

Robotica Mobile

*Lezione 18:
Strutture di controllo di robot
avanzati*

Un esempio: la *subsumption architecture*

31-05-2004

Robot tradizionali e robot avanzati:

The diagram illustrates two control architectures. On the left, a traditional robot control system is shown where a human operator (represented by a stick figure) receives input from 'Problema' and 'Ambiente' boxes and provides a 'Soluzione' (solution) to a robotic arm. On the right, a subsumption architecture is shown where a mobile robot receives input from 'Problema' and 'Ambiente' boxes and provides a 'Soluzione' (solution) directly to the robot.

31-05-2004

Quindi, i passi sono:

Robot tradizionale

- ⇒ Analisi del problema
- ⇒ Formulazione dell'algoritmo
- ⇒ Codifica dell'algoritmo
- ⇒ Debugging

Robot autonomo

- ⇒ Esecuzione dell'algoritmo

I programmi che abbiamo scritto sul Pioneer...

- ⇒ Sono puramente reattivi, o puramente algoritmici
- ⇒ Reattivo è bello, ma deve essere complesso per ottenere comportamenti sofisticati
- ⇒ Una formica è reattiva? O pianifica?
- ⇒ Occorre trovare il modo per combinare insieme tanti comportamenti

L'articolo più famoso della letteratura robotica moderna:

14 IEEE JOURNAL OF ROBOTICS AND AUTOMATION, VOL. 8, NO. 1, FEBRUARY 1992

A Robust Layered Control System For A Mobile Robot

RODNEY A. BROOKS, MEMBER, IEEE

Abstract—A new architecture for controlling mobile robots is described. Layers of control system are built to let the robot operate at increasing levels of autonomy. Layers are made up of subsystem modules that communicate over low-bandwidth channels. Each module is an instance of a fully encapsulated machine. Higher-level layers can subsume the robot's lower levels by reorganizing their outputs. However, lower levels continue to function as higher levels are added. The result is a robust and flexible robot control system. The system has been used to control a mobile robot wandering around unstructured laboratory areas and computer monitor rooms. Eventually it is intended to control a robot that wanders the office areas of our laboratory, building maps of its surroundings using an onboard wire to perform simple tasks.

1. INTRODUCTION

A CONTROL SYSTEM for a completely autonomous mobile robot must perform many complex information processing tasks in real time. It operates in an environment where the boundary conditions (viewing the instantaneous control problem in a classical control theory formulation) are changing rapidly. In fact the determination of those boundary conditions is done over very noisy channels since there is no straightforward mapping between sensors (e.g., TV cameras) and the forms required of the boundary conditions.

The usual approach to building control systems for such robots is to decompose the problem into a series (possibly of functional units) as illustrated by a series of vertical slices in Fig. 1. After analyzing the computational requirements for a mobile robot we have decided to use task-achieving behaviors as our primary decomposition of the problem. This is illustrated by a series of horizontal slices in Fig. 2. As with a functional decomposition, we implement each slice explicitly then tie them all together to form a robot control system. Our new decomposition leads to a radically different architecture for mobile robot control systems, with radically different implementation strategies plausible at the hardware level, and with a large number of advantages concerning robustness, buildability and versatility.

Manuscript received February 3, 1990. This work was supported in part by an IBM Faculty Development Award, in part by a grant from the Science and Technology Foundation, in part by an equipment grant from Motorola, and in part by the Advanced Research and Agency under the Office of Naval Research contract N00014-89-C-0039 and N00014-89-K-0034.

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IEEE Log Number 900896.

0882-4002/90/0300-0014\$01.00 © 1992 IEEE

Fig. 1. Traditional decomposition of a mobile robot control system into functional modules.

Fig. 2. Decomposition of a mobile robot control system based on task-achieving behaviors.

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31-05-2004

La novità fondamentale di Brooks:

⇒ Decomporre per comportamenti, non per moduli funzionali

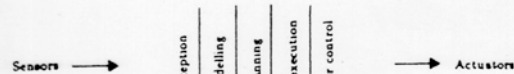


Fig. 1. Traditional decomposition of a mobile robot control system into functional modules.

