

Developing information and communications technology to provide more intelligence and leverage more wisdom for a dramatically changing World

-Part 1-



Prof. Eng. Ph.D. Victor GREU

Abstract

The paper analyses the context of the dramatic trends of the global processes in the Earth ecosystem, affecting a diversity of domains (which have the potential to be extended almost randomly, because of the accumulated negative premises of the World context), considering also the benefic ways Information and Communications Technology (ICT) is already influencing the humankind and our planet, with the expectation that this influence will be continued under the new conditions. It is very important to analyse such premises of the complex World context, in order to identify the optimal or at least the sustainable ways ICT could be further developed in order to support the approaching and facing of the most probable and dramatical changes/processes/events which would have the potential to strongly affect the life quality on Earth and even the whole planetary ecosystem. Although sometimes it is considered that the **accumulated negative premises** are not critical, yet, for example in the climate changes case (when the opinion is already more than dubitable), as prominent challenge for the Earth and humankind, **another significant difference versus the past is the Earth resources fading critical stage (including food), which already began to generate cascades of dramatical consequences in more and more domains, from energy to social and geopolitical crises.**

As a consequence of such negative context premises for the Earth ecosystem evolution, it is necessary to analyse all the possibilities of humankind to mitigate these trends/challenges, including first the well-known potential of ICT to influence the World and support IS/KBS. The expected challenges, dilemmas and dramatical changes/crises, we will have to face more and more, must be approached by rational and complicate analyses, in spite of the extreme uncertainty levels these problems could have, leveraging our success chances if using for such purposes all the acquired and potential power of ICT advances, including AI along with HI and wisdom. Among the priorities of the rational mentioned analyses, we consider, with priority, **the necessity of the research for new alternative energy and materials (including food) solutions, along with recycling and saving the actual but fading Earth resources. This crucial challenge will determine the ways the World progress, based on production and consummation, could be continued in a sustainable manner, a longer or a shorter period of time, i.e., it will define the balance between apogee and survival, on Earth.** Another significant issue, making the difference over the past, is given by **the extreme urgency and last mile stage World is in, before being too late!**

Planning a long road by concrete steps, we think that the systemic and structural approaches should be based on some value/relevant principles, criteria and examples, as our paper shortly presents. As a principle

consequence of considering ICT influence at planetary scale, i.e., a real leverage factor for all human activity domains, being also a huge consumer of energy and materials, is to carefully analyse both positive and eventual negative issues of ICT exponential evolution, but pointing just the necessity to adapt the ICT future pace and systemic structure to the dramatical context premises, understanding that although some development areas/directions should be slowed down, other could be faster. This way, the analysis of ICT advances issues, where artificial intelligence (AI), among others, is prominent, remains the starting point, as the power of all ICT products, services or applications, considering, still, the refined knowledge which could reconfigure the weights of different areas of applications, must be the basic potential of computing and networking power to be provided where World priority goals will arise.

Following such goals, but not being limited to them, our analysis is based on relevant cases/examples, as a support for their eventual integration in useful studies or advices for incumbents, or reference for everyone - an education component, necessary to face the emerging dramatical/dynamic World. We consider that the education should be the main mass way to refine the knowledge for the appropriate actions everyone has to understand, in the dynamic mentioned World and ICT context, but it is also clear that we could not expect the fast appearance of necessary refined knowledge, nor the consequent actions, just knowing the humankind history. Identifying the "refined knowledge" and the "necessity" will rise more and more complex, complicate and difficult problems, but here comes the expected power of ICT and AI, which has the potential to bring the data from all areas, to extract the relevant information and then to imply humans in all associated processes of creation/innovation, education, debating and eventually decision, providing the appropriate approach and speed for each category, case and stage.

Analysing sophisticated examples of actual AI applications, we observe that the reality is still more challenging, as for providing only the necessary data, ICT impact on IS/KBS is huge and must be optimized because of the hidden costs. Under the hidden costs, we have to include more than energy and material resources, but also innovation and management necessary to integrate relevant data at Earth scale based on refined knowledge models, i.e., a lot of studies, models, methods and AI along with human intelligence (HI).

The relevance of these examples is much beyond the application domain and context, as we propose to extract from it the huge potential of ICT/AI/HI to extrapolate such kind of applications to a higher level of IS/KBS, in order to optimize other, more complex processes, at Earth scale, based on their mentioned power and advances, but using the appropriate refined knowledge each time. We have to use all the chances and human resources to continue a sustainable development of our ecosystem, including the power of ICT/AI necessary advances we just mentioned above. When speaking about the **sustainable development of our ecosystem**, each time we have to see first the premises of the actual/normal development which are **less** sustainable or to carefully analyse the challenges which lead to such difficult evolutions. On the other hand, it is necessary to analyse such premises/challenges and eventually address the appropriate, even preliminary, solutions to mitigate them.

One of the analysed examples (the World actual chip shortage crisis) just showed the emergence and realism of such approach, along with useful conclusions, as **always we have to find first the causes/premises which led to a crisis/problem, in order to have chances to optimally solve it**. Considering the huge industry around ICT and beyond, it is naturally to keep (and spread) the optimism, especially for this global chip shortage, but we consider that **it is mandatory to maintain a rigorous vigilance about such systemic and overwhelming risk/crises (like chip shortage), especially before having confidence that we have got over them and most of all, that we have learned all the lessons to prevent/manage them for future**.

The paper aim is also to propose some urgently needed orientations, observing that the Earth civilization history could be seen as long, considering human life and the incredible progress we made, although at Universe scale it is only a short scenario that our recent history appears to make it shorter. ICT exponential speed of development, leading to a similar IS/KBS pace evolution, sometimes could "add" to the mentioned premises toward a shorter scenario, but now, more than before, **it is important to learn from history, including ICT recent evolution, in order to make the scenario longer, in a sustainable manner**.

