

The Information and Communications Technology is Driving Artificial Intelligence to Leverage Refined Knowledge for the World Sustainable Development

-Part 3-



Prof.Eng.Ph.D. Victor GREU

Abstract

The paper approaches the analysis of the complex processes of artificial intelligence contribution to knowledge refining, in the general context of Information and Communications Technology (ICT) exponential evolution as main driving factor of the progress of the Information society (IS) toward Knowledge Based Society (KBS).

In this context ICT grows, but considering its complex proliferation and exponential development at Earth scale, lately by artificial intelligence (AI), as leading to a planetary digital disruption, it is necessary to estimate how big would be this iceberg, because this growing with no precisely known perspective offers enough reasons to be timely and responsibly analysed. The analysis is a dynamic challenge because the question has multiple angles to be answered, mainly twofold: how much ICT can really grow in its diverse directions (applications fields) and, on the other side, to which extent the specific and then global consequences of these growings (advances) are sustainable for humankind and Earth? The author presented, by a systemic approach, some relevant examples of this complex space/time plan where ICT/AI is fast evolving, aiming both the growing and the knowledge refining potentials.

The domain of “understanding natural language” (UNL) was selected first just because it is actually one of the most prominent, prolific and challenging fields of AI, without mentioning the essential role of man-machine communication in this digital époque of humankind evolution and generally in the IS/KBS processes. UNL rises difficult problems of accuracy (false understanding) in the important applications for security, where the performance is critical for avoiding false identification or service denial.

As the impact of AI to the health care field is enough important for humankind, it is developed and analysed with priority and perhaps one of the most prominent work in the AI use for the medical field is done by IBM, but the detailed analysis of this case showed that IBM powerful technology (Watson) is not enough for the complex reality of today's health care system. At least when trying to apply Watson to cancer treatment, one of medicine's biggest challenges, IBM faced a big difference between the way machines learn and the way doctors work.

One of the conclusions is that in the ICT/AI struggle to win higher and higher peaks of performance, especially in the health care field, where humankind expectations are naturally the most justified, all the progress efforts must be supported, encouraged but also carefully and realistically timely analysed in order to obtain the optimal results, even when "the downs" appear to be prominent. It is also very important to use and learn lessons from all the refined knowledge these ups and downs of ICT/AI provide, adding new human expertise and use all available resources to get sustainable progress in all activity areas, keeping humankind health as first priority, not only in the ICT/AI direct health care applications, but also in the indirect consequences that could come sooner or later from other fields progress.

The paper analysis includes another relevant systemic example of AI growing, the communications vast area, because, albeit the idea of intelligent network is not new, the actual AI potential and the trend of using most of wireless communication capacity are generating very important applications aiming optimization. Considering the complex picture of the factors that could influence wireless communications performance, it seems that the medium access control is a zone where they could benefit most from AI(machine learning) support in optimizing areas like Signal detection, Channel encoding and decoding, Channel estimation, prediction, and compression, Resource allocation etc.

An important conclusion of paper is that extending applications area of AI could be less efficient if we do not add some new approaches of the ways to understand and use the complex relations between data, information and knowledge resulting from these applications and more than these, **add the cognitive principles we must develop AI on**, in order to perform towards human brain-like models that leverage **learning from that knowledge, i.e. properly refining knowledge**.

Another conclusion is the necessity of conceiving and using the new systems/technologies with a balance between perpetual human values/principles and the **rational** actual trends. There is still a reasonable expectation that ICT/AI could better leverage the management of this balance by their implementation in most advanced cognitive systems, i.e. we have to **keep alive wisdom principles** and update them with the refined knowledge that reflects the actual needs of humankind and Earth, not only for immediate efficiency, but for **a stable future of the available resources and life environment**. The actual challenges of ICT/AI development must be synchronized with the humankind surviving (on Earth) challenges and risks, but here the point is that, more than AI, the cognitive computing systems (CCS) could really be a part of the right decision in a matter that is closing now to the human intelligence stage, just by the potential to approach high level problems. Considering the high level of cognitive science, in the concrete development of AI toward CCS there is a long way, naturally similar to the IBM-Watson bitter-sweet evolution, i.e. very difficult and complex. Going to the core of CCS, the aim is the human brain map and functionality, which must be replicated in the future.

The paper also referred to concrete principles, methods and technologies to reach such performance and complex objectives, which are among the most **sophisticated ingredients** of the evolution from AI to CCS, without neglecting **brain complex operating processes and the ways these are related to reality**. For a progress from here ahead it is very

probable to refer to the **people's changing behaviour** and evolutionary epistemology, or simple to the **brain**. Without offering solutions here, this philosophy approach (one of the many possible!) has the quality to reveal the complexity of the AI target to follow the human brain model and in the same time is a good instrument of orienting the AI/CCS design to overpass inherent human limits of reflecting reality, by **using objective measures/metrics for sensing most of reality parts, but unfortunately not for all**.

