Analysis of Ontology Matching System and their Countermeasures

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Abstract- **A new paradigm in intelligent system research focuses on the enhancement of a new era of intelligent-based obstacle amelioration technique, which can develop the enormous amounts of formally precise information obtainable on the system, to fabricate novel intelligent functionalities such ontology matching. It is envisioned that ontology matching will play a central role in the processing, sharing and reuse of knowledge among web applications. The emerging of ontology matching focuses on bringing knowledge representation capabilities to the web. It is one of the emerging research areas in artificial intelligent community and has high potential for research. This work also elaborates the complicatedness that occurs among matching systems. These issues must be addressed so that ontology matching tool can share and collaboratively to exploit heterogeneous knowledge in a scalable way.**

Keywords: Ontology Matching, Ontology Matching System, DDSim. Semantic Web.

I. INTRODUCTION

With the rapid growth of World Wide Web, it is more complicated to retrieve knowledge oriented information from the web. It has become essential to apply some precious approach so that essential information can be accessed and a satisfactory result is given to the users. Ontology matching is the most promising solution in such circumstances.It is a competent technique to study design of conceptualization, where conceptualization is an apparition of different words, which reveal the objects and their relationship with other entities [42]. The central goal of ontology matching is to afford a knowledge based experience to the information world. To accomplish this ambition it uses some appropriate autonomous tools. It is widely used as a universal medium for information sharing among intelligent agents. Intelligent agent system is vital future of ontology.

The modern generation of internet illustrates that internet is not just an information access system although it provides knowledge oriented information to its users. However this deliberation is extremely complicated. Because of distributed and dynamic nature of web, there arise numerous obstacles to attain and exchange information with their intended meaning. Ontology matching opens novel strip for attaining knowledge from web. It finds correspondences between semantically related entities of ontologies and determines the set of synonym concepts, those concepts which are parallel in meaning but have different names or structures [43]. These correspondences can be used for various tasks, such as ontology amalgamation, question answering, data transformation, etc. Thus, ontology matching has potential abilities to achieve consequent tasks.

This paper has been broadly divided into six sections. Section 2 gives a classification of ontology matching. Section three introduces ontology matching systems. Section 4 presents a comparative summary of ontology matching systems. Fifth section highlights the challenges and section sixth concludes by presenting open research challenges. The upcoming section classifies the ontology matching system.

II. Classification of Ontology Matching

Ontology matching can be accomplished in many types but generally it done into two types, schema matching and structural matching [25]. There are many other ontology matching techniques such as rule-based matching, learning matching, instance based matching and element matching. However in this work, we have elaborated schema based element matching technique.

A. *String Based Technique*: is used to match name and name description of ontologies entities in terms of sequence of alphabets letters [25,26]. It based on finding similar strings, which represents the same concepts. There are many string matching techniques such as:
   - *Substring similarity*: is used to compute the similarity measure of two strings, which is based on their common longest substring [27].
   - *Jaro measure*: finds words with spelling mistake [28].
   - *N-gram*: is an amalgamation of n successive characters that attained from a string [28].
   - *Edit-distance*: is employs to characterize the number of removals, insertions and replacements.
   - *Prefix*: is takes the input of two strings and analysis whether the first string begins with the second one [25].
   - *Suffix*: is takes the input of two strings and analysis whether first string ends with the second one [26].
   - *Cosine similarity*: is used to transfers the input string into vector space, which used by Euclidean cosine rule to determine similarity [29].

B. *Language Based Technique*: uses natural language processing approaches for exploiting morphological properties of the input words such as English. This technique generally applied before string based techniques, to improve the results. These techniques are:

- *Tokenization*: it represents the entities into sequence of token such as punctuation, white space, black charters and escape character [25].
- *Lemmatization*: is morphological analysis method, which used to find basic appearance of subject.

C. *Constraint Based Technique*: is used to match the definition properties and their internal constraints such as data types and cardinality.

