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EDITORIAL

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Focus on: Big Data, Cognitive Computing and Innovative Teaching Models

In this special issue, we want to focus on two main drivers of innovation that, in the last years, have emerged overwhelmingly from a plethora of equally prominent topics. Specifically, we refer to (*i*) big data and (*ii*) cognitive computing. In more detail, (*i*) is the wide availability of heterogeneous data coming from both software applications and diffuse sensor networks, which can be profitably managed by means of suited techniques, analysis tools, methodologies, and storage systems; (*ii*) is the adoption of innovative systems based on cognitive computing principles, which enable them to interacting with humans in an effective way, fostering collaboration among people and machines and the adoption of innovative decision strategies as well as personalized support systems for many fields of application, ranging from heavy industry to health. Moreover, cognitive computing and big data are often considered as a whole. In conclusion, we argue that both big data and cognitive computing, independently or joined together, will have a leading role in defining the directions for the future changes of IT systems and many other aspects of daily operations in people's everyday lives, including education.

As today, we are living in fast-changing times where society and technology are evolving rapidly as the relationships between humans and machines, which are undergoing a major change, involving persons, computers and the ever growing number of networked real-world objects, also including their mutual interaction mechanisms. In fact, owing to the speedy and unstoppable technological advancements, today a huge number of smart devices such as, e.g., wearable devices and smartphones, instruments, machineries and appliances are specifically designed to interact with people and are connected each other over the Internet or even in small Personal Area Networks (PAN), adopting common protocols and formats, thus being fully interoperable, based on the Internet of Things (IoT) paradigm and relying on cloud-based computing systems and services.

This results in the rise of a class of new generation services populating a complex, yet apparently simple, digital eco system, aimed to enhancing individuals' quality of life in comfortable smart environments. In addition, such new generation networked devices can exchange information with remote servers or other "elements" in the neighbors, based on location services and maps, and they are not just passive information consumers. They can gather data from the surrounding environment or get them upon specific requests, then they process such data based on suited analysis techniques and algorithms, to produce brand new information. Hence, we can say that the era of an Internet populated by the so-called User Generated Content (UGC) is at its apex, because now people produce valuable contents in a number of different ways, even without realizing, while they perform common daily operations such as, e.g., browsing the Web, searching answers to specific questions, buying tickets for a cinema show, booking a flight and room in a hotel at an affordable price, sharing pictures and thoughts on Social Network Sites (SNS), texting and using modern Instant Messaging (IM) systems, making voice calls through Voice Over IP (VOIP) systems. Moreover, people provide contents effortlessly even simply moving around, without being asked to perform specific actions, write something, push buttons or accept privacy protection statements. This last point highlights the necessity of keeping into account security and privacy issues while using SNS (Caviglione & Coccoli, 2011; Caviglione et al., 2013a; 2013b; 2014) and any other systems requiring and using data intensively.

The above-described situation leads to the generation of a huge amount of data every second, from a variety of sources and the descending information creates a continuous stream, which flows in novel settings with less and less boundaries, allowing interconnected systems to spread it at a very high speed and to a very large audience. This is what we call big data.

As a consequence, the labor market and the society must adapt to this new information model and adopt suitable systems and solutions. They both need developing new attitudes, capabilities, and systems, to be able to deal with the problems of analysis and management of big data and exploiting the new possibilities they originate.

In this scenario, we notice that there is a significant number of situations in which big data are generated by humans for humans, hence they are non-structured. Consequently, software created to consume them, as well as computer systems in general, should be able to simulate human thought processes to better understand their meaning and using them at the best of their potentiality. Such novel computers are called cognitive computing systems and they claim to be able to interact in a natural way with people, primarily understanding their language and terminology, including their mind and interactions schemas. It is worthwhile noticing that this is not a revamping of old-fashioned expert

systems that were developed in the branch of Artificial Intelligence (AI), yet they can learn by experience. The fact that all of the major IT players are making significant investments in research and development in the specific area of cognitive computing witnesses their strategic role in the present and future scenario of informatics and other related fields of application.

Of course, this should impact dramatically on education too, involving people (i.e., academics, teachers, students, administrative personnel and technicians), methods, processes, and infrastructures. In a modern and effective educational system, all of these aspects should be strictly interconnected and should be able to exchange and use information to the aim of empowering each other. Persons, IT systems and things can strongly benefit from the described innovations but, to this aim, a change of mind is mandatory, beside the adoption of new methodologies and techniques.

