Tackling Innovation Challenges in an Industry 5.0 context with an Ontology-based Open Translation Environment

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1. Introduction

In order to reach the goal of a more sustainable, human-centric and resilient European Industry, as discussed in a report by the European Commission on Industry 5.0 [1], innovation systems and processes are required that firmly put the human in the loop.

The OntoTrans project [2] has been contributing to these objectives [3] by (a) further developing and testing the so-called "Translator" approach [4, 5, 6] to industrial innovation, (b) expressing human knowledge and joint understanding of innovation challenges in a standardised, well-grounded, machine-readable ontology, and (c) building and implementing a set of tools that help to democratise the use of diverse information sources (including materials modelling), empowering users to make informed decisions.

2. Translation for human-centred innovation

Translation in the context of innovation and Industry 5.0 is a process that involves teams that guide the interaction and knowledge exchange between actors in customer-focused industrial R&D. The teams typically involve experts from different fields including the materials//manufacturing domain experts, but also computer science and semantic technologies that build and customise digital tools to support gathering and exchanging relevant knowledge. Together they follow the six steps of translation [4]. OntoTrans revealed that solving an overarching innovation challenge may embrace assessing a series of characteristically related innovation cases sharing relevant concepts and datasets which in manufacturing represent distinct combinations of materials and processes. The project has confirmed the pertinence of the underlying translation approach and supports it with a range of digital tools and technologies, which together are called the Open Translation Environment (OTE).

3. Semantic knowledge management

Semantics provides the ability to carry out unified analysis of data from different data sources, enables augmented analysis, recommendations and AI orchestration. These

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developments are driven by the need and opportunity of democratising data access and enabling 'self-service' analytics.

Despite the success of semantic knowledge management in a range of business and technology fields, materials semantics remains somewhat scattered [7] and with little industrial uptake.

To address this issue, a number of EU projects have been developing an ontology framework that incorporates fundamental principles and concepts from the natural sciences, in particular physics, chemistry and materials science: the EMMO (Elementary Multiperspective Material Ontology) [8]. It is unique in providing users with a combination of rigorous, science based axiomatisation and flexibility of expression. On that basis, the OntoTrans project has built a semantic knowledge system based that enables users to represent innovation challenges and connect them to a range of data sources including data from modelling and simulation. It facilitates the creation of FAIR data.

In particular, the OTE framework employs semantic mapping techniques to convert raw data from various formats into machine-readable RDF instances [9]. Through pipelines connecting data resources to parsers and semantic mapping schemas, the OTE facilitates the creation of structured, semantically enriched information. This process ensures that data is documented in a standardized ontological form, laying the foundation for FAIR datasets.

Central to the OTE framework is the creation of a knowledge base supported by domain ontologies and populated with RDF instances organising data and metadata in a structured way. Thus, the OTE enables users to capture and organize relevant information systematically, fostering collaboration between various stakeholders in Industry 5.0.

4. OTE tools: connecting data sources and data exploration

Since OntoTrans needs to work with a wide range of data sources as well as connect to models that can generate data on demand, OntoTrans has developed the OTEAPI [10] package, which can be described as an actionable data documentation system for semantic interoperability. The OTEAPI plugin architecture facilitates the implementation of various data interfaces in one place. The creation (i.e., configuration) of OTEAPI pipelines provide a simple interface for data providers to document their data (Figure 1).

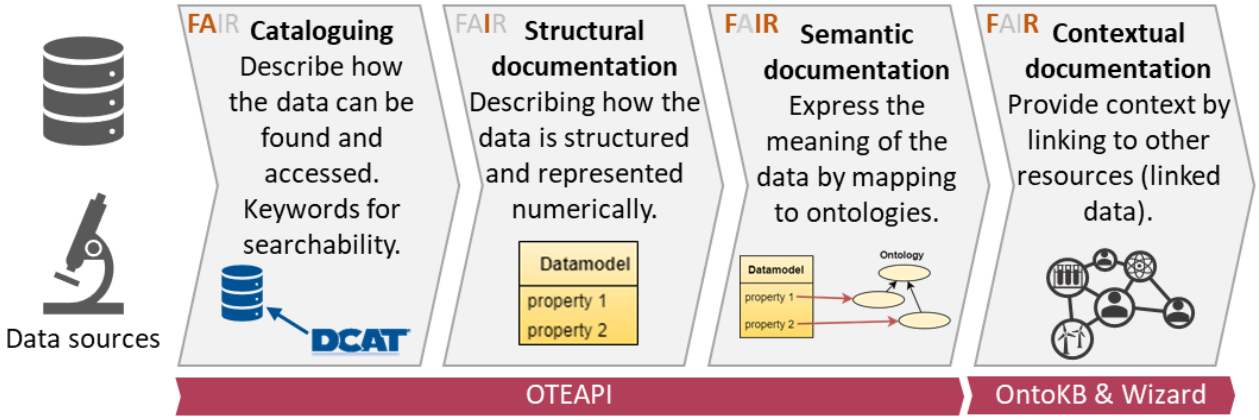

Figure 1. The four levels of data documentation. The aspects of FAIRness that each level contribute to is also indicated.

The OTE incorporates an Exploratory Search System (ESS) [11] designed to enhance information-seeking tasks through semantic-enriched data exploration. By leveraging the underlying semantic structure, users can interactively search and navigate through the knowledge base, facilitating the retrieval and discovery of relevant information.

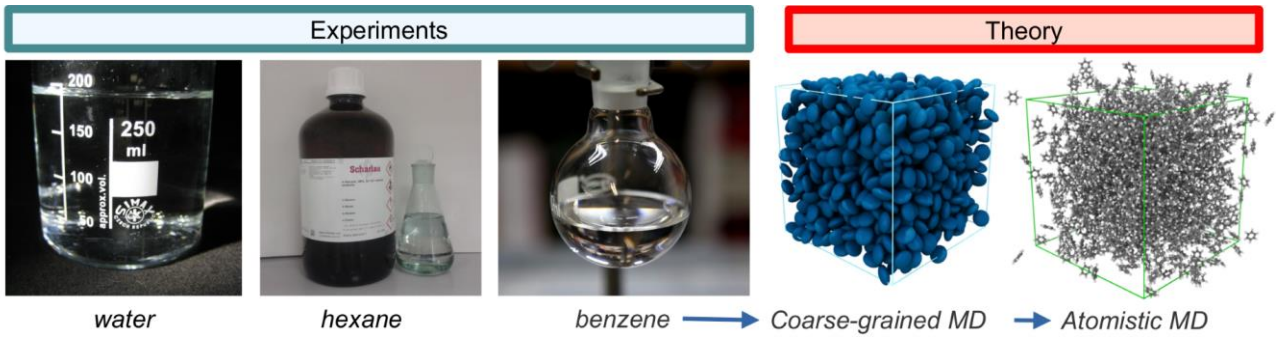

Figure 2: OTE enables FAIR data starting from common data formats such as a spreadsheet and plain-text log files. The use case used to demonstrate the OTE includes a dataset of experimental properties for three solvents, and the thermodynamic output simulations.

5. Conclusions

The Open Translation Environment is a set of open-source software for the creation of FAIR data in materials science. By integrating semantic technologies into the data documentation and knowledge creation process, the OTE framework enables users to represent, access, and utilize information in a standardized and interoperable manner. he OTE facilitates a translation approach to advance materials innovation in an Industry 5.0 context.

6. References

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7. Acknowledgments

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