

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

-Part1-



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Abstract

The paper approaches the analysis of the role of collective intelligence in the context of Information and Communications Technologies (ICT) exponential evolution, which tends to have an important impact on the progress of the Information society (IS) toward Knowledge Based Society (KBS).

Premises for this impact refer to the most prominent advances and challenges of ICT, including Cloud, Big Data, IoT, green ICT, artificial intelligence (AI) and Digital Disruption (DD), which have to be approached in a responsible and systemic way, as their interdependent consequences reached unprecedented complexity and crucial importance for World economy, humankind life and future of Earth ecosystem. It is enough to recall the pace of ICT's carbon footprint growing versus the totality of airplanes.

The Collective intelligence main concrete components, crowdsensing (CSENS), crowdsourcing (CSOURS) and generally crowd intelligence (CI), enable AI to create more knowledge from the real time data deluge that is generated at Earth scale, impacting IS/KBS, people's life and Earth environment. The functional structures of crowdsourcing are analysed and classified by two main criteria, referring to the degree individuals are implied and respectively the way crowd intelligence is collected.

Machine learning (ML) is pointed as the most important, performant and productive subfield of AI due to its unprecedented capacity of self-learning algorithms, which make the difference between ML and the prior advances on AI. Going further and deeper into ML, the AI most prominent performant applications will be based on Deep Learning (DL).

On the other hand, the paper point out the fact that the further AI advances, the complexity of its jobs and challenges is increasing and this way new kind and complicate issues are raising. IoT and other emerging sensing systems could be more performant using highest technologies as AI - HI combinations, but this way they become more complex, especially by volunteer and generally human participation and eventually progressively changing from sensing to sourcing or including both CSENS and CSOURS. As a consequence, combining HI and AI deep learning is an emerging trend in Big Data and Collective intelligence, based on the power of AI to offer performant solutions of processing the overwhelming data volumes, along with the HI's deepness of imagination, capacity of generalize and superiority of processing sparse data.

Practically AI could further improve its performance when approaching difficult problems for machines, which could be solved by addressing CSENS and CSOURS systems and then discovering information/patterns in collected data, but we have to watch every time to reasonably keep the control of this complexity increasing, as remarkably also argued the genial and regretted Stephen Hawking.

Consequently, we have to watch this HI/AI combination as the natural trend of high technologies exponential progress and keep it in the secure area of KBS development.

We have to notice the need for human intervention to resolve issues and improve algorithms, but we would add the imagination and responsibility of human to design safe AI (including algorithms).

A paper's conclusion is that AI needs high value data in order to generate information and eventually knowledge, but the data value is depending on ... crowd wisdom. In order to assure an efficient contribution of crowd, we have to carefully manage the combination of AI-HI in all typical scenarios, i.e. providing expertise for reference design tools, improve algorithms, supervising ML/DL processes and ...contributing in large volumes of data/information/knowledge by CSENS and CSOURS systems.

We have to conclude that responsibly analyzing people and information quality or refining knowledge are among the most complex, complicate and time sensitive problems to be solved, perhaps perpetually.

Keywords: *artificial intelligence, collective intelligence, crowd wisdom, crowdsensing, crowdsourcing, crowd intelligence, Deep Learning, human intelligence, Big Data, machine learning, Internet of Things, information society, knowledge based society*

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

1. Artificial intelligence, crowdsensing and crowdsourcing - everywhere through Information and Communications Technologies

“Why the Many Are Smarter Than the Few and How Collective Wisdom Shapes Business, Economies, Societies and Nations” - James Surowiecki (*Wisdom of crowds*-2004)

The amazing progress of mobile communications and computation along with sensors technology are generating a huge potential of applications and services the Information and Communications Technologies (ICT), as the main driving factor of the Information society (IS) toward Knowledge Based Society (KBS), could deliver for all human activity domains.

The exponential pace of ICT development, that Moore Law is still leveraging, determines also a continue re-evaluation of the processes ICT generate, along with their complicate consequences at Earth scale.

