Intelligent Agents

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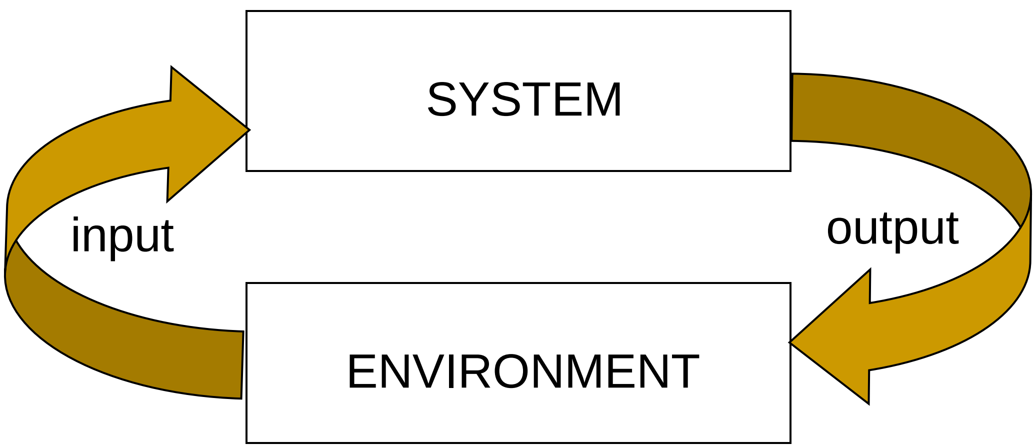
What is an Agent?

- The main point about agents is they are *autonomous*: capable of acting independently, exhibiting **control** over their internal state
- Thus: *an* agent *is a computer system capable of* autonomous action *in* ***some environment*** *in order to meet its* **design objectives**



What is an Agent?

- Trivial (non-interesting) agents:
  - thermostat
  - UNIX daemon (e.g., biff)
- *An* intelligent agent *is a computer system capable of* **flexible *autonomous action*** *in some environment*
- By *flexible*, we mean:
  - *reactive*
  - *pro-active*
  - *social*

Reactivity

- If a program's environment is **guaranteed to be fixed**, the program need never worry about its own success or failure – program just executes blindly
  - Example of fixed environment: compiler
- The real world is not like that: things change, information is incomplete. Many (most?) interesting environments are *dynamic*
- Software is **hard** to build for dynamic domains: program must take into account **possibility of failure** – ask itself whether it is worth executing!
- **A *reactive* system** is one that maintains an ongoing interaction with its environment, and responds to changes that occur in it (in time for the response to be useful)

Proactiveness

- Reacting to an environment is easy (e.g., stimulus $\rightarrow$ response rules)
- But we generally want agents to *do things for us*
- Hence *goal directed behavior*
- Pro-activeness = generating and attempting to achieve goals; <u>not driven solely by events</u>; taking the initiative
- **<u>Reco</u>**gnizing **<u>opportunities</u>**

Balancing Reactive and Goal-Oriented Behavior

- We want our agents to be reactive, responding to changing conditions in an appropriate (timely) fashion
- We want our agents to systematically work towards long-term goals
- These two considerations can be at **odds with one another**
- Designing an agent that can balance the two remains **an open** research problem

Social Ability

- The real world is a *multi*-agent environment: we cannot go around attempting to achieve goals without taking **others** into account
- Some goals can only be achieved with the cooperation of others
- Similarly for many computer environments: witness the Internet
- *Social ability* in agents is the ability to interact with other agents (and possibly humans) via some kind of ***agent-communication language***, and perhaps cooperate with others

Other Properties

- Other properties, sometimes discussed in the context of agency:
- *mobility*: the ability of an agent to move around an electronic network
- *veracity*: an agent will not knowingly communicate false information
- *benevolence*: agents do not have conflicting goals, and that every agent will therefore always try to do what is asked of it
- *rationality*: agent will act in order to achieve its goals, and will not act in such a way as to prevent its goals being achieved — at least insofar as its beliefs permit
- *learning/adaption*: agents improve performance over time

Agents and Objects

- Are agents just objects by another name?
- Object:
  - encapsulates some state
  - communicates via message passing
  - has methods, corresponding to **operations** that may be performed on this state

