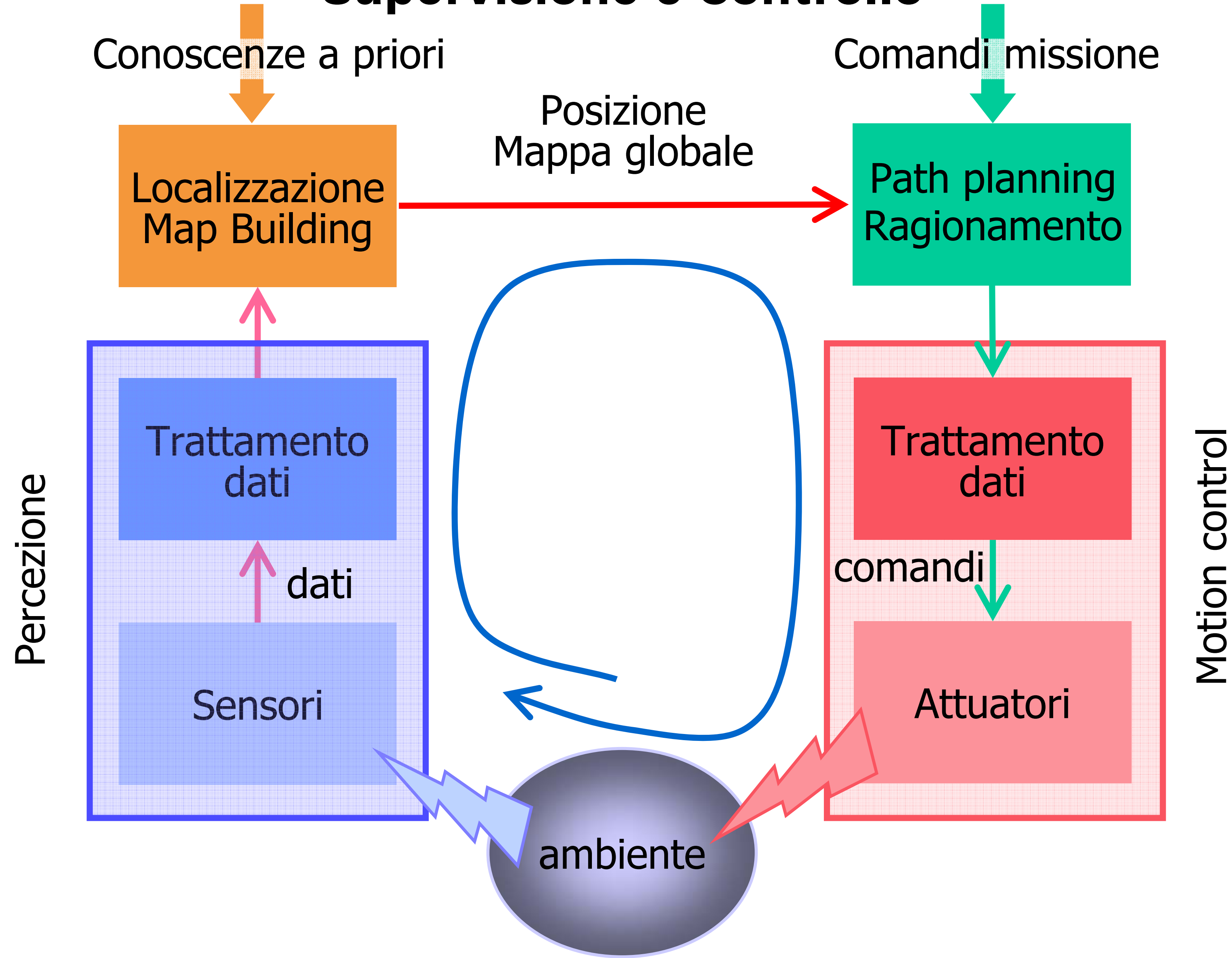
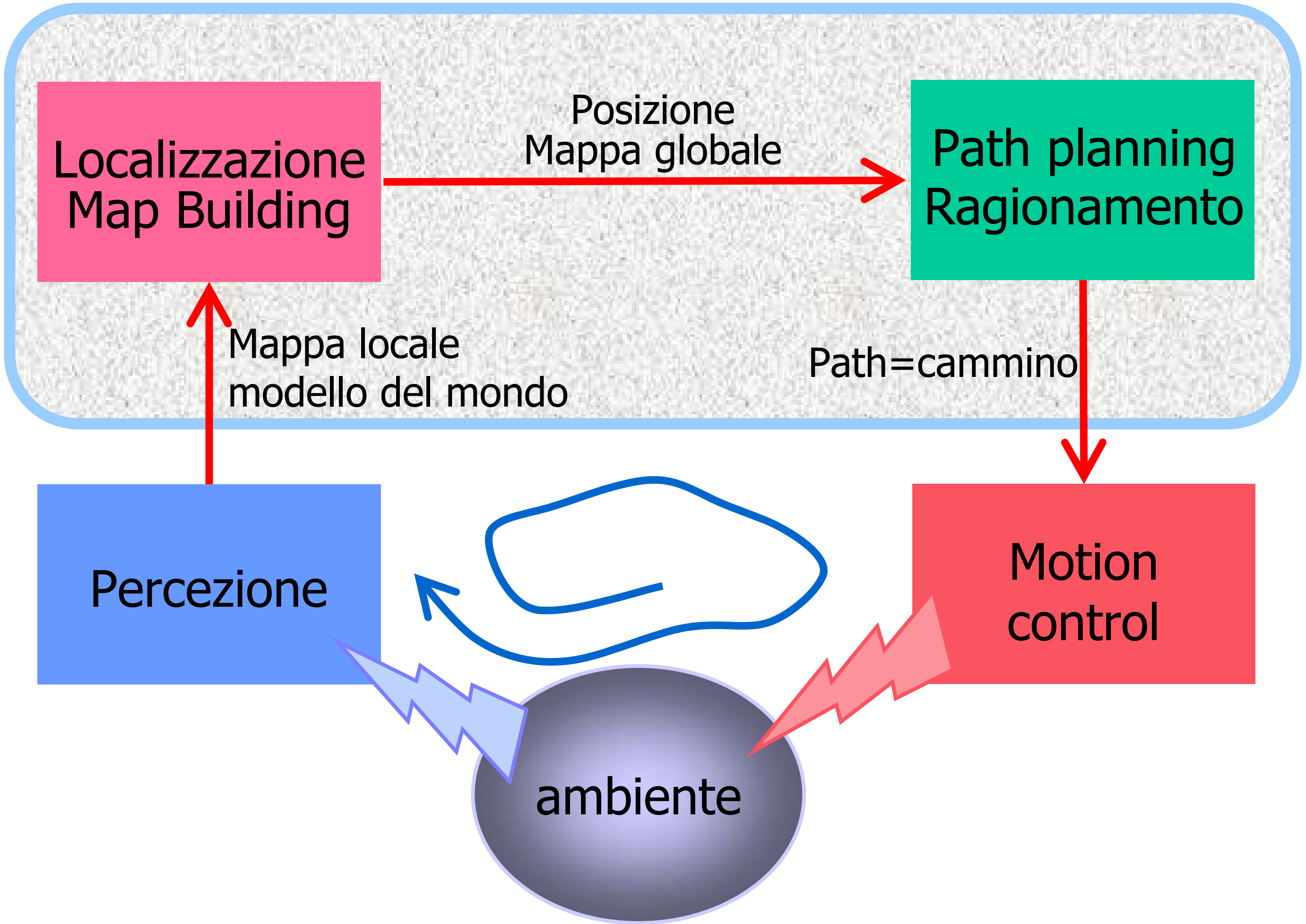
Supervisione e Controllo



