Agents: From Premises to Definition

Multiagent Systems LS
Sistemi Multiagente LS

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Outline

1. Epistemological Premises
   - How Much Science in Computer Science & MAS?
   - On the Notion of Definition

2. Agents: Definitions & Conceptual Framework
   - Autonomy
   - Definitions

What is Science in Computer Science?

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

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On the Notion of Definition

Out of the mess

- Many different & diverging definition 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

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- 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

Rules for definition by genus and differentia

- A definition must set out the essential attributes of the thing defined
- Definitions should avoid circularity
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- The definition must not be obscure
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Explanation in the Sciences of Nature

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

Lex Parsimoniae

Entia non sunt multiplicanda praeter necessitatem
(entities should not be multiplied beyond necessity)

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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

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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

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

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Lex Parsimoniae: Autonomy

- Autonomy as the only fundamental and definitory feature of agents
- Let us see whether other typical agent features follow / descend from this somehow

Computational Autonomy

- Agents are autonomous as they *encapsulate* (the thread of) *control*
- Control does not pass through agent boundaries
  - only data (knowledge, information) crosses agent boundaries
- Agents have no interface, cannot be controlled, nor can they be invoked
- Looking at agents, MAS can be conceived as an aggregation of multiple distinct *loci* of control interacting with each other by exchanging information

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(Autonomous) Agents (Pro-)Act

Action as the essence of agency

- The etimology of the word *agent* is from the Latin agens
- So, agent means "the one who acts"
- Any coherent notion of agency should naturally come equipped with a model for agent actions

Autonomous agents are pro-active

- Agents are literally active
- Autonomous agents encapsulate control, and the rule to govern it

→ Autonomous agents are pro-active by definition

  - where pro-activity means "making something happen", rather than waiting for something to happen

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Agents are Situated

The model of action depends on the context

- Any "ground" model of action is strictly coupled with the context where the action takes place
- An agent comes with its own model of action
- Any agent is then strictly coupled with the environment where it lives and (inter)acts
- Agents are in this sense are intrinsically *situated*

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Are Agents Reactive?

Situatedness and reactivity come hand in hand

- Any model of action is strictly coupled with the context where the action takes place
- Any action model requires an adequate *representation* of the world
- Any *effective* representation of the world requires a *suitable* balance between environment *perception* and representation

→ Any effective action model requires a suitable balance between environment perception and representation

  - however, any non-trivial action model requires some form of perception of the environment—so as to check action pre-conditions, or to verify the effects of actions on the environment

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Reactivity as a (deliberate) reduction of proactivity

- An autonomous agent could be built / choose to merely react to external events
- It may just wait for something to happen, either as a permanent attitude, or as a temporary opportunistic choice
- In this sense, autonomous agents may also be reactive

Reactivity to change

- Reactivity to (environment) change is a different notion
- This mainly comes from early AI failures, and from robotics
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(Autonomous) Agents Change the World

Action, change & environment

- Whatever the model, any model for action brings along the notion of *change*
  - an agent acts to change something around in the MAS
- Two admissible targets for change by agent action

agent an agent could act to change the state of another agent

environment an agent could act to change the state of the environment

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agent: an agent could act to change the state of another agent
- since agents are autonomous, and only data flow among them, the only way another agent can change their state is by providing them with some information
- change to other agents essentially involves *communication actions*

environment: an agent could act to change the state of the environment
- change to the environment requires *pragmatical actions*
- which could be either physical or virtual depending on the nature of the environment

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Autonomous Agents are Social

From autonomy to society

- From a philosophical viewpoint, autonomy only makes sense when an individual is immersed in a society
  - autonomy does not make sense for an individual in isolation
  - no individual alone could be properly said to be autonomous
- This also straightforwardly explain why any program in any sequential programming language is not an autonomous agent *per se* [Graesser, 1996, Odell, 2002]

Autonomous agents live in a MAS

- Single-agent systems do not exist in principle
- Autonomous agents live and interact within agent societies & MAS
- Roughly speaking, MAS are the only "legitimate containers" of autonomous agents

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Interactivity follows, too

- Since agents are subsystems of a MAS, they interact within the global system
  - by essence of systems in general, rather than of MAS
- Since agents are autonomous, only data (knowledge, information) crosses agent boundaries
- Information & knowledge is exchanged between agents
  - leading to more complex patterns than message passing between objects

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Autonomous Agents Do not Need *Exactly* a Goal

Agents govern MAS computation

- By encapsulating control, agents are the main forces governing and pushing computation, and determining behaviour in a MAS
- Along with control, agent should then encapsulate the *criterion* for regulating the thread(s) of control

Autonomy as self-regulation

- The term "autonomy", at its very roots, means self-government, self-regulation, self-determination
  - "internal unit invocation" [Odell, 2002]
- This does *not* imply in any way that agents *needs* to have a goal, or a task, to be such—to be an agent, then
- However, this *does* imply that autonomy captures the cases of goal-oriented and task-oriented agents
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- Along with control, agent should then encapsulate the *criterion* for regulating the thread(s) of control

Autonomy as self-regulation

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Goal-/Task-Orientedness is not a Definitory Feature for Agents

Example: finite-state automaton with encapsulated control

- An agent might be a finite-state automaton
- Encapsulating control as an independent thread
- Equipped with state transition rules
- The criteria for the govern of control would there be embodied in terms of (finite) states and state transition rules

Goal-orientedness and task-orientedness are just possible features for agents

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1. Epistemological Premises
   - How Much Science in Computer Science & MAS?
   - On the Notion of Definition

2. Agents: Definitions & Conceptual Framework
   - Autonomy
   - Definitions

"Weak" Notion of Agent

Four key qualities [Wooldridge and Jennings, 1995]

Weak agents are

- Autonomous
- Proactive
- Reactive (to change)
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Intelligence helps autonomy

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- Intelligence makes it easy for an agent to govern itself
- While intelligence is not mandatory for an agent to be autonomous
  - however, *intelligent autonomous agents* clearly make sense

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Mobility is an extreme form of autonomy

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"Strong" Notion of Agent

Mentalistic notion [Wooldridge and Jennings, 1995]

Strong agents have mental components such as

- Belief
- Desire
- Intention
- Knowledge
- ...

Intelligent agents and mental components

Intelligent autonomous agents are naturally (and quite typically) conceived as strong agents

Summing Up

Definition (Agent)

Agents are *autonomous computational entities*

genus agents are computational entities

differentia agents are autonomous, in that they encapsulate control along with a criterion to govern it

Agents are *autonomous*

- From autonomy, many other features stem
  - autonomous agents are interactive, social, proactive, and situated;
  - they *might* have goals or tasks, or be reactive, intelligent, mobile
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Agents: From Premises to Definition

Multiagent Systems LS

Sistemi Multiagente LS

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