Another useful conclusion is that the most difficult problems for AI/CCS progress are in the area of managing knowledge associated to abstract concepts (like compassion, causality or democracy) where never the human perception, imagination and creation would be completely replaced.

Consequently AI/CCS should be developed in a close collaboration between AI and **human intelligence, expertise and responsibility**, i.e. **CCS should include selected humans in all processes, from design to implementation and usage, as intrinsic parts of the systems and applications**, valuing the AI natural language processing, computer vision or other similar advanced man-machine interfaces (like emerging brain-computer interfaces). Although all the above (at least) human contributions are important, it is worth to notice that the most prominent should be in **responsibly designing AI/CCS as the knowledge used and refined must have the potential to generate sustainable progress of humankind and Earth ecosystem**.

Keywords: natural language, IBM Watson, knowledge refining, deep learning, physical layer optimization, machine learning, neural networks, medium access control, evolutionary epistemology, information society, knowledge based society.

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

Failure is simply the opportunity to begin again, this time more intelligently

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Henry

Ford

1. Where the Information and Communications Technology intelligence grows

Typically, the humans have the ancestral tendency to grow everything they like and this is far from ... being limited to food.

This simple observation has major implications all around us and lately we can see that the Information and Communications Technology (ICT) became the main driving engine of the Information Society (IS) toward Knowledge Based Society (KBS), just by using its overwhelming influence on all humankind activity, as, step by step, ICT products and services succeeded to bring more and more benefits for humankind life and IS/KBS progress [22] [23] [26] [19].

Perhaps this is the main way ICT grows, but its complex proliferation and exponential development at Earth scale, reflected by Internet of Things (IoT), Cloud, Big Data, or lately artificial intelligence (AI), leading to a planetary digital disruption (DD), rise a question that we have repeatedly expressed [8] [3] [14]: **How big would be this growing iceberg?**

With simpler words, this growing with no precisely known perspective offers enough reasons to be timely and responsibly analysed.

The analysis is a dynamic challenge because the question has multiple angles to be answered, mainly twofold: how much ICT can really grow in its diverse directions (applications fields) and, on the other side, to which extent the specific and then global consequences of these growings (advances) are sustainable for humankind and Earth?

This way we could observe the eventual link between this twofold dynamic challenge and the intelligence we expect to be found in every ICT growing.

More than these, a complete understanding of this section title/aim should include the inherent link between an **intelligent growing** and the AI that is the actually the most promising advance of ICT development.

Further we could analyse and eventually understand how these ICT/AI advances are leveraging the knowledge refining everywhere are used and this way easing the World sustainable development.

In such complex context, any analysis, far from being exhaustive, should consider both the dynamic of ICT/AI exponential pace of development and the ubiquitous horizontal spreading of applications fields at planetary scale.

Our approach will first consider some relevant examples of this complex space/time plan where ICT/AI is fast evolving, aiming both the growing and the knowledge refining potentials.

It is obvious that selecting examples from the huge diversity of ICT/AI context is itself a multicriteria problem and consequently a systemic approach is essential, as it is indirectly confirmed by this first example [1]:

“...one of the major challenges in developing systems that understand natural language is coverage of possible inputs. This is a symptom of the limited imagination of individual humans, which can be remedied by harnessing the power of the crowd to amplify the imagination of an individual developer, and provide more complete coverage of the input space. The benefits of crowdsourcing are not limited to enhanced understanding of language, as the crowd can also provide common sense knowledge and enhanced creativity...”

Here we should observe that the systemic approach is provided by the global condition to cover all “possible inputs” (system parts) and the relevance of this example is also systemic if we recall that in the AI modelling theory an essential rule is **to provide the logical coverage of all scenarios that could be generated in the problem context**. This first observation shows in fact that this example has also relevance for the mentioned selection multicriteria problem.

In addition, we have approached “understanding natural language” domain just because it is actually one of the most prominent, prolific and challenging fields of AI, without mentioning the essential role of man-machine communication in this digital époque of humankind evolution and generally in the IS/KBS processes.

More than these, “the limited imagination of individual humans” and “benefits of crowdsourcing” were already presented in our previously papers [11] [21], but here we have one more confirmation of the fact that in the knowledge refining processes “crowd can also provide common sense knowledge and enhanced creativity”.

The model and the technology used in this AI example is further relevant for our analysis:

“Content creation is crowdsourced by recording thousands of human performances, which are mined for patterns representing elements of narrative structure (e.g. events, dependencies). Patterns guide a novel runtime architecture which combines plan recognition with casebased planning to replay fragments of recorded games at runtime. Initial work explored automatically discovering patterns in data. Ultimately, patterns were discovered through a human-machine collaborative process, where human annotated recorded performances with meta-data representing narrative structure, from which patterns were extracted. Browser-based tools allowed hiring people anywhere in the world to annotate transcripts of recorded human performances.”

