

Logics for Data and Knowledge Representation

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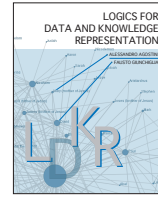
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The order of the names is alphabetical.



Outline



- The World
- Models
- Modeling
 - Abstraction
 - Representation
- The Problem of "Semantic Gap"

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The World

- The "world" is always the first component to take into account in modeling.
- Some basic questions on the world are: what is it?
Do we see the same world? Is it unique?
- Only the question in red (**semantics**) has interest for us in this course.

World

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The World (Definition)

- Definition. A **world** is the (unique) place (real-world, ideal-world, etc.) from where the modeler picks the problem to be represented (and solved).

World

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Models

- The "model" is always the second component to take into account in modeling.
- Several authors defined this concept, often with a very different meaning, e.g.
 - **Mental models** by Johnson-Laird
 - **Truth-tables** by L. Wittgenstein.

Model

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Model (Definition)

- Definition (*Webster*). A **model** is one of the following:
 - A representation to show the construction or serve as a copy of something.
 - A representative, typical form or pattern.

Model

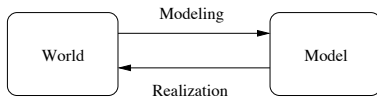
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World vs Model

- Our view of the relation between the world and the particular model is:



- Note: We shall use the term “model” also in the technical sense of a *formal semantics*.

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Modeling

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Modeling + Realization (IT view)

- **Modeling**: a (computer-tractable) transformation of a suitable abstraction of the **World** into a representation, the **Model**.
- Our “slogan”: modeling is generation of a model by abstraction and representation.
- **Realization**: the inverse-function of modeling, i.e., a function from the model to the world.

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Realization (Remark)

The **realization** of a **model M** may get to a **world** which is different from the world the model M is for!


See the next slide (example)

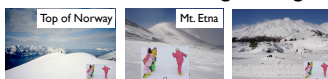
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Modeling + Realization (Example)

- **Modeling**: Suppose the world is 
- **Abstraction**: the girls
- **Representation**: Valentina, Benedetta, ...
- **Realization**: suppose the model is (*). Then:
- **the world** is one of the following, among others:

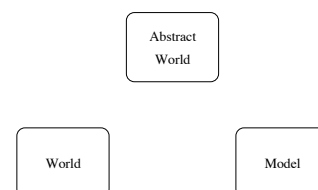


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Modeling Components



Modeling = Abstraction + Representation.

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Abstraction

- Modeling is first of all an activity of abstraction, i.e., building a **conceptual model**.
- A model “as abstraction” will contain only the **significant data** and **knowledge** of the world necessary for the modeling situation.
- In fact, these data and knowledge (i.e. the abstraction) **define the problem!**

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Abstraction

conceptual model:
data + knowledge

Modeling = **Abstraction** + Representation.

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Example

- Take the Monkey-Bananas problem.
- Some **significant data** are: the monkey, the bananas, the box, positions A, B...
- Significant knowledge** is: Low, High, Go, ClimbOn...
- All other data and knowledge **are irrelevant!**

*“There is a **monkey** in a laboratory with some **bananas** hanging out of reach from the ceiling. A **box** is available that will enable the monkey to reach the bananas if he **climbs on** it. Initially, the monkey is at **A**, the bananas at **B**, and the box at **C**. The monkey and box have height **Low**, but if the monkey climbs onto the box he will have height **High**, the same as the bananas. [...]”*

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Generalization

- The picture may be used as a model of **any** winter resort, **any** fun day on the snow, **any** small group of playing girls, and so on.
- An abstraction (e.g. the three girls) results in a **generalization** too, because an abstract (or partial) description is equivalent to the class of concrete descriptions consistent with it.

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Generalization (Example)

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Abstraction (Summary)

- Modeling is a process involving two actions by the modeler (“designer”):
 - Selection of **essential data** and **knowledge** from the world (**Abstract World**).
 - Combination of data and knowledge into a well-defined problem (**Question**).

