World Models

extensional representation

Sept 28,2023

Models and assertional theories - limitations

Assertional theories and models have three main limitations:

- We are considering only the facts of the model in focus. What about the facts which can occur in the other possible models, describing possibly very different, situations?
- The language consists only of the set of assertions which describe the facts of the model in focus. What about the assertions describing facts in the other models?
- As a consequence, a new and different interpretation function must defined for any new assertional theory and model

Domains and models

Definition (Domain (of interpretation)). A Domain (of interpretation) is a set of facts {f}.

$$D = \{f\}$$

Definition (Model). Given a domain D, a model M is a subset of D.

$$M = \{f\} \subseteq D$$

Observation (Domain, model). A domain is the set of all facts that we are willing to consider. A model is just the subset of fact that we define as depicting what is the case in the current situation.

Models and assertional theories - limitations

Observation (Domain) While a model is the set of facts which are the case in a certain situation, a domain consists of the set of facts which are potentially the case for all possible situations. A Domain defines all and only what can be potentially perceived.

Observation (Mutually inconsistent facts in a domain) A domain, differently from a model, can contain facts which are mutually inconsistent. Given a domain, there are many potential models, some of which are potentially mutually inconsistent.

Note. Domains must allow for the possible instantiation of distinct mutually inconsistent models, as it is normally the case in the world.

Assertional languages and theories

Definition (Assertional language). An assertional language LA is a set of assertions $\{a\}$

$$\mathrm{L}A = \{a\}$$

Definition (Assertional theory). Given an assertional language LA, an assertional theory TA is a subset of LA.

$$\mathrm{TA} = \{a\} \subseteq \mathrm{L}A$$

Observation (Assertional language) While an assertional theory is the set of assertions which describes what is the case in a certain model, an assertional language consists of the set of assertions which describe all the facts that can potentially occur (i.e., the domain of interpretation).

Assertional languages – completeness and correctness

Observation (Completeness and correctness of an assertional language LA with respect to a domain D).

An assertional language is not necessarily complete, that is, it does not necessarily contain assertions for all the facts in a domain (which, among other things, are in principle infinite). The key feature is that is should contain all the assertions deemed relevant.

Vice versa an assertional language is requested to be correct, that is to contain only assertions which denote facts in the reference domain. This in order to avoid nonsensical assertions.

Assertional languages – Examples

1. Relational databases (DBs) describe facts about the world. The language used to describe the contents of a relational DB are tables;

2. Entity-relationship (ER) models describe general facts about the contents of databases. The are written using the ER diagram language, a specific labelled graph language

3. Languages which allow only for assertions in natural language of the form

   "<subject> <verb> <object>"

   describe facts about the world.

Types of assertional languages

Relational databases (DBs) describe *data* about the world.

IsProof(Fausto,Marco)

Entity-relationship (ER) models describe *knowledge* about the world.

IsProfOf(Professor,Student)

Languages with assertions of the "<subject> <verb> <object>" can describe both data and knowledge about the world

IsProof(Fausto,Marco)
IsProfOf(Professor,Student)

Interpretation function

Definition (Interpretation function) Let LA be a language of assertions and D a domain. Then an Interpretation Function IA is defined as

$$\mathrm{I}A : \mathrm{L}A \rightarrow \mathrm{D}\ (\mathrm{I}A \subseteq \mathrm{L}A \times \mathrm{D})$$

We say that a fact f ∈ M is the interpretation of $a \in \mathrm{I}A$, and write

$$\mathrm{f} = \mathrm{I}A(a) = a^{\mathrm{I}}$$

to mean that a is a linguistic description of f.

We say that f is *the interpretation* of a, or, equivalently, that a *denotes* f.

Interpretation functions - observations

Observation (Interpretation function, non-ambiguity and synonymity) Interpretation functions, being functions, are not ambiguous thus not allowing for polysemous assertions and words, while allowing for synonymity.

Observation (Interpretation function, totality) Interpretation functions are total. This guarantees that any element of the language has an interpretation.

Observation (Interpretation function, non-surjectivity) Interpretation functions are not necessarily surjective. In other words, if $I_A : L_A \rightarrow D$, L_A may not be able to name all the facts in D. This property is useful with infinite domains or when one is not interested in mentioning all the known facts.

