Moderated by Susanne Biundo.

Austin Tate

Representing Plans as a Set of Constraints - the <I-N-OVA> Model

The article mentioned above has been submitted to the Electronic Transactions on Artificial Intelligence, and the present page contains the review discussion. Click for more explanations and for the webpage of the author, Austin Tate.

Overview of interactions

N:o	Question	Answer(s)	Continued discussion
1			8.9 Austin Tate
2	23.9 Erik Sandewall	29.9 Austin Tate	
3	8.12 Mark Drummond		
4	24.2 Anonymous Referee	8.9 Austin Tate	
5			24.2 Austin Tate

C1-1. **Austin Tate** (8.9):

The ETAI Colloqium on Actions and Change (see: general debate) is raising issues from a formal representation of action perspective which could usefully be linked with the more practically derived representation that < I-N-OVA > represents. Murray Shanahan's message raises a number of requirements for an action formalism that could usefully be checked against any proposed action, plan or process representation. He also suggests the use of practical scenarios as a way to validate any proposal.

In this context it may be worth noting that < I-N-OVA > is based on 20 year's experience of the use of plan representations for a wide range of domains in AI planners. It also seeks to bring in work from a very wide range of process and activity modelling communities beyond AI.

Analysis of about 20 candidate activity representations against an extensive set of requirements and against a set of engineering, manufacturing and workflow

scenarios is being undertaken in recent work in the National Institute of Standard's and Technology (NIST) on the Process Specification Language which is seeking to create a meta-model for activities that has a formal semantics (see http://www.nist.gov/psl/). The OMWG Core Plan Representation work (now at RFC version 2) is also being validated against a range of military planning problems.
< I-N-OVA > has being used as a conceptual framework to input to both these programmes.

Austin Tate

Q2. **Erik Sandewall** (23.9):

Austin, I think you are bringing up a very important point when you mention "process and activity modelling communities beyond AI" in the discussion (your comment C1). Besides the work in engineering and manufacturing, there is active work in the healthcare area, where they have an interest in characterizing the medical history of a patient as a process, involving both health events ("raise in temperature", "severe back pain") and medication and other treatment events. The work has progressed so far that there is reportedly a European prestandard, ENV 12831, called "Medical Informatics - Time Standards for Healthcare Problems".

In addition, there is of course the work in the research communities for databases and information systems, where they want to model processes within an enterprise.
It seems to me that the AI field is not sufficiently aware of these developments. The world doesn't stand still while we try to figure out the best way of dealing with the ramification problem.

Erik

A2. **Austin Tate** (29.9):

Excellent comment from Erik Sandewall. Its precisely for the reasons that Erik quotes that I want to get some discussion on this going. We have been too insular in AI.

I believe we have very important insights to offer the standards communities and the applications communities who will come to rely on communication of information about activities, plans and cooperative activity. AI planning people in both the theoretical and practical areas have really thought about these things very deeply. We need to engage with the wider community now to influence the directions that will be taken.

Conversely, there is little in the AI literature to indicate awareness of the wider context and the wealth of work we ourselves can draw on.

My paper is meant to provide a model that can give a shared perspective across a range of communities and to see if more can be exchanged between those involved.

Austin

Q3. **Mark Drummond** (8.12):

Folks --

I really like the basic paper, and think that it's a great idea to try to 'open up' O-Plan, by describing its basic representations, and explaining how those representations relate to others worked on over the years.
The upside of such work is clear: others can start to understand O-Plan, and can then do formal analyses of properties of the representation and of systems that might use it.

However, the thing that I'd like to see more of (perhaps in this paper), is discussion of how the various representations for time, change, and level-of-detail all relate to one another. Where is one representation or another one appropriate? In more detail, how to the characteristics and aspects of each representation interrelate? I'd really like to see more discussion and analysis (even if speculative) of the merits of each representation and how they line up.

There's an interesting historical footnote to this, and I'm sure Austin is aware of it, too. There's an old psychology book called something like "Plans and the structure of behavior", by (if I recall correctly) Pribham, Miller, and Galanter (can't quite dig up my reference to this book, but the title and authors are dang close to what I've given).
The book is a great read, by the way; highly recommended for anyone who's wondering how far we might have come in 20 or so years of worrying about general purpose planning and problem solving.

Now, Earl Sacerdoti was greatly moved by this early book, and, in naming his own dissertation, paid homage to it. His dissertation was called "A structure for plans and behavior", both in the sense of computer data structure and in the sense of adding structure to the previous work in this area. Sacerdoti was very interested by the basic unit of behavioral composition employed by Pribham, et al., namely, the "Test-Operate-Test-Exit" unit, or TOTE. The TOTE was proposed as a general execution mechanism, out of which intelligent (or at least, flexible) mechanisms could be built.

