Final Assignment
02287: Logical Theories for Uncertainty and Learning 2023

1   Requirements

The final assignment of the course is writing a research paper. The papers should be:

- coauthored by four students (group hand-in);

- maximum 8 pages long;

- typeset in latex;

- featuring Introduction, Main Matter, Conclusions with Further Work and full Bibliography;

- concerned with an overview of the chosen problem, modelling, design, analysis, or simulations (with the use of techniques taught in class), positioned within the context of existing research on the topic.

The timeline is as follows:

- Thursday, November 9th: beginning of the topic selection and research group forming (action: join groups in DTU Learn).

- Monday, November 13th, 23:59: deadline for submitting the commitments to groups and topics (action: submit declaration in DTU Learn).

- **Wednesday, November 29th, 23:59: deadline for submitting final papers (action: submit in DTU Learn).**

The basic approach to this assignment is to write an overview paper based on the proposed literature. You are encouraged however to find a specific issue/angle you wish to focus on in your project.

2 Topics

The choice of topic is free, but it should be related to methods, techniques and problems presented in the course. Below I list some examples. If you have an original idea on a topic not listed below, please get in touch via-email, and we will discuss the details.

You are strongly encouraged to be creative and inquisitive, use your preferred approaches, programming languages, literature. The basic literature you are expected to use in your project is included on the inside, in folder 'final reading'.

Information Cascades and Conformity   Information cascade occurs when a person observes the actions of others and then, despite possible contradictions in his/her own private information, engages in the same acts. A cascade develops when people abandon their own information in favour of inferences based on earlier people's actions (vis. the urn problem).

1. Baltag et al, Logical Models of Informational Cascades.

2. Easley and Kleinberg, Information Cascades.

Pluralistic Ignorance and Group Knowledge   Pluralistic ignorance is a situation in which a majority of group members privately reject a norm, but incorrectly assume that most others accept it, and therefore go along with it. This is also described as "no one believes, but everyone thinks that everyone believes." Pluralistic ignorance may help to explain the bystander effect. If no-one acts, onlookers may believe others believe action is incorrect, and may therefore themselves refrain from acting.

1. Bjerring et al., On the Rationality of Pluralistic Ignorance.

2. Hansen, A Logic-Based Approach to Pluralistic Ignorance.

Dynamics of Knowledge and Epistemic Logic   Epistemic Logic serves is an adequate tool for modelling complex phenomena related to uncertainty in multi-agent context. Dynamic epistemic logic enriches this framework with a systematic approach to information flow. This allows to understand and identify complex scenarios of knowledge exchange, where our regular intuitions fail (vis. Muddy Children Puzzle). This modelling opens a wide spectrum of issues, logical and computational.

1. Moses et al., Cheating Husbands and Other Stories: A Case Study of Knowledge, Action, and Communication.

2. Gierasimczuk and Szymanik, A Note on a Generalization of the Muddy Children Puzzle.

3. van Benthem et al.,Symbolic model checking for dynamic epistemic logic — S5 and beyond.

Modelling Surprise in Logic and Probability   The phenomenon of surprise is very common among humans, but quite difficult to model and implement in artificial agents. Many traditional approaches to knowledge and uncertainty lead to paradoxical consequences when it comes to surprise (vis. Surprise Examination Paradox).

1. van Ditmarsch and Kooi, The secret of my success.

2. Halpern and Moses, Taken By Surprise: The Paradox of the Surprise test revisited.

3. Gerbrandy, The Surprise Examination.

Bayesianism and Foundations of Probability Under certain circumstances a model of learning behaviour can be deemed rational. There are many methodological questions related to such postulates of rationality. Where do the prior probability distributions come from?

1. Sober, Bayesianism – It's Scope and Limits.

2. Gillies, On philosophical theories of probability (Ch 5: Frequency Theory)

Paradoxes of Probability Sleeping beauty paradox, Judy Benjamin problem and lottery paradox challenge the relationship between the notions of belief, probability and acceptance. Various solutions have been proposed to solve the issues, including advanced approaches to probability but also ones involving logical toolbox.

1. Douven and Romeijn, A New Resolution of the Judy Benjamin Problem.

2. Hawthorne and Bovens, The Preface, the Lottery, and the Logic of Belief.

3. Aumann, Hart, and Perry, The Forgetful Passenger.

4. Bovens, Judy Benjamin is a Sleeping Beauty.

Axiomatic Properties of Knowledge Equipping agent with knowledge and beliefs requires careful consideration of the desired properties of epistemic states. Do agents know whatever follows logically from what they know? Do agents know what they know and what they don't know? Is everything that is true knowable?

