

Preface

In the past decades, the role and value of information has significantly increased in nearly all aspects of daily life. Information besides matter and energy has become a primary conceptual component of human thinking, as evidenced by the growing appearance of the word “*information*” in a widening range of contexts. Alongside the factories, power plants and relevant industries which provide, store, process and transport matter and energy, a system of infocommunication services providing analogous functionalities with respect to information now pervades our everyday experience. As a result, access to infocommunications has become a basic need, in much the same way as the ability to access electric power through outlets in walls is taken for granted. In fact, most services pertaining to matter, energy and information are co-dependent at various levels, with each service relying on others for its own sustained efficiency.

At the same time, it is important to realize that while services relevant to matter and energy primarily stem from and serve physical needs, infocommunications is motivated by and serves high-level mental activities, which are supervenient on human knowledge and intelligence. Given that human mental capabilities are generally more flexible to adaptation than material-energetic capabilities governed purely by physical-biological reality, new patterns, modes and structures are constantly appearing in the ways we interact with information. Coupled with recent advances in technology, this inventiveness in means of interaction is culminating in a process of human entanglement with information and communication technologies (ICT). This process has been identified and described by many authors, and can be observed from a number of different perspectives relevant at different scales of time, including the *key measures used to characterize the performance of new technologies*, the *multiple (physical) levels at which interaction can occur*, and the *increasing relevance of what we refer to as “human-oriented fields” in the development of new technologies*.

With respect to the ways in which the performance of new technology is characterized, it can be observed—at least in the case of personal informatics devices and from the perspective of end users—that measures of hardware performance are losing importance in comparison with high-level (soft) functional capabilities.

While 20 years ago the specifications of personal computers would have included details on power consumption, processor clock frequency, cache size and other low-level hardware details, later the capacity of random access memory, as well as networking and graphical capabilities gained relative importance. Today as end users of personal informatics devices, we rarely take note of such specifications, despite their still being accessible. Instead, we take for granted that a new device will include capabilities for the most common communication protocols, and will include a camera, for instance, that produces images of decent quality for most practical purposes. Even our focus on battery life is much more oriented towards capability than towards raw measures of hardware performance: if the battery life of a device can last for a full working day, most practical requirements for functionality will be satisfied. As this tendency continues, the specifications of personal informatics devices most important to us will soon be—and already are to some extent—those that focus on high-level capabilities built into and around the operating systems running on them, such as the richness of associated application stores, the various capabilities of built-in personal assistants such as Siri, Google Now and Cortana (including capabilities for generating and understanding speech, text, gestures and other emotional behaviours), or capabilities for handling multiple or multi-user profiles for family use. In the end, our personal informatics devices can be expected to evolve into tools that merely provide an “intelligent window” into a ubiquitously and collaboratively accessible augmented world of personalized information services—a fact that yields significant motivations, and important support for key notions behind research areas such as *speechability*, *ethology-based CogInfoCom* and *mathability*, as discussed extensively in the book. The capabilities of future devices will be judged based on the extent to which they are motivated by and fulfill the goals of such branches of CogInfoCom, and once this is the case, it can be said that these are the research areas which supply the most relevant parameters requiring specification.

With respect to the multiple levels at which interaction can occur (i.e. in terms of the second perspective behind entanglement listed earlier), it can be observed that the phenomenon of entanglement is gaining strength at levels of communication ranging from the low level of cell-electronics connections (as in, e.g., brain-computer interfaces and some areas of bionics) through connections expressed at the representational, structural or command level (involving, e.g., multimodal interaction), all the way to high-level collective relationships among populations of humans and ICT (involving e.g. high-level services based on data aggregation and analysis). These three levels and their impacts are discussed extensively in the book, in relation to research areas such as *CogInfoCom channels* and *socio-cognitive ICT*. The point is also made that as the three levels of interaction gain strength, they can be expected to influence each other in as yet unforeseen ways.

Finally, with respect to the increasing relevance of “human-oriented fields” in new technologies (i.e. in terms of the third perspective behind entanglement listed earlier), it can be observed that as our interaction with information evolves, both the theory and practice of infocommunications are increasingly relying on results from fields of scientific inquiry motivated by the goal of better understanding how

