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# MANAGING UNCERTAINTY IN ONTOLOGY MAPPING IN E-LEARNING CONTEXT

## *Digest of paper*[1]

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**Abstract:** Many of the mapping methods propose mappings, leading to inconsistency of resulting ontological network. Such mappings are unusable in reasoning-based applications. And most of automatically proposed mappings are uncertain in some sense. In this paper we make a short analysis of the approaches for modelling ontology uncertainty and the ways for detecting inconsistent mappings. We discuss some mapping, mapping evaluation and refinement strategies, well working in e-learning.
**Key words:** e-learning; ontology alignment; ontology mapping uncertainty; reasoning with alignments.

## 1. INTRODUCTION

Applications often need to use multiple ontologies, modeling knowledge in related domains or from different views on one and the same domain. In e-learning for example, to describe semantically one and the same course, pedagogical knowledge modeling ontology, psychological knowledge modeling ontology, domain ontologies, having different logical complexity and granularity, e-learning standards ontology are needed. And to compare two courses, it is important to know the relationships (mappings) between related concepts, relations, or instances in the ontologies, describing them. So, it is necessary to map corresponding ontologies.

Ontology Matching is a process of creation of alignments (or mappings) between concepts, properties, relations or instances of two ontologies. When aligning two ontologies, problems arises are related to the correctness/completeness of

[1] The full paper is proposed for including in the IEEE Xplore Digital Library

mappings between them and the consistency of the integrated ontology network. Matching systems in many cases generate incorrect or logically contradictory (incoherent) mappings. According to OAEI, for example up to 50% of all generated correspondences have to be removed until a coherent subset can be found.

Reasoning-sensitive applications need consistent alignments and can work well only when the used ontology network is consistent. Checking and improving mapping quality is usually domain and tack-dependent. The aim of this paper is to survey approaches for checking logical correctness of mappings, analyze research and achieved results related to ontology alignment correctness and discuss ways of its application in mapping ontologies in e-learning. We will show important specifics of mapping improvement in e-learning domain.

## 2. MODELING ONTOLOGY MAPPING UNCERTAINTY

Semantic modeling of the knowledge can have high level of uncertainty. Uncertainty can have different origins (from unclear context to the natural language ambiguities and incomplete models). Ontologies produce uncertainty when natural language labels are used, when incomplete definitions of the concepts are used, or when mapped ontologies are used, as a result of automated ontology mapping. The most popular ontological approaches dealing with uncertainty are classified in [1] as Fuzzy approaches, Probabilistic approaches and Dempster-Shafer approaches. As alignments consist of rules used in the same way as ontological axioms in onto-logy networks, uncertainty of mappings can be modeled as uncertainty in ontologies.

Probability theory is the most frequently-used mathematical theory dealing with uncertainty. It provides a formal calculus and mathematically sound representation language for dealing with beliefs. BayesOWL [2] is the OWL variant to model uncertainty in ontologies through Bayesian networks (BN). Dempster–Shafer theory [3] of evidence is the generalization of Bayesian probabilistic theory by usage of belief, belief functions and plausibility. Dempster's belief in a hypothesis is calculated as the sum of the masses of all sets. This theory allows combining evidence from different sources. Other Probabilistic models use Markov logic (ML) [4]. ML combines Markov networks with first-order logic by attaching weights to first-order axioms. Example of models, that combine probability theory and distributed description logics are DISPONTE (DIstribution Semantics for Probabilistic ONTologiEs) and Log-linear description logics (LLDL) [5]. BUNDLE and TRILL are good-working reasoners, computing the probability during inference [6].

## 3. APPROACHES FOR DEALING WITH ERRORS IN ALIGNMENTS

There are three main approaches for finding alignment problems:

- Ontology mapping evaluation;
- Debugging ontology mappings alignment debugging;
- Reasoning with ontology mappings.

Ontology mapping evaluation is the process of estimating results of ontology mapping algorithms. Ontology mapping evaluation can be based on reference mappings, on reasoning or combined approaches can be used. Reference mappings can be previously specified as gold standard or dynamically entered during human interaction. Ontology Design Patterns (ODPs) also can be used in ontology mapping evaluation. Successful evaluation does not guarantee consistency and coherence.

Reasoning with mappings helps in logical problem detection. Only a few systems participating in the OAEI competition implement reasoning and repair techniques. KOSIMap framework [7] for example uses description logic reasoning to extract implicit information as background knowledge for every entity, and to remove inappropriate mappings from an alignment. Alcomo implements two reasoning approaches with mappings [8]: a pattern-based reasoning and classical black-box approaches. DL reasoners can detect unsatisfiable concepts, but determining what mapping exactly causes it can be more difficult. The problem worsens significantly when the number and complexity of axioms of the ontology grows During debugging important suggestions to users (experts, knowledge engineers) about mapping problems can be proposed. These suggestions can be useful for supporting experts final decision about mappings or help researchers to improve mapping algorithms.

## 4. DISCUSSION AND CONCLUSION

E-learning is a complex domain, integrating sub domains as pedagogy, psychology, e-learning standards, web and cloud terminology, as well as the domain of the learning content. Every learning resource can be described, using one or more ontologies, covering some of these domains. And comparison or usage of several such resources require mapping of its describing ontologies. We will discuss some important mapping and mapping evaluation strategies. In our view, basic mapping strategy is to map ontologies, describing the same sub domain. Different mapping and evaluation strategies should be used in different sub domains of e-learning.

The resources in E-learning systems meet strict standards such as IEEE LOM, IMS Learning Resource, and IMS CP. Scientific projects for ontology-based representation of learning metadata, used in some standards have been developed. As all the standards are clearly described, mappings of ontologies, describing different e-learning standards also should be presented by standards developers. Mapping evaluation problems should be solved by e-learning experts manually or using specialized tools, as reasoners or debuggers. Pedagogical ontologies also should be mapped carefully and mappings should be evaluated by teachers or resource development experts. There are several well-known learner profile ontologies and standardized mappings between them should be stored in mapping libraries and used when needed. If other learner description terminology is used, interactive evaluation of mappings by experts is recommended.

The most interesting is the evaluation of learning domain ontologies. These ontologies can differ significantly in his granularity, size, logical complexity and used natural language terminology. Mappings between taxonomies uses mainly equivalence or subsumption relations, while mapping between specific domain ontologies, describing details of e-learning content may use more complex relations.

Reasoning, specific for the learning domain, debugging and ODPs can be used to evaluate logically-complex mappings. Annotation of mappings with probability values and recalculate these values during reasoning is useful strategy and involvement of learners in the evaluation process is useful for understanding learning content. Every mapping axiom in ontological network with a probability and assume that each alignment is proposed independently of the others. All the axioms in ontologies can be annotated with a probability equal to 1, and mappings are annotated with a probability between 0 and 1 depending of a degree of belief in the mapping. We recommend reasoners which generate explanations (Pellet), graph-based reasoners [9] and probabilistic reasoners [10] as TRILL which implements a tableau algorithm in Prolog to find the set of all the explanations and compute probabilities.

Our short analysis of ontology mapping management in e-learning context shows that it is not easy to ensure correct and consistent mappings. Intelligent systems in e-learning need automated ontology mapping and evaluation of mapping correctness. To ensure needed quality mappings, applications should integrate modules for specialized ontology mapping, debugging, reasoning, easy to use graphical interfaces to involve teachers, learners and experts in the evaluation of proposed mappings. Involving learners in validation of the mapping suggestions generated by the ontology alignment systems, recommendations for alignment strategies, as well as in use of validation decisions can be useful both for mapping and learning quality. Libraries to store correct mappings are also important part of such systems.

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