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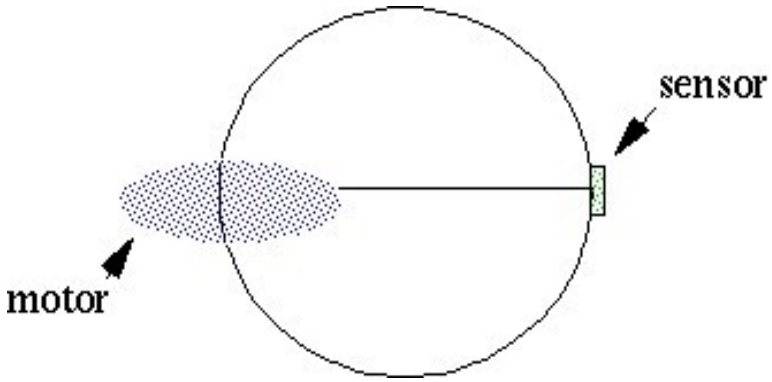
Simple behaviours: Braitenberg vehicles

- Direct connections between sensors and motors
- Created in 1984 as thought experiments in study of intelligence in Braitenberg's book “Vehicles”.

Variable speed – single direction



- Sensor controls speed of motor - always forward
- Sensor detects increasing heat or light increasing motor speed in response

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Observed Anthropomorphic Behaviour

- With heat sensor robot appears to avoid warmth, seek cool areas.
- If uses a light sensor, appears to avoid light.
- If sensor has a threshold then motor will cut when sensed value is below a certain level.
- Light sensor robot appears to run towards shade - so exhibits **timid** behavour

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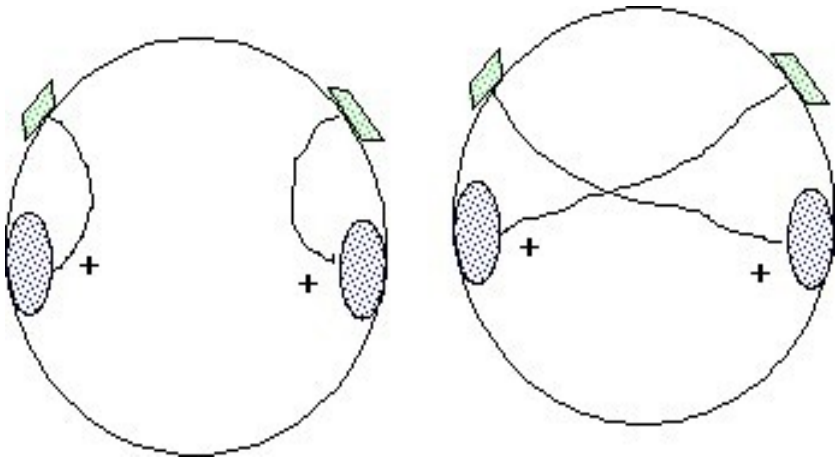
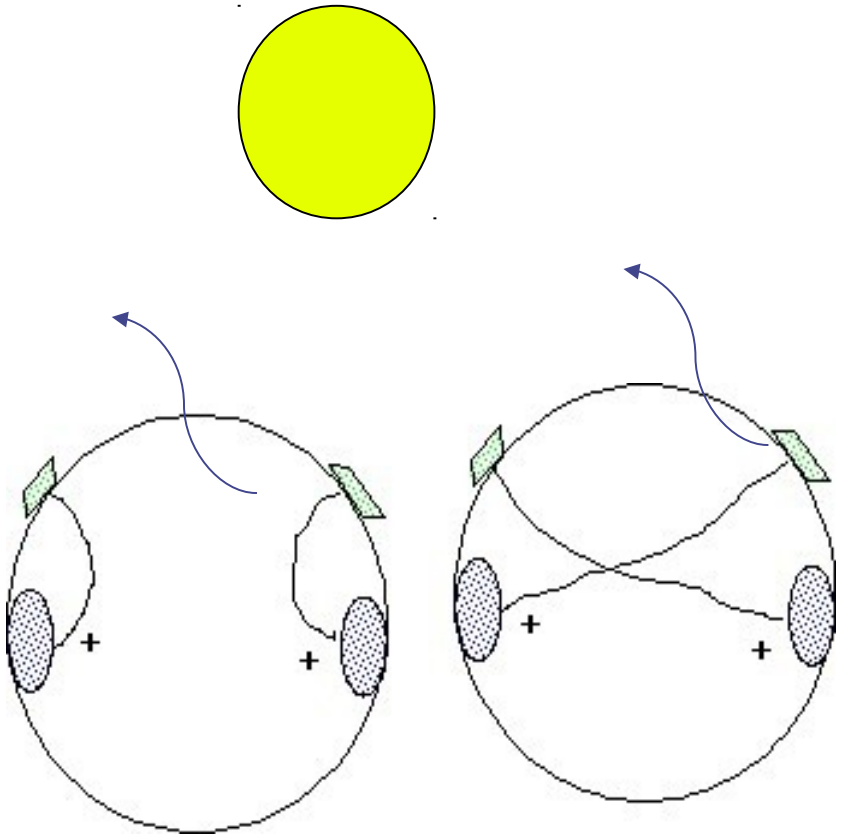
Two sensors and two motors



