A view on Information and Intelligent Systems and Society

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The last half of the twentieth century has witnessed the revolutionary growth of communication and computing means. According to Moore's law[2] the number of transistors that can be placed inexpensively on an integrated circuit has doubled approximately every two years and that this trend will continue in the near future. This simple law has enormous implications because it dictates that the computational power available for communications, information processing and intelligent systems design, will be following an exponential law in the near future. This exponential behavior is not new, it has been preceded by the growth of computational power and communication bandwidth due to the introduction of electronics. It is also extrapolated in the future by the apparition of new foundations for computational devices, such as quantum computing[3]. An effect of exponential growth is our inability to predict the future evolution. Things happen much faster than we expect. For instance, some of the futuristic applications envisioned for a distant future three or four decades ago, like electronically controlled cars o the global connectivity through communication networks, are a reality nowadays. The Internet Age is a natural by-product of both increased computational and communication powers.

Being human, human beings and human societies are defined in terms of conscience and intelligence, therefore, it can be expected that the exponential growth of computational resources would greatly affect our way of live and of being human. Whether there has been a qualitative change in our personal and social lives as a consequence is a relevant philosophical question. The way we can communicate or manipulate information, has had an irreversible effect in the essential being of individuals and societies? Following a physical metaphor, as water changes its qualitative properties at some critical temperatures, could we assume that information flow has a similar role in our social organisms and our own individual human beings? If so, have we trespassed some critical threshold so that societies and individuals are becoming qualitatively different from their ancestors? Posing these questions is a first step to become fully conscious of the actual effect of technology on our lives. However, in this brief essay we could only scrap for hints of the answers.

Besides, the increased computational power allows us to build more autonomous artificial systems, more "intelligent" in a sense. Will these systems gain independence from their creators? May even turn against them? This is the subject of many science-fiction films and books, reflecting some archetypical fear deeply rooted in our subconscious collective mind. A sensible answer to these questions under the light of the exponential computational power growth is that this situation is closer in time than we imagine today. However, the actual

nature of these devices may be quite distinct from their science-fiction projections.

Information has become a space when people live and work. Intelligence has become an attribute of things besides people. In the past, information was a token acquired through intense labor, dedicated efforts and purpose. Nowadays, information is a kind of sea where people navigate armed with the resources provided by computers and navigators, on the wings of Internet search engines. In the past, intelligence was a mysterious gift provided with uneven abundance and quality to people. Nowadays, intelligence is a design issue of systems that must accomplish tasks in all the domains of life.

About some definitions

The first issue that must be considered is that of the definition of Intelligence. As for the definition of Life, there is no definitive agreement in the human spectra of beliefs and thinking systems. And there are also emotional and political components in the arguments. Therefore, I would first acknowledge here a relativistic operational definition of intelligence: there is intelligence when there is appearance of intelligence to a human observer. Of course, that leaves open an evolutive view of intelligence: it will not be the same thing for our grand parents and our grand children. But this is according to the times we live in: one of fastest changes in all aspects of human life. We may want to maintain some "principles" but very quickly the tide of external intellectual forces moves everything and imposes changes in our mental frameworks. The ever-growing pace of communications and information technology improvements accelerates this phenomenon, providing us with new facts and data that force us to acknowledge the relativity of our beliefs.

Next we may consider the relation between intelligence and information. Under a productive view, intelligence is a transformation of information. In other words, information is the substance where intelligence builds and works. In the classical view, we reason about and on information, producing new evidences through reasoning. Propositional logic, and other new logics (fuzzy logic, lattice based logic) give a mechanical description of this process. However, new intelligent systems are more and more based on statistical reasoning, which is not so easy to view as a productive process. To include this, we can adopt an input-output definition of intelligence, as a black box that performs some kind of transformation between information: given a collection of data samples, intelligent systems provide some new data by whatever means can be handy[4].

Taking a different perspective, we can distinguish three stages in the intelligent system: perception, reasoning and actuation.

- Perception as the means to get information from the outside world.
- Actuation as the manipulation of the outside world, the transformation of inner knowledge into outside effects.
- Reasoning as the transformation of information in order select the appropriate actions.

This way to define intelligence is more specific of robotics, but can be generalized to any other instances of domains of intelligent system application[5]. Decision makers assess the state of the system through surveys and polls, they "perceive" the system situation, the reason about it and take some action that affect the system. The higher the hierarchy level, the information is more abstract, the actions are more undefined and uncertain in their consequences, and these consequences affect greater chunks of the human population.

Information transfer (communication) channels appear naturally everywhere. They relate perception and action with decision components, which can be separate entities spread over different locations, and diverse reasoning agents as well. Perception and communication are sources of uncertainty, ambiguity and noise, which are omnipresent in nowadays systems. Reasoning systems must deal with them, and they are the motivation for a innovative reasoning techniques: fuzzy reasoning, linguistic modeling, biological inspired techniques and a long list of methods proposed in the last decades.

Exponential increase of computational power has revolutionized all these aspects of intelligence. We can perceive in ways unbelievable in the past, we can observe the big and the small with great precision. Every minute huge amounts of information are generated from remote sensing, medical image, conventional digital photography, vigilance systems, transactions among people and other entities, planning and commerce, systems simulation, etc. This information needs to be stored, processed to produce decisions and intelligence. So while huge data centers are devoted to data mining applying new ways to realize intelligence, embedded small systems are making our everyday appliances smarter and friendlier.

We can appreciate the existence of intelligence in the form of information manipulation at very different society organization scales and levels of a social abstraction hierarchy. That is, diverse kinds of information are processed at levels of the social organism. Accordingly, the current technological state of the art has developed diverse intelligent system designs suited for the diverse scales and operational abstraction levels. The diversity is growing continuously as the new devices for information representation and manipulation are evolving. People use automated information transfer and transformation devices at each level of the hierarchy and for all imaginable purposes.

Still there is a last view on intelligence definition: most intelligent systems[6] try to optimize something. They look for the best system state or the best solution of some explicit or implicit problem. In fact, learning systems are constructed as prediction error minimization systems and control systems are designed and tuned as behavior error minimization systems. Thinking in terms of optimization gives an easy technological/scientific paradigm for the construction of intelligence systems, but leaves open from a philosophical point of view the question of teleological behavior. Most modern philosophical schools reject this point of view because of its obvious connection with religious thinking. Those concerns are not relevant to us.

Relevant questions

The effect of increasing computational power and increased potential to deal with information and to create intelligent systems must have a critical impact on the way we live, on the way we are and how we interact with the "outside" world. If information is such a central element of humanity, can we identify how the information revolution has affected other aspects of science and art? Even the consideration of the questions that can be posed is a complex issue. In an attempt to set some order into our disquisition, we can consider the following axes of exploration/contemplation:

- The effect on the individual. The education of the individual, his empowering, his manipulation and control. That is, exploring to consider the effect of the information revolution on the atomic element of the human system. How the individual is transformed by the availability and use of these new intelligent tools. How he gets new abilities, new needs, new resources, and how the system outside has new power means on him. A two-face

- The effect on the society. The organic system composed of human beings is being transformed into a new kind of system. The current crisis[7], has it been motivated by the uncontrolled use of new intelligent tools?[8] Is the instantaneous global communication a key factor for global instability? The government of society has new tools to manage the complexities of human organization, however, as a side effect, new ethical conflicts arise everyday. Can we identify how new computational resources have changed society? Can we extrapolate the near future evolution of society under this trend?

- The effect on the environment, the creation of new environments to live in. Information seems to be so ethereal that it may not affect the environment. However, power consumption[9] and waste disposal are uncomfortable side effects of computational processes, which may not be well addressed. Besides this "trivial" effect, the increased "Mind" power implies that the magnitude of how we can alter the environment was previously unheard of. Even we can consider the creation of new artificial environments were people can choose to "live in".

- The creation of independent life. Can artificial intelligence become artificial life? What is the threshold for the creation of a new life form? May be we are already giving birth to new life forms, which can carry the future flag of life. How much independent they are or will be?

A daring question is that of the interrelation between the natural human intelligence and the artificial intelligent constructs. Will the artificial systems that we are creating boost the natural abilities of humans, or will they substitute them, making humans redundant and disposable? This seems to be the subject of sci-fi plots, but many of the current technological gadgets invading our lives were only sci-fi toys in a near past. So this, seemingly improbable scenario could be presented to us sooner than we expect.

