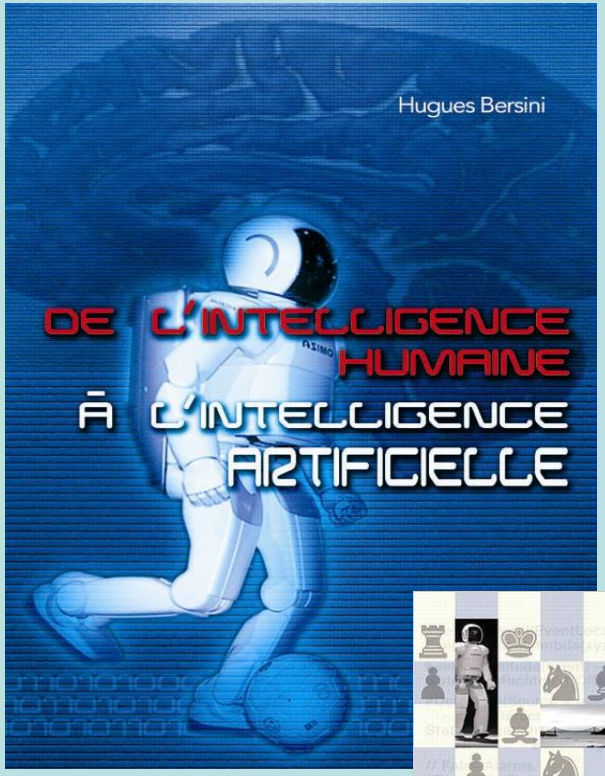
Techniques of AI

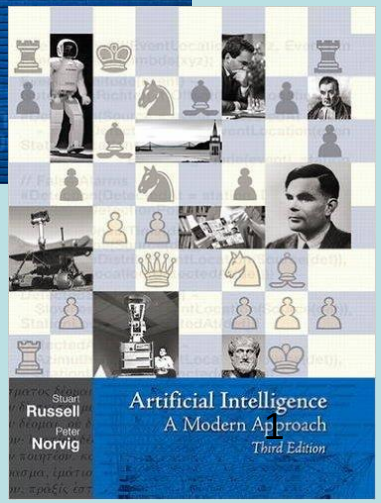
Hugues Bersini, bersini@ulb.ac.be



Course material:

De l'Intelligence Humaine à
L'intelligence Artificielle by H. Bersini

Artificial Intelligence, a modern approach
by Russel and Norvig



Prerequisites:

Basic knowlegde of logic, statistics and programming.

What is AI?

Various definitions:

- Building intelligent entities.
- Getting computers to do tasks which require human intelligence.

Simple things turn out to be the hardest to automate:

- Recognising a face.
- Navigating a busy street.
- Understanding what someone says.

AI Pantheon

FINISH

Team DARwIn
00
BotSport.tv
00:00
00
CIT Brains

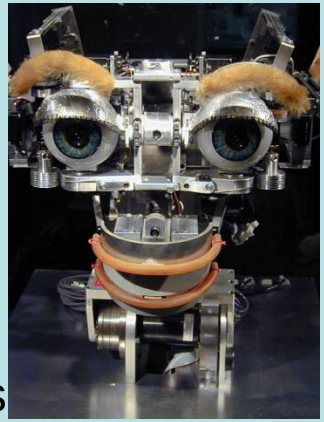
$3,400
$4,400
$1,200
KEN
WATSON
BRAD

ALPHAGO
00:00:49
LEE SEDOL
00:01:00
AlphaGo
Google DeepMind

- Everyday applications
  - cars – cruise control, fuel injection
  - planes – autopilots and lower-level control systems
  - lawnmowers & vacuum cleaners
  - washing machines
  - environmental control – light, thermostats, etc.
- Large scale applications
  - military strategy planning – Desert Storm
  - prevention of mid-air collisions between planes
  - disaster recovery services – 9/11
  - Deep Space 1 – remote agent experiment

OVERVIEW

- The human side of AI
  - Good old fashioned AI
  - How computers think, resolve, play or discuss of restaurants.



- The animal side of AI
  - New fashioned AI
  - How computers drive, refuse a credit or control a process

Why doing AI?

Two main goals of AI:

- To understand human intelligence better. We test theories of human intelligence by writing programs which emulate it.
- To create useful “smart” programs able to do tasks that would normally require a human (expert).

Who does AI?

Many disciplines contribute to goal of creating/modelling intelligent entities:

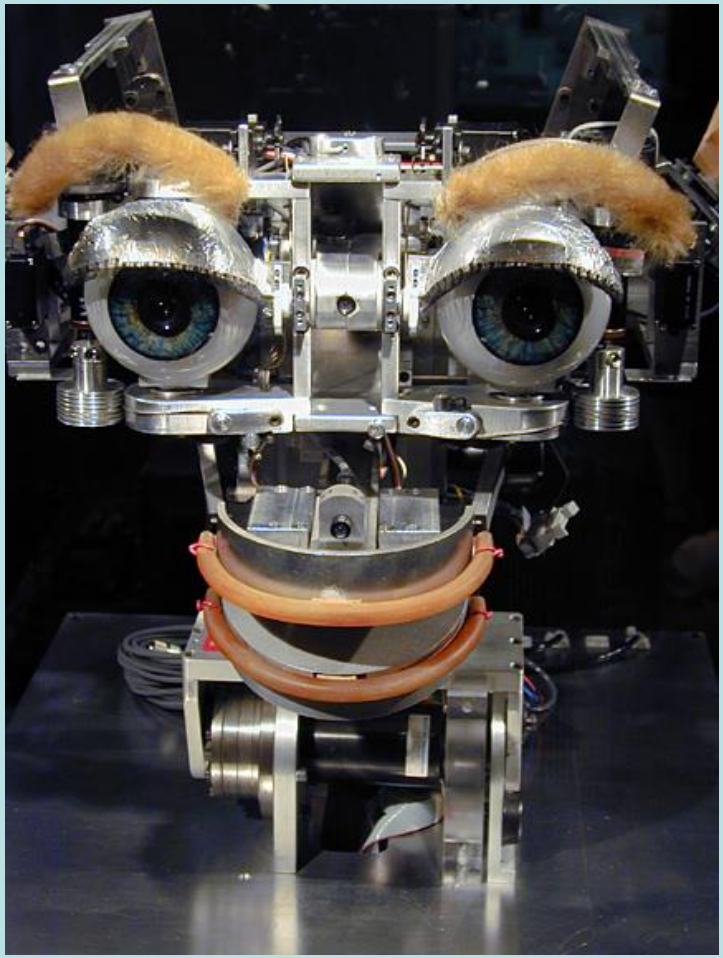
- Computer Science
- Psychology (human reasoning)
- Philosophy (nature of belief, rationality, etc)
- Linguistics (structure and meaning of language)
- Human Biology (how brain works)

Subject draws on ideas from many disciplines.

PLAN

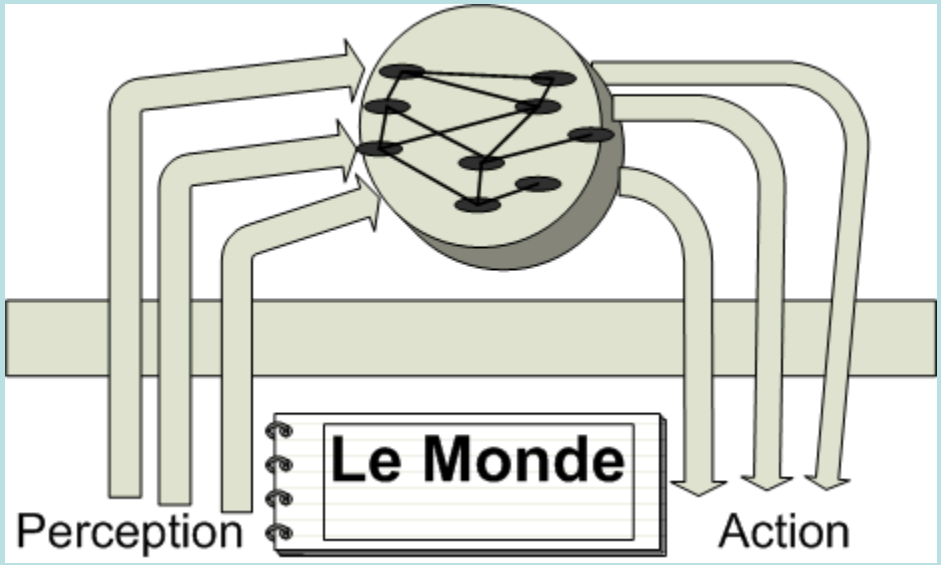
- The human side of IA
- Good old fashioned AI
- How computer think, resolve, play or discuss of restaurants.
- The animal side of AI
- New fashioned AI
- How computers drive, refuse a credit or control a process

The human side

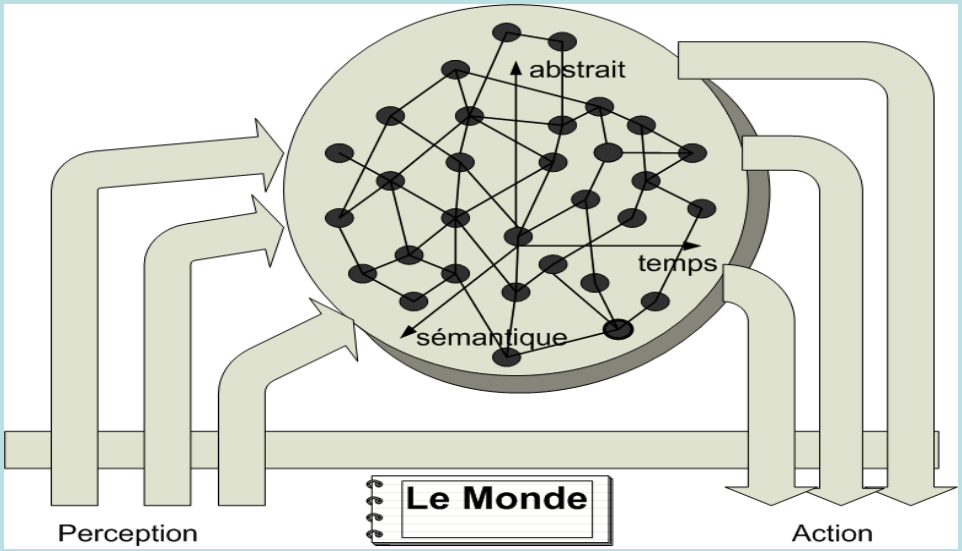


- Intelligence = Mental inferences
- Deductions, planning, mental simulations, reasoning, logics
- Rational intelligence to distinguish from fake intelligences:
  - *Emotional intelligence*
  - *Animal intelligence*
  - *Embodied intelligence*
  - *Collective intelligence*
- Intelligence = IQ, chess, math, logical solving
  all the rest is just skills

The inferential brain



ANIMAL



Human

Good old fashioned AI

The problem of the water jugs

- There are two jugs of water but with no indication on quantity. One has a maximal capacity of four litres, the other of three litres. How to exactly get two litres in the four litres jug.

