

Extending Information and Communications Technologies' Impact on Knowledge Based Society through Artificial and Collective Intelligence

-Part 2-



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Abstract

The paper analyzes the role of artificial intelligence (AI) and human intelligence (HI) in the context of Information and Communications Technologies (ICT) exponential development as driving factor of the Information society (IS) progress toward Knowledge Based Society (KBS).

ICT potential is enabled by the most advanced technologies, where AI has the highest penetrating power by its increasing performances and self-developing features, but AI limits have been also revealed, as AI is not yet capable to solve some classes of complex problems where only HI has the capacity to be effective, as creation/innovation, image tagging, speech/emotion recognition or complex classification.

Paper analysis leads to a natural combination between HI and AI towards highest results and performances, which is today a very complex and difficult problem, considering the amazing level of AI/ICT and implied challenges. It also results that AI progress could be „magic” but it could and should not replace HI nor the natural evolution of humankind life, although we have to admit that AI will influence them more and more.

A paper conclusion is that the „symbiosis” of AI and HI will leverage ICT applications performances and penetration, including the huge area of emergent fixed/mobile IoT, but adding the benefits collective intelligence(COLI) could bring when combining AI with HI for extracting knowledge from data in areas like environment/utilities monitoring, Big Data, user experience, home working, smart city and mainly for IS/KBS applications.

The paper analysis also covers the concrete approach of using COLI and data/information that is generated World-wide in order to create models and algorithms oriented to extract relevant knowledge or applied rules for the complex and dynamic challenges of IS/KBS. On this line, crowdsourcing(CSOURS) is the most important component of COLI, as it already represents a practical but dynamical approach toward optimizing the AI-HI integration. COLI is a very complex concept, where, beyond CSOURS and other social technologies, HI coming from a huge diversity of people could be implied, especially in the benefic conditions of the actual connected World.

The paper also analyzes how the concrete COLI/CSOURS activities could be developed with maximal efficiency/benefits for communities and generally for IS/KBS and identifies the most prominent factors that could influence their results and efficiency.

A final conclusion is that a fundamental challenge for all COLI approaches and applications is the complicate issue of carefully selecting first of all the participants/workers and then their answers/solutions, this issue asking a further analysis.

Keywords: *artificial intelligence, human intelligence, Big Data, crowd wisdom, collective intelligence, crowdsourcing, machine learning, information society, knowledge based society.*

JEL Classification: L63; L86; M15; O31; O33

1 .Using AI to improve human thinking and life, but not replacing them

Change is the law of life. And those who look only to the past or present are certain to miss the future—John F. Kennedy

The products, applications and services of the Information and Communications Technologies (ICT), as driving factor of the Information society (IS) progress toward Knowledge Based Society (KBS), are continuously change all human activity domains and even Earth ecosystem.

That is the reason, in a world of amazing changes, we have to further and deeply analyse all the implications of the exponential pace of ICTdevelopment, in order to optimize this development, facing all challenges of the implied complex processes, at Earth scale.

As we presented in [3], the most important advances of ICT, including Cloud, Big Data, Internet of Things (IoT), artificial intelligence (AI) generate also complex challenges for ICT, as Digital Disruption (DD) and green ICT.

Among these challenges, the need to efficiently process and benefit from the huge amount of data generated every day at Earth scale is asking for ... more advanced processing power and highly human selected/experimented expertise. This way AI and human intelligence combination becomes a benefic solution [6].

It is well known that along with the complexity of ICT processes the difficulty to optimize ICT development is also increasing.

Here we have to recall [13] that ICT potential proved salutary for improving IS/KBS processes, in spite of the complicate ways ICT is involved in these processes and leading to non-linear multi-criteria optimization problems.

Actually, this ICT potential is enabled by the most advanced technologies, where AI has the highest penetrating power, by its increasing performances and self-developing features [3][7][22].

