Frontiers of Information Technology & Electronic Engineering
www.zju.edu.cn/jzus; engineering.cae.cn; www.springerlink.com
ISSN 2095-9184 (print); ISSN 2095-9230 (online)
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A swarm intelligence design based on a workshop of meta-synthetic engineering

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Received Jan. 3, 2017; Revision accepted Jan. 13, 2017; Crosschecked Jan. 13, 2017

Abstract: In this paper, we present a swarm intelligence design technology based on a workshop of meta-synthetic engineering, including the architecture, the decision-making process of swarm intelligence design based on a meta-synthetic workshop, and the design resource delivery technology involved in the design. We conclude the paper with a discussion of future research.

Key words: Meta-synthetic engineering; Swarm intelligence; Design resources delivery
http://dx.doi.org/10.1631/FITEE.1700002 **CLC number:** TP391

1 Introduction

The era of 'Internet plus artificial intelligence' is coming. The rapid development of the new generation of information and communication technology, the important breakthroughs in intelligence science and technology, and their deep integration with manufacturing technology are initiating a game-changing transformation in the manufacturing model, process, and means, and in their ecosystems (Li *et al.*, 2010; 2015).

Swarm intelligence refers to an emerging artificial intelligence technology whose capacity is beyond that of individuals in terms of intelligence. Swarm intelligence emerges when a specific organizational structure attracts, pools, and manages large-scale autonomous participants, to jointly cope with challenging tasks, in particular those in the open environment of a complex system, in the way of competitive cooperation (Andreasik, 2009; Li, 2016; Pan, 2016). The deep fusion of swarm intelligence technology with product design technology in particular in manufacturing industry will lead to great changes in the design pattern and design means and to improvement in efficiency (Lee and Chang, 2010; Ripon *et al.*, 2012; Hassani *et al.*, 2015). For example, in the United States, the time taken for the design, prototype manufacturing, and marketing of various vehicles has been greatly reduced through swarm intelligent design using thousands of car design enthusiasts at the website of Local-Motors.com.

As early as the 1980s, a famous Chinese scientist Xuesen QIAN had put forward the idea of a semi-theoretical and semi-empirical approach that combines scientific theory with individual's experience and expert assessment. He presented the 'qualitative-quantitative meta-synthetic approach' and the 'qualitative-quantitative meta-synthetic engineering workshop system' (hereafter referred to as the 'meta-synthetic integration method'). The essence of this method is to combine expert groups, statistical data, and information materials with computer

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technology to form a highly intelligent man-machine integrated system, which is used to address the issues arising in complexity science (Qian *et al.*, 1990; Dai and Cao, 2002).

In this paper, we present a swarm intelligence design technology based on a workshop of meta-synthetic engineering, including architecture, workshop process, and design resource delivery technology. At the end of the paper, future research is envisioned.

2 Architecture of swarm intelligence design based on a workshop of meta-synthetic engineering

The architecture of swarm intelligence design based on a workshop of meta-synthetic engineering is as shown in Fig. 1.

Resource layer: It provides dynamic, shared, and reusable resources with a variety of distributions for the product's swarm intelligence design applications, including hardware, software, and network resources required for the basic operation, and the knowledge, data, models/services, algorithms, case resources, and others for the design field and workshop process.

Core support function layer: It includes the basic support layer and the core function layer. The basic support layer provides the workflow engine, the distributed virtual workshop space, resources management middleware, and CAX/DFX tool integration, constituting an interconnected runtime environment among resources, tools, and users. The core function layer provides functions such as product design, project sponsoring, task management, workflow management, workshop modeling, design resources search and smart delivery, meta-synthetic workshop, and multi-attribute decision-making. It helps users conduct product design and seminars.

Application layer: It provides groups/individuals-centric interactive interfaces for swarm intelligence and a meta-synthetic workshop to accomplish the innovative product design in a cooperative and efficient way through the use of various design tools and knowledge, cases, and other resources by users, which facilitates information sharing and communication during iterative seminars and design processes.

3 Meta-synthesis workshop process and design resources delivery

In the meta-synthesis workshop space, users submit their innovative design schemes through interactive multimedia. Subsequent group decision-making with respect to the design scheme will be

