Computers in Industry 63 (2012) 252–264

Contents lists available at SciVerse ScienceDirect

Computers in Industry

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

The development of a modified TRIZ Technical System ontology

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ARTICLE INFO

Article history:
Received 15 June 2011
Received in revised form 28 September 2011
Accepted 18 January 2012
Available online 11 February 2012

Keywords:
TRIZ
Ontology
Functional design
Patent mining
Computer Aided Innovation

ABSTRACT

This paper considers the development of a TRIZ Technical System ontology with the aim of facilitating the indexing of knowledge contained within available resources in a way that will make it accessible and useful to a user undertaking a design engineering task. The function of the developed ontology is evaluated using a case study, in which a patent is classified using the defined scheme. The quantitative nature of the classification structure developed to support this procedure offers a mechanism that may be further developed and integrated into research aiming to support the computerisation of the knowledge elicitation and representation process. The ontology developed to enable the classification methodology will support the integration of design by analogy procedures and enable effective information retrieval via the TRIZ based approach.

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1. Introduction

It must be accepted that providing access to resources that are capable of adding information and inspiration to a design process must be a good thing. There are many sources of such information and an increasing number of mechanisms for accessing them. This is a natural consequence of the continued development of the Internet and the content of the World Wide Web (WWW) that it makes accessible. The challenge facing those researchers considering a means of supporting creative design processes is to engineer a framework within which such knowledge may be expressed, preserved, accessed and exploited by users or agents from any perspective.

TRIZ is the theory of inventive problem solving arising from an original process in which some 400,000 patents were analysed in a systematic attempt to explain the nature of the process of invention. TRIZ thinking stipulated that there are a set number of basic conflicts that need to be resolved in the solution of design problems. This work together with more intensive analysis of the invention process as contained in 40,000 of these patents led to the proposition that the invention process may be formulated as a contradiction of thirty-nine different engineering quantities or qualities. It is also suggested that these contradictions can be solved by the application of one or more of forty inventive principles [1].

The term 'ontology' was originally a philosophical term commonly used to refer to the branch of metaphysics dealing with the nature of being. However, computer scientists have incorporated the word into their own environment, defining it as 'a specification of a conceptualisation' [2]. In more explicit terms, ontology may be taken as a structure of metadata that classifies terms or objects and defines relationships amongst them. Of course it should be recognised that the most appropriate technology to support to accommodate this space today is the WWW. However there are problems in that the information on the WWW is intended for human use and is often not friendly towards machines. From the early stages of development it was identified that a future direction would have to provide data that would be readable by computers so that they may interact with the web more effectively [3]. It is in this environment that web-based Information Retrieval (IR) systems or Search Engines have been developed [4] and at this point, a clear link can be established between the TRIZ problem solving process and the search engine IR process. Both processes match a query and a result (problem and solution) in 'generalised space' where data is in a format that is friendly to the tool (whether it is TRIZ tools or the search and match function). This suggests that IR Systems (web based or otherwise) and TRIZ can feature in a highly effective symbiosis as shown in Fig. 1.

Fig. 1 indicates the possibility that a document processor may potentially eliminate the need for user experience by providing the necessary knowledge or information from the WWW. The approach developed here in proposes a process based upon an inverted file that can be created by a document processor using the rules and tools of TRIZ to form a 'generalised solution database'. The challenge then becomes designing an ontology structure based on the TRIZ framework which will allow a classification of data suited to problem solving applications.

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doi:10.1016/j.compind.2012.01.006

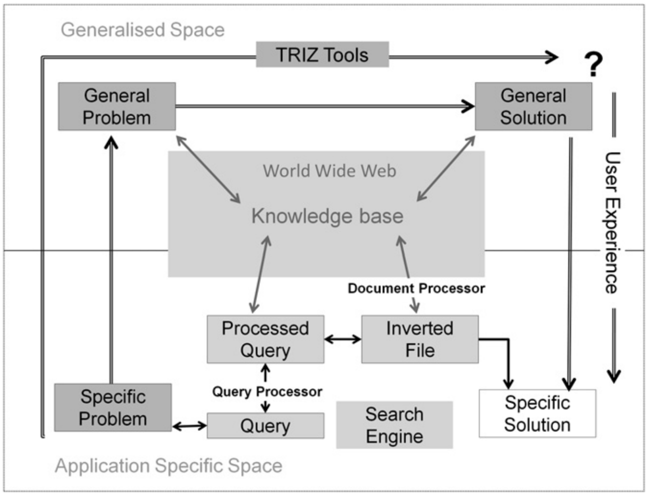

Fig. 1. The TRIZ problem solving process incorporating a web based IR system.