So, why the historical digression? Simply to point out that there are lots of different hierarchical representations for action and problem-solving behavior, and it would be a tremendous contribution to more completely explain their interrelationships, strengths, and weaknesses. For instance, why aren't we all building planners that generate sets of TOTEs? What might a construct of TOTEs be able to express that an O-Plan plan can't?

Cheers,

Mark Drummond

Q4. **Anonymous Referee** (24.2):

The bottom line of the INOVA model is to represent a plan as a set of constraints, as the title goes---in fact, it is a tuple of sets of constraints, where it depends on the resolution of the OVA/A representation whether it is a triple, a quintuple, or an 8-tuple. However, the paper does not state what precisely a constraint is supposed to be here - could you clarify this point?

Because of the lack of precise definition, it appears to me that practically everything can be cast into this very general framework. For example, the model seems to fit perfectly a configuration system (nodes correspond to partial configurations) and a diagnosis system (nodes are partial mappings from suspected causes to known defects). Of course, this generality is no fault; but I feel the need for a fairly concrete explanation as to how such a general model is supposed to be of help. In particular:

- Can something specific be said about how to map objects from different models to identical objects in the INOVA models?
- Does the framework help to identify non-trivial correspondences or differences between different frameworks?

It is by now pretty widely known that other communities and fields than AI planning are dealing with processes, activities, or tasks in their respective ways; you have great merits in making the AI planning community aware of this. The correspondences between different plan representations or planning models that the INOVA model allows to be established are interesting in principle, but I do not see them being exploited or analysed in the paper. What exactly is it that people from other fields have done that INOVA allows us to import easily into AI planning? What exactly is it that we AI planning people know how to do, and INOVA helps us translate it into some other field?

The paper is very brief with many of the issues it addresses, for example, in what it says about abstraction levels in planning. We always knew it is tricky in practice, and at least since Tenenberg's work do we know it can also be tricky in theory. Given the state of the art in AI planning, it's not appropriate I think to just postulate there is such a thing as a hierarchical model and claim it is a framework for further study.

A4. **Austin Tate** (8.9):

Specific comments on referee inputs

> *The bottom line of the <I-N-OVA> model is to represent a plan as a set of constraints, as the title goes---in fact, it is a tuple of sets of constraints, where it depends on the resolution of the OVA representation whether it is a triple, a quintuple, or an 8-tuple. However, the paper does not state what precisely a constraint is supposed to be here - could you clarify this point?*

Using the <I-N-OVA> concepts for planning (relationships between activities, time points and objects) the top level is a 3 tuple of constraints (I, N and OVA) with the OVA category itself being sub-categorised into 3 types at its next level (O, V and A). All these top level constraints can be further sub-categorised. In some of our work described at http://www.aiai.ed.ac.uk/~oplan/inova-model.html A(uxiliary) constraints are sub-categorised into 5 at the next level and we define 3 levels of such constraints. This represents work to relate our approach to the practical needs of specific application plan representations.

> *Because of the lack of precise definition, it appears to me that practically everything can be cast into this very general framework. For example, the model seems to fit perfectly a configuration system (nodes correspond to partial configurations) and a diagnosis system (nodes are partial mappings from suspected causes to known defects).*

Excellent, my paper has communicated this genericity well. We looked at a configuration system called CORECT built here at Edinburgh and it had a quite natural I-N-CA (Issues, Nodes, Connections, Auxiliary Constraints) framework. If the authors had realised this generality, there could have been many benefits and potential code reuse from other systems in quite disparate areas. A link to capabilities described as issues handlers will allow some of this generality to be used. The US High Performance Knowledge Bases (HPKB) program in which AIAI is involved is looking at this in its problem Solving Methods and Ontology work. We hope to make a contribution there using our <I-N-OVA> experience.

> *Of course, this generality is no fault; but I feel the need for a fairly concrete explanation as to how such a general model is supposed to be of help. In particular:*
>
> - *Can something specific be said about how to map objects from different models to identical objects in the <I-N-OVA> models?*
> - *Does the framework help to identify non-trivial correspondences or differences between different frameworks?*

Yes and Yes, perhaps for a future paper:-) Or for work by PhD students who are seeking new topics to explore:-)

> *It is by now pretty widely known that other communities and fields than AI planning are dealing with processes, activities, or tasks in their respective*

ways; you have great merits in making the AI planning community aware of this. The correspondences between different plan representations or planning models that the INOVA model allows to be established are interesting in principle, but I do not see them being exploited or analysed in the paper. What exactly is it that people from other fields have done that INOVA allows us to import easily into AI planning? What exactly is it that we AI planning people know how to do, and INOVA helps us translate it into some other field?

