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Protocol of the discussion during December, 1997 on

Ontologies of Actions and Change

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From: Erik Sandewall on 9.12.1997

Vladimir,

You wrote (ENRAC 27.11)

> *I'd like to understand this better. The need to define new action languages arises when we want to describe aspects of reasoning about action that have not been understood in the past. Here are some examples.*
>
> ...
>
> *These phenomena could not be described in the original action language $\mathcal{A}$ and in some of its successors. New, more expressive languages had to be designed. I am wondering what the status of examples 1-3 in the F&F framework is. Would you be able to formalize them in your original language, which you described as sufficiently expressive right from the start?*

Yes. By the original language I then mean a first-order language having three predicates:

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Holds(t,f,v)    feature f has value v at time t
Occurs(s,t,e)   event e takes place over the interval [s,t]
Occlude(t,f)    the fluent f is occluded at time t
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The fuller picture is as follows. Recall that we use

1. a surface language, SD, for writing scenario descriptions conveniently
2. a base language, presently chosen as the first-order language FL with the three relations *Holds*, *Occurs*, and *Occlude*
3. the macro expansion from SD to FL
4. the classical semantics of FL (straightforward)
5. proof methods using circumscription or tableau methods and operating on the FL representation of scenarios

plus, for analysing the properties of those,

6. ontologies characterizing the phenomena at hand (e g ramification, concurrency) (and also, clear expression of epistemological assumptions)
7. underlying semantics based on the respective ontologies, defining the set of intended models for a given scenario description
8. entailment methods for obtaining an approximation to the set of intended models, for example by imposing preferences on the set of classical models
9. relationships between proof methods and entailment methods (in principle, entailment methods are implemented as proof methods)

The interesting thing is that quite a number of phenomena, including the ones that occur in your examples, can be accomodated within the same base language FL. Sometimes it is useful to extend the surface language SD with more macros, in order to obtain convenient expressivity, but the proof methods survive the extension since they are defined for FL.

To see how it works in more detail, a recent reference for your first two examples (involving concurrency and ramification, respectively) is a recent article by Lars Karlsson and Joakim Gustafsson, [f-cis.linep.se-97-014] As for qualification and the qualification/ramification tradeoff, this is the topic of a paper by Patrick Doherty that is just about ready. In fact, within our lab it is mostly Patrick and his colleagues and students that work on these issues and extend the limits with respect to expressivity as well as proof methods. In the course of their work, the approach is now being renamed from PMON to TAL (for Temporal Action Logics). There will be more details about this in Patrick's forthcoming answer to your questions to him.

The three relations in FL have been with us all the time since 1988-89, although their usage has been extended along the way. Also, in some of the publications the *Occurs* relation has been viewed as a 'macro'. That simplifies things and is sufficient for some purposes, but not always.

Whereas FL has been remarkably able to accomodate additional phenomena (including not only the ones in your questions, but also things having to do with mixed continuous/ discrete behaviors, imperfect sensors, etc), it has certainly been necessary to revise items 6 through 9. In fact, it is part of the basic idea that the formal ontology and underlying semantics should represent those phenomena as clearly as possible. This is the topic that I focus on in my own work. Sometimes the entailment method is developed and assessed first, and "implemented" afterwards as a proof method; sometimes it is the other way around. The approach to concurrency in the recent PMON-TAL work, for example, has not yet been analyzed wrt range of applicability and on the basis of an underlying semantics. There is some earlier work (by Choong-ho Yi) which does provide a reasonable candidate for an underlying semantics for concurrent actions, but so far it has only been used for analysing the case of independent concurrency.

With respect to ramification, my KR-96 paper [c-kr-96-99] and a related paper [s-Stock-97-289] describe a formal ontology for causal-chain ramification, where one microevent (= elementary change) causes another one, which causes another one, all within one and the same main event or action. A number of entailment methods are assessed on the basis of that ontology. However, there are also other kinds of ramification that do not fit into that framework, for example, those based on physical connections between objects. It seems to me that the notion of ramification is too crude to allow a single ontological analysis.

With respect to qualification, no underlying semantics has been proposed. My belief is that even more than for ramification, a serious ontological analysis of qualification needs to identify a number of different cases which have entirely different character, and which deserve different logical treatment. However, this does not of course prevent one from proceeding with the work on representation and proof methods for qualification.

Erik

References:

[c-kr-96-99] Erik Sandewall. *Assessment of ramification methods that use static domain constraints.* Proc. International Conf on Knowledge Representation and Reasoning, 1996, pp. 99-110.

[f-cis.linep.se-97-014] Lars Karlsson and Joakim Gustafsson. *Reasoning about actions in a multi-agent environment.* Linköping University Electronic Press, 1997, Nr. 14.

[s-Stock-97-289] Erik Sandewall. *Underlying Semantics for Action and Change with Ramification.* In: Oliviero Stock (ed): Spatial and Temporal Reasoning, pages 289-318. Kluwer Academic Publishers, 1997.