

**Mihail C. Roco, William S. Bainbridge,
Bruce Ton), George Whitesides (Eds.):**
*Convergence of Knowledge, Technology and
Society: Beyond Convergence of
Nano-Bio-Info-Cognitive Technologies,*
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The main ideas of this noteworthy volume are that there is an evolutionary process toward convergence, which started with nanotechnology, and that this process needs a new stage, involving knowledge and technology, for the benefit of society (CKTS), as a desideratum for progress, in general, and for establishing a future knowledge society, in particular. Starting from these ideas, the editors mention that the book is a study aiming at proposing solutions for challenges such as accelerating technological progress, increasing economic productivity, stimulating creativity and innovation. An important aim is directed toward improving human life: healthcare, education, and enhancing human physical and cognitive potential, the latter aim being linked to the development of a cognitive society, which we may see in a transhumanist perspective.

CKTS is considered as a third stage of convergence, after those of nanotechnology (which included a convergence of research and development in biology, chemistry, physics, electrical engineering, etc.) followed by the convergence of nanotechnology, biotechnology, information, and cognitive technologies (NBIC). This evolution also involves, after each stage of convergences, spreads/divergences of the achievements.

The study is based on the results of a series of five workshops held from November 2011 to October 2012 in the USA, South America, Europe, and Asia, involving, in

brainstorming sessions, experts from all over the world, covering academia, industry, government, and NGOs, some of them being authors of the book's chapters.

The book has a comprehensive introduction, ten chapters conceptually grouped in two parts, references, and appendices. Each chapter has the same sequence of sections: Changes of vision over the past decade and vision for the next decade; advances in last decade and current status; goals for the next decade; infrastructure needs; R&D strategies; conclusions and priorities; R&D impact on society; examples of achievements and convergence paradigm shifts; description of the panels during the workshops dedicated to the chapter's topic.

The first part of the book contains four chapters, which present platforms for convergence. The first chapter is dedicated to the foundational tools (NBIC), mainly considering nanoelectronics, brain imagery (and brain modeling), and cognitive computing. The main subject of the second chapter is the relation between humans and technology: human-robot interaction, arts and culture in the context of multi-player online role-playing computer games (MMOs), digital government, post-industrial society, and the extreme post-humanist idea of mind uploading. Monitoring and management of environmental problems is the subject of the third chapter, specific topics being water management, global "nano-geobiochemistry", global climate-change, and Spaceship Earth Mission Control Center. The last chapter of the first part discusses several means for achieving the convergence ideals.

The second part of the book contains six chapters dedicated to the implications of the envisioned convergences. The fifth chapter discusses the implications for health: health monitoring, cancer detection and treatment, regenerative medicine and advanced prosthetics, new types of vaccines (this last topic being now very well known for us after the success of the new vaccines against Covid-19). The sixth chapter is dedicated to human cognition and cognitive society: cognitive technologies and the understanding of human cognition, with the aim of construction of the "cognome" ("the rule set that subserves decision making"), a new concept that is introduced starting from an analogy to the "genome".

The relation between manufacturing and social sciences is the subject of the seventh chapter, with examples from ethnomethodology applied to computer science (in an Xerox PARC case study), and wearable computers and sensors. The eight chapter discusses about education, giving also details about many universities and research institutes involved in NBIC and CKTS. Problems of water, agriculture, food, energy, minerals, materials, climate change, and environment related to a sustainable society and how knowledge and technology can contribute are the topic of the ninth chapter. Eventually, in the last chapter are presented directions for the governance of the convergence in the considered domains.

The CKTS studies presented in the book are the result of an amazing collective work of a considerable number of experts from various domains, covering a wide range of topics, following the very generous and ambitious aim of converging efforts for achieving the progress and well-being of humanity. The reader may find state-of-the-art achievements in many domains that are considered for a convergence, a non-exhaustive enumeration being: electronics, semiconductor manufacturing, nanotechnology, noninvasive brain imagining, biology, cyber security, risk management, human-robot interaction, computer games, wellness-focused medicine, oncology, climate change, and administration. Moreover, ideas for managing convergences are proposed, including details for the domains of education and government.

The book puts a lot of emphasis on nanotechnologies and their convergence with other technologies and knowledge for the development of a cognitive society and cognitive science. Many pertinent analysis and proposals may be found, relevant examples are included. Nevertheless, due to the complexity of the subject, it is normal that it is hard to cover everything, and some subjects are inherently less considered. For example, one of the main domains of cognitive science, artificial intelligence (AI) could have a wider extent in the book, as it is in a subsequent paper of the main editor of the book [Roco, 2020]. This fact is now very important because, since the publishing of the book, it is said that we entered in the AI era, which may be considered that it converges with the cognitive society envisioned by the CKTS book. Moreover, the new concept of cognome, introduced in Section 6.3.2, which needs further clarifications, might be viewed related to the approaches of developing knowledge bases in the symbolic AI. Furthermore, in the recent years, major advancements were obtained due to the achievements in deep artificial neural networks such as Convolutional Neural Networks (Gu et al., 2018) and Transformers [Vaswani et al., 2017], enhanced also by hardware implementations like the tensor processing units (https://semiengineering.com/knowledge_centers/integrated-circuit/ic-types/processors/tensor-processing-unit-tpu/).

A central concept of the book is the future cognitive society. One interesting, related idea is the proposal for creating and implementing higher-level, multidomain languages (Section 4.3.2), music being one suggestion of the authors. I agree that music is an universal language, known from ages. However, I would add to it the human, natural language, which is an universal way of communication (especially now, on the social networks), and it suits in an important way the desired requirements, particularly in the new context, in which natural language processing (including language translation) is one of the main domains of AI, which benefited from the achievements of deep artificial neural networks in the last decade. In fact, computational linguistics has a central position in a cognitive society, and it should be included in a CKTS vision.

Convergence seen as a mean for evolution is the driving idea of the book. In addition, divergence processes are discussed as following convergences, spreading the achievements in many applications. An example emphasized in the book are smart phones, a remarkable achievement of a convergence of nanotechnologies, materials science, communication, and cognitive science, which had as consequence divergences in the direction of a large number of applications with major implications on the society. However, divergences should be considered not only as a "by product", they may have the role of generating contradictions driving to the need of a new convergence, fact that should be considered in the proposed framework in the book. Divergences may be viewed as having the same importance as convergences, as Mikhail Bakhtin exemplified by the analogy of centrifugal-centripetal forces [Bakhtin, 1981].

Arts, Humanities, and Culture, which are major elements of any human society, are briefly considered in the CKTS framework, and they would need more attention. I appreciated the proposal of music as a high-level, multidomain language in Section 4.3.2, but the only other discussion about art that I remarked is the case study of convergence in computer games, in Section 2.8.1. In fact, a discussion on the human nature would have been very useful, especially in the context of the proposed post-humanist, controversial project of mind uploading (Section 2.8.4). Moreover, the considerations about art and culture are important also because some new products and technologies may be successful if they take into account a specific culture and have artistic design, as was the case, for example, of the iPod revolution.

References

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