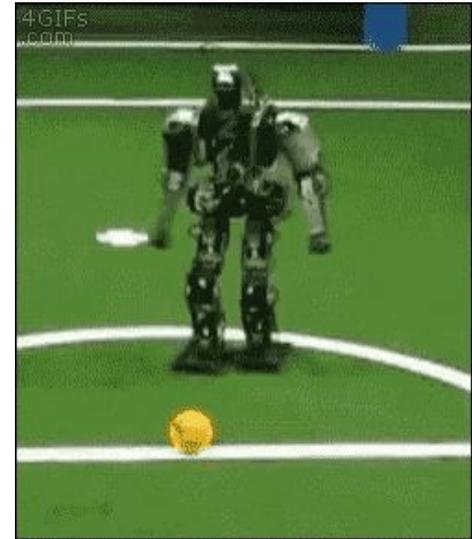
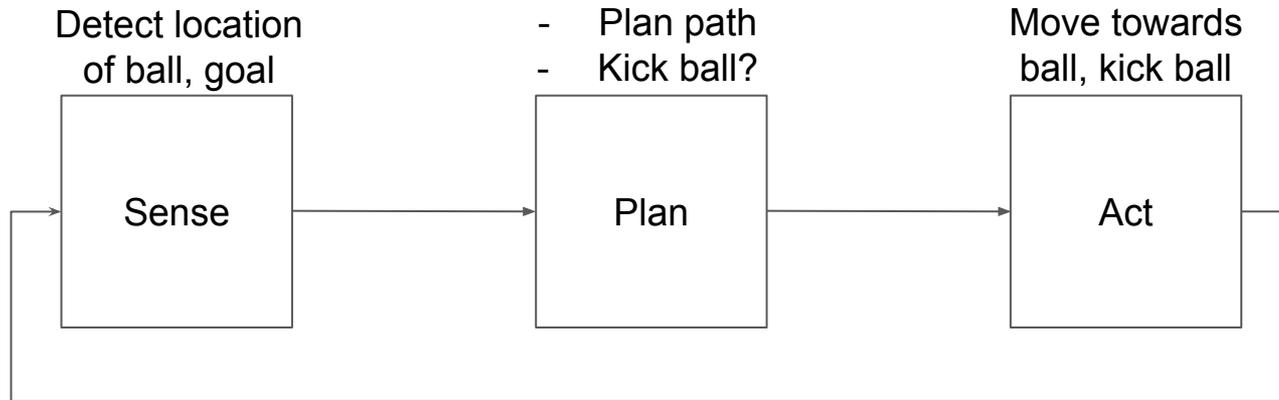


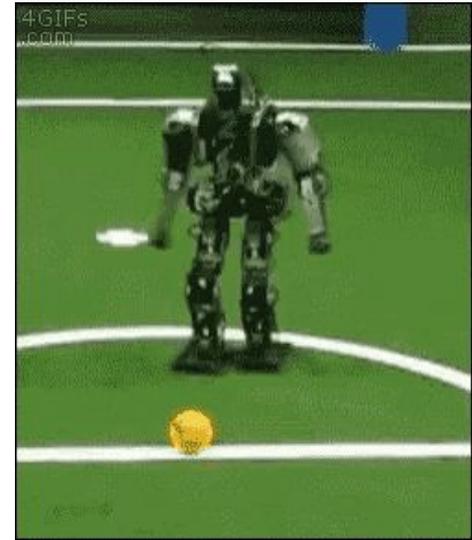
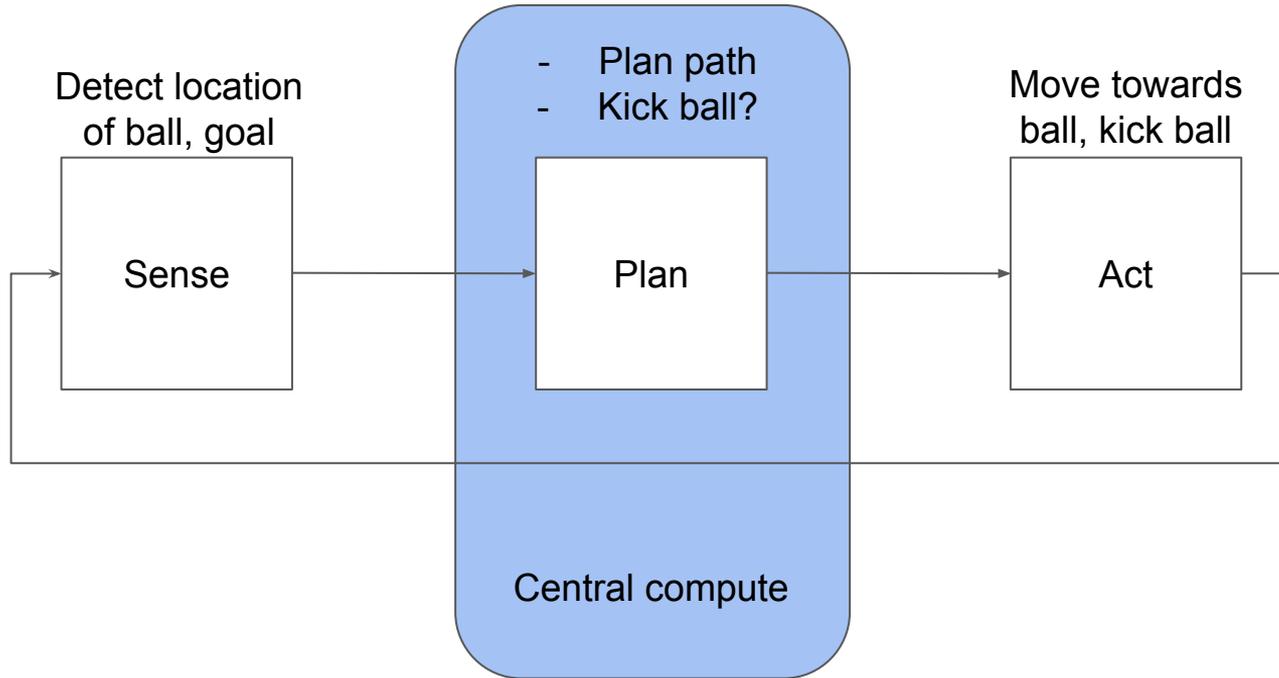
A Robot that Walks

Rodney A. Brooks

SPA | The dominant robot architecture (at the time?)



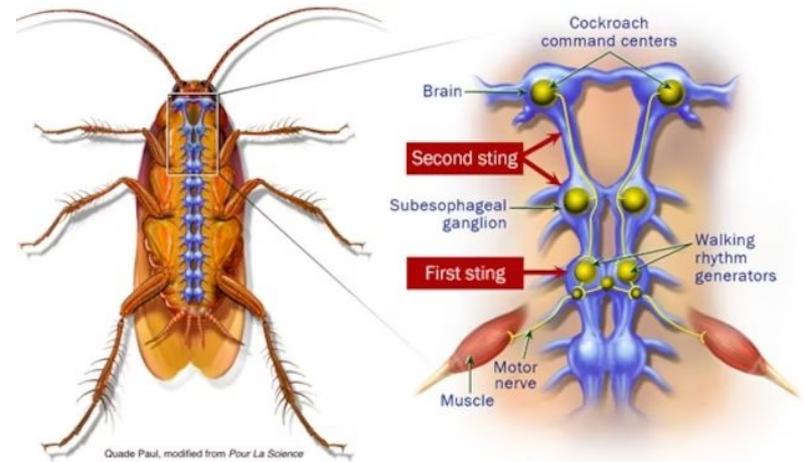
SPA | The dominant robot architecture (at the time?)



Brook's and Flynn's rules for creating intelligence

- (1) that there would be no traditional notion of planning
- (2) that no central representation was needed
- (3) that notions of world modelling are impractical and unnecessary
- (4) that biology and evolution were good models to follow in our quest
- (5) that we insist on building complete systems that existed in the real world so that we would not trick ourselves into skipping hard problems

(4) biology is a good model to follow



Robots of the 80s | skipping leg day



Flashbak
The Great Toy Robots, Circa ...



WIRED
Top Ten 1980s Robots | ...



Tedium
The Forgotten '80s Hom...



PCMag
7 Robots Every Geeky 80s Kid Wanted | PC...



Lite 98.7
5 Forgotten 80's Robots



Pocket-lint
world robots f



Facebook
80s Robot - 80s Robot added ...



Pinterest
80s robot toy, Robot to...



Flashbak
The Great Toy Robots, ...



Muppet Wiki - Fandom
80s Robot | Muppet Wiki | Fandom



Amazon.c... · In stock
BESPORTBLE Clockwor...



PCMag
How Many Electronic Toy Robots Did You ...

Exploring Novel Harsh Environments

FAST, CHEAP AND OUT OF CONTROL: A ROBOT INVASION OF THE SOLAR SYSTEM

RODNEY A. BROOKS and ANITA M. FLYNN
MIT Artificial *Intelligence Lab**, Cambridge, MA, USA.