As we already presented [3][6][13][19], the most prominent advances and challenges of ICT, including Cloud, Big Data, IoT, green ICT, artificial intelligence (AI) and Digital Disruption (DD), have to be approached in a responsible and systemic way, as their interdependent consequences reached unprecedented complexity and crucial importance for World economy, humankind life and future of Earth ecosystem. Here it is enough to recall the pace of ICT's carbon footprint growing, versus the totality of airplanes [19][14][16].

In this challenging context, the ICT potential is still offering advanced solutions for all above mentioned development domains and much more, but AI has the highest power, by its increasing performances and self-developing features [3][23].

Speaking of self-developing features, it is obvious that this way AI tends to have a similar potential with human capacity of improvement, but this is just the tip of the iceberg, as the reality is a dynamic and complex process we intend to shortly analyse.

Anyway, these are the premises and reasons for a responsible approach of the complicate link between AI and human intelligence (HI), which inherently leads us to *crowd wisdom*.

Using crowd wisdom (CW), by crowdsensing (CSENS), crowdsourcing (CSOURS) and generally *crowd intelligence* (CI), enables AI to create more knowledge from the real time data deluge that is generated at Earth scale, impacting IS/KBS, people's life and Earth environment.

The status and evolution of CSENS and CSOURS are very well expressed, as basic components, in the frame of the functional structures of Next Generation Crowdsourcing for Collective Intelligence [1]: "*CrowdSensing; Wearables Crowdsourcing; Situated Crowdsourcing; Spatial Crowdsourcing*".

From the point of view of human participation, these 4 functional structures could be classified as passive (Wearable CSOURS; CSENS) or active (Situated CSOURS; Spatial CSOURS), while by the intelligence/information type, they could be individual (Wearable CSOURS; Situated CSOURS) or environmental (CSENS; Spatial CSOURS).

These structures could also be represented in an intuitive diagram, as it is sketched in Fig.1.

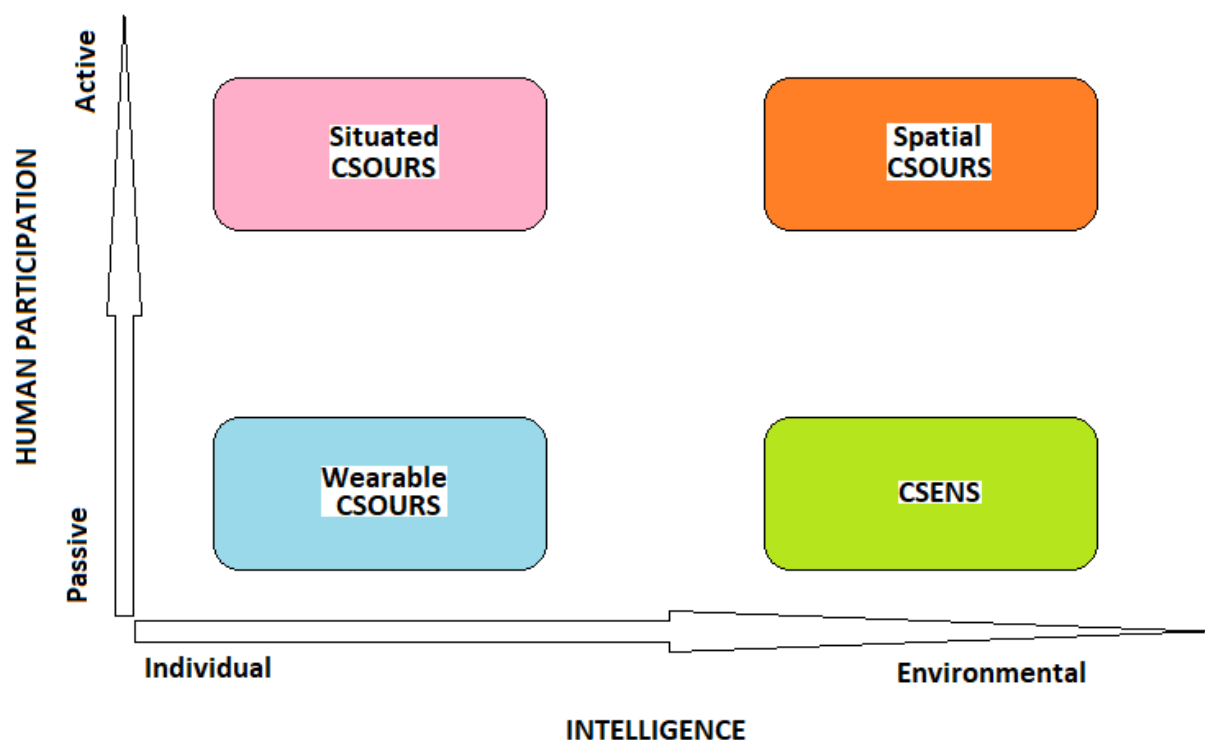


Fig.1 Functional structures of crowdsourcing (CSOURS= crowdsourcing; CSENS= crowdsensing)