Sensors again control speed of motors

Increase in sensed value increases speed of motor

Observed behaviours



Light avoider

Light seeker

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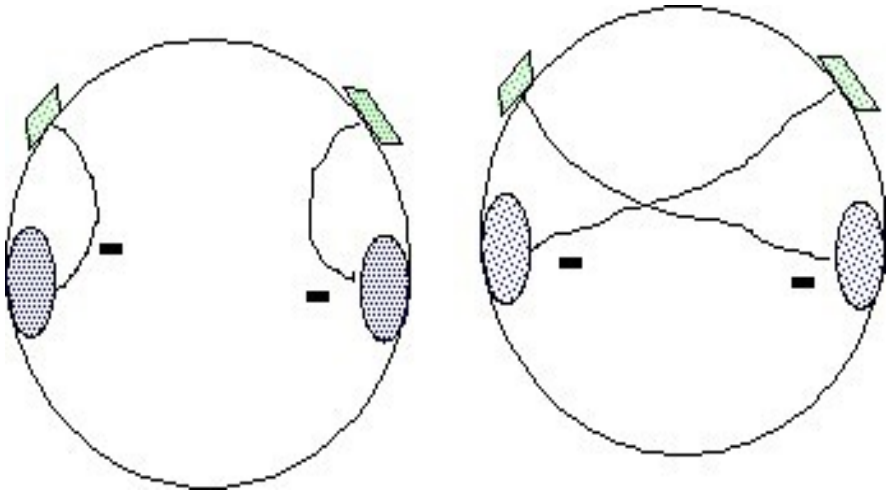
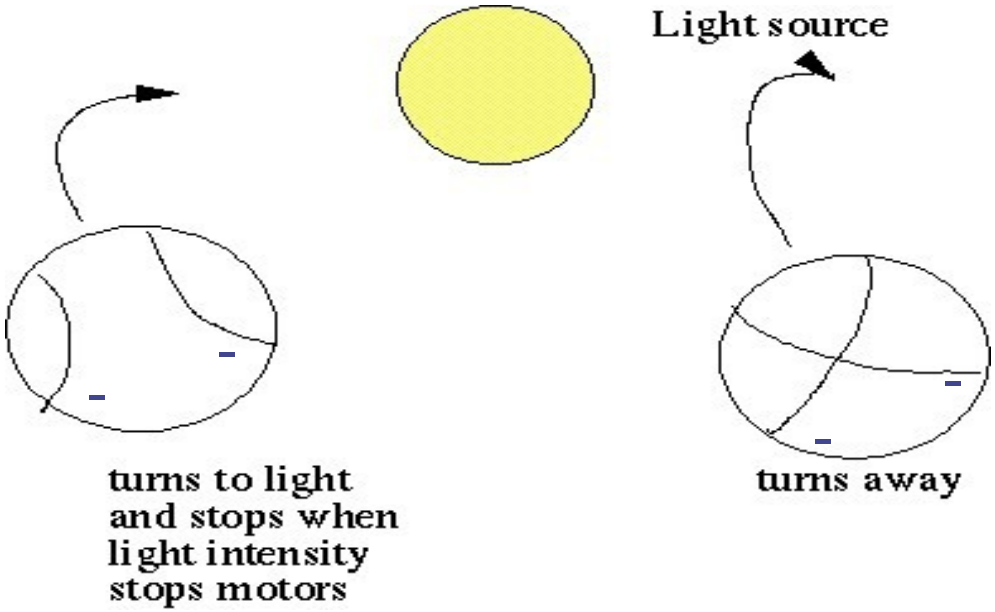
Two inhibiting sensors and two motors