The magnitude of the effort needed to support this approach at a local and global level has been previously considered from the perspective of an organisation needing to access and distribute internally information associated with previous experience [5]. The paper also examines the means by which information located outside of the company can be integrated into the design process. Based upon the problem solving framework used by TRIZ to transform specific problems into consideration of the Main Useful Function (MUF) the authors propose the formation of an internal database. This will use a drop-down menu from which the user will select a function and define the state of matter which it is to function in. The database returns a list of scientific effects and inventions which perform the function requested. This is considered in more detail in Section 2.2 of this paper.

Access to the database allows designers to exploit all the knowledge contained therein. What is proposed is a 'matrix search' tool that can support this process. The paper considers how information gleaned from activities such as patent searching can identify conflict resolutions that may be used to support innovation at the company level whilst identifying the potential of extending such ontology on a global level. The paper concludes that if such a system is to become truly effective it must be self-updating [5]. This is a difficult challenge even when confined to a managed resource.

Given that the WWW is a virtually limitless source of information, any search for relevant information must be confined to 'solution domains'. These are regions that contain the information needed to support the creative design process. The WWW contains an almost infinite pool of solution-rich web domains some of which are currently being explored in relation to their providing inputs into the various elements of the TRIZ process. The most obvious and in some ways accessible source of such information is patents. Consequently there is a great deal of interest in this topic within the computer aided design and innovation community.

2. The TRIZ methodology

TRIZ provides the basis for innovation as it evolves solutions towards an ideal embodiment largely based upon existing knowledge, following a process referred to as ideality. This process considers that not only are problems and solutions repeated across industries but patterns of technical evolution are repeated across technical systems as well. The potential benefits of such a development are great, particularly in an environment where the sharing and distribution of knowledge can be supported through accepted communication and resource infrastructure that is readily accessible using the WWW.

The accepted model for the generic process of TRIZ problem solving is represented in Fig. 1. The user-specific problem is abstracted into a generalised form and solved in this generalised form using the TRIZ tools. From this generalised form it must then be concretised to produce a specific solution. The arrows on the edges of Fig. 1 labelled 'TRIZ Tools' and 'User Experience' are intended to highlight the use of TRIZ and its limitations. The first arrow indicates the steps that the TRIZ toolset can take the user through. TRIZ is effective when it comes to producing a general solution (with numerous specific applications) from a specific problem. Note that TRIZ tools match a generalised solution to a generalised problem, thus working in a 'generalised space'. The basis of TRIZ is to apply design knowledge using the principles of inventive problem solving to support creativity and invention. These principles are utilised to solve problems in the generalised space which is detached from the specific solutions (or patents) that they originated from.

The downward arrow at the right of Fig. 1 indicates how the process of finding a specific solution from the TRIZ evolved general one is highly dependent on user expertise and knowledge. There is a however a knowledge gap in the problem solving process and this is the area of most concern to the continued deployment of TRIZ methodologies. In order to explain why such a gap should arise it is necessary to briefly consider the tools available within TRIZ. For the purpose of this paper these may be conveniently divided into four main paradigms: Contradictions, Functionality, Ideality and Use of Resources, each of which is briefly considered below.

2.1. Contradictions

This is the most known and utilised field of TRIZ. It is based on Altshuller's axiom that an inventive solution to a problem involves the removal of a technical contradiction within the system in question [6]. During the analysis of patents TRIZ researchers identified the engineering characteristics of technical systems (such as temperature, reliability, loss of energy, etc.), which come into conflict to produce a technical contradiction. This evolved into the most widely used tool of TRIZ: The Contradiction Matrix [6]. This takes the form of a 39×39 matrix in which all the possible conflicts are represented by the 1482 coordinates. Forty so-called 'Inventive Principles' were identified as being potentially capable of eliminating contradictions so allowing an inventive solution to be reached. A number of the forty Inventive Principles were allotted to each of the matrix coordinates to serve as guidelines (or general solutions) to solving the problem being investigated.

Using the matrix within the TRIZ process it becomes possible for the user to isolate the relevant contradiction in their problem. The effective operation of this process remains a challenge that is central to the developments outlined in this paper and in the work of many other researchers. Once this has been done, the coordinate on the matrix corresponding to the user's contradiction will display the appropriate inventive principles. These are in effect general solutions to the initial problem; the limitations of the approach arise due to the lack of context in these solutions. To contextualise this process it is possible to develop a simple example. Suppose an inspection process is trying to measure the flatness of a plate, which is currently requiring the taking eighteen different measurements against a parallel datum with a bar micrometre. This process is arduous for an operator and inefficient. Reference to the Contradiction Matrix suggests, amongst other inventive principles, Principle 17 'Transition into new dimension.' In this case this means a transition from one to two dimensions, and the solution to the measurement problem could be to develop

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