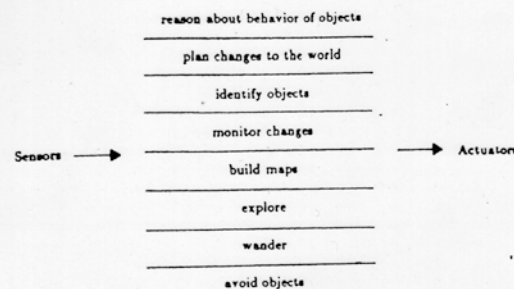


Fig. 2. Decomposition of a mobile robot control system based on task-achieving behaviors.

Lezione 18: Strutture di controllo di robot avanzati

L'idea della subsumption

BROOKS A ROBUST LAYERED CONTROL SYSTEM FOR A MOBILE ROBOT

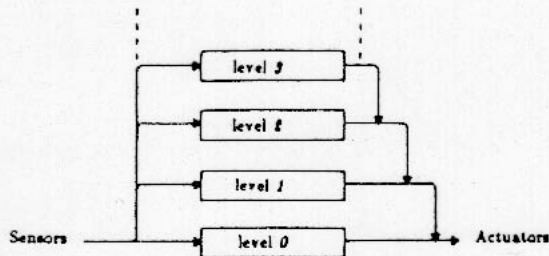


Fig. 3. Control is layered with higher level layers subsuming the roles of lower level layers when they wish to take control. The system can be partitioned at any level, and the layers below form a complete operational control system.

Lezione 18: Strutture di controllo di robot avanzati

31-05-2004

Esempio di una cella:

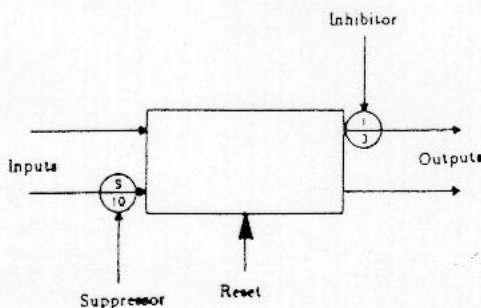


Fig. 4. A module has input and output lines. Input signals can be suppressed and replaced with the suppressing signal. Output signals can be inhibited. A module can also be reset to state NIL.

Lezione 18: Strutture di controllo di robot avanzati

31-05-2004

Subsumption architecture: livello 0

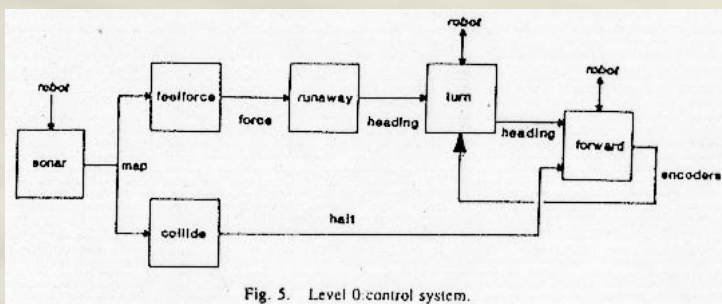


Fig. 5. Level 0 control system.

Livelli 0 e 1

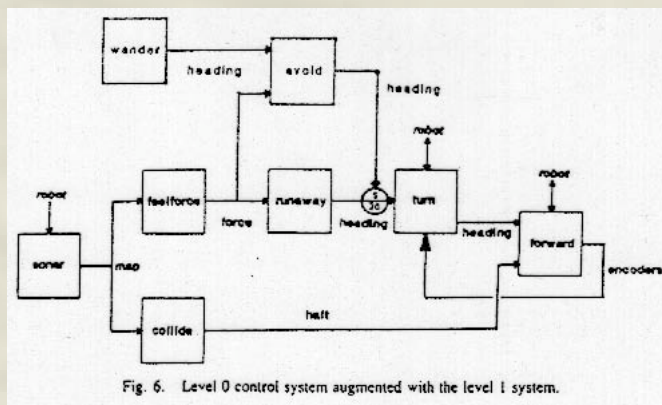


Fig. 6. Level 0 control system augmented with the level 1 system.