Definition of the problem

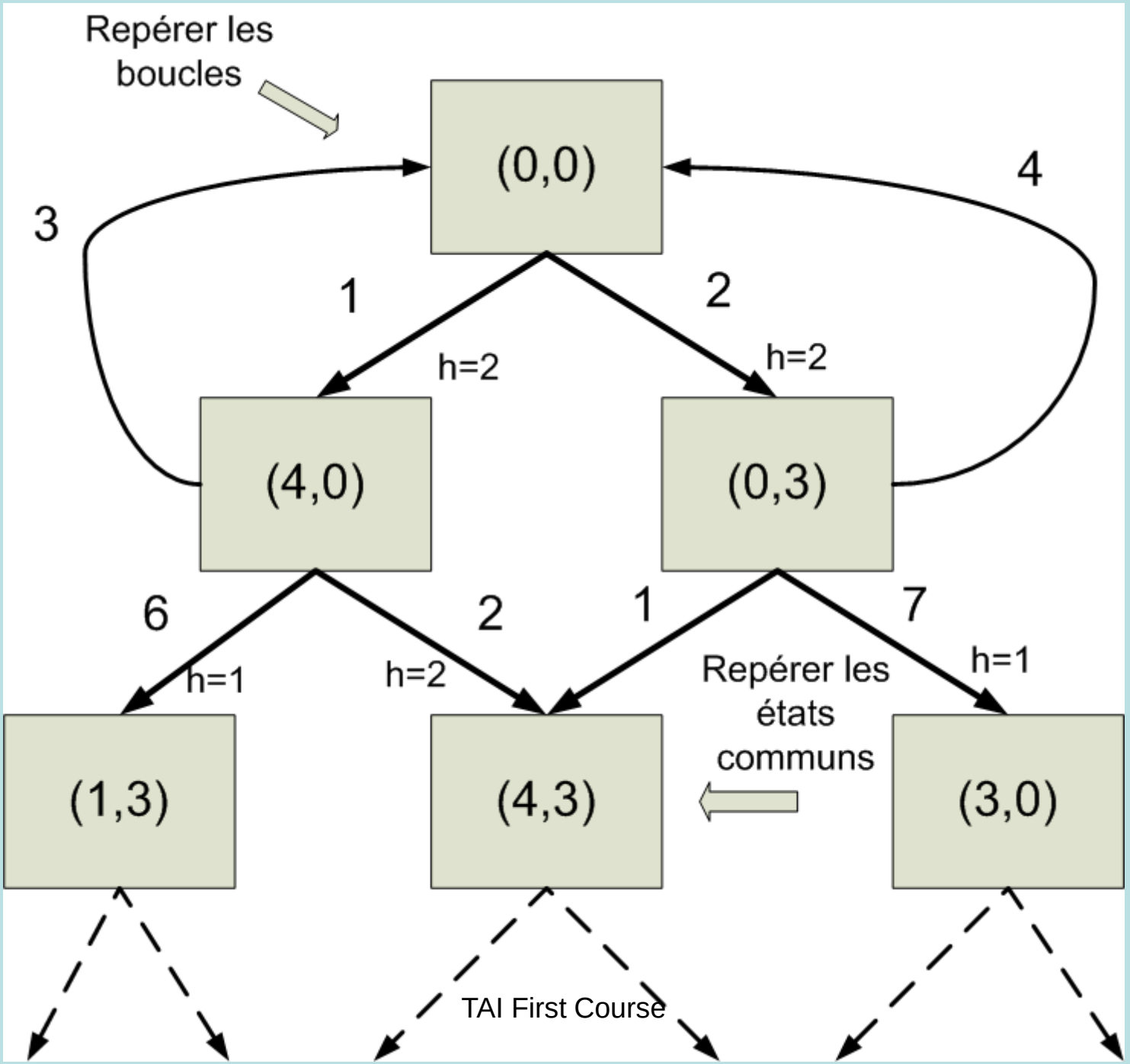
- The state of the world: (x,y)
- The initial state : (0,0)
- The final state: (2, n)
- Then a set of operators allowing to evolve the world:

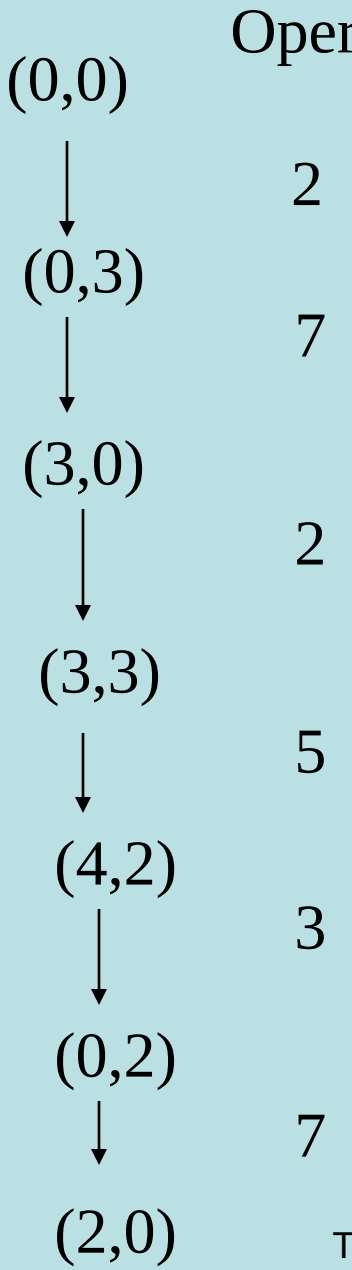
The set of operators

- (x<4,y)→ (4,y) fill up the first
- (x,y<3)→ (x,3) fill up the second
- (x>0,y)→(0,y) empy the first
- (x,y>0)→(x,0) empty the second
- (x+y>4,x<4)→(4,y-(4-x)) fill x with part of y
- (x+y>3,y<3)→(x-(3-y),3) fill y with part of x
- (x+y<4,y>0)→(x+y,0) empty y in x
- (x+y<3,x>0)→(0,x+y) empty x in y

The inferential engine

- Find the operators that can be applied: their pre-conditions need to match the current state of the world
- Select one → the control strategy:
  - In depth or in width, with heuristics or not
- Avoid looping
- Be able to backtrack
- Do that iteratively until to find the final state
- The solution of a planning problem is the sequence of operators. Often the shortest if you find several solutions.

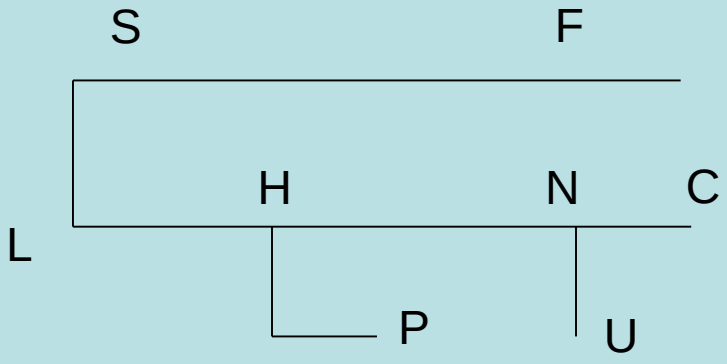

Repérer les boucles
(0,0)
3
4
1
2
h=2
h=2
(4,0)
(0,3)
6
2
1
7
h=1
h=2
h=1
Repérer les états communs
(1,3)
(4,3)
(3,0)

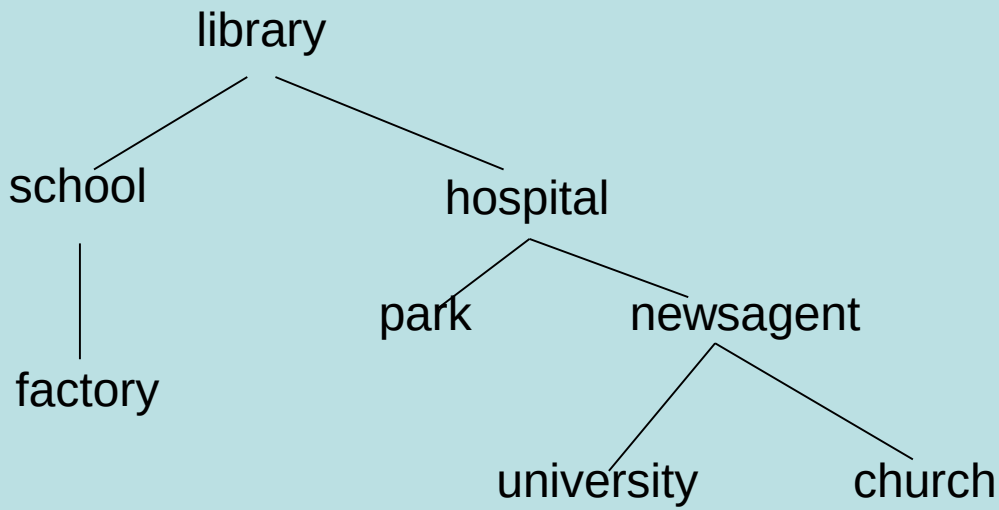


One possible solution

Search Space

- The set of all possible states reachable from the initial state defines the *search space*.
- We can represent the search space as a tree.



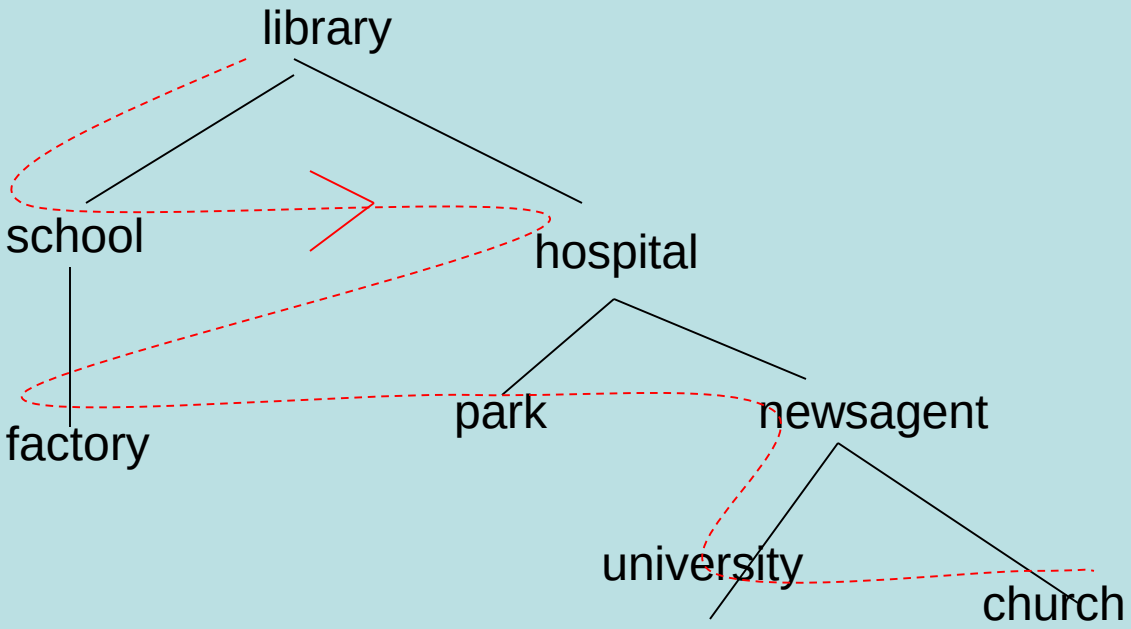


Simple Search Techniques

- How do we search this tree to find a possible route from library to University?
- May use simple systematic search techniques, which try every possibility in systematic way.
- Referred to as **brute force** or **blind** techniques
- Breadth first search
- Depth first search - Follow a path as far as it goes, and when reach dead end, backup and try last encountered alternative.

