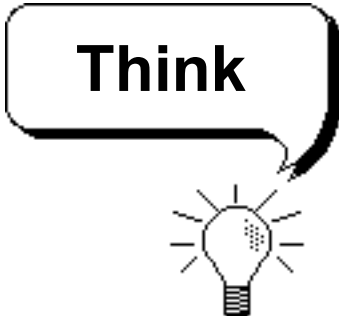
ARTIFICIAL INTELLIGENCE



ARTIFICIAL INTELLIGENCE

Eugénio Oliveira

Ana Paula Rocha
Henrique Lopes Cardoso

Sitio web institucional
Sítio web específico: http://paginas.fe.up.pt/~eol/IA/ia1415.html

ARTIFICIAL INTELLIGENCE

GENERIC GOALS OF THE COURSE:

BUZZ WORD

Going to a "new continent" of knowledge!
3 key words:

* KNOWLEDGE
* LOGIC (more than Data)
* ENGINEERING/ TECHNOLOGY (besides Science)

Objectives:

* TO LEARN	new	METHODS for problem solving
* USE	other	TECHNIQUES for implementing systems
* DEVELOP	different	PROGRAMS for solution search

Conclusion: TO LEARN new ways of **solving Problems** **(usually complex)** that need specific KNOWLEDGE

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Artificial Intelligence

I-INTRODUCTION TO ARTIFICIAL INTELLIGENCE

Methods and Objectives:

They are specific, although intersecting other areas: Computer Science, Cognitive Science, Neurosciences, Economics, Sociology, Psychology, Electronics,…

Scientific and technologic aspects

In the domains of Programming, Algorithmic, Systems Analysis, Sensors and other Engineering topics.

Methodologic weaknesses

Lack of formalization for certain topics, regardig both theory and methods proposed to design and implement "**Intelligent**" Systems.

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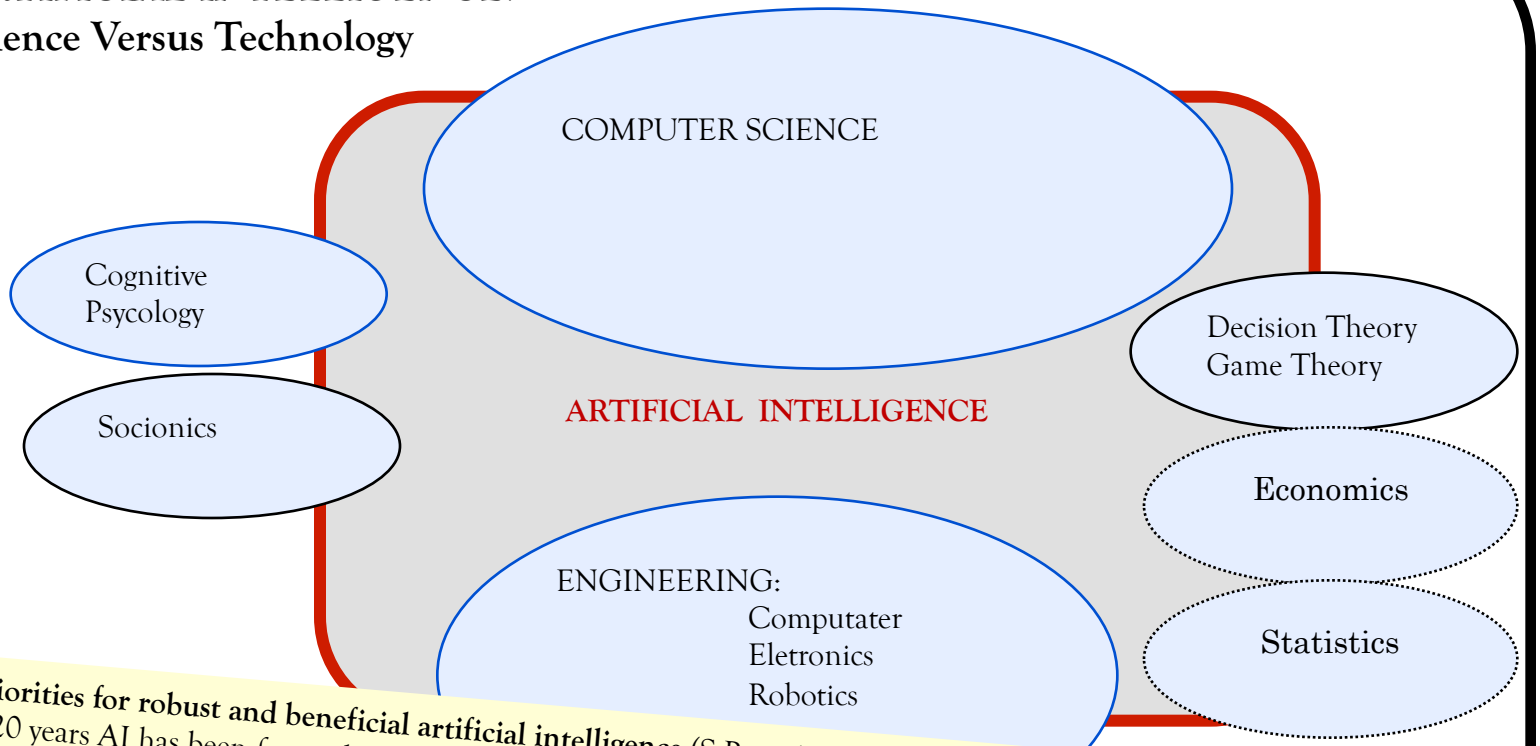
ARTIFICIAL INTELLIGENCE

