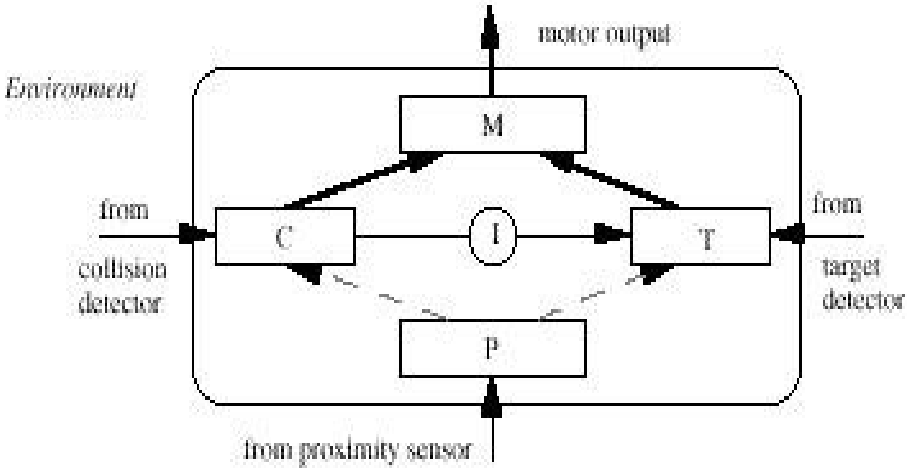
Roboter Kontroll-Architekturen



Verschiedene Kontroll-Architekturen

- *Reactive Control*
  - *Don't think, (re)act.*
- *Deliberative Control*
  - *Think hard, act later.*
- *Hybrid Control*
  - *Think and act independently, in parallel.*
- *Behavior-Based Control*
  - *Think the way you act.*

Reactive Control

– Ansammlungen von *sense-act (stimulus-response) Regeln*

– Inherent *concurrent (parallel)*

– Kein oder minimaler “state“

– Kein Gedächtnis

– Sehr schnell und reaktiv

– Kein Planen

– Kein Lernen

„Elsie“

Deliberative Control

- Basiert auf dem “sense-plan-act” (SPA) Modell
- Inherent sequentiell
- Planen erfordert Suche -> langsam
- Suche erfordert ein Welt-Modell
- Das Welt-Modell muss ständig angepasst werden
- Suche und Planen dauert zu lange

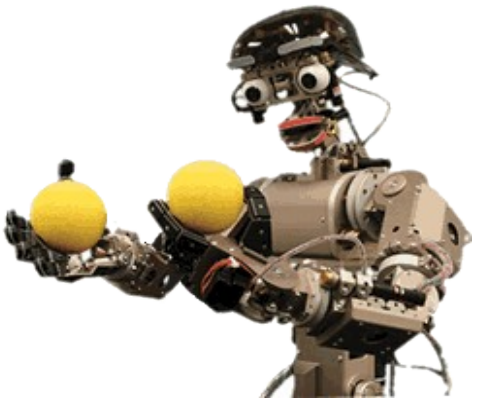
„Shakey“

Hybrid Control

- Kombination der beiden Extreme
  - reactive system on the bottom
  - deliberative system on the top
  - connected by some intermediate layer
- Auch 3-layer Systeme genannt
- “Layers must operate *concurrently*“
- Unterschiedliche *representations and time-scales* zwischen den Schichten
- “The best or worst of both worlds?“