humans think, feel and act. In particular, all fields dealing with high-level aspects of human cognition, including even the humanities, can ultimately be expected to make important contributions. It is true that this is a slower process, characterized by a larger time constant than the processes of change behind functional capabilities and levels of interaction; nevertheless, it is important to note that the effects of such “human-oriented fields” can already be observed in the plethora of new research directions emerging within ICT. For example, the *Future Internet* concept that is actively supported by the EU has several branches that are strongly relevant to this phenomenon, such as the *Internet of Things (IoT)* and *3D Internet*. In IoT, the goal is to deploy as many sensors and actuators as possible into the surrounding physical network, enabling the measurement and actuation of previously inaccessible parts of physical-biological-mental reality. Irrespective of how the data collected in this way is represented, it will serve as a kind of informational, or virtual image of everything in the world that is important to us. Through the concept of 3D Internet, researchers are seeking ways to attribute 3D geometry to this growing collection of data—including both data that is naturally and directly amenable to 3D representation and abstract data sets requiring “virtual” visualization—in order to support our capabilities for interpretation and manipulation. The increasingly popular domain of *Big Data* also represents an initiative towards processing IoT data, albeit primarily in more automated, less human-interpretable ways. A common effect of these research areas is that a new infrastructure is emerging, which can be seen as a collection of artificial “*sensory organs*” that extend across the globe and are capable of extracting different kinds of information in a way that integrates humans into the picture. It can be expected that this human integration will eventually bring about new forms of entanglement, which extend through periods of time that are much longer than the relatively episodic interactions imagined today. New generations are already growing up in a kind of “*co-evolution*” with ICT, as evidenced by the growing number of psychological effects that have been documented with respect to changing cognitive-social-technological relationships. In the book, the term “*cognitive entity*” is introduced to characterize such entangled relationships in terms of cognitive capabilities. Further, the term “*generation CE*” (*generation of cognitive entities*) is introduced by analogy with the generations X, Y and Z, to reflect the fact that members of today’s generation are growing up in this new world starting from the first phases of their personal and social development, and that through their entangled co-evolution with ICT, they can be seen to embody an entirely new set of cognitive capabilities. The general conclusion is that if researchers would like to record, explain and understand the diverse phenomena surrounding human-ICT entanglement and newly emerging cognitive entities, as well as build new technologies based on those phenomena, then having recourse to results from relevant “human-oriented” research fields will be essential, in much the same way as the development of personal informatics devices today involves joint efforts from information and electrical engineers as well as experts of psychology and ergonomics.

The goal of the emerging field of cognitive infocommunications (CogIn-foCom) is to support the investigation of human-ICT entanglement related

phenomena as well as how such phenomena lead to new cognitive entities and the appearance of the generation CE. The field places special emphasis on the qualification and quantification of cognitive capabilities, and aims to adopt a multi- and interdisciplinary approach in doing so. The distinction between multi- and interdisciplinarity is an important one: while the formulation of the scope and goals of the field encourages the involvement of a large variety of pertaining disciplines, it also aims towards an integration of the perspectives and methodologies which they represent. Thus, besides aiming to create a common language, it is also the goal of CogInfoCom to establish a common way of thinking about relevant problems, and a common approach towards designing new technologies. This is not without challenges. The engineering sciences—and by extension, infocommunications—generally emphasize the synthesis of novel systems so as to provide functionalities that are guaranteed to be stable and reliable in at least some respect. Crucially, even the modeling of component structures and phenomena—serving as a prerequisite to engineering design—proceeds with these ultimate goals in mind. Considerations in engineering often do not extend to the requirement of holistic completeness; instead, specific interpretations are focused on that are relevant to specific design goals. In contrast, the primary focus of most branches of the cognitive sciences is analytical in nature, with the goal of recording, understanding and explaining cognitive phenomena in a way that is phenomenologically complete. However, such analyses do not necessarily lead to functional reproducibility. As a result, it is often the case that a set of experiments and models separately deemed precise from the perspective of an engineering field are seen as inadequate from the perspective of a cognitive science-related field, and vice versa. If a personal computer from our century were to have suddenly appeared functionally complete 100 years ago, surely its operation would have been described from a different set of perspectives than those descriptions that are accepted as blueprints for their production today. The former set of descriptions would also likely have been inadequate for the design of a fully functional computer. From the perspective of CogInfoCom, the key point is that while investigations in the cognitive sciences focus on a biological structure that has been highly differentiated through the complex processes of evolution, and that as a result cannot easily be “copied” or “reproduced” using today’s engineering concepts, it is nevertheless possible to obtain new knowledge by attempting to extend human cognitive capabilities through the synthesized design of technologies in infocommunications. This latter goal in turn necessitates a broadening in scope of the human-oriented methodologies used in the cognitive sciences to address (artificial) cognitive phenomena relevant to artificial systems.

It can often be observed that well-established research fields become more specialized, or perhaps show increasing signs of segmentation, while specific segments meet with previously distinct research fields to form completely new synergies. This process can be likened to the roots of a tree, which meet at various points to create the trunk, which in turn gives distinction to different branches, which then meet with the foliages of neighbouring trees. In this process, some researchers choose to maintain focus and achieve completeness in their own specialized research, while others instead are in constant search of new possibilities for synergy

with other fields. Although seemingly there may be a contradiction between the two approaches, in fact both of them together are necessary for the emergence of valuable new research directions. So it is the case with CogInfoCom: one can find in it the influence of well-established research fields (e.g. augmented cognition, human-computer interaction, virtual reality and others), while at the same time new directions and specializations are also appearing due to the unique viewpoint of the field, as discussed in several chapters of this book. It is important to emphasize that these new specializations born under CogInfoCom are often difficult, if not impossible, to categorize into already existing fields. Interesting and novel changes in viewpoint are often possible by considering various phenomena from tighter, or broader perspectives. All of these tendencies can be observed in parallel at the IEEE CogInfoCom conferences series. In some cases, sessions with well-specified topics have included presentations of researchers coming from widely different areas, such as information, medical or cognitive sciences, which has led to valuable exchanges with respect to a focused topic. In other cases, sessions named after completely new research directions appeared, and have included presentations which aimed to establish novel perspectives. This heterogeneity can also be observed in the fields represented by researchers who have co-authored papers at conferences and special issues on CogInfoCom; for example, joint papers were published together by researchers with backgrounds in computer science, systems and control theory, mathematics, ethology and cognitive psychology.