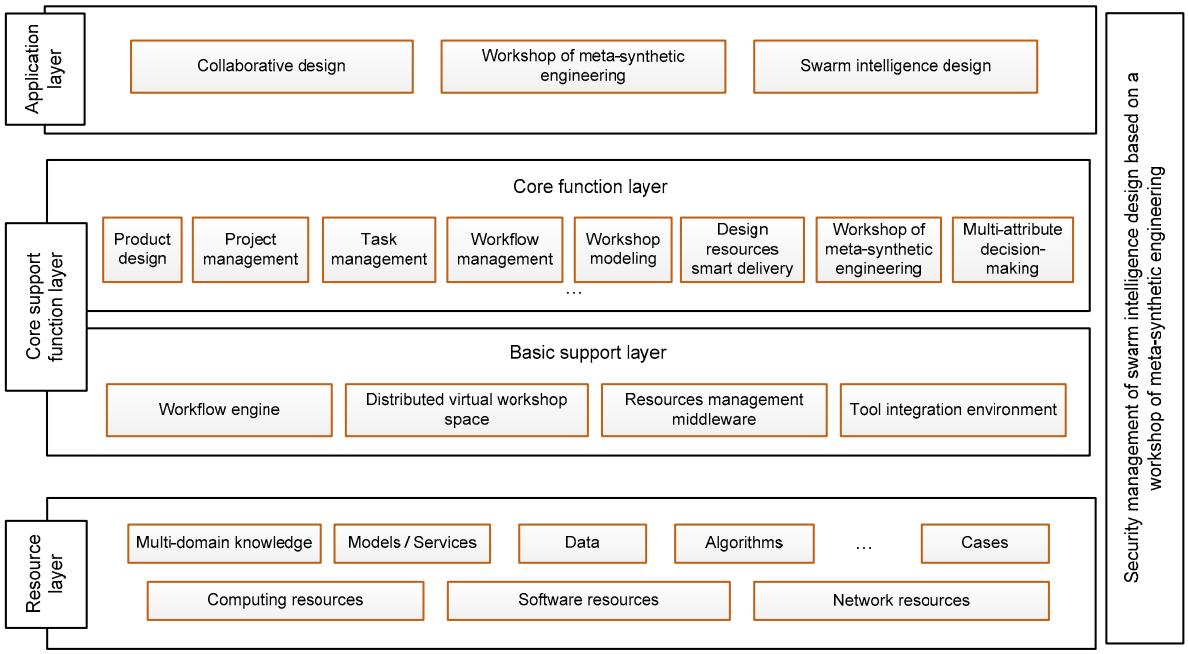

Fig. 1 Architecture of swarm intelligence design based on a workshop of meta-synthetic engineering

made under the organization of the sponsor. Fig. 2 shows the whole process from the presentation of issues for decision-making to the decision optimization, which includes the process of qualitative understanding, quantitative analysis, and independent decision-making of experts, and the procedure of conflict elimination and result optimization under the guidance of the sponsor, with the support of the core function layer. Usually, the decision-making process involves multiple iterations until consistent and convergent decision results are obtained.

In the swarm intelligence design environment, the user, expert, and the integrated product team (IPT) are inter-connected to form a highly integrated intelligence group through network technology, to conduct product design and rapid verification collaboratively by effectively using the basic hardware and software resources as well as knowledge resources. The design resources include all kinds of resources needed in the design activities and workshop process. In a broad sense, the design knowledge here refers to the design activities and their resource requirements obtained from existing design projects, enabling the sharing and reuse of historical design knowledge through smart delivery so as to increase design efficiency rapidly. The delivery of design knowledge includes mainly constructing the knowledge spectrum to characterize the knowledge, search and delivery process (Fig. 3).

4 Conclusions and future work

Swarm intelligence design technology based on the workshop of meta-synthesis engineering provides new models, new means, and a new environment for product design in the intelligent manufacturing field. It transforms the current isolated design pattern, which is individual user centric, into an interactive, collaborative, and social design pattern with the group users as the center. Through the extensive application of design resource management and knowledge engineering, and through smart search and delivery of design resources, it achieves rapid conceptual design and verification, opening the way for innovative design. The network technology used connects users, experts, and the IPT team to form a highly integrated intelligence group, breaking the limits between design organizations, and providing a possibility for the formation of open-sharing, cross-border integration, and a multi-innovation new environment.

In our follow-up work, there will be further integration with advanced information technologies such as cloud computing. Further research into establishing the meta-synthesis workshop cloud and cloud swarm intelligent space should be conducted. Meanwhile, study on the security technology for swarm intelligence design based on the workshop of meta-synthesis engineering should be strengthened to provide security mechanisms in terms of both technical safety and business security.

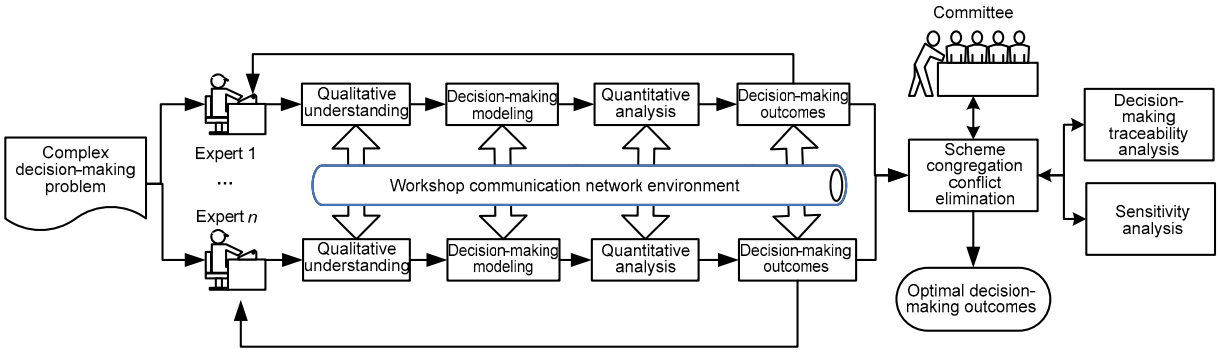

Fig. 2 Decision-making process of swarm intelligence design based on a workshop of meta-synthetic engineering

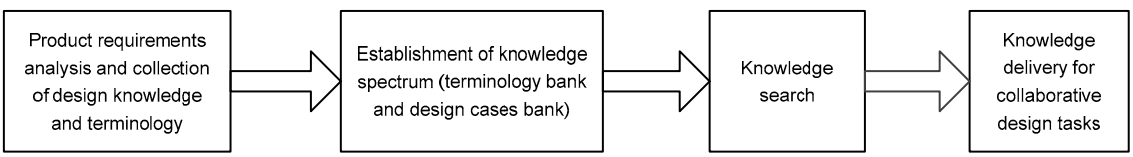

Fig. 3 Process of smart delivery of design resources

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