Supervisione e Controllo



Strategie di controllo

- Struttura dell’anello di controllo
    - L’ambiente o “mondo” si modifica dinamicamente
    - Non esiste un modello “compatto” del mondo
    - Vi sono molte sorgenti di incertezza, sia nel mondo sia nel robot
- Due approcci possibili
  - AI “classico” – modello <u>deliberativo</u>
    - Modellazione completa (model-based)
    - Basato su funzioni
    - Decomposizione orizzontale
  - AI “moderno” – modello <u>reattivo</u>
    - Nessun modello o quasi: basato su comportamenti (behavior-based)
    - Decomposizione verticale
    - Approccio bottom-up

Caratteristiche delle strategie di controllo

DELIBERATIVO Model-based	REATTIVO Behavior-based
Puramente simbolico	Riflessivo

Velocità di risposta →

← Capacità predittive

← Dipendenza da modelli accurati del mondo

Deliberativo:

- Dipendente dalla rappresentazione del mondo
- Risposta lenta
- Intelligenza ad alto livello (cognizione)
- Latenza variabile

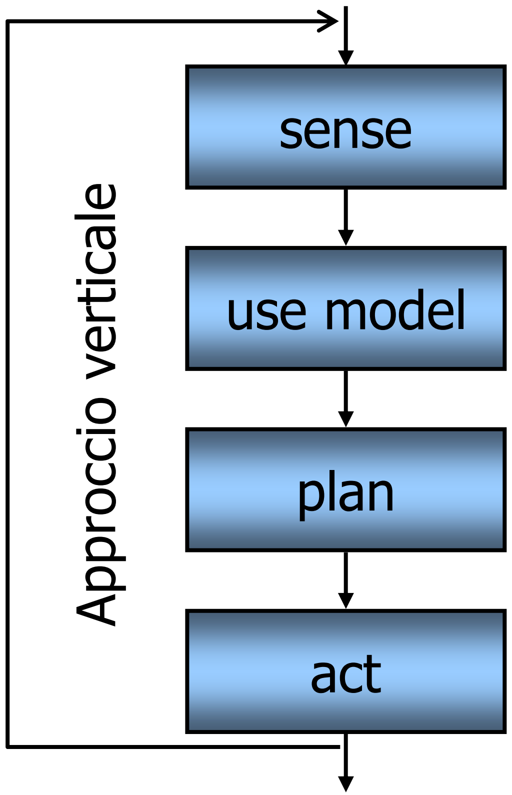
Reattivo:

- Indipendente dalla rappresentazione (representation-free)
- Risposta in real-time
- Intelligenza a basso livello (stimolo-risposta)
- Calcolo semplice e veloce

Caratteristiche delle strategie di controllo

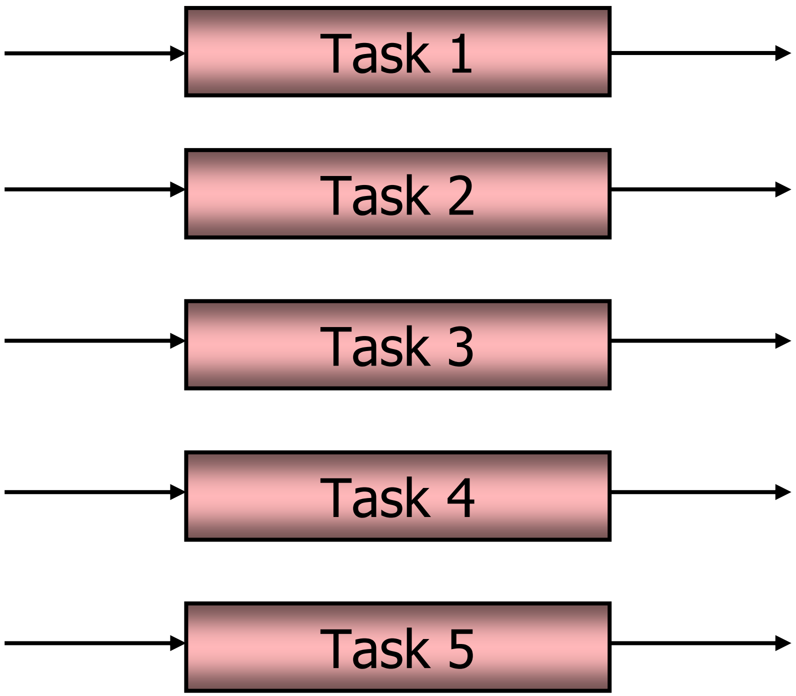
Sense – Plan – Act

Questo paradigma può impedire una risposta tempestiva ed efficace del robot



Subsumption/Reactive model

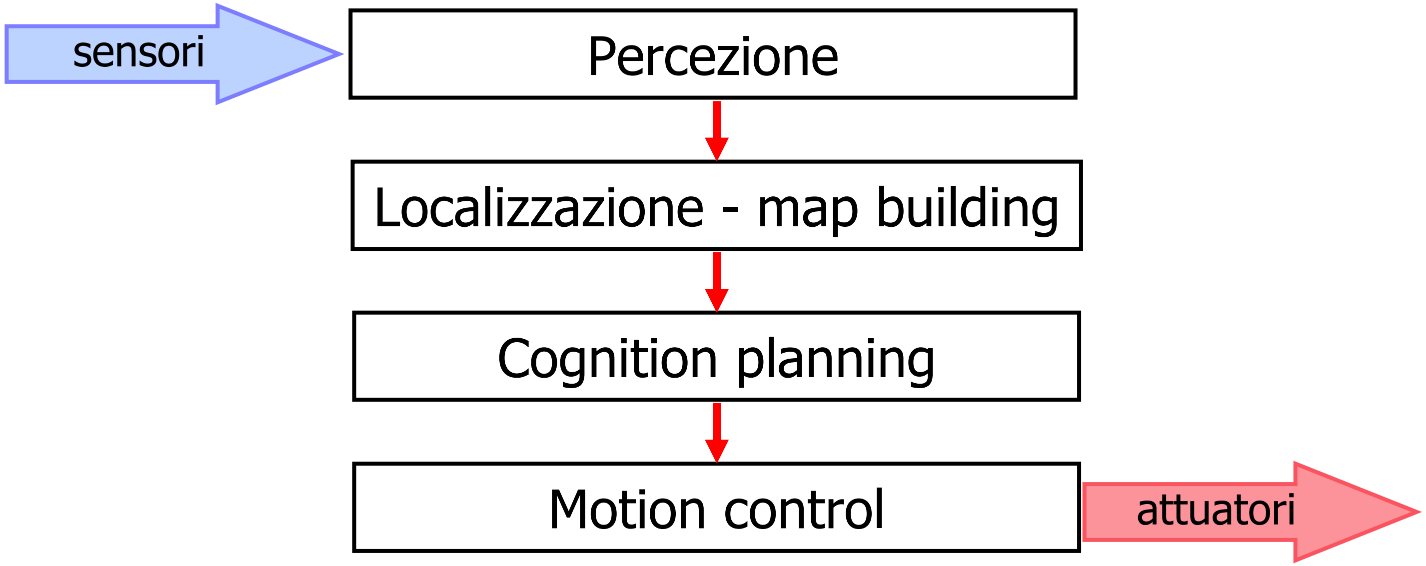
http://ai.eecs.umich.edu/cogarch0/subsump/