At all levels of complexity and on everyone of the suggested axes, the computational revolution is producing new ethical and legal issues that

Governments are too slowly or too technologically naïve to tackle with. Regulations appear many years after the technology has made able behaviors that may be sources of conflict. Education is also lagging behind the technological advances. People seem to believe that old wisdom is of no application to the new found "promise lands", however old cautions are still very useful to deal with new "temptations". Is the ethical and moral knowledge[10] accumulated during centuries suddenly obsolete? Privacy, information ownership, the value of information for making decisions, how information is distributed and filtered, what are the legal cautions and defenses of the individual and the society, how responsibilities are exacted, those are issues and questions that are barely touched in the current state of affairs of technological hype. It seems all the involved agents believe that mere extrapolation of previous legislation and practices could be enough to solve potential problems.

Another interesting general question is that of irreversibility. May the changes on individuals, society, the environment reach some irreversible (undesired) state? The desirability of this state may be debatable, but if its irreversibility is by itself a catastrophic effect. If we have reached or are close to reach some kind of evolutionary landmark due to the quantum leap in computational power, do we have any telltale sign? Can we distinguish new human beings which are the seed for the next evolutionary stage?

Of course, I cannot give answers, even partial, to all these questions. Perhaps my own background is biasing me into consider Information Technologies and Intelligent Systems as core elements of nowadays change and life. In the following I will try to touch on some of these topics drawing some kind of impressionistic tapestry.

Science, Technology and Industry

To address the question of the existence of intelligent systems science, technology and industry, to deal with the interplay between knowledge engineering disciplines and society, we can define Science, Technology and Industry as a hierarchy of knowledge categories defined by the degree of the ignorance that drives humanity to develop them. Of all knowledge categories, Science is motivated by the greatest ignorance. Science happens in the actual frontier between the known and the unknown. Science pushes the curtain of fundamental ignorance a bit farther with each question and each quest for an answer. Science comes from such a blind ignorance that often needs to redefine its questions, its objects and itself. Next in blunt ignorance is Technology, which pursues constructive puzzles. Most often the technological question is "Can I build that?" Thus technological ignorance is born in the human imagination. Technological Ignorance is precluded by Imagination and driven by it. Technological advance is, therefore, always akin to a challenge of one's abilities. Finally, Industry is driven by need and profit, so that there is no fundamental ignorance behind, but only the problem of scale, repeatability, reliability and quality. The industrial questions are "How many?", "How often?", "How costly?", "How trusty".

Then the next question: is there a corresponding categorization of the knowledge field of information and intelligent systems? The question is by itself

paradoxical: categorization of knowledge about knowledge, in a recursive pattern like the ones ever present in computer science. My own impression is that there has not been a proper science of Information and Intelligent Systems. Computational devices and systems have been born out of the computational needs of diverse areas of science and technology. Computational Science is therefore at the intersection of many intellectual paradigms, a truly cross-discipline entity. It is even impossible to find a single mathematical field that could be identified as its root.

The formal definition of Information given by Claude Shannon[11], coming from the Thermodynamic's notion of entropy, could be a kind of keystone to the building of such science, which was born as a science of Communication. This definition was proposed when dealing with the problem of communication in the pre-digital era, when communication channels and computing devices were still viewed as continuous state space systems. It grounded the idea of information quanta that set the stage for the digital revolution, for the transition from continuous measurements to a world made of discrete signals and items. It was then when Information Space was born, the space where the new developments of humanity have been happening in the last decades. Technology, transfer and manipulation, has been developed inside this space, and industry has flourished. It would be astounding for an economist of the early years of the twentieth century to asses that nowadays one of the big economical factors is the entertainment industry, whose mission is to bring to the people the information they need to absorb for alienating them of their own reality: music, films, games.

The other keystone of a would-be Information and Intelligent System Science is the definition of computability embodied in the von Neuman architecture and the Turing Machine[12]. Intelligence involves information processing, and these works set the stage for dealing formally with these matters. Finding that things could or could no be computed, how the resources (time, space) needed were related with intrinsic features of the problem, opened the field of Computational Intelligence, encompassing many developments, from simulation to reasoning. Surprisingly, issues considered difficult (automatic reasoning) turned out to be feasible soon, while others considered easy (artificial perception) turned out to be difficult. Here inspiration from nature either physical or biological, like Cybernetics[13], Artificial Neural Networks, Evolution Algorithms and others have been critical to the present rise of applications of Intelligent Systems. The key feature of Intelligent Systems is Learning, which in mathematical terms means fitting the system parameters from the data obtained from reality. Instead of building the system based on *a priori* ideas without reality feedback, Learning tries to minimize some kind of error or to perform parameter estimation based on data. As such, it is deeply related with statistics as a general field. Computational techniques for Learning are the basis for Intelligent Systems Technology, which produces subsystems embedded in control systems, human machine interaction, games, data mining.

The technological drive to develop Information Systems and Intelligent Systems have been always come from the needs of other fields of science, industry and technology. The engineering fields asked if it was possible to build machines that could compute the structural equations required by the design of systems

such as engines, dams, bridges, trains, cars, etc. They required the means to visualize, simulate and to have virtual experience of products being designed. The scientific community required increasing power to test hypothesis through simulation, to design and control new instruments, to analyze data searching for answers and clues to their scientific questions. Large complex models, such as the space-temporal weather models, become routine prediction instruments, asking for routine availability of huge computational power[14]. Banking was one of the first actors pushing for the development of improved computational and communication systems. Telephone companies have pushed the digital revolution, that has affected unrelated worlds, such as the musical and video arts, which have become digital and also universal media whose management is becoming a technological challenge by itself. Each of these, and many others, technological questions have given birth to a technological branch.

The question of the existence of an industry of Intelligent and Information Systems is not an easy one. There are already some industry giants, such as Apple, Microsoft, Google, IBM, but they have a shifting shape and its production is somehow shifting focus. Apple builds computers and designs its operating systems, but its key for survival has been the music market (iPod) and the new mobile phones (iPhone). Microsoft banner is the operating system, which is increasingly challenged by Linux[15], but its game branch and other applications are becoming key to the company survival. IBM has become a kind of high-end information systems consultancy firm. Google revenue comes from advertisement, and it is the equivalent of a data cookie-monster trying to capture any data item that can be useful later on[16]. Google may thus be the first truly Information Industry in the world, whose primary matter and product is information in astronomical quantities. Such an industry requires some *ad hoc* solutions[17] and a great deal of Information and Intelligent System Science and Technology for data management, data mining, communications, data sharing, system security and a host of applications that are being continuously upgrading in order to capture people's attention and data.

The role of Science Fiction

Introducing Science Fiction in this context may seem some kind of joke, however more than in any other domain of Science and Technology, Science Fiction has been a driving force in many of the current developments in the field of Information and Intelligent Systems. First it has been a source of inspiration and a way to state goals abstracting from the actual difficulty of reaching them. In the nineteen century, Julio Verne predicted Internet, though in some far future[18]. Ambient Intelligence has been precluded by sci-fi ambiences in many novels and movies. Even classic sci-fi TV series have popularized the spoken computer interface well before it is really feasible at the levels shown there. They are pushing the frontier between conventional ways to understand life and would-be new life forms arising from the human creativity[19] with new ways to understand intelligence and identity. The existence of virtual worlds built in the ethereal landscape of information has been the subject of movie blockbusters, over the background of the conflict between robots and humans.

Nowadays sci-fi is full of boosted personages that have nano-implants and all kinds of computer related enhancements predicting a future of people being manipulated and updated to tailor them to desired tasks and qualities. The role

of sci-fi is to create expectations of things to come so that efforts can be dedicated to pursue their realization[20]. It has also anticipated some ethical conflicts, such as the problem of ubiquitous people monitoring[21] or the genetically tailoring of a population[22]. Although, commonly focused on the scientific advances, sci-fi is usually also a perfect ground to state such moral and ethical conflicts that may be aggravated by the scientific and technical advances.

Creating expectations is the business of innovation motors. In some cases the line between sci-fi and on going research results is intentionally blurred, to capture attention of the media and resources from the public. For instance, the biotechnological and medical sciences have great interest in letting fostered public imagination fill in the holes of their true achievements. Sometimes, "realistic" histories are more fantastic than "honest" sci-fi. And sometimes reality goes in ways unexpected to accomplish sci-fi prophecies. Google and other data gatherers (i.e. social networks) are the true equivalent of Orwell's Big Brother. However, they are more likely to the sugarhouse witch than to a politically driven megalomaniac-paranoid establishment. They offer a bunch of perks to lure people into trusting their data to them. They do not have, at least claim to, interest in the personal identity, only in the anonymous features of the data which can be sold to a third party commercial interest.