Verso la complicazione: livelli 0,1 e 2

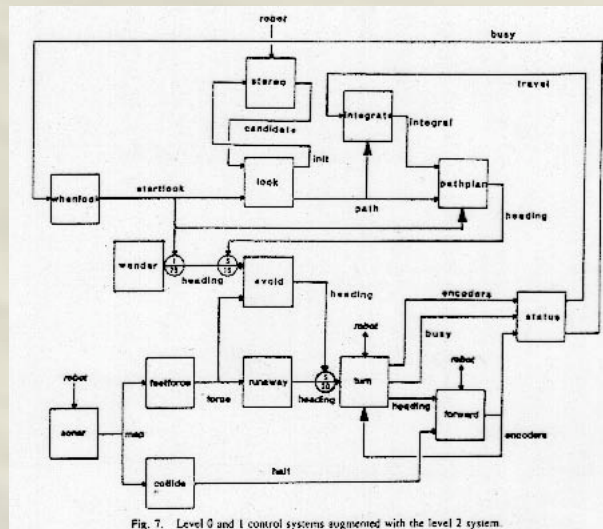


Fig. 7. Level 0 and 1 control systems augmented with the level 2 system.

Lezione 18: Strutture di controllo di robot avanzati

31-05-2004

Ingressi (percettori) e uscite (azioni)

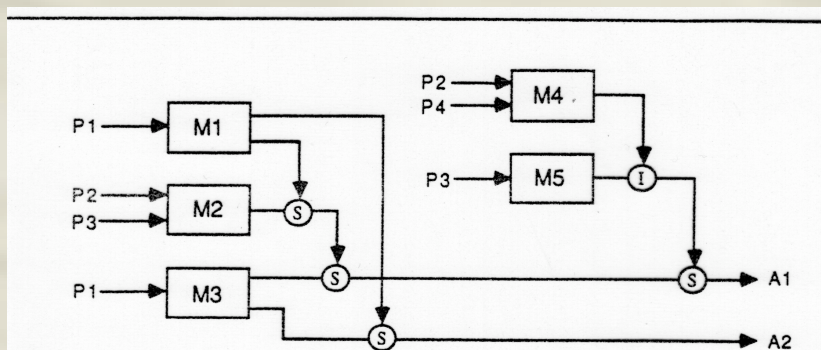


Figure 2-1. Our control system consists of a number modules (the M's), each of which implements a particular behavior. These module use the available sensor primitives (the P's) to directly generate commands for the actuator resources (the A's). The outputs of different modules are combined through a fixed arbitration network, represented here by circles.

Lezione 18: Strutture di controllo di robot avanzati

31-05-2004

La natura semplifica le cose:

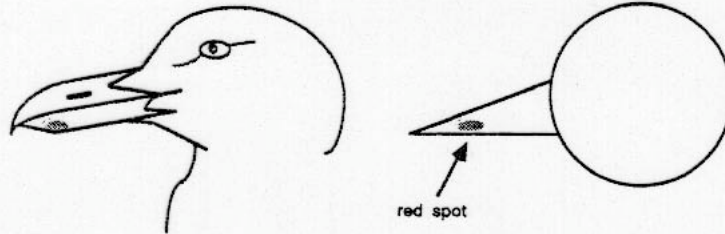
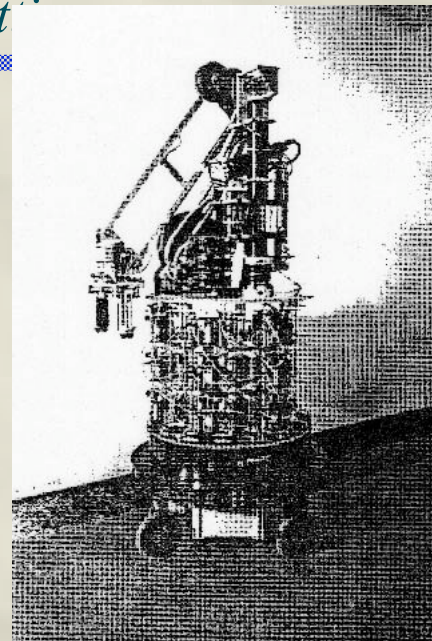


Figure 1-2. Animals seem to use incomplete models for many activities. Baby seagulls respond just as well to the mockup on the right as they do to their own parent (left). The critical features are that the object must be pointed and must have a red spot.

Lezione 18: Strutture di controllo di robot avanzati

31-05-2004

Herbert, il raccatta-lattine



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