Approccio Model-Based

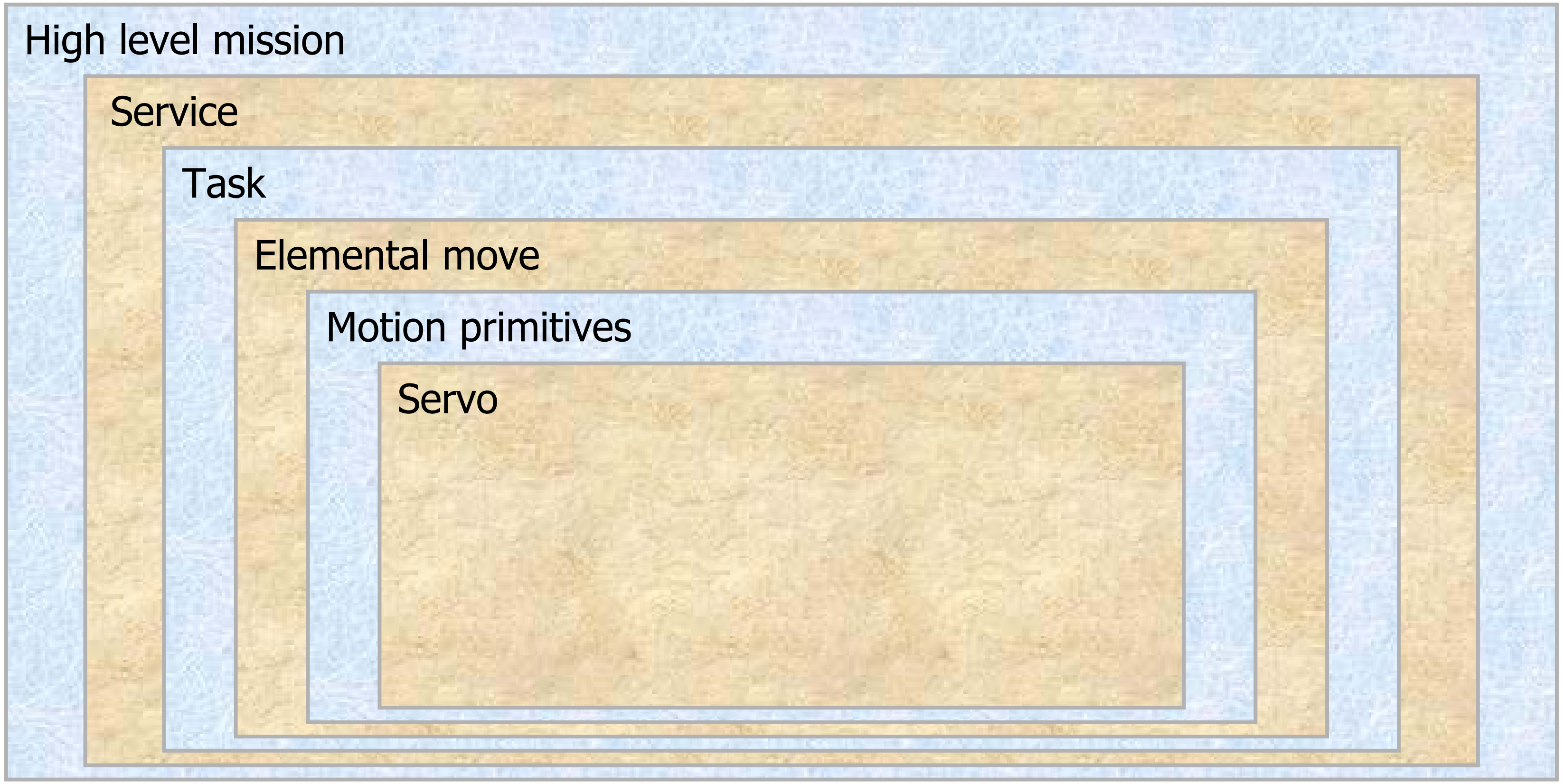
- Modellazione *completa* del mondo
- Ogni blocco è una funzione computata
- Decomposizione verticale dell'architettura e nested-embodiment delle funzioni:

