Shifting the Paradigm of Philosophy of Science: Philosophy of Information and a New Renaissance

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Abstract. Computing is changing the traditional field of Philosophy of Science in a very profound way. First as a methodological tool, computing makes possible "experimental Philosophy" which is able to provide practical tests for different philosophical ideas. At the same time the ideal object of investigation of the Philosophy of Science is changing. For a long period of time the ideal science was Physics (e.g., Popper, Carnap, Kuhn, and Chalmers). Now the focus is shifting to the field of Computing/Informatics. There are many good reasons for this paradigm shift, one of those being a long standing need of a new meeting between the sciences and humanities, for which the new discipline of Computing/Informatics gives innumerable possibilities. Contrary to Physics, Computing/Informatics is very much human-centered. It brings a potential for a new Renaissance, where Science and Humanities, Arts and Engineering can reach a new synthesis, so very much needed in our intellectually split culture. This paper investigates contemporary trends and the relation between the Philosophy of Science and the Philosophy of Computing and Information, which is equivalent to the present relation between Philosophy of Science and Philosophy of Physics.

Key words: computation, digital philosophy, information, information society, information technology, information-theoretic methodology, philosophy of AI, philosophy of computer science, philosophy of computing, philosophy of information, philosophy of science

1. What Ultimately Matters, Indeed?

The ideal of Science of the 20th century was Physics (Kuhn, 1962; Chalmers, 1990; Carnap, 1994; Popper, 1999): *relativity*, *quantum mechanics* and finally, *chaos*. Physics was the model of scientific understanding of reality. Questions in focus were:

- What is the (physical) Universe (microcosm, macrocosm)?
- How is the Universe built up? How does it work (interactions, symmetries)?
- What is matter/energy, time, space?

On the threshold of the new millennium we have answers to those questions that seem to fulfill our present needs. At the same time the efforts necessary to further improve knowledge within Physics exceed by orders of magnitude corresponding efforts needed to improve other basic scientific disciplines of interest. Therefore the paradigm of Science changes rapidly.

Historically, parallel with the growth of the body of physical theory, there was the emergence of the "intentional sciences": disciplines that deal with symbols, references and interpretations, such as Logic, Cognitive Science, Psychology, and

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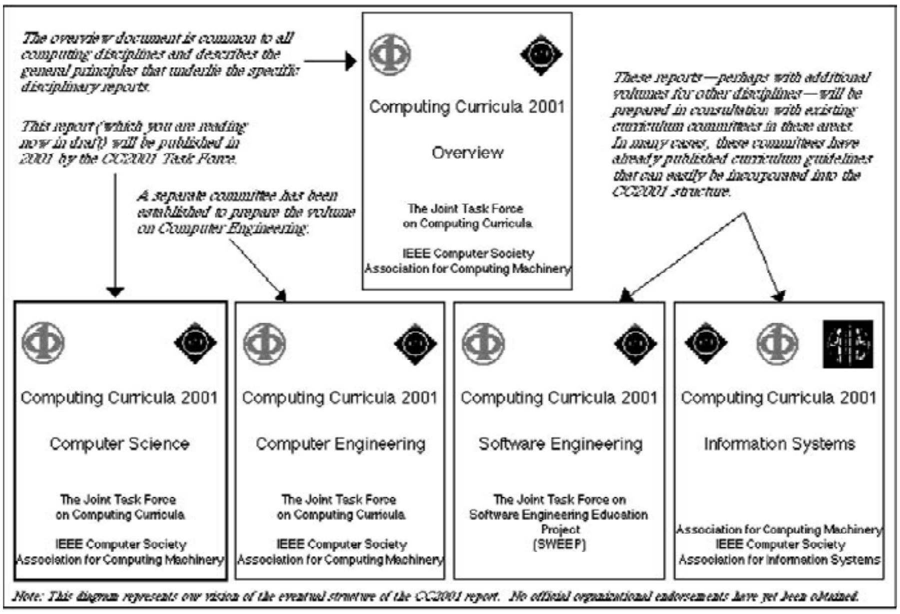

Figure 1. Field of computing.