It is worth to notice that another relevance of the example is given by the fact that “*understanding natural language*” (UNL) is a prominent class of AI complex applications, where deep learning (DL), a higher form of machine learning (ML), is used in a combined unsupervised-supervised process, as we generally already presented [3].

The last, but not the least, we should stress that “*the limited imagination of individual humans*” and “*The benefits of crowdsourcing*” confirm once again the objective necessity of combining AI and human(collective) intelligence HI in order to maximize the efficiency and performance of the ICT/AI processes [17][11].

In the case of UNL, this necessity is asked due to the huge diversity of languages, dialects, but especially variations from individual to individual even for the same language.

These variations rise difficult problems of accuracy (false understanding) in the important applications for security, where the performance is critical for avoiding false identification or service denial.

In the same direction, the emerging area of cognitive intelligence (CI), an ultimate performance horizon for AI [25][3], for example at humanoid robots, requires the capacity to understand and express sophisticated issues like emotions or intellectual creations, which is essentially challenging for UNL features.

Exceeding the UNL domain, it is worth to observe here that “Crowdsourced Common Sense” and “*common sense knowledge*” represent subjects very relevant for ICT/AI capacity to leverage knowledge refining.

First, we have already presented that Crowdsourcing and generally collective intelligence are prominent trends for the ICT/AI performance/efficiency improvement [11], but in this context they are increasing the potential to extract knowledge from large amounts of useful data.

Perhaps this subtle connection is even more interesting in the case of common sense knowledge, but for the emerging applications and benefits of new technologies like social media, the above example, [1], shows that when

“... leveraging the crowd to understand language, however, the crowd is equally useful for providing common sense knowledge, and possible narratives... from which it is possible to learn common sense about everyday physical and linguistic interactions...”

Our opinion is that we can use the new AI technologies associated with UNL for leveraging knowledge refining in a very complex field of intelligence, like common sense,

where, for AI, it will be one of the latest barricades to conquer in the fight to compete with humans.

Talking about common sense, it is obvious that it is a vast sphere, where always is something to observe, but, as AI/ML is progressing, one could believe there is few to discover or connect.

For example, when thinking for choosing the next “AI example” in this section, it could appear strange to imagine that it will be very tight with ... *the natural language*.

As this start was just an idea about how common sense could be tricky, let’s say that, for the mentioned systemic approach, the impact of AI to the health care field is enough important for humankind to be developed and analysed with priority [27].

Perhaps one of the most prominent work in the AI use for the medical field is done by IBM and a very comprehensive analysis of this case, we will shortly discuss here, is made in [2]:

*“In 2014, **IBM** opened swanky new headquarters for its artificial intelligence division, known as **IBM Watson**. Inside the glassy tower in lower Manhattan, IBMers can bring prospective clients and visiting journalists into the “immersion room,” which resembles a miniature planetarium. There, in the darkened space, visitors sit on swiveling stools while fancy graphics flash around the curved screens covering the walls. It’s the closest you can get, IBMers sometimes say, to being inside Watson’s electronic brain. One dazzling 2014 demonstration of Watson’s brainpower showed off its potential to transform medicine using AI—a goal that IBM CEO Virginia Rometty often calls the company’s moon shot. In the demo, Watson took a bizarre collection of patient symptoms and came up with a list of possible diagnoses, each annotated with Watson’s confidence level and links to supporting medical literature. Within the comfortable confines of the dome, Watson never failed to impress: Its memory banks held knowledge of every rare disease, and its processors weren’t susceptible to the kind of cognitive bias that can throw off doctors. It could crack a tough case in mere seconds. If Watson could bring that instant expertise to hospitals and clinics all around the world, it seemed possible that the AI could reduce diagnosis errors, optimize treatments, and even alleviate doctor shortages—not by replacing doctors but by helping them do their jobs faster and better.”*

As we have repeatedly presented [18] [3], as ICT/AI progress is aiming higher peaks, it is more difficult to progress and even to keep pace, performance, efficiency or credibility. As a consequence, we have proposed to timely and carefully analyse these evolutions, in order to foresee not only benefits but also the less positive implications of their too fast proliferation at Earth scale.

If this general opinion could have, naturally, a level of relativity, it is sure that when speaking of the AI struggle to get closer to the human intelligence, this degree is lower and the IBM studied case is a good confirmation.

Anyway, it is important to stress, from the beginning, that we do not completely agree with all the (extreme) quoted opinions, but, as study example, we consider that the ups and downs of this AI challenging field could lead to realistic conclusions for the ICT/AI too fast pace versus the complexity of all the consequences for humankind and Earth, that must be analysed in too short time, counting ICT contributions to climate changes, Earth resource fading, social/human implications etc.[8][15][24][16].

