# LECTURE 1

# Introduction to Multiagent Systems

**Course description, requirements, and grading available [here]**

## SUMMARY



## 1. Introduction

**Artificial Intelligence**

- **Symbolic AI**
  - symbolic representation of knowledge
  - logic, expert systems, rule based systems,…
- **Computational Intelligence**
  - numerical representation of knowledge
  - fuzzy systems, evolutionary computation, ML, **MAS**

**Application domains**

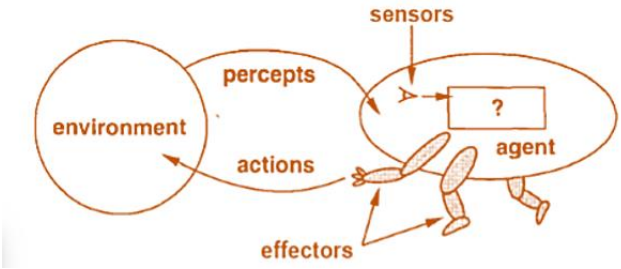
- medicine
- bioinformatics
- software engineering (*Search-based software engineering* - SBSE)
- psychology
- financial
- *e-business*: e-commerce, e-banking, e-gambling, etc
- computer vision
- ….

**Distributed Artificial Intelligence (DAI)**

- a research and application field which brings together and draws on results, concepts and ideas from many disciplines, including:
  - AI
  - SE
  - Sociology
  - Economics

- Organization and management science
- Philosophy
- Game theory
- Social sciences
- …

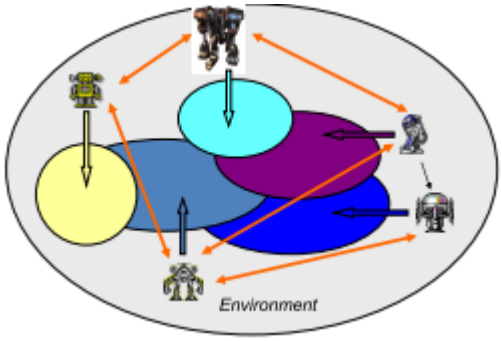
– the study, construction and application of **multiagent systems (MAS)**, that is, systems in which several interacting (intelligent) agents pursue some set of goals or perform some set of tasks.
  - **agent**
    - model the concept of human agent
    - computational entity such as a software program or a robot that can be viewed as perceiving and acting upon its environment
    - perception through **sensors**, actions through **effectors**/**actuators**
    - acts **autonomously** on behalf of their users




[https://www.educba.com/agents-in-artificial-intelligence/]

- **agents?**
  - **human agent**
    - eyes, ears, skin, etc. for **sensors**
    - hands, fingers, legs, mouth, etc. for **effectors**
    - powered by **muscles**
  - **robot**
    - camera, infrared, etc. for **sensors**
    - grippers, wheels, lights, speakers for **effectors**
    - often powered by motors
  - **software agent**
    - **functions** as **sensors**
      - information provided as input in the form of encoded bit strings or symbols
    - **functions** as **effectors**
      - results deliver the output

  - **MAS**
    - multiple agents in a common environment




- 1975-1980
- distributed (descentralized) solutions to AI problems
- directions
    - DPS (distributed problem solving)
        - field of DAI in which the objective lies in getting individual agents to work and interact with each other in order to solve problems that require a collective effort
    - traditionally there are two disciplines in DAI
        - MAS
            - in which several agents coordinate their knowledge and activities and reason about the processes of coordination.
            - initial work on behaviour coordination.
            - **toy problems** from the Agent/MAS domains
                - robotic football
                - predator and prey problem
                - Wumpus agent
                - Vacuum cleaning agent
        - DPS
            - the work of solving a particular problem is divided among a number of nodes that divide and share knowledge about the problem and the developing solution.
            - Characteristics
                - speed up the solution process
                - expertise and problem solving may be distributed
                - the knowledge may be distributed
                - the solution may need to be distributed in order the solution to be executed
            - initial work on task decomposition and solution synthesis.
        - DPS $\leftrightarrow$ MAS

**Agents**

- an important research and development area in the field of Computer Science and of AI
- are considered a new important way in conceptualization and implementation of different kind of applications
- agents vs. **intelligent** agents
- are related to other programming paradigms (e.g. OOP) $\rightarrow$ the **agent oriented programming paradigm** (AOP)

- agent-oriented techniques represent exciting new means of analysis, designing and building complex software systems.
- are a new paradigm for developing software applications
- **agent based computing** has been hailed as a "new revolution in software"
- **applications**
  - **industrial applications**
    - process control (robotics)
    - manufacturing (intelligent manufacturing, ERP, BPM)
    - air traffic control
  - **commercial applications**
    - information management
    - electronic commerce
    - business process management
      - viewing a BP as a society of negotiating, service providing agents
  - **medical applications**
    - patient monitoring
    - health care
  - **sciences**
    - geography (GIS – *geographical information systems*)
    - meteorology
      - weather forecasting, climatology, etc
  - **entertainment**
    - games
    - interactive theater and cinema
  - **other**
    - web mining, information retrieval, data mining, search engines, etc
- **agents** are frequently used nowadays in:
  - sociology, biology
  - cognitive psychology
  - social psychology
  - computer science

- **emotional agents**
  - affective computing

**DAI – Agents**

- the long term of **DAI** is to develop methods and mechanisms that enable **agents** to interact as well as humans (or even better) and to understand the interaction among intelligent entities wheathet they are computational, human or both
- the goal raises a number of challenging issues that are all centered around the elementary question of "WHEN and HOW to interact with WHOM"

