POLITECNICO DI MILANO





Philosophical Issues of Computer Science

An Introduction

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The structure of today class

- The topics and the tools of this course
- Philosophy of Computer Science
  - What is Computer Science/Engineering?
  - *Questions? (only by chat) --> please close your mic*
  - What is Science?
- The organization of this course
  - Final project and exam
- The next lecture

Philosophical Issues of Computer Science

- **Critical analysis** of some **key concepts** in computer science and engineering
  - Presentation of the **conceptual tools** to be used in the analysis (mainly philosophical analysis)
  - Discussion of **key concepts** and issues of computer science and engineering
  - **Final project**

The structure of the course

- What are science, technology and engineering?
  - Philosophical and historical analysis of science, technology, and engineering
  - The philosophy of computer science/computing
- What is computer science? Foundational issues
  - The Universal Computer: The Road from Leibniz to Turing
  - Philosophical Issues of Computation
  - Experimental Computer Science
- The philosophy of AI
  - Machine and thought: from Turing Test to embodied cognition
  - The physical system hypothesis
  - Minds and brains: the Chinese room argument
  - Computational models of consciousness
  - Invited lecture (Silvia Crafa)
- Computer and information ethics
- Final project
  - Paper assignment and discussion
  - How to choose a (good) topic and to write a (good) paper
  - Papers' supervisions

Philosophy as a tool

- Philosophy as an **analytic** and **critical** discipline (not the history of philosophy)
- Centrality of **critical analysis** and **rational enquire**
- Philosophy of x as the study of the **fundamental assumptions** and **main goals** of any discipline x
- **Philosophical questions** for conceptual clarification

What is computer science /informatics?

- Science of **computers** and related phenomena (Newell, Perlis, Simon 1967)
- **Study** (and not science!) of **algorithms** and related phenomena (Knuth 1974)
- **Empirical study** ('artificial science') of phenomena related to computers (Newell e Simon 1976; Simon 1996)
- **Natural science** of **procedures** (not of computers and algorithms) (Shapiro 2001)
- Study of **computational processes** (Colburn 2004)
- **Synthetic engineering** discipline (Brooks 1996)
- Study of **information** (Hartmanin e Lin 1992)

Objects and perspectives

- Different **objects**
  - Computer (**hardware**)
  - Algorithms, processes, procedures (**software**)
  - **Information**
- Different **perspectives**
  - Computer science as a **science** or as other (**study**, **corpus of knowledge**, **discipline**, …)
  - **Different names** (computer science, computing science, informatics, computer engineering, information science, …)

CS as an interdisciplinary science

*"Computer science is in part [1] a **scientific discipline** concerned with the empirical study of a class of phenomena [...], in part [2] a **mathematical discipline** concerned with the formal properties of certain classes of abstract structures, and in part [3] a **technological discipline** concerned with the cost-effective design and construction of commercially and socially valuable products"*

(Wegner 1976)

RESEARCH PARADIGMS IN COMPUTER SCIENCE*

Peter Wegner
Brown University

Keywords and Phrases: Paradigms, research, computer science, methodology, philosophy, empirical method, abstraction, software engineering, complexity, programming languages, analysis of algorithms.

"The empirical method is generally characterized by the collection of large amounts of data before much speculation as to their significance or without much idea of what to expect, and is to be contrasted with more theoretical methods in which the collection of empirical data is guided to a large extent by preliminary theoretical exploration. The empirical method is necessary in entering into hitherto unexplored fields and becomes less necessary the greater the acquired mastery of the field."

- P.W. Bridgman, McGraw-Hill Encyclopedia of Science and Technology

be studied using the empirical techniques of the natural sciences. Section 4 distinguishes between "micro computer science" concerned with the study of individual algorithms and "macro computer science" concerned with the study of mechanisms and notations for specifying all algorithms; and between intensional "how" specifications and extensional "what" specifications for programs and computing systems. Section 5 distinguishes between the uses of the term "complexity" in software engineering and the analysis of algorithms and suggests that different terms be used to denote these two kinds of complexity. In a final section it is argued that the diversity of research paradigms in computer science may be responsible both for our difficulties in deciding how computer scientists should be trained and for divergences of opinion concerning the nature of computer science research.

"Computing as a discipline" (ACM report)

> "*The discipline of computing is the systematic study of* ***algorithmic processes*** *that* ***describe*** *and* ***transform information****: their theory, analysis, design, efficiency, implementation, and application. The fundamental question underlying all of computing is, '****What can be (efficiently) automated****?'"*
>
> (Denning et al. 1989)

- Roots both in **mathematics** (analysis) and engineering (design)
- Discipline with a **theory**, an **experimental method**, and **engineering** (different from natural sciences that are separated from their engineering sciences)
- Constant **exchange** between the **scientific paradigm** and the **engineering one**

Uniqueness of computer science (Colburn 2004)

- Natural sciences deal with models to test hypotheses explaining phenomena
- Computer science realizes and manipulates **non-physical models**
  - Computer science is the study of **computational processes**
  - Computational processes are different from other processes as they are studied **without any reference to their physical nature**
- Computer science realizes computational models of processes in the form of **programs**
  - These models can be **tested** by executing the program and observing its behavior
  - These models can be **analyzed** from a pure abstract point of view

Computer science as an empirical inquiry

Computer Science as Empirical Inquiry: Symbols and Search

*"Computer science is an **empirical discipline**. We would have called it an **experimental science**, but like astronomy, economics, and geology, some of its unique forms of observation and experience do not fit a narrow stereotype of the experimental method. None the less, they are experiments. Each **new machine** that is built is an **experiment**. Actually constructing the machine poses a **question to nature**; and we listen for the answer by observing the machine in operation and analyzing it by all analytical and measurement means available. Each new program that is built is an experiment. It poses a question to nature, and its behavior offers clues to an answer. Neither machines nor programs are black boxes; they are artifacts that have been designed, both hardware and software, and we can open them up and **look inside**. We can relate their structure to their behavior and draw **many lessons** from a **single experiment**."* (Newell and Simon 1976)