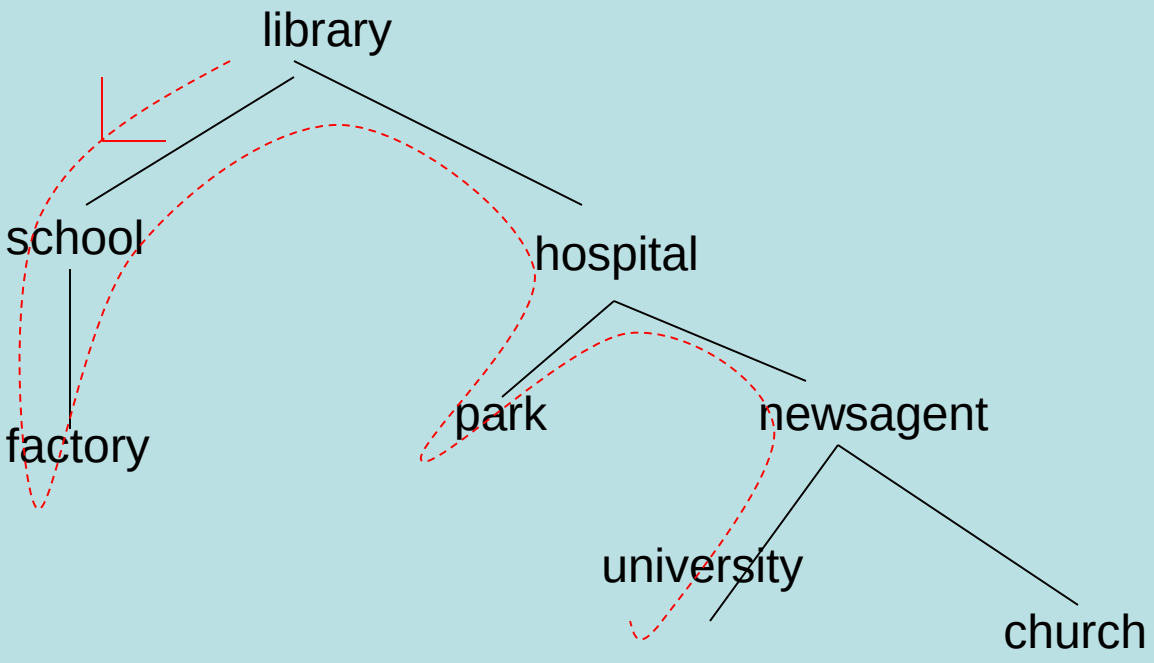
Breadth first search

Explore *nodes* in tree order: library, school, hospital, factory, park, newsagent, university, church. (conventionally explore left to right at each level)

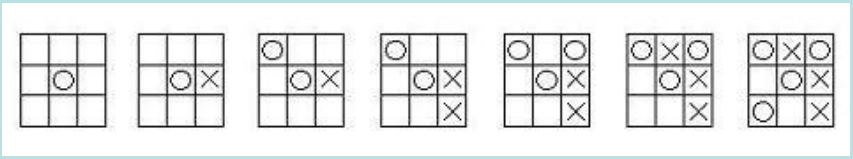


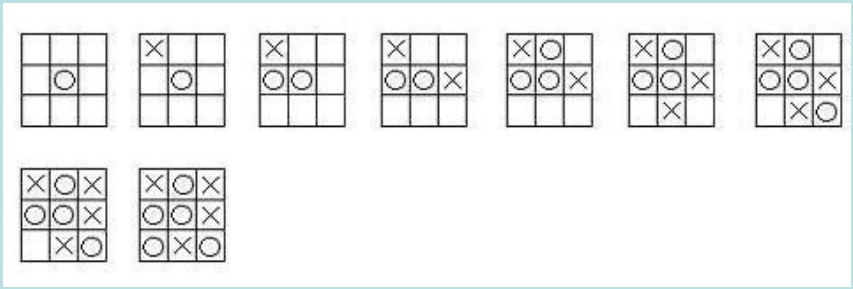
Depth first search

- Nodes explored in order: library, school, factory, hospital, park, newsagent, university.