As in the case of all newly established conference series, the CogInfoCom conferences have been attended by both supporters and sceptics of the motivations and ideas behind the field. At the 3rd IEEE International Conference on CogInfoCom, it happened that a professor dealing with human-computer interaction voiced his criticism, saying that *“There is nothing new in CogInfoCom. . . it is just another name for what I am working on”*. Later at the same event, another scientist from the field of computational linguistics made almost the same remark, expressing his view that CogInfoCom was just another label given to the already existing field he was dealing with. As the same criticism was later raised with respect to cognitive informatics and neurocomputing as well, it is worth considering what these criticisms would entail, if accepted as true:

$$\text{CogInfoCom} = \text{HCI}$$

$$\text{CogInfoCom} = \text{computational linguistics}$$

$$\text{CogInfoCom} = \text{cognitive informatics}$$

$$\text{CogInfoCom} = \text{neurocomputing}$$

Were these equalities to be accepted as true, clearly they would also suggest relationships of equivalence among their right-hand sides—something that has never been claimed by any serious researcher acquainted with the scope and goals of these fields:

HCI = computational linguistics
computational linguistics = cognitive informatics
cognitive informatics = neurocomputing
HCI = cognitive informatics

...

No researcher has ever suggested that cognitive informatics is just another name for HCI, or that computational linguistics is actually the same as any of these fields. These facts go well to demonstrate the multi-disciplinary nature of CogInfoCom: the criticisms of novelty were raised by researchers who were all able to discover the motivations for their own work behind it, and yet, they all came to the same conference representing different fields, never before seen to have much in common! However, in addition to having this strongly multi-disciplinary background, the CogInfoCom conferences have also led to the formulation of a wide range of new research perspectives and initiatives, which, as outlined in this book, cannot be trivially broken down into the contributions of previously existing individual fields. Thus, the emergence of CogInfoCom has shown that the time is ripe for all of the cognitive + social + technological phenomena discussed above to be investigated from a unified perspective. For these reasons, we respectfully ask readers to look further than the ways in which their own research perspectives are represented in the book, and to support the development of CogInfoCom by actively looking for ways to approach this new and common perspective. In parallel to the process through which humans and ICT are merging together and becoming increasingly entangled, we encourage readers to help develop both our analytical and synthesis-oriented understanding of newly emerging cognitive entities.

Writing a book that does justice to the influence provided by the large number of fields behind CogInfoCom and also adequately represents the new perspectives it has brought about is a significant challenge. No attempt at meeting this challenge would have been possible without the invaluable suggestions and contributions of many people who have influenced our thinking about CogInfoCom over the years. Although providing a complete list of mentors, colleagues and students who have made such contributions would be impossible to compile, we would like to express our gratitude to Nick Campbell, Tom Gedeon, Hideki Hashimoto, Kristiina Jokinen, Toshikazu Kato, Tetsuo Kotoku, Joo-Hoo Lee, Gabor Magyar, Helen Meng, Adam Miklosi, Geza Nemeth, Mihoko Niitsuma and Csaba Pleh for their active involvement in initiating a common conceptual framework for further discussions at the very beginning of the CogInfoCom conference series. We would also like to thank Hassan Charaf, Valeria Csepe, Anna Esposito, Peter Foldesi, Hamido Fujita, Attila Gilanyi, Andras Hajdu, Karoly Hercegfi, Thomas Hermann, Ferenc Honbolygo, Laszlo Hunyadi, Lajos Izso, Joni Jamsa, Zsolt Janko, Anita Komlodi, Maria Koutsombogera, Laszlo Kovacs, Szilveszter Kovacs, Mika Luimula, Jean-Claude Martin, Frederic Noel, Harris Papageorgiou, Sakari Pieska, Claudiu Pozna, Radu-Emil Precup, Laura Slaughter, Bjorn Solvang, Wei Deng

Solvang, Peter Varlaki, Gabor Vattay, Klara Vicsi, Alessandro Vinciarelli, Carl Vogel and Yeung Yam, who have significantly contributed to the success of the conference series by helping to organize sessions and tracks that were often pioneering in their subject matter, and also by supporting through their work the appearance of several special issues on CogInfoCom in international scientific journals. We thank the entire CogInfoCom community for helping to create a friendly and scientifically stimulating atmosphere, as well as for bringing their valuable perspectives into the fruitful discussions held during and often—through e-mail and Skype—between the CogInfoCom conferences. Last but not least, special thanks is due to Anna Szemereki for her Herculean efforts in the organization of every last detail of the CogInfoCom conferences year after year.

Budapest, Hungary
April 2015

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<http://www.springer.com/978-3-319-19607-7>

Cognitive Infocommunications (CogInfoCom)

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2015, XIX, 219 p., Hardcover

ISBN: 978-3-319-19607-7