Neuroscience, parts of Biology and Computing. These new sciences are changing our concept of reality, and that of the relation between Science and reality. Truth and meaning have been brought within the scope of Science pertaining to the completely new context. The views of realism and metaphysics are being modified. Scientists are starting to scrutinize fields of norms and values. Traditionally, it is in Philosophy or in the religious domain that questions of most general significance have been asked, as e.g.: What ultimately matters? (see Dodig-Crnkovic, 2001)

In the last century expectations on Science have grown enormously. Whether it knows it or not, Science seems to be entering into the classically philosophical and theological territory taking the place of highest authority. New questions in focus are:

- What is life (its laws, mechanisms, limitations)?
- What is mind?
- What is meaning?

Computing has many interesting methods and techniques making possible new insights that can contribute towards clarifying the above ideas, as for example the issues related to meaning such as truth, proof, and symbol manipulation (how symbols acquire meaning), "location" of meaning, form.

2. What Is Computing?

According to ACM/IEEE (2001), Computing can be described as encompassing Computer Science, Computer Engineering, Software Engineering and Information Systems (Figure 1).

The German, French and Italian languages use the respective terms "Informatik", "Informatique" and "Informatica" (Informatics in English) to denote Computing. It is interesting to observe that the English term "Computing" has an empirical orientation, while the corresponding German, French and Italian term "Informatics" has an abstract orientation. This difference in terminology may be traced back to the tradition of 19th-century British empiricism and continental abstraction respectively.

The view that information is the central idea of Computing/Informatics is both scientifically and sociologically indicative. Scientifically, it suggests a view of Informatics as a generalization of information theory that is concerned not only with the transmission/communication of information but also with its transformation and interpretation. Sociologically, it suggests a parallel between the industrial revolution, which is concerned with the utilizing of energy, and the information revolution, which is concerned with the utilizing of information.

3. Futurist Projection: Glimpses of the Philosophy of Artificial Intelligence

Questions of relevance for the Philosophy of Science (as, e.g., concepts of mind and meaning) have many practical consequences in the field of the Philosophy of Artificial Intelligence, AI. Among others there is an interesting current controversy about Machines and Minds. The questions simplified are as follows:

- Can machines be intelligent (think)?
- Can machines have self-consciousness?
- Can machines have a soul?

As usual in the history of important controversies there are two confronting groups claiming opposite answers to these questions. That debate is in many ways instructive. First of all it is because it reveals our basic attitude to the question of what ultimately matters? Secondly, and at least equally interesting and illustrative, is the argument itself.

There are a number of results of mathematical logic used to show that there are limitations to the powers of (discrete-state) machines. The best known of these results is Gödel's theorem (1931) which shows that in any sufficiently powerful logical system statements can be formulated which can neither be proved nor disproved within the system, unless the system itself is inconsistent. It is established that there are limitations to the powers of any particular (discrete state) machine due to Gödel's theorem. Yet it has only been stated without any sort of proof that no such limitations apply to the human intellect (which is actually as a rule both incomplete and inconsistent ...).

One can as well ask more pragmatic questions, as e.g.: Can a machine be made which can:

- Pass the Turing test
- Create an artefact that can be acknowledged as genuine by experts (compose music, write a sonnet ...)
- Prove theorems/check theorem proofs through the "mechanization" of reasoning
- Posses the best knowledge within a certain field and can act like an expert system (medical expertise helping to set an accurate diagnosis), etc.

The question is: does it necessarily need to be one single machine? Do we need humanoid machines? There is namely a difference between the ambition of *representing the common behavior (including knowledge) of the average person and the attempt to construct the machine able to compete with the best of scientists, artists, philosophers etc. within their special fields*.

Part of AI research's objectives is to understand the *computational* principles underlying intelligence in man and machines and to develop methods for building computer-based systems to solve problems, to communicate with people, and to perceive and interact with the physical world. Floridi (2002) in "What is the Philosophy of Information?", calls the Philosophy of Artificial Intelligence a premature paradigm of the Philosophy of Information, PI.

The researchers in Artificial Intelligence have discovered a wide variety of ways to make machines do pattern recognition, learning, problem-solving, theorem-proving, game-playing, induction and generalization, and language manipulation, to mention only a few. AI is a steadily growing field within computing. To be sure, none of the different AI programs seemed much like a mind, because each one was so specialized. But now we are beginning to understand that there may be no need to seek either any single magical "unified theory" or any single and hitherto unknown "fundamental principle". Thinking may instead be the product of many different mechanisms, competing as much as cooperating, and generally unperceived and unsuspected in the ordinary course of our everyday thought.