Coming back to *the natural language* we have mentioned above, as a coincidence, it lays at the Watson basics and explain an essential part of the IBM involved technology for medical support:

<<The Jeopardy! victory in 2011 showed Watson's remarkable skill with natural-language processing (NLP). To play the game, it had to parse complicated clues full of wordplay, search massive textual databases to find possible answers, and determine the best one. "It almost seemed that Watson could understand the meaning of language, rather than just recognizing patterns of words," says Martin Kohn, who was the chief medical scientist for IBM Research at the time of the Jeopardy! match. "It was an order of magnitude more powerful than what existed." What's more, Watson developed this ability on its own, via machine learning. The IBM researchers trained Watson by giving it thousands of Jeopardy! clues and responses that were labeled as correct or incorrect. In this complex data set, the AI discovered patterns and made a model for how to get from an input (a clue) to an output (a correct response). Long before Watson starred on the Jeopardy! stage, IBM had considered its possibilities for health care. Medicine, with its reams of patient data, seemed an obvious fit, particularly as hospitals and doctors were switching over to electronic health records. While some of that data can be easily digested by machines, such as lab results and vital-sign measurements, the bulk of it is "unstructured" information, such as doctor's notes and hospital discharge summaries. That narrative text accounts for about 80 percent of a typical patient's record—and it's a stew of jargon, shorthand, and subjective statements.>>

The huge progress of ICT/AI/Watson has naturally impressed medical specialists and their hopes are partially confirmed, as:

<<Kohn, who came to IBM with a medical degree from Harvard University and an engineering degree from MIT, was excited to help Watson tackle the language of medicine. "It seemed like Watson had the potential to overcome those complexities," he says. By turning its mighty NLP abilities to medicine, the theory went, Watson could read patients' health records as well as the entire corpus of medical literature: textbooks, peer-reviewed journal articles, lists of approved drugs, and so on. With access to all this data, Watson might become a superdoctor, discerning patterns that no human could ever spot. "Doctors go to work every day—especially the people on the front lines, the primary care doctors—with the understanding that they cannot possibly know everything they need to know in order to practice the best, most efficient, most effective medicine possible," says Herbert Chase, a professor of medicine and biomedical informatics at Columbia University who collaborated with IBM in its first health care efforts. But Watson, he says, could keep up—and if turned into a tool for "clinical decision support," it could enable doctors to keep up, too. In lieu of a Jeopardy! clue, a physician could give Watson a patient's case history and ask for a diagnosis or optimal treatment plan.>>

Unfortunately we have to comeback, this time to the mentioned AI ups and downs, as Watson is such case [2]:

"MD Anderson Cancer Center partnered with IBM Watson to create an advisory tool for oncologists. The tool used natural-language processing (NLP) to summarize patients' electronic health records, then searched databases to provide treatment recommendations. Physicians tried out a prototype in the leukemia department, but MD Anderson canceled the

project in 2016—after spending US \$62 million on it. Outside of corporate headquarters, however, IBM has discovered that its powerful technology is no match for the messy reality of today's health care system. And in trying to apply Watson to cancer treatment, one of medicine's biggest challenges, IBM encountered a fundamental mismatch between the way machines learn and the way doctors work.”

Our opinion is that in the ICT/AI struggle to win higher and higher peaks of performance, especially in the health care field, where humankind expectations are naturally the most justified, all the progress efforts must be supported, encouraged but also carefully and realistically timely analysed in order to obtain the optimal results, even when “the downs” appear to be prominent [2]:

<<At a 2017 conference of health IT professionals, IBM CEO Rometty told the crowd that AI “is real, it's mainstream, it's here, and it can change almost everything about health care,” and added that it could usher in a medical “golden age.” She's not alone in seeing an opportunity: Experts in computer science and medicine alike agree that AI has the potential to transform the health care industry. Yet so far, that potential has primarily been demonstrated in carefully controlled experiments. Only a few AI-based tools have been approved by regulators for use in real hospitals and doctors' offices. Those pioneering products work mostly in the visual realm, using computer vision to analyse images like X-rays and retina scans. (IBM does not have a product that analyses medical images, though it has an active research project in that area). Looking beyond images, however, even today's best AI struggles to make sense of complex medical information. And encoding a human doctor's expertise in software turns out to be a very tricky proposition. IBM has learned these painful lessons in the marketplace, as the world watched. While the company isn't giving up on its moon shot, its launch failures have shown technologists and physicians alike just how difficult it is to build an AI doctor.>>

We also consider that it is very important to use and learn lessons from all the refined knowledge these ups and downs of ICT/AI provide, adding new expertise from CI and use all available resources to get sustainable progress in all activity areas, keeping humankind health as first priority, not only in the ICT/AI direct health care applications, but also in the indirect consequences that could come sooner or later from other fields progress.