Ambient Intelligence

Ambient Intelligence is one of the last (which is becoming nowadays obsolete as a technological banner) buzzwords in the Intelligent Systems arena, and a paradigm of its effects, contradictions and expectations. In essence, the Ambient Intelligence ideal is that ubiquitous computing resources and intelligent devices would allow the continuous adaptability of the environment to the human living inside it. That is, Ambient Intelligence would reverse the actual paradigm where the user must learn how to address and interact with the automatic and computational systems surrounding him. The arrow of adaptation pressure would, therefore, shift its weight direction from the user to the system. This seems to be a natural corollary of the efforts in improving the Human Machine Interface, with an expected quantum leap that would produce a radically new world to live in. The early lever and gear controls of some primitive machine control panel, the punched cards, the keyboard, the graphical interface and the mouse with the point and click interaction metaphor, all of them as a logical sequence in which commanding the system, knowing the system's state and deduce corrections are easier with each advance. However, up to the proposition of Ambient Intelligence it is always assumed that it is the "user" the one that has to "learn" how the system "works", adapt to the system's interface, develop required abilities to cope with the system, etc. The single conceptual leap of Ambient Intelligence is the idea that the system may proactively adapt to the user.

The computational elements that would allow such a revolution would be ready at hand, or near after some innovations:

- Improvements in sensitivity and miniaturization of sensing devices would allow the acquisition of a real cloud of information about the individual

human, assessing its state with great precision, in a many-dimensional computational representation.

- Enhanced intelligent data processing would allow building accurate models of the human individual which will monitor its evolution and allow to predict its needs.
- Enhanced reasoning (intelligent) systems would produce the appropriate environment action decisions to make life easy for the human, predicting its evolving needs and adjusting the environment to him.
- Enhanced signal processing algorithms would allow to extract information from the wide streams of data coming from the various sensors.

From a general and wide application, the idea has been narrowing into something related with the design of intelligent houses and the caring of the elder. Aiming to obtain visible technological results in a short time, big research corporations have built experimental test sites, consisting of model home components (living room, kitchen, etc.) where demonstrations of the behavior of fixtures and technological gadgets can be performed. Some of the test sites have had short lives, while others have a delayed life cycle and still are being used or built in second order research centers.

Nowadays, the idea is lagging behind the raised expectations, despite the big amounts of money devoted to it from the public and (much less) private funding sources in Europe. At its current state of development there are some achievements and failures that set the stage of the state of the art. There has been little development of new sensors motivated by Ambient Intelligence, on the contrary, most sensing innovations consist in the adaptation of sensing devices developed by other industries with other aims in mind. A paradigmatic example is the Nintendo Wii interaction wand, developed with as a game interaction device. Its incorporated cheap and very sensitive inertial sensors and near infrared camera have been put to good use in many clever applications of home intelligence and intelligent devices. However, these applications remain at the stage of “proof of concept” demonstrations, because the final push into commercial viable products lack the needed financial support. A similar example is the on coming use of new mobile phone terminals that have enhanced interaction capabilities as well as some new sensors (GPS, inertial sensors, cameras) and higher computational capabilities which are being put into use for applications that fall in the fuzzy domain of what was Ambient Intelligence, for automatic self-localization, on-line monitoring of ambulant patients, on-line tutorial advise and many other applications. However, much of these applications are mere technological demonstrations of communication channel capabilities, low intelligence entities.

On the intelligence side, key issues such as user modeling, advances on robust sensing and modeling of the user-environment state or reasoning for prediction of user behavior and needs have been scarce, usually again the naïve transposition of methods and results developed in other domains, such as e-learning or interactive command and control (military applications). Currently, alarm activation is one of the key issues, because it has wide applicability in

Ambient Intelligence, from the monitoring of elder people up to household critical conditions (fire, flooding, assaults, managing, etc.). However, alarm detection techniques have been developed for signal processing applications, and its adaptation to Ambient Intelligence seems not easy, again resulting in "proof of concept" demonstrations that do not end up into mature products in the near future. Robust sensing is also far from the raised expectations. For instance there is no spatial behavior modeling and understanding from camera input, at most some trajectory tracking has been put into show for quite controlled environments, again making use of techniques developed for security surveillance. Finally, multimodal interaction (voice, gesture, emotion) is far from being a reality outside quite specific settings.

The issues involved by Ambient Intelligence are at the core of the continuous development of intelligent systems, therefore though the emphasis in this precise buzzword will decrease with time, developments will continue in the future, in all these aspects, despite the failure to meet expectations. This is a common paradoxical effect of the general field of intelligent systems since its starting steps in the decade of the 50's: many times very high expectations have been created by "hype and buzz" and the results have been poor, the efforts have shifted to other buzzword, though the underlying issues are the same and continue to be attacked from the scientific and academic community, until the next wave comes and the new tools improve previous attained goals.

From an ethical point of view, it is quite evident that the achievement of the Ambient Intelligence utopia would involve a radical change on the living conditions, the living environment of many human beings. What would be the effect on the individual human being? Reasoning analogically: presently many people on the "first" world societies suffer from physical and physiological diseases which are the by-product of our current way of living supported by current technologies. Could we predict the new psychological diseases that such an over-protecting environment as proposed by Ambient Intelligence proponents could induce in the future population raised in the womb of an environment that smoothly, continuously and subconsciously adapts to the wishes, needs and caprices of the user?

Control systems

Control systems embody intelligence at the hardware systems level. They are the guiding component of the systems. We can picture a hierarchy[23] of systems and components that goes from the upper spatial or organizational levels down to the elementary local or atomic levels. At each level, control subsystems get information from lower level subsystems and provide information for upper levels decisions, besides producing its own decisions. Control systems digest information at very different abstraction levels, corresponding to spatial resolutions and organizational compositions. Systems that are quite different in nature could be viewed under this view as an integrated organism. However I am not trying to pursue in depth this all-encompassing analysis here, I am only interested in remarking the similarity of information processes implied by control processes found at diverse places. Where we can found them? They are pervasive. Cars may have up to a hundred such subsystems looking at diverse

subsystems. Trains, trucks, satellites, washing machines, robots, you name it. Every machine performing any operation with a minimum of autonomy contains a subsystem that is in charge of ensuring that the required task is performed under given specifications. Each subsystem can be embodied in a separate computer (microcontroller in a chip). This idea can even be extended to "soft" systems: inside organizations such as manufacturing companies, banks or political parties such control subsystems could also be identified.

In essence, control systems feed on information about the state of the controlled system and produce actions, which can be information for other components. Control systems must filter and distil important features from the perceived information, translating the values of variables into appropriate codifications for automatic processing, removing noise that can be due to the information gathering processes (sensing), compressing information, performing significant transformations of the data[24], selecting variables before or after transformation. These operations appear in most control systems, under different disguises, depending on the nature of the system and the precise nature of the information processed. A detailed enumeration is out of the scope of this paper.

Determining the actions to be performed, the output commands of the control systems, the computations may involve linear or non-linear transformations of the filtered data, reasoning to produce classification results, regression or predictions of future values. An underlying model of the controlled system is maintained by the controller, so that reasoning and/or about decisions about the corrections imposed on the controlled system are based on this model. Designing the control system involves first building such model, the so-called identification problem. Second is building the reasoning process for correcting the system behavior towards the desired behavior. Both problems can seldom be solved analytically in growing complex systems so they are increasingly solved via learning approaches. Which leads to the application modern Intelligent Systems techniques. For instance, so-called reinforcement learning[25] has been successfully applied to derive the control laws of some complex systems (i.e. mobile robots) from experience and simple reward responses.

Advances in the intelligent processing of information as described above, due to increased computational power and evolution of ideas and methodologies, has been accompanied by the development of sensing devices, from the ubiquitous cameras to more specific sensors, and of actuation devices with increased power. These improvements are due also to increasing computational resources that allow better design, test, simulation, and management of manufacturing resources and life cycles, increased miniaturization and son on. All these advances have lead to a big leap in the capability of automatic systems to affect the natural world, to create artificial environments where human society lives free of the dangers of nature. Cities, communication links, transportation tracks (roads, trails, rail-road), landscape works for pleasure, agriculture, mining, are changing the face of the world, reducing the area of wild life, of wild lands at an increasing pace. It is a fact that human presence can reach everywhere in dry land and most of the ocean and sea floor above a certain depth[26]. Not only they can reach, humans can transform landscape in a dramatic way[27]. The advent of digital computers in the form of microchips has

produced a qualitative as well as quantitative increase in power and autonomy of robots and machines that are instrumental to such human exploitation of the environment.

