Ontology Mapping Tools, Methods and Approaches – Analytical Survey

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Abstract. In this paper we present the results of browsing, analyzing and comparing many ontology mapping tools, approaches and methods. We extract and classify valuable parameters for strict and unambiguous tool or method description. Every mapping tool, algorithm or approach must have such a description, practically usable for both human and software agents and sufficient for easy checking if it suitable or not for a given task. We will use our classifications for developing ontology, conceptualizing all valuable metadata for semantic machine-processable mapping tools description.

Keywords: ontology mapping tools, ontology mapping approaches, ontology alignment evaluation, ontology alignment

1 Introduction

Almost any application that uses multiple ontologies must establish semantic mappings among them. Mapping is also needed to ensure interoperability among different applications in many domains, including e-commerce, knowledge management, e-learning, information extraction, bioinformatics, (semantic) web services, multiagent systems etc. A grand number of ontology mapping methods and tools have been developed so far, including early mapping investigations [1], [2], [3], or modern ones, such as [4] and [5]. As each one of these tools is appropriate for some tacks or domains and give poor results (or may not work at all) for others, to choose the right mapping tool one have to explore thousands of pages, containing tool descriptions and test in his own risk some of tools. The aim of this paper is to analyze and classify ontology mapping tools and methods and extract its valuable properties, needed for strict and unambiguous machine-processable description, usable in automatic tool selection or for making dynamic goal – directed recommendations.

2 Research Methodology

We use many sources of information about mapping tools and methods: mapping projects Web sites, scientific papers from digital libraries, scientist opinions (from blogs, forums and other web 2.0 applications), Ontology Alignment Evaluation Initiative (OAEI) materials [5], tool's documentation. We obtain these resources using keyword based web search (google, yahoo, bing), folowing citations in scientific papers or surveys, browsing project sites or downloading tools extracting and reading tools documentation. We browse, analyze and make a brief comparision of at about 90 ontology mapping tools. Our aim is to extract basic classification dimensions, make structured classification of terminology, used in ontology mapping domain and collect metadata for semantic description of ontology mapping tools, methods, approaches.

3 Ontology Alignment Tool Characteristics

There are many independent dimensions along which approaches, algorithms or tools can be examined, classified or selected. After analyzing several surveys [1], [2], [3], 4], tool documentations and many other represented in the last few years related to mapping papers we propose the following main dimensions for comprehensive description and classification of ontology matching tools (table 1):

Tool dimension	sub dimension	second sub dimensions	S/P
Input	Size	Number of ontologies	Р
	Size	Ontology size	S
	category	Dbschema, ontology, thesaurus	S
	formality level	Informal, Semi-formal, formal	Р
	Input natural languages	One language, multilanguage	Р
	Input representation language	One, several	Р
	Input ontology type	task, domain, upper, application	
Output	Output type	For software, For human	S
	Matching Cardinality	Global, local	Р
	Execution Completeness	Subjective, injective, partial, full	
Usage		Application domain	Р
	Application type Area	Knowledge management	S
	Application place of usage	Local, network, web	Р
		one	Р
	Application domain Area	Multi domains	S
	User type	Human, software	S
Adaptation ability	Domains, applications	(list) P, or classification (S)	
	Tasks, usage	(list) P, or classification (S)	
Evaluation	benchmark	P	
features	Tested parameters	S	

Table 1. A part of the classification of the important ontology mapping tool characteristics.

The tool's input characteristics: size; The characteristics of the matching process, which describes the matching approaches, methods and algorithms themselves; The output of the tool (output type, matching cardinality, execution completeness[6]); The usage characteristics of the matching tool (different situations where the tool have been used: for various approaches, application areas, etc.; Matching strategy; Matching quality; Tool code characteristics; Tool vendor and support characteristics; Documentation characteristics, and cost characteristics. Some of the upper levels of tool characteristics, related to the used algorithms, as we will discuss them latter. The valuable subdimensions

are listed in, column 2 from the left, and second level subdimensions - in column 3. "P" stands for property, and "S" – for subdimension.

4 Ontology Alignment Approaches Characteristics

We present the simple mapping approaches terminology classification and the methods combination related terminology. We also analyze and classify mapping evaluation terminology, but don't present this classification here because of the restricted space. We classify ontology mapping approaches according to subsequent dimensions (table 2): Automation level, Type of mapped ontology elements, Kind of mapped relations, Mapping cardinality, Used External information source types, Mapping metric types, Mapping aim, Tack-dependency, Domain dependency, mapped Ontology types, used during mapping Relation types, Ontology size, expressiveness, Terminology language, globality, general matching directions, strategies, Mapping discovery base, Mapping representation (output), quality (left column of table 2). The valuable subdimensions are shown in column 1 from the left. Because of the restricted space, in column 2 only little part of terminology, related to every subdimension, is shown, and in the right column some algorithms or tools, classified to corresponding dimensions are listed.