Still, AI is not (yet?) capable to solve some classes of complex problems where only human intelligence (HI) has the capacity to be effective, as creation/innovation, image tagging, speech/emotion recognition or complex classification.

More than these, life experience, responsibility or human intuition represent features difficult to provide by AI in a predictable future, but it is important to observe that all these could be associated with a diversity of activity fields.

In fact, in order to understand the implications of AI/ICT state-of-the art, we have to recall that all AI evolution pointed to get closer to HI [1]:

“The idea of creating an artificial creature gifted with intelligence has always fascinated people. Early on researchers dreamed of recreating human intellectual capacity in a machine, effectively reproducing the act of creation a rational being through technology. Wilhelm Schickard constructed the first calculator in 1623. From the beginnings of formal logic in the philosophy of classical antiquity, through the propositional logic of George Boole, to digital computer theory (Alan Turing), the foundation for modern research on artificial intelligence (AI) has evolved”

The relevance of these aspects shows the natural combination between HI and AI towards highest results and performances, which is today a very complex and difficult problem, considering the amazing level of AI/ICT and the mentioned advances and challenges.

If we also consider the diversity of HI on Earth, an essential face of the problem is inherently leading us to *crowd wisdom* (CW) and step by step to crowdsensing (CSENS), crowdsourcing (CSOURS) and generally to crowd intelligence (CI) [3].

Of course, the processes that link HI and AI are very complex and go beyond the natural diversity, education, cultural and other social/political issues, but the global effect is in the efficient ways both are leveraging AI/ICT impact on IS toward KBS[1]:

“... most applications require a significant amount of hard work on the part of humans before neural nets, machine learning, and natural language processors can work their magic”

We still consider that the impact is not limited to the above “hard work” issues, including other classes of features like innovation, responsibility, reliability and security.

That is why it is clear that **AI progress could be „magic”, but it could and should not replace HI nor the natural evolution of humankind life, although we have to admit that AI will influence them more and more**[18][20].

Consequently, **we should carefully watch the AI/ICT evolutions in order to keep this line of safety, where humankind and Earth to remain as natural as possible, but above all, to survive!**

We may conclude this way that the „symbiosis” of AI and HI will leverage ICT applications performances and penetration, including the huge area of emergent fixed/mobile IoT, but adding the benefits collective intelligence (COLI) could bring when combining AI with HI for extracting knowledge from data in areas like environment/utilities monitoring, Big Data, user experience, home working, smart city and mainly for IS/KBS applications.

Now that the context is pointed, we have to analyze the most complex issues of the AI/HI integration, including collective intelligence (COLI).

Looking to the AI-HI cooperation, we have to see first the picture main influences from both sides and then the relevant features and challenges [4]:

<<We argue the thesis that “Artificial intelligence methods can greatly simplify the process of creating and managing complex crowdsourced workflows.”>>

From the HI side, the implications are very complex and naturally diverse, but first is to point where they complement the machines (AI) in the most advanced applications, as expressed in [5]:

„There are two revolutions occurring simultaneously, related to the increasing availability of processing power and storage required to collect, store, and work with large data sets. On the one hand, powerful machine learning and data mining algorithms exist to automatically discover patterns in data ... On the other hand, realities of today's connected digital world have enabled viable alternatives to clever algorithms. Human Computation (von Ahn & Dabbish 2004) refers to an approach in which problems that are difficult for machines but easy for humans (e.g. image labeling) can be divided into small manageable tasks, and distributed online for humans to solve...”

More than pointing both sides, it is important to observe the benefit of combining them, due to their natural evolution, but we consider also very relevant to notice the opportunity of this HI-AI symbiosis in the actual phase of the most advanced ICT:

„...There are pros and cons to each approach, and combining them is likely a fruitful direction. While there are obvious benefits to a completely automated process, unsupervised machine learning algorithms can be difficult to control (especially by non-experts), and their performance degrades in the face of sparse data. In contrast, humans can generalize from few examples, bringing to bear background knowledge from a lifetime of experience”

Here we can reveal one of the prominent features of HI against AI, consisting in human superiority in sparse data, based on human experience and correlating capacity.

