Dynamic epistemic logics: promises, problems, shortcomings, and perspectives

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LF'2016, Toulouse, March 4, 2016

1986: first year of thesis

$$database \circ new\_info \rightsquigarrow new\_database$$

- the plan:
  - design appropriate semantics
  - find nice axiomatics
  - prove completeness
  - get famous
- how it went:
  - good minimal change semantics
    - take models of *new info* that are closest to *old database* wrt some distance measure (Winslett's PMA, 1988)
  - failed to find axiomatics: many tentatives, no good solution
- how it ended:
  - paper with axiomatisation of case where *new_info* is a literal (atom or a negation of an atom), published 1988
  - changed thesis subject after one year

1990: the supervisor and the postdoc

Hagenberg Castle, Austria, 1990
workshop of the ESPRIT project MEDLAR (“Mechanising Deduction in the Logics of Practical Reasoning”)

~2000

DEL = Dynamic Epistemic Logics

- Amsterdam, Indiana, Liverpool, Toulouse, ...
- only updates by literals
- moreover: updates of higher-order beliefs

*I **believe** Luis doesn't **know** there is a feast*

- *there is a feast* !

$\rightsquigarrow$ *it is **common knowledge** that there is a feast*

- today: mini-tutorial on DEL
  - hundreds of published papers explained in 10mn
  - message: many open problems

Dynamic Epistemic Logics: language

1. epistemic operators: “agent knows proposition”

$$\mathsf{Knw}_{Andreas}\ feast$$

$$\mathsf{Bel}_{Andreas}\ (\neg\, \mathsf{Knw}_{Luis}\ feast)$$

2. dynamic operators: “proposition is true after event”

$$\langle Event \rangle\ feast$$

where *Event* can be:

- assignment of propositional variable (change in the world)

$$Luis\_in\_auditorium := \top$$

N.B.: this is nothing but update where new info is literal!

- announcement (change of beliefs; no change in the world)

$$feast!$$

- more generally: *Kripke models*
  - world = announcement and assignments
  - accessibility relations: model agents’ perception of the event

Dynamic Epistemic Logics: semantics

$$M, w \models \mathrm{Knw}_{Luis}\, feast \;\text{ iff }\; \text{for all } w' \text{ Luis cannot distinguish from } w,\; M, w' \models feast$$

$$M, w \models \langle feast! \rangle \varphi \;\text{ iff }\; M, w \models \varphi \text{ and } M^{feast!}, w \models \varphi$$

where $M^{feast!}$ is the update of M by *feast*:

eliminate from M all worlds where *feast* is false

Dynamic Epistemic Logics?

1. not a modal logic in the strict sense
   - modal logic = set of formulas containing all classical propositional theorems, closed under uniform substitution, modus ponens and necessitation
   - not closed under uniform substitution:
     - $[p!]p$ is valid
     - $[q \wedge \neg \mathrm{Knw}_i q!](q \wedge \neg \mathrm{Knw}_i q)$ is not
2. Kripkean event models amalgamate syntax and semantics
   - [French, Hales & Tay, AiML 2014]: all event models can be constructed from
     - private announcements to groups

       $$\text{thea\_is\_henri}!_{\text{Auditorium}}$$

     - the PDL program operators
3. almost always fails to be a conservative extension of the underlying epistemic logic [Balbiani et al., AiML 2012]
   - existential properties not preserved under world elimination

Dynamic Epistemic Logics?

1. problems with Knw when we move from S5 to 'better' logics of knowledge (cf. [Lenzen, Voorbraak]) e.g. S4.2
   - conservativity fails, v.s.
2. problems with Bel are worse
   - conservativity fails, v.s.
   - requires extension by (multiagent) belief revision:

$$\models \mathrm{Bel}_{Luis}\, \neg \mathit{feast} \rightarrow \langle \mathit{feast}! \rangle \mathrm{Bel}_{Luis}\, \bot$$

   - some approaches exist
     - [van Ditmarsch 2006]: ...
     - [Aucher, PhD 2007]: ...
     - [Baltag&Smets 2012]: based on safe belief (belief that will never be revised) $\Rightarrow$ begs the question

Dynamic Epistemic Logics?

1. evolution of the world: fairly unrelated to reasoning about actions literature [Reiter,. . .]
   - elegant solution to the frame problem [de Lima, PhD 2008]
   - no account of qualification problem
   - no account of ramification problem
2. evolution of epistemic states: does not provide an account of communication yet
   - speech act theory requires intentions!
   - integrate (simple version of) Bratman's theory of intentions [Xiao, Phd ongoing]

Conclusion

- Dynamic Epistemic Logics are nice
  - more compact models
  - mathematically simpler than product logics
  - push the envelop: replace indistinguishability relation by 'mental programs' [Maffre, PhD 2016] (forthcoming)
- but there is still a lot to do!