ARTIFICIAL INTELLIGENCE:
Science Versus Technology



Research priorities for robust and beneficial artificial intelligence (S.Russel et al. Jan2015)
for the last 20 years AI has been focused on the problems surrounding the construction of intelligent *Agents* - systems that perceive and act in some environment. In this context, the criterion for intelligence is related to statistical and economic notions of **rationality** - colloquially, the ability to make good decisions, plans, or inferences.

ARTIFICIAL INTELLIGENCE

Definitions

" **Artificial Intelligence** studies those ideas that, when implemented in the computer make it possible to reach the same objectives that make people seem intelligent".

" More specifically, AI tries to make computers more useful and, simultaneously, studies those principles that make intelligence possible"

Patrick Winston: ex-director of AI Lab at M.I.T.

Comments > ambiguous (definition contains what is being defined);

> "Lapalice-like" kind of statement (computers become more useful).

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"AI area presupposes the existence of processes on which perception and reasoning rely and that these processes may be scientifically studied and understood. Besides, it is absolutely irrelevant for the theory of AI who (or what) "perceives" or "thinks" - man or computer. This is an implementation detail ..."

N. Nilsson ex-director of Stanford Research Institut; Stanford Robotics Lab.

Comment:> polemic. AI deviate , at least for a certain time period, from this paradigm in order to become more realistic and more independent from the way human brains work.

NOW: Back to the fundamentals

ARTIFICIAL INTELLIGENCE

"**AI** is the study of those processes that make it possible the computers to **execute** tasks for which, at the moment, **people** is more **effective**."

E. Rich.

Coment:> Vague. Incomplete. But closer to the real truth in its simplicity

ARTIFICIAL INTELLIGENCE

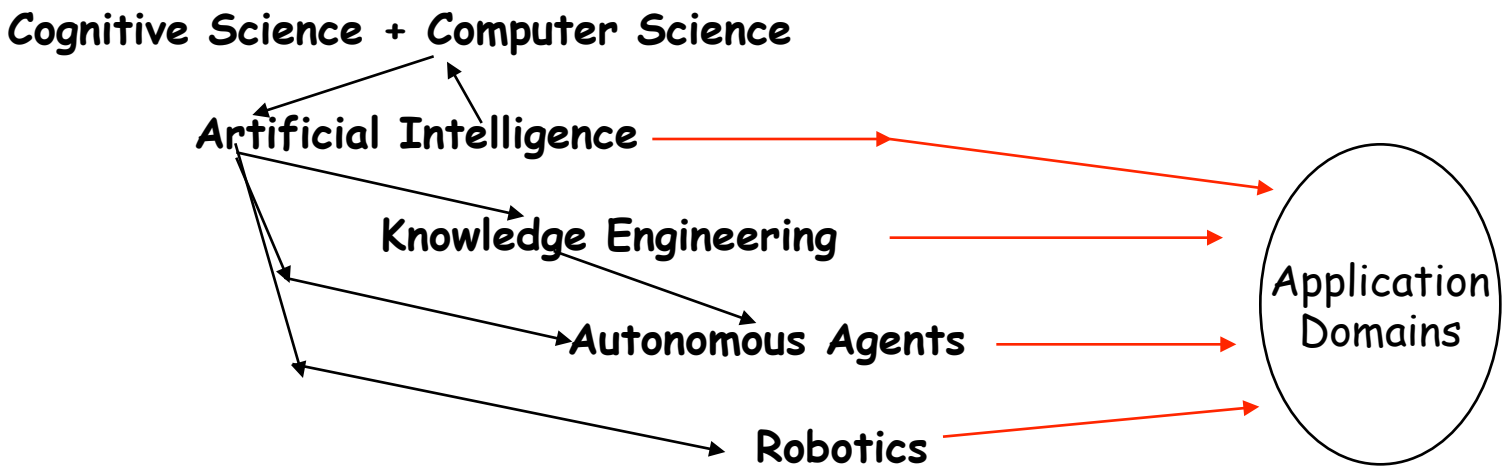
Another Definition:

Artificial Intelligence is a scientific discipline whose fundamental aim is to develop computational **systems** capable of showing operational Behaviours that are similar to those of the humans in stereotyped situations.

Techniques of **programming** used, like non-deterministic **search**, are based, at least partially, on **declarative** languages, namely logic-based, functional or at least, object-oriented.