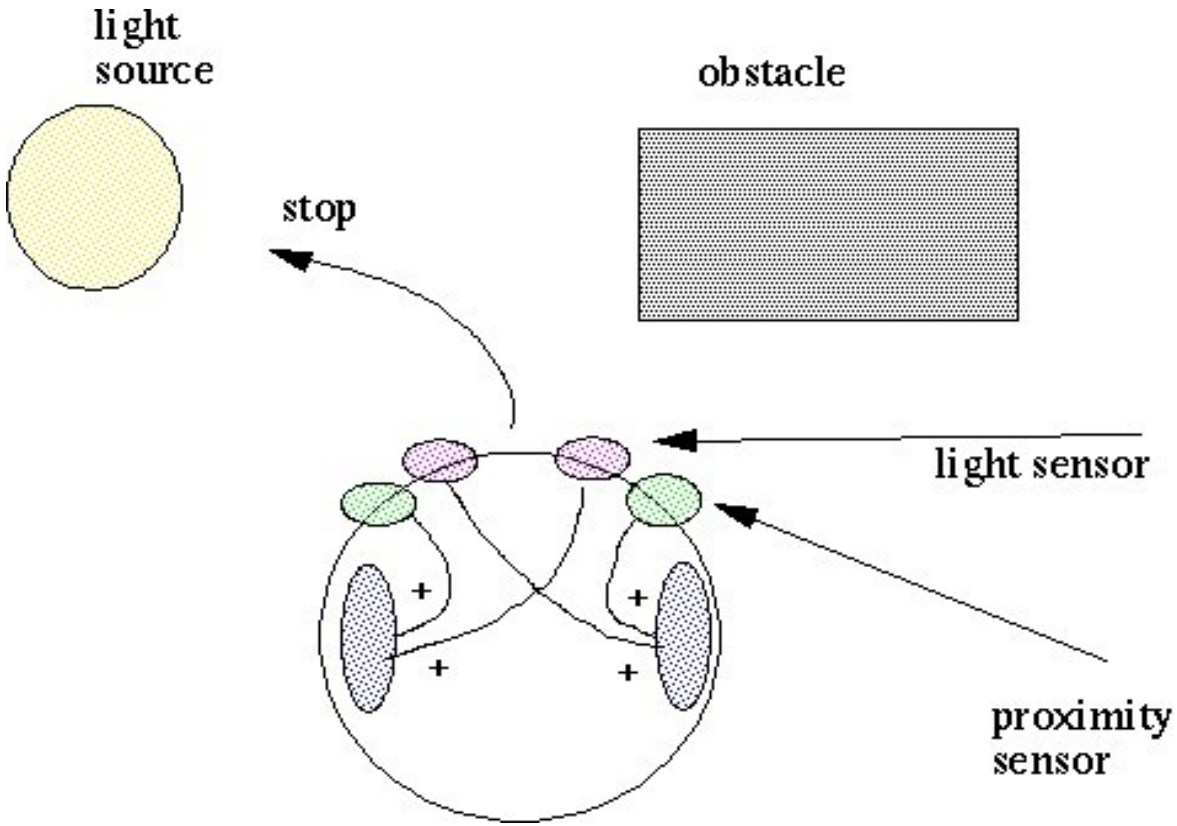


Increase of sensed value decreases linked motor speed, and vice-versa.