Behavior-Based Control

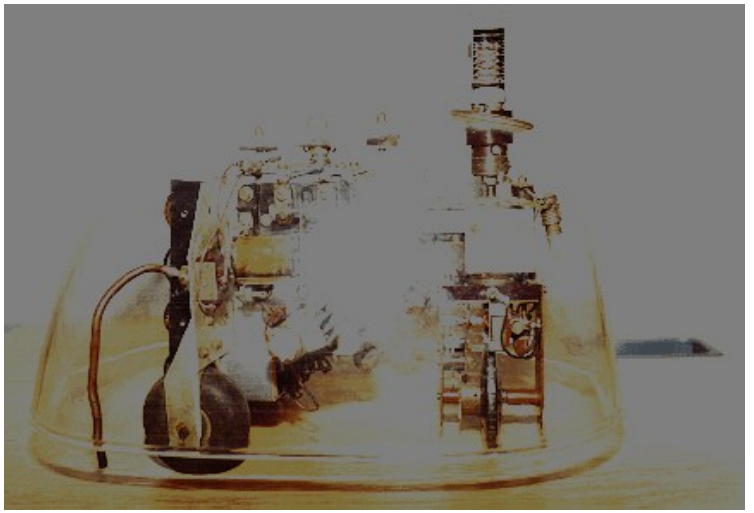
- Alternative zu hybriden Systemen
- Gleiche Eigenschaften:
  - the ability to act reactively
  - the ability to act deliberatively
- Keine Zwischenschicht
- Eine “unified, consistent representation” wird im gesamten System benutzt => *concurrent behaviors*
- Lösung für die Zeit-Probleme

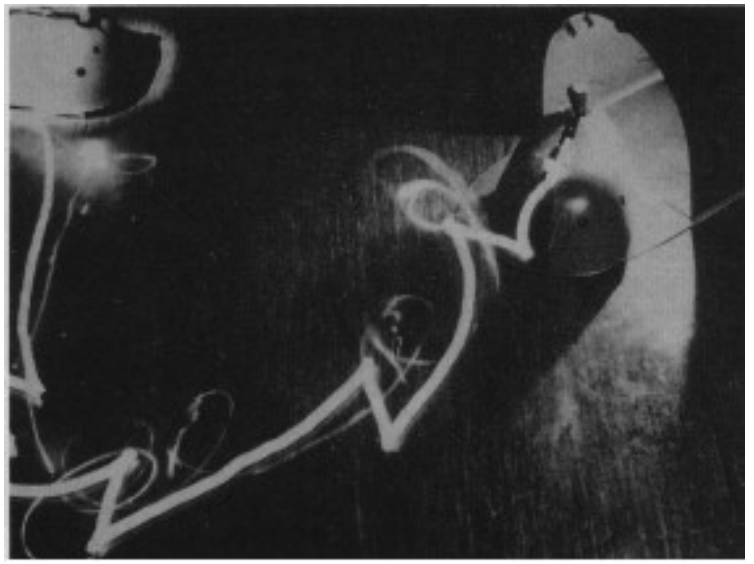


„Infanoid“

Grey Walters Tortoises

- *Machina Speculatrix*
- 1 Photozelle & 1 Bump Sensor, 1 Motor
- Verhaltensmuster:
  - seek light
  - head to weak light
  - back from bright light
  - turn and push
  - recharge battery
- Reaktive Kontrolle