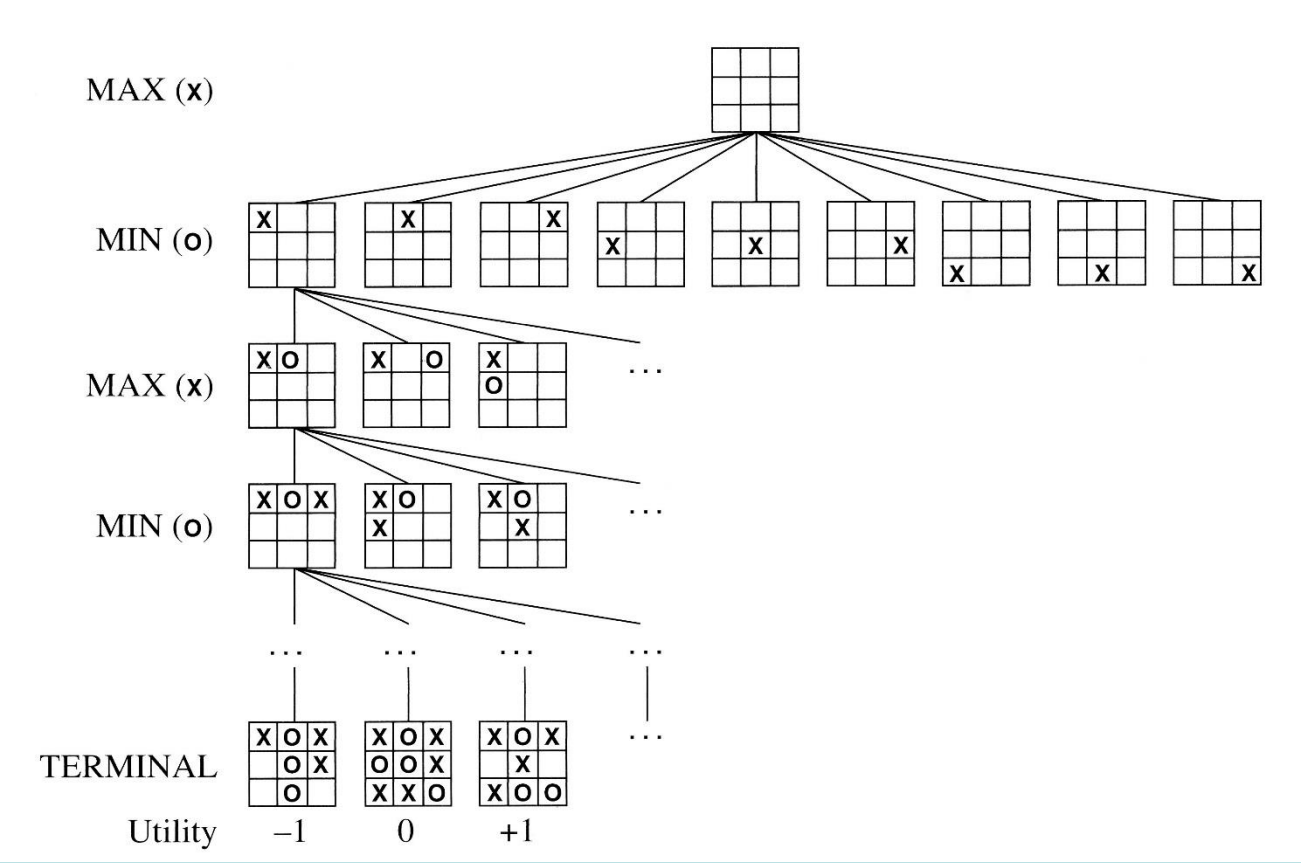


Society games

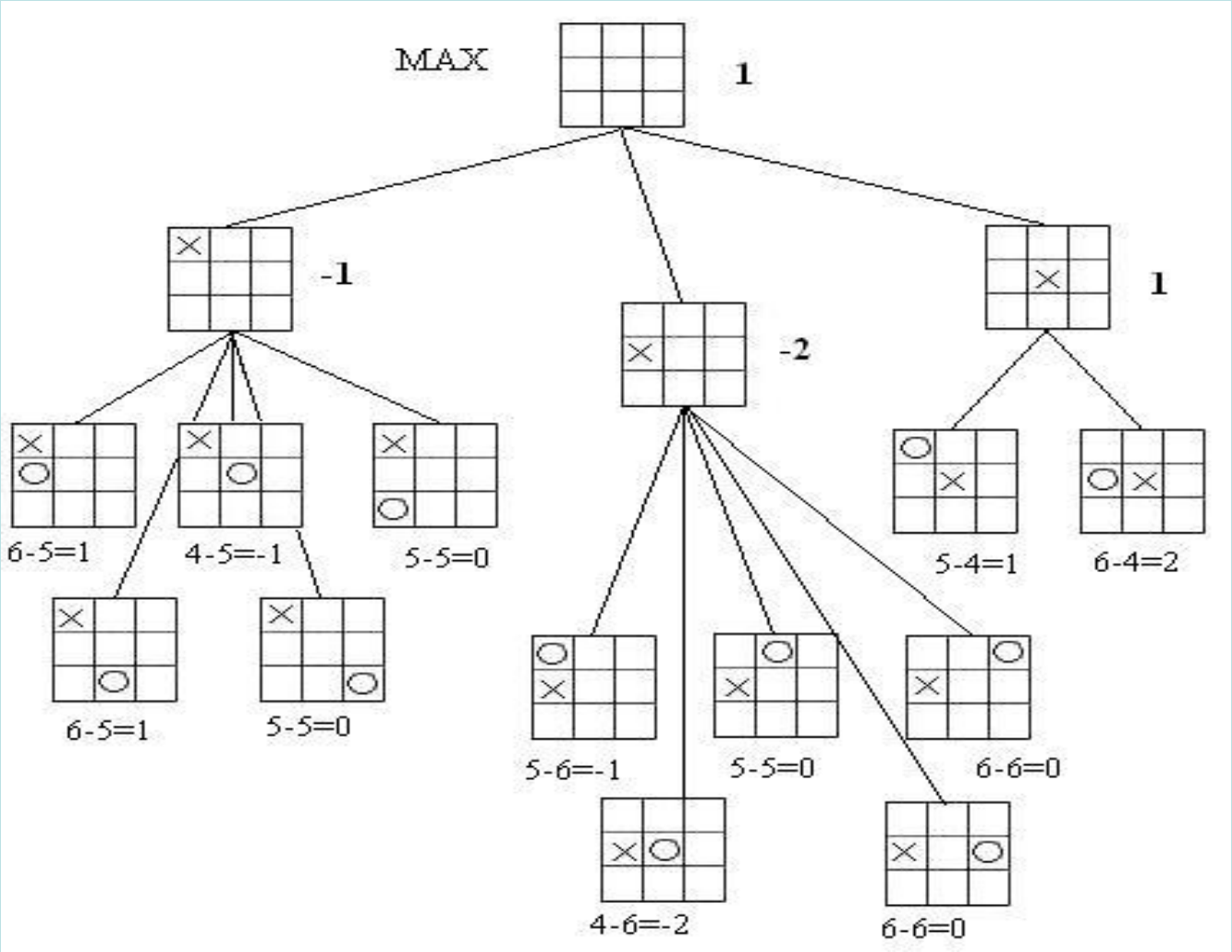




The Min-Max Strategy



With heuristics

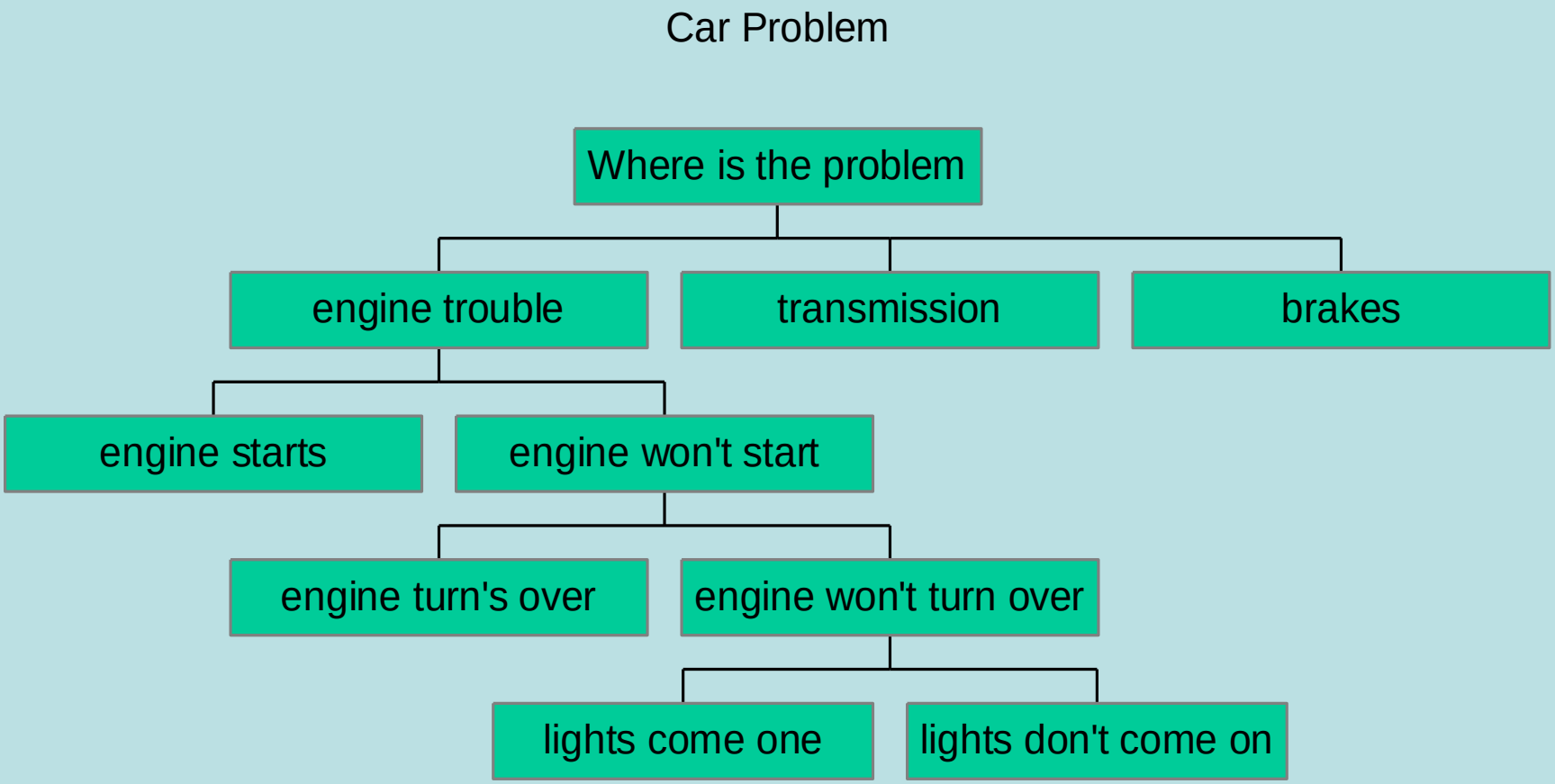


What a software knows about a restaurant

- **Nom:** restaurant
- **Objets:** tables
  menu
  nourriture
  addition
  argent
  pourboire
- **Rôles:** client
  serveuse
  cuisinier
  caissier
  patron
- **Conditions d'entrée:**
  - Le client a faim
  - Le client a de l'argent
- **Résultats:**
  - Le client a moins d'argent
  - Le patron a plus d'argent
  - Le client est rassasié
  - Le client est satisfait

- **Scène 1: entrée**
  - Le client entre dans le restaurant
  - Le client cherche une table
  - Le client choisit une place
  - Le client va vers la table
  - Le client s'assoit
- **Scène 2: commande**
  - Le client prend le menu
  - Le client regarde le menu
  - Le client choisit les plats
  - Le client appelle la serveuse
  - La serveuse vient à la table
  - Le client passe la commande
  - La serveuse va à la cuisine
  - La serveuse donne la commande
  - Le cuisinier prépare le plat
- **Scène 3: repas**
  - Le cuisinier donne la nourriture à la serveuse
  - La serveuse apporte la nourriture au client
  - Le client mange la nourriture
- **Scène 4: sortie**
  - La serveuse prépare l'addition
  - La serveuse va vers le client
  - La serveuse donne l'addition au client
  - Le client paie la serveuse
  - Le client donne un pourboire à la serveuse
  - Le client sort du restaurant

Diagnosis of a car problem



The AI failures

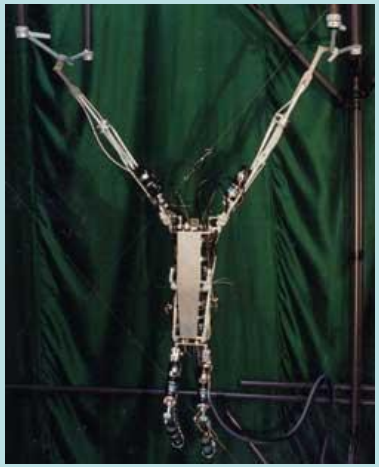
- → Man is embodied in his environment
  - → Man is a sophisticated sensori-motor process much before any cogitive process takes on.
    - →His perception is intrinsically and materially parallel
- → The sensori-motor processes essentially depend on their biological grounding: parallel and adaptable
- → World outside is complex and requires an interface of a similar complexity.
- → But this complexity can be achieved by learning and experience rather than being handcrafted
  - → Based on learning and an interative simplicity. Complex processes emerge from iterating simple mechanisms

- Man possess 2 cognitive systems
  1) Parallel, automatic, unconscious, reflex, adaptable, and very efficient
     - Based on neuronal hardware
     - For playing tennis, piano, becoming an expert ….
  2) Sequential, rigid, conscious and very laborious
     - Based on neuronal software
     - For playing chess, for testing IQ
- Man goes from one to the other in the cases of breakdowns in his automatisms
- Machine intelligence and human intelligence can be of different nature
- For the machines today, recognizing a face is much more difficult than playing chess
- But doesn’t Kasparov in part play chess like indeed we recognize a face ?

