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Using the Collective Intelligence for inventive problem solving: A contribution for Open Computer Aided Innovation

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ABSTRACT

In the industrial context, an interest exists in the collective resolution of creative problems during the conceptual design phase. In this work we introduce an information-based software framework useful to collaborate for inventive problems solving. This framework proposes the implementation of techniques from the Collective Intelligence (CI) research field in combination with the systematic methods provided by the TRIZ theory. Both approaches are centered in the human aspect of the innovation process, and are complementary. While CI focuses on the intelligent behavior that emerges in collaborative work, the TRIZ theory is centered in the individual capacity to solve problems systematically. The framework's objective is to improve the individual creativity provided by the TRIZ method and tools, with the value created by the collective contributions. This work aims to contribute formulating the basis to extend the research field of Computer Aided Innovation, to the next evolutionary step called "Open CAI 2.0".

1. Introduction and scientific context

Nowadays, the act of innovation is a social activity, which requires the management of knowledge, and the techniques and methodologies to drive it. As Yannou, Bigand, Gidel, Merlo, and Vaudelin (2008) remark: innovation is not the product of one isolated intelligence, instead, it is the result of a multidisciplinary workgroup led by a process or a methodology. In the last years, the open innovation paradigm has attracted the attention from researches and business communities, because it is a model that promotes the open participation in the way to generate and commercialize the ideas and technologies; specifically it requires a high degree of interaction between participants—internal and external—who develop strong and weak relationships (Michelfelder & Kratzer, 2013). As a branch of innovation management, open innovation is a paradigm that suggests a change from a closed to an open model (Duval & Speidel, 2014). Chesbrough (2003) coined the term to present under the same denomination a group of existing management practices; Chesbrough defined open innovation as "*the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively*". Therefore, the adoption of open innovation concerns two complementary modalities: outside-in and inside-out processes (Gassmann & Enkel, 2004).

Outside–in or inbound is the integration of knowledge, ideas, concepts or technologies externally generated. Namely, it denotes the integration of outside sources of innovation within one or more phases of the internal R&D process (Herzog & Leker, 2011). Inside–out or outbound, is the transfer of internal ideas or technology toward the market through external channels in order to generate additional value; concerned technologies are those not exploited commercially because they do not correspond to the enterprise business model (Chesbrough, Vanhaverbeke, & West, 2006). The inbound activities related to conceptual design of new product/process are perhaps one of the main difficulties the manufacturing industry faces, because of the highly demand for creative solutions. In this scenario, active researches are oriented to provide the means in the form of methods and computational tools for generating innovative ideas (Hüsig & Kohn, 2009), providing structured approaches to problem solving (Ilevbare, Probert, & Phaal, 2013), and harnessing the benefits of the collective effort of individual intelligences (Garcia-Martinez & Walton, 2014). Hence, the main objective of our proposal is to provide the elements for an information-based framework to improve the capacity for addressing the collective creative effort of participants during the preliminary (critical) phase of conceptual design. Consequently, it is important to understand the techniques, methods and tools that best support the generation of novel ideas and creative solutions. In addition, it is necessary to study the contribution of Information and

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[1] Lopez Flores is a family name that may be ambiguous; it is according to Spanish naming customs: composite with two family names.

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Acronyms

CAD	Computer Aided Design
CAI	Computer Aided Innovation
CBR	Case-Base Reasoning
CI	Collective Intelligence
ICTs	Information and Communication Technologies
LOD	Linked Open Data
NPD	New Product Development
OWL	Ontology Web Language
R&D	Research & Development
RBR	Rule-Based Reasoning
RDF	Resource Description Framework
RHA	Rapid Heat Ablation
RSS	Really Simple Syndication
SOA	Service Oriented Architecture
TRIZ	Theory of Inventive Problem Solving
XML	eXtensible Markup Language

Communication Technologies (ICTs) as tools to effectively support the collective work during the inbound process of open innovation.

The use of purposive inflows of knowledge in the phase of conceptual design makes necessary the incorporation of new technologies to collaborate across geographical distances (Huizingh, 2011). It is acknowledged (Enkel, Gassmann, & Chesbrough, 2009), that the developments in Internet and Web technologies enable companies to interact with different sources during innovation activities. Consequently, these technologies allow to set up distributed collaborative environments to bring together the resources and the experts who can relate the existing pieces of knowledge to new contexts (Lee & Lan, 2007). But the adoption of a collaborative technology does not necessary contribute to the implementation of open innovation in the companies. On the other hand, collaborative technologies facilitate the aggregation of multiple intelligences for the search of new ideas and innovative solutions within a community. Thus, the collective search of innovative solutions is the result of the aggregation of multiple intelligences. However, an organization is required to aggregate the Collective Intelligence (CI) to complete, improve and implement an idea that seems innovative (Christofol, Richir, & Samier, 2004). According to Zara (2008), the challenge of CI and knowledge management is how to improve the collective efforts in order to be better than individual efforts. Zara defines CI as "*the capacity to join intelligence and knowledge to achieve a common objective*". CI takes a new dimension with the incorporation of the information-based systems. For example, the center for CI at the MIT develops systems to connect people and computers so that collectively they act more intelligent (Leimeister, 2010).

