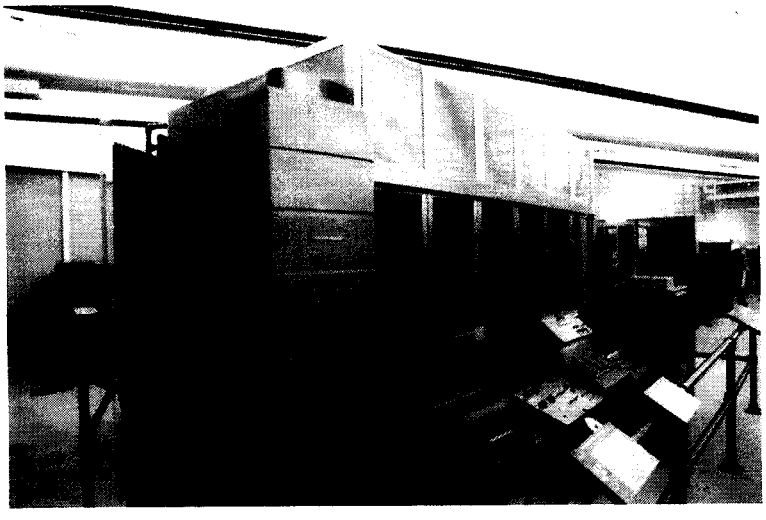
Towards a Philosophy of Information and Computing Sciences

By Jan van Leeuwen

Jan van Leeuwen is the first recipient of the Distinguished Lorentz Fellowship prize, a new prestigious award instituted by NIAS together with the Lorentz Center in Leiden. The prize honours scientists who bridge the divide between the sciences and the humanities. The prize consists of a personal prize, a stay of up to one academic year at NIAS, and a budget for organising an inter-disciplinary workshop at the Lorentz Center. Jan van Leeuwen is Professor of Computer Science at Utrecht University. He received the Distinguished Lorentz Fellowship for his contributions to the foundations of informatics. He will use the prize to develop the elements of a philosophy of informatics.



Old computers in the Computer History Museum, California (all photos: Scott Beale)

Informatics has been called the science of the 21st century, but can we predict its future? Let me reflect a little on the field which we also call Computer Science or, more elaborately, Information and Computing Sciences. Some may even prefer the term ICT, although this only covers the applied side of the field.

With at least four different names for the field, is it clear which is the right one? Do we have a good picture of the field as a science? What are the fundamental questions the field is addressing? If the questions are part of a discovery process, then what is the field aiming to discover? What is the role of information technology and computing in this process of discovery? What is the scientific core of the field?

Informaticians tend to be too busy to look at these questions. It is not where the money is, so to speak. And yet they complain that many people only associate informatics with 'what runs on their pc', and in particular that young people have the wrong impression of the field; Student enrolment in the information and computing sciences is thus too low; and industry therefore cannot find the skilled ICT

experts it needs. They complain furthermore that in general, public awareness of informatics as a science is low.

History

People have been trying to capture the nature of Computer Science from the very beginning of the computer era. One early definition says for example, that "computer science concerns the science, development, construction, and application of the new machinery for computing, reasoning, and other handling of information" We would be quite happy with this definition, except for the very prominent role it gives to "machinery". This definition dates from 1947, and debates on defining the field and what to name the profession (*computologist*?) continued well into the 1950s and 1960s. In 1966 the Danish computer scientist Peter Naur, Turing Award winner in 2005 for his contribution to compiler design and algorithmics, suggested naming the field "*datalogy* - the science of the nature and use of data". Europe settled for Computer Science and Informatics although, until today, departments of computer science in Denmark are still called "*Datalogisk Institut*".

The early computer scientists may have searched for the scientific identity of the field, but they haven't quite managed to standardise it. Some described the field as an 'art' (namely: the 'Art of Computer Programming') or as a form of mathematics, while others viewed it as engineering or even as a socially constructed science. How do we characterise informatics as a science? While we study this question, the field goes off into new directions and changes character. For example, until a year ago few realised the extent of the body of knowledge and technologies now called 'Web Science'.