Usually, Wearable CSOURS and CSENS provide data through ICT devices without human permanent intervention, i.e. in a semi-automated mode, while Situated CSOURS and Spatial CSOURS need a human intervention during every task/job they are involved in.

It is very interesting to point out that CSENS and Spatial CSOURS are based on information/intelligence collected from environment, but in the case of Spatial CSOURS the environmental intelligence could be obtained only through human, i.e. not directly digitally transferred – the typical example being image labelling.

More than these, CSOURS could generally contribute in a diversity of scenarios like [18]:

“Solving tasks that computers cannot easily perform without human assistance. Human computation projects include work on crowdsourcing, where sets of people jointly contribute to the solution of problems. Crowdsourcing has been applied to solve tasks such as image labelling, product categorization, and handwriting recognition”

The AI status and potential are also largely confirmed in the literature, as it is crucially impacting the World [2]:

“The collection of “Big Data” and the expansion of the Internet of Things (IoT), have made a perfect environment for new AI applications and services to grow. Applications based on AI are already visible in healthcare diagnostics, targeted treatment, transportation, public safety, service robots, education and entertainment, but will be applied in more fields in the coming years. Together with the Internet, AI changes the way we experience the world and has the potential to be a new engine for economic growth”

Above the context and horizontal potential development, the deep mechanisms of AI applications implementation and operation are also very important for the clear picture, but also for its inherent impressive benefits and challenges [5]:

“In this age of modern technology, there is one resource that we have in abundance: a large amount of structured and unstructured data. In the second half of the twentieth century, machine learning evolved as a subfield of Artificial Intelligence (AI) that involved self-learning algorithms that derived knowledge from data in order to make predictions. Instead of requiring humans to manually derive rules and build models from analyzing large amounts of data, machine learning offers a more efficient alternative for capturing the knowledge in data to gradually improve the performance of predictive models and make data-driven decisions. Not only is machine learning becoming increasingly important in computer science research, but it also plays an ever greater role in our everyday lives. Thanks to machine learning, we enjoy robust email spam filters, convenient text and voice recognition software, reliable web search engines, challenging chess-playing programs, and, hopefully soon, safe and efficient self-driving cars.”

Here, machine learning (ML) is pointed as the most important, performant and productive subfield of AI due to its unprecedented capacity of *self-learning algorithms*, which make the difference between ML and the prior advances on AI.

As we also presented [3][6], going further and deeper into ML, the AI most prominent performant applications will be based on Deep Learning (DL)[4]:

“Artificial intelligence is growing exponentially. There is no doubt about that. Self-driving cars are clocking up millions of miles, IBM Watson is diagnosing patients better than armies of doctors and Google Deepmind’s AlphaGo beat the World champion at Go—a game where intuition plays a key role. But the further AI advances, the more complex become the problems it needs to solve. And only Deep Learning can solve such complex problems and that’s why it’s at the heart of Artificial intelligence.”

Here we just arrived where our paper is intended to focus, i.e. the fact that the further AI advances, the complexity of its jobs and challenges is increasing and this way new kind and complicate issues are rising.

For instance let pass over the meaning of above remark, referring to the complexity of applications or fields where AI is expected to offer solutions, as predictive or creative problems.

It is also known and we also presented, in[3][9], the risk of developing AI out of human control, where the regretted Stephen Hawking and other prominent savants even made investment for preventing.

Besides, among the actual and emerging challenges we consider as very important the complex relation of AI with HI, including both “cooperation” and “competition” sides, so we further will analyse each of them, but focusing on cooperation.

