would require a little bit of care:

1) The listing mentioned in Example 49 is missing and the table indicated in the side margin is missing too, both appear as “???”. I’d recommend revising the contents of page 129. The absence of the listing and table makes it hard to grasp the meaning of the abstraction proposal.
2) I wonder whether the decomposition flaws amount to the preconditions of the methods in HTN planning. Perhaps it would be a good idea to establish a comparison between the language elements of HEART and some other known language for HTN planning; e.g.

   SHOP(2)
   Nau, D. S.; Au, T.; Ilghami, O.; Kuter, U.; Murdock, J. W.;Wu, D.; and Yaman, F. 2003.
   "SHOP2: An HTN planning system". JAIR 20: 379–404, 2003.
   HPDDL
   Alford, R.; Shivashankar, V.; Roberts, M.; Frank, J.; and Aha, D. W. 2016b.
   "Hierarchical planning: Relating task and goal decomposition with task sharing".
   In Proc. of the IJCAI.
   HDDL
   Daniel Höller, Gregor Behnke, Pascal Bercher, Susanne Biundo, Humbert Fiorino, Damien Pellier, Ronald Alford.
   "HDDL - A Language to Describe Hierarchical Planning Problems". CoRR abs/1911.05499 (2019)

3) I fail to see what the intent recognition in Sohrabi et al (2016) is used for. I assume the problem goals are defined in HEART via specification of the tasks that must be executed as it is usually the case in HTN planning. I think that some clarification about what the author means by “the most likely goal” and “observation” is needed in the context of the HEART planner.

Intent Recognition

The use of abstract plans for intent recognition is an interesting idea. The text provides some intuition on how abstract plans can be used for this purpose. I think this is an exciting research thread for future work.

Corrections

The contents of pages 55, 115, 122, 126 and 133 should be revised as they contain missing references that appear as “??”.

Some references are missing in page 142 (see label CITATION).

For all the above reasons, I authorize the defense of the doctoral thesis.

Valencia, 18th January 2020

EVA|
ONAINDIA|DE
LA
RIVAHERRERA

Firmado digitalmente por EVA|ONAINDIA|DE LA RIVAHERRERA
Fecha: 2020.01.18 19:29:46 +01'00'

Eva Onaindia de La Rivaherrera
Professor on Computer Science
Universitat Politècnica de València
Email: onaindia@dsic.upv.es
Tel: 34-963877755