What has all this to do with consciousness? Well, consider what happened in biology. Before the 19th century there seemed to be no other explanation of the phenomenon of life but the concept of "vitality", i.e., some sort of life-force. There simply seemed no other way to explain all the things that animals do. But then, scientists gradually came to see no need for a "unified theory" of life. Each living thing performed many functions, but it slowly became clear that each of them had a reasonably separate explanation. The same may apply to the mind.

The next fundamental question is if we can claim to understand the phenomena only on account of their experimental predictability and reproducibility? Does the answer to the question "how?" automatically mean the answer to the question "why?". If we construct the machine that can distinguish sweet from bitter, can

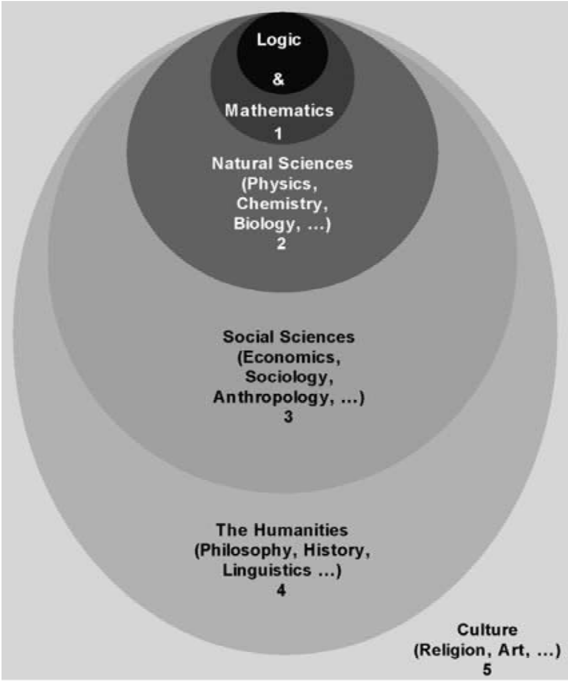

Figure 2. What is science? Classical scheme.

we say that *we* understand what "sweet" and "bitter" means? Can we say that *the machine* understands what "sweet" and "bitter" means?

4. What Is That Thing Called Science?

The whole is more than the sum of its parts. (Aristotle, *Metaphysica*)

In order to be able to talk about Computing, let us take a closer look at the very definition of Science. Saying "Science" we actually mean a plurality of different Sciences. Different Sciences differ very much from one another. The definition of Science is therefore neither simple nor unambiguous. For example, History and Linguistics are often but not always catalogued as Sciences (see Dodig-Crnkovic, 2002).

The traditional Sciences have *specific areas of validity*. Logic and Mathematics (the most abstract and at the same time the most exact Sciences) are a more or less important part of every other Science. They are very essential for Physics, less important for Chemistry and Biology and their significance continues to decrease towards the outer regions of our scheme. Logical reasoning as a basis of all human knowledge is of course present in every kind of Science as well as in the Humanities.

Figure 2 may be seen in analogy with a microscope view. With the highest resolution we can reach the innermost region. Inside the central region Logic is not only the tool used to form conclusions; it is at the same time the object of investigation. Even though large parts of Mathematics can be reduced to Logic (Frege, Russell and Whitehead), complete reduction is impossible. On every step of zooming out, the inner regions are given as prerequisites for the outer ones. Physics uses Mathematics and Logic as tools, without questioning their internal structure. In that way information about the deeper structure of Mathematics and Logic is hidden looking from the outside. In much the same way, Physics is a prerequisite for Chemistry that is a hidden level inside Biology, etc. The basic idea of Figure 2 is to show in a schematic way the relation between the three main groups of Sciences (Logic & Mathematics, Natural Sciences and Social Sciences) as well as their relation to the Humanities, and finally to the cultural environment which the whole body of human knowledge, scientific and artistic, is immersed in and impregnated by.