Another relevant systemic example of AI growing is placed, where else but in ... the communications vast area.

Although the idea of intelligent network is not new, the actual AI potential and the trend of using most of wireless communication capacity are generating very important applications aiming optimization [4]:

“The field of machine learning (ML) has a long and extremely successful history. For example, the idea of using neural networks (NN) for intelligent machines dates back to as early as 1942 when a simple one-layer model was used to simulate the status of a single neuron. ML has shown its overwhelming advantages in many areas, including computer vision, robotics, and natural language processing, where it is normally difficult to find a concrete mathematical model for feature representation. In those areas, ML has proved to be a powerful tool as it does not require a comprehensive specification of the model. Different from the aforementioned ML applications, the development of communications has vastly relied on theories and models, from information theory to channel modelling. These

traditional approaches are showing serious limitations, especially in view of the increased complexity of communication networks. Therefore, research on ML applied to communications, especially to wireless communications, is currently experiencing an incredible boom.”

Looking to the complex picture of the factors that could influence wireless communications performance, it seems that the medium access control is a zone where they could benefit most from AI/ML support in optimization, as the authors in [4] collected many papers and found:

“This collection of Best Readings focuses on ML in the physical and medium access control (MAC) layer of communication networks. ML can be used to improve each individual (traditional) component of a communication system, or to jointly optimize the entire transmitter or receiver. Therefore, after introducing some popular textbooks, tutorials, and special issues in this collection, we divide the technical papers into the following six areas:

- Signal detection*
- Channel encoding and decoding*
- Channel estimation, prediction, and compression*
- End-to-end communications*
- Resource allocation*
- Selected topics*

Even if ML in communications is still in its infancy, we believe that a growing number of researchers will be dedicated to the related studies and ML will greatly change the way of communication system design in the near future.”

In a concrete manner, a new and comprehensive approach of using deep learning in wireless communication for the physical layer optimization is given then by [6] as:

“We present and discuss several novel applications of deep learning for the physical layer. By interpreting a communications system as an autoencoder, we develop a fundamental new way to think about communications system design as an end-to-end reconstruction task that seeks to jointly optimize transmitter and receiver components in a single process. We show how this idea can be extended to networks of multiple transmitters and receivers and present the concept of radio transformer networks as a means to incorporate expert domain knowledge in the machine learning model. Lastly, we demonstrate the application of convolutional neural networks on raw IQ samples for modulation classification which achieves competitive accuracy with respect to traditional schemes relying on expert features.”

Without discussing the theoretical details, it is worth to notice that such approaches show the potential of AI/ML to leverage the optimization, really needed, for one of the most complex issues of ICT development in the crowded/congested future networks (including IoT), especially due to the fact that this methods could be *“extended to networks of multiple transmitters and receivers and present the concept of radio transformer networks as a means to incorporate expert domain knowledge in the machine learning model”*.

More than these, we observe that the idea of aiming and then refining knowledge is included here and confirms this systemic way of thinking and implementing applications for the most advanced ICT/AI development fields.

The analysis of this series of examples, of where AI growing is more needed and present, could be obviously completed by adding applications fields like climate changes, computer vision, self-driving cars, smart agriculture, blockchain, smart grid, wind/solar energy, bio-surveillance or weather forecast global prediction models.

Extending applications area of AI could be less efficient if we do not add some new approaches of the ways to understand and use the complex relations between data, information and knowledge resulting from these applications and more than these, **add the cognitive principles we must develop AI on**, in order to perform towards human brain-like models that leverage **learning from that knowledge, i.e. properly refining ... knowledge**.

2. Learning from cognitive systems

It is well known that the wise human is “learning from everything”, although actually this trend is not so spread like in the past, first because the whole humanity history data are equivalently generated in only two years of our days [5][10].

Perhaps a second reason is given by the **people’s changing behaviour**, which now are rather eager to be informed (only on priority issues) than to “learn from everything”.

For a sustainable ICT/AI and IS/KBS progress we all should take into account these realities by conceiving and using the new systems/technologies with a balance between perpetual human values/principles and the **rational** actual trends. There is still a reasonable expectation that ICT/AI could better leverage the management of this balance by their implementation in most advanced *cognitive systems* [12] [13] [20] [9] [3].

In a simpler expression, we have to **keep alive wisdom principles** and update them with the refined knowledge that reflects the actual needs of humankind and Earth, not only for immediate efficiency, but for **a stable future of the available resources and life environment**.