ARTIFICIAL INTELLIGENCE

- **EVOLUTION:**



- **DIFERENTIATION:**

Artificial Intelligence for:

i) **Complex** problems

ii) Reasoning Models

ARTIFICIAL INTELLIGENCE

Artificial Intelligence Definitions organized in 4 categories

Think	Make Machines think…	Computational *Models* to **study** the rational mind
Act	Machines that **execute** tasks that require intelligence	To study *computational* ***processes*** to simulate intelligence
	humans	rationality

Syst. that "Think" like Humans	Syst. that "Think" rationally
Syst. that "Act" like Humans	Syst. that "Act" rationally

ARTIFICIAL INTELLIGENCE

CRONOLOGICAL SYNOPSIS

"Pré-Historical" | 1956 Classic | 1962 Romantic | 1974 Pragmatic | 1982 Difusion/Integration | Refounding 1990 | Antropomorfi 2000

Philosophy(Logics)
Matematics : Boole
Frege
Psycology: Behaviorism
Cognitivism
(experimentalisme W. James)

Cybernetics

Turing test
Information Theory
(Shannon)

Artificial Neuron Model
(McCulloch & Pits)

Neural Computation
Minsky PhD thesis)

Logic Theorist and G.P.S.
(Newell&Simon&Shaw)

(IBM) Geometry P.S.

Game of Chekers
(A. Samuel)

LISP, Time-sharing
(McCarthy)

Search+ Knowledge
(advice taker)

Reaserch Groups:
MIT (Minsky)
U.Stanford (McCarthy)

Robotics("Shakey")
Integral Calculus(SAINT)
Grammar SIR (B.Raphael)
Perceptron (Rosenblatt)
Eliza
Minsky & Papert and
Perceptron polemics
Resolution Principle
(A.Robinson)

Pattern Recognition gets out

HEARSAYII- Blackboard

Knowledge Engineering
(Feigenbaum)
Dendral
Expert Systems:
MYCIN
Uncertainty Reasoning
Probabilistic :
Prospector

Frames (Minsky)

PROLOG (Colmerauer)
Tom Mitchell at
Stanford, "Cdoncepts
Formation (ML)

5th Generation Computers
(MITI)
Hdw dedicated:
"Fuzzy" control

ESPRIT

Neural Networks

Reactive Robotics
(Brooks)

KBS
In practice
SOAR - Newell

Machine Learning

Software Agents

Distributed AI
Multi-Agent Syst.

Cognitive Ag

AI + Web

Deep Blue

COG at MIT
Humanoide Robot
(R.Brooks)

Emocional
Agents
KISMET

Robotic
Agents

Networked
/ Social
Intelligence
s

Data & Text
mining

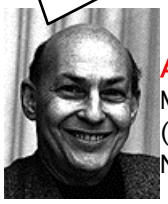
Semantics
For NL and,
Web

E-
Business
Intelligenc
e

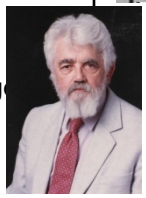
Mentalisti
c
Agents
Deep
Learning

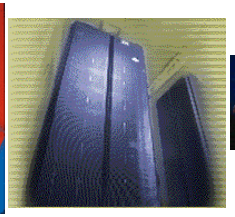
Bringing Common Sense, Expert Knowledge, and Superhuman Reasoning to Computers

What is more popular now in AI? Statistic-al Learning. You are killing yourself scientifically



AI is born:
Meeting at Dartmouth Colleg
(Minsky, McCarthy, Simon,
Newell, Shannon,..).





ARTIFICIAL INTELLIGENCE

INTRODUCTION TO ARTIFICIAL INTELLIGENCE SYLLABUS

I INTRODUCTION

Objective
Methodology (teaching and assessment)
AI Evolution and Chronology
Documentation

II BASIC CONCEPTS

Definitions: what is AI?
Applications: what domains?
Agent Basic Definitions
Agent Architectures : from Reactive to Cognitive

III PROBLEM SOLVING METHODS

"Production" Systems
Control Strategies for Systematic Search
Forward and Backwards Chaining (Depth-first and Breadth-first)
Irrevocable Search: "hill climbing" and "Simulated Annealing"
Search by trial: "backtracking; Graph search
"Branch and Bound"

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III PROBLEM SOLVING METHODS (cont.)

Evolutionary Computation (Genetic Algorithms)
Heuristic Search : "Best-First"
A* Algorithm and admissibility
Means-Ends Analysis
Constraint Satisfaction: "Relaxation" Principles
** Search for "Games": Minmax algorithm
Alfa-Beta pruning
Prolog examples of basic methods:
Interpreters breadth-first and depth-first

** Students Oral presentation and mini-test assessment in the class

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IV INTRODUCTION TO KNOWLEDGE REPRESENTATION

Representation Systems definition

Structures for representing knowledge:

Production Rules; Assotiative Networks (Semantic Networks)

"Frames";

Predicate Logic; Other Logics

Uncertainty Reasoning:

Probabilistic Models;

Certainty Factors;

Dempster-Schafer Model;

** Fuzzy Sets Logic

Logics: Propositional Logic, Predicate Logic; Intentional Logic (mention)

**** Students Oral presentation and mini-test assessment in the class**

V KNOWLEDGE ENGINEERING

KBS

Expert Systems:

Charaterization

Architecture

Knowledge Representation and Meta-knowledge

Inference Motor and Explanation Generation

Expert Systems Case studies:

ORBI; SMYCIN; ARCA

Demonstrations

Generic Systems: "Shells"