Un primo esempio



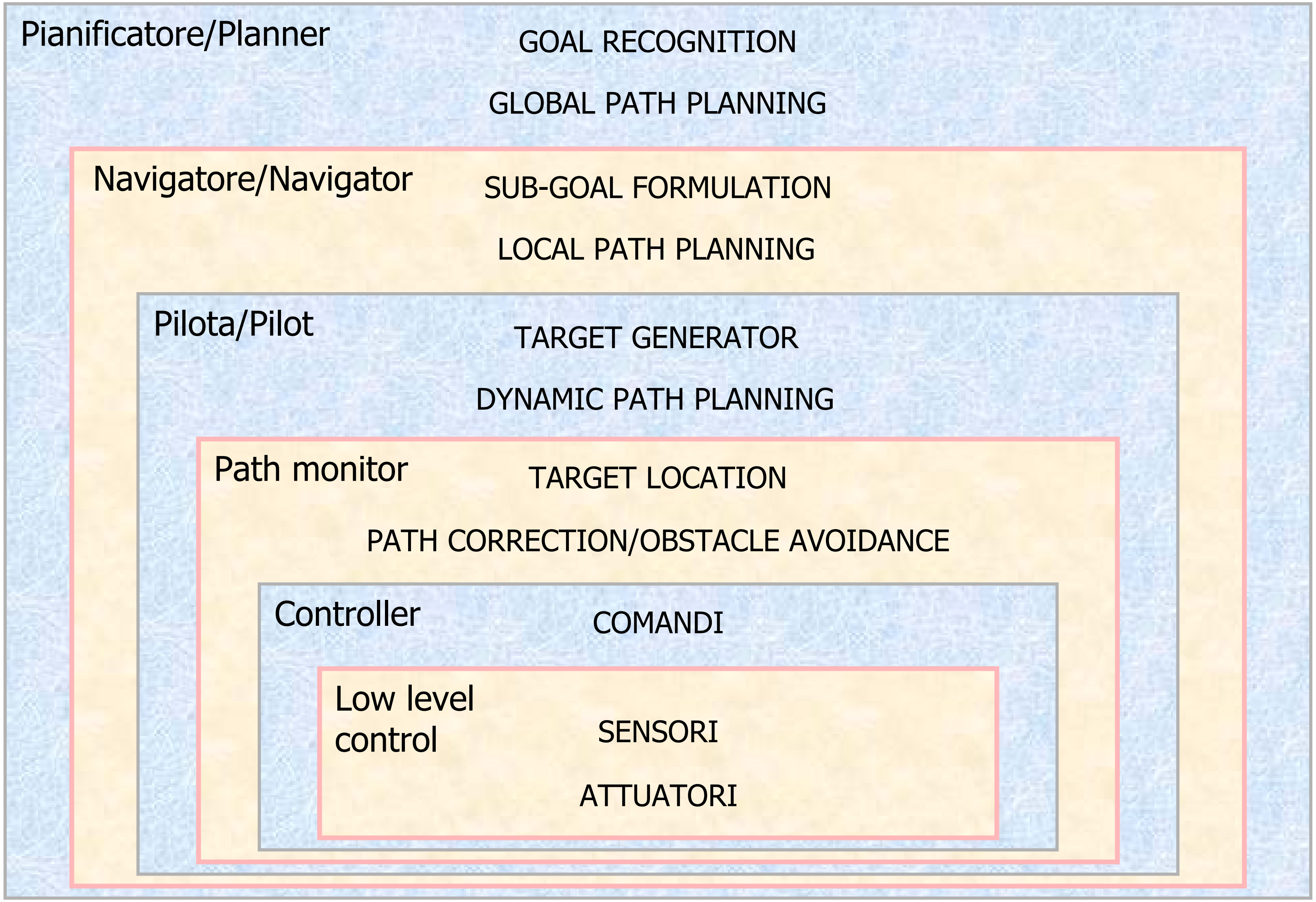
Approccio Model-Based

Un secondo esempio: nested embodiment



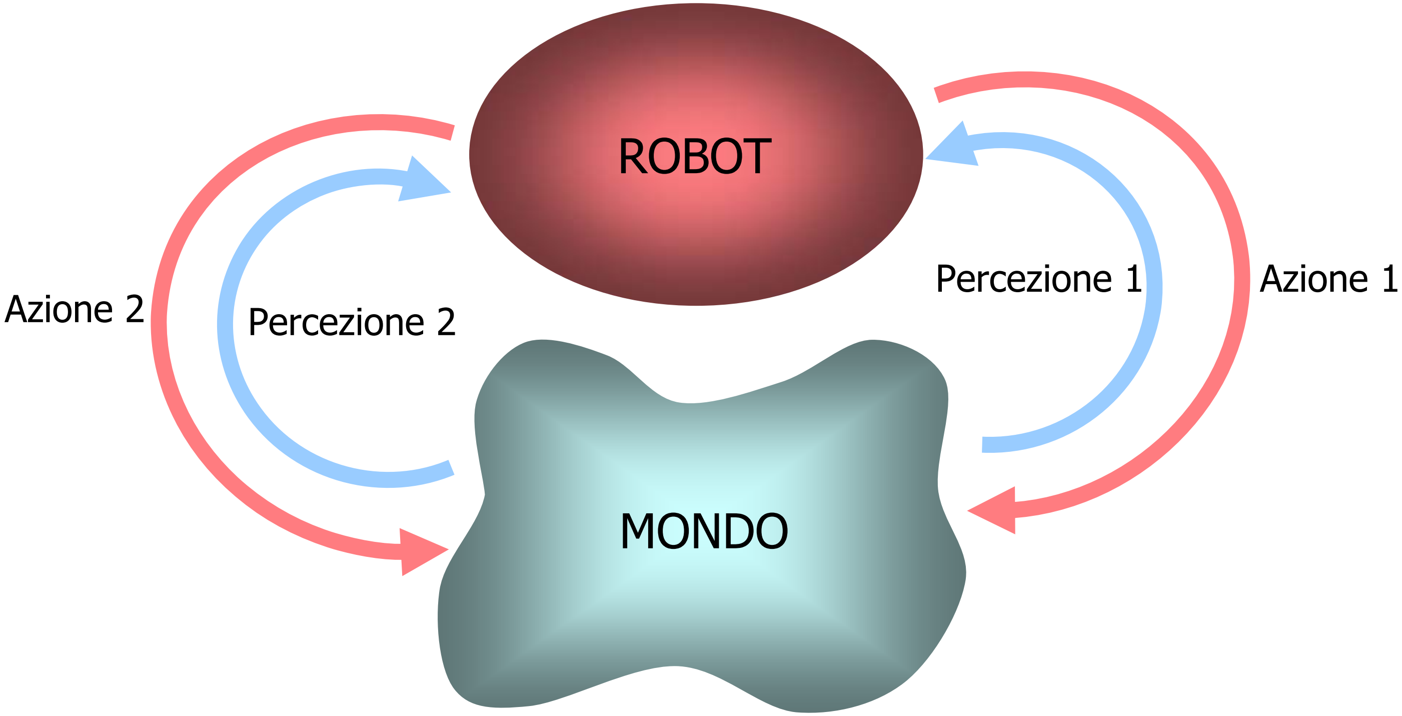
Approccio Model-Based

Un terzo esempio: nested embodiment



Approccio Behavior-Based

- Sistema "reattivi"
- Comportamento "riflessivo"
- Percezione-azione
- Subsumption



