Reasoning and
Formal Modelling
for Forensic
Science
Lecture 12

Prof. Dr. Benedikt
Löwe

Reasoning and Formal Modelling for Forensic Science
Lecture 12

Prof. Dr. Benedikt Löwe

2nd Semester 2010/11

Plan for today.

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Plan for today.

▶ Summarize the aims of the course.

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- ▶ Evaluate how much we have been able to do with respect to these aims.

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- ▶ **Q & A Session.**

Aims of this course.

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Aims of this course.

▶ Develop a formal modelling technique that allows us to model the intricacies of real world cases.

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Aims of this course.

▶ Develop a formal modelling technique that allows us to model the intricacies of real world cases.

▶ Understand the methodology of modelling: this is an informal technique, relying on human interpretation of natural language text or real world data.
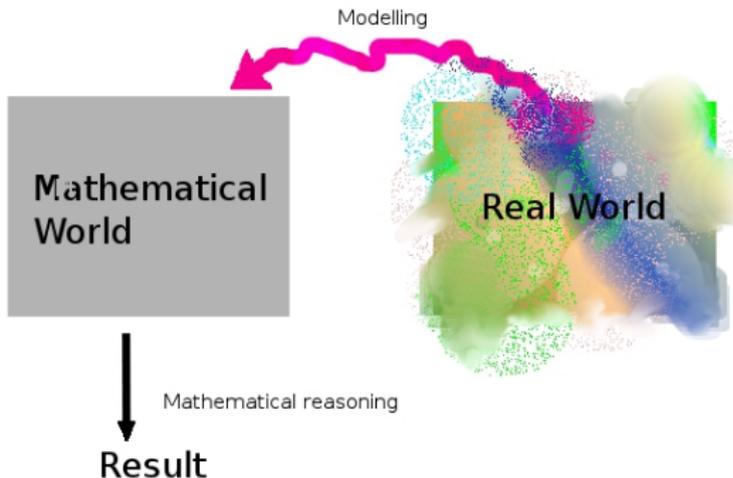
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Defeasible reasoning.

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All reasoning in the real world is defeasible. No conclusion is
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All reasoning in the real world is defeasible. No conclusion is
ever 100% certain. In order to deal with this, we need to
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Argumentation Schemes provide an informal framework,
listing critical questions for each argument that allow us to
assess how problematic a defeasible argument is.

Argumentation Schemes.

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Argumentation Schemes.

In class, we have seen many argumentation schemes from the book of Walton, Reed and Macagno. They all come in the form

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- ▶ Premiss 1
- ▶ Premiss 2 (sometimes missing)
- ▶ further premisses (rare)
- ▶ Conclusion
- ▶ Critical questions

Argumentation Schemes.

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Note that not all premisses are always explicitly mentioned in the text you are analysing: enthymemes.

Then we start asking critical questions in order to assess the strength of the argument.

Modelling: formal or informal?
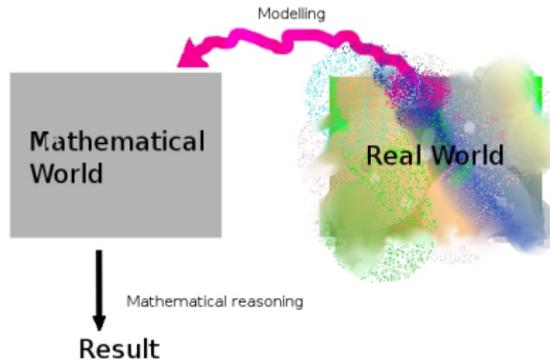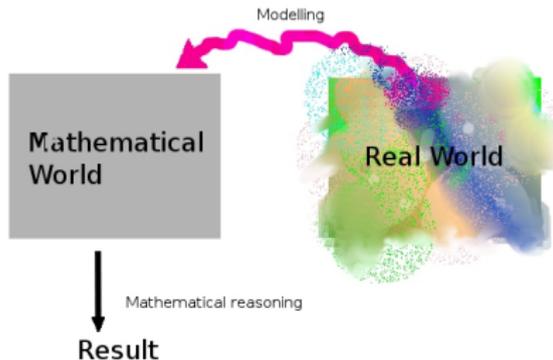
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Modelling: formal or informal?

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As a process that leads from the "real world" to the "mathematical world", the process of modelling is inherently informal and thus modelling decisions only allow defeasible arguments.

Modelling: formal or informal?

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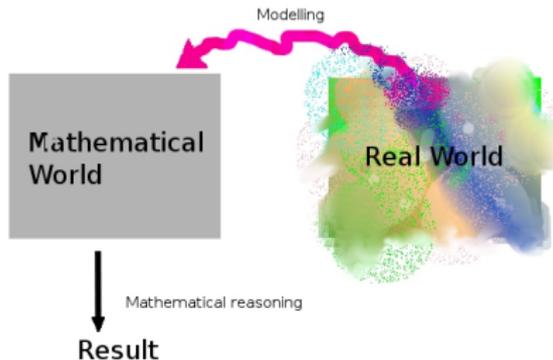

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We can use the technique of argumentation schemes in order to argue for our modelling decisions.

The mathematical side of the world (1).

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The mathematical side of the world (1).

The mathematical side of the world consists of syntax (the rules that govern what language we use and which expressions have a chance to be meaningful) and semantics (the rules that govern the interpretation of our symbols).

The mathematical side of the world (1).

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The relationship between mathematical world and real world is rules by the third area: pragmatics.

The mathematical side of the world (2).