D. *Linguistic Resources*: technique is utilized to retrieve common knowledge of domain specific thesauri, which gives words-based linguistic relations among them.

E. *Alignment Reuse Technique*: explore the initiative of reusing alignment of earlier matched ontologies [26].

F. *Upper Level and Domain Specific Formal Ontologies*: is appropriate medium to uses external source for exploiting common knowledge in the form of ontologies. These sources are Suggested Upper Merged Ontology (SUMO), Descriptive Ontology for Linguistic and Cognitive Engineering (DOLCE) [25,26].

G. *Graph Based Technique*: takes the input as labeled graphs and their inter-relationships. It efforts to solve graph homomorphism problem.

H. *Taxonomy Based Technique*: is based on graph based algorithm and containing the specialization relation such as "is-a" links [27].

I. *Repository of Structure*: technique is used to stores ontologies and their fragments or pair wise similarity between them [27].

J. *Model Based Approach*: covenant with handle input based ontologies semantic interpretations. It done by specific method such as propositional and description logics.

The next section incorporates with ontology matching systems.

III. Ontology Matching Systems

The matching of assorted information resources has been extensively addressed in the last decades. Some of these systems include:

A. *DSSim*

DSSim is a multi agent based ontology matching framwork, which utilize in semantic web for managing uncertainty and inconsistency. It is joint work of Open University in UK and Poznan university of Economics in Poland. Multi-agent system used DSSim for mapping ontology framework, in form of question-answering form and employ Dempster Shafer theory of substantiation into the mapping process in order to improve the correctness [1]. This system is able to handle large scale ontologies with one to one alignment by OWL and SKOS. DSSim system also uses of multi-agent system architecture for fabricate belief function for the correctness of specific communication hypothesis [3]. This belief function can improve the correctness of the ontology matching through combining the similarities. DSSim system finds semantic similarity among ontologies in two forms, Syntactic similarity and semantic similarity.

- *Syntactic Similarity*: to achieve syntactical similarity among the string that necessitates some specific string matching techniques such as Monger-Elkan and Jaccard. These techniques provide Concept-Name similarity and Property-Name or set of similarity tools. However string similarity cannot easily accomplished. It faced many problems, where classes consist with similar name but different meaning. In that instance WordNet plays an important role for exploit synonymy at the lexical level.
- *Semantic Similarity*: is used to discover similarity between concept, relations and properties. It employs XML, RDF, TRUST, PROOF, ONTOLOGY and OWL techniques to interoperate with meaning and attain inter-relationship.

DSSim provides a very efficient method for dealing with large scale ontologies and it obtained the highest performance. This system have not dedicated user interface but they use AQUA question answering system [1], which provides a specific way for handling natural language queries.

B. *ASMOV (Automatic Semantic Matching of Ontologies with Verification)*

ASMOV is an ontology matching system, which used for eradicate semantic inconsistency among ontologies. It developed by INFOTECH SOFT and University of Miami in Florida [5]. It utilizes lexical and structural features of two ontologies or computes similarity measure among them and attains semantic similarity. On the basis of these alignments, they summarized results and ensure to these semantic measure does not contain semantic inconsistency. It used ontology matching process for finding similarity alignment and integration of information in bioinformatics [6]. They provide facilitate the integration of heterogeneity systems and using their data source. ASMOV system summarized similarity measures into two types. These are Similarity calculation and semantic verification.

1. *Similarity Calculation*: is based on four key characteristics of ontology matching. These characteristics are lexical similarity alignment (SimAlgL), internal structure similarity alignment (SimAlgI), external similarity alignment (SimAlgE) and individual similarity alignment (SimAlgN).

