Materials' Tribological Characterisation: an OntoCommons Use Case

Iker Esnaola-Gonzalez[0000−0001−6542−2878], Izaskun Fernandez

TEKNIKER, Basque Research and Technology Alliance (BRTA)
Iñaki Goenaga 5, 20600, Eibar, Spain
iker.esnaola@tekniker.es

April 29, 2021

Abstract

This paper introduces an ontology-based approach for facilitating the access to the available information in different sources to help tribologists shortening the time, number and size of experiments required to identify the tribological characteristic of a material or combination of them (e.g., metal, coating, lubricant) with respect to specific operation conditions. More specifically, how the use of ontologies for mapping relevant tribological information sources, containing from experiment results to patents/scientific publications, enables the development of a holistic Semantic Federated Search service for tribology domain.

1 Introduction

The tribology is the science that deals with the design, friction, wear, and lubrication of interacting surfaces in relative motion (as in bearings or gears), being one of the key enabling technologies in the development of novel products and the driving of new materials into sustainable solutions within any machine or mechanical system. Wherever moving bodies are in contact with each other, the constitutive materials contributing to friction and wear and the environmental conditions are determining the tribological performance of engineering components and machines.

In this context, experiments are carried out towards the understanding of the behaviour of different materials with regards to mechanisms of friction, mechanical wear, chemical wear (corrosion) and the wear-corrosion synergy at different scales, for certain environmental/test conditions. Many of these experiments are similar in terms of the type of materials used and test conditions. However, this type of experiments are not adequately documented nor publicly available, so the reusability of their results is very limited. In most cases, the details about the findings are published in form of scientinfic publications and/or patents.

The goal of the OntoCommons project's[1] Tribological use case is to help tribologists shortening the time, number and size of experiments required to identify the behaviour of a material or combination of them (e.g., metal, coating, lubricant) with respect to specific operation conditions, exploiting and reusing as much as possible the existing scattered information. Depending on the desired target tribological characteristic to measure, a single experiment could take a month. So reusing the pre-existing knowledge is so critical for minimizing the number of experiments and so the time and costs of a tribological material characterisation. To do so, semantic technologies and more specifically, ontologies are proposed to abstract tribologists from the underlying (vaguely documented) experiments' results findings, and provide a logic layer, facilitating the relevant information finding, no matter where and how it has been stored.

The rest of the article is structured as follows. Section 2 presents the approach proposed and in Section 3 the next steps are discussed.

2 The proposed approach

In order to support tribologists and shorten the time, number, and size of experiments that they need to perform to identify the behaviour of a given material under certain operation conditions, this section describes the approach proposed by the OntoCommons Tribological use case.

First of all, let us explain that the scenario presented in this article takes place in the context of the i-TRIBOMAT H2020 project[2]. i-TRIBOMAT is aimed at providing an open innovation test bed dedicated to validating and upscaling new materials, thereby enabling intelligent tribological materials characterisation and fostering industrial innovation in the European manufacturing industry, through a completely new, cross-institutional collaborative approaches in sharing infrastructure, competence and data approach.

The modelling of the information is one of the key and basic aspects for a success full sharing approach. Without a common data model, the integration of data coming from different sources becomes almost an unfeasible work: difference in used units, result variable descriptors and configuration parameter names need to be avoided in order to combine data. A well-organised data model can be exploited to find relationships and similarities between different characteristics such as experiment conditions and sample materials. This can be further enhanced with the use of semantic reasoning, complementing the data with information coming from external databases and material research approaches [4].

Since most of the times, the results from tribological experiments are not made open to external stakeholders, in this scenario, other sources of information will also be considered towards helping tribologists. Namely, databases where materials' non-tribological information (i.e., mechanical and chemical properties) are stored, as well as patents and repositories containing scientific articles

[1] https://ontocommons.eu/
[2] https://www.i-tribomat.eu/

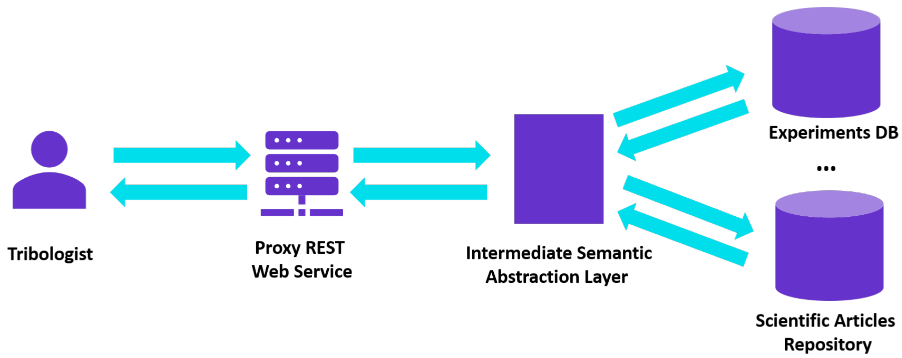

Figure 1: Semantic Federated Search approach

will be targeted. In order to avoid performing manual searches in each of these repositories, the proposed approach advocates for developing an intermediate abstraction layer that enables accessing all this information in a homogeneous way, even dealing with normalisation issues and providing filters for advanced searching options such as alternative materials able to behave in a similar manner under certain conditions. Furthermore, in order to enhance security and abstract the underlying configuration of the whole system, RESTful APIs are considered. Figure 1 summarises the proposed approach.

