Poster: Data Integration for Supporting Biomedical Knowledge Graph Creation at Large-Scale

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Abstract. In recent years, following FAIR and open data principles, the number of available big data including biomedical data has been increased exponentially. In order to extract knowledge, these data should be curated, integrated, and semantically described. Accordingly, several semantic integration techniques have been developed; albeit effective, they may suffer from scalability in terms of different properties of big data. Even scaled-up approaches may be highly costly because tasks of semantification, curation and integration are performed independently. In order to overcome these issues, we devise ConMap, a semantic integration approach which exploits knowledge encoded in ontology in order to describe mapping rules to perform these tasks at the same time. Experimental results performed on different data sets suggest that ConMap can significantly reduce the time required for knowledge graph creation by up to 70\% of the time that is consumed following a traditional approach.

1 Introduction

With the rapid advances in different techniques in biomedical domain such as Next Generation Sequencing \cite{1}, and access policies such as FAIR \cite{2} and open data principles, big data has become a quotidian occurrence. However, knowledge discovery from all these big data, as the criteria to make decisions and actions to be taken, is still an unsolved problem. In order to extract knowledge the data should be curated, integrated and semantically described. Recently, the development of Semantic Web technologies has facilitated the implementation of various semantic integration applications, e.g., Karma \cite{5}, MINTE \cite{6}, SILK \cite{7}, and Sieve \cite{8}. The main purpose of Semantic Web Technologies is to describe the meaning of data, a machine readable fashion. Existing semantic data integration approaches rely on a common framework that allows for transformation of data in various raw formats into a common data model, e.g., RDF \cite{3}; mapping languages like RML \cite{4}, are used to express these mappings. Albeit effective,
Fig. 1. The ConMap Approach. ConMap receives structured data sets from heterogeneous sources as input, and produces a knowledge graph. It relies on conceptual or class-based mapping approach in performing all tasks of semantic enrichment, integration, and transformation i.e. both semantification and integration are performed during class-based mapping and afterwards, based on generated mapping rules, normalized data is transformed as RDF model into the knowledge graph.

existing semantic data integration tools may suffer from scalability in terms of the dominant dimensions of big data, i.e., volume, variety, veracity, velocity, and value. In fact, even scaled-up approaches mainly scale up in terms of variety, and may be highly costly since the tasks of semantification, curation, and integration are performed independently.

To overcome drawbacks of existing approaches, we introduce ConMap, a semantic integration approach for big data. ConMap exploits knowledge encoded in a global schema to perform all the three mentioned tasks, i.e., semantification, curation, and integration, in a single step; thus, ConMap provides a scalable solution for semantic integration of big data. We have performed initial experiment study over data sets of various sizes; observed results suggest that ConMap reduces the RDFization time [9], i.e., the time required for transforming heterogeneous structured data sets into RDF.

The rest of the paper is structured as follows: in Section 2 the general idea of ConMap is presented as well as detailed explanation of ConMap architecture and components. In Section 3, the experiments that are performed between ConMap and the attribute-based mapping approach are described and the results are evaluated in terms of time complexity. Finally, Section 4 represents our conclusions.

2 The ConMap Approach

ConMap is a semantic data integration approach able to use mapping rules not only for data semantification, but also for curation and integration. ConMap implements a class-based mapping paradigm that resembles the Global-As-View [10] approach of data integration systems [11]; it enables the definition of the mapping, curation, and integration rules per each class in the global schema. Thus, ConMap executes all the tasks, i.e., semantification, curation, and integration at the same time by evaluating these class-based rules. Figure 1 devises
Fig. 2. Experimental results. (a) The required time for RDFization of one class including five attributes from three different sized data sets. (b) The required time for RDFization of one class including twelve attributes from three different sized data sets.

3 Experimental Study

In this paper, the performance of two mapping paradigms are compared: the class-based mapping approach provided by ConMap, and an attribute-based
approach which is commonly followed by existing tools, e.g., Karma. We address two research questions: RQ1) Does ConMap reduce the time complexity of RDFization? RQ2) How influential a mapping approach can be in terms of execution time when the complexity of the class increases?

**Benchmark:** In this study, a data set with overall size of 169.8 MB is extracted from COSMIC\(^4\), an online database of somatic mutations that are found in human cancer. The data set is in tab separated format comprising 557,162 records of lung cancer related coding point mutations that are derived from targeted and genome wide screens.

**Metrics:** The behavior of the studied mapping approaches is evaluated by measuring the execution time in seconds for transforming a data set into RDF applying that approach.

**Implementation:** The mapping rules\(^5\) are expressed in the RML mapping language. The RDFization is implemented in Python 3.6. The experiment was executed on a Ubuntu 17.10 (64 bits) machine with Intel W-2133, CPU 3.6GHz, 1 physical processor; 6 cores; 12 threads, and 64 GB RAM.

**Experimental Setup:** Two experiments are set up in this study: E1) In order to better understand the influence of mapping approach on time complexity of RDFization, the experiment is run on three different sized data sets: the first one is the preprocessed data set derived from the original mutation data set that is extracted from COSMIC without any decrease regarding its size while the two other data sets are extracted from the first one. The records that are included in two latest data sets are 50% and 25% randomly selected records of the first data set. The result of this experiment is shown in Figure 2(a). E2) To study how time complexity of each mapping approach fluctuated with the increase in the number of attributes for a class, for each mapping approach two separated sets of mapping rules are defined; one mapping rule set for an RDF class with twelve attributes and the other one including five attributes. The experimental results can be seen in Figure 2(b). Based on the results of explained experiments that are illustrated in Figure 2, the execution time increases in case of using the attribute-based mapping rules for transformation of data in both sets including different numbers of attributes which positively answers the RQ1. Moreover, the observed results lead to answer RQ2 as follows: in attribute-based mapping approach, the required execution time for transforming one class of data will grow when the number of its attributes increases, however, in class-based mapping the time complexity is not a function of class complexity.

The evaluation results can be simply explained according to the fact that the attribute-based mapping approach performs the same procedure of creating subject-predicate-object triple for every single attribute of a class. In contrast, the class-based mapping approach transforms each concept or class including all its attributes to one RDF class in a single run. Therefore, class-based mapping approach can be considered as a fundamental procedure for transforming raw data into RDF model in an integrated non-redundant way.

\(^4\) [https://cancer.sanger.ac.uk/cosmic](https://cancer.sanger.ac.uk/cosmic)
\(^5\) [https://github.com/samiscoding/DILS](https://github.com/samiscoding/DILS)
4 Conclusions and Future Work

We introduced ConMap, a semantic integration approach that deploys the knowledge encoded in an ontology to perform semantification, curation and integration simultaneously, in order to acquire a scale-up integration system. We displayed that ConMap can significantly optimize the transforming of structured data sets to a knowledge graph, in terms of time complexity. Although empirical results demonstrated in this paper were derived by all components of ConMap, there is still to illustrate the power of this approach in terms of integration optimization which will be revealed in future work.

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