Weight – w, Entities – n1, n2, Ontologies – o1, o2, Similarity – A, Lexical – L, Internal – I, External – E, Individual – N

$$\text{SimAlg (n1,n2)} \quad \frac{\sum_{I \in A} w1 \times \text{SimAlg I (n1, n2)}}{\sum_{I \in A} w1}$$

- *Lexical Similarity Alignment*: use to indentifying labels and descriptions. It provides an infrastructure, where user readable information stored on ontologies.
- *External Similarity Alignment:* confers relationship among parents and child of classes and properties.
- *Internal Similarity Alignment*: similarities involving property of domain, classes and range of assets.
- *Individual Similarity Alignment*: similarities among the sets of class members.

2. *Semantic Verification*: is prepared in five ways: multi-entity correspondences, crisscross correspondences, disjointness, equivalence incompleteness and domain and range incompleteness [6].

ASMOV system also used several similarities calculations approaches such as WordNet and UMLS.

C. SAMBO (System for Aligning and Merging Biomedical Ontologies)

Sambo is an ontology matching tool, which employs for merging and matching biomedical ontologies [9]. It developed at Linkoping universitet in Sweden. Currently Dr. Patrick Lambrix and their research scholar are effort to formulate it more appropriate comportment [8]. It recommends web based user friendly graphical interface and supports DAML, OIL and OWL languages, where users can communicate with system. Sambo accomplish ontology matching task into two forms, *suggestion merge* and *manual merge*. Suggestion merge is exploits to comparing the classes of two dissimilar ontologies and manual merge is employ in system, where user select classes without any suggestion from sambo and each matching item merge independently.

In general ontology matching system consists of domain knowledge with relation, instance and axioms and each domain have different domain knowledge. In biomedical ontologies contains dissimilar conceptualization for preserving the knowledge such as organizing vocabulary, taxonomic and thesauri and uses some specific merging and filtering techniques. Which are able to extract valuable results? These techniques are terminological matcher, structural matcher, use of domain knowledge and learning matching [7].

- *Terminological Matcher*: The concept of terminological matcher is stand on the textual explanation of concepts and their relations. These relations are based on string matching algorithms, which are n-gram, edit distance and linguistic algorithms. N-gram is a amalgamation of n successive characters that attained from a string. Second one is edit distance is employ to characterize the number of removals, insertions or replacements. This needed for exchanging one string into other. Third one is linguistic algorithm is used for compute the correspondence and comparing the list of words.
- *Structural Matcher*: is an iterative algorithm, which provides a hierarchies review of the ontologies. Use of domain knowledge refers to mechanism for describing objects their properties and the relation between different resources or objects. Learning matcher is employ to find the similarity measure among concepts in dissimilar ontologies.

D. Falcon

Falcon is an automatic ontology matching tool, which provides semantic interoperability among dissimilar web applications and ontologies. It has been intending with the objective of dealing with large ontologies [14]. This system is able to find similarity measurement between different ontologies and attaining knowledge from web with ontology driven technologies. It also uses ontologies language such as OWL and RDF. Falcon system implemented with java and it is open source tool. It provides much feature of graphical user interface. It operates in three forms. These are (i) Separating Ontologies (ii) Compute Similarity (iii) Amalgamate Similarity.

1. *Separating Ontologies*: is organization on structure based partitioned, which makes separate classes and properties. The each ontologies class is alienated into a small cluster. Then it makes alignment on the bases of these clusters.
2. *Compute Similarity*: is used to calculate semantic alignment. It employ four property to compute semantic similarities such as Linguistic Matching (V.DOC), Structure Matching (GMO), Partition-Based Block Matching of Large-Scale Ontologies (PBM) and I-SUB-String comparison technique [13].
   - *V.DOC*: is employ linguistic method for ontology matching and making virtual documents. The similarity alignment of document can be calculated by vector space approach and RDF structure.
   - *GMO*: is an interactive structural matching technique [13]. It exploits RDF bipartite technique for authenticate structural similarity among domain entities and triple graph.
   - *PBM*: is utilizes divide and conquer technique to locating semantic similarity among large scale ontologies and partitioned the large ontologies into small clusters.
   - *I-SUB*: is a string comparing approach.
3. *Amalgamate Similarity*: is an approach for combining the all ontologies results.

