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Publication Trail and Update Rules

The Electronic News Journals (ENJ) are a medium for exchange of scientific information and debate. In particular, they serve as the forum where articles received by the ETAI (Electronic Transactions on Artificial Intelligence) are discussed publicly for review, in separate News Journals for each ETAI area.

The Electronic News Journal on Reasoning about Actions and Change (ENRAC), in particular, uses a publication trail where contributed information is first distributed on a daily basis as *Newsletters* using electronic mail and web pages in HTML. Then, contributions during the same month are compiled into an HTML version of the monthly *News Journal*. Finally, the same information is converted via Latex to a postscript version that is suitable for printing on paper and reading off-line. It is formally published and archived by the Linköping University Electronic Press in both its electronic and its paper form, as described on page (iv).

Offprints of individual segments. Each News Journal issue consists of a sequence of *segments* relating to specific topics. "Offprints" of these can be obtained from the URL:s indicated at the head of the first page of each segment, or from the ENRAC service page specified below. It is intended to maintain these URL:s and their contents for the foreseeable future. Misprints of minor significance are corrected in these offprints (but not in the E-Press version since it is considered archival).

Corresponding HTML edition with dynamic links. The HTML edition contains considerable numbers of links to other pages and structures on the net: articles that are available on-line, home pages of conferences and of individual researchers, links to other part of the ETAI structure, and so on. Due to the natural limitations of the paper medium, only some of the WWW links have been retained here as footnotes. In order to retrieve articles and other information that are referenced in the present issue, it is recommended to look up the corresponding issue in HTML and to use its link. The HTML issues of the News Journals on Reasoning about Actions and Change can be found at the ENRAC *service page,*

`http://www.etaij.org/rac/nj/`

It is intended that the HTML issues will by updated continously to the largest extent possible, for example by replacing URL links to the home pages of authors that have changed to another site.

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Dates of Publication

Since the date of publication may be understood either as the date of first public appearance, or as the day of reproduction on paper in many copies, and since both of these definitions may be difficult to apply in the case of electronic publication, we make the following clarifying statement.

The contents of the present issue were put on-line in their original, versions as Newsletters in plaintext, HTML, and latex/postscript during the month of October, 1998. Then the contents were edited and formatted, resulting in the present, formatted version which was published on 16.7.1999, in two concurrent editions: an on-line edition and a paper edition. The on-line edition was timestamped electronically and put on-line by Linköping University Electronic Press at the URL specified on page (i). The paper edition was obtained by printing the on-line edition on a standard computer printer. It was reproduced in 25 copies, legally archived, and made available for distribution.

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The Month of October

Summary of News Journals Contents

Johan van Benthem has kindly accepted our invitation to comment on the topic discussion on the ontologies of time, and his discussion note is included in the present News Journal. He summarizes the past discussion and puts it into perspective from a philosophical-logic point of view. Additional contributions are welcome!

In this issue we also open another topic discussion area, namely on *the use of modal logic for reasoning about actions and change.* This is a classical "hidden debate" in our field. None of the main approaches to reasoning about actions and change uses modal logic in an explicit sense, although some variants of the situation calculus, in particualr, are closely related to dynamic logic. John McCarthy commented on the possibility of using modal logic in one of his early papers on the frame problem, and more recently he has written a position statement with the title "Modalities, si! Modal logic, no!"

When the *Journal of Logic, Language, and Information* recently featured a special issue on modal logic, edited by Herbert Wansing, its introductory statement had the title "Modalities, of course. Modal logic, si!" and it was of course a riposte to McCarthy's position.

We think this is an important discussion, and invite additional contributions to the topic. In order to facilitate access, we republish Herbert Wansing's article, with the kind permission of Kluwer Scientific Publishers.

Another non-standard approach to reasoning about actions and change, namely linear logic, is the topic of an article that Graham White submitted to the ETAI in September. The present issue contains extensive discussion about his article as well as about the approach in general.