Agents and Objects

- Main **<u>differences</u>**:
  - *agents are autonomous:*
    agents embody <u>stronger notion of autonomy **than**</u> objects, and in particular, they **<u>decide</u>** for themselves whether or not to perform an action on request from another agent
  - *agents are smart:*
    capable of **<u>flexible</u>** (reactive, pro-active, social) behavior, and <u>the **standard object model** has nothing to say about such types of behavior</u>
  - *agents are active:*
    a multi-agent system is inherently multi-threaded, in that each agent is assumed to have **<u>at least</u>** one thread of active control

Objects do it for free…

- *agents do it because they* ***<u>want to</u>***
- *agents do it* ***<u>for</u>*** *…….*

Agents and Expert Systems

- Aren’t agents just expert systems by another name?
- Expert systems typically disembodied ‘expertise’ about some (abstract) domain of discourse (e.g., blood diseases)
- Example: **MYCIN** knows about blood diseases in humans
  - It has a wealth of knowledge about blood diseases, in the **form of rules**
  - A doctor can obtain expert advice about blood diseases by giving MYCIN facts, answering questions, and posing queries

Agents and Expert Systems

- Main **<u>differences</u>**:
  - agents ***<u>situated in an environment</u>**:*
    MYCIN is not aware of the world — only information obtained is by asking the user questions
  - agents ***<u>act</u>**:*
    MYCIN does not operate on patients
- **<u>Some</u>** *real-time* (typically process control) expert systems *are* agents

Intelligent Agents and AI

- Aren’t agents just the AI project?
  Isn’t building an agent what AI is all about?
- **<u>AI</u>** aims to build systems that can (ultimately) understand natural language, recognize and understand scenes, use common sense, think creatively, etc. — **<u>all of which</u>** are very hard
- So, <u>don’t we need to solve all of AI</u> to build an agent…?

Intelligent Agents and AI

- When building an agent, we simply want a system that can choose the right action to perform, typically in a limited domain

- We *do not* have to solve *all* the problems of AI to build a useful agent:

  a little intelligence goes a long way!

Environments – *Accessible* vs. *inaccessible*

- **An accessible** environment is one in which the agent can obtain complete, accurate, up-to-date information about the environment's state
- Most moderately complex environments (including, for example, the everyday physical world and the Internet) are **inaccessible**
- The more accessible an environment is, the simpler it is to build agents to operate in it

Environments –
Deterministic vs. *non-deterministic*

- A **deterministic** environment is one in which any action has a single guaranteed effect — there is no uncertainty about the state that will result from performing an action
- The physical world can to all intents and purposes be regarded as **non-deterministic**
- Non-deterministic environments present greater problems for the agent designer

Environments - *Episodic* vs. *non-episodic*

- In an **episodic** environment, the performance of an agent is dependent on a number of discrete episodes, <u>with no link between </u>the performance of an agent in different scenarios
- Episodic environments are simpler from the agent developer's perspective because the agent can decide what action to perform based only on the <u>**current**</u> episode — it need not reason about the interactions between this and future episodes

Environments - *Static* vs. *dynamic*

- A **static** environment is one that can be assumed to remain unchanged except by the performance of actions by the agent
- A **dynamic** environment is one that has other processes operating on it, and which hence changes in ways beyond the agent’s control
- Other processes can interfere with the agent’s actions (as in concurrent systems theory)
- The physical world is a highly dynamic environment

Environments – *Discrete* vs. *continuous*

- An environment is **discrete** if there are a fixed, finite number of actions and percepts in it
- Russell and Norvig give a chess game as an example of a discrete environment, and taxi driving as an example of a continuous one
- **Continuous** environments have a certain level of mismatch with computer systems
- Discrete environments could *in principle* be handled by a kind of "lookup table"

Agents as Intentional Systems

- When explaining human activity, it is often useful to make statements such as the following:

  Janine took her umbrella because she *believed* it was going to rain.

  Michael worked hard because he *wanted* to possess a PhD.
- These statements make use of a *folk psychology*, by which human behavior is **predicted** and **explained** through the **attribution of *attitudes***, such as **believing** and wanting (as in the above examples), **hoping**, **fearing**, and so on
- The attitudes employed in such folk psychological descriptions are called the *intentional* notions

Agents as Intentional Systems

- The intentional notions are thus *abstraction tools*, which provide us with a convenient and familiar way of describing, explaining, and predicting the behavior of complex systems
- Remember: most important developments in computing are based on new *abstractions*:
  - procedural abstraction
  - abstract data types
  - objects

  Agents, and agents as intentional systems, represent a further, and increasingly powerful abstraction
- So agent theorists start from the (strong) view of agents as intentional systems: one whose simplest consistent description requires the intentional stance