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EDITORIAL

One Thing is Certain in Design: Design is Uncertain

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There is one thing that is certain in design: design is uncertain.

The uncertainty in design is rooted in the nature of the design problem: the recursive evolution of design problem along with design solutions and related design knowledge (Zeng, 2004; Zeng & Cheng, 1991; Zeng & Gu, 1999). Design uncertainty takes many forms; one most acknowledged form is its unpredictability in that the future decisions are uncertain in its behaviour, in its value, and in its reliability; another uncertainty comes from misunderstanding in design communications in that people may have different perceptions for the same received information (Nguyen & Zeng, 2017; Tan *et al.*, 2016); the third one is resulted from the imperfect understanding of a design situation.

This issue presents three research papers addressing different aspects of design uncertainty.

The first paper, titled "Classification of Change-Related Ilities Based on a Literature Review of Engineering Changes" by Colombo *et al.*, argues that uncertainty is a major hurdle for effective and efficient system changes, which are central to the design of complex and innovative systems. A meta-framework is proposed to define and identify the needed Ilities that may facilitate changes in technical systems. Ilities represent a common terminology to reduce the ambiguity in effective communication of knowledge resided in best practices. Seven engineering change features are summarized based on nine change Ilities frameworks and about 330 sources. Founded on the systematic literature review of change-related Ilities, the authors aim to propose a classification of the Ilities in terms of system lifecycle. Some future directions are also discussed in the paper.

The second paper, titled "A Novel Modular Redesign Method for Mechanical and Electrical Products Aimed at Continuous Improvement" by Zuo *et al.*, investigates how to reduce design uncertainties by systematically clarifying customer needs and motivation in the early stage of design and by considering modular design methodology in the redesign process. A method called TAMCI was proposed for motivation analysis, in an effort to avoid biased problem formulation by meeting dynamic requirements of users, focusing on the development direction of the industry and responding to the major concerns of the community. The concept of the continuous improvement is also integrated into the modular design of products.

The last paper, titled "Uncertainty in Communication with a Sketch" by Ekwaro-Osire *et al*, aims to understand and quantify the uncertainty associated with imprecisely defined sketches. To address this issue,

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this paper established a framework for the quantification of uncertainty for the improvement of design communication. The framework consists of three major components, which are, first, to determine the ranking of the features in a sketch; secondly, to determine the probability of importance of the features in a sketch, and finally, to quantify the uncertainty of a sketch using Shannon's normalized entropy. Examples are used to demonstrate the effective use of the established framework. The same research line may be extended to quantify other uncertainties in design representations.

Design uncertainty is an issue attracting more and more attentions in design and reliability research. While we also welcome the work on design uncertainty that can be handled beautifully with sound mathematical theory, we strongly encourage authors to submit their investigations into the formal formulation of the uncertainty issues associated with early design stages that are often believed to be challenging for mathematical quantifications.

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