Manufacturing has been transformed by the increase in intelligence that can be introduced in the machines and processes. Automation has reached the job shop, the warehouses, reducing daily the need of human labor. Even “stupid” robots need precise commanding computers that allow autonomous forward control of complex systems of robotic components performed a task. They can be very sensitive to deviations from the nominal environment parameter values, as introduced by uncertainty, noise and ambiguities in the measures, positions, sensing information, etc. The development of statistical learning tools, fuzzy systems[28] reasoning tools, artificial neural network systems, and the like, has allowed to deal with these imprecise, fuzzy or probabilistic observations leading to more flexible and robust manufacturing systems, increasing productivity and industrial output. The current (experimental) 3D printers may allow in the future the precise and automated manufacturing of complex items and parts, allowing for in-home manufacturing systems.

Prosthetics have evolved at an astonishing pace in the last decade, thanks to the embedding of microchip control systems and advances in intelligent robotics, so that the frontier between robotics and prosthetics is a blurred line[29]. Lighter strong materials and increased power storage converge with increased computational power to produce artificial limbs, while improvements in sensing and signal processing lead to interfaces such as the direct brain control interface[30] that allow for communication even in the case of extreme dysfunction. In the biomedical area of applications, advanced control systems have also an impact on the development of intervention tools, surgery computer aided tools[31]. These advances (whose expectations have been created by sci-fi culture) increase the widespread of the sensation that extreme losses can be reverted to normal configuration of body operation. Reversibility of ill or disease conditions lead to increase in life expectancy, but also to the irresponsibility in affronting risks. People in developed countries suffer from the growing expectation of miraculous health recovery based on technological wonders, which is good business for the medical equipment manufacturing companies. Computer Aided Systems are growing market in the medical sciences, as they have been in many other manufacturing and processing areas.

The question of teleological design and explanation appears when we deal with control systems, or we try to impose them as a metaphor to understand the mechanics of real world. In order to obtain effective control schemes, a precise goal must be somehow stated. Reaching this goal becomes the system’s purpose. If we put a purpose on top of a system’s behavior, then we must include some control subsystem in charge of pursuing such purpose. It is true that in nature many systems do not appear to have a specific purpose, however all human made systems have a purpose, hence the pervasiveness of control systems and control related ideas and techniques. Advanced intelligent systems empower society agents to impose their intended purposes, sometimes leading to conflicts among them, and always clashing with nature. Maybe Nature has not a Purpose, but humans always had one[32] and they fight to impose it.

The question of irreversibility of the impact that human kind has over the wild environment is the natural following up. Up to a certain level of activity, after the disappearance of the human presence "nature" fills the gap, destroys remnants, and restores wild life presence. However, after a critical threshold is trespassed the effect becomes irreversible. Extinct species would not be recovered, nuclear wastelands need thousands of years to clean up, forest become deserts, oceans depleted of oxygen[33] become water cemeteries. However, humans are being educated in the belief of reversibility, they are taught by the media to believe that any condition could be healed. Intelligent systems are part of the problem, empowering the humans that do transform the wild environment. They do not seem to be part of the solution, because very likely there is no solution: there is no way to revert to the previous natural state. Early attempts[34], also based on control theory modeling and simulation approaches, to warn the political agents about this danger seem to have ended in the trash basket. That is, the political agents have systematically disregarded the use of intelligent systems to predict and prevent the trouble that increased human effect may cause. They trust technology to destroy the environment, but not to reason about political issues and guide decisions.

Chaos versus order

The dawn of the Internet Age is akin to the discovery of a new land, of a new source of resources unexploited. Internet is a new space unfolding before the foot of the explorers, which at the same time contribute to create it. A land with no rules, no controls, no responsibilities, a boiling magma of possibilities unrestricted, unconstrained. That was, at least, the picture until recent times. It was a new land of freedom open to the ones that dare to tread its ways. This picture is quickly changing, with the corresponding tensions and conflicts. The social and political powers have begun to understand its big potential and are trying to set controls and harvest the economical and political fruits of the web.

To illustrate the conflicting interests, we can pursue an analogy with the prehistoric agricultural revolution. Gathering and chasing nomadic people were used to free spaces and no prices for picking needed resources. The advent of agriculture set fences, put borders, claimed lands and put prices. What was obtained for free, was now under control of some people. Land, the basic spatial resource, was possessed, claimed by force, distributed in the name of authorities based on the superiority of organized violence. This conflict has been reproduced recently in some regions of the world, repeating a drama enacted since old times: that of the victory of culture and progress over wild life[35]. Internet is under such a transition, with a special feature: Internet space is created by the users, it is not a natural space where fruits are produced by natural forces out of the control of the gatherer. In the early times of Internet, amateurs produced the contents, and shared them under a non-profit understated accord, following a philanthropic effort to disseminate knowledge. Nowadays, industries compete to create contents and to protect them while using Internet to distribute them. For instance, spontaneous attempts to communicate through the web have led to the development of web companies offering social services, with a business model based on publicity, and other hidden assets.

Internet is, thus, in the transition from a disordered realm into a “civilized” space. Nevertheless, the fences have been low for a time and the new generations have tasted the freedom of reaching things easily, fast and for free, and they seem to be very reluctant to lose it. Besides, through Internet political boundaries are permeated and almost non-existent[36], so that imposing some kind of order implies some transnational power. This capability to permeate frontiers has been used by the economical power and the criminal organization as well as by the idealistic pursuers of the utopia. Internet lives in an ethical limbo, as a mean to serve the user interests without judging them. As mentioned before, claiming the right and ownership of things always leads to the consideration of the capability of violence that may be enforcing it. Paradoxically, in the time of virtual realities, physical brute force remains the key to put some kind of order in this virtual space.

Another kind of order arises from the collaborative altruistic works channeled trough some specific sites. For instance, some sites[37,38,39] allow people to contribute their programming skills and results to build software left free for the general public[40]. Some corporations have had the vision to profit from this source of quality software[41] to improve their products, contributing also to the increase in competitive pressure to improve the quality of the software available from free and private developers. Initially, a negligible economical and social curiosity, it is growing to big proportions, with the paradoxical effect of providing in some cases better solutions than the commercial software engineered by private companies, or being the foundation, as mentioned before, for the improvement of a company proprietary products. Examples of such open source free software appear in all areas of activity, from science and mathematics, to organization, e-learning, group interaction, medical software, etc.

A paradigmatic example of guided self-organized construction of a successful product is wikipedia[42], which has become a prime reference for many cultural and scientific issues. The initial instability of the contents, because of the freedom to introduce changes allowed to the readers, has converged to stable contents when the supervised interaction between parties that want to present partial views of an issue reaches an equilibrium based on the recognition that endless cycling interactions are worthless for all the parties involved. Also, some basic rules of style and a growing academic presence have helped to settle content issues. That way of solving conflicts is really a big contribution of wikipedia philosophy. Mathematics and science have been much less controversial than political, cultural or religious issues. In fact, wikipedia is becoming a quick reference for all mathematical and scientific questions, because of the permanent character of the knowledge involved. These movement may ask for a deep reflection on how people self-organize, how knowledge can be shared and build by a kind of communal mind. Most important, they constitute a kind of constructive power that is one of the closest examples of the ideal of anarchic self-government. As such, they have potential to be highly disruptive of the established order, so attention must be put on how this whole self-organization phenomenon evolves.