With this special issue we aim to give an overlook of the actual situation and perspective of using big data and/or cognitive computing in education, including visions, methodologies, systems, experiences and case-studies. We are going to give a glance on how they can empower the whole learning process, the related e-learning infrastructures and services and, ultimately, the people involved in both learning and teaching as well as in management.

Such an outlook will follow the findings of previous researches carried on by the guest editors of this number. In fact, on the one hand, big data and cognitive computing enable the realization of advanced management systems and sophisticated analytics as outlined in the smarter universities model (Coccoli *et al.*, 2014), which depicts the possible evolution of universities based on the smart city model, which has proven its effectiveness in e-learning in very practical case-studies (Coccoli *et al.*, 2015). On the other hand, the exploitation of big data and cognitive computing techniques in e-learning will complete the review of technologies used to empower learning along an evolutionary path passing through (*i*) collaborative learning in Computer Programming (Coccoli *et al.*, 2010; Coccoli *et al.*, 2011), (*ii*) innovation in instructional design (Adorni *et al.*, 2010), (*iii*) the design and development of novel educational settings nurtured by Next Generation Networks (Caviglione *et al.*, 2011), (*iv*) the exploitation of the semantic web capabilities (Coccoli *et al.*, 2012), (*v*) interactive systems based on the use of IoT (Adorni *et al.*, 2012), and, which allowed to sketch unprecedented scenarios.

Owing to the variety of topics that can be related to cognitive computing and, especially, big data, this special issue includes a heterogeneous collection of papers, ranging from cloud computing-based services and applications, learning analytics, as well as innovative and immersive technology enhanced learning experiences.

The remainder of this number is organized as follows:

Timothy Arndt and **Angela Guercio**, in their paper "*A formalism for PLAN: a big data personal learning assistant for university students*" describe a formalism and an application aimed at improving e-learning outcomes. In particular, they propose a learning assistant supporting students who study exclusively through e-learning channels. In this respect, the authors give students the responsibility of monitoring their own educational goals by providing them with a suited instrument. Specifically, they do this by exploiting big data and applying appropriate analytics. In this respect, the authors define the formalism on which they based their application, an architecture, a possible scenario, and some clues about the possible implementation of the system.

Stefania Manca, **Luca Caviglione**, and **Juliana Elisa Raffaghelli**, in their paper "*Big data for social media learning analytics: potentials and challenges*" explore the possibilities offered by the large amount of information circulating across massive learning platforms and social media sites, which allows deriving a heterogeneous set of information. To this aim, they investigate applications and issues of big data for the design of the massive online learning platforms and social network sites, addressing the methodological tools and instruments for social learning analytics, and also focusing on the paramount aspects of privacy and security protection.

Livia Ştefan, **Florica Moldoveanu** and **Dragoş Gheorghiu**, in their paper "*Evaluating a mixed-reality 3D virtual campus with big data and learning analytics: a transversal study*" discuss the importance of analyzing big data to extract suited learning analytics able to drive the development of 3D multi-user environments, which are a trending topic for prospective developments of virtual campus settings. The authors propose an automatic in-world Learning Analytics (LA) monitoring system, within an experimental 3D virtual campus. They recall the importance of 3D multi-user virtual environments, especially for prospective developments and improvements in education.

Mauro Coccoli, **Paolo Maresca**, and **Lidia Stanganelli**, in their paper "*Cognitive computing in education*" present a review of experiences and applications that adopt cognitive computing services for learning and give a glance on possible future development directions of this trend.

Ridi Ferdiana, in the paper "*Cloud storage integration as a learning object repository for massive open online course*" stresses the importance of the qua-

lity of learning contents within massive open online course platforms, an, in particular, highlights the problem of storage. The author proposes a model in which a cloud-based storage system is included in MOOCs, acting as a Learning Objects repository, hence duly structured and with indexing capabilities relying on meta data.

Francesca Oddone, in the paper "*Cloud computing applications and services fostering teachers' self-efficacy*" presents the specific Italian situation with respect to the use of Information and Communication Technology by teachers in schools. The author's finding is that the adoption of cloud computing based applications and services can foster the adoption of new technologies by teachers, thus improving their performances and learning achievements accordingly.

Laura Freina, in the paper "*From e-learning to VR-learning: an example of learning in an immersive virtual world*" highlights how big data and related analysis tools are enablers for a revamping and a further development of virtual reality as an effective learning environment. In fact, in such an interactive setting, users learn performing actions and interacting with both other learners and the surroundings, creating unstructured big data, which can become relevant if duly managed and analysed through suited analytics tools and techniques. The immersive virtual reality game she presents aims to fostering spatial perspective taking skills in young adults with mild cognitive impairments, which implements the kinaesthetic approach to learning.

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