Dynamic Epistemic Logic

1. Introduction

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April 24th, 2019

What is Dynamic Epistemic Logic?

And Why Should I Care?



What is

Hanahi

DEL within A

Remark:

Ultimately, we are interested in planning with dynamic epistemic logic.

Objective:

- Social robots should have a theory of mind.
- \rightsquigarrow ability to take perspective of humans they interact with.
- Example for how easily this perspective-taking comes to humans and how it leads to smooth interaction:

https://www.youtube.com/watch?v=RK8rKKp-vP0&t=1m1s



What is DEL?

Hanabi

DEL within A

What is Dynamic Epistemic Logic?

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Theory of mind and developmental psychology:

What is Dynamic Epistemic Logic?

False beliefs, Sally-Anne test (Wimmer and Perner, 1983)

- Sally takes a marble and hides it in her basket.
- Sally then leaves the room and goes for a walk.
- While Sally is away, Anne takes the marble out of Sally's basket and puts it in her own box.
- Sally comes back to the room.
- Question: Where will Sally look for the marble? In the basket or in the box?

false) beliefs, i. e., a theory of mind.

Question: Can we make machines pass the Sally-Anne test? Can something like Dynamic Epistemic Logic help?

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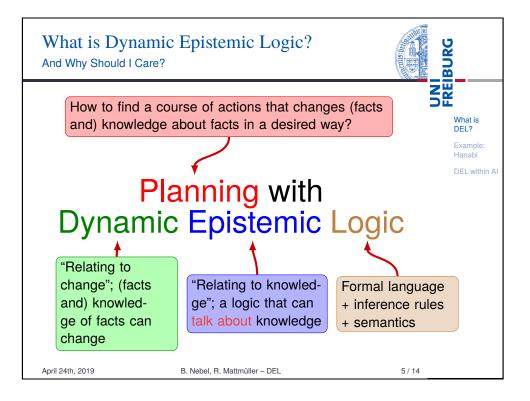
What is

Example:

DEL within Al

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What is Dynamic Epistemic Logic?

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What is DEL?

Example: Hanabi

DEL within Al

Remarks:

- From now on, we often abbreviate Dynamic Epistemic Logic as DEL.
- DEL mostly interesting in a multi-agent setting where knowledge can change, e. g., through announcements/communication.
- DEL can be seen as a modal logic.

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What is Dynamic Epistemic Logic?

And Why Should I Care?

Remarks (ctd.):

- We will look at different dynamic epistemic logics:
 - In simpler ones, actions can only change knowledge (epistemic actions).
 - In advanced ones, actions can also change facts (ontic actions).
- Remark: Don't confuse epistemic and ontic actions. Otherwise, this can happen:

Two hunters are out in the woods when one of them collapses. He doesn't seem to be breathing and his eyes are glazed. The other guy whips out his phone and calls the emergency services. He gasps, "My friend is dead! What can I do?" The operator says, "Calm down. I can help. First, let's make sure he's really dead." There is a silence; then a gun shot is heard. Back on the phone, the guy says, "OK, now what?"

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Example: Hanabi

DEL within A

Example: Hanabi

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What is DEL?

Example: Hanabi

DEL within AI

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Hanabi

Concrete example: Hanabi

(the "Hello world!" of DEL-based planning?)



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What is

Example:

DEL within A

Hanahi

DEL?

Hanabi



What is

Example:

DEL within Al

Hanabi

DEL?

Rules:

■ Cooperative card game

■ Five suits (red, yellow, green, blue, white)

Per suit: three 1's, two 2's, 3's, and 4's each, and one 5

■ Three fuse tokens, five information tokens

■ Players (between two and five) are dealt cards (five per player for two to three players, four cards for four or five players).

Each player holds the cards so that only the other players can see them, but he himself cannot.

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Hanabi

Rules (ctd.):

Play proceeds around the table. Three options:

- Give information: The player points out for one other player either color or face of the cards. Give up one information token.
- Discard a card: Putting one card on the discard pile face-up. Get back one information token. Replenish your hand.
- Play a card: If it fits, okay; otherwise, a fuse token is taken away. Replenish your hand.
- After the third fuse token is gone, the game is over/lost.
- Winning means:
 - All five piles completed
 - No more cards on the replenishment pile

What is

Example: Hanahi

DFI within A

Hanabi

Successful play requires reasoning about others' knowledge.

■ We will later model simplified versions of Hanabi (with fewer cards) in DEL and plan for the individual agents to achieve successful cooperative play.

Questions when building a Hanabi bot:

- How to represent the knowledge states of the agents?
- How to change the representation when (epistemic) actions are executed?
- See also: Bard et al., The Hanabi Challenge: A New Frontier for Al Research, 2019. (https://arxiv.org/abs/1902.00506)

What is

Example:

DEL within Al

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What is DEL?

Example: Hanabi

DEL within Al

DEL in the Al landscape

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DEL in the AI landscape

(hugely simplified ...)



Symbolic Al, e.g....

Knowledge representation and reasoning

You are here!
Al planning,
search

Knowledge and symbols

■ Often model-based

■ Explainability:

What is DEL?

Example: Hanabi

amability: DEL within Al

Sub-symbolic Al, e.g. ...

Perception (vision, ...)

Pattern Recognition

(Deep) Learning

■ Data, no symbols

Often model-free

■ Explainability: X

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