Computer science and its methods

- In 1960s and 1970s computer science became **distinct from mathematics**
- Mathematical, empirical, and engineering methods
- Whether computer science has to be **mostly** considered as a **mathematical discipline**, a branch of **engineering**, or as a **scientific discipline**

CS as a mathematical discipline

- Programs are **mathematical entities**
- Purely **deductive reasoning** provided by the **formal methods** of theoretical computer science
- Original motivation for a mathematical analysis of computation coming from **mathematical logic**
  - **Hilbert's problem**: could there be an algorithm, a procedure, for deciding of an arbitrary sentence of the logic whether it is provable?

CS as an engineering discipline

- From proofs of programs' correctness to **methods managing** the **complexity** of those systems and evaluating their **reliability** (1970s)
- Emphasis on how **to produce** artefacts
- Production of the phenomena to be studied, those concerning **computational artefacts**

CS as a scientific discipline

- Both **formal methods** and **empirical testing** used to evaluate the correctness of computational artefacts
- CS understood as **scientific discipline** in that it makes use of both **deductive** and **inductive probabilistic reasoning** to examine computational artefacts

Questions?

Please use the chat

Science, technology, engineering…

- Not an easy task…
- Critical analysis of the given concepts and ideas
- Science, technology and engineering in relation to CS

How does science work?

- Where does science begin and end?
- Which kinds of activity count as science?
- Lot of **disagreement**
  - Not about **clear cases** (the work done by physicists when they test hypotheses is science while playing a game of basketball is not)
  - But about **grey areas** (in the past: classification of economics and psychology; in the present: classification of anthropology)
- Science is a rhetorically loaded term
- **Different conceptions** of science (in the philosophical theories)
  - General understanding of how humans gain knowledge of the world around them (**broad meaning**)
  - Understanding of what makes the work descended from the Scientific Revolution different from other kinds of investigation of the world (**narrow meaning**)

Three answers

- How does science work?
- Three answers, or pieces of an answer
- Rivals, alternative starting points, or paths into the problem
  - **Empiricism**
  - **Mathematics and science**
  - **Social structure and science**

Empiricism

- Empiricism: the only source of real knowledge about the world is **experience**
- Empiricism and science: the only source of real knowledge about the world is experience, but **science** is especially successful because is **organized**, **systematic**, and especially **responsive to experience**
- Problem: direct empirical tests are no guarantee of success (see history of science)
- Role of experience more fundamental than that of reasoning in making sense of what we observe

Mathematics and science

- What makes science different from other kinds of investigation, and especially successful, is its attempt to understand the natural world using **mathematical tools**
- Peculiarity of science as an attempt to **quantify phenomena** and detect **mathematical patterns** in the flow of events
- Alternative view to empiricism or view that can be combined with it (see Galileo Galilei)
- Are we really sure that all of science makes use of mathematics to understand the world (Darwin's *On the Origin of the Species*)?

Social structure and science

- What makes science different from other kinds of investigation, and especially successful, is its unique **social structure**
- Elaborate networks of **cooperation** and **trust**
- Balance of **cooperation** and **competition**
- A great deal of what went on in the Scientific Revolution had to do with working out new ways of policing, controlling, and coordinating the actions of groups of people in the activity of research

Practical info

- http://home.deib.polimi.it/schiaffo/TFI/
- Slides and reading materials (syllabus)

Date	Topics	Slides and Reading Material
1. Monday February 25th	**Course introduction**	"Computing: The Fourth Great Domain of Science" (P. Denning, P. Rosenbloom)
2. Thursday February 28th	**Science, paradigms and scientific revolutions**	
Thursday April 26th	**NO CLASS (HOLIDAYS)**	
14. Monday April 29th	**AI and Ethics**	"What is Computer Ethics?" (J. Moore)
15. Thursday May 2rd	**Invited lecture by Federico Cabitza (Università degli Studi di Milano Bicocca)**	
16. Monday May 6th	**Final project assignment and discussion**	

Exam

- Grading will be on the following basis
  - 50% final essay (English or Italian)
  - 50% oral discussion on the papers published on the course web-page (English or Italian)
- You have to deliver you essay at least one week before the oral exam
  - **Exam June 23** (TBC) 2020 – paper due June 16 2020
  - **Exam July 8** (TBC) 2020 – paper due July 1 2020

More on practical info

- No prerequisite required
- Bibliography
  - Scientific papers available on the course web page
- Timetable
  - Mo 10:15-12:15
  - Thur 10:15-12:15

References

- Colburn, T. (2004) “Methodology of Computer Science”, *Philosophy of Computing and Information*, Luciano Floridi (ed.), 318-326
- Denning, P. et al. (1989) “Computing as a discipline”, *Communications of the ACM* 32(1): 9-23
- Newell, A., Simon, H. (1976) “Computer Science as Empirical Inquiry: Symbols and Search” *Communications of the ACM*, 19:3, 113-126

More questions?

Please use the chat

End of the lecture

- **Introduction** to the course Philosophical Issues of Computer Science: **topics and methods**
  - What is Computer Science?
  - What is Science?
- You can find the **slides of this lecture** http://home.deib.polimi.it/schiaffo/TFI/syllabus.html
- We'll meet again **Monday March 9** (no class Thursday March 5 – graduation day)
  - From science to **technology** and **engineering**