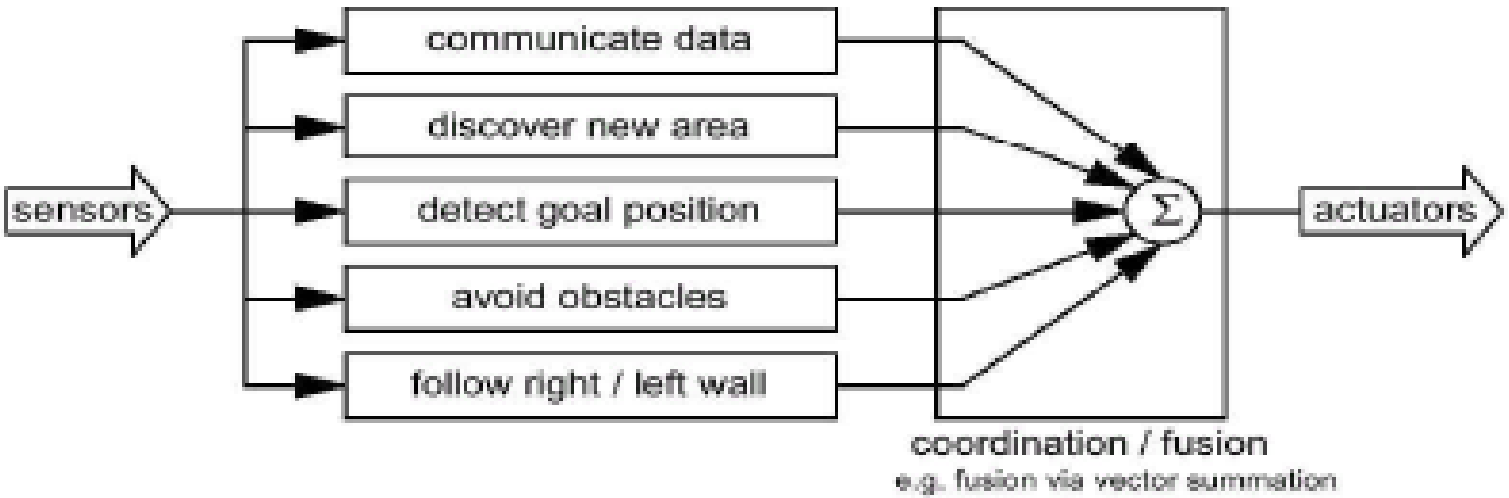
Approccio Behavior-Based

Brooks è il fondatore di questo approccio:
ecco alcune sue frasi chiave

- Complex behavior need not necessarily be the product of a complex control system
- Intelligence is in the eye of the observer
- The world is its best model
- Simplicty is a virtue
- Robots should be cheap
- Robustness in the presence of noisy or failing sensors is a design goal
- Planning is just a way of avoiding figuring out what to do next
- All onboard computation is important
- Systems should be built incrementally
- No representation. No calibration. No complex computers. No high band communication

Approccio Behavior-Based

- Nessun modello è necessario
- Decomposizione orizzontale
- Coordinamento + Priorità = Fusione
- Biomimesi = osservare e copiare il comportamento animale
- Embodiment



Embodiment

- to embody = verb: manifest or personify in concrete form; incarnate; incorporate, unite into one body
- **Embodiment** is the way in which human (or any other animal's) psychology arises from the brain's and body's physiology.
- It is specifically concerned with the way the adaptive function of categorisation works, and how things acquire names.
- It is distinguished from developmental psychology and physical anthropology by its focus on cognitive science, ontogeny, ontogenetics, chaos theory and cognitive notions of entropy – far more abstract and more reliant on mathematics.

Embodiment

- Embodiment theory was brought into AI by Rodney Brooks in the 1980s.
- Brooks and others showed that robots could be more effective if they 'thought' (planned or processed) and perceived as little as possible.
- The robot's intelligence is geared towards only handling the minimal amount of information necessary to make its behavior be appropriate and/or as desired by its creator.
- Brooks (and others) have claimed that all autonomous agents need to be both embodied and situated. They claim that this is the only way to achieve strong AI.

Embodiment

- (Rolf Pfeifer AILab Zurich) there are essentially two directions in artificial intelligence: one concerned with developing useful algorithms or robots; and another direction that focuses on understanding intelligence, biological or otherwise.
- In order to make progress on the latter, an embodied perspective is mandatory. In this research branch, artificial intelligence *is* embodied.

Situated robot

Critica ad un approccio reattivo puro

A *situated* robot is one which does not deal with abstract representations of the world (which may be simulated or real), but rather reacts directly to its environment as seen through its sensors.

An alternative to having a situated robot would be one which builds up a representation of its world and then makes plans based on the representation.

Because of the limitations of our present technology, these two approaches often seem contradictory.

In the present, each approach is better for different applications.

If we want to make an "artificial person" at some point in the future, we will need to incorporate both approaches.

Situated robot

The situated approach can only deal with a small domain of problems.

When a robot gets into a situation where it needs to reason or plan ahead in order to reach a goal, simply reacting to its environment is insufficient.

A situated robot can be thought of as sensors and goals feeding into a fixed network of difference engines which have actuators as their outputs.

For example, we might have a light sensors and a goal of reaching lights fed into a difference engine.

The robot would then activate its actuators in an attempt to reach its goal.

Situated robot

This network might be slightly more complex with a controller suppressing and activating difference engines in response to an FSM state or a sensor input (for example, causing the robot to flee when danger is detected).

However, this architecture does not give us the flexibility we need to solve more complicated problems, such as figuring out that we need to move further from some goals in order to reach an overall goal.

A situated robot might have special cases built into it (e.g. for dealing with getting stuck in a corner or down a dead-end hallway), but it would be very difficult to deal with the general case this way.

Situated robot

The situated approach is good for dealing with problems where planning ahead is unnecessary or takes too much time.

However, the representation approach is needed for solving more complicated problems where it is necessary to reason about the state of the world.

For dealing with complicated tasks in the real world, it will probably be necessary to fuse the two approaches.

Reasoning can be used to build up higher level plans and solve high level problems while lower level agencies may use a more situated approach for carrying out plans and dealing with problems which need immediate attention.

Subsumption

- The subsumption architecture was originally proposed by Brooks [1986].
- The subsumption (or 'Brooksian') architecture is based on the synergy between sensation and actuation in lower animals such as insects.
- Brooks argues that instead of building complex agents in simple worlds, we should follow the evolutionary path and start building simple agents in the real, complex and unpredictable world.
- From this argument, a number of key features of subsumption result:

Subsumption

1. No explicit knowledge representation is used. Brooks often refers to this as "*The world is its own best model*".
2. Behavior is distributed rather than centralized.
3. Response to stimuli is reflexive -- the perception-action sequence is not modulated by cognitive deliberation.
4. The agents are organized in a bottom-up fashion. Thus, complex behaviors are fashioned from the combination of simpler, underlying ones.
5. Individual agents are inexpensive, allowing a domain to be populated by many simple agents rather than a few complex ones. These simple agents individually consume little resources (such as power) and are expendable, making the investment in each agent minimal.

Subsumption

- Several extensions (Mataric, 1992) have been proposed to pure reactive subsumption systems.
- These extensions are known as behavior-based architectures.
- Capabilities of behavior-based systems include landmark detection and map building, learning to walk, collective behaviors with homogeneous agents, group learning with homogeneous agents, and heterogeneous agents.

Robotica e AI

- La struttura e le relazioni che nascono dall'interazione tra controllori (semplici) e ambiente (complesso) viene denominata emergent behavior
- Le sette aree dell'AI applicata alla robotica
  - Knowledge representation
  - Understanding natural languages
  - Learning
  - Planning and problem solving
  - Inference
  - Search
  - Vision

R.R. Murphy, Introduction to AI Robotics, MIT Press, 2000.

Knowledge representation

- Definire e realizzare le strutture fisiche e virtuali con cui il robot rappresenta
  - il mondo
  - i compiti
  - sé stesso
- Esempio: un robot sta cercando un essere umano sotto le macerie: come lo rappresenta?
  - Una possibilità: modello strutturale:
    - Testa ovale
    - Torso cilindrico
    - Braccia cilindriche ma più piccole
    - Simmetria bilaterale
  - Cosa succede se è visibile solo una parte della vittima?