For the analysed dramatical Earth ecosystem context, full of uncertainty, **our opinion/proposal**, a general but realistic and practical approach, is that, when analysing ICT development actual resources and challenges, we should follow step by step a multi-fold goal for our future World, which should include: Providing support for the urgent/emergent research/production/actions to mitigate the World crises, like alternative energy resources, new and recycled materials etc.; Searching solutions to approximately continue Moore Law and similar resources of ICT; Identifying challenges that determine reconfiguration of performance and areas of priorities for ICT advances; Export ideas, models, algorithms and conclusions from ICT experience of development, in dramatical context premises, to other human activity domains; Search principles and models of optimizing the AI-HI combination in order to leverage knowledge refining for a sustainable World progress. Even step by step and long time, such generous and consistent results will not be easy to achieve, but it is essential to agree that they could have a huge importance in terms of opportunity and impact, for the present and future of our Earth ecosystem.

The paper shortly analyses some relevant examples of ICT actual resources and challenges, which would be lessons to consider, for future sustainable development, even beyond the sphere of ICT, due to the ICT impact over the entire IS/KBS, leading this way to the benefic multi-disciplinary results/innovations. Beyond the sphere of ICT could mean not only all the linked industries, as ICT impact covers almost all domains of human activity. More than these, **the actual and emerging dramatical context, and especially the material crises, will expect research and solutions in many industries, like chemistry, food and of course energy, including everywhere ICT will certainly come with support and added value.**

Among the examples, the spectacular advance of microscopy could push toward many research areas and even industries (among other, biotechnology, medicine, chemistry and food), just in the above-mentioned struggle to find new material resources or useful features, starting from innovations at the nanoscale domain and meeting the research goals, with a higher speed and accuracy. The example of the crucial field of processors development (a superconducting CPU from Japan) is also very relevant when facing the energy crisis, was above analysed. Here we observed an accumulation of many factors, including both ICT new resources and challenges issues, as 2 (or soon 8) percent of the world's electricity is consumed by World data centers, which is not only huge, but it is really a signal of alarm (especially considering the emergent energy crises) about the consequences of ICT exponential development at planetary scale, we also repeatedly presented, revealing in the same time the necessity of a radical change, i.e., a new paradigm of advancing ICT/CPU.

An important conclusion is that the future ICT expected solutions, along with other actions generally intended for the World urgent crises, should not be necessary only in the direction of intensively advance in the areas already started for improvements of the performances in the associated domains, but (and sometimes, on the contrary) in the new directions, i.e., changing the paradigm or the way of thinking, or simply changing the humankind/society behaviours that are not sustainable. These ideas are also confirmed, in the huge industry of CPU innovations, by another example of new model of CPU (from Switzerland), above presented, which seems to provide a substantial gain in the desired energy efficiency, but it comes also with an impressing increase of speed. Our opinion is that, in this area of ICT/CPU improvements, any relevant research/result is more than expected/benefic, but it is also true that each case must be analysed in the larger context of associated applications. In this case, we believe that the relevance/importance of results is given by the fact that generally we do not need state-of-the-art performance in all applications and consequently we could have a great sustainable progress if there is a diversity of applications, counting huge cost savings at planetary scale. More than these, we think that, from this example, the idea of better matching performances with applications levels and cost is a very relevant criteria for ICT (and other industries too) sustainable development, in order to face the energy and materials crises to come. On this line, it is relevant to consider the huge area of IoT applications, where the diversity and the number of applications at Earth scale will be so high, as the mentioned matching is the main criteria of development and optimization and could provide just the expected savings.

The paper final conclusion is that, after referring only to the first step of the multi-goal approach we have proposed (support for the urgent/emergent research/production/actions to mitigate the World crises), **a further analysis is needed and naturally to be continued, without considering that it would be exhaustive, but keep thinking that the huge context of ICT sustainable development is crucial for mitigating the consequences of emergent World dramatical changes/crises.**

Keywords: changing/dynamic normality, superconducting CPU, chip shortage, deep learning microscopy, Earth resources fading, artificial intelligence, information and communications technology sustainable development, refining knowledge, information society, knowledge-based society

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

Intelligence is the ability to adapt to change
-Stephen Hawking

1. Premises and expectations for the Information and Communications Technology, in the deeply changing Earth ecosystem

We are used to live in a World where the most impressive news come fast with the latest incredible products, services or applications of the Information and Communications Technology (ICT), but, lately, this **normality** has changed.

Perhaps many major events, from the last years, could be considered as impressive changes examples, but the *changing/dynamic normality* appears to be starting with the Covid 19 pandemic, and now it is *blowing by dramatical scenes of Ukraine war*, mentioning just the actual and prominent tips of *icebergs* that seem to be the appropriate metaphor for a probable future we have to live in.

Of course, this is only a generic approach (as extreme potential image) of the complex and still dramatic trends of the global processes which we really can see in the Earth ecosystem, affecting a diversity of domains, which have the potential to be extended almost randomly, because of the accumulated negative premises of the World context, but we have to consider also the benefic ways ICT is already influencing the humankind and our planet, with the expectation that this influence will be continued under the new conditions.

With simple words, it is very important to analyse such premises of the complex World context, in order to identify the optimal or at least the sustainable ways ICT could be further developed in order to support the approaching and facing of the most probable and dramatical changes/processes/events which would have the potential to strongly affect the life quality on Earth and even the whole planetary ecosystem.

It is also important to try to define from the beginning the relevant elements of the context premises, because other way the subject could appear inconsistent and eventually at least inopportune (or even a panicky approach), considering the complex and mixed (positive and negative) major events of the World recent (or not) history.

