Archives for the Philosophy and History of Soft Computing

European Centre for Soft Computing
www.softcomputing.es

Issue 1/2015

INTERNATIONAL ONLINE JOURNAL OPEN ACCESS
ISSN 2341-0183

Cybernetics, Fuzziness and Scientific Revolutions – An Interview with Settimo Termini

Massimiliano Lincetto[1], Sergio Perticone[2], Valerio Perticone[2] and Marco Elio Tabacchi[2,3]

[1] Università degli Studi di Padova, Italy
[2] DMI, Università degli Studi di Palermo, Italy
[3] Istituto Nazionale di Ricerche Demopolis, Italy

Email: Massimiliano Lincetto massimiliano.lincetto@studenti.unipd.it; Sergio Perticone, Valerio Perticone, Marco Elio Tabacchi - sergio.perticone|valerio.perticone|marcoelio.tabacchi@unipa.it;

Abstract

Settimo Termini pioneered along with Aldo de Luca the concept of fuzziness measures in the sixties. Today he is a Full Professor of Theoretical Computer Science at the University of Palermo and an affiliated researcher at the European Center for Soft Computing, Mieres (Asturias), Spain. He has directed from 2002 to 2009 the *Istituto di Cibernetica "Eduardo Caianiello"* of CNR (*National Research Council*) in Italy. Among his scientific interests, the introduction and formal development of the theory of (entropy) measures of fuzziness; an analysis in innovative terms of the notion of vague predicate as it appears and is used in Information Sciences, Cybernetics and AI. Recently he has been interested also in the connections between scientific research and economic development and the conceptual foundations of Fuzzy Sets and Soft Computing. He is Fellow of the International Fuzzy Systems Association and of the Accademia Nazionale di Scienze, Lettere ed Arti of Palermo. In 2015 he will be 70, and we want to celebrate his birthday with the Soft Computing community with this interview where he discusses history of Cybernetics. The interview was conducted in Italian and translated by the authors.

Submitted: 01/05/15. Accepted and Published: 22/07/15

Interviewers: How do you define yourself: physicist, cyberneticist or computer scientist?

Settimo Termini: It's a bit difficult to say because the degree in Physics is something that I care for a lot. When I finished high school I was undecided for several months between several different subjects: Mathematics, Philosophy and Physics.

Physics was the original choice because it is a kind of synthesis between serious scientific aspects (now called "hard science") and quantitative ones, like Mathematics, and at the same time it presents a number of issues and conceptual questions more cogent than in Mathematics. This was my initial impression, which I maintained in the following.

Even in mathematics there are conceptual questions a little more focused, but not enough. Having this relationship with an external referent, which is nature, I thought that Physics would put more questions of this kind. From this point of view I am very attached to being a physicist, because it is the culmination of this idea I had, of a balance between technical-formal developments and conceptual questions.

I have been a physicist in the strict sense for two years following the thesis, and published only three works in Physics. But I think I've carried this also in new areas of which I was involved, and more generally in Cybernetics.

Figure 1: Settimo Termini at work in his office at Università degli Studi di Palermo.

I: What is the exact meaning of Cybernetics?
ST: Cybernetics, which in the 50s had the role of an emerging scientific discipline, now seems almost forgotten: this fact puts me forward a series of conceptual questions. Ask the question "what is to be a cyberneticist"? is interesting, but it does not say anything to anyone.

"A computer scientist"? I'll answer yes, but today's "computer scientist", in common usage of the term and in a very specific and technical meaning, is understood as the person who knows how to tweak with a particular object technology, extraordinary and unique. From this point of view, I am not it at all, because I cannot hack computers.

I find interesting to notice that from a general point of view Computer Science is a very important chapter of a broader discipline that in the '50s was called "Cybernetics". This name, "Cybernetics", was to be the name of a class that covered different disciplines. Historically, alas, this was not to be for various reasons: the names have, like people, a "fortune", which determines the fact of being used or not[1]. The other unusual thing is that "Cybernetics" was not replaced by another name: various terms competed as a label for this new field of activity, but none has proved successful. There's this strange situation but also extremely interesting, because these kind of phenomena never happen by chance.