Our opinion is very interestingly confirmed, at a larger scale of cognitive science, where we could find solid foundations, like *evolutionary epistemology*, for the actual most complex theories to develop AI toward *cognitive computing systems* [7]:

“The cybernetician Ashby [1960, 1964] noted that appropriate selection is the essence of intelligence. Indeed, we have defined intelligence as the ability to solve problems, and we have analysed problem solving as selecting the right sequence of actions that lead from the initial state to the goal state. Anything that helps us to make the right selection—such as heuristics or simply additional information about the problem situation—will therefore increase our power to solve problems, and thus amplify our intelligence. In essence, a cognitive system is therefore something that helps us to make the right selection from a variety of possibilities, i.e. the right decision. The larger the variety (i.e. uncertainty), the more difficult it becomes to find the solution by trial-and error, and the more need there is for some cognitive mechanism to reduce complexity and support adequate selection. This creates what evolutionary theorists call a strong “selective pressure” for cognition. Since we are all alive, we have adapted to that pressure. In other words, all the presently living agents have been selected to survive ... The surviving agents must have evolved some mechanism(s) to choose adequate actions. Donald T. Campbell [1974], the founder of evolutionary epistemology, called these internal mechanisms “vicarious selectors”. They select

*appropriate actions from the myriad possibilities. In that way, they “stand in” for, substitute, or represent natural selection by the environment. (Note the meaning of the term “vicar”: delegate, representative, substitute). If the vicarious selector had not eliminated the wrong actions, natural selection would have eliminated the agent itself ... There exist many different types of vicarious selectors at different levels of complexity. These include “instinctive” knowledge inherent in the genes, perceptions, which “stand in” for the external situation, knowledge learned from experience, and information received via communication from others. From the point of view of evolutionary epistemology, all cognitive mechanism function essentially as vicarious selectors: they all help us to select the right actions, and do so **in order for us to survive natural selection.**”*

Our opinion is that the actual challenges of ICT/AI development must be synchronized with the humankind surviving (on Earth) challenges and risks, as we have already presented [8], but here the point is that, more than AI, the *cognitive computing systems (CCS)* could really be a part of *the right decision* in a matter that is closing now to the human intelligence stage, just by the potential to approach high level problems – like <<“instinctive” knowledge inherent in the genes, perceptions, which “stand in” for the external situation, knowledge learned from experience, and information received via communication from others>>.

If the above “gene” inclusion could appear too much, it is the case to recall, for example, the genetic engineering actual achievements, where AI is more and more prolific in linking DNA genes analysis (and “processing”) with long expected results in practical health care.

In the same time, leaving the high level of cognitive science, in the concrete development of AI toward CCS there is a long way, naturally similar to the IBM-Watson bitter-sweet evolution, i.e. very difficult and complex.

The concrete principles, methods and technologies to reach such performance and complex objectives are among the most **sophisticated ingredients** of the evolution from AI to CCS [9]:

” ‘Cognitive computing represents self-learning systems that utilize machine learning models to mimic the way brain works.’ Eventually, this technology will facilitate the creation of automated IT models which are capable of solving problems without human assistance. The result is cognitive computing – a combination of cognitive science and computer science.”

Going further to the core of CCS, the aim is the human brain map and functionality, which must be replicated in the future as:

“Cognition comes from the human brain. So what’s the brain of cognitive systems? Cognitive computing represents the third era of computing. In the first era, (19th century) Charles Babbage, also known as ‘father of the computer’ introduced the concept of a programmable computer. Used in the navigational calculation, his computer was designed to tabulate polynomial functions. The second era (1950) experienced digital programming computers such as ENIAC and ushered an era of modern computing and programmable systems. And now to cognitive computing which works on deep learning algorithms and big data analytics to provide insights. **Thus the brain of a cognitive system is the neural**

network, the fundamental concept behind deep learning. *The neural network is a system of hardware and software mimicked after the central nervous system of humans, to estimate functions that depend on the huge amount of unknown inputs.”*

The next step is pointing the CCS model features to be implemented, further described as requirements to be fulfilled as [9]:

„With the present state of cognitive computing, basic solutions can play an excellent role of an assistant or virtual advisor. Siri, Google assistant, Cortana, and Alexa are good examples of personal assistants. In order to implement cognitive computing in commercial and widespread applications, Cognitive Computing Consortium has recommended the following features for the computing systems –

1. Adaptive

They must learn as information changes, and as goals and requirements evolve. They must resolve ambiguity and tolerate unpredictability. They must be engineered to feed on dynamic data in real time or near-real time.

2. Interactive

Similar to a brain, the cognitive solution must interact with all elements in the system – processor, devices, cloud services and user. Cognitive systems should interact bidirectionally. It should understand human input and provide relevant results using natural language processing and deep learning. Some intelligent chatbots such as Mitsuku have already achieved this feature.