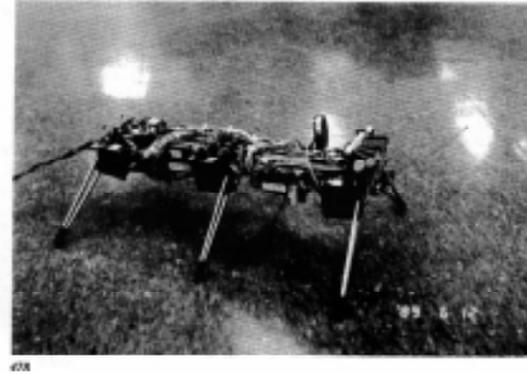
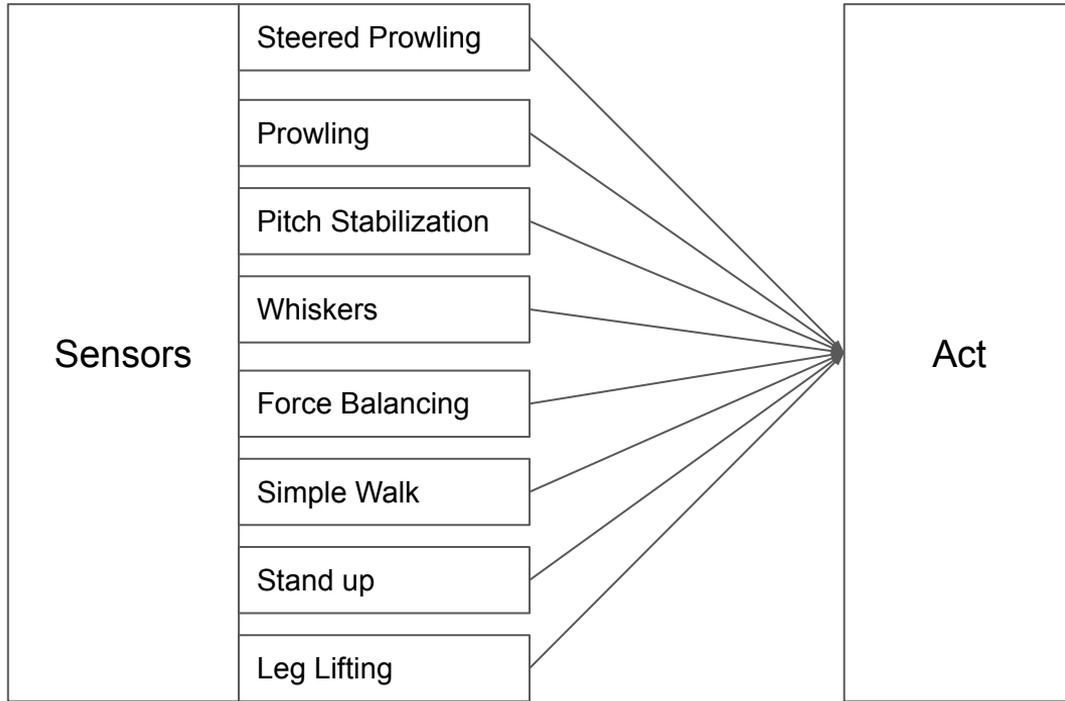


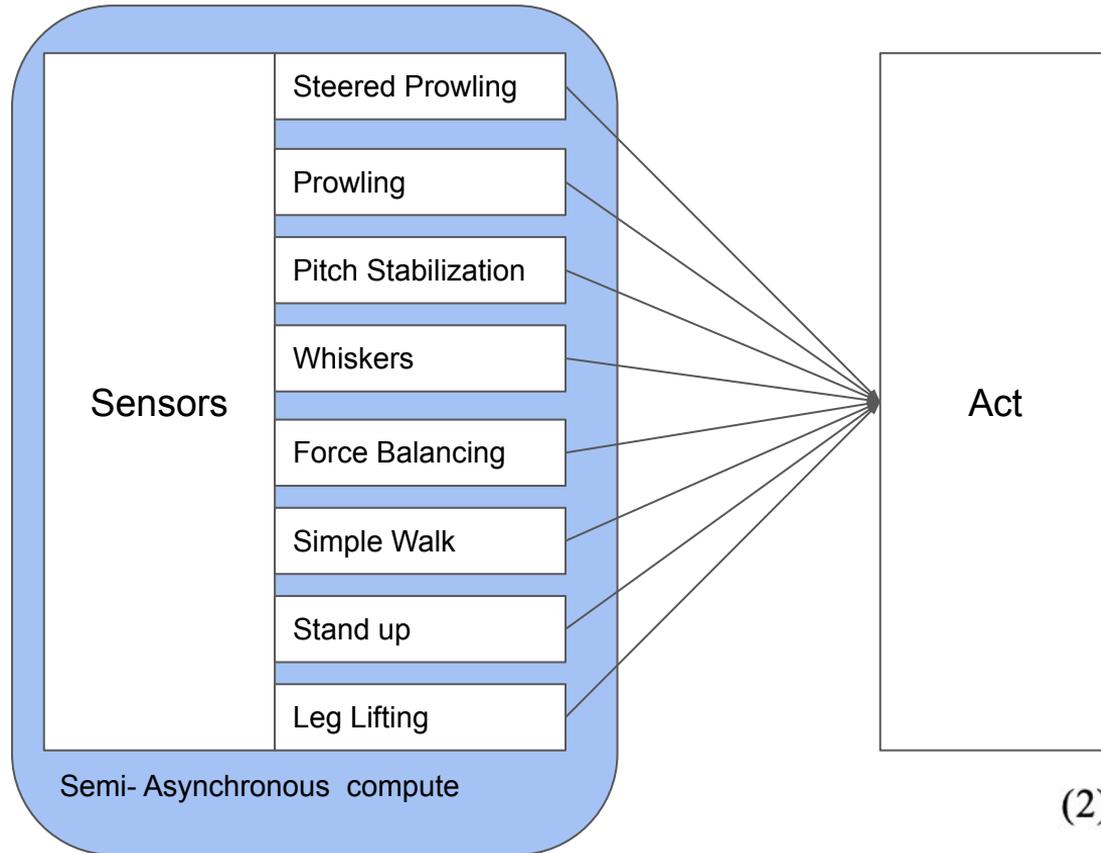
Fig. 1 Genghis is a 1 Kg six legged robot. It can walk and climb over rough terrain. It has four onboard processors, twelve actuators with force feedback, six pyroelectric sensors, two whiskers, and pitch and roll inclinometers. Total time for the project between initial conception and completion of the robot was twelve weeks.

The Subsumption Architecture



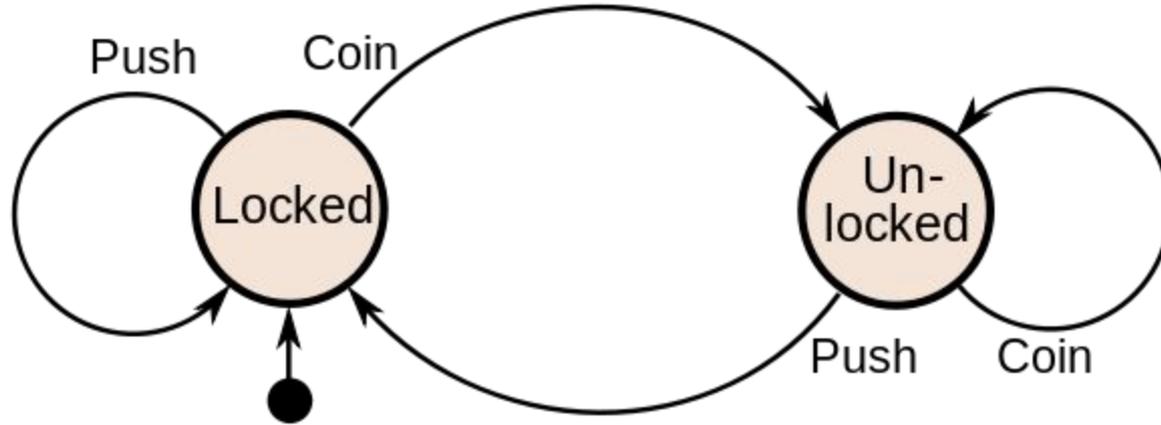
(2) that no central representation was needed