However, such distinctions of sciences are quite recent, having their origins in the 16th and 17th centuries. In the Middle Ages "Science" was a very different type of academic discipline. Natural Philosophy was the term applied to what would now be known as Physics, but in the medieval era it was a very profound and philosophical subject.

Universities in the Middle Ages were of two main types: "Master Universities" such as Paris or "Student Universities" such as Bologna. The curriculum followed the division of the seven liberal arts into the lower level *Trivium*: Grammar, Rhetoric and Logic and the more advanced *Quadrivium*: Music, Arithmetic, Geometry and Astronomy. These subjects were studied in order to give the student an academic and intellectual foundation before studying the most important part of their course of studies, the three Philosophies — Natural, Metaphysical and Moral. The advanced student was expected to study the Ethics, Physics and Metaphysics of Aristotle and be able to demonstrate significant ability to dispute these topics in learned debate.

It is interesting to notice that during the Middle Ages no sharp distinction was made between Natural Science and religion, magic and the occult, because physical and magical causes were accepted as being equally likely to be responsible for physical phenomena. For example, medieval Astronomy encompassed the disciplines of Astrology and Cosmology.

Early Science (Alchemy, Astronomy, Botany, Cartography, Horology [Time, Calendars], Instruments [Weights, Measures], Mathematics, Medicine, Physics, Technology, Astrology) was not a neat orderly system. It was a deeply interconnected blend of philosophy, magic, analysis, observation, experimentation and religion. But from these confusing origins scholars slowly began to develop the fields of science with which we are today familiar.

5. The Scientific Method

Having in mind its historical development, we may ask the question: what characterises Science? And a most common answer is: the method. Since the scientific revolution of the 16th and 17th centuries, many have also argued that Science strives to produce explanations in terms of matter, energy, symmetry, and number, the framework of ideas associated with Descartes, Copernicus, Galileo, Hobbes, Newton, Locke, etc.

This is the reductionist programme of modern Science. Its ideal is a minimum number of the most general laws, expressed by mathematical formulas, that assure description of phenomena, their behavior and precise quantitative prediction.

Traditionally, the reductionist ideal is also implicit in the ranking of disciplines which places Mathematics and most reductionist Natural Sciences, e.g., Physics and Chemistry, above Biology. Within the field of Biology, Bioinformatics, Molecular Biology and Biochemistry rank above Physiology, Morphology, Taxonomy, Ethology and Evolutionary Psychology. Biologists, in turn, are considered more scientific than behavioral and social scientists. The Medical Sciences are all over this map, since some are exquisitely experimental and quantitative, e.g., Neurochemistry and Endocrinology, while others are far from being so, e.g., Psychiatry and Psychotherapy. Outside all this are the Humanities. Nevertheless there are attempts to conform with the reductionist scientific ideal even within the Humanities, and attempts are made to found Linguistics, History and even parts of Philosophy (such as Epistemology) as exact sciences. The question is, however, what sort of method could be common for all those different sciences, that are "scientific" in their specific and varying ways?

The scientific method may be described as the logical scheme used by scientists searching for answers to the questions posed within Science. Scientific method is used to produce scientific theories, including both scientific meta-theories (theories about theories) as well as the theories used to design the tools for producing theories (instruments, algorithms, etc). The simple version looks something like that shown in Figure 3.

It is crucial to understand that the method of Science is *recursive*. Prior to every observation or experiment or theoretical test there is a hypothesis that has its origins in the pre-existing body of knowledge. Every experimental/observational result has a certain world view built in. Or, in the words of Feyerabend (2000), every experimental data is "theory-contaminated".

The scheme of the scientific method in Figure 3 is without doubt an abstraction and simplification. Critics would argue that there is in fact no such thing as "the scientific method". By the term "the scientific method" they actually mean the concrete set of rules defining how to proceed in posing new relevant questions and formulating successful hypotheses. Of course, no such magic recipe exists!