Understanding natural languages

Supponete di ordinare al vostro PC

"formatta la mia tesi di laurea come vuole il professore"

e domandatevi ora quali sono i passi necessari per portare a termine l'ordine

Riconoscere le parole NON significa comprendere la frase

Struttura grammaticale vs **Semantica**

Le due frasi

We gave the monkeys the bananas because they were hungry
We gave the monkeys the bananas because they were over-ripe

Hanno la stessa struttura grammaticale, ma differente significato. Per capirlo bisogna conoscere sia le scimmie sia le banane.

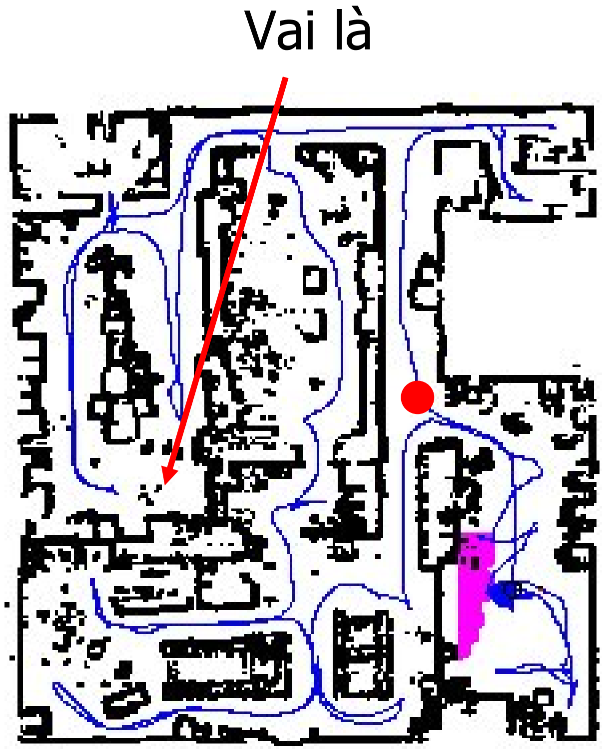
Necessità di sviluppare **ontologie**

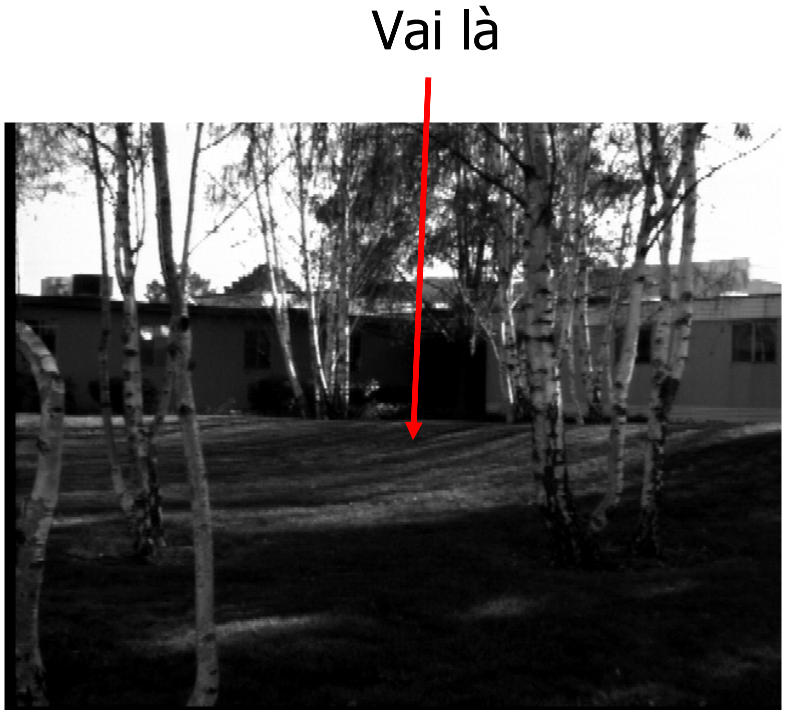
Learning

- Si intende la capacità di memorizzare comportamenti e azioni e di ripeterli in modo da adattarsi agli obbiettivi (implici o espliciti) richiesti
- In a broad sense, learning is the ability to adapt during life
- We know that most living organisms with a nervous system display some type of adaptation during life.
- The ability to adapt quickly is crucial for autonomous robots that operate in dynamic and partially unpredictable environments, but the learning systems developed so far have so many constraints that are hardly applicable to robots that interact with an environment without human intervention.
- Il learning richiede
  - una struttura capace di memorizzare e ricuperare i dati
  - uno o più obbiettivi dichiarati
  - un meccanismo di adattamento (bastone+carota)
  - un teacher implicito o esplicito

Planning and problem solving

- L'intelligenza è associata all'abilità si pianificare le azioni necessarie a portare a termine un compito e di risolvere i problemi che nascono quando i piani non funzionano





Planning and problem solving

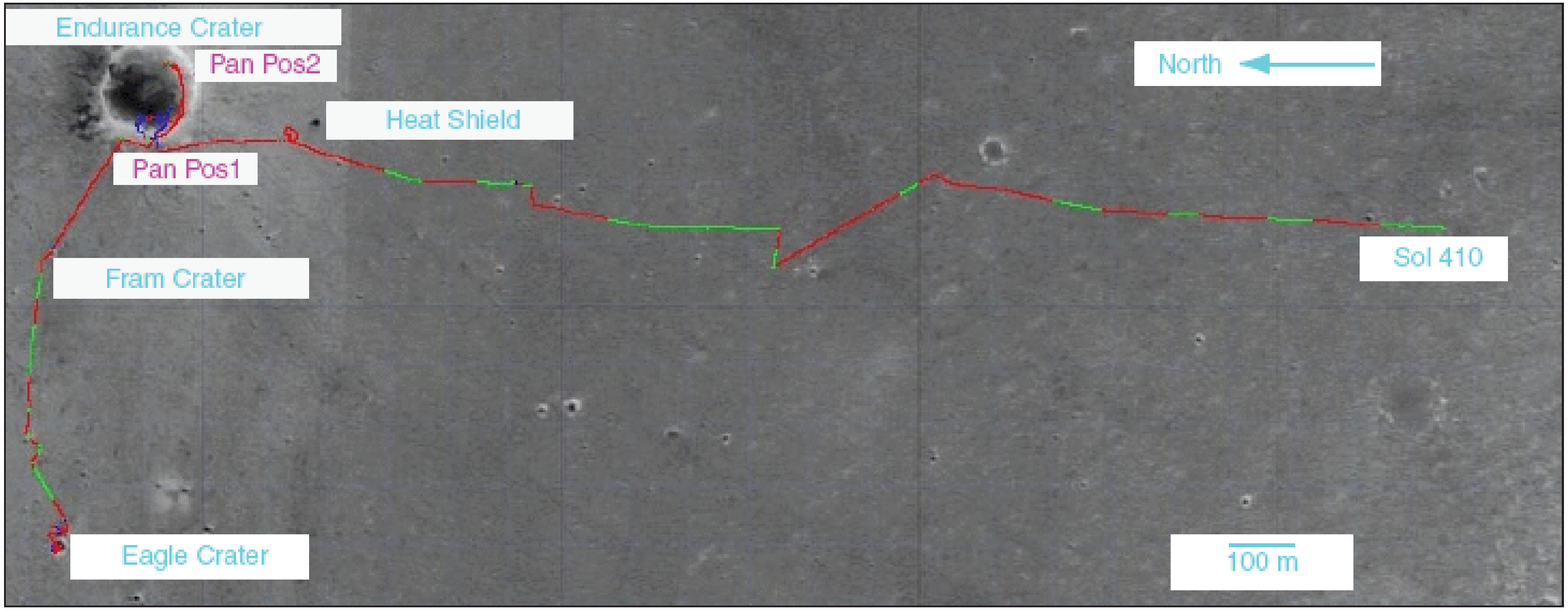


Figure 1. Opportunity's *estimated position as of Sol 410; red for blind driving, green for auto hazard avoidance, and blue for visodom.*