The animal side

AI
Software
Cognitive Science

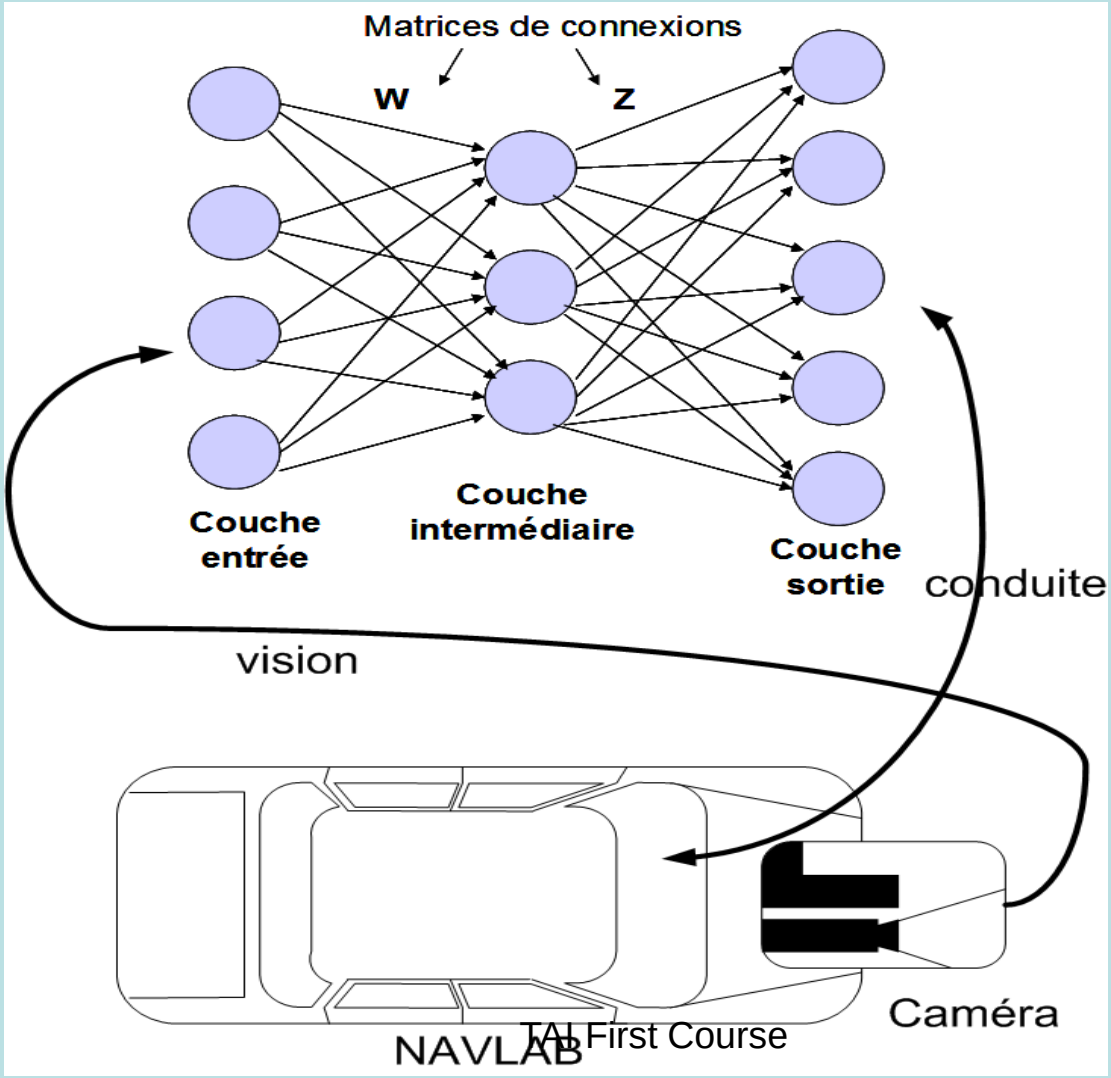
ALife
Hardware
Biology



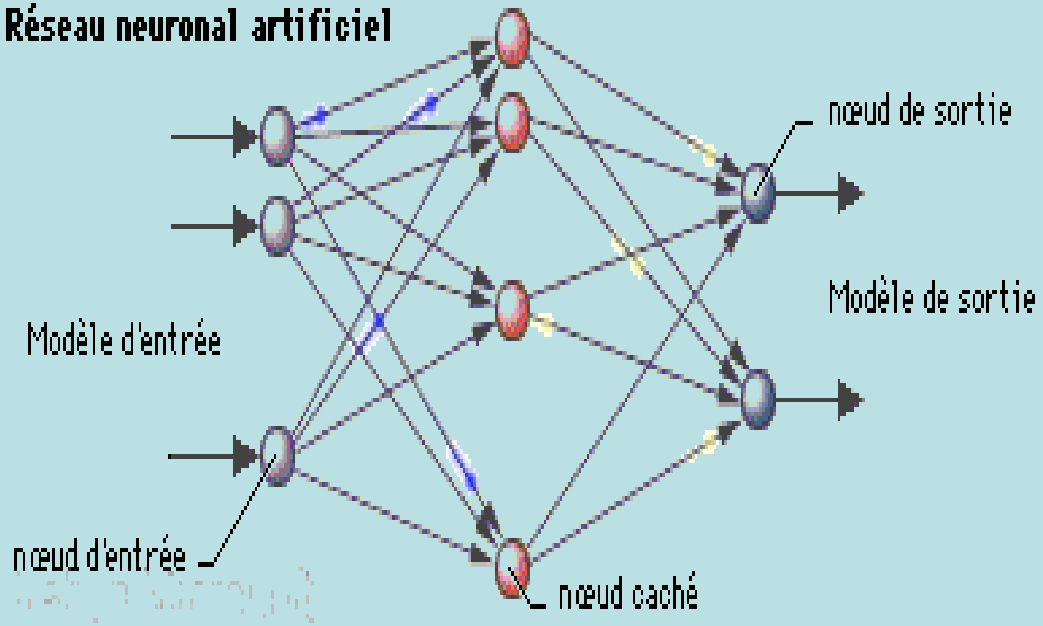
- The animal hidden in each of us might be unavoidable on the road to intelligence
- Our intellectual skill are embodied in our automatisms. They depart from there.
- Don’t ever try to fully understand what a chair is without having ever sat in it.
- A turn back is needed towards our biological interface with the outside world.
- Can we as engineer bypass this biology ?
- Do we have to get rid with good old fashioned AI ? NO