Without intending to open a socio-historical approach, we could recall other examples of history events or periods, including wars, pandemics, economical crises or (industrial) revolutions, as it is possible to observe a plenty of dramatical changes and challenges/trends, which have been also considered major for the humankind evolution and even survival, in shorter or longer periods.

The special relevance and significance of the actual mentioned context premises could be clearer if we add some other examples of challenges/trends/events, like climate changes, Earth resources fading, social unbalances or other potential crises, like the emergent energy/food/materials or geopolitical ones.

Still, one could say that essentially “*nothing is new under the sun*”, meaning that such “*turbulences*” of the World ecosystem are, in fact, a well-known and expected/inherent characteristic of the humankind evolution on planet Earth.

We also agree, in a way, with such opinion, but the new significance, we want to analyse, is coming from the relevance of the actual stage of humankind evolution on Earth, which have accumulated, mainly positive but also negative, premises of the recent history, facing in fact what we called a *race for a balance between progress and survival* [3].

Perhaps it is even more relevant if we consider this actual stage a sort of *apogee* and see, today, the level of dramatism as a humankind **race for a balance between apogee and survival**, because in a such picture/expression, it is no doubt, we could observe the extreme high position our civilization is in, by the huge difference created in years of incredible progress and the unacceptable perspective of losing the survival race.

If one could consider that the **accumulated negative premises** are not critical, yet, for the climate changes (when the opinion is already more than dubitable), as prominent challenge for the Earth and humankind, **another significant difference versus the past is the Earth**

resources fading critical stage (including food), which already began to generate cascades of dramatical consequences in more and more domains, from energy to social and geopolitical crises.

As a consequence of such negative context premises for the Earth ecosystem evolution, it is necessary to analyse all the possibilities of humankind to mitigate these trends/challenges, including first the well-known potential of ICT to influence the World and support the information society (IS) on the way towards the knowledge-based society (KBS), as we already presented [16][12].

In fact, the essence, the opportunity and the urgency of such analyses could be expressed by a simplified example, considering that, **in a large desert land/context, any person should think twice before consuming the last reserves of food and water.**

This way, it is sure that, keeping the proportions of complexity, the expected challenges, dilemmas and dramatical changes/crises, we will have to face more and more, must be approached by rational and complicate analyses, in spite of the extreme uncertainty levels these problems could have, leveraging our success chances if using for such purposes all the acquired and potential power of ICT advances, including artificial intelligence (AI) along with human intelligence (HI) and ...wisdom[15][6][9][14][17][11][13].

A special and prominent role, among the priorities of the rational mentioned analyses, must be considered **the necessity of the research for new alternative energy and materials (including food) solutions, along with recycling and saving the actual but fading Earth resources. This crucial challenge will determine the ways the World progress, based on production and consummation, could be continued in a sustainable manner, a longer or a shorter period of time, i.e., it will define the mentioned balance between apogee and survival, on Earth.**

It is obvious that such general (but still necessary and benefic) goal could be approached only by successive and concrete steps, keeping in mind, as much as possible, all global and specific criteria that should be largely identified and agreed at planetary scale, although this condition is perhaps the most difficult of all, as the **World history just proved again and again that humankind just tried to delay to recognize and ultimately act as the worst scenarios appear more and more probable.**

Here we have to point another significant issue, making the difference over the past, which must be given by **the extreme urgency and last mile stage World is in, before being too late!**

On the long road of the mentioned concrete steps, we think that the systemic and structural approaches should be based on some value/relevant principles, criteria and examples.

One of the ideas that we already approached [16][12], is to consider the practical importance of the general context of ICT development, due to the crucial role of ICT in IS toward KBS and to the necessity to agree that refining knowledge is essential in the mentioned stage World is in, recalling that ... *Intelligence is the ability to adapt to change* (Stephen Hawking).

As a principle consequence of considering ICT influence at planetary scale, i.e., a real leverage factor for all human activity domains, being also a huge consumer of energy and materials, is to carefully analyse both positive and eventual negative issues of ICT exponential evolution, but pointing just the necessity to adapt the ICT future pace and systemic structure to

the dramatical context premises, understanding that although some development areas/directions should be slowed down, other could be faster.

This way, the analysis of ICT advances issues, where AI, among others, is prominent, remains the starting point, as the power of all ICT products, services or applications, considering, still, the refined knowledge which could reconfigure the weights of different areas of applications, must be the basic potential of computing and networking power to be provided where World priorities will arise.

Starting from such goals, but not being limited to them, our analyses will be based on relevant cases/examples, as a support for their eventual integration in useful studies or advices for incumbents, or reference for everyone - an education component, necessary to face the emerging dramatical/dynamic World.

In fact, we consider that the education should be the main mass way to refine the knowledge for the appropriate actions everyone has to understand, in the dynamic mentioned World and ICT context, but it is also clear that we could not expect the fast appearance of necessary refined knowledge, nor the consequent actions, just knowing the humankind history.

This way we have just arrived to the point where the ICT optimization development could serve the most important social need of the emerging World, by contributions to the refined knowledge and to the critical and fast necessary decisions, at planetary scale and also at individual level.

If this purpose could appear not new, then we have to analyse and further understand, by *examples*, the deeper and concrete meanings of the above-mentioned general terms, like “necessary” and again “refined knowledge”, in each of the stages/moments of the emerging dramatical/dynamic World.

It is clear that identifying the “refined knowledge” and the “necessity” will rise more and more complex, complicate and difficult problems, but here comes ***the expected power of ICT and AI***, which has the potential to bring the data from all areas, to extract the relevant information and then to imply humans in all associated processes of creation/innovation, education, debating and eventually decision, providing the appropriate approach and speed for each category, case and stage.

