Temporal ontology for representation and reasoning about uncertain historical time periods.

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Applications in the area of historical monuments protection, like record keeping of historical artefacts, require specific data handling in specialized information systems. The most popular solution is to use the database technology as the information system core. This approach allows fulfilling all specific needs ranging from detailed object descriptions, fast search facilities, reliable data storage to safe data access and processing. Advanced systems may include features like secure data communication, and data sharing between monument locations and a supervisory organization, management of artefact transfers, inventory checking etc.

Current needs of our knowledge society require perceiving the data from a broader perspective. It is necessary to answer queries requesting data that are often based on partially incomplete, uncertain or even vague information. Moreover, some of the requests can include "background" information, which is in the traditional relational information systems not directly apparent, therefore they usually lead to incomplete, inadequate or wrong system responses. To overcome some of these drawbacks, knowledge modelling approaches are suggested that enable to describe and structure data in such a way, that semantic and contextual relationships can be used while retrieving the desired information and knowledge. In particular, the ontology modelling offers mature object-oriented knowledge structures suitable for this case.

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Temporal ontology for representing uncertainly specified time periods is presented. Mature approaches like Allen interval relations are combined with introduction of time granularity concept and a concept of time uncertainty. The ontology is applicable both as a static data representation and for logical data inference. Logical conclusions can be derived using an automated inference system. Uncertainty parameterization was developed for handling the domain specific uncertainty characteristics. Temporal statements containing the most frequent expressions in the domain of cultural heritage preservation are identified and categorized with respect to their accuracy. A temporal inference system is implemented using OCML language. Consistency checks can find non-causal data clusters and lead to improving current event data. Final remarks discuss possible W3C OWL 2 language and suitable reasoner utilization.

1 - Uncertainty in Historical Time

In the resources available in the domain of culture, we can find various kinds of data specifying time periods. Many "statements" of this kind contain imprecise, uncertain, or vague data. Possible forms of expressing time specifications were analysed and resulting seven basic statement categories are formulated.

2 – Framework for Representing Uncertainty in Time

The presented theoretical framework for representing uncertainty in time specifications includes proven approaches to modelling time instants and intervals and their relationships, as e.g. Allen interval relations, and it was enriched by a new way of expressing time granularity and a new concept of time uncertainty.

In the language Operational Conceptual Modelling Language (OCML) for conceptual modelling utilizing ontology design, an inference system capable to handle uncertain time specifications was created, which uses the designed theoretical framework. The resulting ontology in OCML, based on the theoretical framework for reasoning in the time domain, is a general-purpose temporal reasoning inference engine with possible exploitation in many domains.

3 – Temporal Ontology Challenges

Current approaches and challenges for further development of temporal ontology representation include:

- Support for a large range of calendars can be included in the inference system by including the corresponding date transformation rules.
- There are ideas worth further development like functionally variable relative uncertainty types for the statements like *About*, which can be different in the recent history and bigger for much earlier times.
- Recurring temporal entities might be represented by *non-convex time intervals* possibly containing "holes". Such entities would require additional modelling effort e.g. with respect to their duration.
- Web ontology language (OWL2)
- Combining relational database extension and the ontology-based inference
- OWL2QL and OWL2RL profiles
- Linked Data

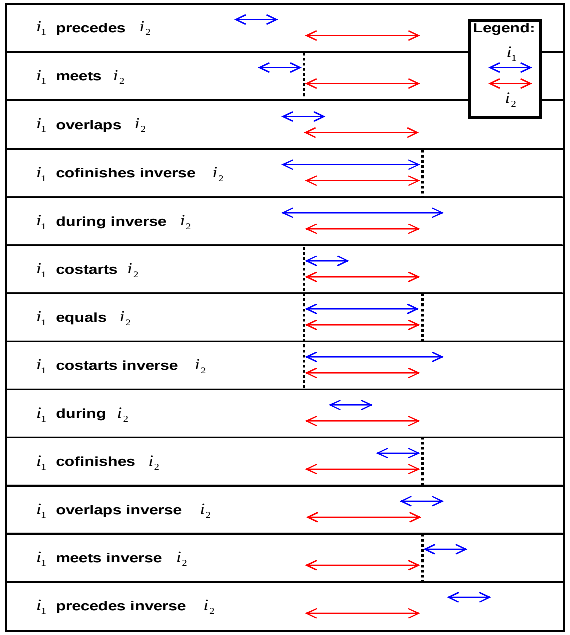

Fig. 1 Allen relationships

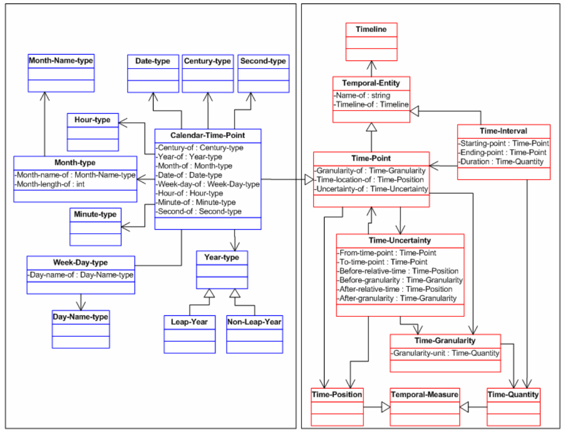

Fig. 2. Temporal ontology classes.