The important feature of the scientific method is that it is impartial ("objective"): one does not have to believe a given researcher; one can (in principle) repeat

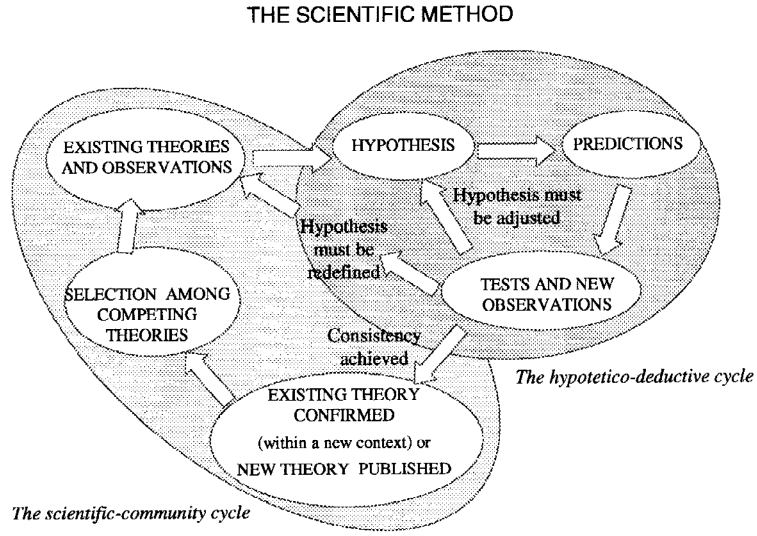

Figure 3. Diagram describing iterative nature of the scientific method.

the experiment/theoretical derivation and determine whether certain results are valid or not. The question of impartiality is closely related to the openness and universality of Science, which are its fundamental qualities. A theory is accepted based in the first place on the results obtained through logical reasoning, observations and/or experiments. The results obtained using the scientific methods have to be reproducible. All scientific truths are provisional. But for a hypothesis to acquire the status of a theory it is necessary to win the confidence of the scientific community (the scientific community cycle of Figure 3).

6. Interdisciplinary Sciences

The development of human thought parallel to the development of human society has led to an emergence of sciences that do not belong to any of the classic types we have described earlier, but rather share common parts with several of these. Many of the modern sciences are of the interdisciplinary, eclectic type. It is a trend for new sciences to search their methods and even questions in very broad areas. It can be seen as a result of the fact that the communications across the borders of different scientific fields are nowadays much easier and more intense than before.

There are also new methodological trends that emerge as a consequence of the development of AI: more and more "manual work" of the scientist is now done by computers. The exciting new field of Automated Discovery is already showing results within Bioinformatics, Vision, Chemistry, Genetics, etc. We seem to be witnessing an exciting paradigm shift:

> We should, by the way, be prepared for some radical, and perhaps surprising, transformations of the disciplinary structure of Science (Technology included) as information processing pervades it. In particular, as we become more aware of the detailed information processes that go on in doing Science, the Sciences will find themselves increasingly taking a meta-position, in which doing Science (observing, experimenting, theorizing, testing, archiving) will involve understanding these information processes, and building systems that do the object-level Science. Then the boundaries between the enterprise of Science as a whole (the acquisition and organization of knowledge of the world) and AI (the understanding of how knowledge is acquired and organized) will become increasingly fuzzy. (Newell, 1985)

Here we can find a potential of the new synthetic (holistic) world view that is about to emerge in the future.

7. Problem With the Traditional View: In What Way Is Computing a Science? AI Example Again

Let us take as an example Artificial Intelligence (AI) that is a branch of Computing according to Computing Curricula. AI is a discipline with two distinct facets: Science and Engineering which is the case for Computer Science in general. The scientific part of AI attempts to understand intelligence in humans, other animals, information processing machines and robots. The engineering part attempts to apply such knowledge in designing new kinds of machines. AI is generally associated with Computing, but it has many important links with other fields such as Mathematics, Psychology, Cognition, Biology, Linguistics and Philosophy, Behavioral and Brain Sciences among many others. Our ability to combine knowledge from all these fields will ultimately benefit our progress in the quest of creating an intelligent artificial being.

The scientific branch, which has motivated most of the pioneers and leaders in the field, is concerned with two main goals attempting to:

- understand and model the information processing capabilities of typical human minds,
- understand the general principles for explaining and modeling intelligent systems, whether human, animal or artificial.

This work is often inspired by research in Philosophy, Linguistics, Psychology, Neuroscience or Social Science. It can also lead to new theories and predictions in those fields.