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VI INTRODUCTION TO COMPUTATIONAL NATURAL LANGUAGE

Objectives and difficulties

Syntactic and semantic Analysis
ATN; Semantic Networks; "Frames"; typical cases (mention)
Classic approach and use of Logic:
Definite Clause Grammars; a few examples in Portuguese
Extraposition Grammars

VII INTRODUCTION TO MACHINE LEARNING

Learning modes

Concepts learning; by example; by analogy
Explanation Based Learning (EBL) :
Algorithms for EBG, mEBG and IOL;
Examples
Inductive Learning: Algorithms ID3 and C4.5
Application Examples

VIII INTRODUCTION TO NEURAL NETWORKS

Basic Principles and Concepts
** fundamental Algorithms
Application Example

** Students Oral presentation and mini-test assessment in the class

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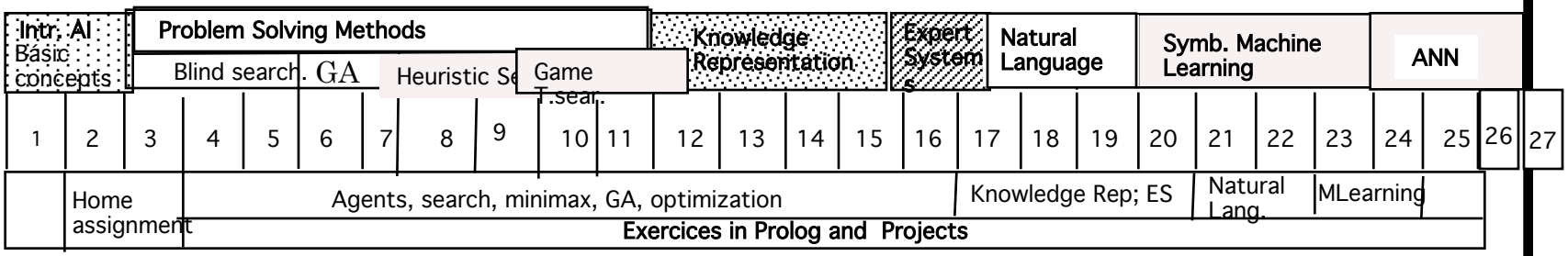
SCHEDULE



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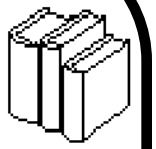
BIBLIOGRAPHY for Artificial Intelligence

***Notes* available at the course web site- Eugénio Oliveira**



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- "ARTIFICIAL INTELLIGENCE" E. Rich; K. Knight, 2nd Ed., MacGraw-Hill, 1991
- "C4.5-Programs for Machine Learning" Ross Quinlan,Morgan Kaufmann,1993
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- "INTELIGÊNCIA ARTIFICIAL-Fundamentos e Aplicações " E.Costa, A.Simões; FCA editores, 2004

- **JOURNALS:**

- "Autonomous Agents and Multi-Agent Sytems", Springer
- "ARTIFICIAL INTELLIGENCE" Elsevier-North-Holland
- "IEEE EXPERT"
- "MACHINE LEARNING" Kluwer A.P.

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ARTIFICIAL INTELLIGENCE

Mini-Projects home assignments

A. Pesquisa Sistemática/Informada de Soluções (SEARCH)

A1. Pesquisa de **trajetos** em redes de transportes públicos

A2. Trajeto de um **robô** em ambiente conhecido

A3. Pesquisa aplicada ao Problema de Alocação de Lotes de Terreno

A4. Pesquisa aplicada à resolução do jogo Rush

A5. Pesquisa aplicada à resolução do Solitário Sokoban

*Métodos: Pesquisa em Profundidade, Largura, Profundidade Iterativa, Bidireccional, Gulosa, **Algoritmo A***, Heurísticas*

- ## B. Resolução de Problemas de Otimização (Optimization)

B1. Otimização de **Corte** de Placas de madeira/vidro

B2. Otimização do Problema de **Alocação** de Lotes de Terreno

B3. Otimização de **Horários** de Motoristas dos STCP

B4. Otimização da Localização de Prontos-Socorro numa Cidade

B5. Aplicação de Algoritmos Genéticos para localização de uma Barragem

*Métodos: Pesquisa Sistemática/Informada, Algoritmos **Genéticos**, Pesquisa Tabu, **Arrefecimento** Simulado*

A few will be changed

ARTIFICIAL INTELLIGENCE

Mini-Projects home assignments

C. Games Tree Search

C1. Jogo de Tabuleiro – Tic-Tac-Ku
C2. Jogo de Tabuleiro – Yinsh
C3. Jogo de Tabuleiro – Hex
C4. Jogo de Tabuleiro – Blockade
C5. Jogo de Tabuleiro – Samurai de Reiner Knizia

A few will be changed

*Métodos: Algoritmo MiniMax com Cortes **Alfa-Beta** e variações deste*

D. Knowledge Engineering and Natural Language

D1. Desenvolvimento de uma "**Shell**" (com fuzzy)
D2. Sistema de **Regras** para controlo de dispositivos de Domótica, usando Jess
D3. Informações sobre voos da TAP em **Linguagem Natural**
D4. Informações sobre Filmes de Cinema em Cartaz em Linguagem Natural
D5. Informações sobre Restaurantes na cidade do Porto em Linguagem Natural