As an application of the CI, crowdsourcing services are useful in the implementation of open innovation (Enkel et al., 2009). According to Yankelevich and Volkov (2013) crowdsourcing is "*the act of delegating (sourcing) tasks by an entity (crowdsourcer) to a group of people or community (crowd) through an open call. Individuals (workers) within the crowd are usually rewarded for completing a task*". An example of the application of crowdsourcing services for open innovation is the InnoCentive platform, which aims to connect people having innovation problems with solution providers to solve business inventive problems (Allio, 2004).

On the other hand, in the industrial context is required to have approaches and supporting tools to help product design, particularly in preliminary phases, where is highly desirable to produce original and inventive solutions. The concept of collective problem solving is seen as a process that occurs among a group of people, in which a shared solution is constructed, defining the conceptual characteristics of a new product. Collaborative innovation reflects the growing interest among industries in developing methodologies and supporting tools. Currently, the innovation process in existing platforms that gather the CI is chaotic and not structured. For Majchrzak and Malhotra (2013) the problems with existing architectures of participation are: minimal collaboration, minimal feedback on idea evolution and isolated efforts to develop new ideas. On the other hand, the TRIZ methodology is presented as systematic approach to developing creativity for innovation and inventive problem solving (Ilevbare et al., 2013). However, software solutions inspired in TRIZ such as Computer Aided Innovation (CAI) tools, are limited to the practice of the closed model of innovation (Hüsig & Kohn, 2009; Leon, 2009). Therefore, the evolution in the development of CAI tools needs to take into account changes in innovation management and recent advances in collaboration technologies.

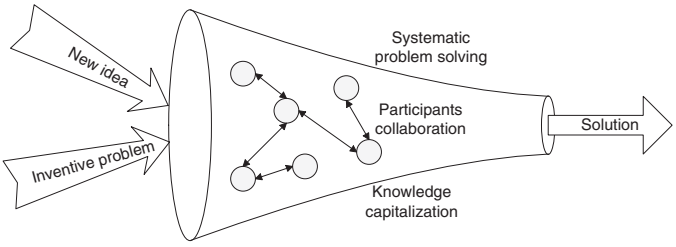

Fig. 1. Directing inventive problem solving under Open CAI 2.0.

Unlike existing implementation of crowdsourcing services for open innovation (i.e., InnoCentive, NineSigma or Hypios), in our contribution, we look at providing the participants with the elements to develop creative solutions under the logical approach of the TRIZ theory. Consequently, the incorporation of the logical approach to crowdsourcing services and vice versa, comes to advance current software solution in the CAI domain. Specifically, this work explores the implementation of the theoretical elements defined in the Open CAI 2.0 concept (discussed in Section 3.1). A general use case to illustrate the approach of this work is presented in Fig. 1. As observed in the figure, the process starts either with a new idea for general situations (e.g., a new development), or an inventive problem for a specific problematic situation (e.g., root cause known). In both cases, the systematic problem solving process provides the elements to reformulate the problem using well-defined models. A solution is built within a group of participants who collaborate; the generated knowledge through the process is managed for capitalization.

To meet the general use case requirements, the paper is organized as follows. Section 2 introduces the concept of CI, its use in the innovation process and its implementation mechanisms. The case of crowdsourcing services is particularly discussed. The limitations while driving creativity in the process of problem resolution are discussed. Finally, the creative design and the TRIZ approach are defined. Section 3 presents different aspects related to the framework core components, its functionality and interaction. Thus, the core elements are presented covering (a) the innovation process based on a problem resolution approach and its implementation via the TRIZ-CBR model; (b) the collaboration support; (c) the architecture of participation and the mechanisms for gathering the CI, and; (d) the main sections of the graphical user interface. The evaluation to demonstrate the feasibility is presented in Section 4 with an example of a rapid prototyping tool. Finally, Section 5 discusses the conclusions and perspectives about future work.

2. Collective Intelligence as an innovation driver

In a world increasingly interconnected via Web technologies, new challenges and opportunities are emerging to manage the innovation process in industries. The business model proposed in existing crowdsourcing services is an effort to democratizing the innovation