This is the subject of a separate paper by Steve Polyak and myself. As part of work with NIST on their Process Specification Language we compared a range of 6 or 7 process or plan representations against over 150 requirements for process specification. This was part of wider work to be published shortly which compared some 26 requirements in total. The paper comparing the ones we did is available at
http://www.dai.ed.ac.uk/students/stevep/apr/documents.html#psl2edin

The paper is very brief with many of the issues it addresses, for example, in what it says about abstraction levels in planning. We always knew it is tricky in practice, and at least since Tenenberg's work do we know it can also be tricky in theory. Given the state of the art in AI planning, it's not appropriate I think to just postulate there is such a thing as a hierarchical model and claim it is a framework for further study.

Oh dear, sounds like someone wants to go over lots of old ground. Hierarchical models are a basis for our approaches and have been for 25 years. I will leave it t others to work out why its so good in practice:-)) Note that <I-N-OVA> itself is agnostic on whether hierarchical models are used or not anyway, so I would argue that this would not be appropriate in this particular paper anyway.

Austin Tate

C5-1. **Austin Tate** (24.2):

It seems reasonable to me that the reviewers consider the work to be more a general introduction to the concept of representing everything in a plan as constraints. This was the point of the paper.

<I-N-OVA> is described in published papers already - in its initial form in SIGART Bulletin (January 1995) and later as a tidied up version with more background in an AIPS-96 conference paper (May 1996). My aim in submitting it via ETAI was to raise the profile of the work and to hopefully get some serious discussion and comments on it. In practice this did not happen. The comments (except for your own Erik) were from people who already knew the work well, and in most cases had contributed over the years to forming the approach. I was disappointed in this respect in the ETAI early experience, but

maybe that aspect will grow and ETAI becomes better known and its high quality standard is set.

I very much agree that high standards are the key to making ETAI (and any similar venture) a success. But we must not equate high quality with mathematical rigour or approaches. This paper was not intended to contribute such a formalisation. We need to ensure we encourage high quality descriptions of approaches, methods, algorithms, applications, successes and failures.

The main criticism of the paper by the reviewers concerns its approach, which was to introduce the concept of all aspect of plans being represented as a set of constraints, which can themselves be categorised. I presented a set of top level categories which are strongly supported by work in a variety of fields within and beyond AI. That is where the top and second level categorisation into I, N, OVA (second level O, V, A) came from. There is categorisation below that in the paper which is more weakly supported (and is variable in domains beyond activity planning). For example, we have related the same approach to configuration with I, N, CA where C is "connections" and represents the "cross constraints" in that particular domain - much as the O and V constraints do in a planning domain. I also believe the approach is valid in design more generally - I consider planning to be a limited type of design activity.

Later papers will describe the sorted first order logic that will be a formal language in which this more general concept can be expressed for a subset of the types of things in plans. The Sorted FOL will also act as a framework to hold "pointers" to information resources that describe aspects of the constraints (e.g. 3D spatial constraints based on solid models) that are not conveniently represented in predicate logic style of language. The Sorted FOL will also be an intermediate language for communication between tools in a new suite of process editors, process and plan libraries, plan enactment workflow support aids, and other items we are working on which we collectively call "O-Plan Technology". A paper at AIPS-98 gives some hint of what is coming with work on new Open Planning Process Panel (O-P3) concepts and their uses as interfaces to the O-Plan web planning server and some US work on Air Campaign Planning Process Panels (ACP3). Watch this space:-)

A plan ontology based on <I-N-OVA> can be found here and the result of a comprehensive analysis of plan representations is at this page.

The best published citation for the <I-N-OVA> work will be:

Tate, A. (1996) The <I-N-OVA> Constraint Model of Plans, Proceedings of the Third International Conference on Artificial Intelligence Planning Systems, (ed. B. Drabble), pp.221-228, Edinburgh, UK, May 1996, AAAI Press.

Austin Tate

Background: Review Protocol Pages and the ETAI

This **Review Protocol Page** (RPP) is a part of the webpage structure for the **Electronic Transactions on Artificial Intelligence**, or **ETAI**. The ETAI is an electronic journal that uses the Internet medium not merely for distributing the articles, but also for a novel, two-stage review procedure. The first review phase is open and allows the peer community to ask questions to the author and to create a discussion about the contribution. The second phase - called *refereeing* in the ETAI - is like conventional journal refereeing except that the major part of the required feedback is supposed to have occurred already in the first, review phase.

The referees make a recommendation whether the article is to be accepted or declined, as usual. The article and the discussion remain on-line regardless of whether the article was accepted or not. Additional questions and discussion after the acceptance decision are welcomed.

The Review Protocol Page is used as a working structure for the entire reviewing process. During the first (review) phase it accumulates the successive debate contributions. If the referees make specific comments about the article in the refereeing phase, then those comments are posted on the RPP as well, but without indicating the identity of the referee. (In many cases the referees may return simply an " accept" or " decline" recommendation, namely if sufficient feedback has been obtained already in the review phase).

From https://www.ida.liu.se/ext/etai/ra/pas/001/

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