*Métodos: Representação do Conhecimento, Raciocínio **Incerto**, **Sistemas Periciais**, **Linguagem Natural***

ARTIFICIAL INTELLIGENCE

Mini-Projects home assignments

E. Machine Learning and Artificial Neural Networks

E1. **Reconhecimento** de Sinais de Trânsito utilizando Redes Neuronais

E2. Aplicação de ID3 ou C4.5 à **classificação** de Área Destruída em Incêndio

E3. **Previsão** de Área destruída num incêndio utilizando Redes Neuronais

E4. Aplicação de ID3 ou C4.5 à classificação da Qualidade de Vinhos Verdes

E5. Previsão da qualidade de um Vinho Verde utilizando Redes Neuronais

*Métodos: Algoritmos de Aprendizagem **ID3 e C4.5, Redes Neuronais** Artificiais*

ARTIFICIAL INTELLIGENCE

GRADING

- **Grading calculation:**
  - Exam **50% (minimum 7,5 in 20)**
  - Continuous learning **50% % (minimum 7,5 in 20)**
    - » Report + **Intermediate work** **15%**
    - » **Final** Report **15%**
    - » Participation and mini-tests in the classes **30%**
    - » Final home work presentation **40%**

GRADING

- Course effort in ECTS = 6 ECTS
- 1 ECTS ~ 26-27H
- Total ~ 156-162 H

• Classes (T +TP):	64h (4h*16s)
• Project:	50h
• Study + Exam preparation	44h

ARTIFICIAL INTELLIGENCE

TECHNICS

SIMPLE EXAMPLES and intuitive approaches "AI oriented" (GOFAI):

1	2	0
0	1	0
0	0	0

O	X	
	O	

A- search:
"Tic-Tac-Toe" Game

Traditional approach:
-Simple algorithm

Matrix M with all possible configurations as vetors (V_i)
Ternary number (configuration) → decimal
Indexing a new position in the Matrix
New position corresponds to the vector result Vj

-Disadvantages

Needs memory; introduce all the situations→ errors;unflexible

- New approach:
- Algorithm:
  Calc …xt possible configurations (sons of a node)
  … the solution OTHERWISE consider possible answers for each node

Advanced: learn with the past

- Disadvantage: More time (all possible sequences before each movement)
-Advantage: Extensible, versatile (different games, heuristics; several levels), less memory

TECHNICS

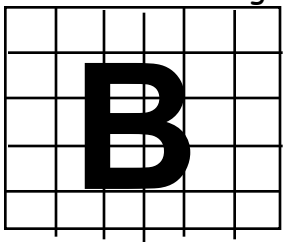
Example B: Knowledge Representation
Letters Recognition

- A traditional approach:

  analogic matrix : Inputs: counting 0s and 1s from the analogic matrix

  "hashing" table to index patterns

  (key: nº 1s in 3 lines of the matrix and combine them without collisions in a hashing f.)



  - Disadvantages:

    I J Are Deviations in letters meaningful or not?

    | I Too many patterns imply collisions

  - An alternative:

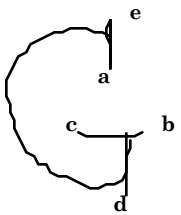
    - Count the nº of 1s in each sub-area (or ratio between "1" and "0")
    - Build a vector with the results
    - Compute the distance to each pattern

TECHNICS

- New approach:

-Patterns as sets of characteristics description:

Other methods includ the use of Neural Networks



arc (a,b) AND up(a,b) AND line(b,c) AND left(c,b) AND
(nil OR (line(b,d) AND down(d,b))) AND
(nil OR (line(a,e) AND up(e,a)))

- Algorithm
  - Find instances of Primitives(arcs, lines)
  - Relate them and compare with existent patterns
  - Select the closer pattern

-Advantage Permits size variation; alternative descriptions become simple

-AI TECHNICS involved in the examples: SEARCH and SIYMBOLIC REPRESENTATION

AI Application and Research Domains

Ai RESEARCH AND APPLICATION DOMAINS

1 Computational Natural Language

understand≡ translate between structures

- superficial understanding : Lexical Analysis (Eg: Eliza)
- Deeper Analysis implies:
  Sintax, Semantics, Pragmatics

Sentence: John kicks the white ball

New approaches are based on words frequency and co-occurrences

S -->NS VS
NS --> Qt NS1
NS --> NS1
NS1 --> N ADJS
ADJS--> nil | ADJ ADJS
VS --> V NS
N --> *John* | *ball* |...
ADJ --> *white* | ...
Qt --> *the* | ...
V --> *kicks*

elemental Grammar

AI Application and Research Domains

• Semantic Interpretation is fundamental to select the Actions

ex: *What is the value of soil Aptitude to Agriculture at coordinates* X_1, Y_1?

After Syntactic Analysis, the semantic analysis generates:

coordinates(X1, Y1, D, V), a(3, D, V-R).