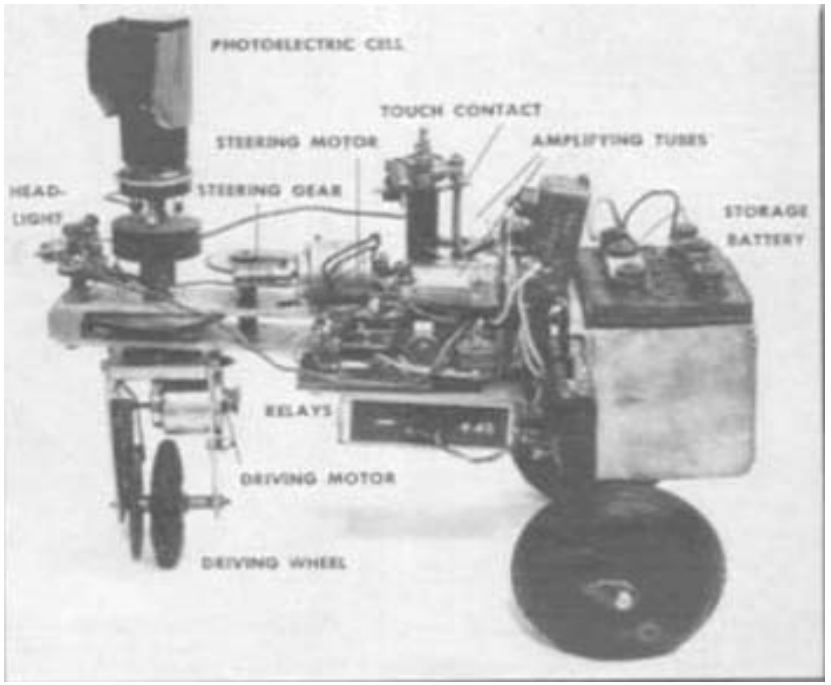




Grey Walter

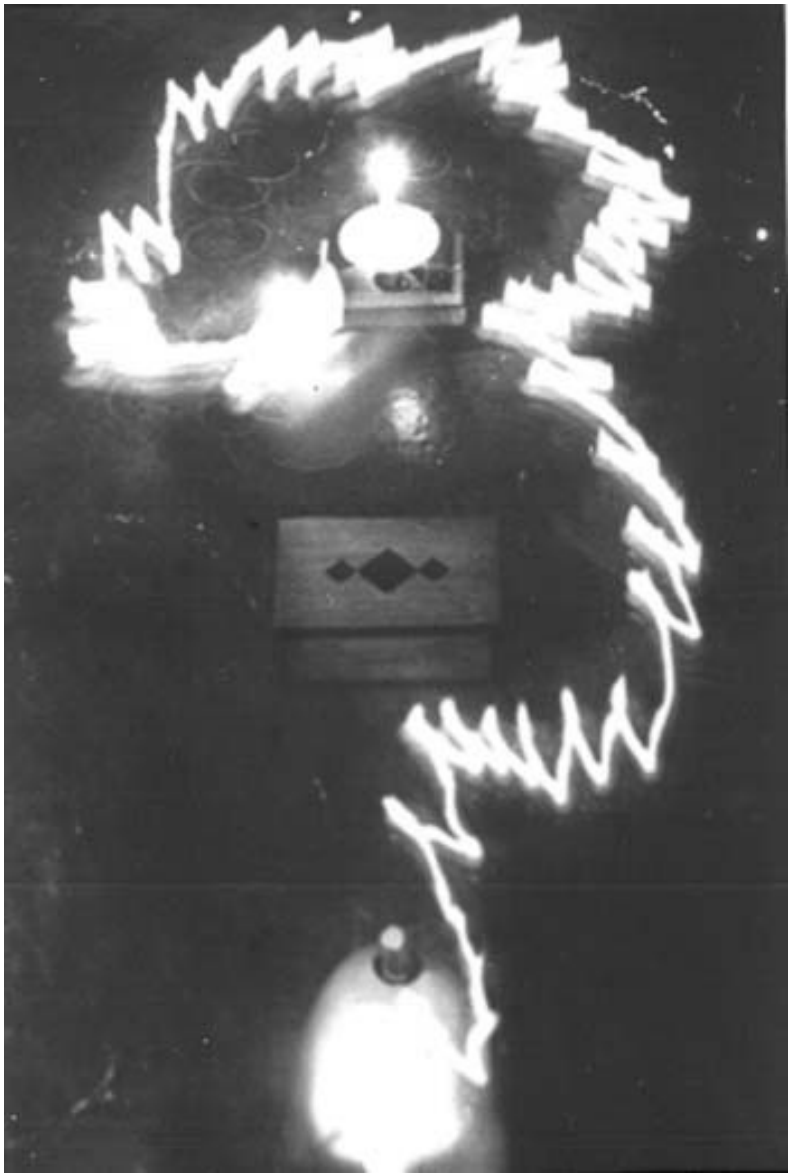
His first robots, which he used to call "Machina Speculatrix" and named Elmer and Elsie, were constructed between 1948 and 1949 and were often described as tortoises due to their shape and slow rate of movement - and because they 'taught us' about the secrets of organisation and life. The three-wheeled tortoise robots were capable of phototaxis, by which they could find their way to a recharging station when they ran low on battery power. In one experiment he placed a light on the "nose" of a tortoise and watched as the robot observed itself in a mirror.

"It began flickering, twittering, and jigging like a clumsy Narcissus", he wrote. If seen in an animal he argued this "might be accepted as evidence of some degree of self-awareness".