SLAM

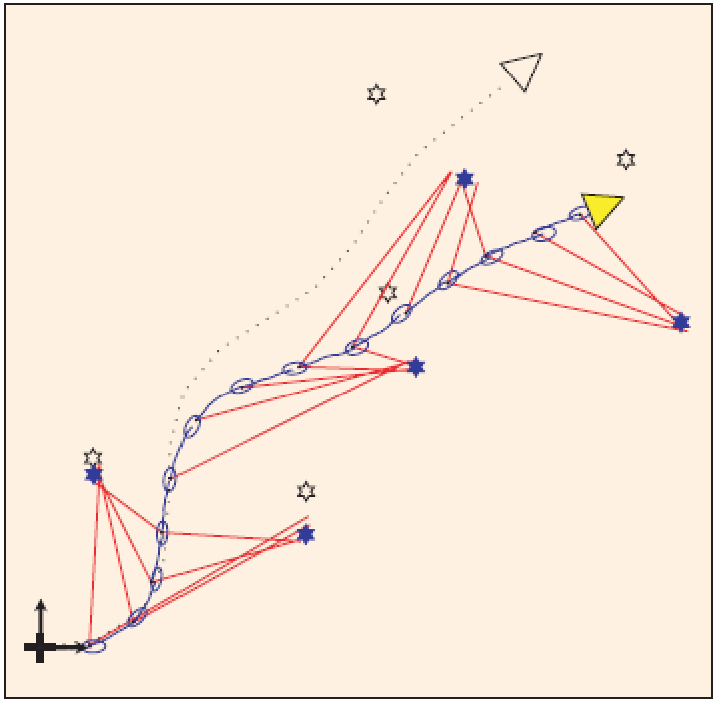
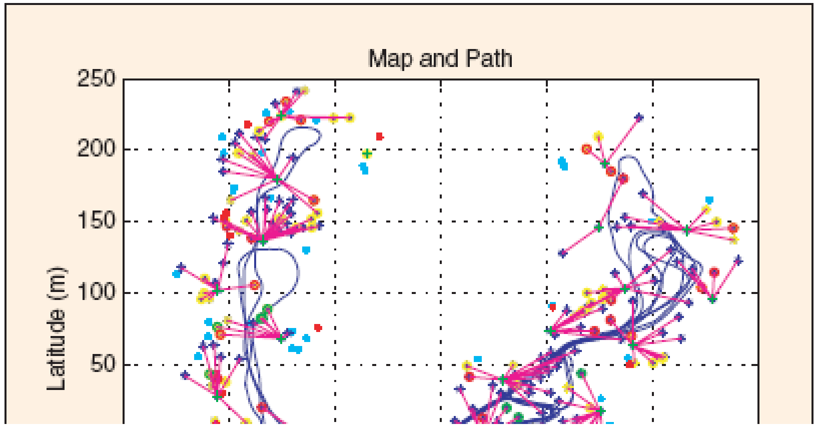


Figure 5. *A single realization of robot trajectory in the Fast-SLAM algorithm. The ellipsoids show the proposal distribution for each update stage, from which a robot pose is sampled, and, assuming this pose is perfect, the observed landmarks are updated. Thus, the map for a single particle is governed by the accuracy of the trajectory. Many such trajectories provide a probabilistic model of robot location.*



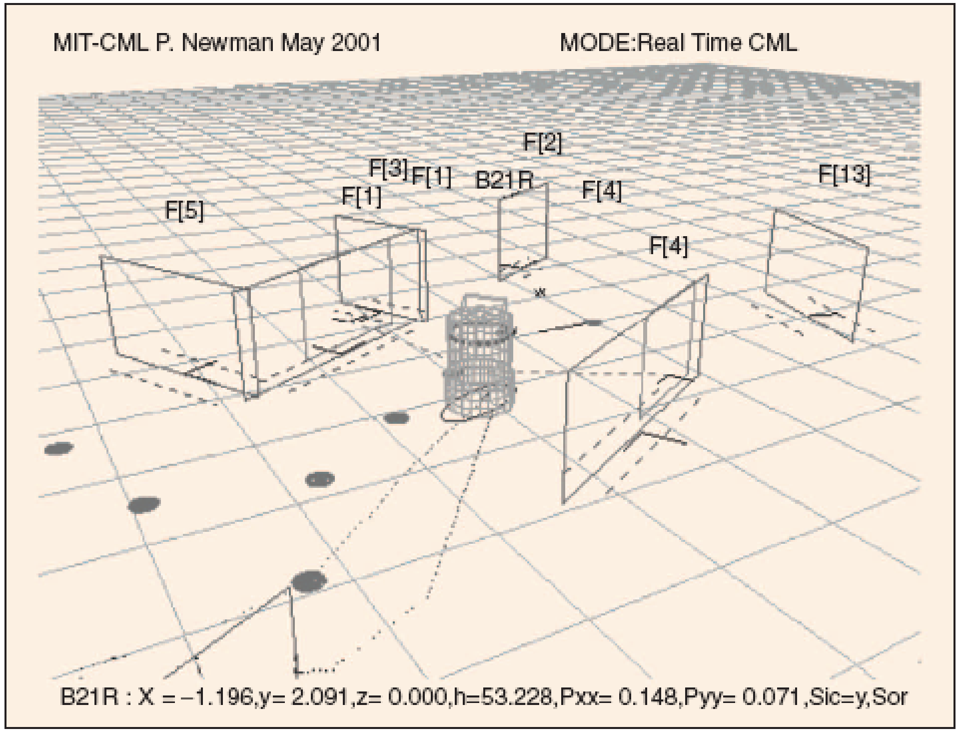


Figure 6. *A real-time SLAM visualization by Newman et al. [37].*

Inference

- L’inferenza è quella procedura che consente di generare una risposta quando si hanno informazioni incomplete
- L’inferenza si basa su modelli statistici (reti bayesiane) o modelli semantici