New economical factors

We have commented previously on the impact that increasing intelligence has in the increasing productivity, through the improvement of automatisms, control, management. This means, that each unit of human labor produces much more value now than some years before. Hence, the need of human labor decreases steadily while the production can steadily increase. The natural question for a sensible mind would be: producing what for whom? Who can buy the products? How the purchasing value is produced? Would the system reach paradoxical states, where it needs to fund the potential clients to avoid collapse? It seems only natural, as natural as trying to disguise the problem under many layers of misinformation[43]. Another interesting effect of intelligent systems in the productive cycle is that the manufacturing becomes less and less dependent on the proficiency of the human labor at hand, hence it becomes easier to move factories from one country to another with cheaper labor. At the same time, increased intelligence of the automatic system means that less formation is required of the human operator. Engineers can be replaced by less qualified people[44] to perform equivalent task, for an additional reduction in the cost of human labor costs[45]. Intelligent systems have contributed to the mobility of jobs, downgrading the value of human labor. Until now, researchers working on issues whose results lead to these results lived in another ethically neutral land. Nowhere the minimal ethical reasoning has been proposed. No consideration of the long-term consequence of their works can hinder them to pursue them[46]. However, Intelligent Systems have a clear economical impact in many of the dimensions of society. No consideration has been given to the emerging issues that they may cause. We must inquiry whether this state of things is irreversible.

The Internet Age has led to its limits the economical permeability of the state's boundaries. This permeability was already there by the increase in communication means: the advent of airplanes, the increase of car and truck traffic, and the increased needs of commerce pushing boundaries to the limits. In this regard, Internet has added a new qualitative factor: ubiquity. Internet servers and clients can be anywhere, so the transfer of value through Internet transactions can go through any frontier. The key to this is the availability of secure communication protocols based on advanced cryptographic algorithms. Global movement of value by the banking and financial entities is a reality, and the speed of the transfer processes is simply astonishing for the common citizen. We, low rank people, cannot imagine the amounts of "value" that are in motion at any given instant, any time. In fact, much of the financial business corresponds to profiting from instantaneous small variations. So that faster decisions are required at each new generation of systems. It is not only that financial systems deal with "virtual" money, with value embodied in "financial instruments", "financial products", whatever the jargon used to hide that they play with emptiness against our "real" lives[47]. The issue here is that they need more intelligent systems to perform their transactions faster (but not safer?)[48]. If computational intelligence techniques (statistical, fuzzy, neuronal, etc.) are used to build such systems, the question of validation becomes a critical one. Validation is always conditional to the data available. The data available is a sample of an underlying stationary population. In other words, whenever conditions change dramatically and in unexpected ways (for which no data is available) the "intelligent system" becomes unreliable. This is the state of the

art, and trying to deny it is calling for trouble. It seems that much of the financial traffic nowadays is controlled by such systems. It is only natural that most these systems behave in a very similar way, though maybe the underlying technology is a bit different. Therefore, the risk for avalanche effects, when all these systems observe the same situation and reach the same conclusion, can be extraordinary, even more in the case of extraordinary situations, outside the training data region. Could it be that the "market volatility" would be due to the synergistic effect of these automatic systems?

Global traffic needs global control, global validations and global responsibilities. To what extend the volatility of the markets, the divergence between financial economy and real economy, and many other effects are due to the lack of such global control instruments is an interesting question. Besides, under such an scenario, the differences between economical systems may seem to be blurring. The meaning of "communist country" when applied to the country that is currently owning the greatest chunk of the world's capital reserves is really a puzzling question.

Finally, the Internet Age has also contributed new industries and changed the way some things were done. Knowledge transfer has been done via paper books in the last centuries. A whole paper and printing industry has grown and it is now under severe and increasing crisis due to the change of information transfer support. Newspapers are becoming Internet sites. Wikipedia is substituting traditional encyclopedias. Books are becoming digital. Music is also changing support, becoming digital and being purchased through Internet. Movie theaters are becoming obsolete and empty[49]. Travel agencies must compete with online services that provide access to cheap flights and hotel reservations. Many other industries are disappearing introducing changes in the way people can get jobs and in the structure of society. Some distribution channels are changing, with producers getting directly in touch with the end consumer, through dedicated web site. Intermediaries now need to offer something more than the connection to the consumer. These changes seem irreversible, in the sense that unless some catastrophic change, they are already integrated elements of all the cultures. They are accepted as the telephone or the car have been accepted everywhere. Also, young generations have grown used to free access to contents, meaning that companies must have innovative business models (which often are not well understood by the "client").

New political factors

The ability to control the life of people has exponentially increased with the evolution of computers, communications and intelligent systems. Most information dealing with the life of a person is going in digital form through computers and switching centers that can be taped by the political powers, justice and police forces. They can also be tampered with, leaving no trace of the past values, if the agent has the appropriate security clearances. Financial information, music, books, movies, telephone conversations, personal information can be read and modified. Tax agencies know almost every move that a person can do, leaving only the uncertainty corresponding to cash

transactions, which are diminishing quickly. All present security cameras can provide information of physical localization, electronic transactions can be monitored, e-mail can be read from the provider offices, mobile phones can be tracked and conversations overheard without any perturbation of the communication. Security agencies, both public and private, can peer into anyone's life without its knowledge and consent and even without leaving trace of their acts. Besides, the protection of numbers is lost, because computational resources allow the processing of billions of data items in short time. Each individual is more conspicuous than ever in the eyes of the people dealing with the security and the political well being of the "system". Intelligent systems are putting to the service of the security agency to process such big amounts of information to find significant facts, to detect anomalies or to track a given person or group activities. Many of these systems fall in the "data mining" category while others are specialized pattern recognition systems for face, voice, remote sensing information, video processing, etc.

In a symmetric effect, nowadays people may have much better access to public information, which can allow the control of the executive power. Citizens could be aware of the status of the system, of the effect of decisions, of responsibilities. The access to public information has changed drastically with the advent of Internet, and the expectations of the people about how to access it and what can be accessible. People expect more and more to be able to look at precise data, like the distribution of subsidies to companies, the expenses of politicians, the way public funding programs have been distributed. People expect to know more if they want to, they expect that the information will be available when they need it (not when the political power wants them to know it). This symmetry goes against the tide of the common history of humanity where information has been power and has been withdraw from people. We firmly hope that this way of accessing public information will rise a new kind of public awareness and lead to new ways of government. In this regard, voting through Internet is anecdotic, because the real power lies in the information that guides the vote. Politicians, of course, sell the empty nut: vote without knowledge.

A key idea is that the social system could be truly directed by a kind of collective intelligence emerging from the interaction of individuals using Internet as a communication tool and as a synergistic catalyzing element. How a collective of intelligent autonomous agents can agree on a collective decision that improves their individual and global status? Can it be done only on the basis of local, individual information and decisions? Democracy is a way to give to an individual the power to perform such decisions. Could enhanced communication and agreement mechanisms allow for new improved ways to perform collective decisions and governance? It is not that some anonymous "intelligent system" could determine our future, the question is if we can rise to a kind of "global conscience" which naturally will allow "good" ethical personal behaviors, and "correct" collective decisions. Sadly, Internet forums are a systematical failure. Only technical forums are sources of useful information. Cultural, political, social open forums become crazy places in very short times, because of the inherent irrationality of people's interests.

The Law can be and must be easily accessible to the general public, so that they can easily and directly know their rights and obligations. However, navigating all this specialized information (the specialized language of lawyers and their own logical reasoning methods) requires support, intelligent systems that interface the layman to this information, in a trustful way, because the consequences can be really dramatic. The efforts to allow the processing of legal transactions through Internet have a two-side face. For once, it can allow more agile processing of legal issues, improving the attention to people and giving a more flexible interface to the people. On the other hand, it hides the responsibilities behind an automated system. In the end, someone is taking a decision, either when programming the system or when the issue reaches its hands. People are, and must be, responsible for their decisions as long as they determine the well being of other people. Hiding behind a computing system that can be blamed for everything without any consequence can be the ultimate source for injustice.

Data mining

The last information industry is that of mining the data in search of unexpected useful information, using computational huge resources and new intelligent system technologies and mathematical approaches. Data mining is performed in the pharmaceutical industry, in the study of genome information, in the security agencies to detect anomalies, but the most successful economical application is that of advertisement. There even very stupid systems can make a big profit, because of the direct access to the data source and the data producer, the user.

A minor problem for the industry is that of data ownership, how they get access to the data and if they are breaking or not the privacy of people or their security. That is, for data mining companies data is a resource that must be obtained and the producers are the people. This is why some companies are giving much “for free”. Free mail services are provided under the permission to mine on the mail information. In other words, the service provider reads every mail sent or received through its server, it is peering over your shoulder on every conversation you make. Even worse, there is no guarantee that they will destroy information that you delete from your account. For them, every bit of information is a resource not to be wasted.

