SEMINAR LOGIC-BASED KNOWLEDGE REPRESENTATION

Introduction / Course Organization

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`https://iccl.inf.tu-dresden.de/web/Seminar_Logic-Based_Knowledge_Representation_(SS2024)`

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Course information

- Seminar sessions: Mondays at DS6 (16:40 – 18:10)
- Examination: presentation and term paper (for modules: INF-AQUA, INF-04-HS, INF-D-940, MCL-PS, CMS-SEM)
- Examination: non-graded oral exam (for module: INF-PM-FOR)
- For each seminar session, there will be a text to read
- Each text will be presented by a student and discussed afterwards
- For more information (e-mail, slides, . . .):

  `https://iccl.inf.tu-dresden.de/web/Seminar_Logic-Based_`
  `Knowledge_Representation_(SS2024)`

Aims of the course

Three objectives:

1. Develop skills to do research on previously unknown formalisms;

2. Learn how to present key concepts in a well-structured way (orally as well as in written form);

3. Obtain an understanding of a selection of key topics in Knowledge Representation and Reasoning such as:
   - The role of logic in KR
   - Modal Logics and some extensions
   - Nonmonotonic Reasoning
   - Algorithms and Systems

What is Knowledge Representation and Reasoning?

What is Knowledge?

Unsettled question and subject to an involved (philosophical) discussion.

What seems clear:

- Statements that involve the notion of "knowledge" typically are of the form: "John knows that Mary is going to the party".
- Knowledge involves an agent (e.g. John) who forms a judgment about some proposition p
  (e.g. $p \mathrel{\hat{=}}$ "Mary is going to the party").
- Knowledge involves the truth of the proposition.
- This observation can be used to distinguish knowledge from belief.

⤳ Our working "definition" of knowledge: Justified true belief.

What is Representation?

This question seems to be equally vexing.

Roughly, we see representation as:

- A relationship between two domains, where the first is meant to take the place of the second.
- We call the first domain the representor. It is typically more accessible than the second.
- We are mostly concerned with formal symbols as type of representor (e.g. "7" stands for the number 7).

Knowledge representation can then be understood as: "The field of study concerned with using formal symbols to represent a collection of propositions believed by some putative agent" (Brachman & Levesque, 2004: 4).

What is Reasoning?

Brachman & Levesque: "It is the formal manipulation of the symbols representing a collection of believed propositions to produce representations of new ones (2004: 4)".

In our case, this production of new propositions is done via logical inference. With that, we could summarize the general procedure of (logic-based) knowledge representation as follows:

1. Start with some set of propositions.
2. Find a good way to formally represent these propositions.
3. Apply a suitable form of logical inference to produce new propositions.

General Course Expectations

Presentation

Expectations:

- Presentation of the text for a session of around 30 minutes.

- Goal: Introduce the formalism and key concepts from the text on a formal as well as on an intuitive level.

- Use slides to support your presentation but try to speak from your notes as little as possible.

- Answer central questions such as:
  - What motivates this particular formalism?
  - How does it accomplish that?
  - What are the advantages and disadvantages of this approach?

- Take questions from the audience after your presentation.

- 50% of the final grade.

Term Paper

Expectations:

- Term paper of around 5 pages where you scrutinize one of the formalisms from the seminar in more detail.
- The term paper will be written during the summer break.
- There will be a consultation session by the end of the semester.
- Make use of additional literature by doing a little bit of research on your own.
- Have a reasonable research question.
- 50% of the final grade.
- Possible approach:
  1. Concisely present one of the formalisms from the seminar;
  2. Pick one of its drawbacks;
  3. Find out how that drawback can be overcome.

Seminar

Expectations:

- Everyone is expected to have read the text for each session (before the seminar starts);
- Everyone is encouraged to contribute to a (hopefully) lively discussion after the presentations.

Literature and Presentation Dates

First Block: Modal Logic and Extensions

08.05. **Introduction to Modal Logics – Semantics**
Text: Rosja Mastop: Modal Logic for Artificial Intelligence (2011), Chapters 2–4.3

15.05. **Introduction to Modal Logics – Proof Theory**
Text: Rosja Mastop: Modal Logic for Artificial Intelligence (2011), Chapters 5 & 6

22.05. **Temporal Reasoning**
Text: Handbook of Knowledge Representation (2008), Chapters 12–12.2.3
& Rosja Mastop: Modal Logic for Artificial Intelligence (2011), Chapters 8–8.4

05.06. **Epistemic Logic**
Text: Ernest Davis, Leora Morgenstern: Epistemic Logic and its Applications:
Tutorial Notes (2009)

Second Block: Nonmonotonic Reasoning

12.06. **Introduction to NMR**
Text: Handbook of Knowledge Representation (2008), Chapter 6

19.06. **Default Logic**
Text: Grigoris Antoniou: A Tutorial on Default Logics (1999)

26.06. **Autoepistemic Logic**
Text: R.C. Moore: Semantical Considerations on Nonmonotonic Logic (1985)

03.07. **NMR – Recap and Criticism**
Text: Raymond Reiter: Nonmonotonic Reasoning (1987)

Third Block: Algorithms and Systems

10.07 **Introduction to Reasoning under Uncertainty**
Text: Denoeux, Dubois, Prade: Representations of Uncertainty in Artificial Intelligence: Probability and Possibility (2020), Chapters 1–3.4

17.07 **Dempster Shafer Theory**
Text: Liu, Yager: Classic Works of the Dempster-Shafer Theory of Belief Functions: An Introduction (2008), Chapters 1–4

Summary and Outlook

Reading material for every session that will be presented by a student.

In case you cannot find a reference, contact me.

Term paper at the end of the semester.

Open questions:

- What's next? (A recap on logic – next week.)
- Are there any volunteers for the first presentations?