Journal of Visual Languages and Computing ∎ (∎∎∎∎) ∎∎∎–∎∎∎

Contents lists available at ScienceDirect

Journal of Visual Languages and Computing

journal homepage: www.elsevier.com/locate/jvlc

The role of big data and cognitive computing in the learning process

Mauro Coccoli [a,*], Paolo Maresca [b], Lidia Stanganelli [a,b]

[a] DIBRIS, University of Genoa, Genoa, Italy
[b] DIETI, Federico II University, Naples, Italy

ARTICLE INFO

Article history:
Received 30 November 2015
Received in revised form
17 February 2016
Accepted 29 March 2016

Keywords:
Cognitive computing
Big data
Smart applications
Collaborative systems
Technology enhanced learning
Smart university

ABSTRACT

In this paper, we investigate how the raise of big data and cognitive computing systems is going to redesign the labor market, also impacting on the learning processes. In this respect, we make reference to higher education and we depict a model of a smart university, which relies on the concepts that are at the basis of the novel smart-cities' development trends. Thus, we regard education as a process so that we can find specific issues to solve to overcome existing criticisms, and provide some suggestions on how to enhance universities' performances. We highlight inputs, outputs, and dependencies in a block diagram, and we propose a solution built on a new paradigm called smarter-university, in which knowledge grows rapidly, is easy to share, and is regarded as a common heritage of both teachers and students. Among the others, a paramount consequence is that there is a growing demand for competences and skills that recall the so called T-shape model and we observe that this is pushing the education system to include a blend of disciplines in the curriculums of their courses. In this overview, among the wide variety of recent innovations, we focus our attention on cognitive computing systems and on the exploitation of big data, that we expect to further accelerate the refurbishment process of the key components of the knowledge society and universities as well.

1. Introduction

Nowadays, people, computers, smart devices, appliances and objects are connected each other in a large and very complex information-driven eco system. In fact, due to the many enabling technologies, social phenomena and economic factors such as (i) the continuous advancements in electronics, (ii) the ever-growing computing power of microprocessors, (iii) the availability of fast and large memory supports at affordable costs, (iv) the prompted miniaturization, (v) the compelling innovation in network infrastructures and networking, a huge amount of data springs from a variety of different sources and is spread at dramatically high speed. This happens in novel settings with less and less boundaries, which drive to the definition of new reference models as well as new standards of services. Accordingly, as stated by Brynjolfsson and McAfee [1], we are living the dawn of the second machine age. An era in which we can attend the evolution of astonishing machines, which are able to surprise us for their capabilities, and that we could not even envisage a few decades ago. Such machines are the ones that will drive the economy of this century and they will not stop evolving because *"the exponential, digital, and recombinant powers of the second machine age have made possible for the human to create two of the most important one-time events in our history: the emergency of real, useful artificial intelligence (AI) and the connection of most of the people on the planet via a common digital network. [..] In this new age we care more about ideas not things, minds not matter, bits not atoms, interactions not transactions, [..] which call for new organizational structures, new skills, new institutions, and perhaps even a reassessment of our values."* An immediate consequence deriving from the introduction of such machines is that new skills are required to manage them suitably.

Besides, Brynjolfsson and McAfee also specify that *"technology like big data and analytics, high speed communications and rapid prototyping have augmented the contributions made by more abstract and data-driven reasoning and, in turn, have increased the value of people with the right engineering, creative, or design skills."* In a few words, there is an increased demand for skilled labor and this demand will be stable, or even growing, in the years to come. Also many economists have confirmed this trend and they called it the *"skill biased technical change"* [2], which favors people with more human capital. In this context, it looks self-evident that education has a paramount role, more than ever before. In particular, the need of T-Shaped professionals is widely recognized as a *stimulus* for the services science, rather than a mere industrial need [3]. The molding of such T-shaped people can only be achieved by putting together two different types of competences:

* Corresponding author.
E-mail addresses: mauro.coccoli@unige.it (M. Coccoli), paolo.maresca@unina.it (P. Maresca), ldistn@gmail.com (L. Stanganelli).

http://dx.doi.org/10.1016/j.jvlc.2016.03.002
1045-926X/

Please cite this article as: M. Coccoli, et al., The role of big data and cognitive computing in the learning process, Journal of Visual Languages and Computing (2016), http://dx.doi.org/10.1016/j.jvlc.2016.03.002

(1) the *stem* of the T, a specific and strongly domain-dependent *bouquet* of deep competences, which represent the mastery in any field of study, discipline, or application;
(2) the *arm* of the T, horizontal competences, which outline the individuals' ability to move abroad the other complementary capabilities (such as, e.g., project management, communication, organizational culture, critical thinking, teamwork, networks, etc.).

