Science of Computers: Epistemological Premises

Autonomous Systems

Sistemi Autonomi

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1. How Much Science in Computer Science?
2. How Much Science in MAS?
3. On The Notion of Definition
Outline

1. How Much Science in Computer Science?
2. How Much Science in MAS?
3. On The Notion of Definition
A general definition of scientific activity might be not enough

- Hard & soft sciences typically deal with worlds that are given, and have to be understood, modelled, and possibly predicted in their behaviour.
- “Computational worlds” have to be both modelled and constructed.
- Concepts, methods, and tools from other sciences, and from “classical” epistemological approaches are surely essential, but might not suffice.
What is peculiar to Computer Science?

- Formal models should follow the same “lines” as, say, mathematical or logical formalisations.
- Models of the physical systems should follow the same approach as, say, models in Physics.
- However, the core of computational systems is human-designed, and obeys to human-conceived laws—unlike, say, physical or biological systems.
Science vs. Engineering I

Science

- Science is concerned with *understanding* the world where we do live
- Science deals then with two main activities: *explaining* and *predicting*
- The ability to explain known phenomena, and to predict yet-to-come ones are two essential features of Western science as we know it today
- So, scientists are concerned with devising out *models* of the world that can explain and predict
Engineering

- Engineering (as a general discipline) exploits both scientific models and empirical experience to *build* new *artefacts* that could *change* the world where we do live.
- Where empirical experience is essentially constituted by known phenomena that scientific models have not (yet) fully explained.
- Engineering disciplines develop new techniques and methods to produce artefacts that have the potential to change our environment and the way in which we live interact within it.
- So, engineers are concerned with developing new *technologies*, *methodologies* and *tools* affecting human environment.
Computer Science

- Computer science is concerned with *computational models*, explaining and predicting the behaviour of computational units.
- So, computer scientists should be concerned with devising out *models* of the computational world.
Computer Engineering

- Computer engineering deals with building new computational artefacts (programs, applications, ...) changing the computational world—and indirectly, the world where we do live.

- So, computer engineers are concerned with developing computational technologies, methodologies and tools for constructing suitable computational environments—so, programming languages, software engineering methods, developing tools...
The Novel Issue

- Computational artefacts change the computational world and call for new computational models in a never-ending *spiral*.
- So, the activities of computer scientists and engineers are permanently interwoven and mutually *interdependent*—with permanent and mutual scorn of those trying to devise out some non-existing separation.
- But... is this really new? Human machines produce new phenomena, or made existing ones observable.
- So, the main difference is that the world of computers is much more and much clearly human-generated—we play God, by defining the entities and the rules, in the World of Computers.
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Models Require Definitions

Out of the mess

- Many different & diverging definitions for the notion of agent around
- Typically, a list of not well-defined properties
- “Definitory” properties are often indistinguishable from desirable ones
- Orthogonality between defining features is not even considered

How should one choose / build a definition?

- We should first make clear what are the required / desirable properties of a definition
- Only after, try to define our entities
How Much Science in MAS?

Models & Meta-models

First step: defining the entities your models are built from

- An ontology is required
- The fundamental entities should be defined, along with their role and mutual relations
- Based on that, models should be conceived and built
- In their turn, providing the sound conceptual basis for technologies, methodologies, and tools
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What is a Definition? I

From Wikipedia

- A definition is a form of words (definiens) which states the meaning of a term (definiendum)
- Definition by genus and differentia
  - genus (the family) of things to which the defined thing belongs
  - differentia the features that distinguish the defined thing from other things of the same family
What is a Definition? II

Rules for definition by genus and differentia

- A definition must set out the *essential attributes* of the thing defined
- Definitions should *avoid circularity*
- The definition must *not be too wide or too narrow*
- The definition must *not be obscure*
- A definition should *not be negative* where it can be positive
Lex Parsimoniae [The14]

Pluralitas non est ponenda sine necessitate
(Plurality should not be posited without necessity)

Entia non sunt multiplicanda praeter necessitatem
(Entities are not to be multiplied beyond necessity)
Occam’s Razor

- The explanation of any phenomenon should make as few assumptions as possible, eliminating, or “shaving off,” those that make no difference in the observable predictions of the explanatory hypothesis or theory.

- In short, when given two equally valid explanations for a phenomenon, one should embrace the less complicated formulation.

- When multiple competing theories have equal predictive powers, one should select the one introducing the fewest assumptions and postulating the fewest hypothetical entities.
Definition in the Sciences of Artificial

Explanation vs. definition

- In the sciences of nature, *phenomena* are just to be observed, described, and possibly predicted, and *noumena* to be possibly understood
  - definition is just a premise to theory and explanation, to build up *models* for natural systems
- In the sciences of artificial, noumena are to be created
  - definition is the foundation for systems, and gives *structure* to *artificial worlds*
  - there, Occam’s Razor and the Lex Parsimoniae may apply to definition instead of theory and explanation
Lessons Learned: Definition by Genus and Differentia

Some rules of thumb

- **genus** A definition should clearly delimit the domain of discourse
- **differentia** A definition should allow what is in and what is out to be clearly determined
- **rules** A definition should follow the rules for definition by genus and differentia
  - essentiality, no circularity, neither wide nor narrow, no obscurity, no unneeded negativity
Lessons Learned: Occam’s Razor & Lex Parsimoniae

Other rules of thumb

minimal assumptions  A definition of an entity should make as few assumptions as possible

minimal complication  Given two equally valid definitions for an entity, one should embrace the less complicated formulation

lex parsimoniae  Definitions should not be multiplied beyond necessity
  - definitory features should not be multiplied beyond necessity
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