Computers in Industry 82 (2016) 119–134

Contents lists available at ScienceDirect

Computers in Industry

journal homepage: www.elsevier.com/locate/compind

Understanding TRIZ through the review of top cited publications

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ARTICLE INFO

Article history:
Received 5 March 2016
Received in revised form 10 May 2016
Accepted 30 June 2016
Available online xxx

Keywords:
TRIZ
Conceptual design
Industrial practice
Information processing
Computer-Aided Innovation

ABSTRACT

The development of the Theory of Inventive Problem Solving (TRIZ) has not followed the usual patterns of scientific validation required by engineering methods. Consequently, its outreach within engineering design is interpreted differently in the scholarly community. At the same time, the claimed powerful support in tackling technical problems of any degree of difficulty conflicts with TRIZ diffusion in industrial settings, which is relatively low according to insights into product development practices. The mismatch between ambitious goals and moderate spill-over benefits in the industry ranges among the various open issues concerning TRIZ, its way of thinking, its effectiveness, the usability of its tools. In order to provide a general overview of TRIZ in science, the authors have attempted to analyse reliable and influential sources from the literature. The performed survey includes the top 100 indexed publications concerning TRIZ, according to the number of received citations. Variegated and poorly interconnected research directions emerge in the abundant literature that tackles TRIZ-related topics. The outcomes of the investigation highlight the successful implementation of TRIZ within, among the others, biomimetics and information processing. The traditional borders of mechanical and industrial engineering have been frequently crossed, as the use of TRIZ is also witnessed in the domain of business and services. At the same time, computer-aided platforms represent diffused attempts to boost TRIZ diffusion and applicability.

Contents

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http://dx.doi.org/10.1016/j.compind.2016.06.002
0166-3615/

1. Introduction

The Theory of Inventive Problem Solving, developed in the former USSR and commonly known as TRIZ, is rated among the most articulated and effective sets of techniques for supporting the initial stages of engineering design. Many contributions stress the capability of TRIZ to enhance ideation and problem-solving performances; we can mention [52,45,35,25] among the most rigorous recent research studies.

On the other hand, several works remark the limited employment of TRIZ in industrial settings and argue about its effectiveness. Rese and Baier [91] highlight how TRIZ is seldom used in innovation networks, as well as its exploitation has resulted in several unsuccessful experiences. Similar results had already emerged in the analysis of German industry performed by Schneider et al. [95]. Sakao [94] mentions an experiment within eco-design, in which solutions obtained through TRIZ were outperformed by concepts elaborated with other design methodologies. Howard et al. [48] underline that the use of TRIZ for concept generation is effective just when designers master the theory proficiently. Most significantly, the limited use of TRIZ in the industrial environment clearly emerges in Graner and Mißler-Behr's [43] review of the literature concerning the diffusion of New Product Development methods in the practice.

Methodological deficiencies are mentioned also within the TRIZ community, but they are insufficient to justify the difficulties in crossing the borders of academia. Cavallucci et al. [22] point out how classical TRIZ does not tackle complex problems appropriately. The concept is shared by Becattini et al. [8], but it is shown how more articulated TRIZ-based techniques can overcome the claimed inefficiency. de Carvalho et al. [33] shed light on limitations concerning the laws of engineering systems evolution, but this does not seem to affect the usability of these tools, as they have been widely exploited in the practice (see Section 3).

Still according to literature, the main reasons of low TRIZ popularity are constituted by problems connected with the dissemination of the theory, as well as difficult underlying principles, which characterize a not structured collection of tools [51]. Moreover, negative judgements could be affected by what is intended as TRIZ, but it does not fully comply with the conventional exploitation of the original teachings: misuses, over-simplifications and intentional deviations from classical TRIZ are claimed frequently in the literature [34,56,81,6,133]. More explanations are provided in the followings.

Although not truly pervaded by an air of mystery, as addressed by some scholars [51], the development and refinement of TRIZ have not followed the common criteria of scientific diffusion and discussion. Genrich Altshuller introduced the elements of more productive thinking in inventive engineering through a publication in "*Vorprosy Psikhologii*" (Issues on Psychology), dated 1956. Making ideation phase of engineering design much more systematic and therefore gaining popularity among practicing inventors, the method evolved into a toolset for systematic creativity under the name of "Theory of Inventive Problem Solving" by the 1980s. Altshuller and his followers deployed TRIZ through extensive public activities, training seminars, articles and books. Consequently, TRIZ gained new instruments and chapters. The main method application roadmap, named the Algorithm for Inventive Problem Solving (ARIZ), evolved through several editions from 1965 to 1985. At the same time, the discussion, intentionally or not, never left the closed circle of TRIZ developers and all the possible developments had to be approved by TRIZ founder rather than peer-reviewed. In other words, the development of the "theory" (as it was named by the adepts) was never supported by the traditional mechanisms of scientific validation. However, many of these developments have proven to be useful in practice, becoming the subject or instrument of current research activities.

As TRIZ crossed the borders of former USSR, the first scientific publications appeared in the late 1990s (more precisely in 1997, according to Scopus database). Starting from the 2000s, TRIZ increasingly attracted scholars' interest, as demonstrated by the steady growth of the number of TRIZ-centred scientific publications [14]. In this way, the presence of TRIZ among the topics of papers concerning design has surpassed other acknowledged methods and tools, although still distant from the diffusion of the most popular instruments [26].

Nevertheless, as aforementioned, the popularity within academia is still insufficient to ensure a wide diffusion of TRIZ mind-set at an operative level. In this sense, the long training required to master TRIZ effectively represents a considerable obstacle [84,9]. Problems are exacerbated by the supposed misalignment between industry expectations about TRIZ support and the structure of traditional training courses [82]. In such a context, University training represents a chance to boost the diffusion of TRIZ knowledge to novel engineers and technicians. The literature does not lack the description of experiences about the introduction of TRIZ in educational programs; we can mention [87,10] as illustrative contributions. However, as a result of a survey conducted in the top 30 technical universities worldwide (according to Quacquarelli-Symonds index), just two courses (out of 294) about engineering design and New Product Development mention TRIZ in their syllabi [3].

As contradictions are the focus of problem analysis and solving in TRIZ, a huge dichotomy invests the theory paradoxically: TRIZ enables the disclosure of first-class creative technical solutions, but it does not succeed in carving out a primary role in the context of engineering design and New Product Development practices, where innovation is besides a mantra.

As several aspects of TRIZ development and employment are unclear, the purpose of the paper is to review scientific