The Subsumption Architecture

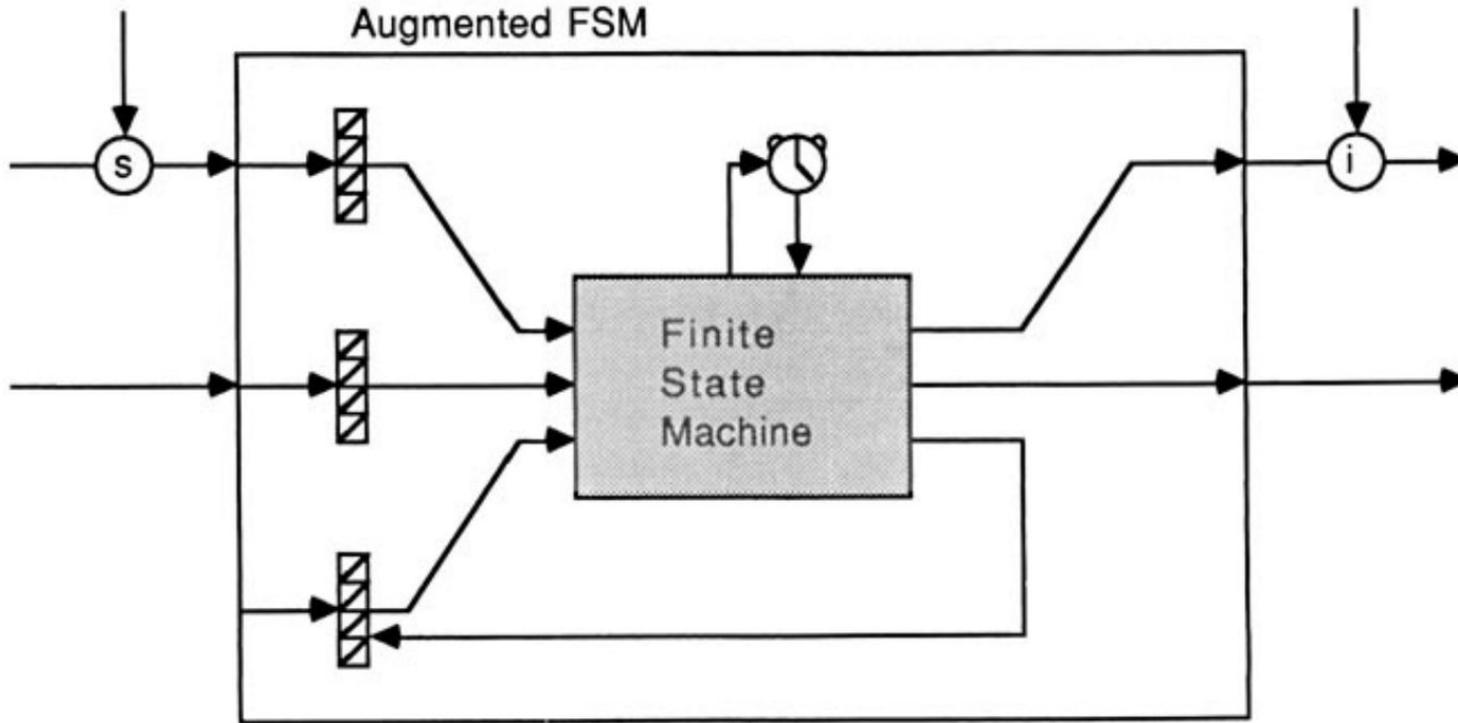


(2) that no central representation was needed

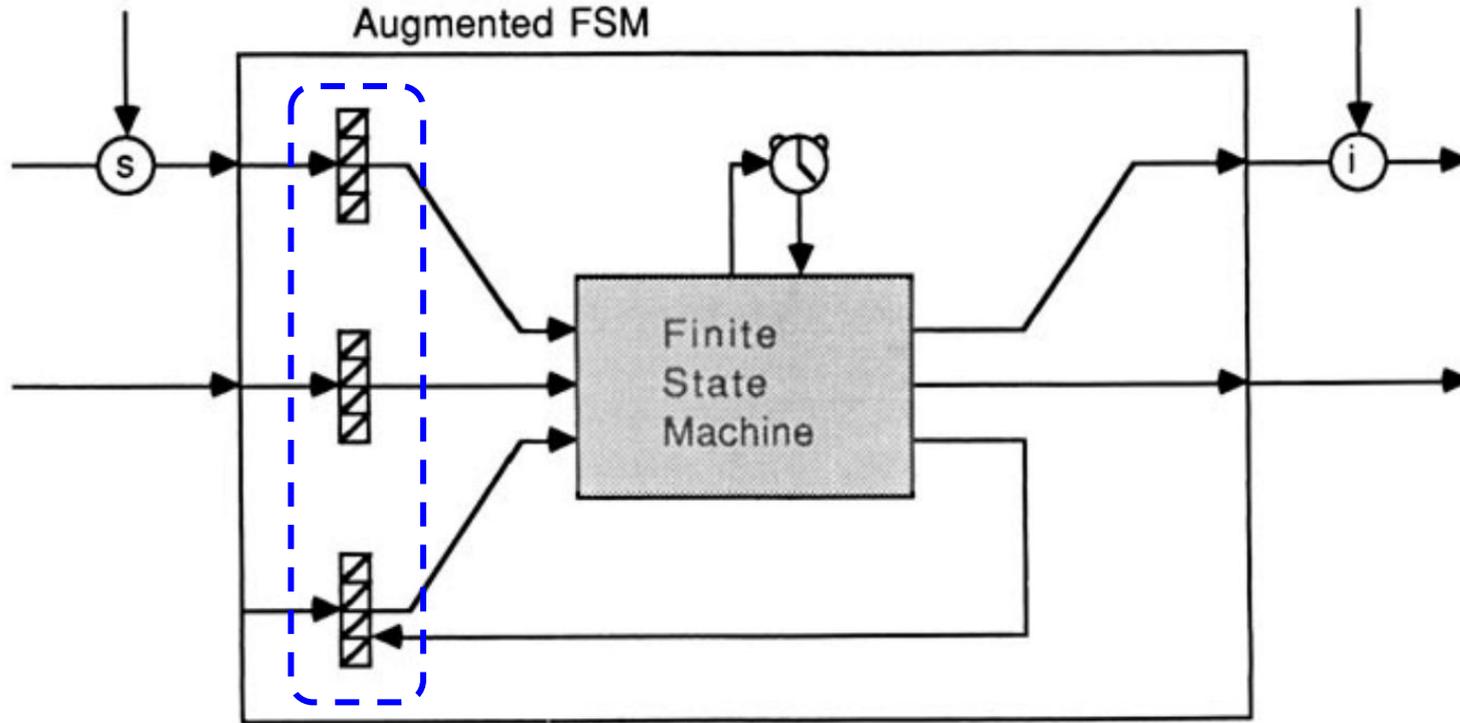
Background | Finite State Machines



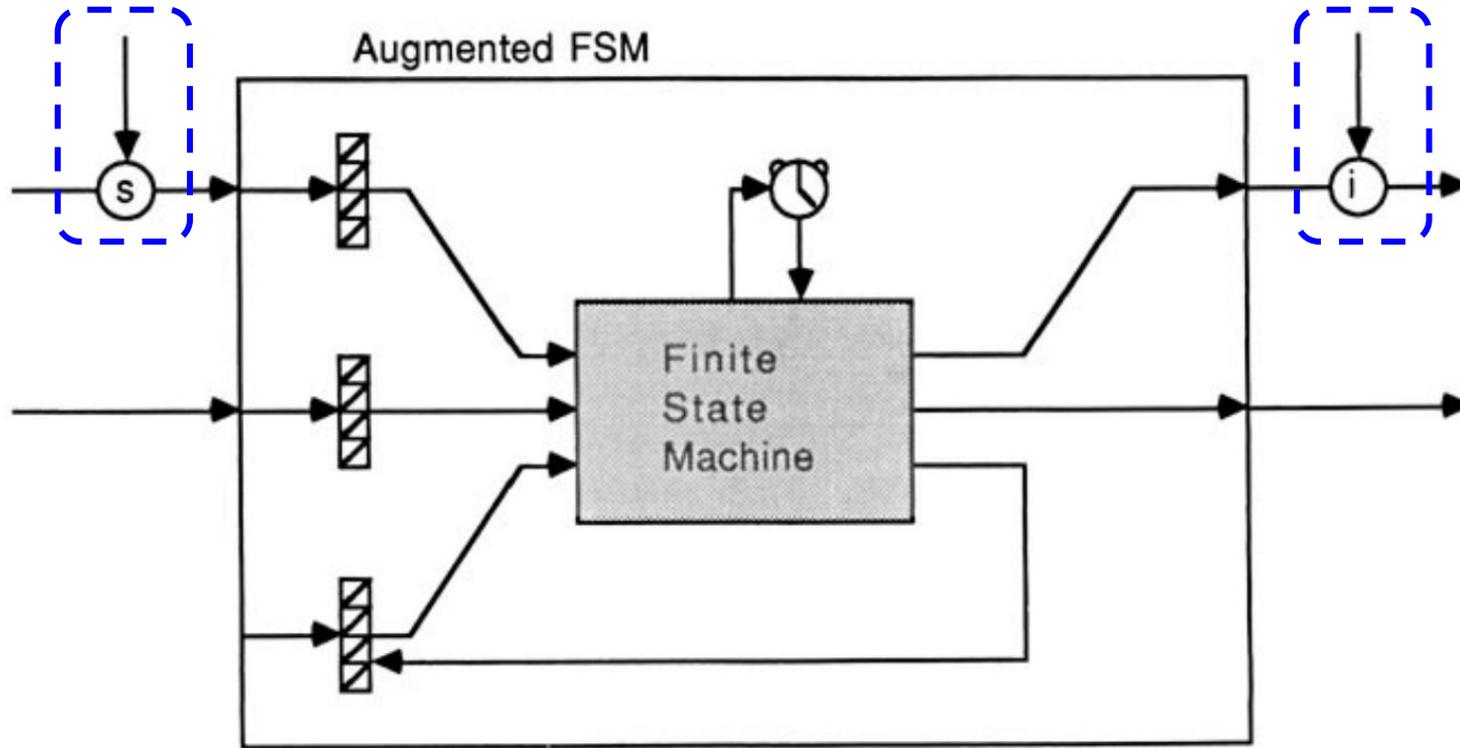
Background | Augmented Finite State Machines



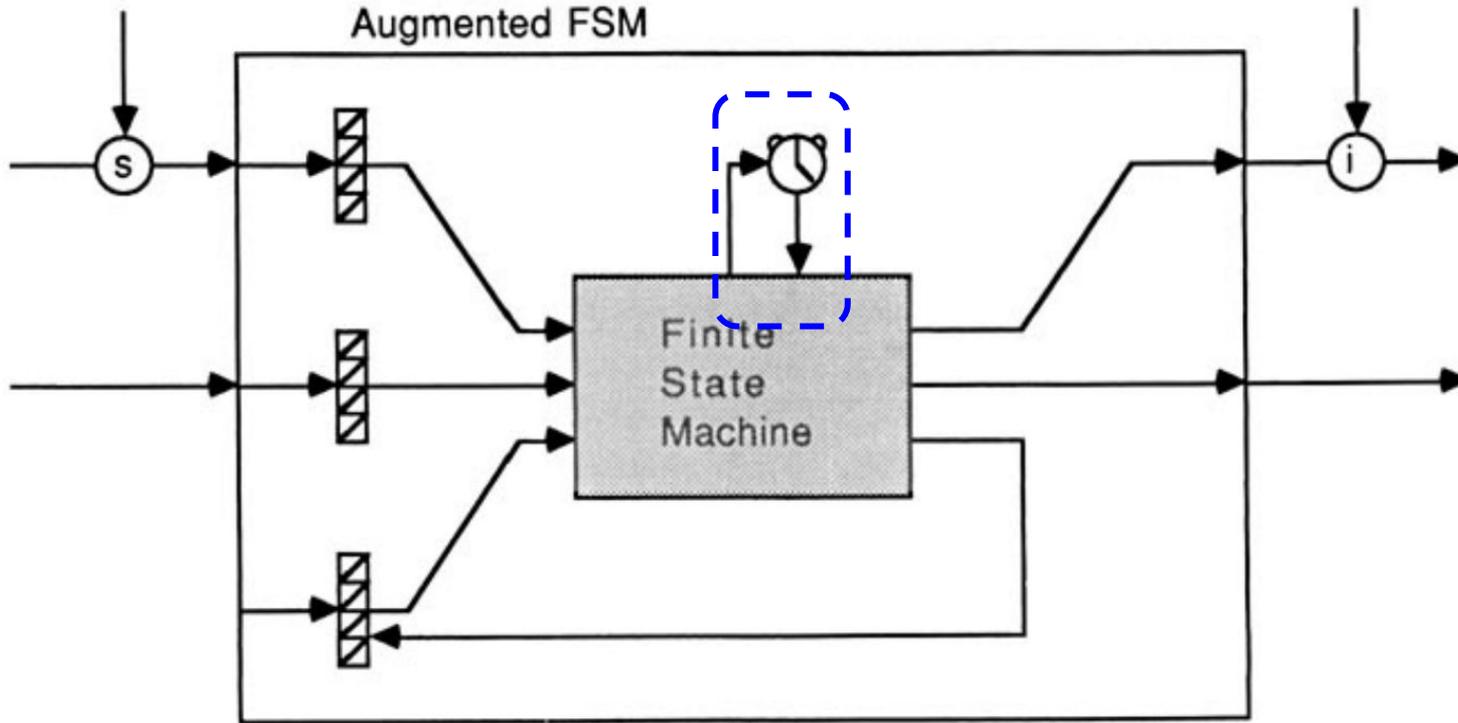
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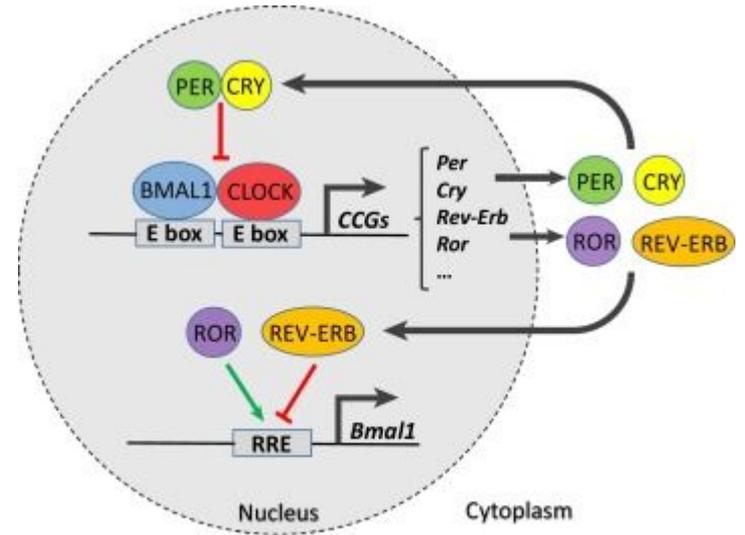
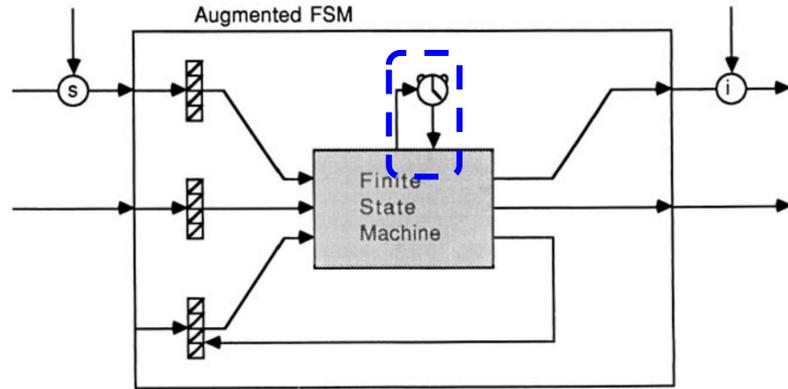
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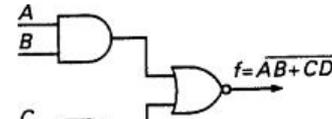
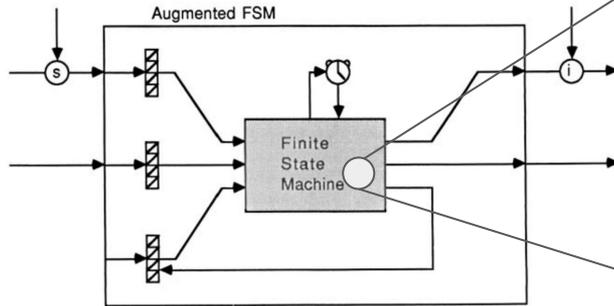
Background | Augmented Finite State Machines