• The Action is the answer to the defined questions (sub-goals)

Other situations requiring semantic analysis:
The politician lied about the subject X → negative opinion about the polititian

There are more efficient methods

AI Application and Research Domains

"EXPERT SYSTEMS"

SPECIFIC VS GENERAL

Knowledge Vs "Intelligence"

SYSTEM THAT SIMULATES THE EXPERT:

- Using SYMBOLIC AND HEURISTIC Knowledge
- Using de UNCERTAIN, VAGUE, INCOMPLETE Knowledge
- MODULAR access to Knowledge

EXPLANATIONS capabilities

Knowledge ACQUISITION (might be automatic)

Domínios para a INTELIGÊNCIA ARTIFICIAL

ARTIFICIAL INTELLIGENCE

ROBOTICS

- ARCHITECTURES: Cognitive and Reactive; Hybrid
- PERCEPTION: Scenes Interpretation
- **DECISION**: Planning. "Frame Problem"
- Languages: Task Level
- Vision + Modelling + Interpretation

- Teams COORDINATION

Domínios para a INTELIGÊNCIA ARTIFICIAL

ARTIFICIAL INTELLIGENCE

LEARNING, ADAPTATION and "DATA MINING"

* Induction of Rules based in:
  - analogy; examples; explanations

* "Data e Text Mining"
  - Generation of new Knowledge;
  - Patterns Recognition (text, image, music…)
  - Opinion Extraction, Summarization
* progressive Adaptation (Evolutionary Algorithms)

NEW LOGICS for Automatic Reasoning

- Order N
- Modal and Intensional
- temporal
- non-monotonic

ARTIFICIAL INTELLIGENCE

CONETIVISTE and NEURAL Architectures

- sub-simbolic Information :
  - Preview
  - Adaptive Control
  - Paattern Recognition

DISTRIBUTED ARTIFICIAL INTELLIGENCE

-DISTRIBUTED AND COOPERATIVE AGENTS

Aplications in domains DDD:

- Networks management and analysis
- Shop floors (CIM)
- Softbots (Shopbots,...)
- Electronic Markets (Auctions, contracts)
- Electronic Institutions (Virtual Enterprises Negotiation, contracting)
- "Emotionl" Agents
- Simulation for traffic,...

Using "Game Theory"

Domains for the ARTIFICIAL INTELLIGENCE

INTELLIGENT TUTORS

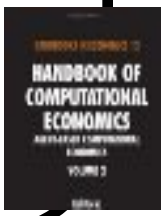
Knowledge Representation of the domain,
Pedagogical strategies
Adaptation/Classification and profile extraction

SIMULATION of Human BEHAVIOURS

Architectures type: "mentalistic" and based in "Emotions"
Team Coordination of autonomous entities
ecological Systems

ECONOMIC COMPUTATION BASED IN AGENTS (ACE)

"Computational study of economic processes as dynamic systems of interacting agents"



Computational AGENTS :

a) Definitions

ARTIFICIAL INTELLIGENCE
Agent Definitions

Elementary Notions :

- **Agents** are computational entities with the capability of perceiving the external environment (through Sensors) as well as interacting with this environment through "effectors").

- **Agents** make possible to humans to "delegate" to them responsibilities that are both costly in time and "power" (computation, memory, Communication, repeatability...)

- **Agents** use perception sequences together with a priori knowledge in order to select actions maximizing their performance

Agent = Platform (Communication and Distribution) + Program

Program = Architecture + Modules' Programs

ARTIFICIAL INTELLIGENCE

Agents Definitions

- Agent Definition:
  - Computing Entity controlled by a program which is *situated* in an Environment and capable of deciding with *autonomy* in that Environment while pursuing its Goals
    - *Autonomy*
    - *Reactivity*
    - *Pro-activity*
    - *Sociability*

Intelligent

- Agents Vs Objects:
  - Agents are autonomous: They may refuse demands. Objects no!
    - Objects control their state, not their behaviour
      Agents control their state and their behaviour

Agent Definitions

- Strong Definition:
  - Autonomous computational Systems, pro-active, whose reasoning process is based on "mentalistic" concepts such as:
    - *Beliefs, Knowledge, Intentions, Commitment, Goals, Emotions…*
  - Other possible Attributes :
    - Mobility
    - Benevolence
    - Rationality / "Emotionality"

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Agent Definitions

Agent "PAGE" Description:
[Perception, Actions, "Goals" (objectives), Environment]
Now (PEAS- Performance measures, Environment, Actuators, Sensors)

Agent Examples

Type	Perception	Actions	Goals	Environment
Medical Diagnostic System	Symptoms	Questio-nairs tests treatments	Patient health Costs Minimization	Pacient signals Hospital instrumentation
Manip. Robot	pixels intensity	Pick up Put down parts	Locate and place parts	Tables Conveyor belts ...
Bibliographic Softbot or ShopBots	Finding and Reading Web pages	Web Navigation Filering, ranking	Relevant Information Selection	Computers Internet Web pages

Agent Definitions

ARTIFICIAL INTELLIGENCE

Is it different from Distributed/Concurrent Systems?

Autonomy implies need for **coordination** and synchronization at runtime

Isn' t it just Artificial Intelligence?

classic AI ignored the "social" aspects of the **agenthood**

Isn' t it just Economy?

