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BLM GROUP

BLMGroup - Ontology Based Maintenance

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Use Case and Goals

Adige S.p.A., part of the enterprise group BLMGroup, manufactures laser-cutting machines. These machines are complex, their maintenance, in particular, requires advanced expertise. With the goal of reorganizing the knowledge management strategy of maintenance expertise, the company investigates semantic technologies in the OntoCommons project with the collaboration of the Laboratory for Applied Ontology (CNR-ISTC). The expected results are, among others, a decrease in the time required to solve previously encountered problems and an increment in the information that can be extracted from maintenance records.

The resulting efforts produced ontologies containing domain terms, as well as methodological guidelines for functional and structural modeling of engineering systems, and failure analysis.

Root Cause Analysis

Failure analysis is an important discipline that makes use of maintenance records. Root cause analysis, in particular, is an activity aimed to pinpoint the causes of failures in such a way as to deepen the understanding of a product and prevent future failures. This activity is especially difficult since it deals with cause-effect relations.

A novel methodology, based on previous ontological work on causation, was proposed to carry out root cause analysis.

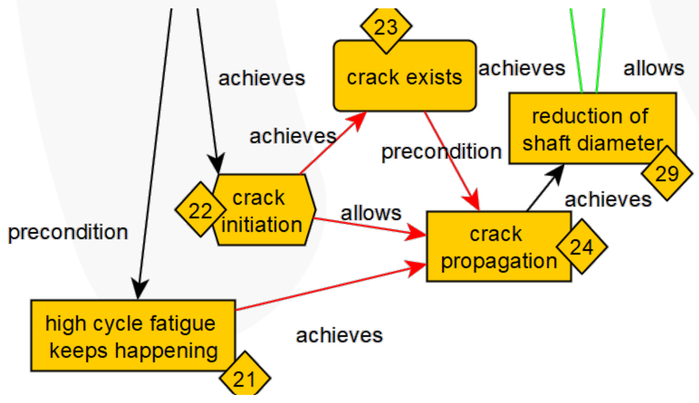

Figure 3: Excerpt of a graph representing a model (an instantiation) of the failure analysis ontology, consisting of a causal explanation of the critical failure of a piece of equipment.

Future Research

Further work is needed to test the ontologies/vocabularies, which also need to be expanded to include a lightweight ontology to standardize recording of machine failures. Additionally, the developed ontologies will be merged with an appropriate machine-learning pipeline in order to be implemented into the company's daily workflow. After that point, an in-depth evaluation of the impact of semantic technologies will be carried out along with an assessment of the convenience to fully develop the approach.

Introduction

Knowledge management requires (also) terminological precision and the ability to share knowledge efficiently. One way to achieve this is by using an ontology (a precise, machine-readable vocabulary). A vocabulary of domain terms was therefore developed in a systematic way.

Another key point consists in the representation of machines' structure and machines' failures. In fact, the representation of a machine structure is usually achieved through various schematics and its bill of materials, which tend to be very complex. In particular, it is not clear how to represent functional information clearly. The ontological approach presents a novel point of view in regard to the representation of machine structures and functionalities, offering methodological guidelines for, e.g., functional decomposition.

A domain terms vocabulary and a clear representation of a machine are useful prerequisites for failure analysis and extraction of data from maintenance records. In addition, the process of failure analysis can itself be enhanced by ontology-based guidelines.

Domain terms vocabulary

The vocabulary is systemically built from ontological principles: having determined key characteristics for the main categories of considered entities (devices and functions among these), taxonomies were built for each of these categories. Classes within these taxonomies are linked through each other by some significant relation, moreover, definitions in natural language are schematically built from their properties, see e.g. Figure 2.

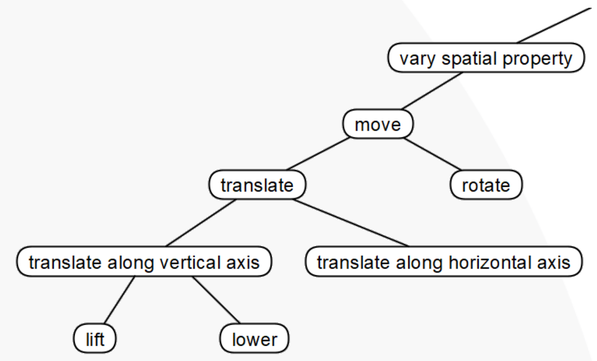

Figure 1: Excerpt of a taxonomy of functional terms.

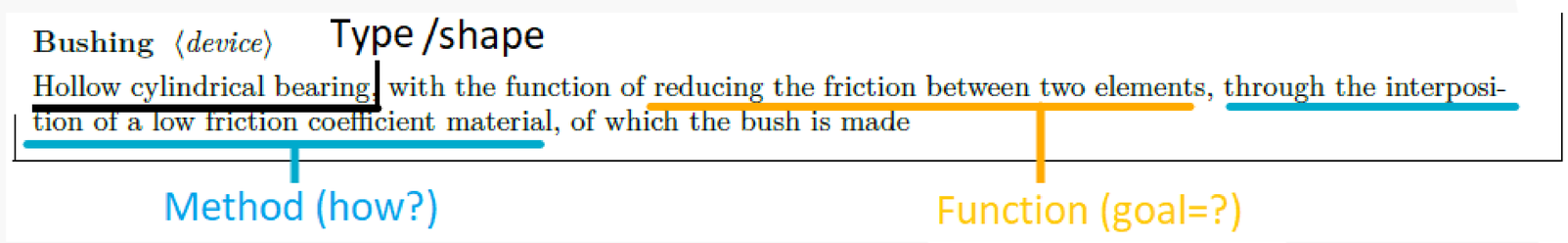

Figure 2: Example of natural language definition of the term 'bush'.

Functional Decomposition

Functional analysis of engineering systems has a rich history in the literature. Building up from that a methodology for functional decomposition was developed, focusing on the effective feasibility and maintainability of the methodology, and applied to a laser-cutting machine-type as proof of concept (see Figure 4. The methodology focuses on the duality between function (what to achieve) and method/means/way of implementation (how to achieve).

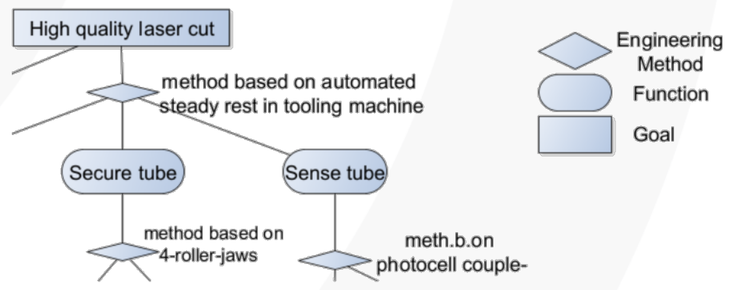

Figure 4: Excerpt of functional decomposition of a laser cutting machine.

Conclusion

The aforementioned work shows how semantic technologies/ontologies can enhance various activities in the context of maintenance and, more broadly, of manufacturing. Such work was made necessary by the absence of appropriate domain and or application-level ontologies ready to be applied to the use case. Additionally, the merge of such semantic technologies into the company's daily workflow is demanded to when an appropriate machine learning system will be developed to accompany such semantic technology by executing tasks such as keyword extraction and semantic tagging. Ontologies development is still needed, though, as it builds a conceptual model and offers a controlled vocabulary which are necessary preliminary steps for the development and augmentation of machine learning technologies.

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