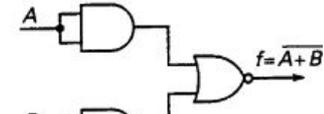
Background | Augmented Finite State Machines



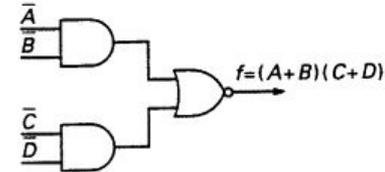
Background | Augmented Finite State Machines



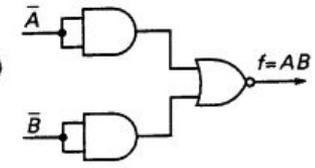
(a)



(b)

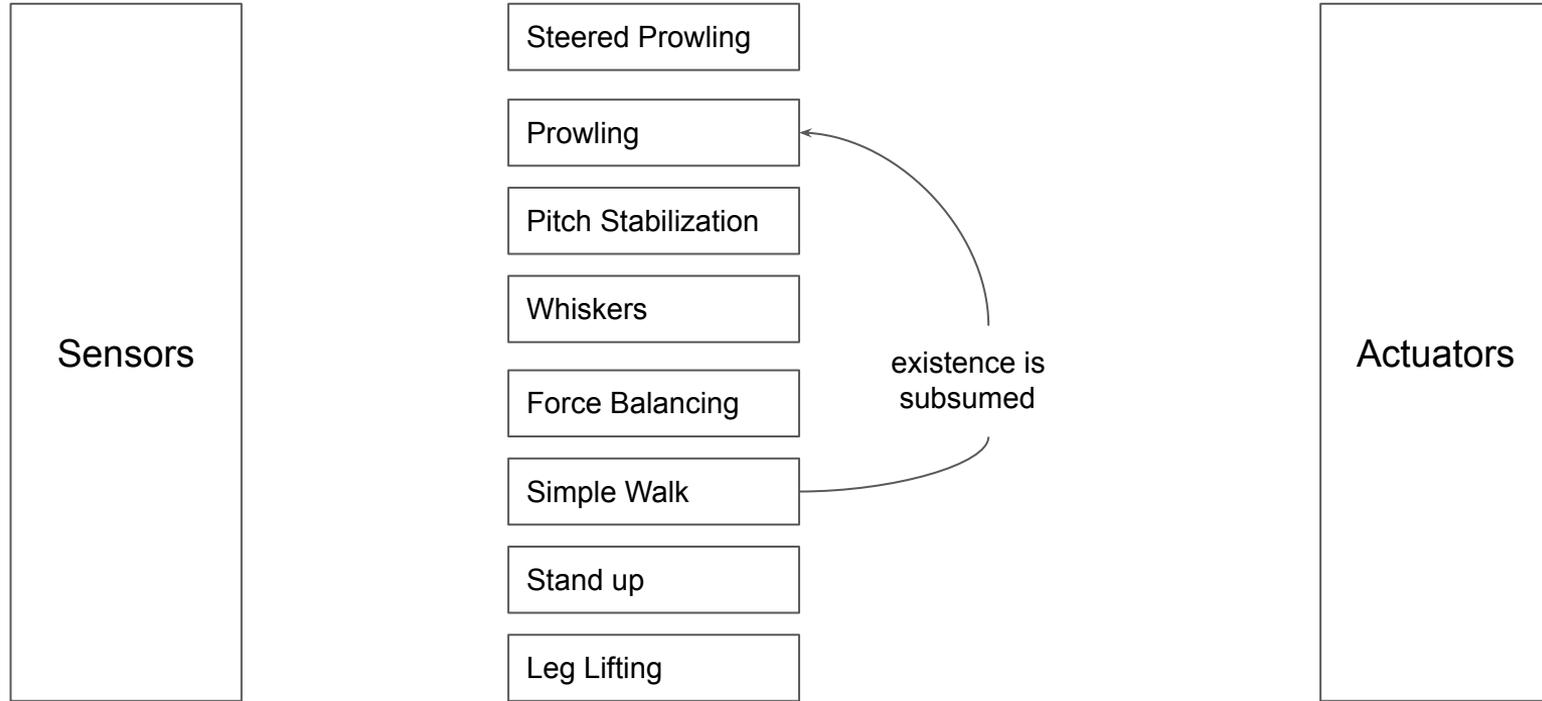


(c)



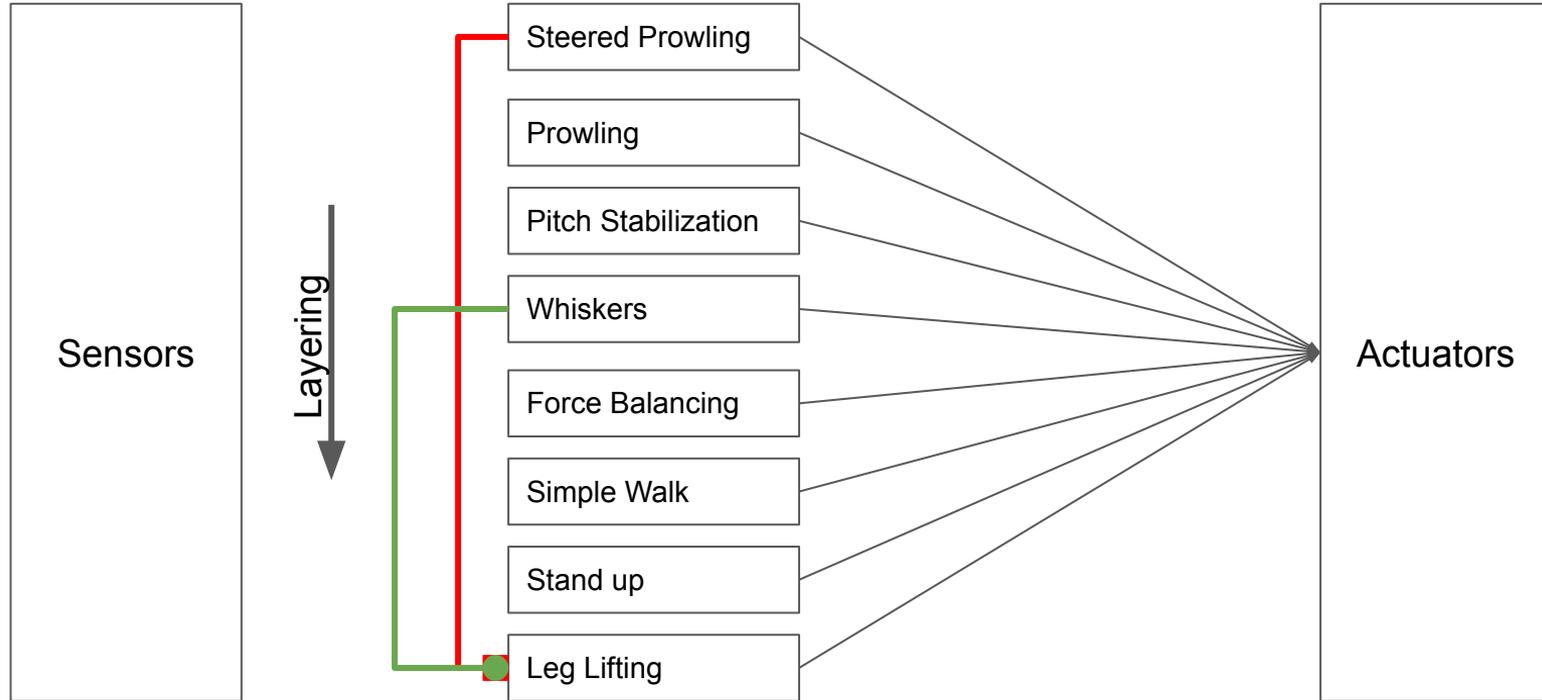
(d)