It means that we are living in a time when important things are emerging: we realize, you experience all of this explosion of technological development that has significant influence on society. But not only that, from my point of view, we are heading for a real scientific and conceptual revolution even we cannot imagine. Probably in fifty years people will say, "Oh, how ingenuous were our predecessors who did not realize what was going on".

But no! If they say "such fools they were!" they are wrong, because, we are living in it, and is very difficult to highlight certain processes. There are, however, a whole series of signs and this we notice: from the point of view of technology, the way of living and thinking has radically changed, and still changes constantly and with increasing speed.

I: What can we know more precisely about this phenomenon?
ST: From the point of view of the concepts and theories there is a lot of high quality work, but for now it is only an indication that we are moving toward a general paradigm shift, as has happened in other periods in the history of science. A paradigm shift that, as we live in, we can not identify yet.

I: A new Industrial Revolution?
ST: It's like a new Industrial Revolution if we see it from a generally sociological point of view, but if we remain within the field of science and the

---

[1] As anyone in Fuzzy Logic knows very, very well.

history of science, is quite similar to the leap of 19th century. Between the end of the 18th and the start of the 19th century the scientific reference, in some way, was Mechanics, for all other disciplines were considered truly "scientific" only if they were reducible to Mechanics.

So Optics, Electromagnetism, Thermodynamics would have to take this kind of presentation, the rigor of the Mechanics even when reduced, and here comes the word "reductionism", to mechanical phenomena.

But no, the great thing is that history and nature are richer than we can imagine, and we were amazed. This is because Electromagnetism presents a whole series of characteristics and problems, which are its own: it does not have a level of stringency less than that of the Mechanics, but brings with it the concept of field and many other additional notions. However Thermodynamics, with statistical mechanics, attempts to reduce the macroscopic thermodynamic phenomena to mechanical microscopic descriptions, that means motion of the particles: this reduction is not trivial. These two disciplines in fact continue to develop as scientific paradigms like Mechanical and pose new problems.

And today we are experiencing a transition of this kind. Among other things, the interesting fact is that it was born in the 20th century, particularly with the Gödel's theorems in logic, quantum mechanics and relativity, which are well-known results and we already know that were revolutionary.

But, especially in the second half of the 20th century, there is this other idea: the notion of information becomes scientifically tractable, or at least that's what we think. The idea is that we can deal with instruments not very different from those with which you treat other scientific notions. But information is not a natural notion.

Indeed, we could say that all the natural sciences have to do with matter and the notion of information is immaterial.

But the way in which we try to deal with this notion of information is, for example, one of the definitions of information is given by linking it to the entropy of Physics. The initial definitions, including that of Wiener[2] first, then Shannon[3], connect it to notions that are purely physical. Then we are dealing with physical methods, similar to those of Physics or, in general, the science of nature, a notion that just by definition is non-material. And this poses problems. There are some big issues that we have to solve, but also interesting questions, because they make us think more and more, and move ever forward the frontier of how to interpret and read the world.

---

[2] Norbert Wiener (1894 - 1964), American mathematician and philosopher, in 1948 defined Cybernetics and introduced the concept of information. Wiener, Norbert. Cybernetics. Paris: Hermann, 1948.

[3] Claude E. Shannon (1916 - 2001), American mathematician and electronic engineer, widely known as "the father of information theory", in 1948 developed the concept of information entropy. Shannon, Claude E. "Bell System Tech. J. 27 (1948) 379; CE Shannon." Bell System Tech. J 27 (1948): 623.

Looking back, how do I call myself? It is not important to define. It is much less important how I call myself, but it was an interesting question, in my opinion, because it gives the occasion to reflect on issues even broader.

I: What do you remember about your experience at the Institute of Cybernetics “Eduardo Caianiello”?
ST: Before I do that, I would answer your implicit question, that is, how this passage happened. As always happens, there are occasional factors in life, in the study, in the development of science. But the occasional factors produce only small deviations. If these occasional factors resonate with other things, combinations that can produce big changes happen.