In June we invited contributions of a new kind of articles, namely *reference articles* that are supposed to contain standard definitions for particular, mature approaches to reasoning about actions and change. The idea is that forthcoming articles shall be able to refer to such reference articles instead of repeating the same definitions time and again. In the world of electronic publishing it is no longer important that articles be "self-contained", since the move to an underlying reference article can be made with the click of the mouse. Four reference articles have been submitted - one in September and three in October - and we hope for one or a few more.

The AAAI Fall Symposiums took place in late October, and included in particular a symposium on *Cognitive robotics* that attracted several of the most active researchers in our area. A visit to the workshop webpage is recommended.

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Protocol of on-line discussion during October, 1998
about the following research article:

Murray Shanahan

A Logical Account of the Common Sense Informatic Situation for a Mobile Robot

A3. **Murray Shanahan** (9.10)

> *I agree that Separation avoids the Hanks-McDermott problem , but doing so you get a restriction in the theory, since you are not able to write formulae using Initiates (or Terminates) and Happens together (on the contrary it won't be clear where to place such formulae in the circumscriptions). Thus, we are not able to express (and infer) some facts.*

It's true that there are some (very few) kinds of formulae that we cannot write using this method. For example, if we wanted to express the fact that **either** flicking the switch terminates the light being on **or** it was initially dark, then there's no obvious way to do it. (This is Tom Costello's example.)

However, I'm a little sceptical that we do ever want to mix these different kinds of information in this way. In this example, I suspect that another layer of reasoning is called for, which explains observations (such as the fact that it is dark), and this may update the Initiates/Terminates part of the theory, or may update the initial situation description.

On the other hand we can, and often do, write other sorts of formulae that mix *Initiates*, *Terminates* and *Happens* predicates. In particular, triggered events can be described using formulae of the form:

$$Happens(a,t) \text{ if } Initiates(a,f,t)$$

These formulae can be included in the circumscription of *Happens*, and this doesn't cause a problem, since the assumption is that the meaning of *Initiates* is already fixed by separate the circumscription of the *Initiates* and *Terminates* part of the theory, and that this formula is, so to speak, just a "consumer" of the *Initiates* predicate.

> *Then, why do not use negation-as-failure instead, since, for the particular case of circumscription we are interested in, the former is equivalent to the later*
>
> *In which sense circumscription is more powerful than negation-as-failure in this framework?*

We could use negation-as-failure (or rather, say, predicate completion). Using circumscription does allow for the addition of, for example, disjunctive facts, however. Predicate completion is only defined for a certain class of theories. Event though this class encompasses most of what we're interested in, there doesn't seem any point in ruling out exceptions.

> *I could not understand the last formula of page 14. There a biimplication is used defining the region g with the formula* Π *. My interpretation of this is that* Π *is not an approximation of g but it describes exactly g . Is that what it means?*

This is exactly what it means. Formula (5.7) on the same page is an example.

> *My question is: what do you do if there is no M2 that explains* Ψ *?*

Then there really is no explanation. The robot is stuck.
Murray Shanahan

A4. **Murray Shanahan** (9.10)

> *Why didn't you circumscribe Initially and Happens in parallel in the first conjunctive term of the expression?*
>
> *Why do we have to circumscribe Abspace letting Initially vary, and not circumscribe only Initially (or both Initially and Abspace)?*

Well, it may be possible to do things that way. I was trying to follow as closely as possible the approach I'd taken in my AIJ paper "Default Reasoning about Spatial Occupancy", where I introduced a predicate similar to *AbSpace*.