**DAI – traditional AI**

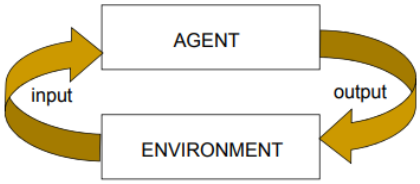
- both DAI and traditional AI deal with computational aspects of intelligence, but they do so from different points of view

| Traditional AI | DAI |
|---|---|
| Cognitive processes within individuals | Social processes in groups of individuals |

| | |
|---|---|
| Concentrates on agents as "*intelligent stand-alone systems*" and on **intelligence** as a property of systems that act in isolation | Concentrates on agents as "*intelligent connected systems*" and on **intelligence** as a property of systems that interact |
| **DAI** is a generalization of traditional **AI** | |

## 2. Agents

- continuous interaction with the environment
- sensor input, action output




**An agent in its environment. The interaction between the agent and the environment is usually an ongoing, non-terminating one.**

- One of the agent tasks/goals is to assist the user by making tasks for him, or teaching the user what he has to do
  - It has to successfully accomplish the task it was delegated to do

- **What an agent is?**
  - there is no such an agreement
  - there is no universally accepted definition of the term agent
  - there is a general consensus that **autonomy** is central to the notion of agency
  - An agent is a computer system that acts in behalf of a user, it is situated in some environment and that is capable of **autonomous** action in this environment, in order to meet its design objectives.
    1. **autonomy**
       - agents are able to act without intervention of humans or other systems, they have **control** both over their **internal state** and over their behavior.
- **Why agents?**
  - **delegation**
    - computers perform tasks for us, autonomously (without our intervention)
    - *give control* to computers
      - fly-by-wire aircrafts
      - fly-by-wire cars
      - intelligent braking systems
      - cruise control systems
      - etc

  - **programming progression**
    - programming has progressed

    machine code → assembly language → machine-independent programming languages → sub-routines → procedures and functions → ADTs → objects → **AGENTS**

- **[intelligence]**
  - implement a rational/intelligent behavior

- **Delegation + Intelligence** ⇒ the need to build computer systems that can act effectively on our behalf to accomplish the tasks we delegated to them
  - ability of computer systems to act *independently*
  - the ability of computer systems to act in a way that represents our best interests while interacting with other humans/systems

- **Examples of trivial agents**
  - a **control system** (e.g. thermostat)
  - **software daemons**
    1. background processes in an operating system which monitor a software environment and perform actions to modify it
       - actions: software actions (e.g. changing an icon on the screen, executing a program, etc)
    2. e.g. **biff** command (UNIX)

## 3. Characteristics/properties of agents

- an **agent** is characterized by
  - an **architecture part**, named the behavior of the agent
    1. the action accomplished after a perceptual sequence
  - the **program part,** the internal part of the agent
    1. the task of AI is to develop the program part of the agent
    2. a function that implements the way to pass from perception to action
    3. the program part of an agent may be summarized as

**Function** AGENT-PROGRAM (*p*: Perception) **returns** an **Action**
**static:** *memory*

*memory* ← **UPDATE-MEMORY (***memory***,** *p*)
*a* ← **CHOOSE-OPTIMAL-ACTION (***memory*)
*memory* ← **UPDATE-MEMORY (***memory***,** *a*)

returns *a*
**EndFunction**

**Skeleton of an agent [2]**

- **performance measure** (conceptually is outside the **agent**)
  - evaluates the success of the agent's performance

- an **agent** is one that is capable of flexible autonomous actions in order to meet its design objectives
  - **flexibility**
    1. **reactivity:** the ability to perceive their environment and to respond to changes that occur in it

2. **pro-activeness**: ability to exhibit a ***goal-directed behavior*** by taking the initiative in order to satisfy their design objectives
    - behavior not driven only by events, but capable of generating goals and acting **rationally** to achieve them
    - **rationality**
        - reasonable/acceptable decisions
            - agents select actions that make sense from the point of view of the information possessed by the agent and its goals (or the task for which it was designed)
        - in some situations (e.g. dynamic environments) **learning** is needed for preserving the agents' rationality
            - **learning** agents – **intelligent** agents
    - *rational agent* – selects actions to maximize the performance measure
    - *ideal rational agent*
        - for each possible percept sequence, such an agent selects the action that maximizes its performance measure
3. **social ability**
    - agents are capable of interacting with the agents (and possible humans) in order to meet their design objectives

## 4. Intelligent agents

- an **intelligent agent** must be endowed with:
    - an initial knowledge
    - the capability of **learning**
        - the **learning** capability assures the autonomy of the agent – the capability to deduce its behavior from its own experience
        - the agents that operate based only on their initial knowledge are not autonomous
            - they will act successfully only if their knowledge remains valid, loosing their **flexibility**
- an **intelligent agent** usually has a utility function, a measure of its actions' performance
    - $u$: *States* $\rightarrow \Re$
        - $u$ associates to an environment state a real number (a measure of the state's success degree)
        - the agent prefers, at a given moment, the state having the maximum *utility*

**Bibliography**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[2] Șerban Gabriela, *Sisteme Multiagent în Inteligenta Artificiala Distribuita. Arhitecturi si Aplicatii*, Editura RisoPrint, Cluj-Napoca, 2006

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