Which Role for an Ontology of Uncertainty?

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Introduction

Nature of Information

Information is hardly ever perfect or certain.

Especially if it belongs to unsupervised environments.

Typical example *weather forecasting*:

- information defined using different models (Fuzzy Concepts (e.g. partially cloudy), Probabilities (e.g. 90% rain));
- information may disagree (one service predicting *rain* with 90% of confidence while another predicting *snow*).

Introduction

Dealing with uncertainty

Several models have been developed in order to effectively handle uncertainty.

Each one of these model is successfully applied only in small-scales scenarios, where the semantics of uncertain information is known *a-priori*.

Grades of truth vs. Uncertainty

Uncertainty falls at meta-level respect to truth. A statement can be associated to a level of truth (Crisp, Fuzzy, Gradual) *AND* to a particular semantics of uncertainty.
Uncertainty can be classified by its:

- **Nature:** epstemic or aleatory;
- **Source:** objetive or subjective;
- **Temporal meaning:** contingent or generic;
- **Type:** ambiguous, inconsistent, vague, incomplete or empiric.

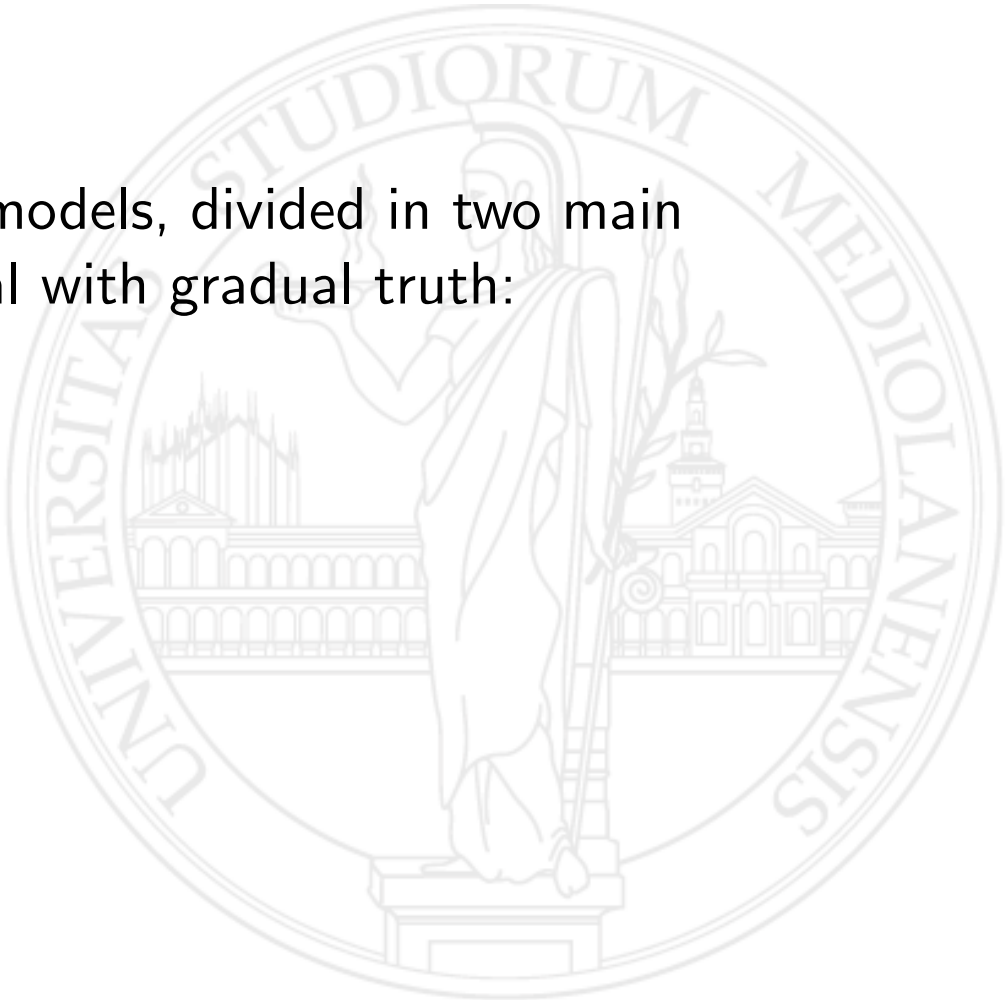
Models

We recognize four main formal models, divided in two main categories, which are able to deal with gradual truth:

- **Two-Valued Logics**
- **Many-Valued Logics**

and uncertainty:

- **Probabilistic Logics**
- **Belief Theory**

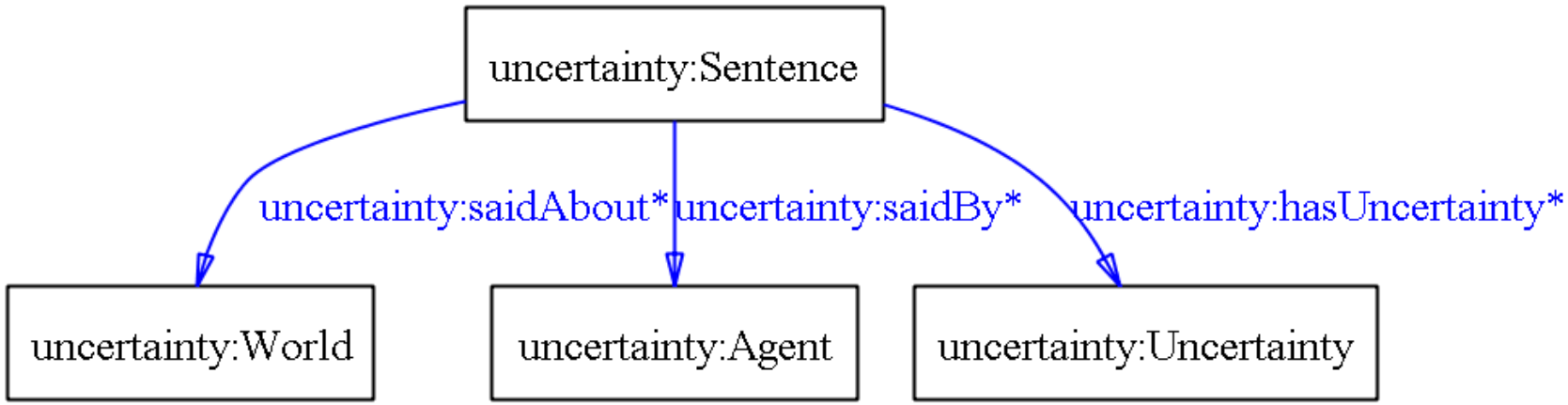


The compositional problem

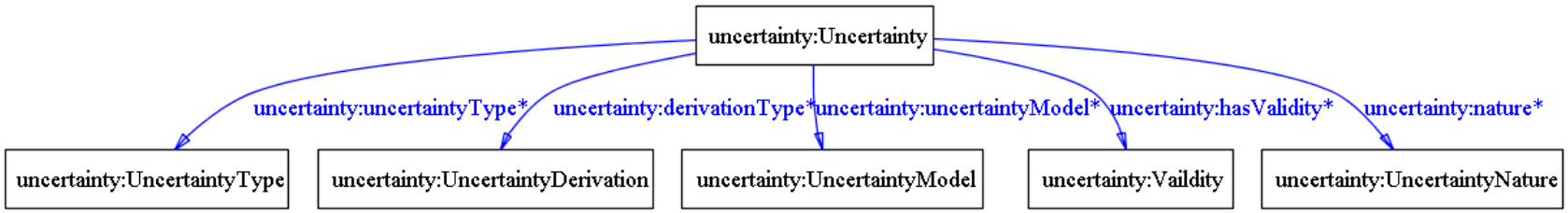
Depending on the features of information analysed one model is more suitable than another.
The need of a unified framework to deal with gradual truth values and levels of uncertainty is arising.
But the two main categories of models used to represent these situations are not fully compositional without imposing some constraints.

The Ontology of Uncertainty

Real world situations, like the *weather forecasting* scenario, need a framework able to deal with different semantics of unceratinty. The W3C Uncertainty Reasoning for the World Wide Web Incubator Group (URW3-XG) has defined an Ontology of Uncertainty as a generic meta-model to represent the semantics of uncertainty in different situations.



The Ontology of Uncertainty annotates each `Sentence` with the respective `Uncertainty`.



Semantics-aware Matching Generation Strategy

Matching Ontology

Each matching operator creates a set of matching relations that are stored in a ontology. The ontology keeps trace of the matching relation and the operator that generated it.

Ontology of Uncertainty

We exploit URW3-XG's Ontology of Uncertainty to explicitly assign uncertainty semantics to each matching relation created by the matching operators.

Reasoning

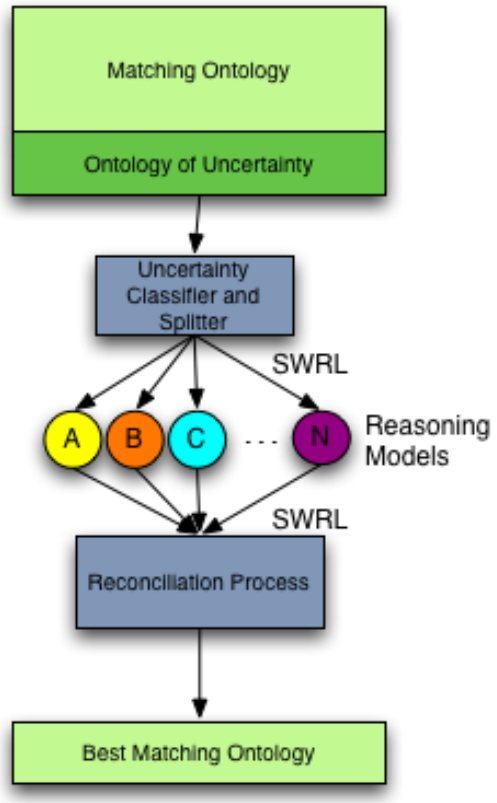
The knowledge base created this way is divided according to the uncertainty type and processed separately by the specific reasoner for that uncertainty type (Fuzzy, Possibility theory, Probability theory). The results of the single reasoning processes are recombined and they represent the final set of matching relations.

Mapping Ontology

Driving the Reasoning process

The inference process is based on three-steps:

1. a set of SWRL rules is used to annotate each sentence with the respective uncertainty;
2. the set of sentences is divided according to the uncertainty model and processed by the respective reasoners;
3. a final set of SWRL rules is used to reconcile the results of the various reasoning processes.



Lucky case

Independent Reasoning

Our semantics aware strategy is a *lucky use case* of the use of Ontology of Uncertainty. The successful application of this approach is due to the fact that we consider all the reasoning processes as independent.

So the processes do not depend on the results of other inference processes.

Conclusions and Open Issues

Ontology of Uncertainty does not specify for each semantics of uncertainty a reasoning strategy nor a particular reasoner to use.
We claim that additional work on the Ontology of Uncertainty is necessary in order to allow effective selection of hybrid reasoning strategies under different categories of uncertainty.
The Ontology of Uncertainty has to provide further information about how the various reasoning processes encode and exchange information.