But anyway, I think you may have uncovered a bug in my formalisation. As you'll see in other papers and in Chapter 15 of my book, usually when I present the event calculus I use two *Initially* predicates: *Initiallyp* to say that a fluent holds and *Initiallyn* to say that it doesn't hold. A counterpart to axiom (EC1) for $\neg$*HoldsAt* and *Initiallyn* is also included. (Using two predicates like this allows us to distinguish fluents that (1) are inertial and true from time 0, (2) are inertial and false from time 0, and (3) are non-inertial from time 0.) I tried to get away with just one predicate here, because I thought the examples didn't need the *Initiallyn* predicate. I need to look into it properly, but I suspect that I need to reintroduce *Initiallyn* to get the minimisation of *AbSpace* right. It's only a minor modification, but at the moment I don't think it works.
Murray Shanahan

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Protocol of on-line discussion during October, 1998
about the following research article:

Chitta Baral and Son Cao Tran

Relating Theories of Actions and Reactive Control

Q1. **Erik Sandewall** (3.10)

Dear Chitta and Son Cao,

Your article addresses a very interesting topic for our group. I have some specific questions about the contents of the article, and also some comments about how it relates to other current approaches to the same or similar problems. I'll write them as two separate contributions. With respect to the article itself, I have the following questions.

1. For maintenance control modules, which are treated in section 3.3, you write:

> *But in the presence of exogenous actions the robot with no control over those actions can only strive to make the maintenance goal true if they are made false by some exogenous action. In other words a maintenance control module can not guarantee that the maintenance goal will never be false...*

This seems right if the maintenance goal is characterized by one single state in the state space. However, many applications do require controllers to keep the controlled system in an acceptable state at all times, which is possible if there is a number of such acceptable states, and the state transitions due to exogenous "actions" sometimes only move within the acceptable set. In such cases the controller strives to keep the system in those states among the acceptable ones that are "at a safe distance" from the unacceptable ones. More precisely, even if the system is in an acceptable state, the controller may perform actions as a precaution against future exogenous "actions", thereby shifting the system to a state where exogenous actions can not be harmful.

Possibly one can reduce this case to the one you consider by identifying the maintenance goal with a subset of the acceptable states, namely those acceptable states where that are at a safe distance from a transition to the unacceptable ones. Is this the way you intend maintenance goals to be defined, and if so, do you claim that the reduction is always valid? (Concurrency and the use of combined achievement and maintenance modules may introduce complications, I believe).

2. A second question concerns to what extent this work relates to current, logic-based theories of actions and change. In section 9.1 you write:

> *... in this paper we do not use any specific action theory... rather we use an abstract "entailment relation". Because of this, our formulation need not change with more sophisticated action theories.*

However, as I read the paper I wonder whether it depends on any of the concepts or results of current action theories at all? (This is not a criticism, of course, I just want to understand the character of your definitions and results). For example, definition 6.1 on page 28 begins

> *Let ... A be an action theory with a transition function* Φ

and then the rest of the definition is expressed only in terms of Φ. Could it be the case, then, that everything in this article could as well be expressed only in terms of states, state spaces, and transition functions? In this case, action languages and other logicist devices ought to be seen simply as a convenient notation for specifying transition functions, but otherwise they'd not play any role in this particular development.

3. Here is a standing question that I now ask regularly to authors in our area. Given that your paper proclaims a number of theorems, as do many of our publications, (a) do your results rely on any theorem previously published in this literature, (b) do you foresee any of your theorems later being used in a forthcoming publication by yourself or someone else? If the answers to both questions are "no", what do you think is the purpose of including theorems in our research articles?

4. There seems to be a close connection between your *Closure* concept and the most commonly studied cases of ramification. In both cases, one first specifies the effects of an action "in itself", and then one adds the possibility of additional changes due to phenomena that are characterized separately from that action. Is this a connection that you have also considered?

The relation to ramification is particularly transparent by comparison with my KR-96 paper, [c-kr-96-99]. That article uses two types of state transitions: one *result* function that maps an action and a state to a set of possible result states, and a binary *successor* relation that characterizes further transitions. The "closure" of an action, in that case, is the set of all states that can be reached via one member of the set of action result states, followed by an arbitrary number of steps using the successor relation, and that do not in turn have any successor. For ramification, the successor relation characterizes spontaneous and "caused" transitions in the world; in your work they would instead characterize the results of exogenous "actions". These two cases seem to be very close to each other.