Web crawlers are constantly monitoring the state of the Internet, prowling at web sites and extracting as much information as possible from them. They feed the search engines, and account for a large chunk of Internet traffic. Again the legal and ethical issues [50] related to data privacy and data ownership which appear to be of no concern for the big companies[51]. Again there is an ethical limbo where corporations work, where their actions have no consequences, but their own profit. The anonymity of the automatic systems involved is the intrinsic cause of this ethical no man’s land. If a person presents you with a tricky contract, he/she can be liable of cheating you, he can be brought to court for not giving you appropriate information, hiding facts. However, a program that presents the layman with a lengthy complex contract, without explanation, offering only two alternatives (click vs. no-click) is not liable. All the legal weight

of the transaction falls on the shoulders of the user, without any assessment about its ability to understand the transaction and its consequences. At the same time, the corporate CEOs feel safe and comfortable, because there is an automatic system doing the dirty work. In the same vein web crawlers are anonymous impersonal objects, they cannot make any moral decision about the data they are reaching, the barriers they are jumping to get to them, the willingness of people to give away the data, the control of people about this data after it has been "harvested". For data mining corporations, the Internet is the wild land where everything that can be found can be appropriated.

Social software

The way that people communicate is at the core of society. It is even previous to what we call culture or other social constructs, such as religion, law, organizations. The social conventions establish how to get in touch, to decide collective actions, to agree on the meaning of things and ideas. This is why the software instruments that have been developed in recent times to channel social interaction constitute an issue that deserves to consideration. In essence, these software instruments allow the publication of personal information for an audience defined inside the corporation users. Privacy here is in the hands of the corporation, up to their strategic decisions. Corporation policies are aiming for profit, not for social well being, so they are inherently to be distrusted. As said elsewhere in this document, corporations try to posses and use any data item that falls in their hands. However, most of their "clients" are young and immature, not aware of long-term consequences or commitments. Social networks on the Internet are, thus, quite volatile, like much of Internet itself.

Professional social networks are less volatile in principle, however they have some annoying features which are representative of the current standards of living. The first one is that they can be very invasive. Active groups can be generating huge amounts of messages that perturb everybody in the group's list. People trying to build an image can be artificially active, with senseless initiatives and very constant unproductive presence. There is a big risk of pretending people building fake networks and luring users into undesired connection, interaction and action. There are few or none validation instruments: ways to confirm that the information given by any individual about himself is true. There are no guarantees about anything that can be found in such places. Validation of the content's truth is by itself a general problem in Internet.

The growing phenomenon is that of people living in a virtual social environment, without physical counterpart, which may lead to reality disconnection. This problem is growing in some highly techno-culture oriented societies, such as Japan. Some people even accept the fake identities built for the social sites as real ones, because the probability of meeting in the "real world" are negligible, therefore virtual identities become the only ones that will be known. Intercultural relations, jumping across nations, cultures and political systems, can be a source of conflicts in this virtual reality, if the interacting agents are not even aware of the different backgrounds.

Cultural standardization

Improved digital communication has somehow deepened the trend of growing cultural uniformity. This effect is not new, improved physical transportations with the advent of the vapor power machine technology, the oil based technology and on going transportation developments have produced that some cultural trends have been diffused and become dominant. Standardization means that several patterns will be found everywhere. This is not inherently bad, since it allows the communication between people from very diverse places, and the easy adaptation of people moving. The need for automatic communication and decision making based on communicated information imposes the need of well-established semantics across the world, hence the standardization obtained through widely accepted semantic definitions. Such an approach can be applied to low-level tasks, such as managing travel arrangements.

Particular cultural idiosyncrasies usually preserve local features of solutions to the general human needs and problems. By themselves, they tend to be local non optimal solutions, or even sometimes downright wrong. For example: It is difficult to sustain nowadays slavery as a “local cultural” trend that must be preserved. However, there is also need of diversity as a seed for innovation in the social system that can come from the separate evolution of several cultural tracks.

Presently, however, the evolution of the computational intelligence tools and means, helps the preservation of local cultural features. For instance: diverse human languages can be easily tuned to be the language of choice for a given task. Low level transformation of the system’s interface to accommodate to a new culture is easy to do. Automatic translation is one of the active fields in intelligent systems research, which favors preservation of local cultures. The European Union has invested big amounts of money in such research programs, and the European Parliament is a multi-cultural institution increasingly supported by intelligent systems technology.

The need for permanent change

The continuous evolution of the systems, methods, interfaces, software, hardware, devices, has become an obsession in this new era. For instance, some public administrations change their Internet site almost every year, with little effect on contents and much confusion to the user. There, we must distinguish between a real need and the artificial need induced by the industry to sustain its activity. Some software solutions, i.e. word processing, have nothing significant added in the last 20 years, however, there is a permanent release of new versions every year. People are forced to update because other people has already done the upgrade and imposes compatibility issues.

In some cases is the evolution of the underlying computational hardware the force driving change, in some other cases change is subsidiary to a new desired way to do things, which becomes feasible because the communication and processing power is available. Social Internet applications are there because the conventional personal computer and the personal access to

internet can manage information bunches that seemed impossible some years ago. However, the basic solution, a text based solution was available years ago, and not much qualitative information has been added although the quantitative leap has been enormous. Our question is if all this development was needed or was imposed in a subtle way.

The exponential growth in computed power arising from Moore's Law seem to justify the continuous evolution of systems and interfaces, however there is always the duality between the need of improved systems and the offer of more computing power. Do improved systems need more computing power or they are an excuse for maintaining an artificial growth? Do enhanced interfaces, realistic rendering provide more useful information (content) or they are consuming computational power just to make things "nice and cute"?

The obsolescence rate has also grown apace with the rate of change. That means that things that are functional are being disposed of just because there is a need for change imposed by the producers over the needs of the consumers. This kind of counter-economical game can be sustained in the case of young immature populations of consumers that thrive on change per se, however, it seems sensible that administrations and companies must be more conservative and accept only proved improvements.

This need for permanent change has lead also to a fast revolution on the companies leading the market. During the 70's and 80's the big computing company was IBM, while the advent of the personal computer opened the dominion of Microsoft during the late 80's and 90's, a recent newcomer Google is becoming the dominant force for the near future. Also, to survive, these giants need to be shifting their focus continuously. IBM shifted from being a computer manufacturer into a kind of IT consultancy for very big companies and administrations. Microsoft operating systems business is shifting into games and internet. Google business is data, and it is trying to find the new ways to capture data offering more services.

While most political agents sell the idea of sustainable growth, the computational industry is leading a movement of perpetual change, even if it is meaningless. Continuous innovation, even at really high environmental and social prices is at the heart of the information and intelligent systems industry and technology, and they seem to be pushing the remaining aspects of society. There is an inherent reason for this need for continuous innovation. This is that anything existing can be duplicated at almost zero cost, so that the copies of products give almost no value in return. Only improvements produce value that can sustain the industry. Therefore, innovation is mandatory for the industry survival. No other industry has this intrinsic need, because others (i.e. shipping) obtain big value for each item constructed.

Ubiquity and the digital continuum

One of the main effects of the Internet Age is that of rather instantaneous communication across the vast spaces that were not long ago a big wall for the communication among people and cultures. Nowadays people of the First

World expect to be connected almost continuously and everywhere, and they expect to be able to know things happening all over the globe. It begins to be seen as natural having direct connection with people on the top of the Everest, and people are asked to worry about cataclysms happening in remote places, because there is almost instantaneous knowledge of it.

There is also another growing view: that of Internet as a vast repository of knowledge, with instantaneous, free and easy access to information and responses to questions. An admirable effort in this regard is Wikipedia, which is becoming the reference for scientific and technological questions; above all, the mathematical sciences are being revolutionized by it.

The quest for knowledge that was demanding of full devotion of life and resources, and that was sometimes in history a risking business, has become trivial in some ways, and terribly complex in others. Navigating over the Internet may seem trivial on the back of the powerful search engines, but it is also very demanding of critical tools. There is no guarantee of information quality and stability. Increased abilities to perform rigorous criticism are more important than finding information. Useful information depend on our ability to filter out the trash of publicity and arbitrary statements. Ubiquitous computing contemplates that continuum of information and computation were people of the developed world is embedded. Everything is becoming addressable, a quantum of information and a computing element.

As the computational power available has changed many things and ways to relate humans between them and with their environment, a relevant question is whether we are becoming a new kind of humanity, with qualitative new properties, and also dependent on the existence of this ubiquitous computing continuum. As computerized implants allow recovering from big accidents and diseases or improving the performance of healthy people, what would be the physical boundary between a “normal” person and a cyber-enhanced person? The frontiers between a person and a robot will be blurring in the future.

