

## New Vision and Goals of Informatics and Megachallenges of Mankind. Extended abstract

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### 1 A birth of modern Informatics

Currently dominating perception of computer science has its origin in a very cleverly written, and much influential, paper of *Newel, Simon and Perlis*, published in Science in 1967, that well captured the perception of the field at that time.

The basic ideas presented in their paper were:

*"Whenever there are phenomena there can be a science dealing with these phenomena. Phenomena breed sciences. Since there are computers, there is computer science. The phenomena surrounding computers are varied, complex and rich."*

Since that time there have been numerous attempts to modernize such a view of computer science. Some of them centered around a slightly modified name of the field as *computing science* with attempts to put emphases on algorithms, programming and software instead of hardware.

Some of the first along these lines was Dijkstra with his position: *"Computing science is - and will always be - concerned with the interplay between mechanized and human symbol manipulation usually referred to as "computing", and "programming", respectively. It is located in the direction of formal mathematics and applied logic, but ultimately, far beyond where those are now."* This was underlined by his famous, satiric but deep vision that *Computer science is as much about computers as astronomy is about telescopes*.

In spite of all these attempts, computer-centric or computing-centric view of computer science still dominates.

One of the first areas of Informatics that abandon such a technology dominating view of the field was artificial intelligence that started (and had to start) to divorce with the main stream of computer science, fortunately.

One example to demonstrate how deep was such computer-centric view of the field can be found in the development of IFIP (International Federation for Information Processing), that played, especially its world congresses, technical committees and working groups, such an important role in the development of the field. Though IFIP was established in 1962, till 1996 there was no technical committee for theory and the reasoning behind was that the only theory behind information processing is theory connected with programming and the rest of "theory" belongs either to mathematics or to electrical engineering.

There are nowadays a variety of reasons why such a computer-centric view of the field should be seen as obsolete, not broad and not deep enough, and actually damaging the development of the field. They will be discussed only briefly in this paper, for more see [1]. Here are some of the reasons.

- An understanding starts to be developed that information processing plays key role both in physical and biological nature. For example, quantum, DNA and molecular information processing. In particular, an understanding developed that information processing is of such an importance for life as breathing and eating and that even very primitive living being can do exceptionally complex and efficient information processing.
- All natural sciences, and not only these sciences, are starting to be increasingly seen as being, to a large extent, information processing driven, and not only that. It starts to be understood that all sciences start to converge to Informatics once seen in a proper broadness and deepness.
- On a more practical level, it starts to be clear that in the coming future any very significant innovation will use advanced Informatics tools, methods and paradigms.

All that requires that a much broader and deeper view of the field should be developed – see [1, 2].

## 2 A new perception of Informatics

A new perception of the Informatics here presented sees the field as consisting of four much interleaved components:

- scientific Informatics;
- technological Informatics;
- new methodology;
- applied Informatics.

As a scientific discipline of a very broad scope and deep nature, Informatics has many goals. Its main task is to discover, explore and exploit in depth, the laws, limitations, paradigms, concepts, models, theories, phenomena, structures and processes of both natural and virtual information processing worlds.

To achieve its tasks, scientific Informatics concentrates on new, information processing based, understanding of universe, evolution, nature, life (both natural and artificial), brain and mind processes, intelligence, creativity, information storing, processing and transmission systems and tools, complexity, security, and other basic phenomena of information processing worlds.

Development and analysis of a variety of formal, descriptive, computation, interaction and communication models and modes, development and analysis of (deterministic, randomized, genetic, evolutionary, quantum, ...) algorithms, protocols and games are some of the main tools of Informatics.

Data, information, knowledge, formal systems, logics, algorithms, protocols, games, resources, models and modes of information processing, communication and interactions are the key concepts behind.

In order to meet its goals, Informatics develops close relations with other sciences and technology fields, especially with physics and biology, on the one hand, and with electronics and nanotechnologies on the other.

Informatics as a science includes also numerous theories much needed for its development to depth and in broadness. Some theories are very abstract, others quite specific, and some theories are oriented on making better use of the outcomes of the scientific Informatics to create a scientific basis of Informatics as of an engineering/technology discipline.

One way to illustrate such a broad and deep perception of scientific Informatics will be in this paper through presentation and analysis of its grand challenges. This will be discussed briefly below. In the same way one can illustrate main tasks of technological and applied Informatics, but this is beyond the scope of this paper, see [1, 2].