The KR article is in fact formulated entirely in terms of states and state transitions, and analyses ramification methods without introducing any logic language at all. Its way of looking at actions is therefore quite close to what you use in your paper. (The main results in my article are assessments that characterize the range of sound applicability for a number of previously published approaches to ramification). Relating back to my question 2, this adds to the impression that ramification and exogenous events are related phenomena.

5. I put quotes around "actions" because I can not get used to the idea of calling natural events 'actions'. Although I understand the background

of this terminology, which comes from the situation calculus, I do think it makes communication with neighboring disciplines a lot more difficult than it ought to be.

Best regards, 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.

Electronic News Journal on Reasoning about Actions and Change 333
Vol. 2: *333-339*, 31.10.1998
http://www.etaij.org/ra/rac/012/

Protocol of on-line discussion during October, 1998
about the following research article:

Graham White

Simulation, Ramification, and Linear Logic

Q1. **Tom Costello** (1.10)

Dear Graham

On page 2 of your article, "Simulation, Ramification, and Linear Logic" you suggest that effect axioms should have Σ_1 antecedents and frame axioms Π_1 antecedents, based on intuitions concerning locality. However, some local properties, such as there being no block in a certain place are expressed as Π_1 formulas, not as Σ_1 formulas, e.g. $\forall(b, \neg at(b, l))$ states that there is no block at location l.

It seems to me that many effect axioms will have preconditions that say that the effect will occur in certain circumstances, unless there is something that prevents it. This is naturally written as a Π_1 formula. Consider the Blocksworld. One effect axiom there can be written

$$\begin{aligned}&\forall b, l, s[\forall b'[\neg On(b', top(b), s)] \wedge \\ &\quad \forall b'[\neg On(b', l, s)] \wedge top(b) \neq l \rightarrow \\ &\quad On(b, l, move(b, l, s))]\end{aligned}$$

The left hand side side of this effect axiom is clearly equivalent to a Π_1 formula. It seems that many preconditions will have this form. This seems to contradict your intuitions that effect axioms have Σ_1 antecedents, and that *sufficient* conditions can be written in Σ_1.

Yours,
Tom Costello

A1. **Graham White** (3.10)

Dear Tom,

Thanks for your question. It seems to me that I would want first of all to differentiate between your two formulations of the basic objection: i) "some local properties ... are expressed as Π_i formulas", and ii) "many effect axioms will have preconditions that say that the effect will occur in certain circumstances, unless there is something that prevents it".

The first formulation has to do with local properties, which I take to be a fairly general, phenomenological notion; the second is to do with action preconditions, which is a notion internal to certain treatments of the frame problem. I'll deal with the second notion first.

My approach doesn't really use action preconditions *per se*. I don't have anything like a result function: given linear logic terms s and a representing a situation and an action, there may or may not be a valid inference of the form

$$s, a \vdash s'$$

where s' is also a situation term. So there are, in some sense, implicit action preconditions, but I don't represent them explicitly. I can deal with your example in my framework as follows. We have to introduce constraints on the space of situations, which I can do by having an extra pair of fluents, say good and bad, which say whether situations are physically realisable or not, and also having extra ramification transitions

$$(on(b,l) \times on(b',l) \times good) \rightsquigarrow (on(b,l) \times on(b',l) \times bad)$$

for b and b' unequal.

We now apply the ramification machinery that I described: that is, we look for sequents corresponding to performing the action, followed by a terminating sequence of ramification transitions, such that we eventually end up with a situation of the form $X \times good$. All of this can be carried out with entirely local data, but the implicit preconditions are as you described. (I'm a bit unsure about the other part of the precondition, which says that you can't pick up a block with another block on top of it. My immediate response to that is "well, I can", but I'm not sure exactly what the impossibility is supposed to be here.)