"Game Theory" makes Models available. However DAI has to make them **computational**. Not all Artificial Agents have to be rational as in the GT.

Isn' t it just Social Science?

We also consider interaction Models for Cooperation/Competition but **not** necessarily **mimicking** social reality

Architectures

ARTIFICIAL INTELLIGENCE

2 b) Basic Architectures

function skeleton-agent (*perception*) **return** *action*

Trivial Agent

```
static:   memory              /* memory of the agent's world
memory                <---- updates_mem (memory, perception)
action                <---- selects_best (memory)
memory                <---- updates_mem (memory, action)
return    action
```

Notes: perception sequence is internally generated.
Performance measure is external to the agent

Implies to program a table including all the actions specifically related to all possible perception sequences.

AI tries to replace exhaustive programming by a more comprehensive and compact code leading to a rational behaviour in several future situations

Agent Definitions

Recap

- Agent Definition:
  - Computing Entity controlled by a program which is *situated* in an Environment and capable of deciding with *autonomy* in that Environment while pursuing its Goals. It includes:
    - *Autonomy*
    - *Reactivity*
    - *Pro-activity*
    - *Sociability*

"Intelligent"

- Agents Vs Objects:
  - Agents are autonomous: They may refuse demands. Objects no!
    - Objects control their state, not their behaviour
      Agents control their state and their behaviour

ARTIFICIAL INTELLIGENCE
Architectures

* How to build Agents for mapping the best actions to current perceptions?

* **Consider five agent types :**

a) simply Reactive

b) Memorizing the World

c) Guided by Objectives

d) Utility Based

e) Adaptive

Architectures

ARTIFICIAL INTELLIGENCE

1) **Simply Reactive** : Apply a set of "situation-action" Rules

* Appropriate whenever correct decision only depends on current perception

function Simple_reactive_agente_ (*perception*) **return** *action*
static: *rules* /*set of situation-action Rules */
state ←interprets_input (*perception*)
rule ← selects *(state, rules*)
action ←rule_conclusion (*rule*)
return *action*

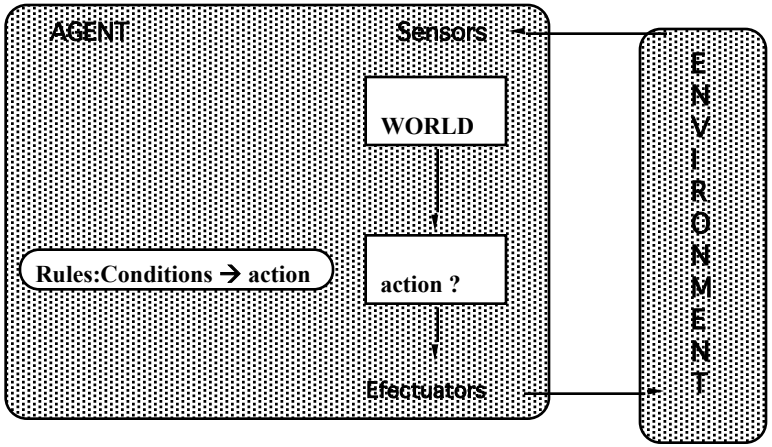

Diagram for a Simple REACTIVE Agent

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2) **Memorizing the World**: Decision implies a priori knowledge about the World

function reactive_agent__w_mem (*perception*) **return** *action*
static: *state* /* description of the current world state */
rules /* set of situation_action Rules */
state ← update_state(*state, perception*)
rule ← select_rule (*state, rules*)
action ← conclusion_rule (*rule*)
state ← update_state(*state, action*)
return *action* /*same perception -->different actions,(World state)

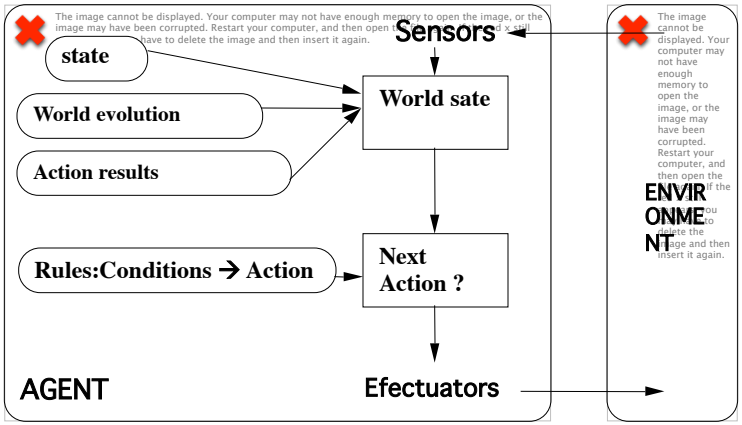

Diagram for a "REACTIVE" Agent with internal state

Arquitecturas básicas

* agente mais elementar: agente_tabela

função agente_tabela (*perceção*) **retorna** *ação*

estática: *memória* /* a memória do mundo do agentetabela indexada pelas perceções. Inicialmente completamente especificada */

Agente trivial

memória <---- atualiza_mem (*memoria, perceção*)
ação <---- seleciona_melhor (*memoria*)
memória <---- atualiza_mem (*memoria, ação*)
retorna *ação*

Desvantagens:

- enormes tabelas. Tempo de construção da tabela
- agente **sem autonomia**

- A IA tenta substituir a programação exaustiva por um código mais compacto que permita gerar comportamento racional

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3) **Guided by objectives**:

Besides the description of the Current state, the agent also uses information about the *objectives*. This implies *search* and *planning*. It is more flexible once different Behaviours may be selected for the same World state, depending on the Objectives.