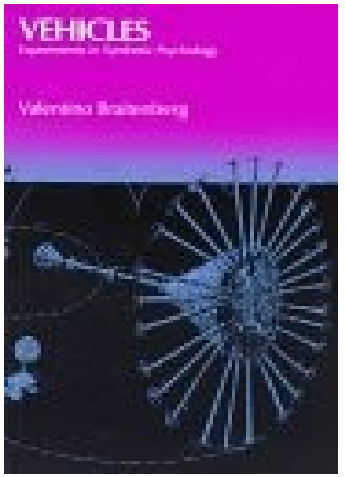


Recently, one of the original tortoises was replicated by Dr. Owen Holland, of the University of West of England in 1995.

„Elsie“



Braitenberg Vehicles

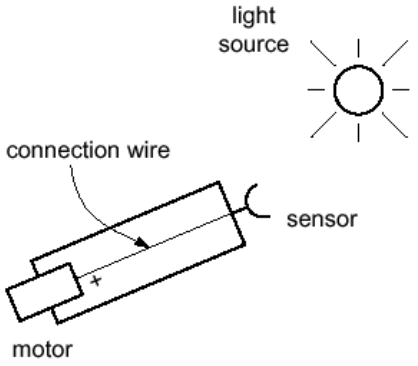


- Valentino Braitenberg (frühe 1980er)
- B. erweiterte Walters Modell in einer Reihe von Gedankenexperimenten
- Basiert auf analogen Schaltkreisen
- Direkte Verbindungen (excitatory or inhibitory) zwischen Licht Sensoren und Motoren
- Komplexe Verhaltensweisen durch sehr einfache Mechanismen

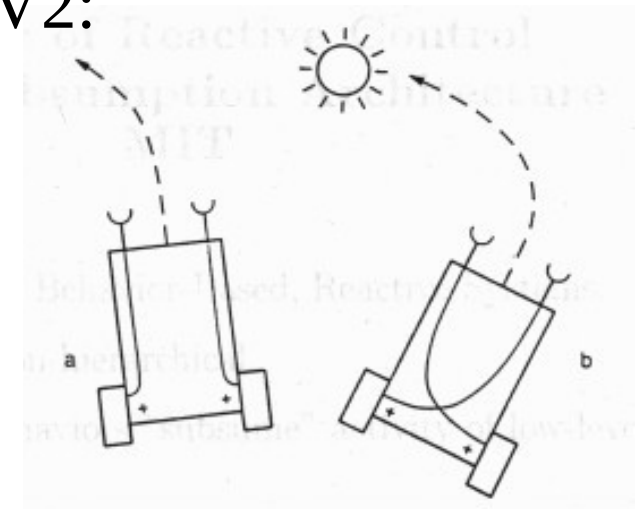
Braitenberg Vehicles

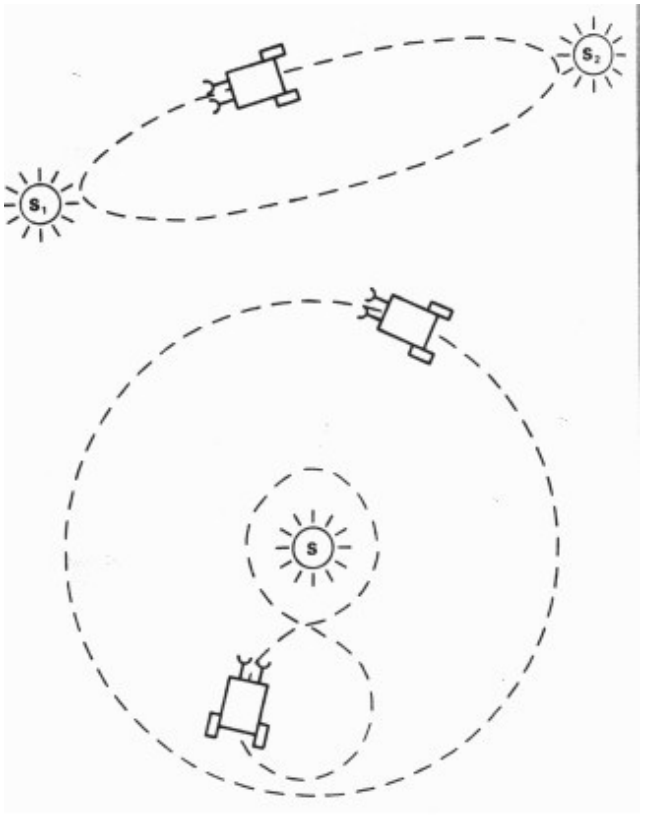
- Beispiele für Vehicles:

V1:



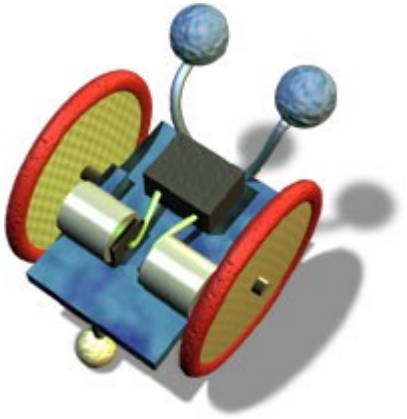
V2:





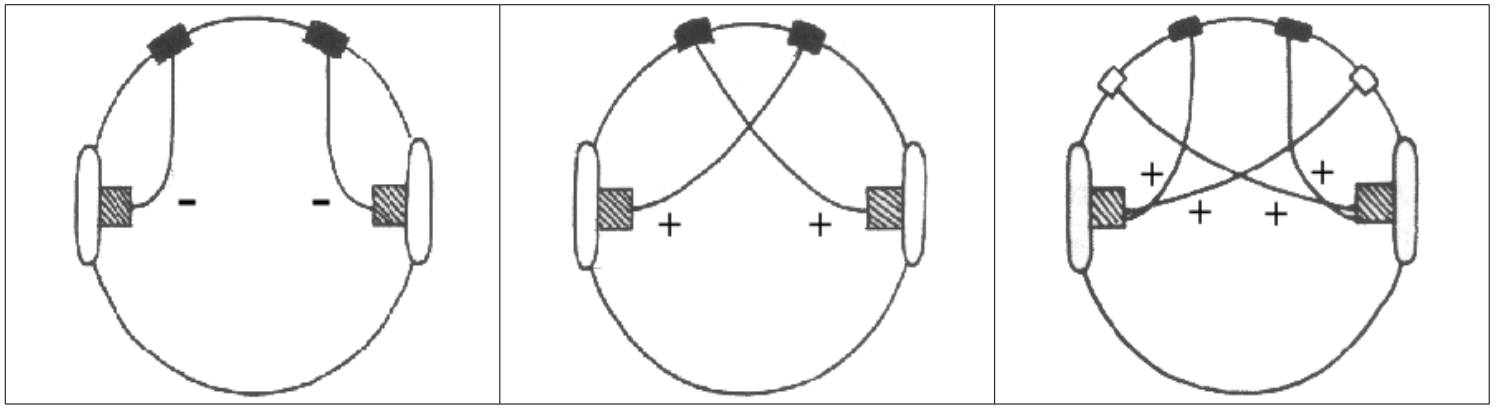
Braitenberg Vehicles

- Mit unterschiedlichen Arten von Verbindungen und Verbindungsstärken erhält man zahlreiche Verhaltensweisen, z.B.:
  - “fear/cowardice” - flees light
  - “aggression” - charges into light
  - “love” - following/hugging
  - many others



- Reaktive Kontrolle
- Wurde später auf echten Robotern implementiert

Beispiele



Early Artificial Intelligence

- "Born" in 1955 at Dartmouth
- "Intelligent machine" benutzt interne Modelle um nach Lösungen zu suchen und diese dann auszuprobieren (Marvin Minsky) => deliberative model!
- *Planning* wurde zur Tradition
- Explizite symbolische Repräsentationen
- Hierarchische System Organisation
- Sequentielle Ausführung

Key Issues

- Grounding in reality: not just planning in an abstract world
- Situatedness (ecological dynamics): tight connection with the environment
- Embodiment: having a body
- Emergent behavior: interaction with the environment
- Scalability: increasing task and environment complexity