Incidentally, I'm not at all sure about the phenomenological motivation of the concept of precondition. It seems to me that it conflates two quite distinct phenomena: the first is of actions (such as "opening the door") described by what Ryle called "success words", where it doesn't make sense to talk of performing them when they don't succeed. The other is of action descriptions such as "trying to open the door", where the possibility of failure is allowed for, and where we usually also have some intuitions about what happens in the case of failure. As Ryle (and I suppose also Wittgenstein) point out, the second case is rather more complex than the first, and probably needs a more elaborate description than simply giving preconditions. The first is the usual case in a great deal of everyday language, but, by its nature, does not need any explicit talk of preconditions (although one could, presumably, in many cases find implicit preconditions).

Your first objection is that many local concepts are in fact Π_i. This may be true, but what surely matters for my analysis is not local concepts per se, but the local concepts that are used in the sort of representation that I am describing. One probably also ought to distinguish between genuine universal quantification and universal quantifications which are, in some way, bounded. Most local concepts would, presumably, only be Π_i in the latter sense, and it would be a sense corresponding to some natural means of verification – I check, for example, that there is nothing on my desk by looking at the locations on my desk and verifying that they are all empty (and I can tell that they're empty just by looking at them). I certainly don't do it by finding all of the objects that there are and verifying that none of them is on my desk; and an analysis of "there is nothing on my desk" that reduces it to a Π_1 *of that sort* is likely to be epistemologically misleading.

I hope this helps, anyway.

Graham

Q2. **Andreas Herzig** (3.10)

Dear Graham,

I appreciate the aims of the paper, viz. the discussion about the logical form and the proof-theoretic account of reasoning about actions as given in sections 1, 2.1.1, 2.4. I think that too little work has been done in the community on such fundamental issues.

Basically you propose Linear Logic (LL) as a proof theory to reason about actions, following Girard who claimed from the beginning that LL would be much better suited for reasoning about actions and change than any other logical system. LL people have tried to support that claim, such as Masseron et al. (LNCS 427, 1990) or Bidoit et al. (JLC, 1996). The same has been tried also by people coming from Bibel's linear connection method - see e.g. Bibel's IJCAI'97 invited lecture, as well as work of Fronhofer and Grosse et al. that Bibel cites; see also the subsequent discussion at

http://www.ida.liu.se/ext/etai/actions/deb/bibel/index.html

In my opinion all these attemps have failed in the sense that the only thing they can handle within LL is the simplest case: deterministic actions, no state constraints, knowledge about the initial situation only. They didn't succeed in going beyond that without violating the spirit of LL: they all introduced extra concepts that were used to constrain deduction in one way or another. In the present paper it is time which is made explicit in the encoding of reasoning about action problems (section 3, 3rd paragraph). But I would expect time to be implicit in a LL account of reasoning about actions: it is the implication of LL which - if we take Girard seriously - should be able capture the dynamics, and not formulas such as $time(0) \wedge occurs(lift)(0)$. There seem to be other extra concepts, such as grouping of those sequent rules corresponding to an action (see below).

This is my main criticism. What follows are more detailed comments.

Sections 2.2. The two-blocks Example 1 is similar to Lifschitz' two switches example, I suppose. (Btw. on p.4, line 8 should be dropped.) I guess circumscription doesn't give *the* solution, but several ones, one of which you give in the table. (Btw. one b_1 should be b_2 there.)

Sections 2.3. I don't understand the difference between Example 1 and Examples 2 and 3. Where does the 'support' concept come from? I need more comments here.

Section 2.4. The expression "equivalent in first order logic to theory T, but expressed in L'" is inaccurate. I don't know whether you refer to logical equivalence in the union of the two languages L and L' under the translation theory of Table 3, or rather to interpretability as in the end of the subsection.

Section 3.2. You claim your rewrite rules for the two blocks theory is 'local data', in the sense that they remain valid 'if we introduce new types of cause'. But what about introducing an action such as cutting or removing the string between the blocks? Then the rewrite rules 'linking' the blocks do not hold any longer.