Semantic Technologies in general, and ontologies in particular, will play a key role in the proposed approach, not only providing a formal and shared representation of the data, but also providing an homogeneous access to heterogeneous data stored with different structures and in different systems via the intermediate abstraction layer. As a matter of fact, once data is annotated with ontological resources, there is no need for the user to be aware of raw data's underlying structure. A common data model for tribological experiments has been proposed in the context of the i-TRIBOMAT project, although this model is not formalised and it could benefit from being aligned to ontologies because of the aforementioned reasons.

In this regard, ontologies for describing the information contained in different storage systems will be necessary. Namely, ontologies for describing tribological experiments, materials information relevant from a tribological point of view, scientific contributions and patents. Following the Semantic Web best practices, the reuse of existing ontologies will be aimed. However, likewise to other domains (e.g. the building domain), not every existing ontology is reusable [2]. This is a direct consequence of neglecting factors that influence the quality of an ontology such as the lack of an explicit license, a proper documentation page or careful metadata with explanatory description of the intended meaning of the ontology terms [3].

Although a thorough analysis of existing ontologies is necessary in order to decide which of them could be reused (if there is such a possibility), there are some ontologies that have already been identified to be considered. The

European Materials and Modelling Ontology (EMMO) [6] is an upper ontology to establish semantic standards that apply at the highest possible level of abstraction, under which all conceivable domain ontologies can be subsumed and interoperated. The TribAIn [5] ontology aims to provide a formal and explicit specification of knowledge in the domain of tribology to enable semantic annotation and the search of experimental setups and results. Likewise, other ontologies may be necessary for representing the rest of areas of knowledge such as the BIBO ontology [1] for representing the information gathered from the scientific publications or patents repositories according to best practices of the Semantic Web.

3 Challenges and next steps

After performing a methodical and thorough analysis of the existing ontologies covering the targeted areas of knowledge, this use case will focus on the formalisation of the final ontology that will be the basis for the *Intermediate Semantic Abstraction Layer* (see Figure 1). This task may involve dealing with low-documented ontologies, as well as the need of extending them to address the use case requirements.

Once the ontology is defined, the next step will consist in the mapping of the ontology with relevant information sources to be able to provide a holistic Semantic Federated Search service.

Acknowledgements

This project has received funding from European Union´s Horizon 2020 research and innovation programme under grant agreements no.814494, project i-TRIBOMAT, more details: https://www.i-tribomat.eu/ and 958371 project Ontocommons, more details: https://ontocommons.eu/

References

[1] Dimić Surla, B., Segedinac, M., Ivanović, D.: A BIBO ontology extension for evaluation of scientific research results. In: Proceedings of the Fifth Balkan Conference in Informatics. pp. 275–278 (2012)

[2] Esnaola-Gonzalez, I.: On the reusability of ontologies for observations and actuations in buildings. In: Proceedings of the 9th Linked Data in Architecture and Construction Workshop (LDAC 2021) (To be published)

[3] Esnaola-Gonzalez, I., Bermúdez, J., Fernandez, I., Arnaiz, A.: Ontologies for Observations and Actuations in Buildings: A Survey. Semantic Web **11**(4), 593–621 (2020). https://doi.org/10.3233/SW-200378

[4] Hofmann-Amtenbrink, M., Hofmann, H., Koopmans, R., Schuring, E., Meneve, J., Gauss, R., Igartua, A., Fernández, P.: Towards a system approach for materials research, development and innovation for Europe (2019)

[5] Kügler, P., Marian, M., Schleich, B., Tremmel, S., Wartzack, S.: tribAIn—Towards an Explicit Specification of Shared Tribological Understanding. Applied Sciences **10**(13), 4421 (2020). https://doi.org/10.3390/app10134421

[6] Morgado, J.F., Ghedini, E., Goldbeck, G., Hashibon, A., Schmitz, G.J., Friis, J., de Baas, A.: Mechanical testing ontology for digital-twins: A roadmap based on emmo. SeDiT 2020: Semantic Digital Twins 2020 p. 3 (2020)