The engineering facet of AI is concerned with attempting to design new kinds of machines able to do things previously done only by humans and other animals and also new tasks that lie beyond human intelligence. There is another engineering application of AI: using the results of the scientific facet to help design machines

Table I.

Sub-fields of AI	Related fields
Perception, especially vision but also auditory and tactile perception, and more recently taste and smell.	Philosophy, Cognition, Psychology, Mathematics, Biology, Medicine, Behavioral Sciences, Brain Sciences
Natural language processing, including production and interpretation of spoken and written language, whether hand-written, printed, or electronic throughout (e.g., email).	Linguistics, Psychology, Philosophy, Logic, Mathematics, Behavioral Sciences, Brain Sciences
Learning and development, including symbolic learning processes (e.g., rule induction), the use of neural nets (sometimes described as sub-symbolic), the use of evolutionary algorithms, self-debugging systems, and various kinds of self-organization.	Logic, Philosophy, Mathematics, Biology, Medicine, Behavioral Sciences, Brain Sciences
Planning, problem solving, automatic design: given a complex problem and a collection of resources, constraints and evaluation criteria create a solution which meets the constraints and does well or is optimal according to the criteria.	Logic, Mathematics, Philosophy
Robotics: provides a test bed for integrating theories and techniques from various sub-areas of AI, e.g., perception, learning, memory, motor control, planning, etc. exploring ideas about complete systems.	Philosophy, Cognition, Psychology, Mathematics, Biology, Medicine, Behavioral Sciences, Brain Sciences, Mechatronics

and environments that can help human beings. This may include the production of intelligent machines.

The complexity of AI and its numerous connections to other scientific and further cultural phenomena is suggested by Table I.

8. Scientific Versus Humanistic View: A Need for Common Context

It is a notorious fact that contemporary scientists do not learn enough in their education and training about the Humanities. In particular, scientists are not expected to reflect over the moral, political and ideological forces and issues from which their work emerges and which it influences. At the same time, as C.P. Snow observed in his lecture on “The Two Cultures and the Scientific Revolution”, modern arts people know even less about Science and Technology. In this context also Alan D. Sokal's famous hoax article (see Sokal, 1996) is very instructive.

> *The targets of Sokal's satire occupy a broad intellectual range. There are those "postmoderns" in the humanities who like to surf through avant garde fields like quantum mechanics or chaos theory to dress up their own arguments about the fragmentary and random nature of experience. There are those sociologists, historians, and philosophers who see the laws of nature as social constructions. There are cultural critics who find the taint of sexism, racism, colonialism, militarism, or capitalism not only in the practice of scientific research but even in its conclusions. Sokal did not satirize creationists or other religious enthusiasts who in many parts of the world are the most dangerous adversaries of science, but his targets were spread widely enough, and he was attacked or praised from all sides.* (Weinberg, 1996)

This shows the width and depth of the existing gap between two cultures. For very interesting attempts to build across the gap, see Lelas (2000), Mitcham (1994) and Rheingold (1985).

The separation of the consideration of technological development from moral, aesthetic, political and ideological determinations has become increasingly problematic. This separation impoverishes people trained in Science, Technology and Medicine, and ignorance of the scientific and technical side impoverishes those who study the Humanities.

Actually, Science, Technology and Medicine — far from being value-neutral — are the embodiment of values in theories, in facts and artefacts, in procedures and programs. All facts are theory-laden and all theories are value-laden, even if the value system is not explicitly given.

The essence of the Humanities is the exploration, maintaining and conducting debates about values. That is central to Literature, the Theatre, Fine Art, much of Philosophy, Cultural Studies, History, Classical Studies and much else.

The separation of fact and value which we associate with modern Science was an innovation of the seventeenth century. The framework of explanation which prevailed in ancient, medieval and Renaissance times was the Aristotelian one in which causes always occurred in fours:

- the material
- the efficient
- the formal and
- the final cause.

All four causes were required for a complete explanation.

Three of the four Aristotelian causes are still a part of the explanatory paradigm of modern Science. The material cause explains out of what kind of matter the effect comes (matter, including the atoms and fundamental particles). The efficient cause is that which imparts energy to the material object and would include intrinsic ideas of energy. The formal cause gives patterns, structures, symmetries.