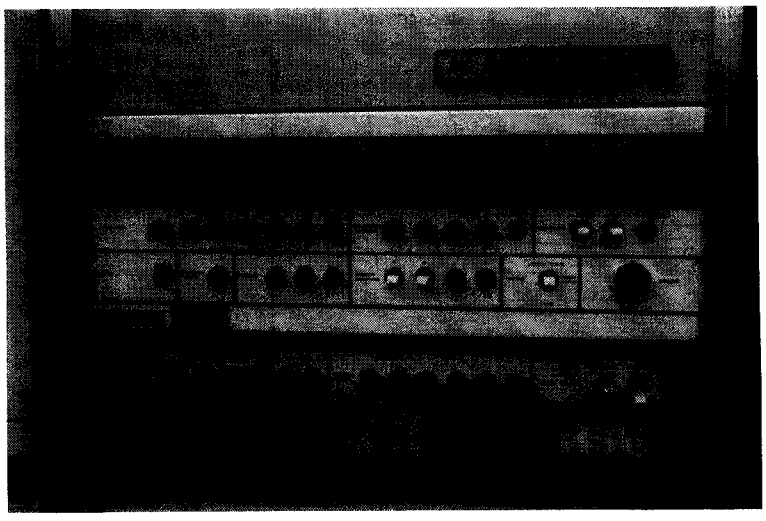
Why is there no generally accepted definition yet? One reason is that people tend to see the field from their own, personal perspective and experiences: algorithm-centric, computer-centric, ICT-centric, information science-centric, programming-centric, software-centric, systems-centric, AI-centric, and so on. Another reason may be that the philosophy of science has not adequately touched the field of informatics yet.

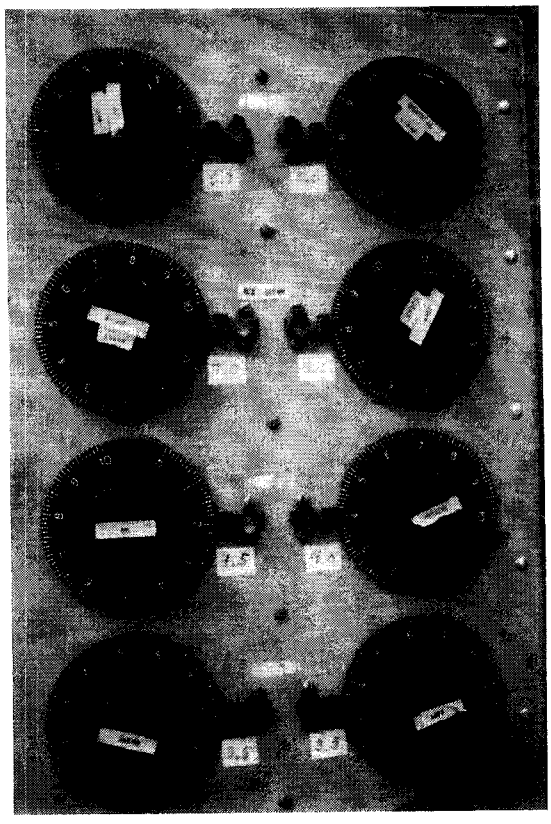
As early as 1967 Newell, Perlis and Simon had written a short article regarding this question in *Science*. They argued that 'computer science is the study of the phenomena surrounding computers.' This view is also reflected in Simon's later book, *The Sciences of the Artificial*, and in the adage 'what can be automated and how' attributed to Denning and others. But many no longer find their description satisfactory. Once again it puts computers central. It gives an incomplete view of informatics as a science, of the phenomena which are targeted, and of the methodologies to be used to observe and analyse these phenomena. With informatics coming of age, its paradigms have shifted.

The Information Dimension

George Forsythe, founder of the Computer Science Department at Stanford University, wrote in 1967 that he considered "computer science, in general, to be the art and science of representing and processing *information* and, in particular, processing information with [...] computers."

His views already point to the impressive development of the ICT field, in which everything is centred around capturing processes in terms of data, and around 'communicating' information to other processes, organisations and people. ICT brings us train schedules, navigation systems, electronic banking, information systems, interactive web applications, and all the other benefits of the field, and has an unprecedented impact on the economy and on our daily lives.





It is a domain with *no limit*: all forms of processes and information will be touched and changed by ICT. Did Forsythe foresee this?

Of course, information is only a derived concept, it points to something deeper. Information relates to a formal description of the world around us, *reality* if you like, with all the complexity of capturing it in terms of representation and process. Physical objects too, which have mass and energy, must submit to being described in suitable frameworks in the 'information dimension' in order to be fully captured and understood. This applies to everything, from biological systems (cells) to administrative systems; from virtual constructs created by and in our imagination (virtual stores, games) and to our very cognitive processes.