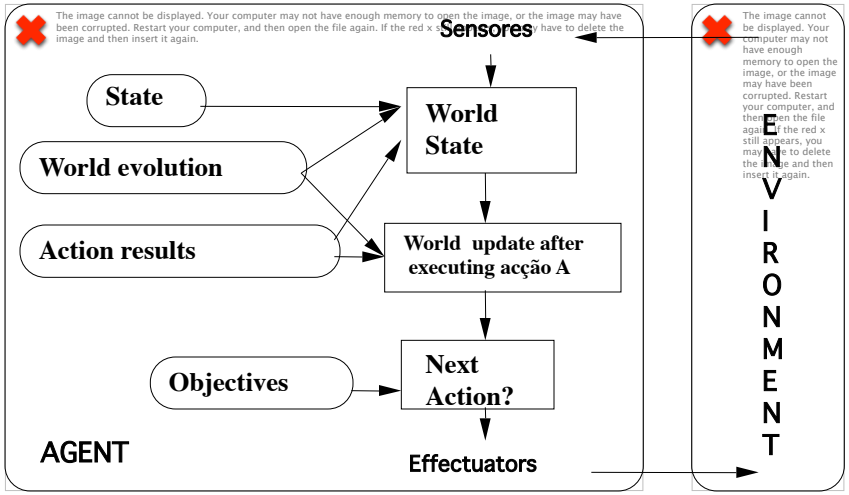

Diagram of an Agent with explicit Objectives

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4) Utility Based

Utilities are measurements of the Agent's "satisfaction" in each one of the possible states. Utilities may be used to decide between conflicting Goals or even (when there is uncertainty about action outcomes) to evaluate the possibility of reaching an Objective Agents that apply an Utility Function become more rational.

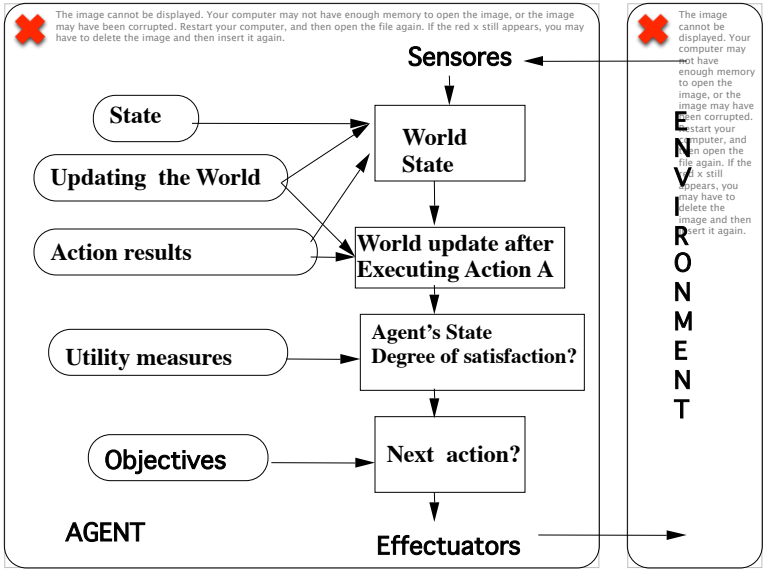

Diagram of an Utility-based Agent

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5) Adaptive Agents

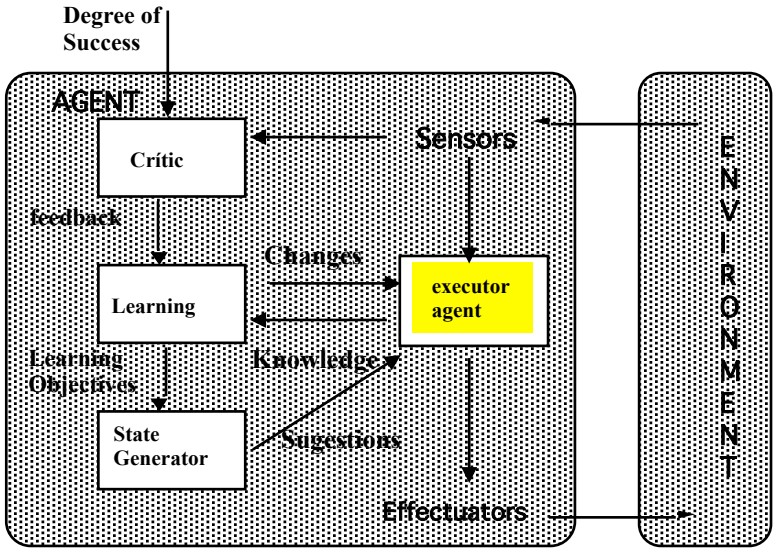

Diagram of an Adaptive Agent