Section 4.1. Wy don't you mention the cut rule here? (you talk about its elimination in the proof of Proposition 1). In the statement of Proposion 1, you don't say what ACI is.

If you have cut, how can composition of rewrites be a problem? Cut is just doing that job, viz. chaining sequents. I guess this relates to my main criticism: in order to identify actions in proofs, you must group together sequences of rules related to the same action. This means that there is a new concept that is exterior to LL. (I think the problem of termination of sequences is similar.)

Section 4.2. I don't understand how the introduction of modal operators solves the above problem.

In the basic rewrite rule of Definition 1, I suppose the LL 'times' operator is rather an ACI bullet.

I found it difficult to understand the exposition on termination. I suppose termination refers to termination of a rewrite sequence corresponding to an action. In the rule, the notation $A - A_i$ has not explained. What is a 'state' A_i?

A2. **The Author** (28.10)

Dear Andreas,

Thank you for your comments on my paper. I'll try to respond in order.

> *In my opinion all these attemps have failed in the sense that the only thing they can handle within LL is the simplest case: deterministic actions,*

I can handle non-deterministic actions; all you need is the additive connectives. If you have linear logic terms a_1 and a_2, each representing an action, then the term $a_1 \wedge a_2$ represents the action which nondeterministically executes either a_1 or a_2.

> *no state constraints,*

I haven't talked much about state constraints because I am a little sceptical about the prominent role given to them in the current literature: I do not believe that the ramification behaviour can be given simply by the state constraints. In this respect, my position is somewhat similar to that of Deneker et al. in the article the recently submitted to ETAI (http://www.ep.liu.se/ea/cis/1998/007)

However, if you do want state constraints (if, for example, you want to do other things than simply generate the ramification behaviour from them), they can be added to my approach, and I've shown how to treat a simple case in my reply to Tom Costello. However, there are important conceptual (not mathematical) issues to be resolved first: in particular, there is an obvious distinction between state constraints which are required to hold *during* the ramification process, or only *at the end* of it.

> *knowledge about the initial situation only.*

I can deal with that too. In my "Actions, Ramification, and Linear Modalities", QMW Technical Report no. 749 (1998), at
`ftp://ftp.dcs.qmw.ac.uk/pub/applied_logic/graham/ramMod.ps`,
I show that every valid inference in the logic corresponds to an evolution of the system according to the intended semantics, and vice versa; so if we carry out a proof search starting with partial data in either or both of the initial or final situations or in the action (representing the partiality be the appropriate quantifiers: $\forall$ before the entailment, $\exists$ after it) then, if that proof search terminates, the corresponding entailment will correspond to a correct evolution of the system.

> *They didn't succeed in going beyond that without violating the spirit of LL: they all introduced extra concepts that were used to constrain deduction in one way or another.*

I think you have to distinguish here between "extra concepts ... used to constrain deduction" and genuine extensions of the system. I have tried to show (in "Actions, Ramification, and Linear Modalities") that my extra connectives have both a good proof theory and a semantics.

> *In the present paper it is time which is made explicit in the encoding of reasoning about action problems (section 3, 3rd paragraph).*

But I only put the explicit time in to make the example conceptually clearer. You don't need it.

> *But I would expect time to be implicit in a LL account of reasoning about actions: it is the implication of LL which - if we take Girard seriously - should be able capture the dynamics, and not formulas such as* $time(0) \wedge occurs(lift)(0)$. *There seem to be other extra concepts, such as grouping of those sequent rules corresponding to an action (see below).*

This is, of course, and important point, and I more or less agree with it. However, I want to make one caveat: you do seem to need to represent some notion of synchronisation. That is, you need to say that a particular tensor product of fluent formulae represents a particular situation, *and that these are all of the fluents in that situation.* Otherwise you can't express universally quantified assertions (for example, if you want to say "all the blocks are on the table" in a given situation). I've gone into this in "Golog and Linear Logic", QMW Department of Computer Science Technical Report (December 1997), at `ftp://ftp.dcs.qmw.ac.uk/applied_logic/graham/golog.ps`.

