

Questions about dynamic epistemic logic

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1 What is dynamic epistemic logic? — Is action model logic the only dynamic epistemic logic?

Is the core of dynamic epistemic logic is the method of updating model? Can you summarize the core ideas and techniques of DEL in a few sentences?

When we say DEL, do we mean a single logic or a set of similar logics? If it is the latter, how do we define the class of those logics precisely? There are just too many of them! What are the necessary technical features do they share? If it is the earlier, do we mean the action model DEL? Is the action model DEL robust enough to be considered as a good unique logic? (It should have some nice closure properties and can be characterized nicely somehow).

Why people always consider product-kind of updates in DEL, is there a good reason for it?

Is action model logic the last word?

- There are other ways to do dynamic epistemic logic than with action models.
- I could think of at least three or four different ways (with probably the same expressivity).
- **To illustrate that we model ‘nobody steps forward’ in 3 Muddy Children.**
- **To illustrate that we model ‘showing a card’ given a card deal of 3 cards over 3 players.**

What is a dynamic epistemic logic? Two features:

- Every dynamic epistemic logic has two sorts of modalities, basic modalities (knowledge) and dynamic modalities (change of knowledge)
- In every dynamic epistemic logic the dynamic modalities are interpreted as model transformers.

There are many model transforming operations.

- a public announcement is a model transformer (*submodel restriction* relative to φ)
- an action model is a model transformer (*pruning* of the tree model generated by pointed Kripke model)
- **please define ten other model transforming operations!**

References:

- Johan van Benthem, Jan van Eijck, Barteld Kooi, *Logics of communication and change*
- Hans van Ditmarsch, *Descriptions of game actions*, JoLLI 2002 (or the corresponding chapter from the DEL book)
- Yanjing Wang & Guillaume Aucher, *An Alternative Axiomatization of DEL and its Applications*, IJCAI, forthcoming
- Barteld Kooi & Bryan Renne, *Arrow Update Logic*, RSL & (similar work in TARK 2011)
- Carlos Areces, Raul Fervari, Guillaume Hoffmann, *Moving Arrows and Four Model Checking Results*. WoLLIC 2012.
- Yanjing Wang & . . . , *Composing Models*

2 Reduction axioms or canonical models?

In the area of public announcement logic, announcement operators are always interpreted as sub-model operators, which is different from the usual modal operator. Maybe it is this special semantics of announcements that determines completeness proof of various proof systems of public announcement logic and its extensions have to depend on reduction axioms and adopt reduction methods. If there are no reduction axioms, the completeness proof will be very difficult and even impossible. So, do you think it is possible to define a canonical sub-model to give a completeness proof for PAL directly? If yes, how? If no, Why?

I do not have much to say and may not have understood the question.

- Completeness for the logic 'arbitrary public announcement logic' (Knowable as known after an announcement, Balbiani et al., RSL, 2008) is with a canonical model construction (and submodels too)
- This involves shifting points in a 'supermodel' consisting of all model restrictions of an 'initial model'.

- Then, dynamics & common knowledge *may* bring you into canonical model area. (Older completeness proofs of DEL, before relativized common knowledge)

3 Real applications and true philosophy

Can you give a concrete example of large-scale applications of DEL in AI (not toy examples please)? Similarly, would you please give a few nice examples of DEL applied in philosophy (preferably not only puzzles)?

Dynamic epistemic logic has shown its surprisingly successful applications in many areas, such as AI, theoretical computer science and various puzzles. What are the main reasons for its success? What is the most important relationship between DEL, AI and CS? What is the most important factor for DEL to formally deal with various puzzles? Can DEL be applied to deal with all of the puzzles?

Are there large-scale applications: **no**.

- **Are there DEL model checking benchmarks?**
- **Are there DEL (expected) satisfiability benchmarks?**
- **Are there DEL planning benchmarks?**

And other matters...

- Johan van Benthem said: a reason for the success of DEL is that it is a *community effort* and that much progress is by PhD students and PhD theses. This is very true.
- Examples of DEL applied in philosophy, that are not puzzles: the Moore-sentence, and the Fitch paradox of knowability (and formal epistemology)
- ...

4 Descriptive and normative

Sometimes the techniques in DEL (for example, lexicographical upgrade in belief revision, or take belief as KD45) seems somewhat normative (although there are some kind of intuition behind it) and people in real life do not think like those models, so my question is about how to balance descriptive side and normative side of the model (i.e. make the model descriptive enough but not too complicated)?

- I do not understand the question. For me, all DEL techniques are descriptive.

- DEL models can be very complex and then do not correspond to ‘real reasoners’
- To model ‘real reasoners’ we can use *unawareness*, *bounded rationality*, ...
- When modelling unawareness, complexity can be in the action instead of in the static model. (See my course at Tsinghua, two weeks ago, last slides of the ‘awareness’ lecture.)

5 Quantification over information change

In your last lecture at Tsinghua last week, you listed quite a few ways of quantification over information change and explored one of them. What are the connections of them with the real life? Are they equally important?

You meet a research topic, and you find that it is theoretically interesting but you don't see it has much to do with the reality. What are you going to do?