In order to have a relevant picture of ***the expected power of ICT and AI***, an example of its necessity, even if we have to notice that it is aiming a “peace” scenario, i.e., a normal evolution of IS/KBS (but even this way important challenges should be also considered), is given by [5]:

<<Consider the following scenario where a typical driver, John gets into his car in the morning and turns on the ignition. A built-in innovative application in the car greets him and asks him if he is going to work based on the time of the day. John responds by saying “yes” and the app replies that the vehicle performance has been optimized for the trip. The built-in system uses the GIS system, road grade data, and speed limits data to create an optimal velocity profile. As John starts driving and is approaching Recker road to turn left, the app informs John about a road repair on Recker road for a 1-mile stretch on his route up to 3pm that day. The app suggests that John should continue driving and take the next left on Power Road. John follows the suggestion and answers a text message that he receives from his collaborator. As he is answering the text message, his car drifts into the neighboring lane. The app immediately notifies John of the drift who quickly adjusts his driving. As John approaches his workplace,

he drives towards Lot 1 where he usually parks. The app informs John that there are only 2 parking spots open in Lot 1. As John is already running late for a meeting, he decides to directly drive to the next parking lot, Lot 2, to avoid spending the time looking for the 2 empty spots in Lot 1. As John enters Lot 2 and is driving towards one of the empty spots, he gets too close to one of the parked cars. The app immediately warns John of a collision. John quickly adjusts his car away from the parked cars and parks in an empty spot. The app logs tracking data about John's style of driving on the server for future use.>>

One could say that such scenarios are already largely analysed and the industry is working to develop ICT/AI in this direction, so we could say that it is just a face of the **normality** we already expect and build, as we pointed at our paper beginning.

The reality of this evolution is still more challenging, as for providing only the necessary data, ICT impact on IS/KBS is huge and must be optimized because of the hidden costs, as it is further suggested:

“In order to build apps for automobiles, access to a number of data sets from various sources is required. Some of this is real-time data that is continuously being updated. Data related to traffic, road repairs, emergencies, accidents, driving habits, maps, parking, fuel economy data, household data, diagnosis data, etc. would be required. Various automotive apps could be built that focus on reducing energy consumption, reducing emissions, provide fuel economy guidance that is based on actual vehicle data, road conditions, traffic, and most importantly personal driving habits and ways to improve them. It is important to effectively integrate data such that the data is tied to a meaningful and rich data model that can be queried by these innovative applications.”

Under the hidden costs, we have to include more than energy and material resources, but also innovation and management necessary to *integrate relevant data* at Earth scale based on refined knowledge models, i.e., a lot of studies, models, methods and AI/HI.

It is worth to remember, still, that this is only a **normality** example, but the accumulated negative consequences (from costs and challenges and risks) could be considerable on medium and long term.

By our opinion, the relevance of this example is much beyond the application domain and context, as we propose to extract from it the huge potential of ICT/AI/HI to extrapolate such kind of applications to a higher level of IS/KBS, in order to optimize other, more complex processes, at Earth scale, based on their mentioned **power** and advances, but using the appropriate refined knowledge each time.

Now it is clear how the signification of this example could help us to have a realistic picture of what we have to realize, at Earth scale, under dramatical World changes, if, for the **normal** conditions and purposes of the example, the data, models and costs are as above suggested.

Still, we have to use all the chances and human resources to continue a sustainable development of our ecosystem, including the power of ICT/AI necessary advances we just mentioned above.

We consider that, when speaking about the **sustainable development of our ecosystem**, each time we have to see first the premises of the actual/normal development which are **less** sustainable or to carefully analyse the challenges which lead to such difficult evolutions.

On the other hand, it is necessary to analyse such premises/challenges and eventually address the appropriate, even preliminary, solutions to mitigate them.

On this way, going further from the observations we have just made, the next example is a realistic approach, as it focuses on the complex role of managing data/information at Earth scale [2]:

“... And in the 21st century this information is being generated ever faster. In its latest survey of data generated per minute in 2018, Domo, a cloud service, listed more than 97,000 hours of video streamed by Netflix users, nearly 4.5 million videos watched on YouTube, just over 18 million forecast requests on the Weather Channel, and more than 3 quadrillion bytes (3.1 petabytes) of other Internet data used in the United States alone. By 2016, the annual global data-creation rate surpassed 16 ZB (a zettabyte is 10^{21} B), and by 2025, it is expected to rise by another order of magnitude—that is, to about 160 ZB or 10^{23} B.”

Although we are referring to general domains of data, step by step such analyses will lead us to the core of the problems, from ICT resources to refining knowledge, as it is further presented:

“These quantities lead to some obvious questions. Only a fraction of the data flood could be stored, but which part should that be? Challenges of storage are obvious even if less than 1 percent of this flow gets preserved. And for whatever we decide to store, the next question is how long should the data be preserved. No storage need last forever, but what is the optimal span? The highest prefix in the international system of units is yotta, $Y = 10^{24}$. We’ll have that many bytes within a decade. And once we start creating more than 50 trillion bytes of information per person per year, will there be any real chance of making effective use of it? It is easier to find new prefixes for large databases than to decide how large is large enough. After all, there are fundamental differences between accumulated data, useful information, and insightful knowledge.”

Recalling the mentioned challenges about **the data, models and costs**, if the previous case referred to the data, although these imply the necessary storage, the next example leads us to the hard face of costs and enter the World crises “atmosphere” [4]:

“Historians will probably spend decades picking apart the consequences of the COVID-19 epidemic. But the shortage of chips that it’s caused will be long over by then. A variety of analysts agree that the most problematic shortages will begin to ease in the third or fourth quarter of 2021, though it could take much of 2022 for the resulting chips to work their way through the supply chain to products. The supply relief will not be coming from the big, national investments in the works right now by South Korea, the United States, and Europe but from older chip fabs and foundries running processes far from the cutting edge and on comparatively small silicon wafers.”