The Subsumption Architecture

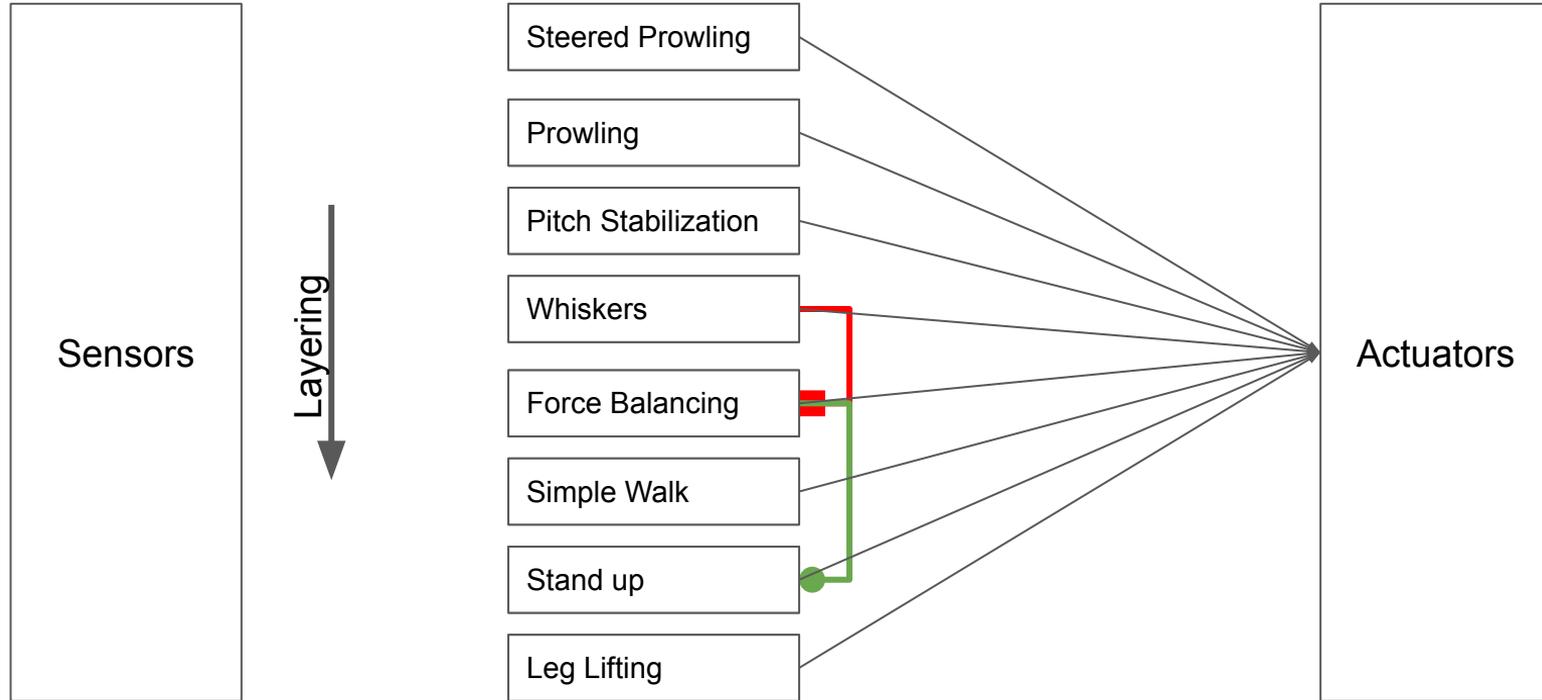


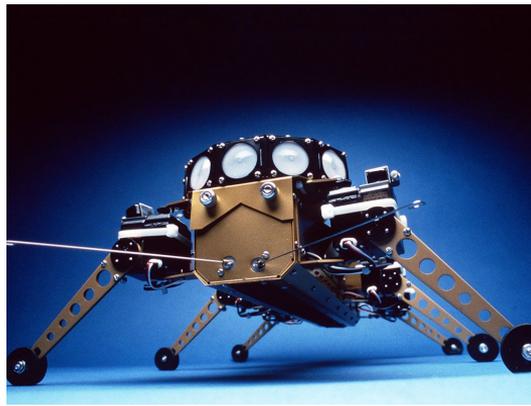
"Bottom-Up" Robots

The Subsumption Architecture

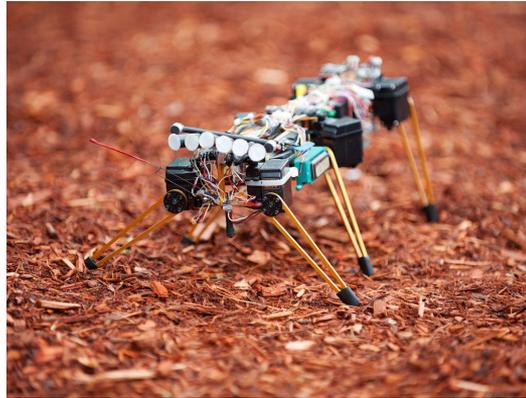


The Subsumption Architecture



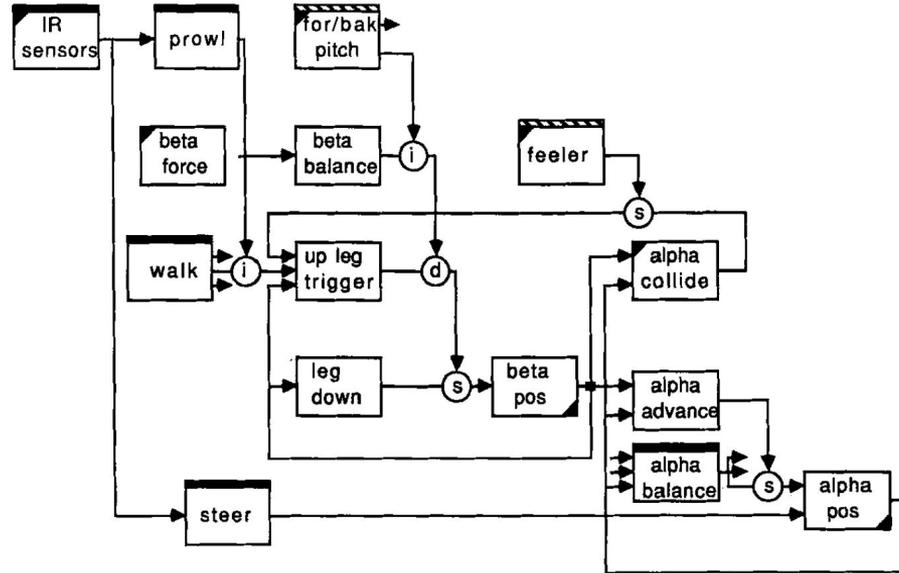


Genghis

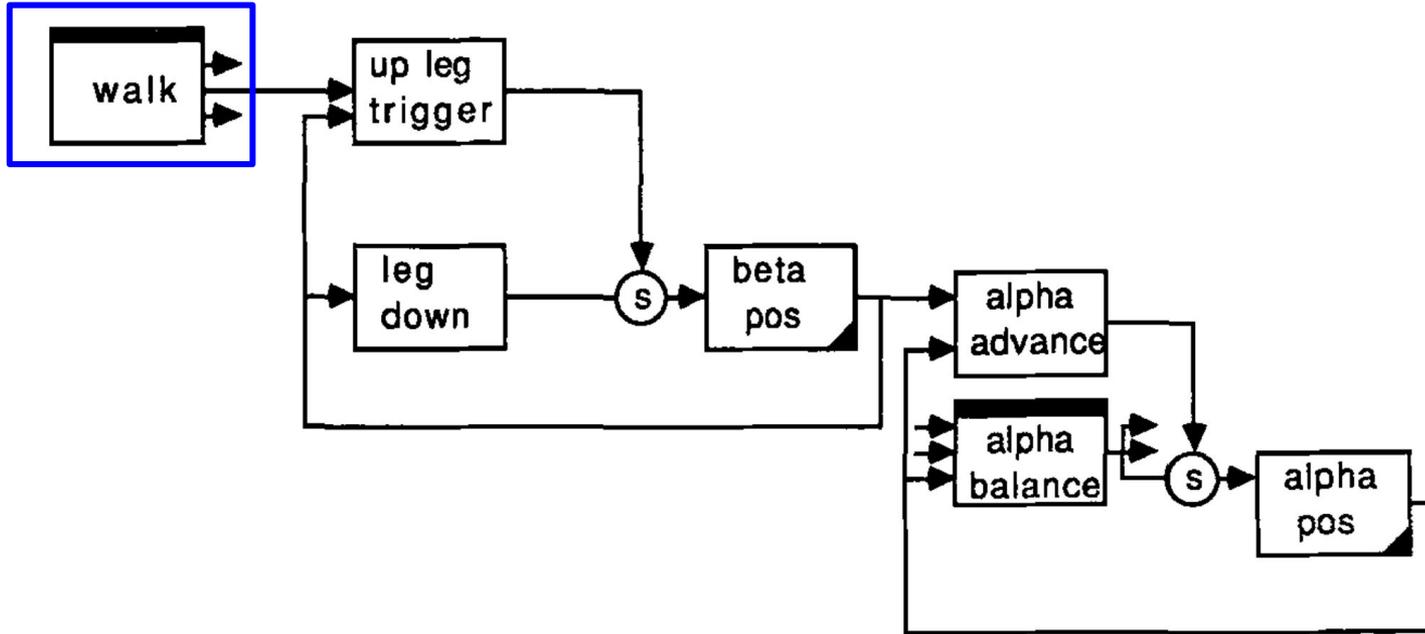


Genghis | System Overview

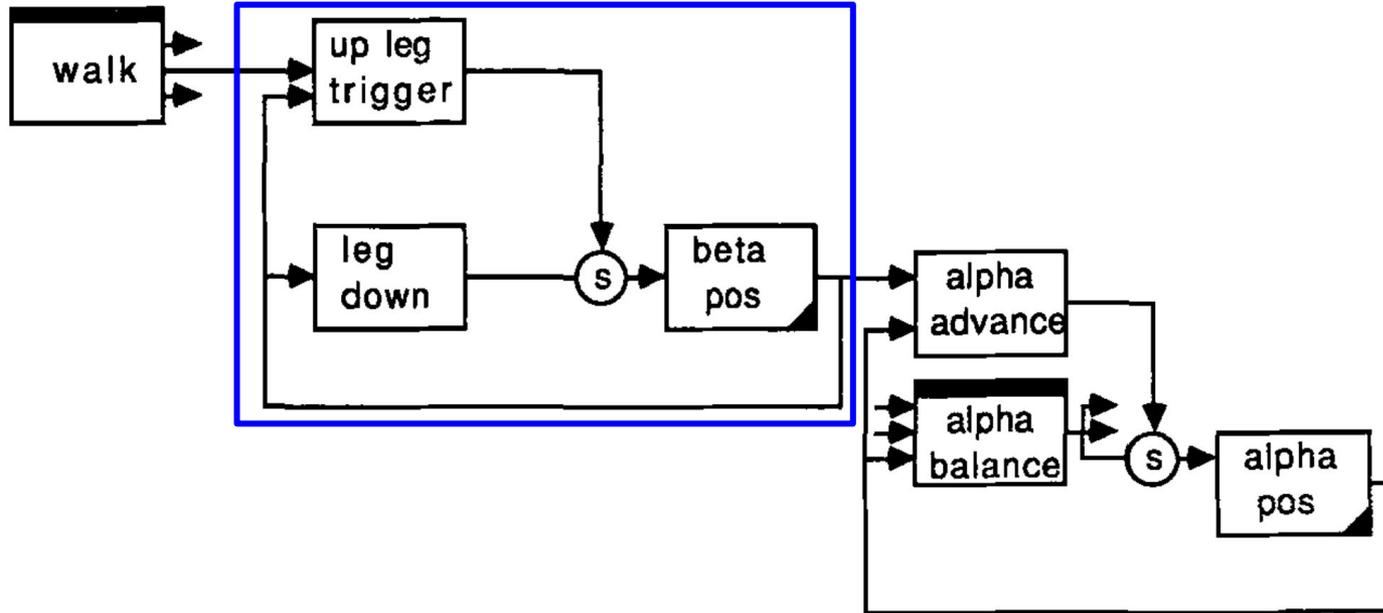
- Steered Prowling
- Prowling
- Pitch Stabilization
- Whiskers
- Force Balancing
- Simple Walk
- Stand up
- Leg Lifting