In this wide and very complex scenario, in this paper we make specific reference to higher education and try to guess which are the evolutions that we can expect and that will be well established on a short-term horizon. To this aim, we rely

on results already published in a previous work, in which we identified the main drivers for universities' empowerment, to be able to draw the reference model of a "smarter university" [4]. It is worthwhile recalling that we decided to use *smarter* in place of the more common and widely adopted *smart* because, generally speaking, today's universities widely adopt cutting-edge technologies and systems and this is sufficient to make them some smart universities. However, we argue that this is not enough and that they should make a further step ahead, in the direction of the "smarter" model, to enhance their effectiveness and improve their performance indexes, as well as achieving higher position in international ratings. Furthermore, in this way universities will be more flexible and they will develop the ability to seamlessly adapt to novel and emerging society needs, which are very fast changing and to face effectively modern challenges such as expanding access to all levels of education, enhancing lifelong learning, and facilitating non-formal education.

Then, we consider new issues recently emerged, by keeping into account novel research trends that are gaining consensus in the scientific community and that we expect will have a prominent role in the very next future, such as: (i) the availability of big open data coming from software applications and sensors, coupled with the ability to effectively manage them by means of suited techniques, analysis tools, methodologies, and storage systems; (ii) the wide diffusion of systems based on cognitive computing principles, which can interact with humans in an innovative way, thus 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 health to education.

In addition, since we report results from specific experiences carried on at software engineering classes, we also consider the benefits deriving from: (iii) the use of a cloud-based computing infrastructure; (iv) the use of a development environment based on the Platform-as-a-Service (PaaS) paradigm, which affected positively the learning outcomes, at least for technical education.

The remainder of the paper is organized as follows. In Section 2 we recall the smarter university model and, in Section 3, we make some general considerations about it, based on the outcome of a project and the relevant data, including results achieved. Then, in Section 4 we analyze the modifications introduced by big data and cognitive systems while, in Section 5, we focus on the skills produced by smarter universities. Finally, the Section 6 on conclusions and future works close the paper.

2. The smarter university model

As already mentioned, in our previous research we have recognized the need of a significant change in education and we have proposed the model of a Smarter University, which is depicted in Fig. 1 and that we are going to recall. The process is made up of several steps, which are described in more details in the

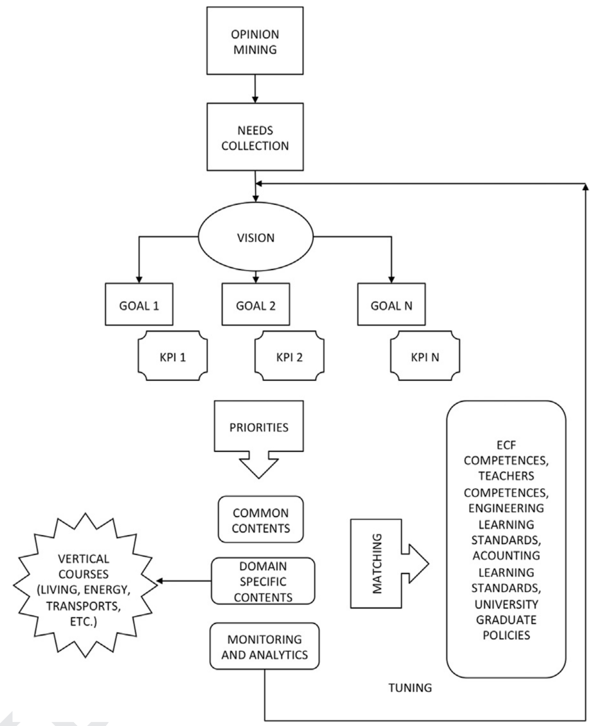

Fig. 1. The smarter university model (borrowed from [4]).

following:

2.1. *Opinion mining*

The first step of the process requires collecting different opinions, which will be later organized and structured.

2.2. *Needs collection*

The second phase of the proposed model corresponds to an in-depth analysis of the needs emerging from the area, the communities and the organizations. In this step, the collected views are organized and structured according to their sources (stakeholders). These views are then translated into specifications and constraints of the system.

2.3. *Vision*

The presence of multiple variables and constraints encourages the creation of a strategic vision that must be translated into clear objectives, ambitious yet realistic. The objectives should clearly state the expected achievements in the medium and long term. Therefore, the strategic vision is structured with measurable objectives, a set of goals $\boldsymbol{G}$, where

$$G = \{Goal_1, \quad Goal_2, \quad \ldots, \quad Goal_N\} \tag{1}$$

whose reach is measured through Key Performance Indicators (KPIs) in $\boldsymbol{K}$, where

$$K = \{KPI_1, \quad KPI_2, \quad \ldots, \quad KPI_N\} \tag{2}$$

is the set of relevant KPIs. The goals are to be constantly monitored and the associated KPIs allow measuring the degree of achievement for each goal. A corrective action accompanies the monitoring and measurement activities and is used to steer the objectives of the system when necessary. At this stage, we can adopt a metric plan based on the Goal Question Metrics (GQM) model [5].

Please cite this article as: M. Coccoli, et al., The role of big data and cognitive computing in the learning process, Journal of Visual Languages and Computing (2016), http://dx.doi.org/10.1016/j.jvlc.2016.03.002