On the other hand, it is obvious that AI is capable to manage Big Data and consequently HI support is salutary to manage gaps in this huge flow of unstructured data.

It is sure that AI is more than machine learning (ML) [2], but in fact ML is just the most relevant and advanced AI component for approaching the actual most important challenge we have mentioned before: extracting the "proper knowledge" from the huge volume of data generated at Earth scale.

On the other side, we have also to mention that much more than CSENS, CSOURS is an important component of COLI, as it already represents a practical but dynamical approach toward optimizing the AI-HI integration.

More than these, COLI is a very complex concept, where, beyond CSOURS and other social technologies, HI coming from a huge diversity of people could be implied, especially in the benefic conditions of the actual connected World.

In this context, the implications and challenges of COLI in IS/KBS, mostly but not necessary only with AI, must be analyzed because in general ICT exponential development consequences need a deep and timely evaluation, as we have already mentioned [10].

In fact, the complexity and the too fast changes AI/ICT exponential pace generates at Earth scale, along with other technologies but clearly being the main force of IS towards KBS evolution, could not be completely evaluated by the regular entities and using the COLI is the only natural way to improve the humankind chances to face, in real time, dramatic challenges like climate changes (*strongly influenced by the ICT carbon footprint too*), Earth resources fading, social unbalances etc.[10][15].

More than these, as we have already mentioned [7], one of the important consequence of these challenges is the fact that even the humankind evolution, as human being, life style and personality are dramatically influenced on medium and long term, without considering here the danger to the survival on Earth (approached by scientists like Stephen Hawking in the case of robots).

Consequently, the concrete implementation of this approach leads us to use COLI and data/information that is generated World-wide in order to create models and algorithms oriented to extract relevant knowledge or applied rules just for the mentioned complex and dynamic challenges [8]:

„The creation and accumulation of Big Data is a fact for a plethora of scenarios nowadays. Sources such as the ever-increasing diversity sensors as well as the content created by humans have contributed to the Big Data's enormous size and unique characteristics. Making sense of these data has primarily rested upon Big Data analysis algorithms. Still, in one too many cases the effectiveness of these algorithms is hampered by the very nature of Big Data: analogue, noisy, implicit, and ambiguous... Enter Collective Intelligence: the capability of interconnected intelligences achieving ameliorated results in activities than each of the single intelligences creating the collective solely would.”

Special circumstances must be analysed for the very complicate consequences of the fast development of ICT impact on IS/KBS, where real time solutions are needed and CSOURS could offer them when combining HI with AI in correlation algorithms [22].

As CSOURS brings, by a diversity of ways, almost unlimited contributions to improve thinking for the difficult and complex mentioned problems, an essential point is to efficiently select these contributions, including for that the AI support, but ... carefully!

2. How collective intelligence and AI could together work to bring knowledge out of data

Sometimes we ignore the existence particularities of other animals, but the true is that all animal societies present cognitive processes at group level, as bees, birds or antelopes are remarkable examples [23].

For humankind, COLI is very special by language capabilities and all the social features generated by the conscience behavior, but we have to admit that one of the fundamental reasons and benefits of COLI is similar to all animals: the need to improve their progress and interests reaching.

From this ancestral approach to our days HI-AI symbiosis, it could seem a very long way, but we have to notice that the above mentioned challenges, including life on Earth survival, are good enough reasons to analyze this processes from the essential needs/goals all animals have, to the most sophisticated products and services the technologies are offering us today in IS/KBS.

As we live in the Information Age, i.e. in IS toward KBS, considering the aspects presented in section 1, the need for humankind and even Earth ecosystem to obtain in real time the relevant information and eventually the refined knowledge is one of the most important goals on medium-long term [13][14].