Creature, or Behavior-Based, AI

creatures --

live in messy worlds
performance relative to the world
intelligence (emerges) on this substrate

***the* creature** → ***all* possible worlds**

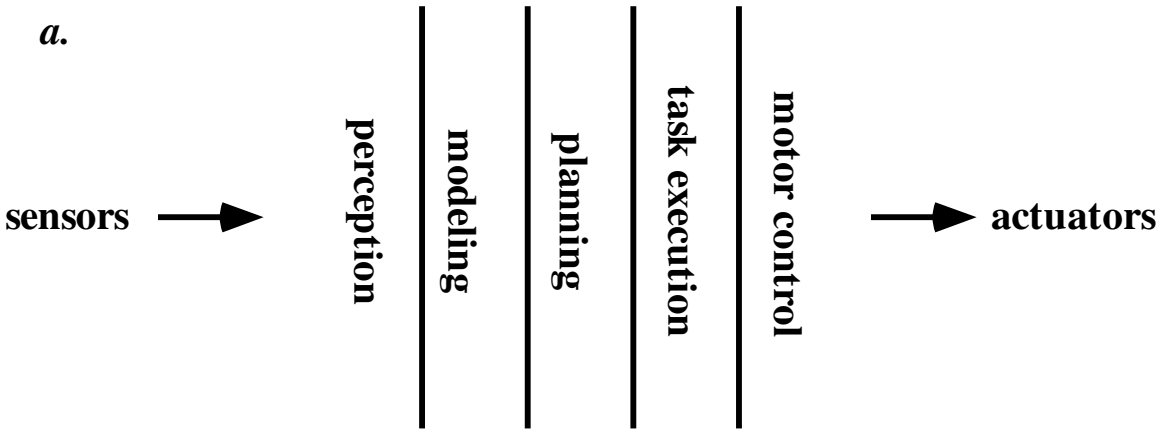
***maintain* goals**

explore, survive

Photo courtesy of Rodney Brooks, MIT CSAIL.