5 Discussion, Conclusions and Future Work

Before selecting the best approach, method or tool for concrete application the comprehensive exploration of grand number of variants is needed. Manual exploration is difficult, time consuming tack and is not suitable for ordinary users as well as not applicable in the cases of automatic Multistrategy or Multiagent mapping in dynamic environment. The exploration of several hundred of textual pages, describing the last research in this area would cost months working of professionals, and all this information is not processable for software agents. So, the clear, short, structured and machine-processable explicit description of valuable characteristics of the ontology mapping tools, algorithms and approaches is needed. The main requirements to this description are: Easy usage by people (domain experts or usual users); Easy readable and processable from software agents and web services; Comprehensive, explicit and clear description of all the characteristics, valuable for choosing in every possible practical situation. Computer programs should make context-aware recommendations to the users in choosing the right tools, or make automatic dynamic choosing of needed mapping services.

Currently, we are working on development of ontology, conceptualizing all listed in the tables dimensions, listed or omitted because of the restricted space subdimensions, it properties and inter relations. The tools, methods and algorithms are individuals in this ontology. Our aim is to develop well structured and comprehensive terminology classification. In this ontology we also will include contextual information about every concept (mapping tool or algorithm describing dimension): synonyms, abbreviations, related words and corresponding relations. Terminology richness and completeness will guarantee successful usage of this conceptualization for tools or methods comparison. Our classification is based to the exploration and analysis of all the ontology mapping

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Ind information X-SOM External information source thesaurus Linguistic, TF/IDF, QGram H-MatchASCOASMOX Information source IR TF/IDF, feature vector PRIOR Iteraring Mashine-learning GLUE OLUE Patterns Hearst pattern based PANKOW user interactive AnchorPrompt Mapping metric fuzzy Fuzzy Conceptual Graphs, global MonorPrompt Mapping aim fuzzy Fuzzy Conceptual Graphs, global MonorPrompt Mapping aim All possible Mapping terminology systems many Mapping aim All possible Mapping terminology systems many Mapping aim All possible Mapping terminology systems many Mapping aim Large [10] Large scale Ontology Matching CTXMATCH Ontology size Global -local Multi-strategy learning MoNIS, OIS Ontology size small Generic Ontology Matching Lily mixed Combination of matchers Anchor-Flood MapPSO <	Approach (dimension)	Approach name	Approach description (synonyms, related terms)	Algorithms /tools
elements Schema – based Quran, grap,-matching, SV MS ASMOV, CIDER Kind of mapped relation syntactic equivalence relation with certain level of plausibility or confidence N-gram, Corpus semantic analyzing how entities are related H-match, Anchor Flood, LIJ, Pool, LIJ, Mapping cardinality One to one Element-level Many One to one Element-level Many Many to many Structural estimation of migromiology Mark RA, SKAT Many to many Structural-level MAFRA, SKAT Information no momation tetreval MAFRA, SKAT Information Intesaurus Linguistic, TFIDF, QGram H-Mach, ASCOASMO Information IR TF/IDF, feature vector PRIOR Information Interast pattern based PANKOW Mapping metric weighted average of measurements ASMOV, MapPSO Mapping aim fuzzy Fuzzy Conceptual Graphs, Jaccard's conflictent GIUE, OMEN, Ombo- Magorthesite theory Mapping aim fuzzy Fuzzy Conceptual Graphs, Jaccard's conflictent GIUE, OMEN, Ombo- Magorthesite theory	mapped ontology	Instance -based (Extensional)	Bayes Classifier, relaxation labeling, Jaccard coefficient	iMapper, SAMBO, ASMOV, OKKAM
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Mapping cardinality One to many Element-level MAFRA, SKAT Many to many structure-level, semantic bridging ontology structural semantics MAFRA structural semantics MAFRA Ino Quik ontology mapping, information Anchoor-fieldo, Prior+, X-SOM Anchoor-fieldo, Prior+, X-SOM Information Itesaurus Linguistic, TF/IDF, QGram H-Math,ASCO,ASMOV Information Itesaurus Linguistic, TF/IDF, QGram H-Math,ASCO,ASMOV Information Itesaurus Linguistic, TF/IDF, QGram H-Math,ASCO,ASMOV Iterative Ontology Domain ontology KitAMO,API Iterative Iterative Anchor-Prompt Iterative Fuzzy Conceptual Graphs, Jaccard's coefficient Monge-Elkan, SLM (algorithms) Mapping metric type fuzzy Fuzzy Conceptual Graphs, Jaccard's coefficient GUEE, OMEN, Onto- Mapper, DSsim Mapping aim All possible Mapping terminology systems many Mapping aim All possible Mapping terminology systems many Mapping aim Minimal [12] Use debugging heuristics MiniSAtch Ontology typ		semantic	equivalence (=); more general (\supset) specification (\subset); mismatch (!);(\cap)	
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quality [9] metrics Precision, recall, efficiency many		metrics		manv

Table 2. A part of the classification of the important ontology mapping algorithm characteristics.

algorithms and tools, tested in OAEI, many surveys and other publications, presenting tools or algorithms. Our ontology will be useful in various tools or algorithms exploration, comparison, recommendation and selection tacks, and will be easily extensible with characteristics of further newly developed ones. Further we will develop recommendation agent that will help in finding the best tool or approach for solving well described mapping problems by comparing the semantic descriptions of tools or methods, stored in our ontology with the application needs.

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