But the final cause or purpose was considered not objective and was abandoned. It is not a part of modern scientific explanation.

That is the idealised story, however, and there are exceptions, e.g., in functional explanations of Anatomy, Physiology and Medicine, in Evolutionary theory, in the functionalist tradition and in the Human Sciences based on biological analogies.

Here it is interesting to mention Steven Weinberg's reflection in Weinberg (2000):

> *It might be supposed that something is explained when we find its cause, but an influential 1913 paper by Bertrand Russell had argued that "the word 'cause' is so inextricably bound up with misleading associations as to make its complete extrusion from the philosophical vocabulary desirable." This left philosophers like Wittgenstein with only one candidate for a distinction between explanation and description, one that is teleological, defining an explanation as a statement of the purpose of the thing explained.*

Weinberg, like modern physicists in general, is opposed to the idea of teleological explanation. He presents his arguments that help us understand why scientists rejected teleology historically, which is good to remember.

Alfred North Whitehead, on the other hand, wrote about the modern world of separated facts and values:

> *"The seventeenth century had finally produced a scheme of scientific thought framed by mathematicians, for the use of mathematicians . . . The enormous success of the scientific abstractions, yielding on the one hand matter . . . on the other hand mind, perceiving, suffering, reasoning, but not interfering, has foisted onto philosophy the task of accepting them as the most concrete rendering of fact.*
>
> *Thereby, modern philosophy has been ruined. It has oscillated in a complex manner between three extremes. There are the dualists, who accept matter and mind as on equal basis, and the two varieties of monists, those who put mind inside matter, and those who put matter inside mind. But this juggling with abstractions can never overcome the inherent confusion introduced by the . . . scientific scheme of the seventeenth century.* (Whitehead, 1997)

Science is a part of culture, and research traditions cannot be reasonably separated from the prevailing world view of the epoch. The social forces affect the origination, funding and deployment of scientific research, the foundations of scientific disciplines and even the scientific world view. Science is *not* value neutral (see Dodig-Crnkovic 2003a, b).

Natural Sciences are interested in classes of phenomena and sets of undistinguishable individuals. Their basic requirements are reproducibility and predictability. They rest upon idealization/approximation and generalization. On the other hand arts, history and literature are exquisitely particular and allow all sorts of interpretations in their depicting the lives of humans. Their stories are unique and individual.

9. Philosophy of Information and Philosophy of Science

Let us start with a definition.
*"***The Philosophy of Information** *is a new philosophical discipline, concerned with*

(*a*) *the critical investigation of the conceptual nature and basic principles of information, including its dynamics (especially computation and flow), utilisation and Sciences; and*

(*b*) *the elaboration and application of information-theoretic and computational methodologies to philosophical problems."*

According to: *What is the Philosophy of Information?* (Floridi, 2002).

It is obviously much more than the Philosophy of Information Theory (for a very interesting text on Information Theory, including even some philosophical consequences, see Chaitin, 1987).

The field of Philosophy of Information (PI) is so new that no consensus is yet found about the nomenclature. So there are different names for essentially the same discipline: Philosophy of Information (see Floridi, 2003), Philosophy of Computing (see Smith, 1995; Floridi, 1999), Cyber philosophy, Digital Philosophy (see Bynum and Moor, 1998) and with related fields such as Philosophy of AI, Computer Ethics, (see Martin and Schinzinger, 1989; Bowyer, 2000), Artificial Morality and Computational Philosophy of Science (see Thagard, 1993).

The same is true when it comes to the use of the terms "Computing" and "Informatics". To make things even more complicated, Informatics is sometimes used in the meaning of Information Systems of ACM/IEEE, 2001. Even Computing is sometimes used as synonymous of Computation, which most commonly is a term for the special discipline which emerged at the intersection of Computer Science, Applied Mathematics and various science disciplines (including modeling with 3D visualization and Computer Simulation, efficient handling of large data sets, and alike) (see Dodig-Crnkovic, 2002).

What is the relation between the Philosophy of Information/Informatics/Computation and the Philosophy of Science? The Philosophy of Information is a broader field, encompassing more than different scientific facets of Computing. It includes an important ethical component as well as ontological and even epistemological elements that are different in character from those studied within the Philosophy of Science. However, there are many common interfaces where synergetic effects can be expected in the course of research, such as the Philosophy of Science discovering the new discipline of Computing as a new paradigm of future Science.