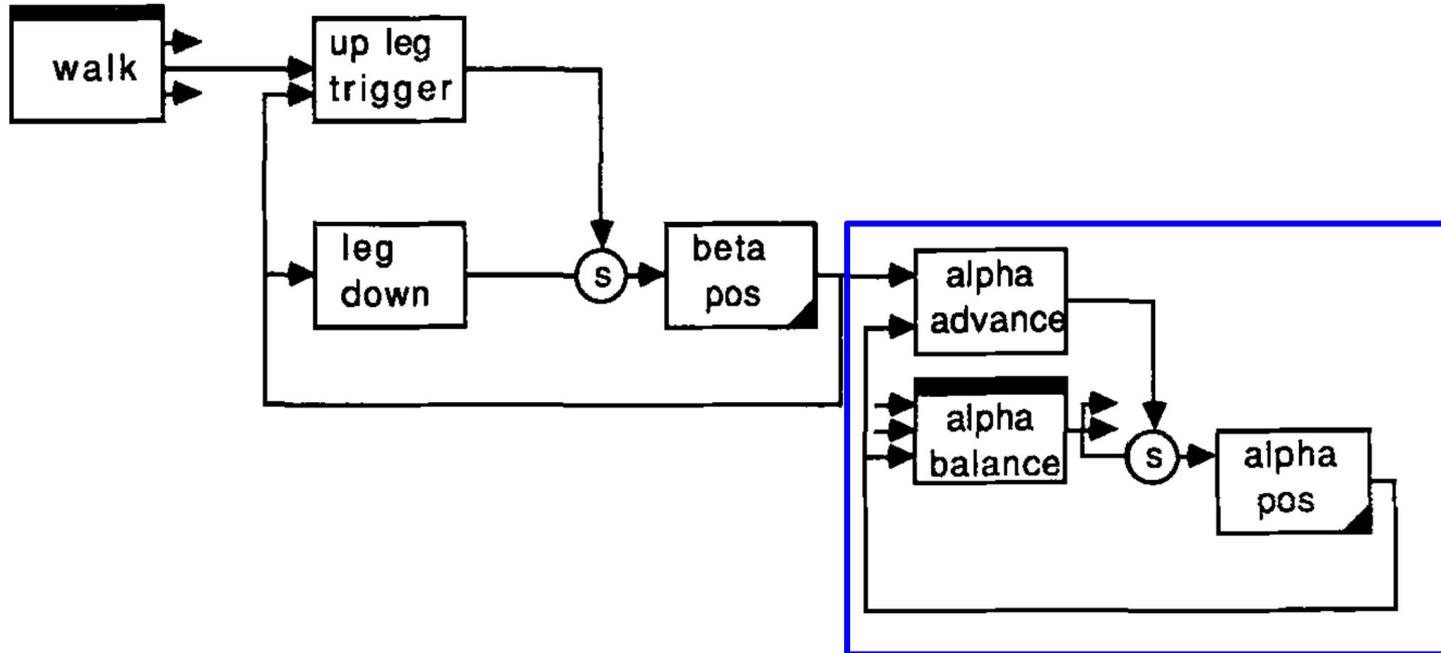
Walking Layer | 1 leg



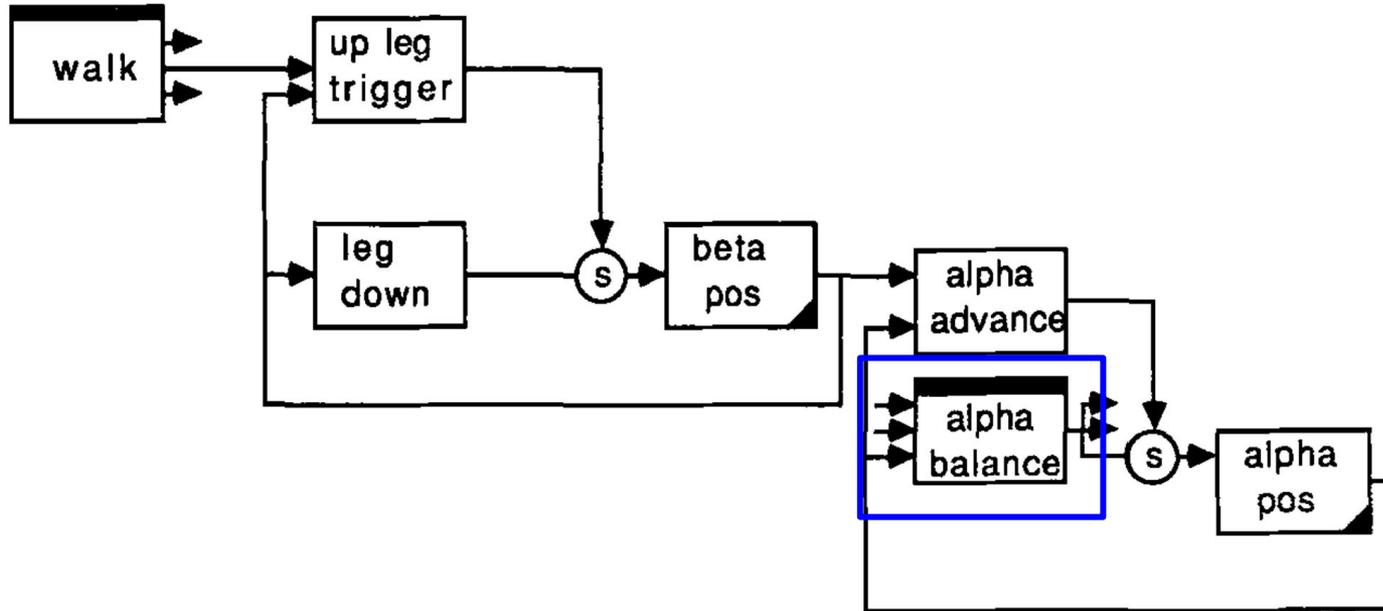
Walking Layer | Lift leg



Walking Layer | Advance

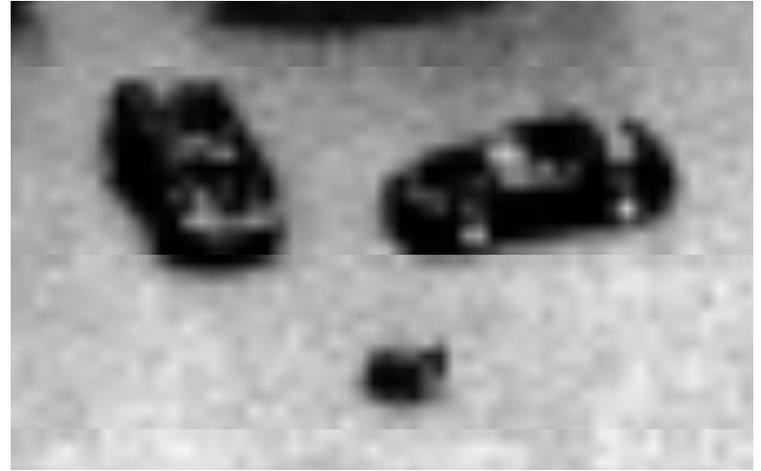


Walking Layer | Global synchronization

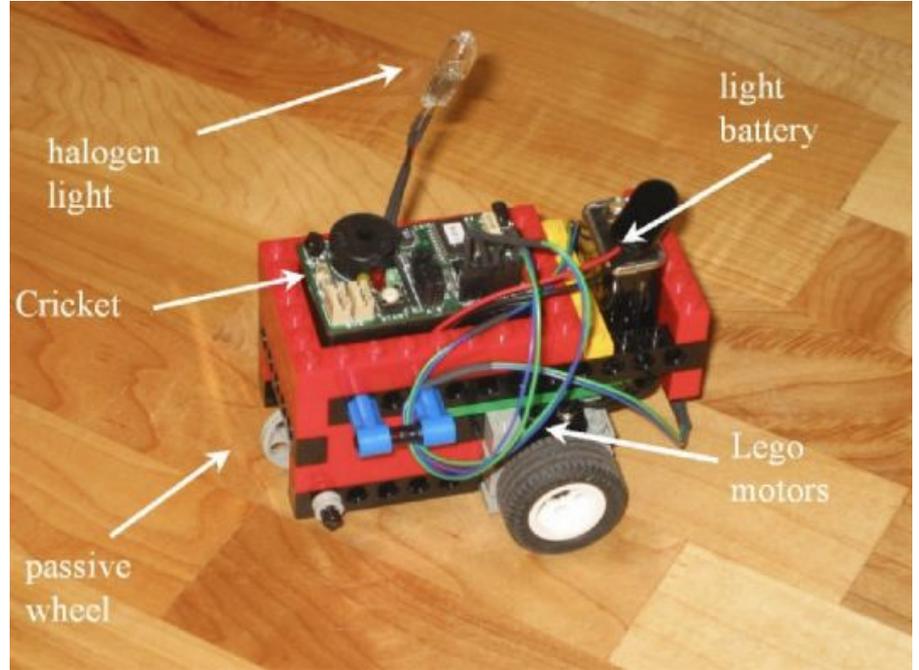
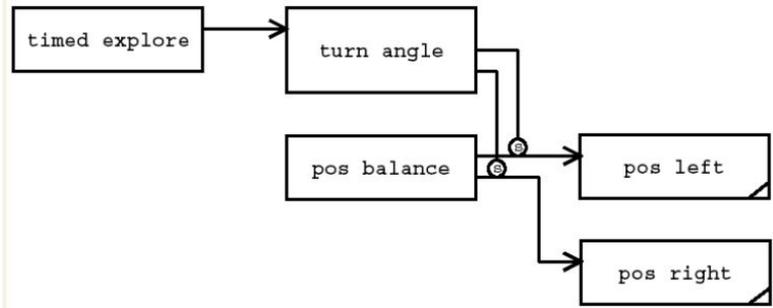