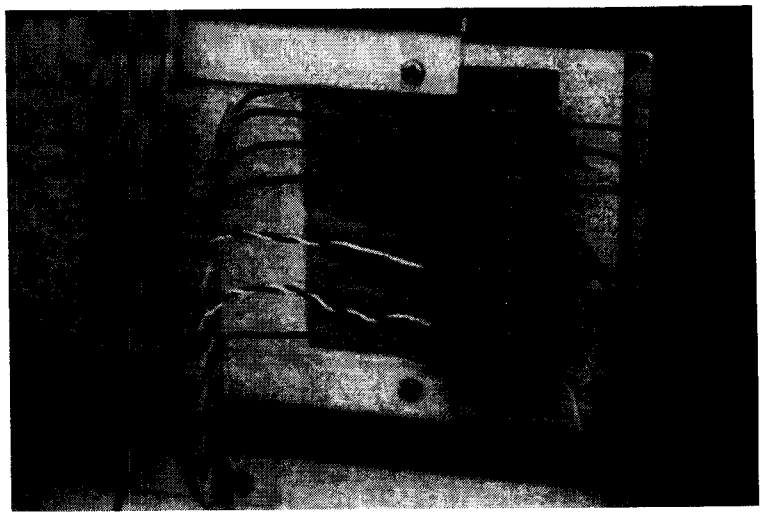
If understanding the processes in the world we live in is part of the rationale, then informatics becomes a natural science of a totally different nature than its older counterparts like physics and mathematics. It is thus not merely a 'science of the artificial' as Simon proclaimed.

Philosophy

Does informatics have a role in our eternal quest for understanding concepts such as 'matter', 'life', and 'mind'; in mastering and re-creating the world around us; and in extending man's capabilities? Many say it does. But how can we analyse this more deeply?

Philosophical investigations of informatics are not new. We know them from the viewpoints of computability theory, logic, information and artificial intelligence. They have inspired new studies of notions like knowledge, awareness and other human qualities ("can computers be made to have these qualities?"), and have led to investigations of the limits of unbounded computation in new models of human computing. All these viewpoints seem to touch fragments of the story. They all give a window, so to speak, to the discipline. Other views (*perspectives*), many interdisciplinary, include:

- the *information-oriented* view, which is mostly seen in a human-centred or business context, and which aims to capture the processing of information in any form;
- the *computing-oriented* view, focusing on the mechanisms of computational processes and their complexity, and which is mostly seen in the sciences;
- the *communication-oriented* view, which emphasises the processes of transferring and distributing information and the



mechanisms of interaction and control;
- the *cognition-oriented* view, which exploits the analogues of human knowledge and intelligence and the principles of understanding and reasoning;
- the *design-oriented* view, which aims at the principles of creating (programming) systems in algorithmic technologies and their possible evolution over time; and
- the *behaviour-oriented* view, which deals with the impact and adaptation of systems as they are used by human users, in networks and in organisations.

If you are interested in applying informatics in your field, for example in the humanities, then you can choose the viewpoint you favour. The views are all about the same discipline (informatics), and are not from separate fields although this is sometimes the impression people give. The development of the field very much needs one consistent and unifying – may I say - philosophy. How this can be done is an intriguing question.

Information Technology

Some readers might ask: isn't it all about technology after all, about what can be computed and how ('computational thinking'); and about the organising and managing of complex systems? Indeed it has been said that "every significant technological innovation of the 21st century will require information technology to make it happen."

This prediction is reflected in the enormous economic impact of the information industries. Companies like Amazon, Google, Microsoft, Oracle, SAP, and Yahoo, push the field every day for new visions, new concepts, new theories of multimedia information processing, new applications, and new products and innovations. ICT is now the biggest factor in industrial and business process innovation. Informatics is a field full of 'all-pervasive unsolved problems' that require great intellect. The creative challenge for the field is gigantic and a major driving force in research.

There is nothing contradictory here. Every science needs its instruments, and in informatics this is as important as it is, for instance, in astronomy. However, as astronomy is more than the science of space telescopes, so is informatics more than the science of computers (Dijkstra). In both fields science and technology are intertwined. Progress in informatics transcends from the abstract to the concrete and vice versa, resulting in an *ecosystem* of science and ICT. If this ecosystem is to work at all, it can only work with a substantial effort from informatics science,. It makes informatics fascinating, as a science, and otherwise!