Without the need of such an invasive transformation of the human body, we nowadays have communication and computing complements that allow us for instantaneous conscience of events and to perform remote actions and decisions. Will this set a definitive evolutive landmark, will the new human race be the “computational homo sapiens” ? One way to define “humanity” is through is relation to power, that is, through the rights that can be claimed and the obligations answered. For instance, if one person decides not to use this computational gadgetry, will he/she become an outcast with fewer rights than the “normal” citizen? Put into other words, the world population outside the Internet field, do they have the same “human rights” than the connected population?

Games as a way of life

Games have been the tools to explore safely in a simulated environment, to develop new abilities that fit to the needs of the adaptation to the real world. Computer games have been growing as full-fledged industry from some specific

entertaining and training cases. The need of people to live new experiences, to alienate themselves from their dull lives, has pushed the demand of computer games. In some population strata (younger ones) games are almost a second life. In some societies, computer games are ubiquitous, they are present in any kind of interface, from mobile phones to workstations.

This develops a new way of seeing life and the life experience, through the filter of the surrogate worlds and identities [52]. People tend to approach problems as instances of a game. This has decreased the ability to perceive real risks and irreversible situations. In a game there is always the possibility to revert to previous states, to recover from failures. Real life contains many irreversible situations for which computer games are a poor training. Also the sense of responsibility is disappearing: being inside a virtual game the agent have not need to respond for the effect of their actions.

Games require enhanced interaction and visualization in order to immerse the player into the virtual reality of the game. They have been a driving motor for the graphics and simulation developments. Besides, the logic of the game and the virtual recompenses are the key addictive component. There is a key concept in the neurosicological sciences, that of ecological validity of a test, which is relevant here. Ecological validity means the existence of a correspondence between the game and the external reality. If the game is about shooting, would the acquired shooting abilities be adequate in the real world, with real guns? Are the reasoning abilities developed in the game adequate for real life? For most entertainment games the response is: Not. This may pose some dysfunction on the habitual player. Most of the times, the players spontaneously solve the contradiction between game and reality.

In the so-called “serious games”[53] the ecological validity is crucial because it determines the usefulness of the game for its intended purpose, either diagnostic or therapeutic. Computer games can be very useful in the diagnostic of some neuropsychological diseases, because they allow for a detailed monitoring of the subject and all the data can be precisely recorded for posterior analysis. Virtual situations are being used to treat some problems, such as phobias or other panic syndromes. They have been successfully applied to cure the panic to fly. Augmented reality has been proposed to treat arachnophobia.

Distributed, online cooperative games have also changed the way interact and have started to build virtual worlds[54]. Reality is a consensus about the existence and the value of things. The idea is that if we can agree on the value of a certain virtual space or virtual object, then it has this value. Again, there must be some correspondence with the external “physical” world that sustains it.

The effect on the arts

New tools for audio-processing have allowed that almost any home computer can be converted into a audio-editing studio. However, this has not improved the quality of music, which follows patterns established by an industry that profits on mediocrity. The last decades have witnessed a fall of creativity and a rise of manipulation. The rock revolution has lead to the lobby of discography

industries trying to put controls on Internet. On the plastic arts, there are new visual artistic expressions based on mathematical simulations, those based on fractal geometry and fractal recursive sytems[55] are most spectacular. They can be used to produce fantastic images, but also to reproduce natural irregular objects. By itself, it is not much of a revolution but it is a new way to do things.

The big revolution has been in the movie industry, where synthetic images have allowed building more realistic renderings of personages, landscapes, objects, allowing to build virtual worlds with high verisimilitude. Animation movies, fully 3D modeled and rendered have become pieces of art by themselves[56]. The digital arts have allowed also the easy reproduction and transmission of the artistic contents. This poses serious economical problems for an industry based on making profits for reproducing and distributing those contents, with little regard for content creativity or quality.

From the sociology of science to the industry of science

We must note at the end of this essay a paradoxical effect of the communications revolution of the Internet Age given by a curious reversal of roles. It is widely acknowledged that there is a certain sociological dimension in Science and Technology. The need to communicate, to set an agreed state of the art, to collaborate has been the driving force behind the organization of conferences and the publication of journals. Journals were backed by the prestige of institutions and later of editorial companies. Peer reviewed publications endorsed the communication of new discoveries or scientific advances.

The advent of electronic publications and the easiness in their automatic handling for some focused purposes, such as matching references, has powered up the usefulness and recognition of some quantitative quality measures of both publications and journals. Therefore, the advent of a new kind of industry: the scientific-technical publications industry whose output is the number of publications fitting a given quantitative scale. Notice that I am not saying that the papers are the product. Is the number of papers that becomes the industrial output, regardless of content.

Academia, universities, research centers, private companies, countries are being ranked by their scientific output measured in abstract quantitative terms. This ranking, and not the ideas of the substrate of papers behind it, is a key to decide many things nowadays: from the assignment of funding to the competition for positions.

That way the consensus mechanism has became a regulatory mechanism, a fitting function in the evolutive process of scientific politics. It is well known fact that random search process, such as genetic algorithms, do not guarantee going to the optimal result if they do not follow the rule that the best found solution is always preserved. The question is whether the bibliometric indices really ensure that the best knowledge is preserved. Maybe they ensure that the communities with higher publishing activity will have higher value, regardless of the value of their publications. However, this puzzle leads to other puzzles, which will be out of this work's scope.

Conclusions

I have tried to show that Information and Intelligent Systems are at the core of society, and that the ongoing revolution in this area has a tremendous impact in all society's aspects. A detailed analysis would require much more space, and a mind much brighter than mine, of course. So, I expect that the reader's mind would be by now full of holes and gaps, whishing to fill in data and information, refuting sketched ideas and partial reasonings. If this is his state of mind, the reader would have started to grasp the enormity of the impact that the computational revolution has in our lives in many ways not as conspicuous as the new communication gadget.

Notes and references

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[1] Though I was very flattered by the invitation to write this chapter, mi initial enthusiasm has end up into a raw catastrophic collision with my philosophical illiteracy. I tried in this chapter to convey a personal view of Information Systems and Intelligent Systems distilled from my own academic experience. This experience encompasses my own humble contributions to the field and my understanding of the contributions of others. However, I cannot claim other than a knowledge worker peasant's perspective, and must apologize for not reaching the "magister" level that would require dealing with the subject of the chapter. As I understand it, the target public of this essay is not technical; hence I will dwell on general ideas rather than precise facts. Also, the structure of the chapter is somehow atypical. Please, bear with me.

2 Moore, Gordon E. (1965). "Cramming more components onto integrated circuits" (PDF). Electronics Magazine. Electronics, Volume 38, Number 8, pp. 4-8, 1965

[3] Philip Kaye, An Introduction to Quantum Computing, Oxford Univ. Press, 2007

[4] Although this definition may seem estrange it is supported by the fact that many "intelligent systems" are composed of Artificial Neural Networks or other equivalent computational tools, which perform such input-output mappings. An issue on their design is that of "explanation", that is, the ability to explain in human reasoning terms how the system reaches its results. Even systems designed with "explicability" in mind may face severe difficulties to "explain" their underlying reasoning. It seems that nature and the artificial world may meet through the appearance of some kind of "instinct" both in animals and machines.

[5]Even in a field so far from physical robotics such as financial systems, the perception-reasoning-actuation paradigm applies. The softbots performing routine transactions have a perception of the risk involved in the transaction, perceived through financial information channels, they perform elementary reasoning to reach their decisions and issue an action.

[6] R. J. Schalkoff, Intelligent Systems: Principles, Paradigms and Pragmatics, Jones & Bartlett Publishers, 2009

[7] At the time of writing, the financial crisis started in the end of the year 2008 has not been solved in Spain. Its end is out of sight for most of us, and the government seems to be utterly ignorant of its true nature, causes, span, solution and escape state.

[8] Roman Beck, Can IT lean against the wind?, Comm. ACM 53(5):38-40, 2010

[9] The greening of Google, IEEE Spectrum, October, 2007

[10] Although I am not philosopher, I believe that ethical knowledge exist in the form of very abstract rules, coded in the diverse cultural and religious traditions. Although these traditions may conflict in “shape” issues, they all share most of these “ground floor” ethical information rules. Moral rules tend to be more particular, strongly related to concrete social circumstances.