Ghengis in Action

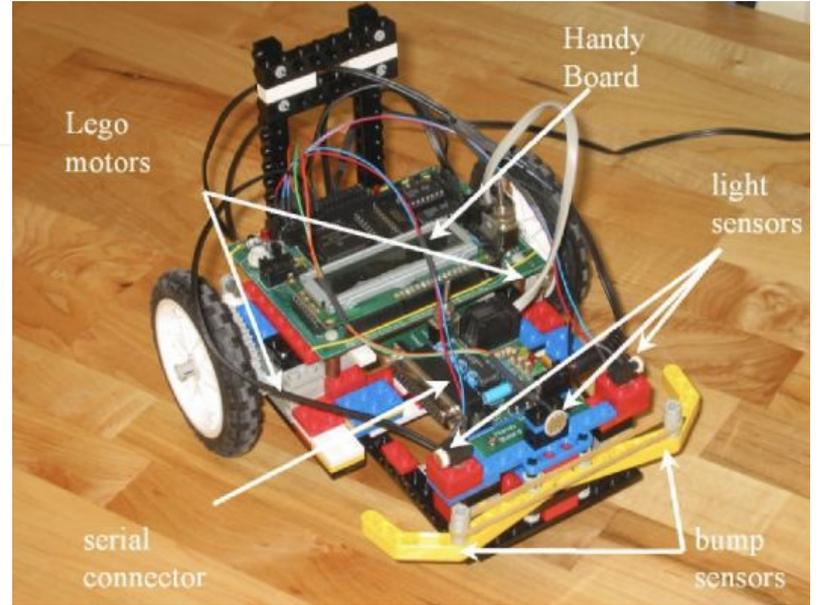
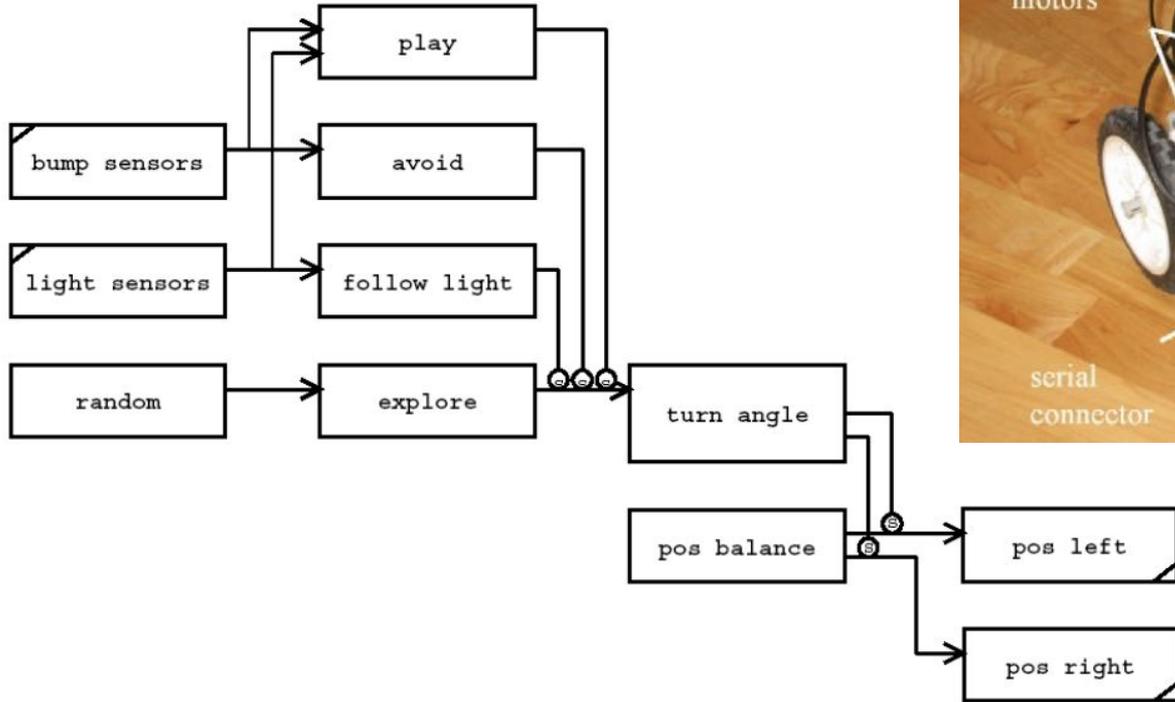
Simple Subsumption Architectures lead to complex behaviors



Jerry



Tom

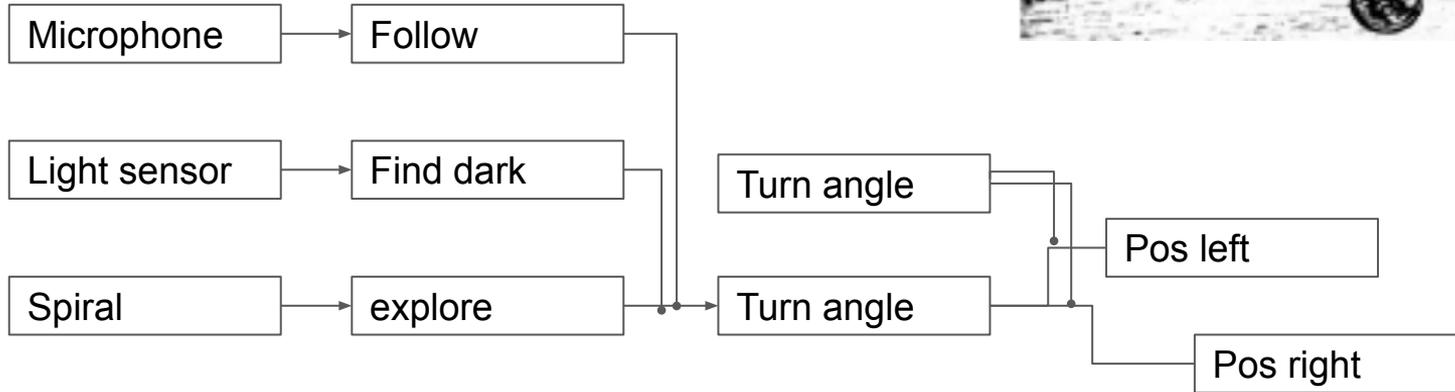


Emergence of Chasing - Social Behavior

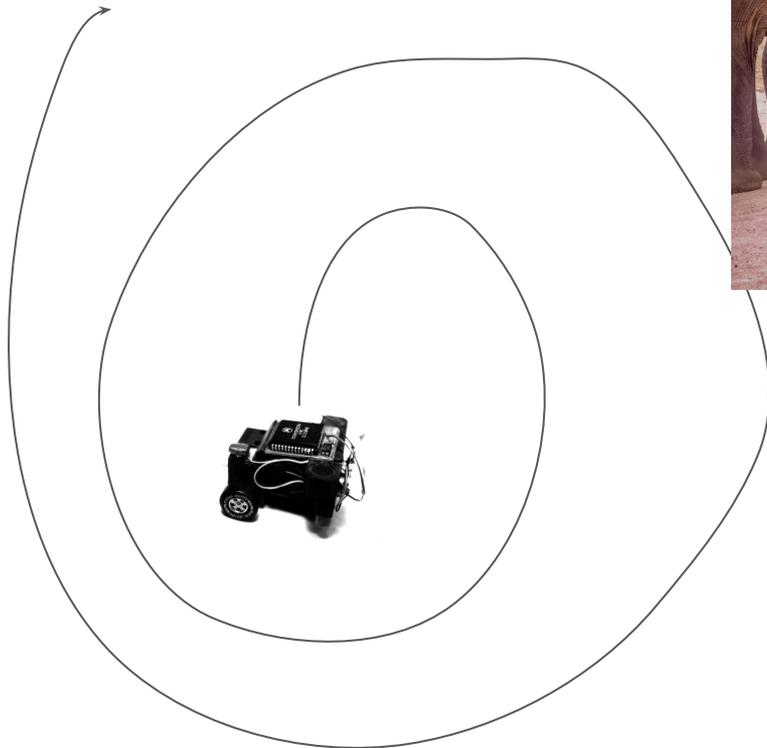
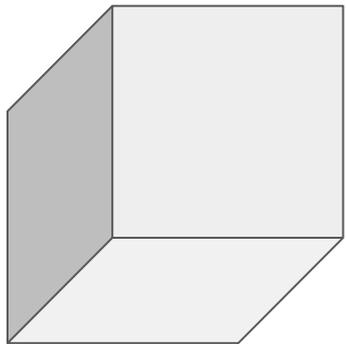