Search

- Non significa necessariamente la ricerca di oggetti nello spazio fisico, bensì la capacità di esaminare un data-base di *knowledge representation* (chiamato *search space*) per trovare la risposta desiderata
- Considerate un computer che gioca a scacchi: la mossa migliore viene cercata e trovata analizzando il search space di tutte le possibili mosse a partire dalla stato presente dei pezzi sulla scacchiera

Vision

- La visione è il senso più importante dell’essere umano
- Studi psicologici suggeriscono che l’abilità di risolvere problemi dipende dalla capacità di visualizzare gli effetti delle azioni nel nostro cervello

Ontologia

- In filosofia, l'**ontologia**, branca fondamentale della metafisica, è lo studio dell'essere in quanto tale, nonché delle sue categorie fondamentali.
- Il termine deriva dal greco *οντος*, "òntos" (participio presente di *ειναι*, "einai", il verbo essere) più *λογος*, "lògos". Significa letteralmente "discorso sull'essere".
- Nell'informatica, una **ontologia** è il tentativo di formulare uno schema concettuale esaustivo e rigoroso nell'ambito di un dato dominio;
- si tratta generalmente di una struttura dati gerarchica che contiene tutte le entità rilevanti, le relazioni esistenti fra di esse, le regole, gli assiomi, ed i vincoli specifici del dominio.
- L'uso del termine "ontologia" nell'informatica è derivato dal precedente uso dello stesso termine in filosofia, dove ha il significato dello studio dell'essere o dell'esistere, così come le fondamentali categorie e delle relazioni tra esse.

Some examples of the problems faced by natural language understanding systems:
The sentences *We gave the monkeys the bananas because they were hungry* and *We gave the monkeys the bananas because they were over-ripe* have the same surface grammatical structure. However, in one of them the word *they* refers to the monkeys, in the other it refers to the bananas: the sentence cannot be understood properly without knowledge of the properties and behaviour of monkeys and bananas.
A string of words may be interpreted in myriad ways. For example, the string *Time flies like an arrow* may be interpreted in a variety of ways:

> time moves quickly just like an arrow does;
> measure the speed of flying insects like you would measure that of an arrow - i.e. *(You should) time flies like you would an arrow.*;
> measure the speed of flying insects like an arrow would - i.e. *Time flies in the same way that an arrow would (time them).*;
> measure the speed of flying insects that are like arrows - i.e. *Time those flies that are like arrows*;
> a type of flying insect, "time-flies," enjoy arrows (compare *Fruit flies like a banana*.)

The word "time" alone can be interpreted as three different parts of speech, (noun in the first example, verb in 2, 3, 4, and adjective in 5).

> English is particularly challenging in this regard because it has little inflectional morphology to distinguish between parts of speech.

Alcuni libri

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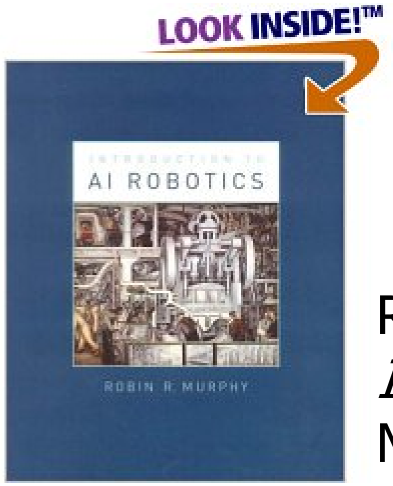

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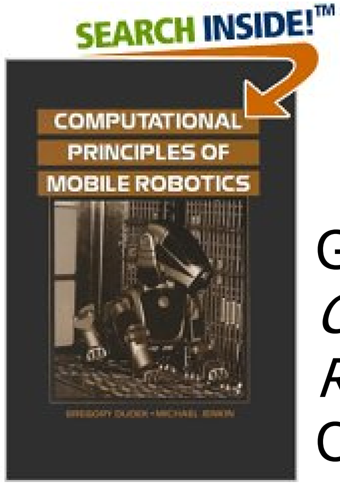

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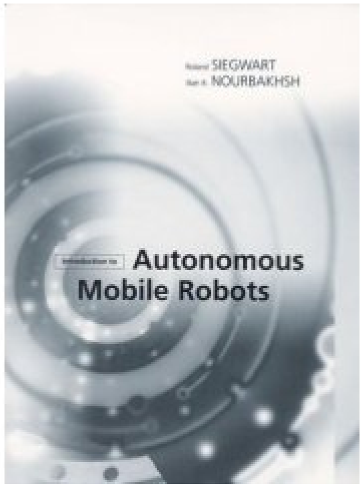

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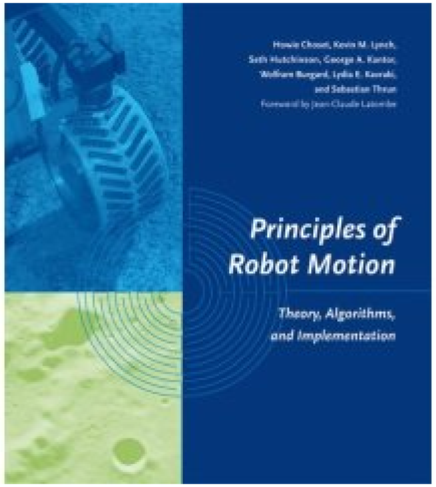

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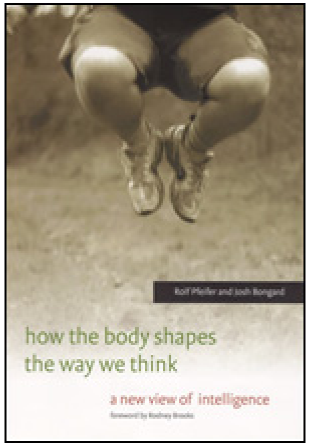
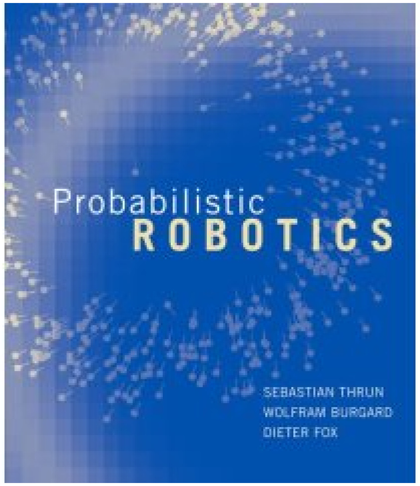


How the Body Shapes the Way We Think
A New View of Intelligence
Rolf Pfeifer and Josh C. Bongard
Foreword by Rodney Brooks

Alcuni libri



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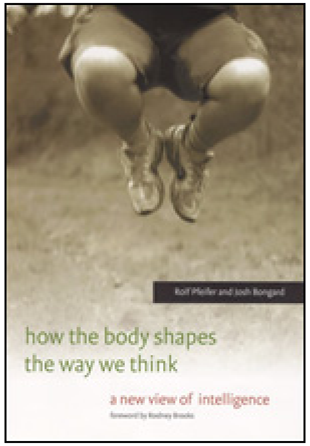

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