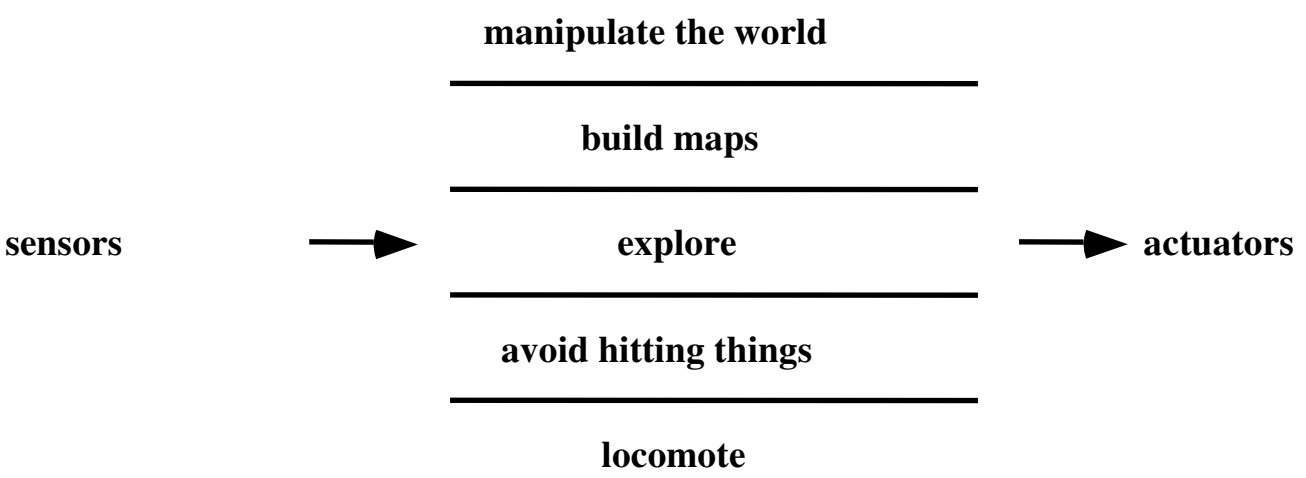
Traditionell

Horizontale Dekomposition

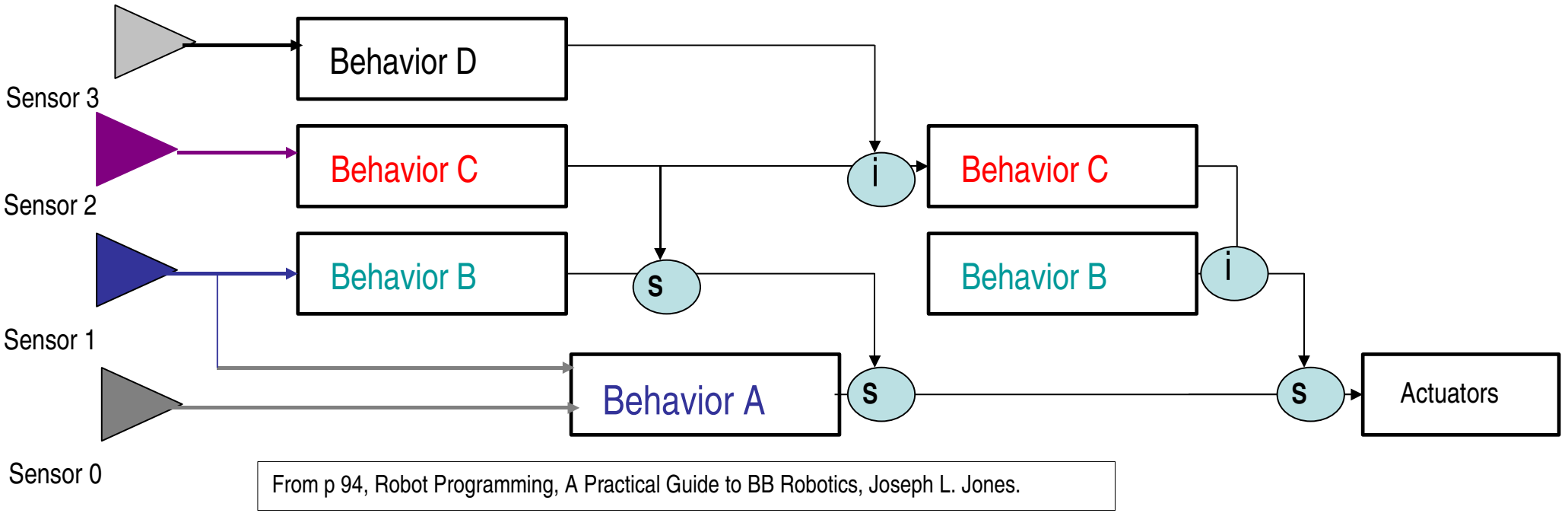


Verhaltensbasierte Dekomposition

Vertikale Dekomposition



Subsumption Architektur



From p 94, Robot Programming, A Practical Guide to BB Robotics, Joseph L. Jones.

S: Suppressor node: eliminiert und ersetzt (nur wenn aktiv)

I: Inhibitor node: eliminiert das Kontroll Signal auf dem niedrigeren Level

Subsumption Architektur - Beispiel

- Roboter, der Lampen einsammeln soll, und nicht mit Hindernissen kollidieren soll.

Prof. M. Mataric + Roboter (nicht Toto)

Literatur

- Brooks, R. A. *"A Robust Layered Control System for a Mobile Robot"*, IEEE Journal of Robotics and Automation, Vol. 2, No. 1, March 1986, pp. 14-23; also MIT AI Memo 864, September 1985.
- Robot Programming: A Practical Guide to Behavior-based Robotics, Joseph L. Jones, McGraw-Hill, 2004.
- A Colony Architecture for an Artificial Creature, Jonathon Connell, AI-TR 1151, MIT, 1989.
- Motor Schema Based Navigation for a Mobile Robot: An Approach to Programming by Behavior, Ron Arkin, Proc. of ICRA, 1987, pp 265-271.
- Behavior-based control: Main properties and Implications, Maja Mataric, *Proceedings, IEEE International Conference on Robotics and Automation, Workshop on Architectures for Intelligent Control Systems*, Nice, France, May 1992, 46-54.