[11] Claude Shannon, Shannon, C.E. (1948), A mathematical Theory of communication, Bell System Technical Journal, 27, pp. 379–423 & 623–656, July & October, 1948

12 Turing, A.M. (1936), "On Computable Numbers, with an Application to the Entscheidungsproblem", Proceedings of the London Mathematical Society, 2 42: 230–65, 1937, doi:10.1112/plms/s2-42.1.230 (and Turing, A.M. (1938), "On Computable Numbers, with an Application to the Entscheidungsproblem: A correction"),

[13] Norbert Wiener (1948), Cybernetics or Control and Communication in the Animal and the Machine, (Hermann & Cie Editeurs, Paris, The Technology Press, Cambridge, Mass., John Wiley & Sons Inc., New York, 1948)

[14] “Huge computational requirements” is always stated in terms of the previous generation of computational devices.

[15] Linux comes in various distributions, and lacks an standardized established industrial support, however it is gaining market and becoming a reliable alternative to industry for profit products. This is an unprecedented situation in the industry, where an anonymous collective effort with no capital or personal benefit behind is setting the solution for the computational problems of an increasing chunk of world population. This idealistic altruistic achievement has no equivalent in any other human activity.

[16] Recently the German government has discovered that Google was keeping a lot of wifi broadcasted information through the cars that were performing street view and localization based on wifi nodes. The claimed innocent listening was not followed by a convenient erasing of the data, and Google may have been infringing the Data Protection laws of European countries.

[17] S. Ghemawat, H. Gobioff, S.T. Leung, (2003) The Google file system, ACM SIGOPS Operating Systems Review, 37(5), 29 - 43

[18] Jules Verne, Au XXIXe siècle: La journée d’un journaliste américain en 2889

[19] Such as the “data” character of Star Trek New Generation, or the “doctor” character in Star Trek Voyager.

[20] There is a recent track of conferences on the influence of sci-fi in scientific research, funded by Intel and Microsoft: www.creative-science.org

[21] G. Orwell, Nineteen Eighty-Four (1949)

[22] Aldoux Huxley, Brave New World (1932)

[23] M. Graña, F.J. Torrealdea, Hierarchically structured systems, European Journal of Operational Research, 25:20-26 (1986)

[24] Such transformation can be linear or non-linear. Principal Component Analysis is the earliest of such transformations and still the most widely used for several purposes. Independent Component Analysis is a linear alternative for several signal processing applications. Non-linear transformations are based on Artificial Neural Networks approaches and other based on kernel tricks or compression algorithms. This area of research is very active in the computational intelligence, machine learning and pattern recognition community.

[25] Richard S. Sutton, A.G. Barto, Reinforcement Learning: An Introduction (Adaptive Computation and Machine Learning), The MIT Press (March 1, 1998)

[26] At the time of writing British Petroleum is routinely providing images of the repair operations on the spilling submarine oil well in the Gulf producing the worst ecological disaster in the United States at a depth of 1500 meters. Operations are performed by remotely commanded submarine robots. Some of the marine oil exploitations require the precise and stable placement of the (floating) drilling platform and auxiliary ships. Such placement could not be possible without state of the art intelligent systems.

[27] Open air mining in the United States is literally flattening mountains to get to the ore. The process removes the top of the mountains, filling valleys and leveling the floor producing artificial plateaus. Such gigantic works could not be done without current intelligent technology to produce cheap enough earth moving machinery, the planning of the works and the gathering of financial resources.

[28] Lotfi Zadeh and Janusz Kacprzyk, Fuzzy Logic for the Management of Uncertainty Wiley-Interscience; First Printing edition (July 1992)

[29] Dean Kamen's "Luke Arm" Prosthesis Readies for Clinical Trials, IEEE Spectrum, February 2008

[30] Mastering the Brain-Computer Interface, IEEE Spectrum, march 2009

[31] To illustrate the impact of this field of research, note that there is a dedicated journal “Computer aided surgery” published by Wiley.

[32] At least we must acknowledge the minimal purpose of preserving life and well being.

[33] A long term effect of oil spills. Most actions to recover after them cannot and neither try to deal with it, being mostly cosmetic actions to remove the stains.

[34] The works based on Forrester's System Dynamics approach: Jay W. Forrester, 1970, World Dynamics, Portland, Oregon: Productivity Press; Donella H. Meadows, Dennis L. Meadows, Jørgen Randers, and William W. Behrens, III., 1972, The Limits to Growth: A Report for the Club of Rome's Project on the Predicament of Mankind, New York: Universe Books.

[35] The recent "Avatar" blockbuster fantasizes on the reversal of historical roles, allowing a romantic victory of virginal wild life over sophisticated artificial societies. The success of the film is a clear reflection of the subconscious guilt felt and feed by our society.

[36] China has recently published the list of censored terms in its internal chunk of the world wide web. During some time now, China has been imposing the implementation of content filters and censoring facilities in the web commuting nodes. Some big companies have been forced to introduce them in their traffic switching devices to be able to do business. Time only will say if this censoring facilities will be profited by other "democratic" countries.

[37] http://sourceforge.net/

[38] http://www.itk.org/

[39] https://mozillalabs.com/projects/

[40] A critical difference can be drawn between products obtained from public funding of research projects, which can also be made available for free, and products resulting from spontaneous non-funded works. It is also important to notice that sometimes people managing these altruistic efforts do get a way of living from them, so the non-profit divide is a kind of ethereal line.

[41] http://www.h-online.com/open/features/Why-open-source-developers-should-thank-Apple-1018783.html

[42] http://wikipedia.org/

[43] Political incompetence is buried under layers of boring ill reasoning. In fact, the system is sustained by the intrinsic stupidity of the leaders that may do the right things for the wrong reasons with a stupefied audience looking a the sports. Revolution was killed by boredom…. and the visa card.

[44] Again, those processes have been taking place under the nose of our politicians for years now. The 2009-2010 and ongoing crisis, could it be dissociated from these outsourcing processes? Personally, I do not believe it. We have been digging under our foot for years. It is only natural that the floor gives up.

[45] An interesting example: The edition of scientific texts was an elaborate an sophisticated work, requiring skillful and trained hands to perform the typesetting, illustrations, revising manuscripts, etc. With the increase use of self-editing tools, latex based, authors provide quite finished manuscripts, so that the labor of editing falls in the side of the authors. Then editorial services may profit from third world cheap labor to do the final stages of editing. Internet allows the transfer of editing material across the world at almost no cost. Therefore, third world countries are becoming the "editors" of scientific publications.

[46] No institution, state agency, control entity has considered the inherent dangers and how to prevent them. On the contrary, only the fuzzy buzzwords "increasing competitivity" were contemplated as some kind of magic spell: no precise recipe for sure success innovation was given anywhere.

[47] I always recommend to re-read the "Emperor's new cloths" from H.C. Andersen. Or its precedent Of that which happened to a King and three Impostors, from the medieval book Tales of Count Lucanor by Don Juan Manuel

[48] Gobally and on the average, near 40% of the financial transactions are performed by automatic "intelligent" systems, according to Thiago Turchetti Maia, Antonio Padua Braga, Introduction to Computational Intelligence Business Applications, ESANN 2010, Brugges, Belgium.

[49] Even porn actors and producers are worried about this state of affairs, and had decided to do a press campaign in May 2010, asking the public not to view "pirate" sites giving porn contents for free.

[50] Y. Sun, (2007) A comprehensive study of the regulation and behavior of web crawlers, PhD Thesis, Pennsylvania State University

[51] Facebook ensured the transfer of ownership of any content uploaded to their servers, thus becoming the only with the right to reproduce and publish. The paradoxical effect was that Facebook could suit you for giving away family pictures that you have uploaded to your facebook account.

[52] The dividing line between game and reality was the subject of "Ender's game", by Orson Scott Card, with a vivid sequel of ethical consequences.

[53] David Michael, Sande Chen, Serious Games: Games That Educate, Train, and Inform, Course Technology PTR, 2005

[54] Second life was such a virtual space promoted and sustained by a private company. (http://en.wikipedia.org/wiki/Second_life), though it seems that is being deserted once the initial hype has passed.

[55] Benoit B. Mandelbrot, The Fractal Geometry of Nature, W. H. Freeman, 1983

[56] Still, Literature is the master art. The key element to produce the spectator involvement, as recognized in the industry, is the plot and the script.