Figure 2: Eduardo Caianiello and Norbert Wiener

The occasional factor was the following: after graduating in Physics, in Palermo, I was especially interested in questions of theoretical physics. The small group of theoretical physicists I had worked with during the thesis had dissolved because the professor had left Palermo. Then wanting to continue doing research, I had to choose how to navigate among all the various possibilities that were presented to me. I was offered a visit to the Institute of Cybernetics of the Italian National Research Council (CNR), founded in 1968, the year of my graduation, as a research institution independent of the university. It was an institute a bit new and different for the time. The CNR had about two or three autonomous institutes throughout Italy, for the rest it was internal university research. Among other things, perhaps even trivial, that led me to work for the institute, one was the international atmosphere. I met the director and founder of the institute and we sat together in the cafeteria, with a Russian and an American: that meeting gave me the idea of an international atmosphere.

The other aspect that convinced me, although it was a discipline absolutely unknown, was that the founder of the institute was also a theoretical physicist. The thing I did agree that, in the end, that change is not just a leap of faith, to lands full of infidels: in short, the head of this new tribe came from Physics. I was struck in particular by one sentence of the then director... there is this idea of what a physicist can do, a kind of presumption: physicists are confident that their formation is in some way superior to that of all other. Eduardo Caianiello[4], who was the director of the institute, suggested this to me in a particularly extreme form. I asked him questions regarding this new sector, topics of which he spoke to me and of which I knew nothing, and he told me at one point: “Excuse me, you told me that you are a physicist, is it?” “Yes” “Are you also a theoretical physicist?” “Yes” “So, physicists can do everything, and if they are theoretical physicists, they are the only ones who can solve new problems in other areas”. It is worth bringing the concept in this extreme form: I agree with this idea for which a great credit of the physicists is to be conscious of being bearers of a scientific method extendible beyond the confines of the same Physics. But there is also a limit: the physicist can be persuaded, as long as he deeply studies a new sector, that his methodology is exactly transferable in it: sometimes this attitude can stop a successful application of the scientific method. This for a variety of obvious reasons: the inanimate world, despite the complications introduced by quantum mechanics (for example the fact that the effect of the measurement can disrupt basically what we observe), has a certain inherent simplicity. Other fields of study, wanting to investigate with the scientific method and in particular trying to generalize that of physics, may present peculiar aspects of complexity that do not occur, in general, in the phenomena of the inanimate world. The physicist must therefore be modest and humble enough to admit that the area under study can present aspects of complexity of a different nature to those characteristic from Physics.

Let's take a trivial example: when we have to deal with the nature and we formalize a theory, it is quite clear that there are certain parameters of the theory more meaningful than others. With a mechanical system we consider the position and velocity, parameters that have been chosen with the knowledge gained in hundreds of years of reflection.

---

[4] Eduardo R. Caianiello (1921 - 1993), Italian physicist, was the founder of the Laboratory of Cybernetics of the Italian National Research Council at Arco Felice, which is now named after him. Pioneer in the theory of neural networks, in 1961 he proposes two types of equations for describing thought processes. See Settimo Termini: Imagination and Rigor: Essays on Eduardo R. Caianiello's Scientific Heritage, Springer-Verlag Mailand 2006

