Building next generation methods for sustainable Innovation in industry

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Summary:
The emerging necessity to support innovation with reliable methods and tools is a global trend among all continents. It concerns not only industry but also social and academic worlds. One of the most struggling bottlenecks for sustainable innovation is to concentrate on an efficient invention step. This unavoidable step in the creation of new objects currently only depends on people’s creativity and this human capacity is nowadays less efficient due to an essential factor: the increasing complexity of technical objects (their multidisciplinary aspect) and our incapacity to cope with the changes it provokes on human mastering. We believe one of the key issues to this difficulty is to benefit from an efficient use of the permanent flow of data available on the web (big data) when inventing new objects. Unfortunately, tools in support to innovation activity are too little the object of scientific research nowadays.

This PhD will be dedicated to build, test and implement new algorithms for investigating large quantities of data coming from the web and extracting out of it useful information in order to support engineers when inventing new objects at the early stages of innovation pipeline.

Full Description

Context and state of the art

The emergence of norms (ISO) related to innovation is now likely to appear worldwide. How will the R&D department (re)organize itself to systematically produce inventions upstream of the innovation chain? How to create new tools that can support teams in charge of breakthrough projects?

The LGéCo (Design Engineering Lab.) is interested in the theories of invention (such as TRIZ) and how they could, in the age of Big Data and FabLabs, serve as a link between knowledge that humanity continuously produce and the way its use could assist idea generation followed by quick prototyping.

This new practical and pragmatic way of inventing, theoretically grounded but governed by performance rules and efficiency expectations, is the core target of our researches in Inventive Design.

Knowledge management in Inventive Design, as defined by our laboratories, is crucial to assist engineers when inventing new objects in the innovation pipeline. It has specific characteristics and requires the selection of certain pieces of knowledge which can induce evolutions; it produces the reformulation of the initial problem in order to build an abstract model of the concerned object, and includes three main steps:

- The “formulation” phase, where the expert uses different tools to express the problem in the form of a contradiction [1, 2] network or another model.
- The “abstract solution finding” phase, where access to different knowledge bases is made to get one or more solution models. Generally, in this step, TRIZ users are required to have wide experience on the TRIZ knowledge sources. They need to be capable of choosing the accurate abstract solution according to the current abstract problem.
- The “interpretation” phase, where these solution models are instantiated with the help of the scientific-engineering effects knowledge base, to get one or more solutions to be implemented in the real world.

Figure 1 presents the process of inventive problem solving. Different knowledge sources exist in order to solve different types of inventive problems, such as the 40 inventive principles for eliminating the technical contradictions and the 11 separation principles for eliminating the physical contradictions. These knowledge sources are all built independently of the application field, and their levels of abstraction are very different, making their use quite complicated.

Previous works in our team and in the framework of another PhD thesis [3, 4, 5, 6] have proposed an approach based on semantic technologies to assist the experts in the use of the inventive design methodology, as shown in Figure 2.

Now we are interested in capitalizing the previous experience of inventors to improve the outcomes of an inventive study, this experience can come from patents, for example; or from another design team. To deal with this permanent flow of freely available knowledge, there exist
several models [7, 8, 9], but they are not adapted to the Inventive Design Ontology we have already built.

Our previous works have developed a framework for a new architecture (knowledge and rules) as shown in Figure 2, for managing data (currently semi-automatically) and partially filter the appropriate one compliant with specific engineering studies. The outcomes of this project will permit the finalization of this general architecture, by the incorporation of experience and of meta-knowledge to guide the use of the domain knowledge, the rules and the experience for completely managing data, populating the inventive design ontology and test the impact of this new knowledge on inventive studies.

**Objectives**

Based on the context and the state of the art, this research topic proposes the use of methods of Knowledge Engineering, Artificial Intelligence, and Semantic Technologies for the development of a formal model of experiential knowledge in the framework of inventive design.

Having this goal in mind, several knowledge capitalization techniques need to be analyzed to propose a general architecture that integrates them in the works already developed by the team.

The expected outcomes of this project include a software prototype implementing the proposed architecture for capitalization, integrated in existing software tools ad test it in real life, with engineers in industry.

**References**

The candidate

The proposed subject is suitable for students that are interested in Innovation and Knowledge Management. He (she) should possess both skills in Computer Science and Design Engineering (Artificial Intelligence will be a plus).

This thesis will permit him (her) to acquire an important broad spectrum baggage in the field of knowledge representation and modelling, as well as an effective experience of working in a dynamic and multidisciplinary environment.

The required competences include:

- rigorous work, autonomy and reactivity
- excellent team work capabilities,
- excellent written and spoken English,
- very good knowledge on development of applications
- Experience in the development of OWL2 ontologies and in the use of reasoning engines will be more than welcome.
- Knowledge about semantics, text mining and data mining will also be a plus.