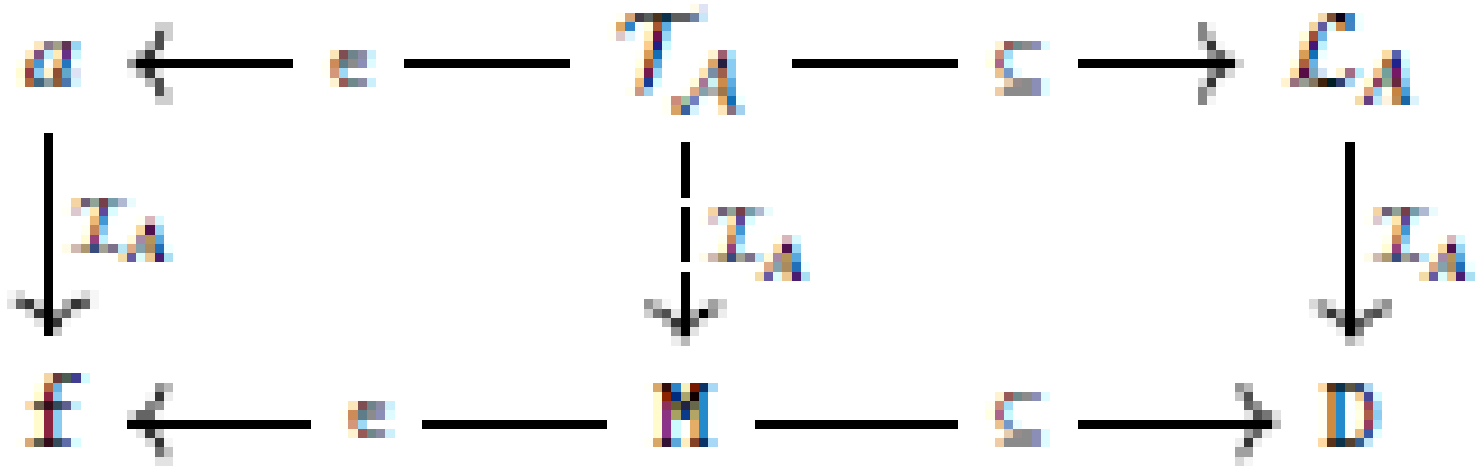
World Model

$$\hat{\mathcal{W}} = (\mathcal{L}_A, \mathtt{D}, \mathcal{I}_A)$$

A *world model* defines all and only what can be said about the world.

World models are spaces of possible representations, i.e., theories, designed to minimize the possibility of different mental representations of the same theory and corresponding model depicting the world.

World models - The roles of D, L, IA, M, TA



World Model - observations

Observation (World model) The components of a world model, i.e., D, LA, IA, define the general elements and corresponding rules which must be followed when building a representation.

They are defined a priori, usually by experts in modeling and knowledge representation as general tools to be used by practitioners.

They provide the general modeling infrastructure which allows to represent real world problems. They also provide a uniform framework under which any two representations can be compared and possibly even merged.

Software practitioners usually study these models during some CS or AI classes and they use them as is when developing systems.

World models, models and theories

World models provide the general framework within which assertional theories and models can be defined and compared. Given a world model

$$W = \langle L_A, D, I_A \rangle$$

we have

$$M = \{f\} \subseteq D$$

$$TA = \{a\} \subseteq L_A$$

World models, models and theories – The practice

1. Select the world model (crucial representation choice)

$$W = \langle L_A, D, I_A \rangle$$

2. Agree on L_A, I_A (… and therefore D)

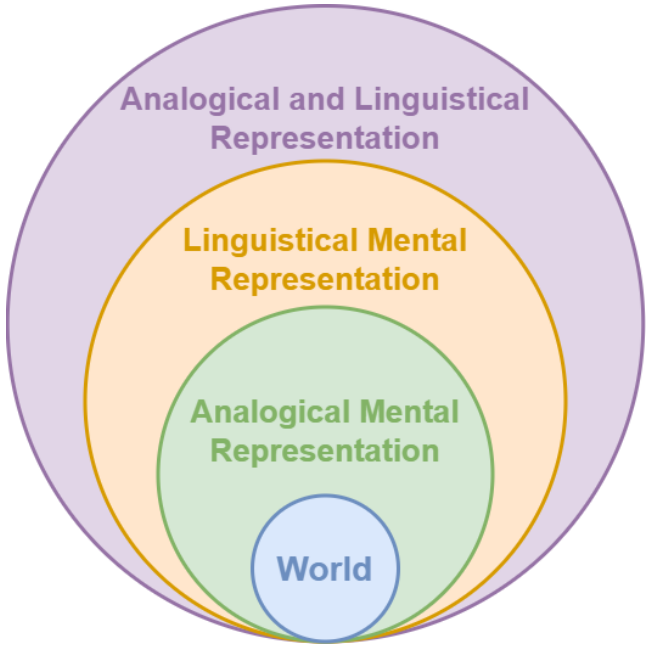
3. Construct $TA = \{a\} \subseteq L_A$

4. The model $M = \{f\} \subseteq D$ is automatically defined

NOTE: Agreement is only on linguistic representation, based on a shared understanding of what language means

NOTE 2: agreement at different levels of formality depending on application

Worlod model: an Analogical *and* linguistical representation



Language and model fully aligned with thelanguage to describe the model completely and unambiguously

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