



Computer Science and Society: Immensity, Precision and Humanization

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Abstract — We show that recent known advances in Computer Science have allowed us to enter in regions of data "immensity" that we thought were unreachable. Besides, formal and precise models of specific parts of the world that we are building are increasingly detailed and allow us to simulate more accurately both human and natural phenomena. Paradoxically, we argue that this growth both of size and precision will take us to a Computer Science that is closer to humanization.

Key Words— Humanization through Computer Science, NP-Complete.

Computer Science contributions to modern society are usually associated with the equipments around us. We can also point to the economical benefits brought by Computer Science, such as the job creation and corporate productivity gains. We can also point to the huge penetration of social networks and the accessibility to information provided by search engines and to the fact that now we can mobilize the masses using these media. On the other hand, there are many who will also point out that with the burst of the computer bubble, Computer Science lost its charm and became an industrial niche, as many others. Nevertheless, none of these are the intended topic of this article.

Given the burst of the so called "IT bubble" in the dawn of the new millennium, there is no hype over IT and we can discuss Computer Science. My goal is to discuss thoroughly the "Science" side. For starters, given the maturity of this field, the suffix "Science" tends to disappear and a single term indicating the area should remain. This is analogous to the fact that no one talks about "Physics Science", "Biology Science", but about "Physics" and "Biology".

There are three main properties of computer science and its repercussion on society that I would like to talk about: its immensity, its precision and its humanization.

Invading the Immensity: The property that might have the largest impact on human activities is the ability of Computer Science to deal with large amount of data, processing, filtering, distilling and present it in a way that is understandable by human beings. That is manifest in the capacity of storing amounts of data previously unheard of and to search and find the required information.

We are invading the data immensity through paths that were previously considered impossible even to computers. Since the first half of the 20th century we knew that there are problems that cannot be computed, in which many consider to be one of the most interesting mathematical results of the previous century. An example of untreatable problem is "the program error detector" program, that is, a program that analyses other programs and decides whether they will ever cause unrecoverable errors, such as being stuck without ever presenting an answer. An error detector that works in all cases is impossible to build.

Among the problems that are not computable, a big part is called untreatable, because they are problems that may be solved when the amount of data is small, but whose solution is not viable as the problem grows. This growth can make the estimated time to achieve a solution larger than the age of the universe, even in computer much faster than the ones currently available. Unfortunately, many of those problems considered as the most interesting are inside the frontiers of the untreatable class, including most of the problems usually associated with human intelligence, such as decision making, logic inference and resource optimization.

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Examples of untreatable problems include consistency analysis (if it is possible to determine whether a certain software configuration will not cause a machine to be in conflict) and the so called Problem of Restriction Satisfaction. Other types on untreatable problems are the optimization ones, where one searches for the best solution that minimizes the amount of fuel used to visit a fixed number of cities, called the Traveling Salesman Problem. These problems were considered unreachable even to machines, in spite of the fact that human beings were apparently able to solve them without any problems.

Modern studies in Artificial Intelligence show that not all instances of those problems classified as untreatable are equally hard. For instance, depending on the road configuration, there are instances of the Traveling Salesman Problem that are quite easy to solve and a small number that are very hard. There are easy and difficult untreatable problems and the easy ones are, in fact, the majority. That allows us to enter the data immensity with more sophisticated techniques.

This evolution transformed forever the way we solve problems, starting with the area that is known for solving problems, Science itself. The mapping of the human genome, a problem mathematically untreatable, would have been unthinkable without the computers to put together the cut sequences that were generated by the human DNA analysis methods.

Likewise, the construction of large particle accelerators would be useless unless there were machines able to register and process the data when particles traveling close to the speed of light collide. The equations used to forecast the weather existed more than a century ago, but the forecasts started to be somewhat accurate only when the climate data collecting network was extended throughout the globe and the satellites were connected to computers that were able to process them. Even so, we still don't have the ability to make accurate forecasts for an interval that extends beyond a few days.