3. Iterative and stateful

They must aid in defining a problem by asking questions or finding additional source input if a problem statement is ambiguous or incomplete. They must 'remember' previous interactions in a process and return information that is suitable for the specific application at that point in time.

4. Contextual

They must understand, identify, and extract contextual elements such as meaning, syntax, time, location, appropriate domain, regulations, user's profile, process, task, and goal. They may draw on multiple sources of information, including both structured and unstructured digital information, as well as sensory inputs (visual, gestural, auditory, or sensor-provided).”

After implementing, as much as possible, these complex features, the results are generally good but the target is still far, because of a lot of factors which remain, in turn, difficult to identify and control, as is finally regnized [9]:

„Cognitive computing is definitely the next step in computing started by automation. It sets a benchmark for computing systems to reach the level of the human brain. But it has some limitations as AI is difficult to apply in situations with a high level of uncertainty, rapid change or creative demands. The complexity of problem grows with the number of data sources. It is challenging to aggregate, integrate and analyze such unstructured data. A complex cognitive solution should have many technologies that coexist to give deep domain insights.”

Still, such approaches are far from the **sophisticated ingredients** we have mentioned above, at least from the point of view of **brain complex operating processes and the ways these are related to ... reality.**

Surprisingly, for a progress from here ahead it is very probable to comeback to the **people's changing behaviour** and *evolutionary epistemology* or simple to the **brain**.

We have already presented [25] that, generally, ICT/AI development optimization is a multi-criteria function, but the implied parameters are sometimes dependent on function values and we could get in a “vicious circle” and on the other hand our target is fast moving and difficult to reach, as **Morgan le Fay** (*Morgana mirage*) [3].

This complex and dynamic face of reality was naturally discovered and analysed in studies of *evolutionary epistemology*, like *problems of the reflection* (of reality by brain) theory [7]:

“... although simple and attractive, this philosophy leads to a range of fundamental problems. First, reality is much too complex to map in detail: we can only register and remember the tiniest fraction of the potentially available information. Moreover, why would we need such an accurate reflection if we have the world itself? Too detailed maps are essentially useless: just imagine a 1/1scale map of a city, where every stone, weed or broken bottle is reproduced in full detail ... Simplifying a map may seem obvious, but the problem is that there is no objective way to decide what to leave out and what to include in the map. All maps, models and representations are strongly determined by the purpose for which they are used ... More fundamentally, as Kant taught us, we have no access to the “Ding-an-sich”, i.e. the objective reality outside of us, only to our very simplified and distorted perceptions of it. We cannot compare our mental contents to reality, only to our perceptions—which are themselves already part of our mental contents. Therefore, there is no absolute way that we can make sure that the reflection is accurate. This forces us to abandon accurate reflection as the ultimate criterion of truth. Yet another problem with the reflection view of mind is that it does not explain abstract or affective ideas. For example, how can you perceive compassion, the number zero, causality, or democracy? Which concrete objects are mapped onto these abstract concepts? Even for the phenomenon that initially inspired this philosophy, imagery, it turns that out that there is no true isomorphism between the mental image and the thing it represents...”

Without offering solutions here, this *philosophy* approach (one of the many possible!) has the quality to reveal the complexity of the AI target to follow the human brain model and in the same time is a good instrument of orienting the AI/CCS design to overpass inherent human limits of reflecting reality, by **using objective measures/metrics for sensing most of reality parts, but unfortunately not for all**.

Another useful observation is that the most difficult problems for AI/CCS progress are in the aria of managing knowledge associated to *abstract concepts* (like *compassion, causality or democracy*) where never the human perception, imagination and creation would be completely replaced.

This way we may consider that AI/CCS should be developed in a close collaboration between AI and **human intelligence, expertise and responsibility**, i.e. **CCS should include selected humans in all processes, from design to implementation and usage, as intrinsic parts of the systems and applications**, valuing the AI natural language processing, computer vision or other similar advanced man-machine interfaces (like emerging brain-computer interfaces).

Although all the above (at least) human contributions are important, it is worth to notice that the most prominent should be in **responsibly designing AI/CCS as the knowledge used and refined must have the potential to generate sustainable progress of humankind and Earth ecosystem.**

3. Conclusions

As ICT products and services succeed to bring more and more benefits for humankind life and IS/KBS progress, ICT grows, but considering its complex proliferation and exponential development at Earth scale, lately artificial by intelligence (AI), as leading to a planetary digital disruption, it is necessary to estimate how big would be this iceberg, because this growing with no precisely known perspective offers enough reasons to be timely and responsibly analysed. The analysis is a dynamic challenge because the question has multiple angles to be answered, mainly twofold: how much ICT can really grow in its diverse directions (applications fields) and, on the other side, to which extent the specific and then global consequences of these growings (advances) are sustainable for humankind and Earth?

