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ScienceDirect

Procedia Computer Science 112 (2017) 323–332

Procedia Computer Science

www.elsevier.com/locate/procedia

International Conference on Knowledge Based and Intelligent Information and Engineering Systems, KES2017, 6-8 September 2017, Marseille, France

Case-based Reasoning for Knowledge Capitalization in Inventive Design Using Latent Semantic Analysis

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Abstract

Nowadays, innovation represents one of the most crucial factors driving the success of companies. The Theory of Inventive Problem Solving (also known as TRIZ) is a well-established method to facilitate systematic inventive design. Although, TRIZ allows solving inventive problems through a panoply of knowledge sources, it may make inventive problem solving a time-consuming, experience demanding process and lead to waste of resources of the companies. To avoid the use of these tools and to help new users in solving their inventive problems without completely mastering TRIZ, we propose in this paper an approach based on the use of the Case-based reasoning (CBR) in order to capitalize experience. CBR is a knowledge paradigm that solves a new problem by finding the old similar cases and reusing them. The retrieval is conducted in order to find the old similar cases, and the old solutions of the retrieved cases are adapted to solve the new problem. In this paper, a systematic three-level adaptation is proposed to reduce the effort required of the users in choosing the suitable solution to solve their problem. An example is used to illustrate in detail the proposed approach.

Keywords: Case-based Reasoning; TRIZ; Inventive Design Theory; Latent Semantic Analysis; Experience Reuse

1. Introduction

Nowadays, innovation represents one of the most crucial factors driving the success of companies. In fact, companies need to innovate in order to satisfy customer requirements and to be distinguished in the global market. To face the evolution of the business environment, industries should create innovative products in a continuous way. For that purpose, more and more companies turn their attention to TRIZ (the theory of inventive problem solving)[1].

TRIZ is recognized as a suitable theory for solving inventive problems in different domains[2]. It differs from other techniques by its three fundamental principles: problems are raised because of the evolution laws and the resolution of the problems should respect the evolution laws; the resolution of a problem is eased by conveying it in terms of a

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1877-0509 © 2017 The Authors. Published by Elsevier B.V.
Peer-review under responsibility of KES International
10.1016/j.procs.2017.08.004

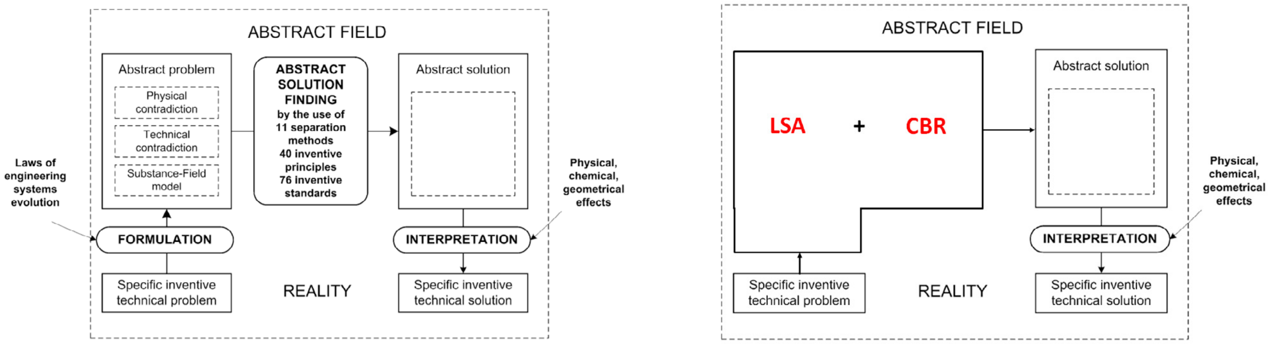

Fig. 1. (a) The approach of TRIZ solving inventive problem [3]; (b) The proposed approach.

contradiction; and a robust solution to a problem is considered to be a solution that minimizes the introduction and use of new resources. According to the TRIZ methodology, solving an inventive problem goes through three phases as illustrated in figure 1 (a):

1. The "formulation" phase, where the experts use different tools to formulate their specific inventive problem into an abstract problem in terms of a technical contradiction or other models.
2. The "abstract solution finding" phase, where, depending on the type of the problem of the former phase, knowledge bases are used to get one or more abstract solutions.
3. The "interpretation" phase, where the abstract solutions need to be interpreted by accessing to the scientific-engineering effects knowledge base in order to get one or more specific inventive technical solutions.

Although TRIZ offers to solve different types of inventive problems, but it is still difficult to use for novice users. In fact:

- TRIZ uses diverse knowledge sources at different abstraction levels. Depending on the abstraction level, it produces results also at different levels: at the highest abstraction level, the results are ideas of solutions (or concept solutions), at the lowest abstraction level (with the help of specific knowledge bases), it produces specific technical solutions.
- The wealth of knowledge available in TRIZ is necessary for solving a large variety of inventive problems but access to the needed specific knowledge might be difficult.
- TRIZ definitions are sometimes ambiguous and cannot be interpreted adequately. Using a recommendation proposed by TRIZ for solving a specific problem requires extensive knowledge of different engineering domains and is not currently supported by the methodology. As a consequence, the user is supposed to possess a high degree of expertise in engineering design.

In this paper, we study the feasibility of the use of case-based reasoning (CBR) [4] with latent semantic analysis (LSA) [5], in order to facilitate the TRIZ problem solving process (Figure 1 (b)), giving the users the possibility of obtaining an abstract solution directly from their concrete problems, avoiding then the error-prone process of abstracting the concrete problem to an abstract one.

The use of CBR permits the reuse of old solutions to solve new cases. The construction of semantic spaces with LSA [6] enables the automation of "analogy" between specific problems and abstract ones.

The remainder of this paper is as follows: section 2 gives a literature review of the current methods used in TRIZ to eliminate technical contradiction. Section 3 details each step of the proposed approach based on CBR. Section 4 studies the recycling bin problem to illustrate the proposed approach. Finally, section 5 sums with a conclusion and future perspectives.