The ability to analyze large amounts of data has migrated from the Exact Sciences to the Humanities. For example, this ability allows us to:

- analyze urban dynamics;
- analyze statistics on crime and violence;
- analyze evolving grammar patterns in texts produced in the last few centuries that were recently scanned.

These abilities have caused us to understand more fully human phenomena. We hope that this understanding will translate into an administrative tool that generated public policies that improve our health and life quality. That is, the ability to provide a management tool for aspect that influence the daily life of millions of people is one of the major potential social contributions of Computer Science.

Precision, Acceleration and Braking: Given those success stories, it seems simple even to insert data in a computer system and to find an answer. Nevertheless, the nature of machines and computing processes require from us a huge effort of knowledge preparation before it is even possible to analyze phenomena.

This preparation is basically due to the requirement of formal and precise framing of the information and of the computational processes that will process it. A large effort is necessary to conceive the phenomena to be computationally treated by this formal window, a process that is generically called **modeling**.

The big advantage of the modeling process is that it does provide us with a model in the end. Models are never perfect, but they allow for analysis on its adherence to data and to successive refinement that, through many modeling iterations (confronted with data and through refinement) end up increasing our **knowledge** of a specific phenomenon.

Knowledge representation in logical and mathematical formats has been one of the major occupations of Artificial Intelligence. Besides, understanding that not all instances of those untreatable problems are really hard has increased our ability to verify properties of those models and to create inferences based on hypothesis on the building of those models. For instance, we have nowadays models that are increasingly better on the interactions of genes when producing certain enzymes and in the blocking of others.

The even more important consequence is the fact that a model with high degree of adherence to the facts allows us to **simulate** the phenomenon at hand and that is a truly new way to access reality. Simulations allow us to speed or slow processes that would not be observable any other way. For instance, simulations recently performed allowed us to visualize the crash between two galaxies and the creation of a new galaxy with a black hole in its center. In a few seconds this simulation allows us to visualize a phenomenon that takes a billion years or more. On the other extreme, we can simulate in "slow motion" the propagation of electro-chemical impulses mediated by neurotransmitters in neuron networks. These are totally different phenomena, but the existence of a model and of simulation techniques adapted to each of those cases allow us to treat each case with its peculiarities even better.

Let us imagine that adaptations of those techniques can be used to simulate social phenomena, such as the impact of a public policy on the number of jobs, or the construction of a new highway on the vehicle traffic, or even the simulation of the deposition of chemical compounds on the walls of veins and arteries, given food intake, or the forecasting of neuronal transmission realignment in drug users when submitted to a new treatment. These adaptations shall, obviously, deal with the peculiarities of each of those cases, but a set of techniques already exists and allow us to enter areas previously unexplored by Computer Science.

Humanization through Computer Science: It is exactly at this point that we stress the apparent paradox on how to deal with huge datasets, going through a modeling process that is precise and rigorous enough to allow us to arrive at a new humanization process that is mediated by computers.

The reason behind this idea comes from the possibility of using simulation to avoid unnecessary *in vivo* experimentation that would cause pain and suffering in the individuals involved. This is not a new form of humanism, but a support to humanist causes and to the fight for the right of several categories, such as mentally ill, patients in general and animal rights. We can also include the civil rights, in which an intervention in a neighborhood will only be performed after simulating its impact on the quality of life of those affected both during construction and through the enterprise's life span.

In the root of this is the ability to forecast and to supervise are preconditions to put in practice humanist values. Computational simulations, whose results are closer to reality due to the ability to deal with more complex and more precise due to the fact that they deal with larger amount of data, will provide the mechanisms of forecasting and security necessary to implement public policies that respect humanist values.

It may seem a paradox, but the ability to deal with large amount of data and the requisite of formalization and precision that many would say that are not human, are the characteristics that may take Computer Science to help preserve and expand human values and rights.

This way, we have an orchestration of effects: the more we are able to deal with difficult problems in a data immensity, the bigger are the models we can work with and simulate and this takes us into an expansion of the domains of Computer Science and take humanization where its access was blocked exactly by the lack of precision and forecasting.

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