- **What is reality?**
- Sometimes you pursue research because a technical question inspires you.
- Sometimes you pursue research because a possible application inspires you.

The importance of quantifiers (and being earnest).

- An existential information change quantifier \exists is like a temporal future quantifier F (‘some time in the future’).
- **So what are the differences? Can you give four differences?**
- Dynamic epistemic specifications versus temporal epistemic specifications, both can serve as the starting point for synthesis.

6 Dynamic modal logic that is not dynamic epistemic logic

DEL seems to be an epistemic logic with a model restriction operator, the dynamics being expressed by such an operator. Is model-change the difference between "statics" and "dynamics" ? Are there other non-epistemic examples of adding dynamics to static logics ?

Modalities are used to describe: knowledge, belief, intention, obligation, time, program execution, ...

- **Please give five dynamic modal logics that are not dynamic epistemic logics.**

7 Common knowledge

How does common knowledge (CK) interact with dynamics ? Are there situations where we can eliminate CK (by showing some bound on length of $K_i K_j K_i$ etc needed) ?

- **Common knowledge does not exist**
- **Card deals:** we model that the players commonly know how many cards there are, and that everybody only knows their own cards.
- Given a stack of card distributed over three players, and any two card deals d and d' , there are two players a and b such that, if d is the card deal, a considers it possible that the deal is d' , in which case b considers it possible that d' .
- Therefore, on models for card deals common knowledge is definable.
- **Flatland:** a line on which agents are placed that can see all other agents in one direction.
- Consider four agents on a line... Propositional variables $a > b$ for ‘agent a sees agent b ’.
- If two agents a and b see each other they have common knowledge of all agents they see. **They have also common knowledge of an agent c that only one of a and b sees. How?**
- In flatland, common knowledge is definable. In flatland, knowledge is definable.

References

- Philippe Balbiani, Olivier Gasquet and Francois Schwarzentruber, *Agents that look at one another*, Logic journal of the IGPL, to appear.
- Hans van Ditmarsch, Knowledge games, PhD thesis, 2000.
- Rohit Parikh (CUNY) has various publications on stacks of epistemic operators ...
- Multi-agent frame characterization! Alessio Lomuscio, PhD thesis, *Knowledge Sharing Among Ideal Agents*, 1999

8 Protocols

In the DEL and PAL worlds, an agent moves from not knowing a proposition to knowing it by single actions (an announcement, an update). This seems to be a very specific form of learning, since learning anything non-trivial in the world seems to take a lot of work. Is there any way to characterize this learning ?

Let me first give some counterexamples:

- In the muddy children puzzle, an agent moves from not knowing a proposition to knowing it by 10 actions (if there are 10 muddy children)
- In the sum and product riddle, the conversation consists of three announcements. (And less is not enough.)
- In the 100 prisoners and a lightbulb riddle (ask Yanjing Wang), protocols can take 9000 steps. On average.

So the answer to this question is: protocols, protocols, ...

9 Measuring information

DEL is a framework for studying knowledge gain. Is there any way to measure this gain, say, information theoretically ? Is there any knowledge loss as well ? (Not artificial loss like going from $K_i \neg K_j p$ to $\neg K_i \neg K_j p$ because i told j that p holds, but more "genuine" loss !)

A big issue with small answers. How do we measure information content? How do we measure information change?

- The size of a Kripke model is the number of worlds?
- The size of a Kripke model is the number of pairs in the relation?
- How about models with equivalence relations / partitions?
- The 'disorder' in a Kripke model is the uncertainty between worlds (measured in 'bits', say)
- So an information change operation can be measured against the *reduction* in this disorder?
- But for the individual agent this may appear very different. What counts for that agent is the reduction of the size of its actual equivalence class.
- Is there such a thing as agent entropy?

10 Dynamic epistemic logic and temporal epistemic logic

How do you compare DEL and Epistemic Temporal Logic?

- A single action in DEL corresponds to a next operator in temporal epistemic logic.
- In arbitrary public announcement logic we can interpret $\Diamond K\varphi$ as $FK\varphi$. So an information change quantifier corresponds to a (F or G) temporal operator.
- **Which of 200 normal temporal epistemic logics is this?**
- **None. Because?**
- ...

11 Dynamic predicate logic

Is there any first-order DEL? We should be able to change the interpretations of functions and predicates as well. Then it seems it is similar to first-order dynamic logic. What is the fundamental differences between the dynamics in dynamic logic and the dynamics in DEL.

References, ideas, ...

- Much older work by different authors: Jan van Eijck, David Harel (etc., etc., etc.), Gerard Renardel, Rix Groenboom,
- Newer work expanding propositional epistemic logic: knowing what, knowing whether, see: Yanjing Wang, Jie Fan, *Knowing That, Knowing What, and Public Communication: Public Announcement Logic with Kv Operators*, IJCAI, to appear.
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12 Complexity

People proved the complexity results of DEL, but do we really use them in practice?

We should distinguish the following three:

- worst case complexity
- average complexity (expected complexity)
- cognitive complexity