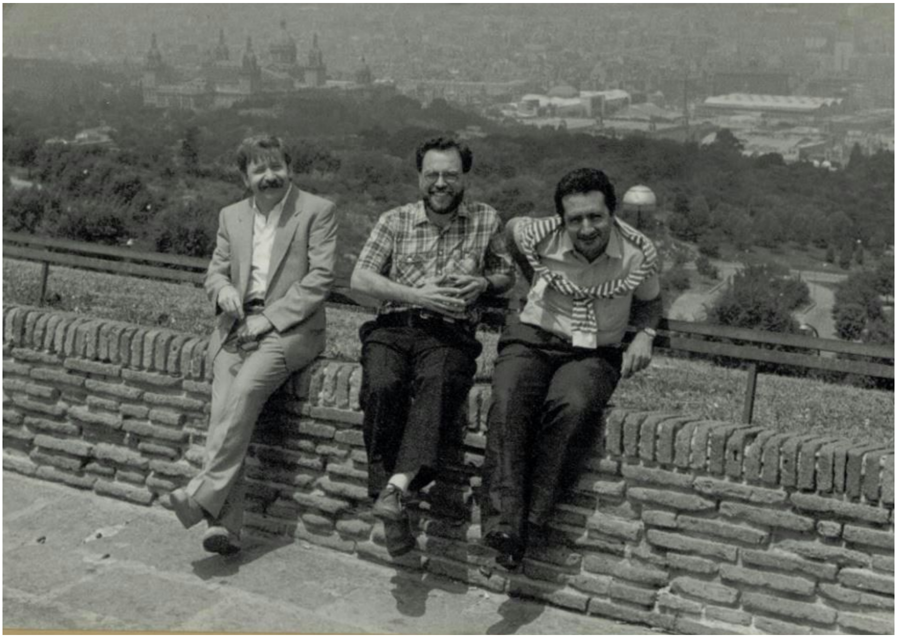

Figure 3: Ton Sales, Enric Trillas and Settimo Termini in 1979 or 1980. The photograph was taken in the castle of Montjuic, in front of the Mediterranean Sea and at the top of the mountain at whose back is Barcelona.

Sure, it is an approach not immune from criticism, for example, when you call into question the relativity that gives problems, not trivial, for example regarding the concept of simultaneity. We could arbitrarily choose other parameters, of course: taking a trivial example, if we describe a system using linear combinations of position and velocity, calling them respectively Pinco and Pallo[5], we will have a description from a formal point of view identical to the previous. Known all values of Pinco and Pallo we can determine all values of position and velocity. But are they meaningful Pinco and Pallo? Of course, not: we understand that position and velocity have a much more significant role than their sum and difference.

If we move instead in areas such as social sciences in which we want to characterize, for example, what are the characteristic behaviors of certain groups of people, we still have to choose the parameters which we believe to be meaningful. But, in many cases, if we are going to pick the linear combinations and do the same little game we did with position and velocity, characteristics that are equally meaningful arise. This already makes it an idea that this system, which in any case will deal with the criteria of rigor learned

[5] A jocular, Italian equivalent of Whatsit and Wotsit.

from physics, has its specific features. It becomes difficult to isolate significant aspects not having that external reference which in the physical sciences is so important.

Back to my transition from physics to cybernetics, from one side it was pure randomness. If I had been in an institute in which engineering systems (I understood nothing about) were developed, even with high prospects of career and fame, I would have probably quit, and if not I would probably have amounted to nothing. So it was by chance, but making a great effort to put everything in perspective, I understand that cybernetic was an environment where the same type of questions were asked, and science was done in the same way.

I: Have you forged a specific relationship with Caianiello?
ST: Yes, but the first problem I had to face by switching workplace was twofold: at one level I was used as a student to a disciplined environment. At the time the term *department* was not yet in use, my department was called Institute of Physics. Some lectures were held in the nearby Institute of Mathematics, chemistry lectures were held elsewhere, but all the other lectures were held in the same place. This marks a difference between academia and the research institutes. While interdisciplinary exchanges are often fostered, in academia fundamentally everything goes round certain disciplines. We can discuss how disciplines are born or evolve, but the situation is somehow crystallised. Then interactions with other colleagues do exist, but they remain interactions between distant people. Everyone was a member of his own institute (or department as it is called now), and there was a strong relationship between students and professors.

When I moved to the research institute there were no students – some PhD student would have been there in the following years, but none of them then. In this sense it was an unaccessible work environment, but at the same time extremely open due to its interdisciplinary nature. The idea was to confront my own baggage of knowledge with this new kind of problems, and this was quite difficult, as it forced me to reconsider my own knowledge and to search for new ways to apply it. While there I discovered in my first months – to be sincere I had some knowledge of Gödel's theorem, but up to when I was 23 years old I had never heard of theory of computation before. And I started discussing and sharing ideas with other colleagues, many of about my age or a few years older, and Caianiello, who was pushing his neural networks model as a cure for every ailment: a large number of things could have been done and understood.