Discussion

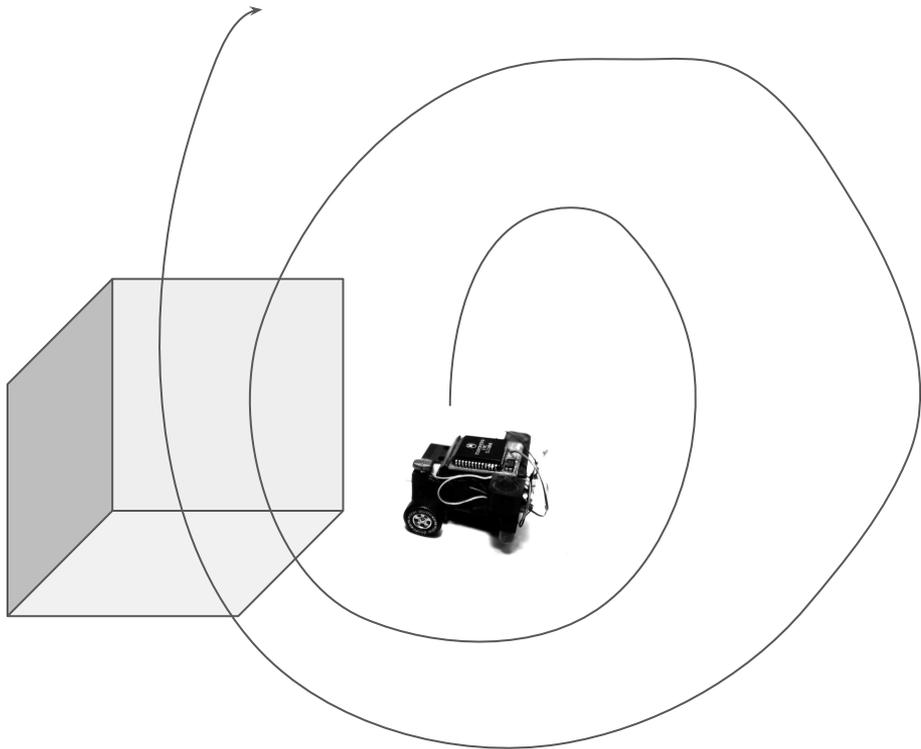
Squirt



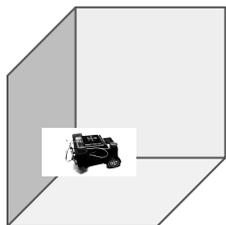
Squirt



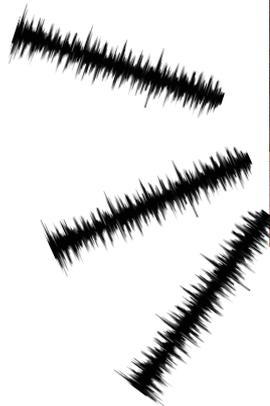
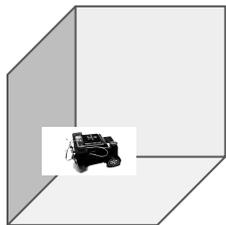
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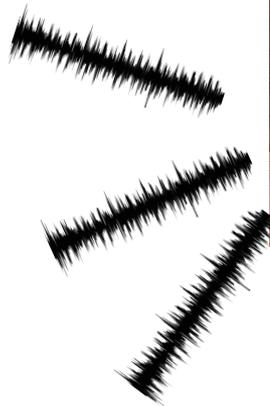
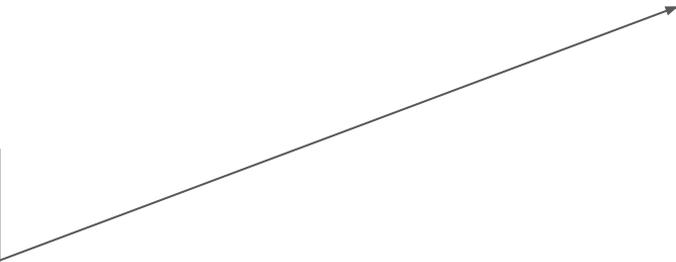
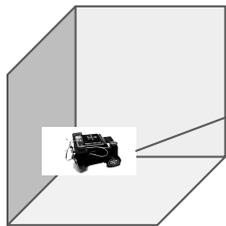
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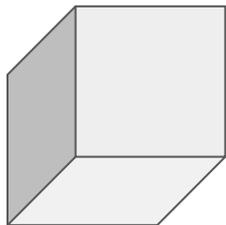
Squirt



Squirt



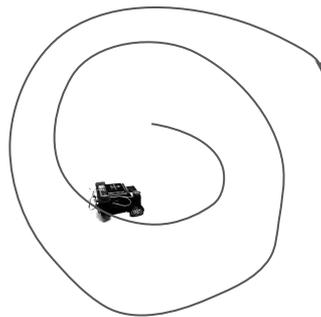
Squirt



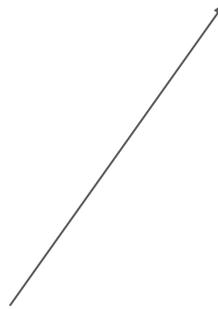
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Squirt



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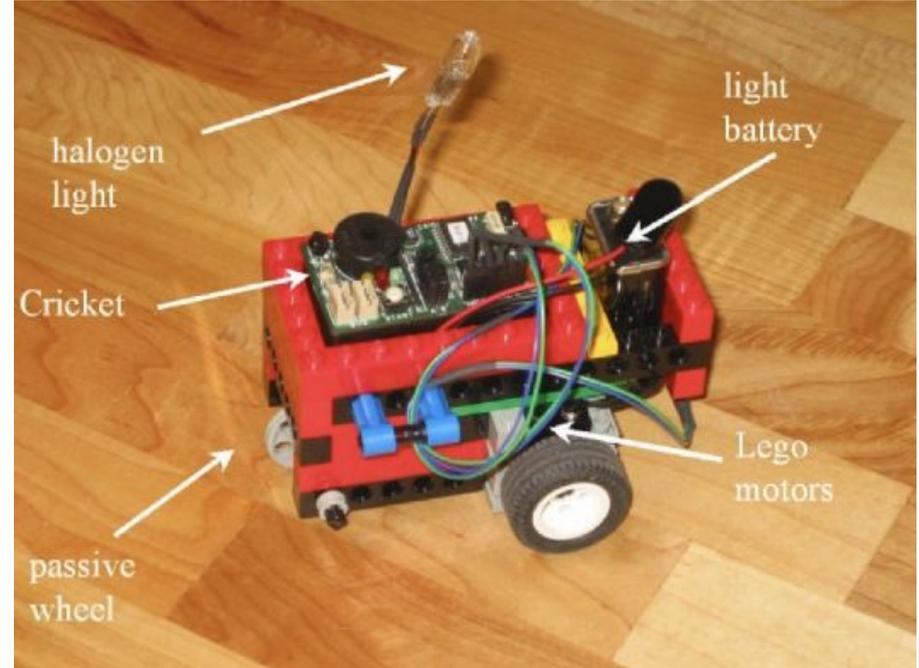
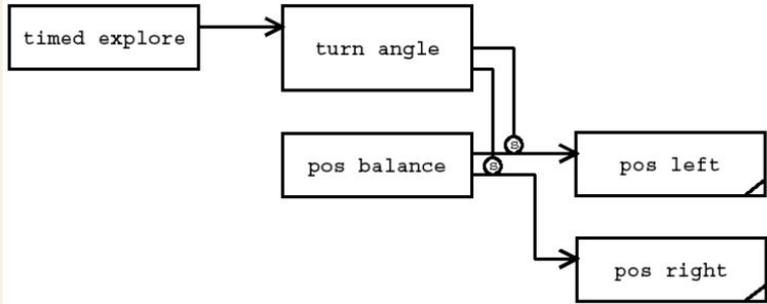
Squirt



How can we make Jerry run away?

What modules can encode hiding behavior?

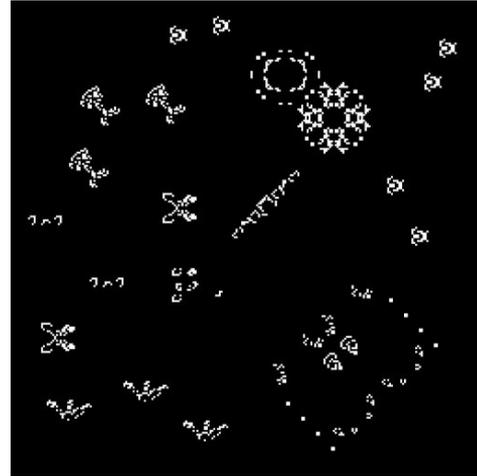
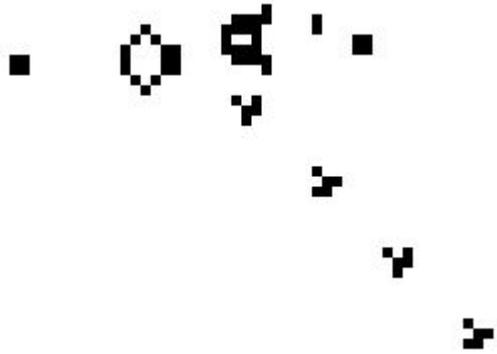
Class solution: A motion sensor to track a moving object, which will compute a opposing direction vector to feed into lower control layers



Mini Discussion Questions

- Does nature ever prefer the SPA or central compute architectures? What contexts would a Subsumption architecture be preferred?(@73_f6)
- How can we organize the relationships or behaviors, is there a natural taxonomy that emerges? (ex: is there a walking prototype? Is there a hierarchy) do we need to? (**class discussion: behaviors may be compositional, high level behaviors can be composed of lower level behaviors - this relationship is encoded in the subsumption architecture**)
- Where do this leave space for our sota pattern recognition systems come into play, how can add a modern approach to this high level architecture.(@73_f8)

Simple local rules can give rise to complex behaviors



Reflex mapping in cats

(snake features directly map to actions, before the animal can form a conscious representation of a snake)

interesting additional content

[Pictures and media relating to Genghis](#)

[Subsumption architecture slides](#)

[Lots of examples of subsumption robots + space travel](#)