Always we have to find first the causes/premises which led to a crisis/problem, in order to have chances to optimally solve it, as it is further presented:

“Before we get into how the shortage will end, it’s worth summing up how it began. With panic, lockdowns, and general uncertainty rolling across the globe, automakers cancelled orders. However, those conditions meant a big fraction of the workforce recreated the office at home, purchasing computers, monitors, and other equipment. At the same time entire school systems switched to virtual learning via laptops and tablets. And more time at home also meant more spending on home entertainment, such as TVs and game consoles. These, the 5G rollout,

and continued growth in cloud computing quickly hoovered up the capacity automakers had unceremoniously freed. By the time car makers realized people still wanted to buy their goods they found themselves at the back of the line for the chips they needed.”

Considering the huge industry around ICT and beyond, it is naturally to keep (and spread) the optimism, especially for this global chip shortage:

“The chip shortage is happening simultaneously with national and regional efforts to boost advanced logic chip manufacturing. South Korea announced a push worth \$450-billion over ten years, the United States is pushing legislation worth \$52 billion, and the EU could plow up to \$160-billion into its semiconductor sector. Chipmakers were already on a spending spree. Globally, capital equipment for semiconductor production grew 56 percent year-on-year through April 2021, according to SEMI. SEMI's 3 June 2021 World Fab Forecast indicates that 10 new 300-mm fabs will start operation in 2021 with 14 more coming up in 2022.”

Still, we consider that **it is mandatory to maintain a rigorous vigilance about such systemic and overwhelming risk/crises (like chip shortage), especially before having confidence that we have got over them and most of all, that we have learned *all the lessons* to prevent/manage them for future.**

2. Learning from the actual ICT resources and challenges for driving a sustainable advance

Although the Earth civilization history could be seen as long, considering human life and the incredible progress we made, at Universe scale it is only a short scenario that our recent history appears to make it shorter.

Here we have to observe that ICT exponential speed of development, leading to a similar IS/KBS pace evolution, sometimes could “add” to the mentioned premises toward a shorter scenario, but now, more than before, it is important to learn from history, including ICT recent evolution, in order to make the scenario longer, in a sustainable manner.

Our opinion is that, when analysing ICT development actual resources and challenges, we should follow step by step a multi-fold goal for our future World:

- Providing support for the urgent/emergent research/production/actions to mitigate the World crises, like alternative energy resources, new and recycled materials etc.;
- Searching solutions to approximately continue Moore Law and similar resources of ICT;
- Identifying challenges that determine reconfiguration of performance and areas of priorities for ICT advances;
- Export ideas, models, algorithms and conclusions from ICT experience of development, in dramatical context premises, to other human activity domains;
- Search principles and models of optimizing the AI-HI combination in order to leverage knowledge refining for a sustainable World progress.

It is sure that, even step by step and long time, such generous and consistent results will not be easy to achieve, but it is essential to agree that they could have a huge importance in terms of opportunity and impact, for the present and future of our Earth ecosystem.

Now it is natural to shortly analyse some relevant examples of ICT actual resources and challenges, which would be lessons to consider, for future sustainable development, even

beyond the sphere of ICT, due to the ICT impact over the entire IS/KBS, leading this way to the benefic multi-disciplinary results/innovations.

Here it is important to notice that **beyond the sphere of ICT** could mean not only all the linked industries, as ICT impact covers almost all domains of human activity. More than these, **the actual and emerging dramatical context, and especially the material crises, will expect research and solutions in many industries, like chemistry, food and of course energy, including everywhere ICT will certainly come with support and added value.**

Although it could appear as a narrow field of applications, the use of AI and deep learning for a spectacular advance of microscopy could *push toward* many research areas and even industries (among other, biotechnology, medicine, chemistry and food), just in the above-mentioned struggle to find new material resources or useful features, starting from innovations at the *nanoscale* domain [1]:

“It’s difficult to find an area of scientific research where deep learning isn’t discussed as the next big thing. Claims abound: Deep learning will spot cancers; it will unravel complex protein structures; it will reveal new exoplanets in previously analysed data; it will even discover a theory of everything. Knowing what’s real and what’s just hype isn’t always easy. One promising—perhaps even overlooked—area of research for deep learning to make its mark is in microscopy. In spite of new discoveries, the underlying workflow of techniques like scanning probe microscopy (SPM) and scanning transmission electron microscopy (STEM) has remained largely unchanged for decades. Skilled human operators must painstakingly set up, observe, and analyze samples. Deep learning has the potential not only to automate many of the tedious tasks, but also to dramatically speed up the analysis time by honing in on microscopic features of interest.”

Without entering details, it is important to imagine that the struggle for urgently finding new materials and useful features could have a benefic support from this AI assisted technology, in the complex processes of identifying the desired combinations when revealing and recording all data that match (even approximately) the research goals, with a higher speed and accuracy:

<< *“People usually just look at the image and identify a few properties of interest,” says Maxim Ziatdinov, a researcher at Oak Ridge National Laboratory. “They basically discard most of the information because there is just no way to actually extract all the features of interest from the data.” With deep learning, Ziatdinov says, it’s possible to extract information about the position and type of atomic structures in seconds, opening up a vista of possibilities. It’s a twist on the classical dream of doing more with smaller things (most famously expressed in Richard Feynman’s “There’s Plenty of Room at the Bottom”). Improving hardware isn’t the only way to increase the functionality of microscopes. Software can play a role, too—by making a microscope autonomous. “Such a machine will ‘understand’ what it is looking at and automatically document features of interest,” an article in the Materials Research Society Bulletin declared. “The microscope will know what various features look like by referencing databases or can be shown examples on the fly.”>>*

This more intimate and agile technology has the potential to discover and point, at nanoscale, i.e., to the extreme of the science horizon, both new structures/features of materials and the defects too, as it is further presented:

<<Despite the “micro-” prefix, microscopy such as SPM and STEM actually deals with objects on the nanoscale, including individual atoms. In SPM, a nanoscale tip hovers over the sample surface and traces its grooves, like the needle of a record player, to create an image. On the other hand, STEM generates an image by showering a sample with electrons and collecting those that pass through, essentially creating a negative. Both microscopy techniques allow researchers to quickly observe the broad structural features of a sample. Researchers like Ziatdinov are interested in the functional properties of certain features such as defects.>>

Another example, reflecting the actual context where of ICT resources and challenges are confronting, when searching solutions for a future sustainable progress, is in the crucial field of processors (CPU) development, which is also very relevant when facing the energy crisis [2]:

“According to one recent estimate, data centers consume 2 percent of the world’s electricity, a figure that’s expected to climb to 8 percent by 2030. To turn back the age of the grid-greedy CPU, a group of researchers in Japan has developed a superconducting microprocessor—one with zero electrical resistance. The new device, the first of its kind, is described in a study published in December in the IEEE Journal of Solid State Circuits. The research group sought to create a superconducting microprocessor that’s adiabatic—meaning that, in principle, energy is neither gained nor lost from the system during the computing process. The device is composed of superconducting niobium and relies on hardware components called adiabatic quantum-flux-parametrons (AQFPs).”

Here we can observe an accumulation of many factors, including both ICT new resources and challenges issues, as 2 (or soon 8) *percent of the world’s electricity* is not only huge, but it is really a signal of alarm (especially considering the emergent energy crises) about the consequences of ICT exponential development at planetary scale, we also repeatedly presented [14][3][15], revealing in the same time the necessity of a radical change, i.e., a new paradigm of advancing ICT/CPU, which is further confirmed by spectacular increase of new technology efficiency:

<< *“The data-processing part of the microprocessor can operate up to a clock frequency of 2.5 gigahertz, making this on par with today’s computing technologies,” says Christopher L. Ayala, an associate professor at the Institute of Advanced Sciences at Yokohama National University, in Japan, who helped develop the new microprocessor. “Even when taking [the] cooling overhead into account,” Ayala says, “the AQFP is still about 80 times more energy efficient when compared to the state-of-the-art semiconductor electronic device, [such as the] 7-nanometer FinFET [fin field-effect transistor], available today.” >>*

It is sure that a long road is still ahead a large use of this technology and this is also true if we recall the fact that the *superconducting* idea, generally, is not very new.

In fact, we just met, as a relevant case, a point of strategic importance, we above have mentioned, when urgent and consistent solutions are desperately expected and needed from ICT advances for humankind and Earth sustainable future.

It is important to notice that the future ICT expected solutions, along with other actions generally intended for the World urgent crises, should not be necessary only in the direction of intensively advance in the areas already started for improvements of the performances in the associated domains, but (and sometimes, on the contrary) in the new directions, i.e., changing

the paradigm or the way of thinking, or simply changing the humankind/society behaviours that are not sustainable, as the next example, also in the huge industry of CPU, presents[8]:

“As society’s insatiable demand for computing power continues to grow, so too does the need for more efficient processors. A group of researchers in Switzerland has devised a new processor design that may help. It is physically small and computationally agile—and aptly named Snitch. (Harry Potter fans will get the reference.) Florian Zaruba, a postdoc at the Integrated Systems Laboratory at the Swiss Federal Institute of Technology (ETH), in Zurich—and a researcher involved in the creation of Snitch—notes that commercial, general-purpose cores today rely on larger and more energy-hungry processors. “Snitch is the opposite,” he says. Typically, processors try to find an efficient instruction order on the fly, which requires additional hardware and thus uses more power. But Snitch is able to execute the majority of its basic instructions instantaneously, bypassing the need for this extra, burdensome hardware.”

The innovations of this new model of CPU seems to provide a substantial gain in the desired energy efficiency, but it comes also with an impressive increase of speed, as it is further pointed:

“Zaruba and his colleagues describe their streamlined, RISC-V chip design in a study published 7 October in IEEE Transactions on Computers. They found that a single Snitch processor with its custom extensions was twice as energy efficient as comparable benchmark CPUs. When multiple processors were used in parallel, Snitch proved to be 3.5 times as energy efficient and up to six times as fast as the others. The researchers have open-sourced Snitch’s hardware design and note that they have seen growing interest from industry consortia, for example from the Open Hardware Group, in supporting commercialization efforts.”

Our opinion is that, in this area of ICT/CPU improvements, any relevant research/result is more than expected/benefic, but it is also true that each case must be analysed in the larger context of associated applications. In this case, we believe that the relevance/importance of results is given by the fact that generally we do not need state-of-the-art performance in all applications and consequently we could have a great sustainable progress if there is a diversity of applications, counting huge cost savings at planetary scale.

More than these, we think that, from this example, the idea of better matching performances with applications levels and cost is a very relevant criteria for ICT (and other industries too) sustainable development, in order to face the energy and materials crises to come.

For a concrete argument of our last opinion, it is more than relevant to consider the huge area of IoT applications, where the diversity and the number of applications at Earth scale will be so high [14][18][10][6], that the mentioned matching is the main criteria of development and optimization and could provide just the expected savings.