Here we just arrived to the importance of methods to obtain the refined knowledge in the dynamic actual context, where the combination HI-AI offers the most advanced solutions – as we pointed above – in our “data rich and information poor” World [9]:

<<Integrating data and extracting knowledge from the market environment is always complex; in fact, this requires sufficient modelling techniques. [5, p. 5] maintain that the world “is data rich and information poor”, due to the vast amounts of data which are collected but not transformed into information. If this is the case, it could be due to failure to use adequate techniques and technologies to analyze and interpret such data.”

It is mandatory to mention that the ‘real-time’ is in fact much more complex because the quotation is pointing just the “market”, but at the Earth scale we have a huge diversity of complicate processes/problems.

Another facet of the CSOURS issues is caused by the progressive complexity that is produced by the actual ICT impact evolution and this way the necessity for refined knowledge is a prominent reason for using COLI, as most of the companies/government specialists are involved in concrete and actual analyses – when necessary –and very few in complex, global and long term studies.

As a consequence, COLI/CSOURS have, by our opinion, along with usual applications (classification, image tagging, speech recognition, face/emotion recognition etc.), a growing field of complex, global and long term issues to contribute to.

Anyway, COLI/CSOURS basic methods/rules include collaboration in groups but also competition and diversity of opinions in order to provide the expected benefits of crowd intelligence [11]:

“In 1906, the statistician Francis Galton observed a competition at a country fair. The crowd accurately guessed the weight of an ox when their individual guesses were averaged (the average was closer to the ox's true butchered weight than the estimates of most experienced crowd members)”

Consequently, some methods and features are summarized as:

- ✓ *Aggregating opinions to boost performance;*
- ✓ *Collaborative work needs to be managed efficiently;*
- ✓ *Independence People's opinions aren't determined by the opinions of those around them;*
- ✓ *People are able to specialize and draw on local knowledge;*
- ✓ *Effective mechanism exists for turning private judgments into a collective.*

A special mention must be done about the forth feature, as ‘*specialize and draw on local knowledge*’ is an essential factor for providing resources and power in order to accomplish the main goal of extracting ‘knowledge out of data’ [19].

We also consider that humans could still be more efficient or accurate than machines in solving some classes of jobs, but it is essential to notice HI contribution in all AI implemented jobs and beyond, especially in scientific, quality, security, social, ethical and emotional implications.

Finally we still have to analyse how the concrete COLI/CSOURS activities could be developed with maximal efficiency/benefits for communities and generally for IS/KBS.

In fact, considering the diversity and complexity of such activities, the realistic approach is to analyze some of the most prominent factors that could influence their results and efficiency.

A good start could be to see some usual approaches, which reveal the way COLI/CSOURS and AI support are actually conceived [12]:

“Crowdsourcing is a relevant construct for our research because it describes research collaboration that radically enlarges the pool of (potential) scientific collaborators. Research projects, such as NASA’s Clickworkers and the “self-organized” research collaboration identifying the cause of the severe acute respiratory syndrome SARS (Stoehr and WHO 2003), go beyond traditional forms of collaboration by embracing electronic communication and cooperation between a very large group of scientists.”

It is worth to observe that the above examples are more than relevant for the high performance CSOURS could reach, as NASA projects are prominent for the scientific research at World level.

A remarkable aspect is also presented by the pointed importance of the ICT context, which is a systemic leveraging factor of CSOURS by the actual ubiquitous “electronic communication”.

Another approach, more concrete, is as [12]:

“Crowdsourcing is the act of taking a job traditionally performed by a designated agent (usually an employee) and outsourcing it to an undefined, generally large group of people in the form of an open call (Howe, 2008)”

Here we have to notice the interesting fact that CSOURS is usually replacing a job by a multitude of jobs, which means that always a multiplication effect is provided.