In fact, the main goal of AI - HI combination is to extend the ICT applications performances and penetration, including the huge area of emergent fixed or mobile IoT.

IoT and other emerging sensing systems could be more performant using highest technologies as AI - HI combinations, but this way they become more complex, especially by volunteer and generally human participation and eventually progressively changing from sensing to sourcing or including both CSENS and CSOURS.

The usability of CSENS and CSOURS services are extending very fast in diverse domains like environment/utilities monitoring, Big Data, user experience, home working, smart city, knowledge based society applications, games/entertainment industry etc.

If we would refer only to user experience, CSENS and CSOURS with opportunistic/volunteer participants could cover a multitude of scenarios [23].

For example, stimulating participants to cooperate in tasks of usual interests like user experience of home utilities, environment, government or social assistance, a diversity of cost effective applications installed on mobile devices deployed in areas of mobility could provide incentive information/elements for both users and participants.

Similar scenarios could include IS/KBS emergent domains like business intelligence searches, human behaviour topics, health care anonymous data collecting from Body Area Network (by cooperation with medical service providers and aiming qualified advices and best practice), intelligence gathering workshops or games (oriented on selecting intelligent and imaginative persons), home working creative jobs, startups ideas, natural language processing etc.

When involving participants in collecting data, through their devices or by direct observation/contributions, they could also benefit of informations or learn about interesting issues and this way AI and HI provide incentive elements, as participants are usually interested of commercial offers, health, jobs, utilities, entertainment, environment etc.

Far from being exhaustive, the above approach of AI, CSENS and CSOURS has been focused on their potential applications and benefits, but these represent just the tip of iceberg, as the complex issues of generating data, extracting information and refining knowledge, by human/crowd intelligence contribution need deeper further analysis.

2. The age of Big Data, the need of knowledge and the crowd wisdom

The actual ICT development, without considering the spectacular proliferation of IoT, determines, as we also have presented [6], in all humankind activity fields, the power to generate exponential growing volumes of data [7]:

“The world’s production of data grew 2,000-fold between 2000 and 2012. Its stock of data is expected to double every two years; 99 percent of it is digitized and half has an IP address. This means that half of the world’s data can now be put together, at near-zero cost, to reveal patterns previously invisible. Half of the world’s data is already, technically, a single, universally accessible document. All this data is linked by fixed and mobile communication networks and is managed by layers of modular, interoperable software ...Information is comprehended and applied through fundamentally new methods of artificial intelligence that seek insights through algorithms using massive, noisy data sets. Since larger data sets yield better insights, big is beautiful.”

Here we have to notice not only the data deluge, but the unprecedented capacity to digitally process them (99%) and the most important, to instantly **access and use these data** (50%).

This situation is generating both opportunities and responsibilities from incumbents, specialists and ... crowd.

Combining HI and AI deep learning is an emerging trend in Big Data and Collective intelligence [21][22][23]. This is based on the power of AI to offer performant solutions of processing the overwhelming data volumes, along with the HI's deepness of imagination, capacity of generalize and superiority of processing sparse data.

Practically, AI could further improve its performance when approaching difficult problems for machines, which could be solved by addressing CSENS and CSOURS systems and then discovering information/patterns in collected data.

As the first section has focused on opportunities, now we intend to analyse how the responsibilities could be better approached, using ... ICT opportunities and the human potential.

Speaking about responsibilities any improvement has to be done carefully setting our target level, especially when facing with complex ICT realities and forecasts like "exponential pace" and "deluge".

We have to recall here a confirmation of this preventing approach [6][20]:

"I enjoyed Samuel Arbesman's first book, The Half-Life of Facts, which was a discussion of the exponential pace of change, as exemplified by Moore's Law, among other things. When I saw the title of his new book, Overcomplicated, I assumed that it would be a warning that we technologists had gone too far in creating complex systems. It would advocate moving to simpler systems, just as a doctor might advise an overweight person to go on a diet. I was prepared to argue against such a conclusion, but as I discovered upon reading the book, Arbesman does not say that complexity is necessarily bad or that we should seek simplicity. Instead, he maintains that systems are now unknowably complex, that they will become even more so, and we should...just get over it. Much of the book is spent in discussing the reasons why complexity is inevitably increasing."