Principle of Modeling as Abstraction

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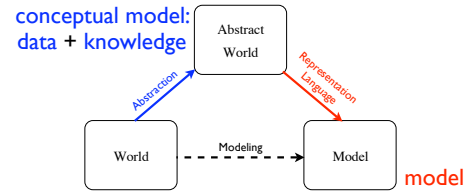


Representation

- In addition to provide the abstraction, modeling is an activity of **representation**.
- The most important component of modeling as representation is **language**.
 - From language the step to move toward logic is short, as we will see.
- Representation is building a **formal model**.



Representation



Modeling = **Abstraction** + **Representation**.



Representation (Summary)

- Modeling is a process involving two actions by the modeler (“designer”):
 - Selection of the **representation language** to express the essential features (i.e. data and knowledge) selected by abstraction.
 - Definition of a (informal vs formal) **semantics** for such language.

Principle of Modeling as Representation



Modeling and Problem Solving

- A problem may change simply by changing the (level of) abstraction in modeling.
- A question we pose on a situation, i.e., the problem we aim to solve, is simply a way to perform an abstraction.
- Let us analyse our main reasoning problems (“**reasoning service**”) in the light of our notions of abstraction and representation.



Modeling and Problem Solving

- **Model Checking (EVAL)**: Is a sentence ψ true according to a model M ?
- **Validity**: Is a sentence ψ true according to every possible model M ?
- **abstraction** is the choice of ψ and M , and the **decision question** (different for each reasoning service) relating ψ and M ; **representation** involves ψ 's “form.”



Modeling and Problem Solving

- **Satisfiability (SAT)**: Is KB satisfiable?
 - **abstraction** is the choice of the sentences which define the knowledge base KB, and the **decision question** on KB; **representation** involves KB's “form.”
- **Consistency**: Is ψ consistent in KB?
 - similar to SAT (ψ and a different question)



Modeling and Problem Solving

- **Entailment:** Is ψ true in a model M if the world represented in KB is true in M?
- **abstraction** is the choice of the sentences which define the knowledge base KB, the choice of ψ , and the decision question relating ψ , KB and M;
representation involves ψ and KB's "form."

The Problem of "Semantic Gap"

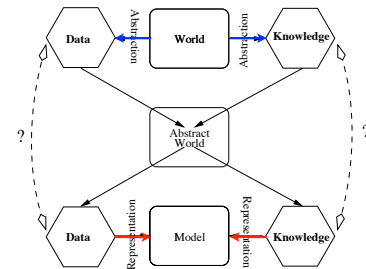


The "Semantic Gap"

- One striking aspect of modeling is the dual feature of abstracting + representing.
- A **problem arises** in the use of any language to convey a precise and unique meaning.
- The problem is caused by a "duplication" of **data** and **knowledge** abstracted from the world and their representation in a model.
- We call such a problem the "semantic gap."



The "Semantic Gap"



Examples

- **Natural Language:** take the world "Java."
What piece of the world does it represent?
- **Diagrams:** take the pictures on the right.
What does each picture represent?
- **Logic:** take the expression "white(snow)." Is it true?

?



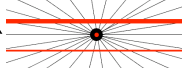
Examples

- **Natural Language:** take the world "Java."
What piece of the world does it represent?
→ Java Island?
→ the programming language?
- **Diagrams:** take the pictures on the right.
What does each picture represent?
→ your best friend?
→ ...
- **Logic:** take the expression "white(snow)." Is it true?



Examples

- **Natural Language:** take the world "Java." What piece of the world does it represent?
- **Diagrams:** take the pictures on the right. What does each picture represent?
- **Logic:** take the expression "white(snow)." Is it true?

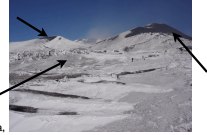


Copyright © 2009-11 Alessandro Agostini and Fausto Giunchiglia bowed or straight?



Examples

- **Natural Language:** take the world "Java." What piece of the world does it represent?
- **Diagrams:** take the pictures on the right. What does each picture represent?
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