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EDITORIAL

Knowledge production, sharing, and design in an age of fundamental transformations

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Knowledge is a central constituent of the societal infrastructure. Knowledge is produced, interchanged, represented, and used for different purposes. In societies, where tangible or intangible artifacts are essential elements of the interaction of humans with the environment, knowledge is a central piece of the reasoning and realization mechanisms of artifacts. In turn, those artifacts can become a source of knowledge production. It is not a human specificity to produce, share, use, or transmit knowledge. Several studies have demonstrated that species such as whales enjoy this capability too (Whitehead et al., 2021). This means that producing and sharing knowledge is associated with social interactions both for humans and whales' groups. On the contrary, social interactions of extremely large groups and the capacity to interact and collaborate with distant, unknown fellows is probably a human specificity. This collaboration implies the sharing of knowledge in a format ensuring diffusion and interchange. But what is happening when a new phenomenon such as knowledge produced by machines can become a reality? Is this extended collaboration remaining human specificity?

Professor Horvath with his paper titled "*On Reasonable Inquiry and Analysis Domains of Sympérasmology*", clears the way by providing an interesting contribution to the theory of synthetic system knowledge (SSK). His contribution opens a new area of investigation permitted by complex systems and their capacity to produce knowledge and use it intelligently.

For us humans, all those elements can be the source of apparent intractable complexity. When faced with the emergence of complex phenomena, a seductive vision of complexity as an emergent, auto-organizing phenomenon is prevalent in multiple communities and crosses multiple domains of sciences such as computing science or economy. Self-organization as such is an interesting line of research but considering that complexity and self-organization can take care of themselves, and without a deep understanding of the multiple interactions, complex control and adaptation is a detrimental approach and can be the source of negative impacts. It is dangerous to see self-organization as an assumed self-organizing property of complex systems. This is, for example, a commonly adopted perspective in the mainstream economic school of thought. Another example is the behaviour of the Internet that gives the illusion of robust self-organizing structures despite high uncertainty in the environment itself. The reality is that for those systems complexity is hidden and that sophisticated control and adaptation procedures of designed systems exist.

Complexity can and should be designed. This can be supported by providing a leading role in the design process to the description of the environment of the system. This is an approach favoured by multiple

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domain experts. Indeed, in multiple domains of knowledge where the design of artifacts is a central activity, such as engineering, biology, or chemistry, successful design approaches tend to favour descriptions of the systems based on external conditions. Those external conditions are the description of the external environment and requirements combined with a detailed description of the structure and architecture of those systems. They are associated with models used for prediction, prescription, or analysis (Simon, 1990).

This pragmatic approach of design is conflicting with the tendency to view complexity emerging from those systems as a phenomenon resulting from a collection of agents auto-organized into a complex state, balanced between order and chaos (Carson et al., 1999).

Professor Zeng in his paper titled "*Environment: The First Thing to Look at in Conceptual Design*" contributes to the vision of a designed and planned complexity by emphasizing the importance of environment analysis, which is one of the three activities in the Environment-Based Design (EBD) theory.

A skilled and experienced designer will consciously decide to spend time and resources to describe the environment of the system to be designed and will avoid jumping too quickly into design solutions. This is especially true at the conceptual design stage when multiple important decisions, for the success of a design project, must be taken. Professor Zeng in his paper proposes an actionable method to support the conceptual phase.

The design process is also involving detailed design phases where the functions, geometry, the behaviour of the system must be described. The behaviour can be complex and evolve over time and space. Consequently, developing a formalized spatiotemporal description of assembly product motion knowledge is an important task. This is what Dr. Khan and his colleagues are proposing in their paper titled "*Interval Algebra and Region Connection Calculus for Ontological Spatiotemporal Assembly Product Motion Knowledge Representation"* and their analysis of the systems' behaviour is fundamental.

A complementary approach to design is the use of biologically inspired solutions in design. Finding inspiration in nature is a good idea. Naturally and artificially designed systems share some common properties, both of which seem often governed by a type of modern golden ratio, namely power laws. Power laws are present in statistical distributions, and governing laws in a variety of phenomena such as wealth distribution, Internet traffic, complex technical properties of systems such as planes, fluid dynamics, the International System of Units, fractals, blood vessels architecture, or animals proportions.

Several works in the statistical physics and technology domain tend to demonstrate (Carson et al., 1999) that the presence of power-law distributions in measured data from complex systems is the norm and not the exception. Power laws seem to be resulting from hierarchical structures in complex systems and the constraining effect of systems of units. This intriguing ubiquitous presence of power laws in nature can also be a source of inspiration for a kind of biologically inspired design relying on the use of power laws.

Dr. Liu and her co-authors are contributing to this volume by proposing a work titled "*Effects of Function-Based Models in Biologically Inspired Design*", exploring the effects of different function-based representations in Biologically Inspired Design. They evaluate the impact of different representations as creative stimuli to obtain recommendations for nurturing innovation in education and training practices.

The research papers presented in this volume offer interesting contributions to themes such as knowledge representation and theorization. This is involving tasks such as mapping human knowledge, extracting knowledge from signal flows, data streams, and information representations, and knowledge synthesis. The volume is also presenting research works integrating different forms of knowledge in the design process.

All of those aspects are very important, but this editorial will not be complete without a small attempt to list important remaining challenges. One key idea in many disciplines is to spend time and efforts to properly formulate a problem, because "a well-stated problem is already half-solved"(Godet, 2000). Undeniably, a central problem in engineering design is the growing complexity of systems and system of systems. The underlying reason is the growing network of requirements to be integrated by those systems. Using the words from Professor Zeng's article, "the natural, the built and the human environments" of the new design systems are significantly broadening. Simultaneously the cognitive aptitudes of human designers remain stable. How do we solve this paradox with constant cognitive capabilities?

A simple answer will be by providing better support tools. It can be improved support tools such as approaches favouring system-oriented thinking (Mobus et al., 2015), or a more radical use and operationalization of analytical concepts coming from different philosophical and engineering traditions such as the concepts of ideality or contradictions (Jordan, 1967) (Dunham et al., 2011) (Savransky, 2000). This should be combined with the creation of efficient design companions in form of a new type of intuitive computer tools. Those tools should be capable of learning from few examples, which is similar to how humans learn. They should support designers efficiently by providing insights in the form of prescriptions or analyses, in form of human-friendly cognition modes. As an example, those methods should be able to reason using qualitative reasoning and provides analyses in form of cause-effect relationships. Such methods are implying the development of novel Machine Learning methods and approaches inspired by qualitative reasoning methods using very small data samples potentially containing imprecisions and uncertainties. Those future tools and methods should also interact using different senses and communication modes. JIDPS will continue to publish excellent articles on those themes and relevant emerging research topics.

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Dr. Eric Coatanéa received his BS degree in mechanical engineering in 1990 from the University of West Brittany, France, his MSc in mechanical engineering from INSA Toulouse, France in 1993, and his teaching certification from Ecole Normale Supérieure of Cachan, France in 1994. Professor Coatanéa worked for 11 years as a teacher of manufacturing engineering at the University of West Brittany while in parallel being very active in track and field. He embarked on joint doctoral studies in 2002 and received his joint Ph.D. degree in mechanical engineering from Helsinki University of Technology, Finland (nowadays Aalto University) and University of West Brittany, France in 2005. Dr. Coatanéa is currently heading the Additive Manufacturing systems research group at Tampere University. His research interests include engineering design theories, systems engineering, and manufacturing methodologies.