

Agents: Definitions & Conceptual Framework

Distributed Systems

Sistemi Distribuiti

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1 Autonomy

2 Definitions



Outline

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2 Definitions



Autonomy as the Foundation of the Definition of Agent

Lex Parsimoniae: Autonomy

- Autonomy as the only fundamental and defining 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

(Autonomous) Agents (Pro-)Act

Action as the essence of agency

- The etymology 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

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*

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
- Agents in this sense are supposedly *reactive* to change

Are Autonomous Agents Reactive?

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
- It stems from agency, rather than from autonomy—as discussed in the previous slide
- However, this issue will be even clearer when facing the issue of artifacts and environment design

(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
 - 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

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

Autonomous Agents are Interactive

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

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
 - where goals and tasks play the role of the criteria for governing control

Goal-/Task-Orientedness is not a Defining 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

- They are not defining features anyway

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“Weak” Notion of Agent

Four key qualities [Wooldridge and Jennings, 1995]

Weak agents are

- Autonomous
- Proactive
- Reactive (to change)
- Social

Are Autonomous Agents Intelligent?

Intelligence helps autonomy

- Autonomous agents have to self-determine, self-govern, ...
- 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

Are Autonomous Agents Mobile?

Mobility is an extreme form of autonomy

- Autonomous agents encapsulate control
- At the end of the story, control might be independent of the environment where an agent lives—say, the virtual machine on which it runs
- *Mobile autonomous agents* clearly make sense
 - mobility, however, is *not* required for an agent to be autonomous

Do Autonomous Agents Learn?

Learning may improve agent autonomy

- By learning, autonomous agents may acquire new skills, improve their practical reasoning, etc.
- In short, an autonomous agent could learn how to make a better use out of its autonomy
- *Learning autonomous agents* clearly make sense
 - learning, however, is *not* required for an agent to be autonomous

“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

- 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
 - they live within MAS, and *interact* with other agents through *communication actions*, and with the environment with *pragmatical actions*

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