Our opinion is similar, but we have to watch every time to reasonably keep the control of this complexity increasing, as remarkably and financially also argued the genial and regretted Stephen Hawking.

Consequently, we have to watch this "HI/AI combination as the natural trend of high technologies exponential progress" and keep it in the secure area of KBS development.

If still a shadow remained about "carefully setting our target level", we have to also recall a deep suggestion resulting from[7]:

<<. . . In that Empire, the Art of Cartography attained such Perfection that the map of a single Province occupied the entirety of a City, and the map of the Empire, the entirety of a Province. In time, those Unconscionable Maps no longer satisfied, and the Cartographers Guilds struck a Map of the Empire whose size was that of the Empire, and which coincided point for point with it..." On Exactitude in Science" - Jorge Luis Borges>>

We believe that the Borges message is also clear today as preventing as to keep reasonable and safety limits in our "exponential pace", before it would not be too late.

About the map, decades ago we were telling to our students "in the future every cub inch of Earth will be digitally known", but recently, after 9-th 11 (2001), we were telling to other students the same, but adding: "we had all the data, but how did we used them safely?"

So here we are, to design AI and HI combinations having as first priority a safer future, i.e. setting the targets levels as to provide safety before performance.

It is obvious that HI and AI cooperation is the natural way for high technologies improvement, due to the fact that AI reached unparalleled levels when closing to humankind model.

On the other hand, the human potential of imagination, lifetime experience knowledge and creativity is still unreachable, so “HI and AI are efficiently supporting each other in a symbiosis, becoming the most advanced and powerful engine for World progress toward KBS” [23].

Such opinions are largely agreed, as it is very eloquently presented in the next example [8]:

<<In her presentation titled “Humans to the Rescue: Troubleshooting AI Systems with Human-in-the-Loop,” Ece Kamar, Senior Researcher at Microsoft Research AI, discussed the need for human intervention to resolve issues and improve algorithms. ...“Behind all the AI improvements has been large amounts of collected training data,” explained Kamar. “That data comes from the crowd.”...“Collaboration with human intelligence is the key for building reliable AI systems. Humans need to be kept in the loop,” said Kamar....One example Kamar highlighted was the series between World Chess Champion, Garry Kasparov, and IBM’s Deep Blue in 1997. After Kasparov lost to Deep Blue, some thought humans wouldn’t play chess anymore. Indeed, according to research, humans haven’t drastically improved their chess-playing abilities since 1980, while chess-playing bots have. However, when humans and chess software play together, it’s superior to the best chess algorithm...To advance AI, identify failures, and enhance algorithms, a crowdsourced feedback loop is essential, Kamar said. “Perfecting these complex systems doesn’t work without the human input.”>>

By this consistent example, coming from Microsoft specialists, we just entered the core of generating data, extracting information and refining knowledge, by human/crowd intelligence contribution to the AI performant processes.

The mechanisms and the dimension of such processes were also recently expressed by IBM specialists [10]:

“According to IBM, about 90% of data existing in the world has been generated in the last 2 years. On average, we generate about 2.5 Quintillion bytes of data every day. This massive amount of data can’t be processed and managed by humans physically. This is where Machine learning comes into the picture”

Here we observe the amazing figures of generated data, but most of all the clear recognition of the fact that “Machine Learning and AI is Improving Lives in 2018” and how ML (and DL how we have presented in the first section) will impact practically all industries, including commerce, health care, robots, mobile devices, trains, cars, Planes, drones etc.

Perhaps ML/DL will support the most impressive applications in the most difficult fields of improvement, as predictive analysis (Climate Changes, Weather Forecast, Data Analytics, Business Intelligence), health diagnosis, real time translation or natural language processing.

In all ML/DL applications the practice proved that the quality of data sets offered for processing is essential, but the point is that these data usually come from the crowd (as Ece Kamar said).

More than these, we have to notice “the need for human intervention to resolve issues and improve algorithms”, but we would add **the imagination and responsibility of human to design safe AI** (including algorithms).

This way we have arrived in the middle of the section idea, as *AI needs high value data in order to generate information and eventually knowledge*, but the data value is depending on ... *crowd wisdom*.