E. RIMOM

Rimom is a dynamic multi-strategy ontology matching tool. It is combined work of researcher of Tsinghua University, China and IBM China research lab. It utilizes for minimization of risk though Bayesian Decision technique and also combing multiple ontologies matching techniques.

Bayesian Decision is a statistical approach to quantifying substitution among various decisions using probabilities. It calculates probabilities into three forms: Decide based on prior probabilities, Decide using Posteriors and Decide using Risk [18].

P – Probabilities, O – Ontologies, O1 – First Ontology, O2 – Second Ontology.

- Decide based on prior probabilities:

$$\text{Decide} \begin{cases} O1 & p(o1) > p(o2) \\ O2 & \text{Otherwise} \end{cases} \quad [18]$$

- Decide using Posteriors:

P (n/o1)

P (n/o2)

$$P(o/n) = \left\{ \frac{P(n/o1)\,P(o1)}{P(n)} \right\} \quad [18]$$

Decide using Risk:

$$P(o1/n) \left\{ \frac{O(n/o1)}{(n/o2)} \right\}$$

Rimom uses multiple ontologies for similarity alignment strategies and compute its weight by manual techniques [15]. The considerable apparitions of strategy alignment are propose a standard for strategy selection and select multiple appropriate strategies. This approach locates similarity measure among two different ontologies into two ways. These are

- *Linguistic Similarity*: techniques describe multiple approaches for measuring the similarity. These techniques are edit distance and vector distance. Edit distance used for deletion, insertion and substitutions. Vector distance is utilized to examine, how structure information are used for identify present status of alignment task [16]. It also play an important role for executing various important tasks such as provides hierarchical information of the structure and enhancement of structure information.
- *Structure Similarity*: is used for innovating structure similarity alignment measure among ontologies and share same information [17]. Structure similarity transmission accomplish into three types: concept to concept (CC), property to property (PP) and concept to property (CP).

F. COMA++

COMA++ is an improved edition of COMA system, which employs to identifying semantic correspondences among schemas. It finds similarity between large continuums of matcher that can be combined in an expandable way. COMA++ is a standard technique for matching schemas and ontologies with SQL, XML Schemas and OWL languages [19]. It also supports GUI (Graphical User Interface) environment and offers the facilities to reuse previously confirmed schema match results. Schema matching is the process of finding semantic alignment among elements to two schemas. COMA++ system uses two basic ontology matching and schema matching approaches [21]. These are simple matcher and hybrid matcher;

- *Simple Matcher*: in simple matcher system elements names are appropriate source for finding similarity among schemas elements. These elements names are Affix, n-gram, soundex, EditDistance, synonym and UserFeedback.
- *Hybrid Matcher*: is a combination of multiple ontology matcher approaches such as NamePath, Typename, Children elements and side elements.

G. Anchor-Flood

Anchor-Flood is an ontology matching tool, which developed by Toyohashi university of Technology. It provides an alignment among two large ontologies in more perfectly manner. It gives preeminent application conveniences in the area of biomedical science, which generally contain very large ontologies approaches. Anchor-Food tool discovers similarity alignment between two ontologies and employs neighboring perception such as super concept, siblings and sub-concepts of ontologies [24]. It also focuses on fragmentation concept that use for segment the large ontologies into sub-ontologies and calculate segment to segment comparison, which helps to improve the system scalabilities. To summarize the similarities measure among segments, it utilizes some suitable terminological tools such as WordNet, Winkler-Based string metrics and structure similarity measures. Find the similarity amongst two ontologies that analysis by the ratio of the number of terminologically such as same direct super concept on the number of total direct concept [23]. The upcoming section gives summarized appraisal of ontology matching systems. The next section highlighted comparative summary of matching systems.