As we have referred just to the first step of the multi-goal approach we have proposed (support for the urgent/emergent research/production/actions to mitigate the World crises), **a further analysis is needed and naturally to be continued, without considering that it would be exhaustive, but keep thinking that the huge context of ICT sustainable development is crucial for mitigating the consequences of emergent World dramatical changes/crises.**

3. Conclusions

Along with the complex and still dramatic trends of the global processes which we really can see in the Earth ecosystem, affecting a diversity of domains (which have the potential to be extended almost randomly, because of the accumulated negative premises of the World context), we have to consider also the benefic ways ICT is already influencing the humankind and our planet, with the expectation that this influence will be continued under the new conditions. It is very important to analyse such premises of the complex World context, in order to identify the optimal or at least the sustainable ways ICT could be further developed in order to support the approaching and facing of the most probable and dramatical changes/processes/events which would have the potential to strongly affect the life quality on Earth and even the whole planetary ecosystem. We consider this actual stage a sort of *apogee* and see, today, the level of its dramatism as a humankind **race for a balance between apogee and survival**, because in a such picture/expression, it is no doubt, we could observe the extreme high position our civilization is in, by the huge difference created in years of incredible progress and the unacceptable perspective of losing the survival race.

Although sometimes it is considered that the **accumulated negative premises** are not critical, yet, for example in the climate changes case (when the opinion is already more than dubitable), as prominent challenge for the Earth and humankind, **another significant difference versus the past is the Earth resources fading critical stage (including food), which already began to generate cascades of dramatical consequences in more and more domains, from energy to social and geopolitical crises.**

As a consequence of such negative context premises for the Earth ecosystem evolution, it is necessary to analyse all the possibilities of humankind to mitigate these trends/challenges, including first the well-known potential of ICT to influence the World and support IS/KBS. The essence, the opportunity and the urgency of such analyses could be expressed by a simplified example, considering that, **in a large desert land/context, any person should think twice before consuming the last reserves of food and water.** The expected challenges, dilemmas and dramatical changes/crises, we will have to face more and more, must be approached by rational and complicate analyses, in spite of the extreme uncertainty levels these problems could have, leveraging our success chances if using for such purposes all the acquired and potential power of ICT advances, including AI along with HI and wisdom.

Among the priorities of the rational mentioned analyses, we must consider, with priority, **the necessity of the research for new alternative energy and materials (including food) solutions, along with recycling and saving the actual but fading Earth resources. This crucial challenge will determine the ways the World progress, based on production and consummation, could be continued in a sustainable manner, a longer or a shorter period of time, i.e., it will define the mentioned balance between apogee and survival, on Earth.** Such general, necessary and benefic goal could be approached only by successive and concrete steps, keeping in mind, as much as possible, all global and specific criteria that should be largely identified and agreed at planetary scale, although this condition is perhaps the most difficult of all, as the **World history just proved again and again that humankind just tried to delay to recognize and ultimately act as the worst scenarios appear more and more**

probable. Another significant issue, making the difference over the past, is given by **the extreme urgency and last mile stage World is in, before being too late!**

Planning the long road of the mentioned concrete steps, we think that the systemic and structural approaches should be based on some value/relevant principles, criteria and examples, as our paper shortly presents. One of the ideas that we already approached is to consider the practical importance of the general context of ICT development, due to the crucial role of ICT in IS toward KBS and to the necessity to agree that refining knowledge is essential in the mentioned stage World is in. As a principle consequence of considering ICT influence at planetary scale, i.e., a real leverage factor for all human activity domains, being also a huge consumer of energy and materials, is to carefully analyse both positive and eventual negative issues of ICT exponential evolution, but pointing just the necessity to adapt the ICT future pace and systemic structure to the dramatical context premises, understanding that although some development areas/directions should be slowed down, other could be faster. This way, the analysis of ICT advances issues, where AI, among others, is prominent, remains the starting point, as the power of all ICT products, services or applications, considering, still, the refined knowledge which could reconfigure the weights of different areas of applications, must be the basic potential of computing and networking power to be provided where World priority goals will arise.

Following such goals, but not being limited to them, our analysis is based on relevant cases/examples, as a support for their eventual integration in useful studies or advices for incumbents, or reference for everyone - an education component, necessary to face the emerging dramatical/dynamic World. We consider that the education should be the main mass way to refine the knowledge for the appropriate actions everyone has to understand, in the dynamic mentioned World and ICT context, but it is also clear that we could not expect the fast appearance of necessary refined knowledge, nor the consequent actions, just knowing the humankind history. Identifying the “refined knowledge” and the “necessity” will rise more and more complex, complicate and difficult problems, but here comes ***the expected power of ICT and AI***, which has the potential to bring the data from all areas, to extract the relevant information and then to imply humans in all associated processes of creation/innovation, education, debating and eventually decision, providing the appropriate approach and speed for each category, case and stage.

Observing some sophisticated examples of actual AI applications, one could say that such scenarios are already largely analysed and the industry is working to develop ICT/AI in this direction, so we could say that it is just a face of the **normality** we already expect and build, as we pointed at our paper beginning. The reality of this evolution is still more challenging, as for providing only the necessary data, ICT impact on IS/KBS is huge and must be optimized because of the hidden costs. Under the hidden costs, we have to include more than energy and material resources, but also innovation and management necessary *to integrate relevant data* at Earth scale based on refined knowledge models, i.e., a lot of studies, models, methods and AI/HI. Starting from a **normality** example, the accumulated negative consequences (from costs and challenges and risks) could be considerable on medium and long term. The relevance of such examples is much beyond the application domain and context, as we propose to extract from it the huge potential of ICT/AI/HI to extrapolate such kind of applications to a higher level of IS/KBS, in order to optimize other, more complex processes,

at Earth scale, based on their mentioned power and advances, but using the appropriate refined knowledge each time. Still, we have to use all the chances and human resources to continue a sustainable development of our ecosystem, including the power of ICT/AI necessary advances we just mentioned above. We consider that, when speaking about the **sustainable development of our ecosystem**, each time we have to see first the premises of the actual/normal development which are **less** sustainable or to carefully analyse the challenges which lead to such difficult evolutions. On the other hand, it is necessary to analyse such premises/challenges and eventually address the appropriate, even preliminary, solutions to mitigate them.