In the same time, it is very important to notice that an essential factor is given by the independence of the dispersed “jobs” resulting as a practical consequence of the mentioned ‘open call’.

Perhaps one of the best approaches is to clearly link COLI/CSOURS with AI in order to get to the highest technological advances in extracting “knowledge out of complex data” as in [16]:

<<By defining collective intelligence as “groups of individuals acting collectively in an intelligent manner,” one soon wishes to nail down the meaning of individual ... individuals may be software agents and/or people and the collective may consist of a mixture of both. The rise of collective intelligence allows novel possibilities of seamlessly integrating machine and human intelligence at a large scale – one of the holy grails of AI (known in the literature as mixed-initiative systems (Horvitz 2007))... chapter focuses on one such integration – the use of machine intelligence for the management of crowdsourcing platforms (Weld, Mausam, and Dai 2011). Crowdsourcing is a special case of collective intelligence, where a third party (called the requestor) with some internal objective solicits a group of individuals (called workers) to perform a set of inter-related tasks in service of that objective. The requestor’s objective may be expressed in the form of a utility function to be maximized>>

This example is further completed by detailing the way AI could be designed to obtain the most powerful feature that could be implemented when combining COLI with AI [16]:

“The vision of artificial intelligence (AI) is often manifested through an autonomous software module (agent) in a complex and uncertain environment. The agent is capable of thinking ahead and acting for long periods of time in accordance with its goals/objectives. It is also capable of learning and refining its understanding of the world. The agent may accomplish this based on its own experience, or from the feedback provided by humans. Famous recent examples include self-driving cars (Thrun 2006) and the IBM Jeopardy player Watson (Ferrucci et al. 2010). This chapter explores the immense value of AI techniques for collective intelligence, including ways to make interactions between large numbers of humans more efficient.”

In fact, here we have a clear approach/confirmation of the general model to approach, with performant AI-HI combination, the ‘‘complex and uncertain environment’’, i.e. the fast changing context generated by ICT in IS/KBS we have above presented.

It is also very well pointed one of the fundamental direction of AI design and development: ‘‘learning and refining its understanding of the world’’.

With other words, here we found, in a deep and realistic analysis, both the rules for improving the above mentioned AI contribution to ICT/IS/KBS sustainable progress (*learning and refining*) and AI performance main target (*understanding of the world*), i.e. competing with HI for improving thinking and human life without replacing anyone of them - a bright goal we also have promoted [7][15], but its accomplishment it’s so dynamic, complicate and difficult as a ‘‘fata morgana’’ and needs a continuous struggle from all the people.

The confirmation could be further extended, if this general model would be mathematically applied by an algorithm for an ‘‘utility function to be maximized’’, in a manner similar with that we have already presented in [22] for optimizing HI-AI combination.

In addition we have to recognize that a fundamental challenge for all COLI approaches and applications is the complicate issue of carefully selecting first of all the participants/workers and then their answers/solutions[21].

The quality of people involved in COLI seems to be, along with incentive issues, one of the most important keys of CSOURS success and represents also a huge and dynamic field where AI support is benefic and have to be stronger promoted.

Now it is obvious that the complexity and diversity of these AI/COLI approaches need a further analysis in order to cover the fast pace of the ICT impact on IS toward KBS.

3. Conclusions

Considering that ICT potential is enabled by the most advanced technologies, where AI has the highest penetrating power, by its increasing performances and self developing features, the AI limits have been also revealed, as AI is not yet capable to solve some classes

of complex problems where only HI has the capacity to be effective, as creation/innovation, image tagging, speech/emotion recognition or complex classification.

This way, paper analysis led to a natural combination between HI and AI towards highest results and performances, which is today a very complex and difficult problem, considering the amazing level of AI/ICT and implied challenges.

It also resulted that **AI progress could be „magic” but it could and should not replace HI nor the natural evolution of humankind life, although we have to admit that AI will influence them more and more.**

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