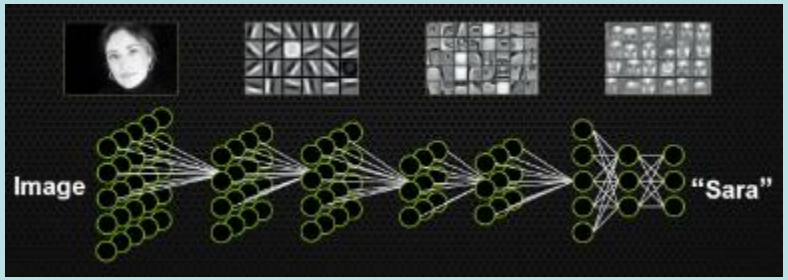
Today AI

How does the computer drive



Neural networks

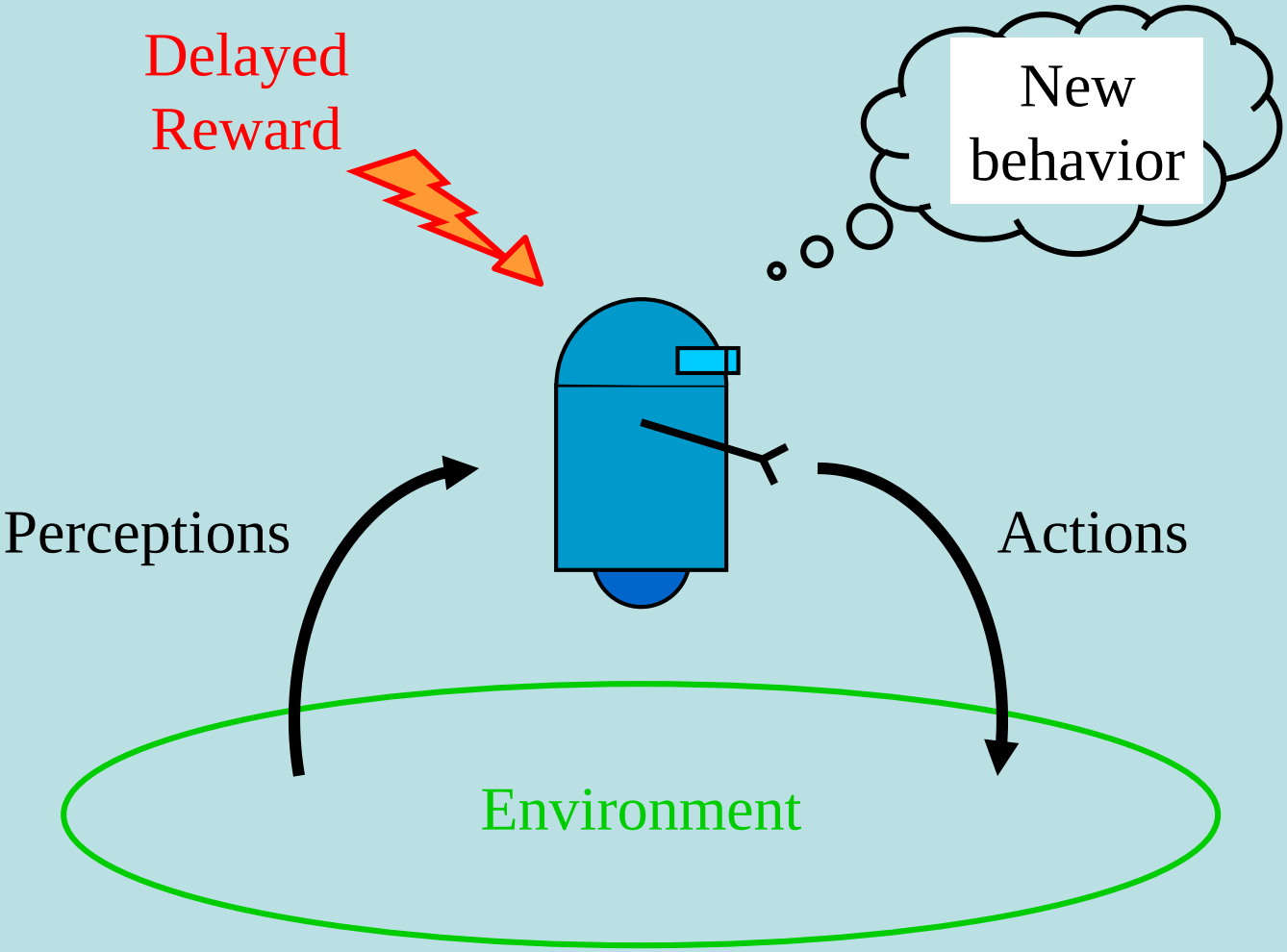




Deep Learning

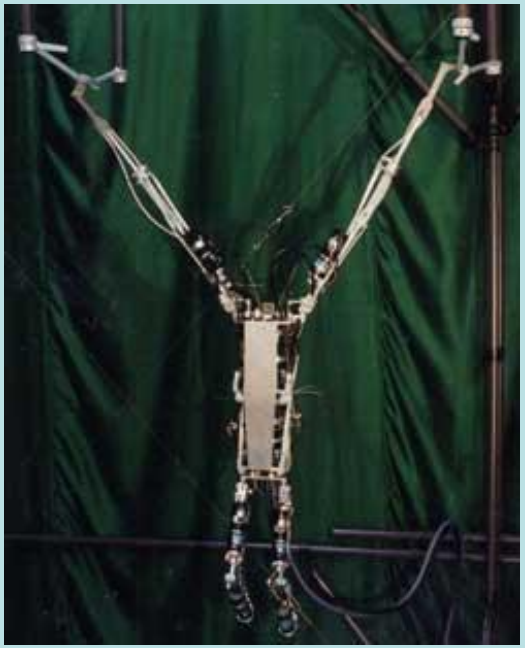
The Darpa Challenge

Learning Autonomous Agent



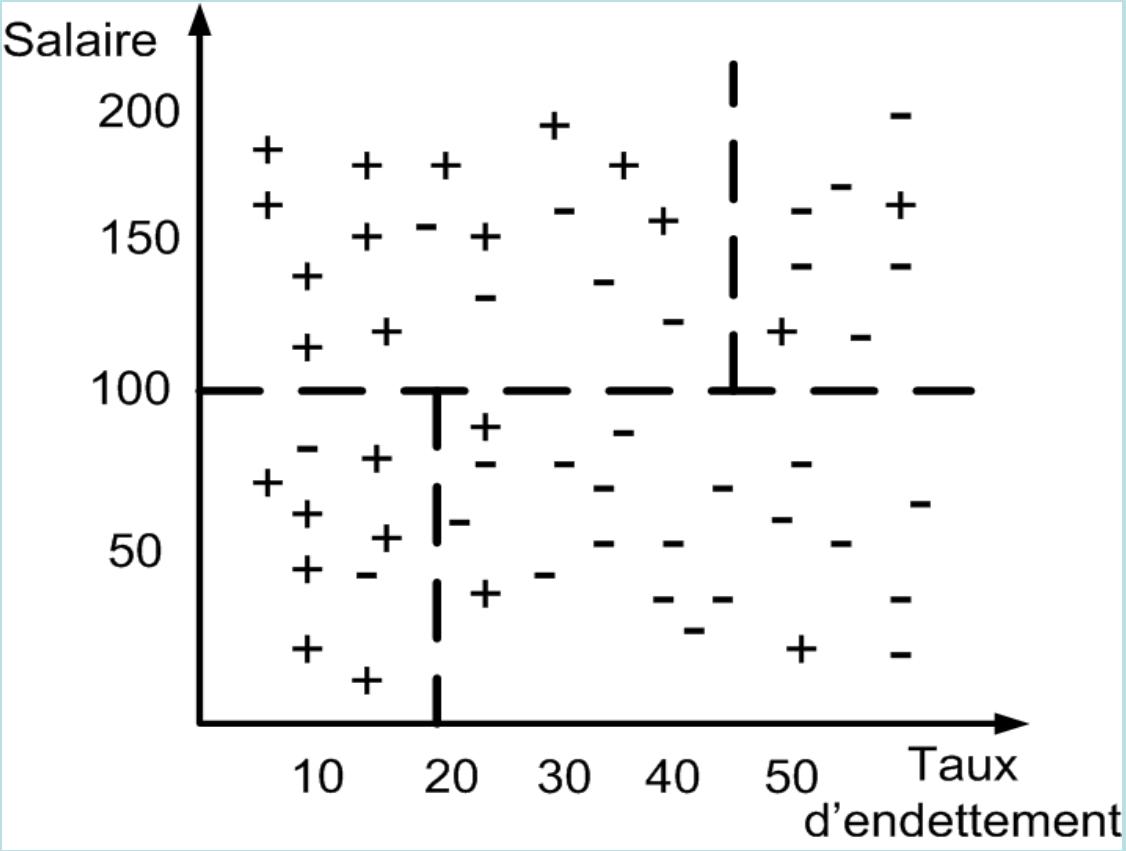
Robotic applications

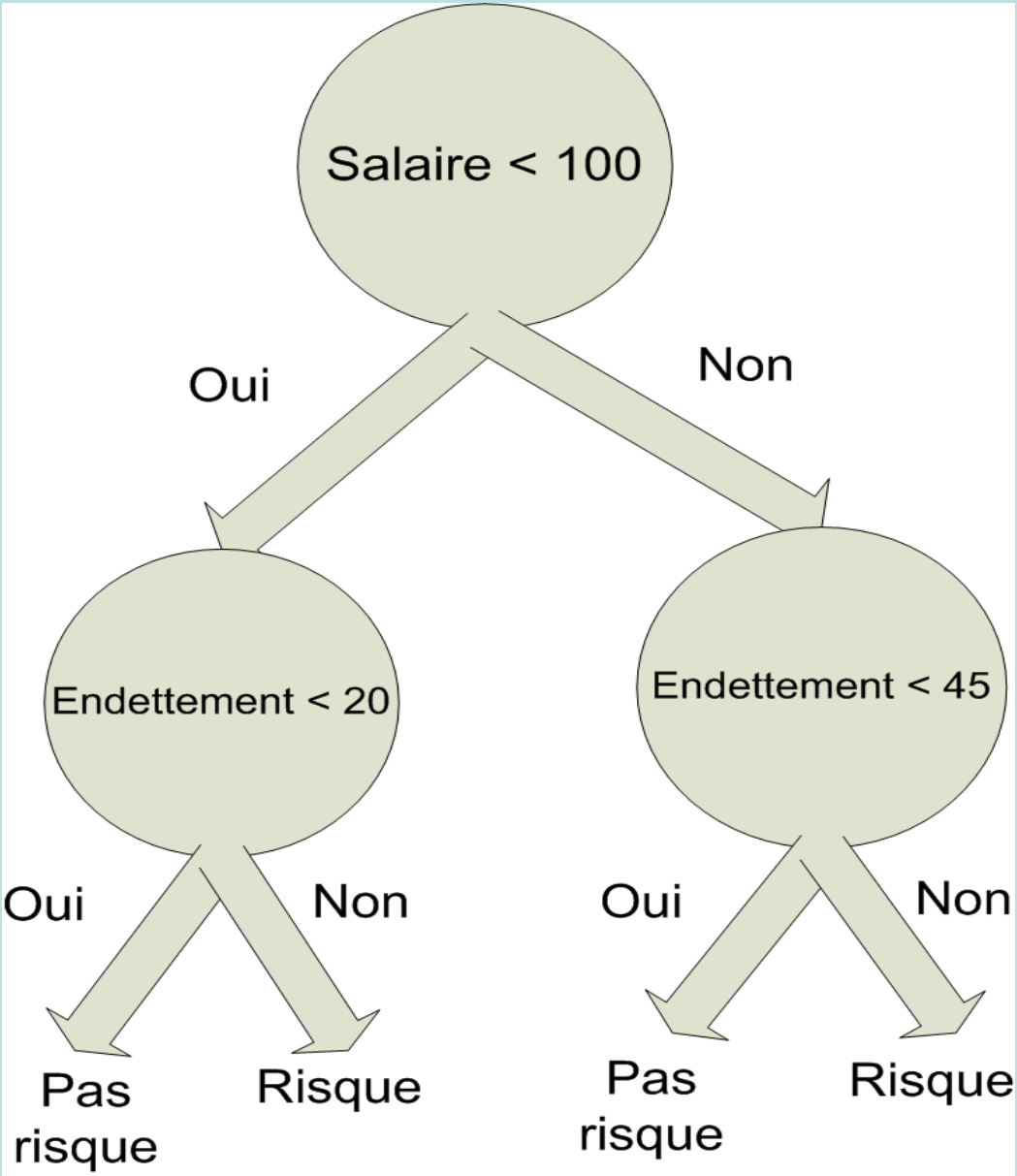
- Autonomous robots:



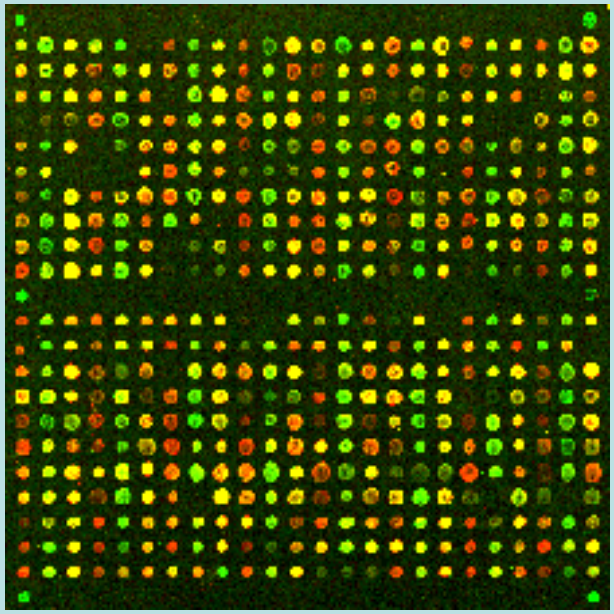
- Softbots: autonomous agents on Internet to profile and help the users.

How does the computer score a credit

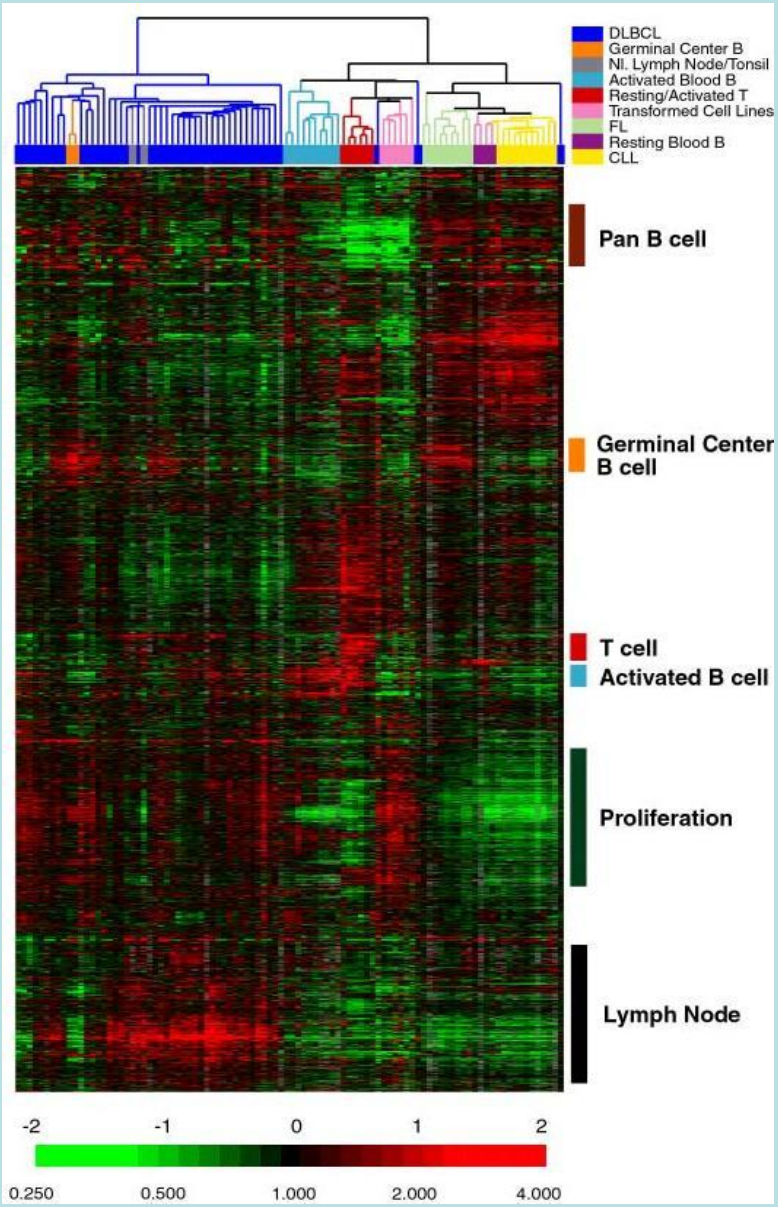


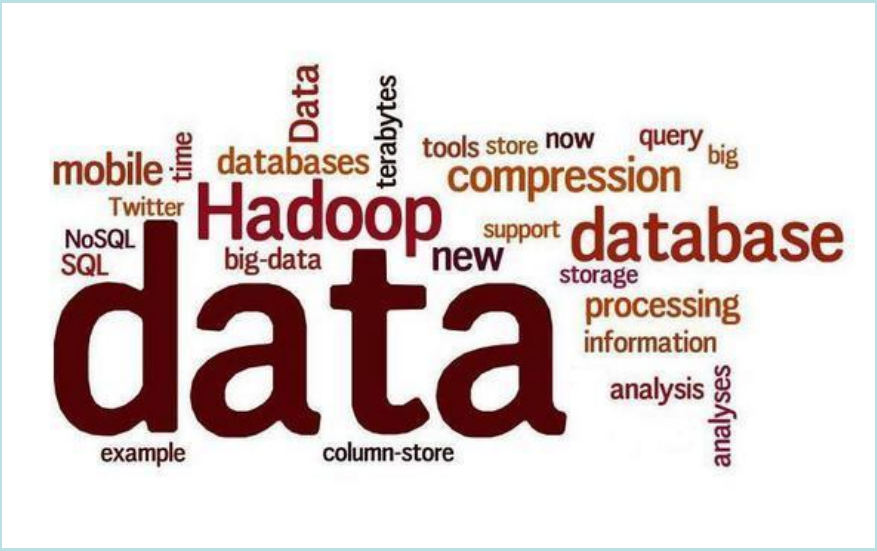

Salaire < 100
Oui
Non
Endettement < 20
Endettement < 45
Oui
Non
Oui
Non
Pas risque
Risque
Pas risque
Risque