Another way to illustrate such a broad and deep view of scientific Informatics is to make an analogy between views of Physics and Informatics because their goals can be seen as being very similar.

The main goal of *Physics* can be seen as to study laws, limitations and phenomena of the *physical worlds*.

The main goal of *Informatics* can be seen as to study laws, limitations and phenomena of the *information worlds*.

Physics and Informatics can therefore be seen as representing two windows through which we try to perceive and understand the world around us.<sup>1</sup>

## 2.1 Grand challenges of scientific Informatics

New main grand challenges of scientific Informatics can be briefly summarized as follows:

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<sup>1</sup>In a similar way we can see life-sciences and Informatics as providing two windows and tools with which we try to understand, imitate and outperform the biological world and its highlights – human brain, mind, consciousness, and cognitive capabilities.

- To explore our world as a point in a space of potential information processing worlds.
- To explore laws and limitations of information processing that governs universe, evolution and life.
- To develop theoretical foundations for design, analysis, verification, security, simulation and modeling of huge information processing systems.
- To understand intelligence, creativity, mind and consciousness.
- To make foundations for science and engineering of the science making activities.
- To understand and manage all aspects of computation, communication and structural complexity.

### **3 Informatics-driven methodology**

Of a key importance for a new perception of Informatics is also an understanding that Informatics, as a symbiosis of a scientific and a technology discipline, develops also basic ingredients of a new, in addition to theory and experiments, the third basic methodology for all sciences, technologies and society in general.

This new, Informatics-based, methodology provides a new way of thinking and a new language for sciences and technologies, extending the Galilean mathematics-based approach to new heights.

The main components of this new methodology can be briefly summarized as follows:

- Simulation methods and systems.
- Modeling – Design of information processing models.
- Visualisation and animation.

- Searching (sophisticated searching as an alternative to deep knowledge based reasoning).
- Design of systems with superhuman intelligence.
- Design of systems for problem solving and reasoning.
- Development of methods to specify, design, analyse, verify and reliably run complex (information processing) systems.
- Design of algorithms, study of their performances and study of inherent complexities of computational, communication and description systems.
- Design, analysis and comparison of descriptive languages and systems and of the relations between objects and their specifications.
- To study problems of the real world as of the one of information processing worlds.

Informatics-driven methodology subsumes and extends the role and improves tools Mathematics used to play in advising, guiding and serving other scientific and technology disciplines and society in general.

Power of the new, Informatics driven methodology, is discussed in the paper [1] in details. Here are only few of the main reasons:

- New methodology brings new dimension to both old methodologies.
- It brings into new heights an enormous power of modeling, simulations and visualisation.
- It utilises an enormous exploratory and discovery power of automata, algorithms and complexity considerations.
- It utilizes enormous exploratory power of the development and study of artificial, man made systems, for understanding of phenomena of natural phenomena and systems.

- It utilizes enormous discovery and exploratory power of the correctness and truth searching considerations, systems and tools.
- It utilizes an enormous potential that the study of virtual worlds brings for an understanding of the real worlds.
- It seems to have a big chance to make hard sciences from (at least some) of the soft sciences.

## 4 Informatics and new megachallenges of science and technology

Because of its enormous guiding power for practically all areas of science, technology and the whole society and an enormously powerful tools Informatics offers, we can see Informatics as a new queen and at the same time a new powerful servant for all of society.

In particular Informatics is expected to play the key role in dealing with two main megachallenges of current science, technology and society. Namely:

- **To beat natural human intelligence.** More exactly, to create super-powerful non-biological intelligence and its merge with biological intelligence.
- **To beat natural human death.** More exactly, to increase much longevity for human bodies and to achieve uploading for human minds. In more details, to fight natural death as another disease and to find ways to upload human mind to non-biological substrate.

Mankind starts to have enough reasons to see the above megachallenges as being currently realistic enough. Here are some of them.

- Because computers performance keeps developing faster and faster, actually exponentially, there are good reasons to assume

to have soon (around 2045?) even laptops with information processing power and capacity larger than of all human brains – see [3].

- Exponential scaling up concerns also of all main information related technologies, especially genetic and nanotechnologies as well as artificial intelligence. This creates another basis for making two megachallenges as already feasible ones.
- Exponential developments of information processing technologies are believed to imply enormous speed up in developments of main sciences and technologies.
- Tools to reverse engineering brains keep also developing exponentially concerning their potential and precision and so we can assume to have quite soon ways to simulate functionality of human brains.
- Society keeps putting enormous effort, actually more and more human and money resources, to develop and apply genome engineering, to model human brains and minds as well as to vastly extend human longevity.
- A vision starts to be accepted to see the development of superintelligent machines as the next stage of evolution and to prepare society for handling and accepting such developments.