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The mathematical side of the world (2).

We have seen various forms of mathematical representations
(with semantics and syntax), of increasing complexity:

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The mathematical side of the world (2).

We have seen various forms of mathematical representations
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- ▶ Propositional logic

The mathematical side of the world (2).

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We have seen various forms of mathematical representations
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- Propositional logic: only $\wedge$, $\vee$, $\neg$, etc.

The mathematical side of the world (2).

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We have seen various forms of mathematical representations
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▶ Propositional logic: only ∧, ∨, ¬, etc.
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We have seen various forms of mathematical representations (with semantics and syntax), of increasing complexity:

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▶ Controlled situations with relations: properties are not enough to describe what people do to each other, how they are related, how they relate to objects etc.

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- ▶ Trees of partially controlled situation sequences: when dealing with the future, we need to represent different and incompatible possibilities. New symbol: possible_i.

What did we learn about the mathematics?

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For each of these notions, we learned how to do the
evaluation of mathematical notions such as validity and
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After the modelling task is done, we can calculate what is
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Modelling decisions.

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▶ Choice of the values: which of the basic statements of our language are true, false, and of which do we not know their value (**?**)?

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Each of these modelling decisions needs an argument, and these arguments (as they involve the real world) are defeasible.

So, how far did we get? (1)

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So, how far did we get? (1)

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Are we now able to represent everything in the real world?

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Are we now able to represent everything in the real world?

Unfortunately, **no**. The real world is too complicated to allow us to learn modelling techniques for it in seven weeks.

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Things that we still don't know how to do:

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- ▶ **Knowledge.**
- ▶ **Belief.**
- ▶ **Actions.**
- ▶ **Moral and legal obligations.**

So, how far did we get? (2)

- **Knowledge.**
- **Belief.**
- **Actions.**
- **Moral and legal obligations.**

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So, how far did we get? (2)

- ▶ **Knowledge.**
- ▶ **Belief.**
- ▶ **Actions.**
- ▶ **Moral and legal obligations.**

Knowledge. We have modelled "knowledge of the modeller" and "knowledge of the investigator".

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So, how far did we get? (2)

- **Knowledge.**
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- **Actions.**
- **Moral and legal obligations.**

Knowledge. We have modelled "knowledge of the modeller" and "knowledge of the investigator".

- "Knowledge of the modeller" is implicit in our general methodology: if we do not know the value of something, we cannot write it down.

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- ▶ "Knowledge of the investigator" is part of our temporal framework: the stages we are modelling are the stages of information change for the investigators.

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What we do not model is knowledge of the individuals. Sometimes, it matters whether a knew at time t that something had happened or not. Depending on whether a knows it, his or her actions might be affected.

So, how far did we get? (3)

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- ▶ **Knowledge.**
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So, how far did we get? (3)

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- ▶ Knowledge.
- ▶ Belief.
- ▶ Actions.
- ▶ Moral and legal obligations.

Belief. Beliefs are not represented at all in our models. One might argue that beliefs shouldn't matter in a forensic investigation, as we should only represent facts. But again, beliefs can matter for the assessment of why people did something.

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So, how far did we get? (3)

- ▶ Knowledge.
- ▶ Belief.
- ▶ Actions.
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Belief. Beliefs are not represented at all in our models. One might argue that beliefs shouldn't matter in a forensic investigation, as we should only represent facts. But again, beliefs can matter for the assessment of why people did something.

Actions. We have some means of describing actions as properties or relations, and the causal relevance of these actions in the form of rules. But we have no general account of how actions work, and will have to resort to *ad hoc* modelling. Since actions and their causal effect plays a fundamental role in crimes, this is still missing.

So, how far did we get? (4)

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- ▶ **Knowledge.**
- ▶ **Belief.**
- ▶ **Actions.**
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So, how far did we get? (4)

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▶ **Knowledge.**
▶ **Belief.**
▶ **Actions.**
▶ **Moral and legal obligations.**

Moral and legal obligations. Some of the argumentation schemes allowed us to argue that a certain action should be done. Our mathematical models cannot talk about this so far.

So, how far did we get? (5)

▶ **Knowledge.**
▶ **Belief.**
▶ **Actions.**
▶ **Moral and legal obligations.**

So, how far did we get? (5)

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- **Knowledge.**
- **Belief.**
- **Actions.**
- **Moral and legal obligations.**

So, why didn't we cover this?

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So, how far did we get? (5)

- **Knowledge.**
- **Belief.**
- **Actions.**
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So, why didn't we cover this?

Because the mathematics gets more and more involved.

So, how far did we get? (5)

▶ **Knowledge.**
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So, why didn't we cover this?

Because the mathematics gets more and more involved.

You have seen how long the modelling of a single, very simple case with just two or three individuals and one event takes. Doing a proper analysis of a full case will take weeks of designing the appropriate language and model and going through all the arguments for and against.

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You have seen how long the modelling of a single, very simple case with just two or three individuals and one event takes. Doing a proper analysis of a full case will take weeks of designing the appropriate language and model and going through all the arguments for and against.

This is a worthwhile advanced project for people who are interested in this.

Example: Knowledge

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Example: Knowledge

Just to give the flavour of this:

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Example: Knowledge

Just to give the flavour of this:

How would we model ignorance of an agent?

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Formal Modelling
for Forensic
Science
Lecture 12

Prof. Dr. Benedikt
Löwe

Example: Knowledge

Just to give the flavour of this:

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This represents "knowledge" and "ignorance".

Questions & Answers.