> *This is my main criticism. What follows are more detailed comments.*
>
> *Sections 2.2. The two-blocks Example 1 is similar to Lifschitz' two switches example, I suppose. (Btw. on p.4, line 8 should be dropped.) I guess circumscription doesn't give* the *solution, but several ones, one of which you give in the table. (Btw. one* b_1 *should be* b_2 *there.)*

No, circumscription (with the indicated fluents) only gives one solution, and that solution is clearly not the intended one. So it's not similar to Lifschitz' two switches example in that respect.

> *Sections 2.3. I don't understand the difference between Example 1 and Examples 2 and 3. Where does the 'support' concept come from? I need more comments here.*

Ah. Sorry about that: I forgot to give enough context for the quote from the referee. The point is that you can try to fix up the state constraints by saying that a ball is either supported directly, or hangs from a directly supported ball.

> *Section 2.4. The expression "equivalent in first order logic to theory* T*, but expressed in* L' *" is inaccurate. I don't know whether you refer to logical equivalence in the union of the two languages* L *and* L' *under the translation theory of Table 3, or rather to interpretability as in the end of the subsection.*

Interpretablity. Sorry about the ambiguity.

> *Section 3.2. You claim your rewrite rules for the two blocks theory is 'local data', in the sense that they remain valid 'if we introduce new types of cause'. But what about introducing an action such as cutting or removing the string between the blocks? Then the rewrite rules 'linking' the blocks do not hold any longer.*

In that case, of course, we'd have to introduce new fluents, since we don't, in this example, have a representation for whether the string is intact or not, and we'd consequently have to change the rewrite rules somewhat.

> *Section 4.1. Wy don't you mention the cut rule here? (you talk about its elimination in the proof of Proposition 1). In the statement of Proposion 1, you don't say what ACI is.*

Well, I can prove cut elimination (in the tech report "Actions, Ramification, and Linear Modalities"), so the system without cut is equivalent to the system with cut.

Cut elimination is important, because, if you have it, you can show that the only proofs of the sequents that encode actions correspond to the changes that those actions produce; that is, it says that the linear logic connectives have their intuitive meaning. This is a theme in a tradition in the proof theory of intuitionism, starting with Martin-Lf; the question is, can you understand the logical connectives simply by their role in proofs? And the answer is, yes you can, *if* the system satisfies cut elimination: because then we only need finite data to decide whether we can apply a rule or not. But the cut rule breaks this, because we can apply it with *any* cut formula, which is an unbounded totality. So systems without cut can be understood, in some way, finitely, whereas systems with cut can't.

> *If you have cut, how can composition of rewrites be a problem? Cut is just doing that job, viz. chaining sequents.*

We need composition of rewrites in order to be able to prove cut elimination.

> *I guess this relates to my main criticism: in order to identify actions in proofs, you must group together sequences of rules related to the same action.*

No, not necessarily; if you look at the examples in "Actions, Ramification, and Linear Modalities", you can see that you don't need to group rule applications together like this.

> *This means that there is a new concept that is exterior to LL. (I think the problem of termination of sequences is similar.)*
>
> *Section 4.2. I don't understand how the introduction of modal operators solves the above problem.*

I say more about this in "Actions, Ramifications, and Linear Modalities", but I can write more about this if you still find this mystifying.

> *In the basic rewrite rule of Definition 1, I suppose the LL 'times' operator is rather an ACI bullet.*
>
> *I found it difficult to understand the exposition on termination.*

I suppose it is a bit compressed. I'm intending the paper as a non-technical guide to the more technical results (which are mostly in "Actions, Ramification, and Linear Modalities"), but I agree with you that some parts of it might have left the technical details out a bit too enthusiastically.