Those two models, neural networks and theory of computation, are exactly the poles around which, up to today, most of the activities of AI have been developed. The research inspired by theory of computation is often termed the "symbolic approach": the idea to create more and more refined computer programs that reproduce more and more of those behaviours we define as intelligent, those activities that are intelligent for us. And this is done by – I am probably oversimplifying – the use of fundamental programs. The neural network approach in contrast does not concern in how things are done: we try to teach a neural network to do intelligent things by example. This was Caianiello's idea, which underlined the implicit hypothesis that neural network was useful not only for the simulation of specific aspects, but were also a model of human brain. Caianiello used to call his own equations "the screwball's equations", and this was a joke with a double meaning! The first one has to do with the fact that since it was a very preliminary model, the kind of person who would have been simulated by it would certainly be a screwball; and the second was because only a screwball can conceive equations for the brain. We never spoke about this, but another screwball before him had a similar idea: George Boole[6] presented the boolean algebra about 150 years ago by saying it was an instrument to simulate the laws of thoughts. And then, by chance, working with some colleagues, and in particular Aldo de Luca[7], who was a bit older than me, and following a tip from Caianiello himself, I discovered the notion of "Fuzzy Sets", a research published a few year before by a certain russian-american engineer[8] (as he was from Azerbaijan, originally a Soviet-influenced country, but as soon as he arrived in the States he became a perfect American!)

This topic presented interesting aspects for me, because from one side we did with my friend and colleague de Luca a lot of conversations, debates and links between fuzziness and facts from quantum mechanics. From these first two years of lively discussion my interest for other research sectors was born. Fundamentally, there has been a passage from fundamentals in physics to fundamentals of uncertainty, and how uncertainty and imprecision can show up in other systems of different nature. This is the transition in a nutshell.

---

[6] George Boole (1815 - 1864), English logician. In 1847 he introduced the boolean algebra, a fundamental tool for design electronic circuits and to building computer architectures. The title of Boole's book cited by Termini is The Laws of Thought (1854).

[7] Aldo de Luca (born 1941). Italian researcher at Institute of Cybernetics of CNR in the 60s. In 1972 de Luca and Termini proposed a measure of fuzzy entropy. See Marco Elio Tabacchi and Settimo Termini, A Few Remarks on the Roots of Fuzziness Measures in Advances in Computational Intelligence (Communications in Computer and Information Science, Vol. 298), Berlin, Springer 2012, 62-67.

[8] Termini jokingly refers to Lotfi A. Zadeh (born 1921), American electrical engineer and professor emeritus of computer science at the University of California, Berkeley. In 1964 he founded the theory of Fuzzy Sets and Systems. For the history of this theory see: Rudolf Seising: The Fuzzification of Systems. The Genesis of Fuzzy Set Theory and Its Initial Applications – Developments up to the 1970s (Studies in Fuzziness and Soft Computing, Vol. 216) Berlin, New York, [et al.]: Springer 2007.

Figure 4: Surrounding Lotfi Zadeh at the 11th IEEE International Symposium on Multiple-Valued Logic in Oklahoma City in 1981. Settimo Termini, Ronald Yager, Francesc Esteva, NN, Sergei Ovchinnikov, Teresa Riera, Lorenzo Peña, Enric Trillas.

I: Is the scientific community unaccessible, secretive?

ST: It may be, but not that much. I am not saying that for the sake of diplomacy. Mathematics, for example, is such a technically specialised discipline that a degree of inaccessibility is connaturated to that kind of research. Science could be more open, but this is intrinsically linked to the interactions I have mentioned before. It is not a specific task of the scientific community to be more open, as the effort from a single community will not work. Society as a whole should stimulate more openness from all sectors, and require it as well. This change in attitude from the whole society would significantly increase openness in individuals. I may be wrong, but my vision is that generally the effort from small communities toward openness is important, but by itself is not sufficient. Problems can be tackled and solved if this effort has a tangible effect on more and more groups of people, and in the end on society as a whole.