To deal with new megachallenges practically all areas of sciences and technologies have to be involved. However, Informatics is expected to play by that a very important role for several reasons.

- It starts to be clear that in order to understand more deeply functionality of living systems, from cells to brains, and to design using other, non-biological substrates, systems to outperform them, information processing models of such systems are needed. Chemistry and biology has been able to gather enormous number of data about composition and behaviour of elements of particular living systems, but Informatics tools are needed to model their



functionality as complex systems in such a way that we can model their functionality using non-biological substrates. It starts to be understood that modeling on the basis of differential equations can hardly lead to design of efficient models and that modeling using Informatics tools to model concurrent and parallel systems may be needed.

- New, Informatics-driven methodology, is expected to increase also exponentially the whole development of science and technology, in all their areas, and this is another essential reasons that we can expect to achieve in few decades what seems to us as needed several hundred years.

## 5 Food for thoughts

New megachallenges for science and technology, and actually for the whole society, to which Informatics is to contribute essentially, aim to bring enormous, hard to imagine to almost anyone few years ago, changes to the lives, value systems and goals of individuals as well as to the life and goals of the whole society. In spite of all revolutionarity of these goals, some of the best minds of society started to foresee them immediately when enormous potential of modern computers started to be revealed. In the same way, deep thinkers have also already formulated in a short but sharp way the essential problems we are to encounter and even the way to deal with them.

In the following some of these deep thoughts, worth to notice and rethink, are presented.

- There is plenty of room at the bottom. *R.Feynman addressing American Physical Society in 1960 – seen nowadays as first understanding of the potential of nanotechnologies.*
- There is nothing in biology found yet that indicates the inevitability of death. *Richard Feynman*
- It seems probable that once the machine thinking method had started, it will not take long to outstrip our feeble power. They

would be able to converse with each other to sharpen their wits. At some stage therefore, we should have to expect machine to take control. *Alan M. Turing, 1952*

- The ever-accelerating progress of technology .... gives the appearance of approaching some essential singularity in the history of the [human] race beyond which human affairs, as we know them [today] could not continue... *John von Neumann, 1950.*
- Let an ultraintelligent machine be defined as a machine that can far surpass all intellectual activities of any man, however clever. Since the design of machines is one of intellectual activities, an ultraintelligent machine could design even better machines; there would then unquestionably be and "intelligent explosion" and the intelligence of man would be left far behind. Thus the first ultraintelligent machine is the last invention that man needs ever make. *I. J. Good, 1965, a British mathematician.*
- Since there is a real danger that computers will develop intelligence and take over we urgently need to develop direct connections to brains so that computers can add to human intelligence rather than be in opposition. *Stephen Hawking, 2011*

One can even go more back to the history to see that seeds of the vision of the future have already appeared long time ago once machines started to be used to improve power of mankind. Indeed, Samuel Butler, an English writer, wrote in 1863, 4 years after the publication of Darwin's *The origin of species* the following thoughts:

*There are few things of which the present generation is more justly proud than the wonderful improvements which are daily taking place in all sorts of mechanical appliances.....*

*But what would happen if technology will continue to evolve so much more rapidly than the vegetable and animal kingdom? Would it displace us with supremacy of earth?*

*Just as the vegetable kingdom was slowly developed from the mineral one and, similarly, the animal kingdom from the vegetable, so in these*

*last few ages an entirely new kingdom has sprung up, of which as yet we have only seen what will one day be considered as a prototype of the race....*

*We are daily giving [machines] greater power and supplying them by all sorts of ingenious contrivances, such as self-regulating and self-acting power, which will be to them what intellect has been to human race.*

## References

- [1] Jozef Gruska. *A perception of Informatics*, web page of Academia Europaea, <http://www.AE-Info.org/ae/user/Gruska.Jozef>, 55 pages.
- [2] Jozef Gruska. *Impulses and roads to a new perception of informatics*, in "Rainbow of Computer Science", edited by C. Calude, A. Salomaa and G. Rozenberg, Springer Verlag, 2011, pp. 183–199.
- [3] Ray Kurzweil. *Singularity is near*, Penguin books, 2007.

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Received October 3, 2013

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