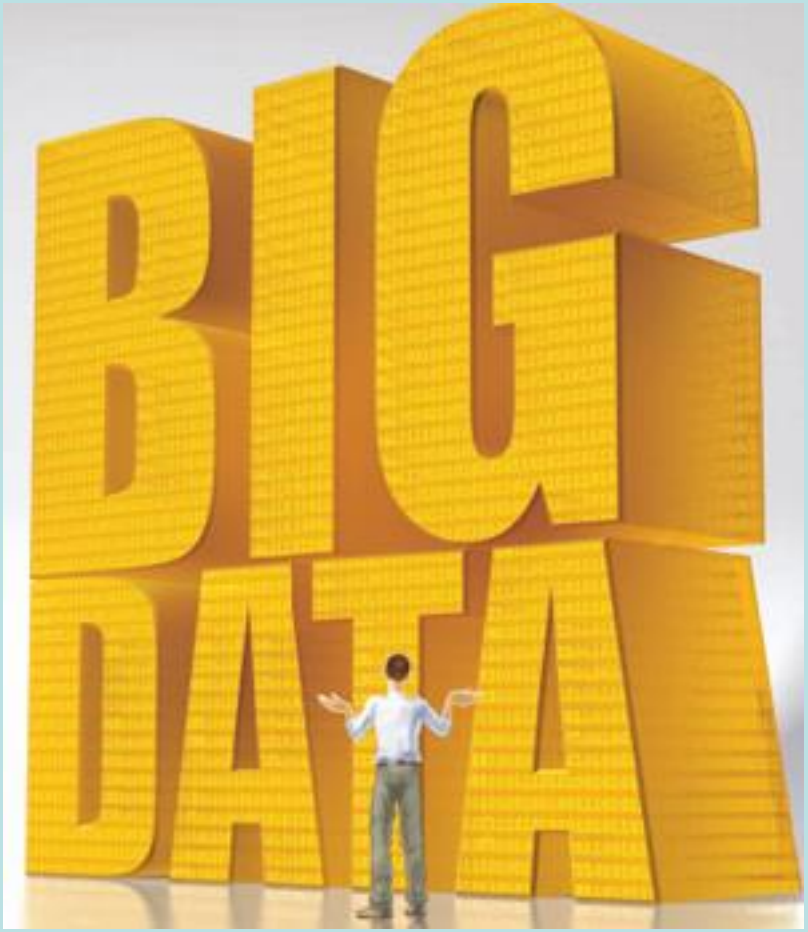
PUCE ADN

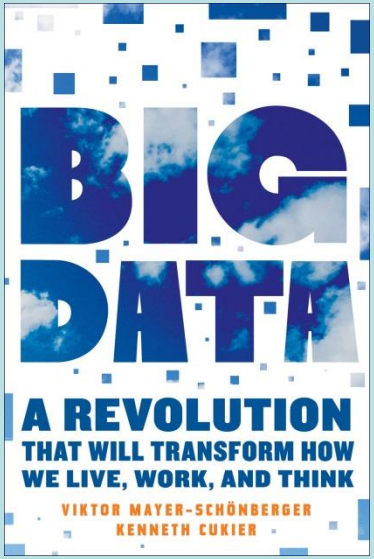


Microarray chip



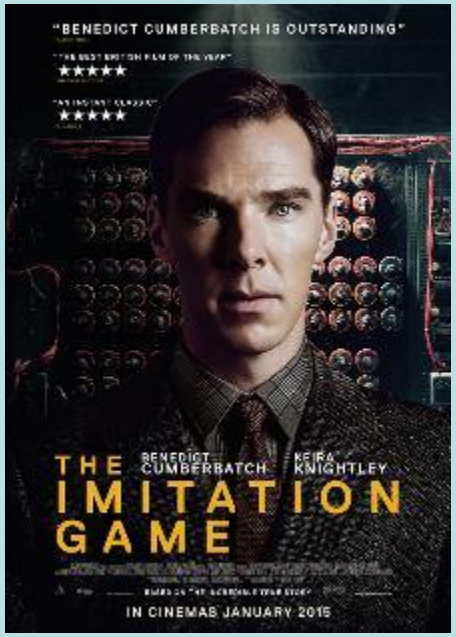

Data
terabytes
mobile
time
databases
tools store now
query
big
compression
Twitter
Hadoop
support
database
NoSQL
SQL
big-data
new
storage
data
processing
information
analysis
analyses
example
column-store


BIG
DATA


BIG
DATA
A REVOLUTION
THAT WILL TRANSFORM HOW
WE LIVE, WORK, AND THINK
VIKTOR MAYER-SCHÖNBERGER
KENNETH CUKIER

Google's AI

The Big Data trends in AI



Whom I'm talking too?

1965: Eliza -> The software psy

Joseph Weisenbaum

Le patient: “My boyfriend made me come here”

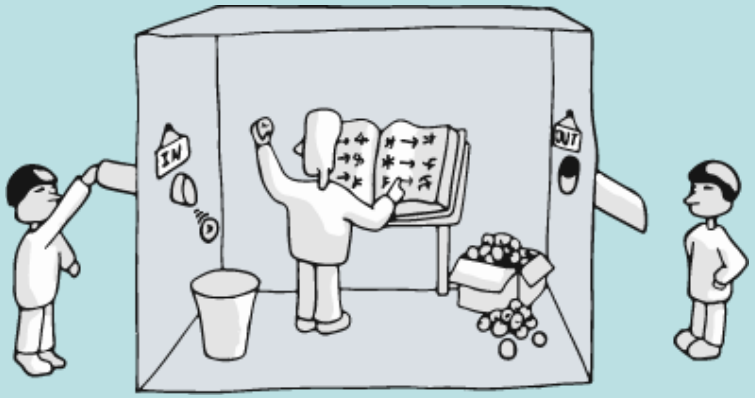
Le psy: Your boyfriend made you come here

Le patient: He says I’m depressed all the time

Le psy: I am sorry to hear you are depressed

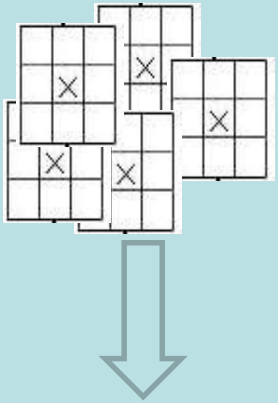
1980: John Searle and the Chinese room

John Searle

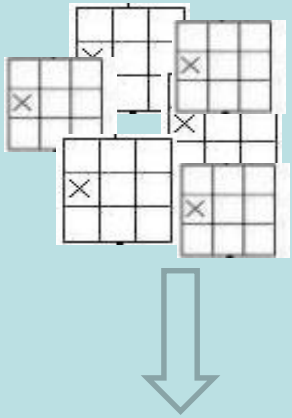


The tic-tac-toe

IA that learns and performs

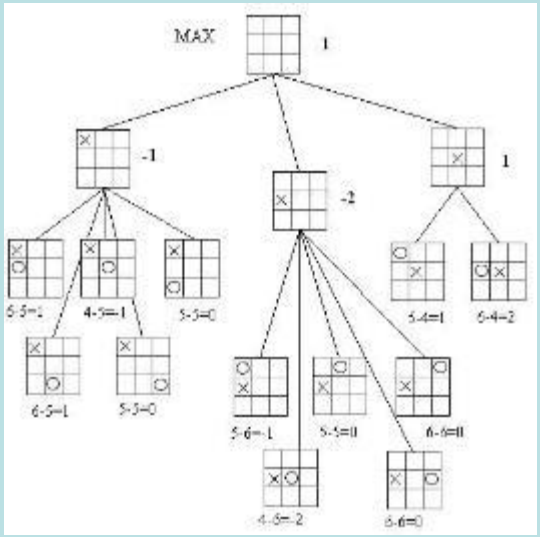


GAGNE !!!



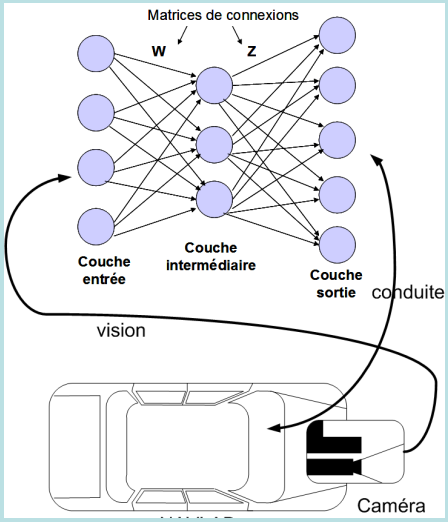
PERDU !!

IA that thinks and understands



The automatic car

IA that learns and performs



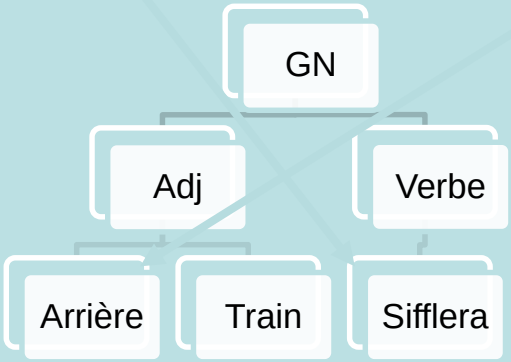
Control Theory

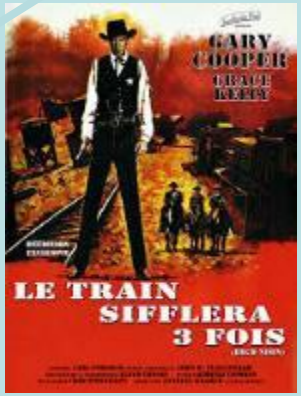
- dx/dt = F(x,u)
- Y = G(x)
- Objectif: min $\int_{-\infty}^{\infty} x + u \, dt$
- u* = K(x,t)