In order to assure an efficient contribution of crowd, we have to carefully manage the combination of AI-HI in all typical scenarios, i.e. providing expertise for reference design tools, improve algorithms, supervising ML/DL processes and ... contributing in large volumes of data/information/knowledge by the above presented CSENS and CSOURS systems.

That is way the specialists largely agreed that quality of crowd contribution is essential for enabling AI, CSENS and CSOURS systems [12]:

“One of the key aspects of crowdsourcing is to engage the right crowd. There is no point engaging members of the crowd who neither have knowledge nor the skill and motivation to partake in the initiative. If the crowd lacks critical knowledge or even a basic insight of the domain, they will only produce results that are way below the set benchmark. On the other hand, if the crowd lacks the necessary motivation, the crowdfunding initiative will fail to realize its full potential”.

Naturally, the next (**complicate**) issue is how to select people in CSOURS systems and eventually **how to filter the collective intelligence toward refining knowledge**.

Here is the point where we have to conclude, although we have partially approached these issues [3][11][15][17], that responsibly analyzing people and information quality or refining knowledge are among the most complex, complicate and time sensitive problems to be solved, perhaps perpetually, i.e. to be further continued.

3. Conclusions

The paper premises refer to the most prominent advances and challenges of ICT, including Cloud, Big Data, IoT, green ICT, artificial intelligence (AI) and Digital Disruption (DD), which have to be approached in a responsible and systemic way, as their interdependent consequences reached unprecedented complexity and crucial importance for World economy, humankind life and future on Earth ecosystem. Here it is enough to recall the pace of ICT's carbon footprint growing versus the totality of airplanes.

An important conclusion is that using crowd wisdom (CW), by crowdsensing (CSENS), crowdsourcing (CSOURS) and generally crowd intelligence (CI), enables AI to create more knowledge from the real time data deluge that is generated at Earth scale, impacting IS/KBS, people's life and Earth environment.

Consequently, the functional structures of crowdsourcing are analysed and classified by two main criteria, referring to the degree individuals are implied and respectively the way crowd intelligence is collected.

The AI status and potential are also largely confirmed in the literature, as it is crucially impacting the World, but *machine learning* (ML) is pointed as the most important, performant and productive subfield of AI, due to its unprecedented capacity of *self-learning algorithms*, which make the difference between ML and the prior advances on AI.

On the opposite side, the paper point out the fact that the further AI advances, the complexity of its jobs and challenges is increasing and this way new kind and complicate issues are raising. IoT and other emerging sensing systems could be more performant using highest technologies as AI - HI combinations, but this way they become more complex, especially by volunteer and generally human participation and eventually progressively changing from sensing to sourcing or including both CSENS and CSOURS.

As a consequence, combining HI and AI deep learning is an emerging trend in Big Data and Collective intelligence, based on the power of AI to offer performant solutions of processing the overwhelming data volumes, along with the HI's deepness of imagination, capacity of generalize and superiority of processing sparse data.

AI could further improve its performance when approaching difficult problems for machines, which could be solved by addressing CSENS and CSOURS systems and then

discovering information/patterns in collected data, but we have to watch every time to reasonably keep the control of this complexity increasing, as remarkably also argued the genial and regretted Stephen Hawking. Consequently, we have to watch this “HI/AI combination as the natural trend of high technologies exponential progress” and keep it in the secure area of KBS development.

We have to notice “*the need for human intervention to resolve issues and improve algorithms*”, but we would add **the imagination and responsibility of human to design safe AI** (including algorithms).

The main conclusion is AI needs high value data in order to generate information and eventually knowledge, but the data value is depending on ... *crowd wisdom*. In order to assure an efficient contribution of crowd, we have to carefully manage the combination of AI-HI in all typical scenarios, i.e. providing expertise for reference design tools, improve algorithms, supervising ML/DL processes and ... contributing in large volumes of data/Information/knowledge by the above presented CSENS and CSOURS systems. The next (*complicate*) issue is how to select people in CSOURS systems and eventually how to filter the collective intelligence toward refining knowledge.

Also, we have to conclude that responsibly analyzing **people and information quality or refining knowledge are among the most complex, complicate and time sensitive problems to be solved, perhaps perpetually**, i.e. to be further continued.

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