1. Halpern and Pucella, Dealing With Logical Omniscience.

2. Holliday, Epistemic Logic and Epistemology.

3. van Benthem, What one may come to know.

False Belief Task Theory of mind (ToM) is the ability to attribute mental state —beliefs, intents, desires, pretending, knowledge, etc.—to oneself and others and to understand that others have beliefs, desires, and intentions that are different from one's own. Most normally developing children are unable to pass the false belief tasks until around age four. Notably, while most children, including those with Down syndrome, are able to pass this test, in one study, 80% of children diagnosed with autism were unable to do so.

1. Brauner, Hybrid-Logical Reasoning in False-Belief Tasks.

2. van Ditmarsch and Labuschagne, My Beliefs about Your Beliefs: a Case Study In Theory of Mind and Epistemic Logic.

3. Bolander, Seeing Is Believing: Formalising False-Belief Tasks in Dynamic Epistemic Logic.

Knowledge and Justification The most classical approach to knowledge, identifying it with justified true belief (JTB), is attributed to Aristotle. It has been famously challenged by Gettier, and henceforth related more and more to the notion of evidence. How to track, count, and reason about evidence? Can it be done on the grounds of logic?

1. Gettier, Is Justified True Belief Knowledge?

2. Rott, Stability, strength and sensitivity: Converting Belief to knowledge.

3. Artemov, The Logic of Justification.

4. Goldman, Discrimination and Perceptual Knowledge.

5. Baltag, Renne, and Smets, The logic of justified belief, explicit knowledge, and conclusive evidence.

Epistemic Logic and Games The paradigm of games allows formalising rational behaviour of agents in interaction. Reasoning about strategic interaction deserves logical analysis, and epistemic logic seems to be especially well suited for this purpose. In particular, the notion of common knowledge has been given interpretations both in Game Theory and in Epistemic Logic. This begs the question of merging the two paradigms.

1. van Benthem, Games in Dynamic-Epistemic Logic.

2. Aumann, Backward Induction and Common Knowledge of Rationality.

Epistemic Planning and Games Many multiplayer games rely upon higher-order beliefs or knowledge. Cluedo, Diplomacy and Poker are examples of such knowledge games; each of them employs reasoning about the beliefs of others, particularly about the beliefs that they might have about your beliefs, or others' beliefs. If these games were to be played against artificial opponents, a very natural approach would be to create an opponent who models the player, including the beliefs the player has about the opponent, etc.

1. Witzel et al., Explicit Knowledge Programming for Computer Games.

2. Löwe et al, Planning Based on Dynamic Epistemic Logic.

3. Bolander, A Gentle Introduction to Epistemic Planning: The DEL Approach.

Learning, truth-tracking, and induction Learning methods should allow convergence to truth. How can a learning method be checked for its reliability? Is induction a reliable reasoning method? Is it possible to confirm a hypothesis? Those questions are equally important for implementing reliable learning agents, and for providing rational methods for scientific inquiry.

1. Miller, Popper's Qualitative Theory of Verisimilitude.

2. Niiniluoto, Verisimilitude: The Third Period.

3. Tichý, On Popper's Definitions of Verisimilitude.

4. Baltag, Gierasimczuk, and Smets, Truth-Tracking by Belief Revision.

The Logic of Social Networks Social Networks are nowadays one of the foundations of information flow in society (vis. Facebook, Twitter). Many unsettling phenomena, like information bubbles, echo-chamber effects, or cyber-bulling require new formal analysis. Several logical approaches to those problems have been recently proposed in literature.

1. Seligman, Liu, and Girard, Facebook and the epistemic logic of friendship.

2. Christoff and Hansen, A Logic for Diffusion in Social Networks.

Attention in Epistemic Logic In public announcement logic it is assumed that all agents pay attention to the announcement. Weaker observational conditions can be modelled in action model logic.

1. Bolander et al., Announcements to Attentive Agents.

2. Belardinelli and Bolander, Attention! Dynamic Epistemic Logic Models of (In)attentive Agents.

Awareness in Logic and Games Game theory and Dynamic Epistemic Logic can be criticised as lacking the possibility of adequately modelling novelty, discovery, and surprise. One solution is to introduce awareness and unawareness elements to the cognitie equipment of agents.

1. Schipper, Discovery and equilibrium in games with unawareness.

2. Fagin and Halpern, Belief, awareness, and limited reasoning.