We considered, by a systemic approach, some relevant examples of this complex space/time plan where ICT/AI is fast evolving, aiming both the growing and the knowledge refining potentials.

The “*understanding natural language*” (UNL) domain was selected first just because it is actually one of the most prominent, prolific and challenging fields of AI, without mentioning the essential role of man-machine communication in this digital époque of humankind evolution and generally in the IS/KBS processes. UNL rises difficult problems of accuracy (false understanding) in the important applications for security, where the performance is critical for avoiding false identification or service denial.

The impact of AI to the health care field is enough important for humankind to be developed and analysed with priority and perhaps one of the most prominent work in the AI use for the medical field is done by IBM, but the detailed analysis of this case showed that IBM powerful technology (*Watson*) is not enough for the complex reality of today’s health care system. At least when *trying to apply Watson to cancer treatment*, one of medicine’s biggest challenges, IBM faced a big difference between *the way machines learn and the way doctors work*.

Our conclusion is that in the ICT/AI struggle to win higher and higher peaks of performance, especially in the health care field, where humankind expectations are naturally the most justified, all the progress efforts must be supported, encouraged but also carefully and realistically timely analysed in order to obtain the optimal results, even when “the downs” appear to be prominent. It is also very important to use and learn lessons from all the refined knowledge these ups and downs of ICT/AI provide, adding new human expertise and use all available resources to get sustainable progress in all activity areas, keeping humankind health as first priority, not only in the ICT/AI direct health care applications, but also in the indirect consequences that could come sooner or later from other fields progress.

Albeit the idea of intelligent network is not new, the actual AI potential and the trend of using most of wireless communication capacity are generating very important applications aiming optimization for another relevant systemic example of AI growing, *the*

communications vast area. Considering the complex picture of the factors that could influence wireless communications performance, it seems that the medium access control is a zone where they could benefit most from AI/ML support in optimizing areas like *Signal detection, Channel encoding and decoding, Channel estimation, prediction and compression, Resource allocation* etc.

An important conclusion of paper is that extending applications area of AI could be less efficient if we do not add some new approaches of the ways to understand and use the complex relations between data, information and knowledge resulting from these applications and more than these, **add the cognitive principles we must develop AI on**, in order to perform towards human brain-like models that leverage **learning from that knowledge, i.e. properly refining knowledge**.

Another conclusion is the necessity of conceiving and using the new systems/technologies with a balance between perpetual human values/principles and the **rational** actual trends. There is still a reasonable expectation that ICT/AI could better leverage the management of this balance by their implementation in most advanced *cognitive systems*, i.e. we have to **keep alive wisdom principles** and update them with the refined knowledge that reflects the actual needs of humankind and Earth, not only for immediate efficiency, but for **a stable future of the available resources and life environment**. Thus the actual challenges of ICT/AI development must be synchronized with the humankind surviving (on Earth) challenges and risks, but here the point is that, more than AI, the *cognitive computing systems* (CCS) could really be a part of *the right decision* in a matter that is closing now to the human intelligence stage, just by the potential to approach high level problems.

Considering the high level of cognitive science, in the concrete development of AI toward CCS there is a long way, naturally similar to the IBM-Watson bitter-sweet evolution, i.e. very difficult and complex. Going to the core of CCS, the aim is the human brain map and functionality, which must be replicated in the future.

A conclusion is also that the concrete principles, methods and technologies to reach such performance and complex objectives are among the most **sophisticated ingredients** of the evolution from AI to CCS, without neglecting **brain complex operating processes and the ways these are related to reality**. For a progress from here ahead it is very probable to comeback to the **people's changing behaviour** and *evolutionary epistemology* or simple to the **brain**. Without offering solutions here, this *philosophy* approach (one of the many possible!) has the quality to reveal the complexity of the AI target to follow the human brain model and in the same time is an useful instrument of orienting the AI/CCS design to overpass inherent human limits of reflecting reality, by **using objective measures/metrics for sensing most of reality parts, but unfortunately not for all**.

Another useful conclusion is that the most difficult problems for AI/CCS progress are in the aria of managing knowledge associated to *abstract concepts* (like *compassion, causality or democracy*) where never the human perception, imagination and creation would be completely replaced.

Consequently, AI/CCS should be developed in a close collaboration between AI and **human intelligence, expertise and responsibility**, i.e. **CCS should include selected humans in all processes, from design to implementation and usage, as intrinsic parts of**

the systems and applications, valuing the AI natural language processing, computer vision or other similar advanced man-machine interfaces (like emerging brain-computer interfaces). Although all the above (at least) human contributions are important, it is worth to notice that the most prominent should be in **responsibly designing AI/CCS as the knowledge used and refined must have the potential to generate sustainable progress of humankind and Earth ecosystem**.

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