> *I suppose termination refers to termination of a rewrite sequence corresponding to an action. In the rule, the notation $A - A_i$ has not explained. What is a 'state' A_i?*

Here you can treat it as a term of the metatheory. We start with atomic terms representing basic fluents; state propositions will then be combinations of them using $\otimes$ (and you can, in fact, use $\oplus$ as well, which will give you a notion of disjunctive states). The rewrite operation will then take state propositions to state propositions. Provided you start with atomic terms, and only combine them in the above ways, you can then prove cut elimination. (In "Actions, Ramifications, and Linear Modalities" I do it rather differently, and I have a representation within the logic for state terms; but you don't need to do that.)

Anyway, I hope this helps. Thanks again for your questions.

Graham White

Electronic News Journal on Reasoning about Actions and Change 340
Vol. 2: *340-340*, 31.10.1998
http://www.etaij.org/ra/rac/014/

Patrick Doherty, Joakim Gustafsson, Lars Karlsson, and Jonas Kvarnström:

TAL: Temporal Action Logics Language Specification and Tutorial

Abstract of the reference article

The purpose of this article is to provide a uniform, lightweight language specification and tutorial for a class of temporal logics for reasoning about action and change that has been developed by our group during the period 1994-1998. The class of logics are collected under the name TAL, an acronym for `Temporal Action Logics`. TAL has its origins and inspiration in the work with Features and Fluents (FF) by Sandewall, but has diverged from the methodology and approach through the years. We first discuss distinctions and compatibility with FF, move on to the lightweight language specification, and then present a tutorial in terms of an excursion through the different parts of a relatively complex narrative defined using TAL. We conclude with an annotated list of published work from our group.

The article tries to strike a reasonable balance between detail and readability, making a number of simplifications regarding narrative syntax and translation to a base logical language. Full details are available in numerous technical reports and articles which are listed in the final section of this article.

Electronic News Journal on Reasoning about Actions and Change 341
Vol. 2: *341-341*, 31.10.1998
http://www.etaij.org/ra/rac/015/

Michael Gelfond and Vladimir Lifschitz:

Action Languages

Abstract of the reference article

Action languages are formal models of parts of the natural language that are used for talking about the effects of actions. This article is a collection of definitions related to action languages that may be useful as a reference in future publications.

Electronic News Journal on Reasoning about Actions and Change 342
Vol. 2: *342-342*, 31.10.1998
http://www.etaij.org/ra/rac/016/

Erik Sandewall:

Cognitive Robotics Logic and its Metatheory: Features and Fluents Revisited

Abstract of the reference article

Cognitive Robotics Logic (CRL) is an extensible logic language for characterizing actions and change, in particular for use in cognitive robotics. Its development emphasizes the issues of syntax, expressivity, underlying semantics and entailment methods (defined in terms of the semantics). Development of proof methods is de-emphasized. The salient results from this approach refer to the range of applicability and other related properties of the entailment methods. These results constitute a metatheory of actions and change.

CRL is syntactically defined as a base language and a surface language. The base language is characterized by the following aspects:

- its three major predicates *Holds*, *Occurs*, and *Occlude*, which provide coherence when the language is extended;
- its reportoire of categorial functions, which is augmented when additional expressiveness is required in the language.

The surface language provides additional notational convenience, and is defined by translation to the base language.

The range of expressivity includes actions with duration, nondeterministic actions, actions in hybrid worlds with piecewise continuous fluents, some forms of ramification and causation, imprecise sensors and actuators, action failure, and some aspects of goal-directed agent behavior.

Entailment methods are functions that map scenario descriptions to sets of *intended models*. They are defined using a reportoire of set-theoretic operations on sets of formulas and sets of models, including but not restricted to minimizing a set of models with respect to a preference relation.

A progression of underlying semantics is defined, beginning with the partial state-transition semantics and its immediate generalization, the trajectory semantics. These underlying semantics are used for the formal analysis of the range of applicability of various entailment methods, including both those proposed by the others in this research, and those that developed in the course of the present work.