10. A 21st Century Renaissance — Cultivating New Ways of Thinking

From the early 14th to the late 16th century, a revival of interest in the values of Greece and Rome led to the cultural age of the Renaissance. The European world image shifted from a religious to a worldly outlook. Renaissance intellectuals had a growing confidence in individual human abilities. This new humanism focused on the personal worth of the individual.

The fundamental idea of the Italian Renaissance was that a man should perfect himself by developing all his faculties. The ideal man should be a scholar and connoisseur of art; he should develop graceful speech and cherish a sense of honor. This Renaissance ideal of the free development of individual faculties and its rules of civilized behavior formed a new conception of humanist personal rights and obligations in Europe.

Nowadays, the outburst of computers and information technologies has created a new environment for the revival of the Renaissance ideal. Computers have enabled the storage, organization, and manipulation of information that was never possible before. The Internet brings about practically instantaneous transmission of information around the world. It is the tool that makes it possible to navigate and surf the oceans of information. Computers have given artists and engineers, scientists and scholars new tools and opportunities of work and communication. Information technology permits faster development of fundamental breakthroughs in virtually every field, including materials, energy, and biotechnology.

As a result we should expect advancements with the character of those of the Italian Renaissance. The technology engine that drove the first Renaissance was the printing press. Today, it is computing and communication that allow faster, wider access to the best information, tools, and practices. What makes it appealing is *humanism*, the force at the heart of the first Renaissance. It placed human needs and aspirations at the center of every endeavor. Assessing Technology and even Science from a humanist perspective will be the greatest challenge to come.

11. Conclusions

"How shall we live?" is, for Socrates, the fundamental question of human existence — and the attempt to answer that question is, for him, what makes human life worthwhile.

Computing is changing our culture rapidly and it affects our lives in a number of most profound ways. The Computer itself is a new research field and its object of investigation is an ever-developing artefact, the materialization of the ideas that try to structure knowledge and the information about the world, including computers themselves. Already the subject of investigation of computing suggests that the traditional science paradigm may not apply for Computing. For classical Sciences the object of investigation is Nature, while scientific parts of Computing to a very high degree have an artefact as an object. Here we can find the first reason of the return to human-centered philosophy: this new field that is partly scientific is about a human project.

However, in spite of all the characteristics that distinguish the young field of Computing from several thousand year old sciences such as Mathematics, Logic, and Natural Sciences we can draw a conclusion that Computing contains a critical mass of scientific features to qualify as a Science. Computing has a traditional core of "hard" (exact) Sciences.

All modern Sciences are very strongly connected to Technology. This is very much the case for Biology, Chemistry and Physics, and even more the case for Computing. The engineering parts in Computing have connections both with the hardware (physical) aspects of the computer and software. The important difference is that the *computer* (the physical object that is directly related to the theory) is not a focus of investigation (not even in the sense of being the cause of a certain algorithm proceeding in a certain way) but it is rather *theory materialized, a tool always capable of changing in order to accommodate even more powerful theoretical concepts*.

Contrary to the present-day scientific ideal of Physics which is defined as the opposite of Metaphysics, Computing/Informatics is vitally connected with Philosophy. It presents an opportunity to rethink from a new fresh perspective our basic concepts from the beginning. Even to reach for a new synthesis of Sciences and Humanities, Arts and Engineering: a fusion of social, cultural, economic, ethical, and ecological values for achieving a rationalization and harmonization of the needs of human society. Technology, humanism, and cross-disciplinary cooperation can combine in the New Renaissance which is the ideal of broad-minded, well-mannered deliberation that cultivates diversity of opinion.

Actually, taking into account the present development within different scientific fields, we must conclude that Science is simply not the same thing it was in the last century. The time is ripe for a paradigm shift in the Philosophy of Science! Computing is winning the ground that was the traditional domain of Physics. The answer to the question what ultimately matters nowadays belongs more to Computing than to Physics. The search for answers to questions about truth, meaning, mind, subjectivity, consciousness etc. lies among others within Computing.

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