Automated translation

IA that understands

- Après ce plat de fayots, mon arrière-train sifflera trois fois





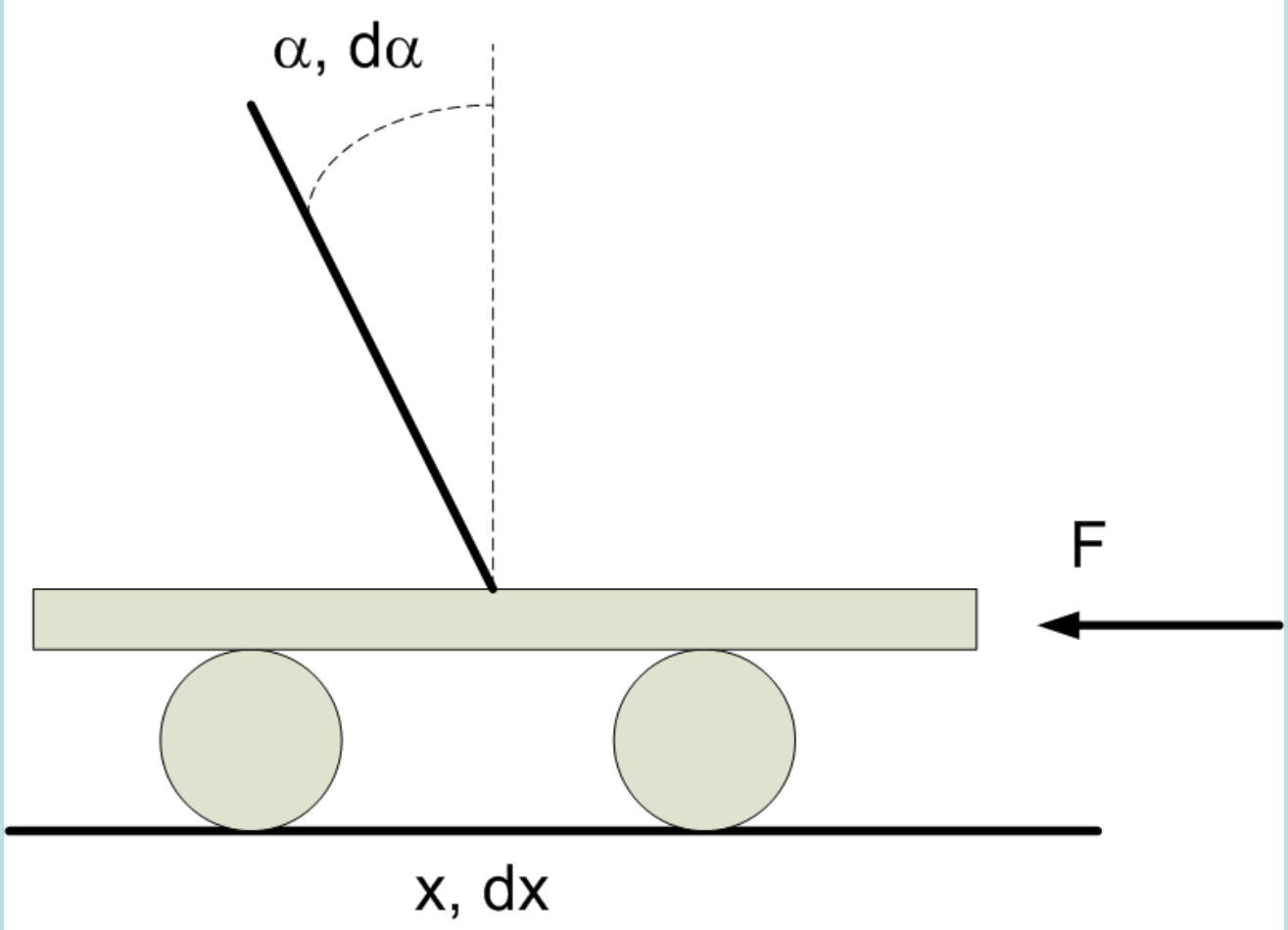
IA that learns and performs

- After this dish of baked beams, my hindquarters whistle three times

Français

Anglais

How does the computer control



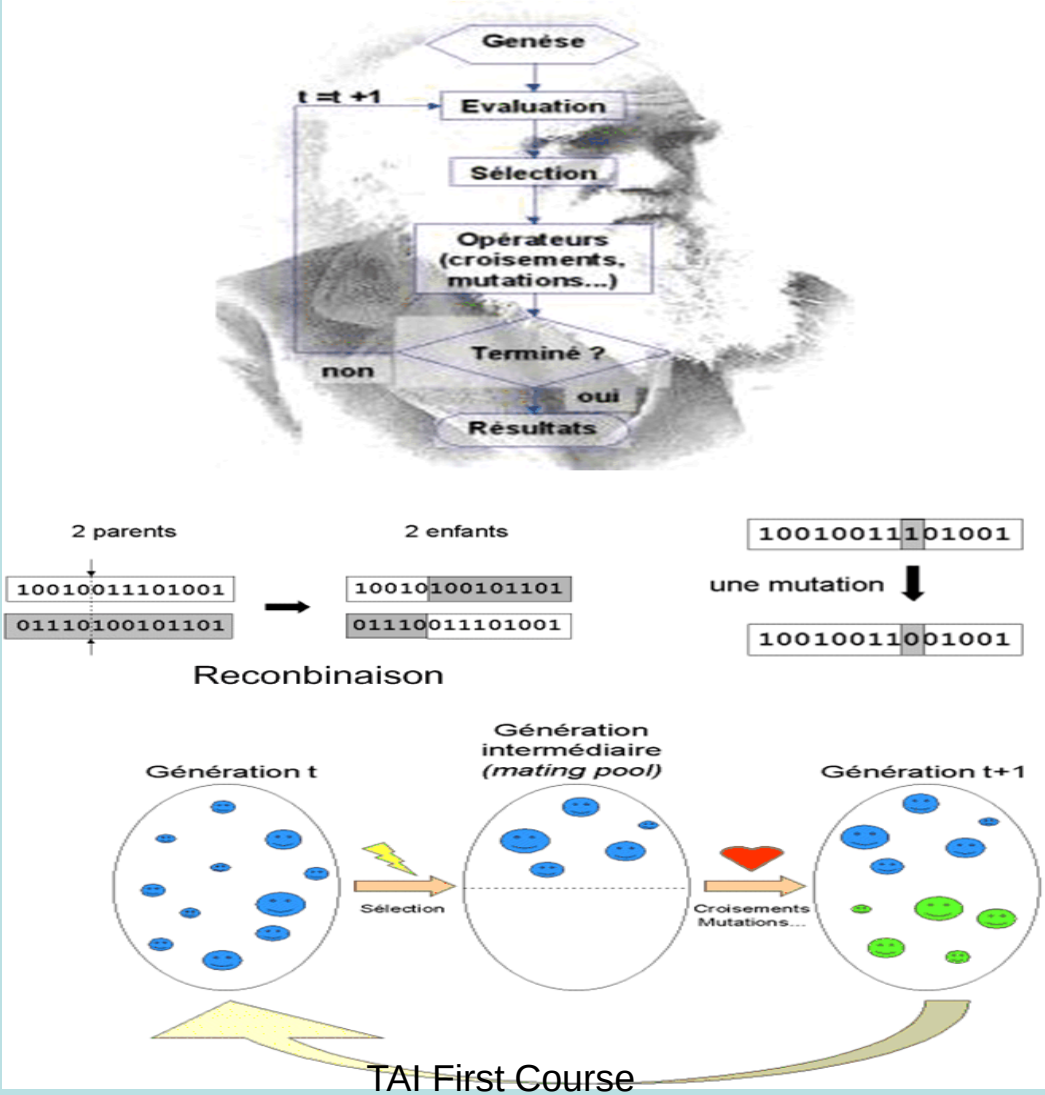
- *Si « -5 <= α <= 5 » ET « -20 <= x <= 20 » ET «+2 <= dα <= +3 » ET « -1<= dx <= +1 »*

Alors « f = +10 »

- *Si « -5 <= α <= 5 » ET « -20 <= x <= 20 » ET « -5 <= dα <= -3 » ET « -1<= dx <= +1 »*

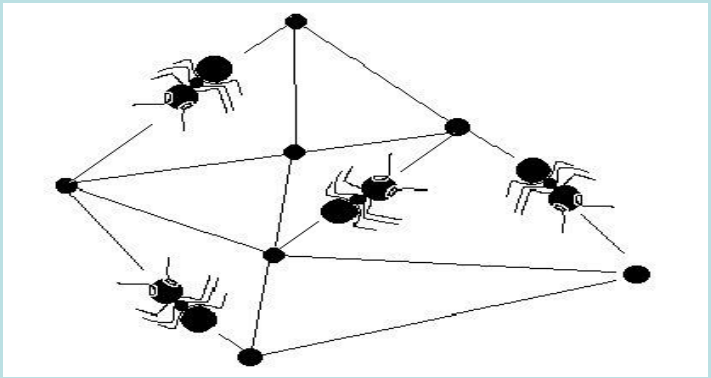
Alors « f = -10 »

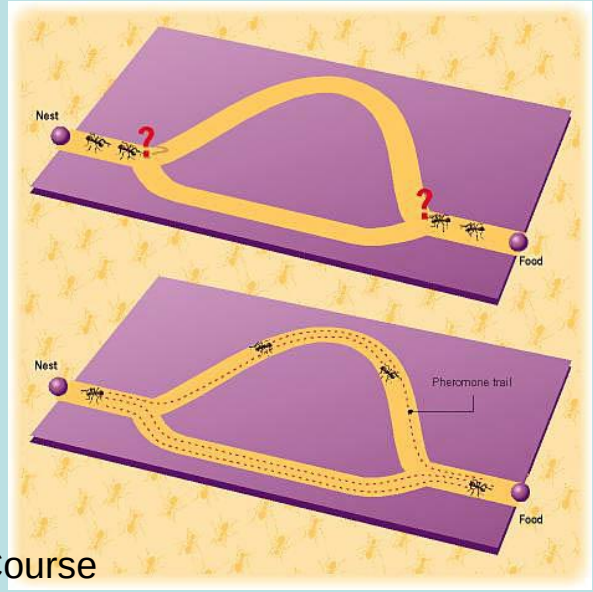
Genetic algoritms



Ant Colony Optimisation

- Emergence: How new processes (often complex) appear at a higher level from simple underlying rules but iterated infinitely in space and time at a lower level.
- Insect societies are striking examples.
- ACO an excellent optimisation strategy



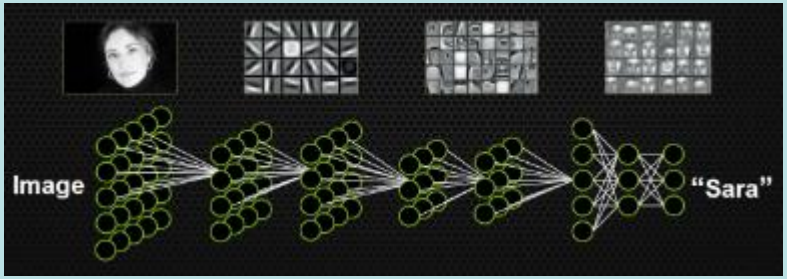


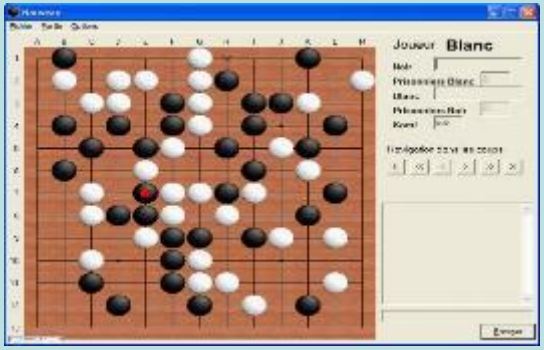
The Good IA

AI that thinks

IA that learns

Deep Learning

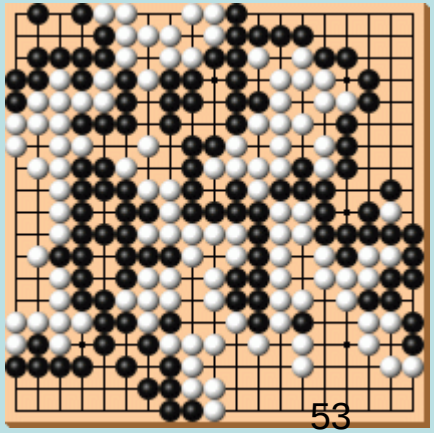




Game
Of Go

Conclusions

- The best chess player is AI based: Deep Blue
- But the best backgammon player is ALife based: TD-Gammon learning by reinforcement learning
- Jeopardy Watson is just brute force search engine + a bit of inferences
- So ? It is possible that at a certain level of complexity, even for an engineer, learning and adaptation is the only way out.
- To the expense of a “lost of control”. The engineer guides but does not find out.



- AI in Entertainment
  - Movies
    - Metropolis (1927)
    - 2001: A Space Odyssey (1968)
    - Bladerunner (1982)
    - The Terminator (1984)
    - AI (2001)
    - I, Robot (2004)
  - TV
    - Star Trek: The Next Generation (Lieutenant Commander Data; 1987-94)
    - Battlestar Galactica (The Cylons; 1978, 2004-5)

- Books
  - Do Androids Dream of Electric Sheep (1968) by Philip K.Dick
  - Neuromancer (1984) by William Gibson (coined term "cyberspace")
  - Hyperion (1989) by Dan Simmons
  - Cryptonomicon (1997) by Neal Stephenson (nanotechnology)
  - The Diamond Age (1998) by Neal Stephenson (early wifi, cryptography)
  - Thinks... (2001) by David Lodge
- Robot pets
  - Tamagotchi
  - Aibo

- Video Games
  - Halo
    - Non Player Characters with real time perceptions of their environment
    - Knowledge of the state of the world, as last perceived
    - Emotions based on events
    - Decision making capability
  - Black and White
    - Characters learn from feedback from player
    - Emergent unscripted behaviour
  - The Sims
    - Toggle 'free will' on and off
    - Agents climb peaks of a 'happiness landscape'