Analysing examples in general domains of data, as the paper also did, step by step such analyses will lead us to the core of the problems/solutions, from ICT resources to refining knowledge, revealing challenges about **the data, models and costs**, implying the necessary storage and energy.

One of the analysed examples (*chip shortage*) just showed the emergence and realism of such approach, along with useful conclusions, as **always we have to find first the causes/premises which led to a crisis/problem, in order to have chances to optimally solve it**. Considering the huge industry around ICT and beyond, it is naturally to keep (and spread) the optimism, especially for this global *chip shortage*, but we consider that **it is mandatory to maintain a rigorous vigilance about such systemic and overwhelming risk/crises (like chip shortage), especially before having confidence that we have got over them and most of all, that we have learned all the lessons to prevent/manage them for future**.

Observing that the Earth civilization history could be seen as long, considering human life and the incredible progress we made, at Universe scale it is only a short scenario that our recent history appears to make it shorter. We have to point that ICT exponential speed of development, leading to a similar IS/KBS pace evolution, sometimes could “add” to the mentioned premises toward a shorter scenario, but now, more than before, **it is important to learn from history, including ICT recent evolution, in order to make the scenario longer, in a sustainable manner**.

Although it is only a general, but realistic and practical approach, in a complex context full of uncertainty, **our opinion/proposal** is that, when analysing ICT development actual resources and challenges, we should follow step by step a multi-fold goal for our future World:

- Providing support for the urgent/emergent research/production/actions to mitigate the World crises, like alternative energy resources, new and recycled materials etc.;
- Searching solutions to approximately continue Moore Law and similar resources of ICT;
- Identifying challenges that determine reconfiguration of performance and areas of priorities for ICT advances;
- Export ideas, models, algorithms and conclusions from ICT experience of development, in dramatical context premises, to other human activity domains;
- Search principles and models of optimizing the AI-HI combination in order to leverage knowledge refining for a sustainable World progress.

Even step by step and long time, such generous and consistent results will not be easy to achieve, but it is essential to agree that they could have a huge importance in terms of opportunity and impact, for the present and future of our Earth ecosystem.

We also shortly analysed some relevant examples of ICT actual resources and challenges, which would be lessons to consider, for future sustainable development, even beyond the sphere of ICT, due to the ICT impact over the entire IS/KBS, leading this way to the benefic multi-disciplinary results/innovations. Beyond the sphere of ICT could mean not only all the linked industries, as ICT impact covers almost all domains of human activity. More than these, **the actual and emerging dramatical context, and especially the material crises, will expect research and solutions in many industries, like chemistry, food and of course energy, including everywhere ICT will certainly come with support and added value.** Among the above examples, the spectacular advance of microscopy could *push toward* many research areas and even industries (among other, biotechnology, medicine, chemistry and food), just in the above-mentioned struggle to find new material resources or useful features, starting from innovations at the *nanoscale* domain. The struggle for urgently finding new materials and useful features could have a benefic support from this AI assisted technology, in the complex processes of identifying the desired combinations when revealing and recording all data that match (even approximately) the research goals, with a higher speed and accuracy. This more intimate and agile technology has the potential to discover and point, at nanoscale, i.e., to the extreme of the science horizon, both new structures/features of materials and the defects too.

Reflecting the actual context where of ICT resources and challenges are confronting, when searching solutions for a future sustainable progress, the example of the crucial field of processors development (a superconducting CPU from Japan), which is also very relevant when facing the energy crisis, was above analysed. Here we observed an accumulation of many factors, including both ICT new resources and challenges issues, as 2 (or soon 8) *percent of the world's electricity* is consumed by World data centers, which is not only huge, but it is really a signal of alarm (especially considering the emergent energy crises) about the consequences of ICT exponential development at planetary scale, we also repeatedly presented [14][3][15], revealing in the same time the necessity of a radical change, i.e., a new paradigm of advancing ICT/CPU. It is sure that a long road is still ahead a large use of this technology and this is also true if we recall the fact that the *superconducting* idea, generally, is not very new. In fact, we just met, as a relevant case, a point of strategic importance, we above have mentioned, when urgent and consistent solutions are desperately expected and needed from ICT advances for humankind and Earth sustainable future.

An important conclusion is that the future ICT expected solutions, along with other actions generally intended for the World urgent crises, should not be necessary only in the direction of intensively advance in the areas already started for improvements of the performances in the associated domains, but (and sometimes, on the contrary) in the new directions, i.e., changing the paradigm or the way of thinking, or simply changing the humankind/society behaviours that are not sustainable. These ideas are also confirmed, in the huge industry of CPU innovations, by another example of new model of CPU (from Switzerland), above presented, which seems to provide a substantial gain in the desired energy efficiency, but it comes also with an impressing increase of speed. Our opinion is that, in this area of ICT/CPU improvements, any relevant research/result is more than expected/benefic, but it is also true that each case must be analysed in the larger context of associated applications. In this case, we believe that the relevance/importance of results is given by the fact that

generally we do not need state-of-the-art performance in all applications and consequently we could have a great sustainable progress if there is a diversity of applications, counting huge cost savings at planetary scale. More than these, we think that, from this example, the idea of better matching performances with applications levels and cost is a very relevant criteria for ICT (and other industries too) sustainable development, in order to face the energy and materials crises to come. Such opinion is also based on the huge area of IoT, where the diversity and the number of applications at Earth scale will be so high [14][18][10][6], as the mentioned matching is the main criteria of development and optimization and could provide just the expected savings.

After referring only to the first step of the multi-goal approach we have proposed (support for the urgent/emergent research/production/actions to mitigate the World crises), **a further analysis is needed and naturally to be continued, without considering that it would be exhaustive, but keep thinking that the huge context of ICT sustainable development is crucial for mitigating the consequences of emergent World dramatical changes/crises.**

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