IV. COMPARATIVE REVIEW OF ONTOLOGY MATCHING SYSTEMS

This section highlights the comparative review of recent matching systems in tabular form.

System	Terminological	Type of Corr-Espondence	Language/ model	Strategy	Characteristics	Limitation
DSSim	Monger-Elkan, Jaccard, WordNet	1:1	OWL, SKOS	Graph-similarity	• Specializes in subclass relations • Multi-agent architecture • Similarity matrix created from different measures	system have not dedicated user interface
RiMOM	Edit distance, vector distance, WordNet	1:1	OWL	Linguistic based matching	• Feature analysis of ontologies • Uses text, and structure matching technique • Use of WordNet thesaurus	RiMOM is abortive when dealing with large scale ontologies
ASMOV	UMLS, WordNet	n:m	OWL	Employed lexical or terminological similarity, iterative fix point computation	• Uses text and structure matching technique Uses class and property instances • Semantic checker resolve inconsistent mapping	System required polynomial time for every relations which leads to inefficiency
SAMBO	n-gram, edit distance, WordNet	1:1	OWL, OIL, DAML	Iterative structure based similarity, is-a, part of hierarchies	• Conflict checker detects alignment errors • Learning technique employed • Learning technique employed	no appropriate approach to prefer the right matchers, amalgamations, and filters for the matching process
ANCHOR-FLOOD	Winkler-based similarity, WordNet	1:1	RDFS, OWL	String based technique , internal and external similarity.	• achieving high performance and resolving • the scalability problem • iterative anchor-based similarity propagation	decrease efficiency of system
FALCON	I-Sub, virtual document	1:1	RDFS, OWL	Structure proximities, clustering, GMO	• GMO: uses RDF bipartite graphs to represent ontologies • and computes structural similarities • PBM: divides large-scale ontologies into blocks and find similarity • V-Doc and I-Sub which are light-weight linguistic matchers	lead to deprived clustering
COMA++	Affix, n-gram, soundex, Edit distance	1:1	XML, RDF	String based techniques and thesauri look-up	• Process XML schema, relational database and OWL ontology.	COMA++ not suitable for complex ontology graph

Table 1: comparative review of Ontology Matching Systems

A critical look at the above literature highlights the fact that there are numerous debatable issues which still need to be researched upon. The upcoming section lists few such issues.

V. CHALLENGES

The literature presented highlights the fact that the agent technology and ontology have comes a long way and it is widely used in different areas of research. An analytical look at the preceding section reveals the unfolded challenge which is listed below:

A. Irreconcilable Ontologies Issue among Agent Communication

Ontology plays a critical role in information system that aims at supporting automatic communication among agents in distributed and dynamic environment such as web. Numerous occasion agents necessitate sharing information among other agents. However those agents are doing work in dissimilar domains and formulating use of different ontologies. Here problem arises when different ontologies used by different domain agents, e.g some agents are working in medical domain and other agents are working in financial domain, how they will share common knowledge among them. This obstacle requires to be taken into account for solving inters agent communication. Thus due to differences in ontologies used by different agents, knowledge sharing and evolution of new knowledge through this process is not possible. This issue needs to be taken care of.

B. Underprivileged Background Knowledge Of Domains

The recent appraisal of ontology matching systems illustrate that lack of background knowledge of domain primitive and most recurrently domain specific knowledge is one of the key troubles of ontology matching systems. Due to the dynamic and distributed nature of the web, it is complicated to extract complete information from multiple domains without their background knowledge. These complications must be addressed so that ontology can share and collaboratively exploit distributed heterogeneous knowledge in a scalable way.

VI. CONCLUSION

In this paper we have tried to throw light on concepts of ontology matching with brief survey of its matching systems and classification. This work also highlights the summarized review of ontology matching systems with their comparatively analysis. There are several emerging trends that suggest the ontology matching will be vital in future for many research areas such as the Semantic Web and knowledge discovery. However implementation of this work is still under progress and is left as future work.

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