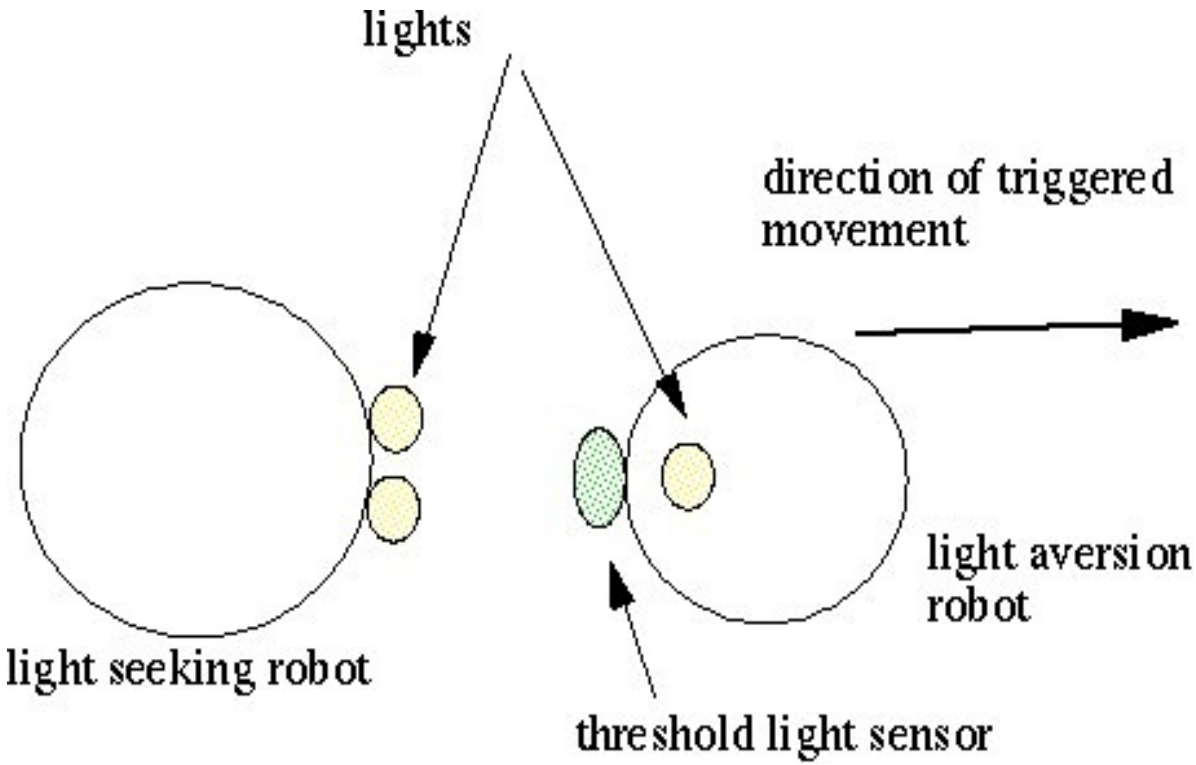
Observed behaviour



Merged behaviours



Following/leading behaviours



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Reactive control architectures

- Many of the successful robot control architectures are assemblies of concurrently executing micro-behaviours
- Two different ways of combining action outputs of the concurrently executing behaviours: subsumption and potential field (or vector field) summation.
- Subsumption similar to TR rule hierarchy, in which behaviours are ranked and highest ranked behaviour wanting to control the robot has control.
- Vector fields similar to the action merging of Braitenberg vehicles (light seeking + obstacle avoidance).

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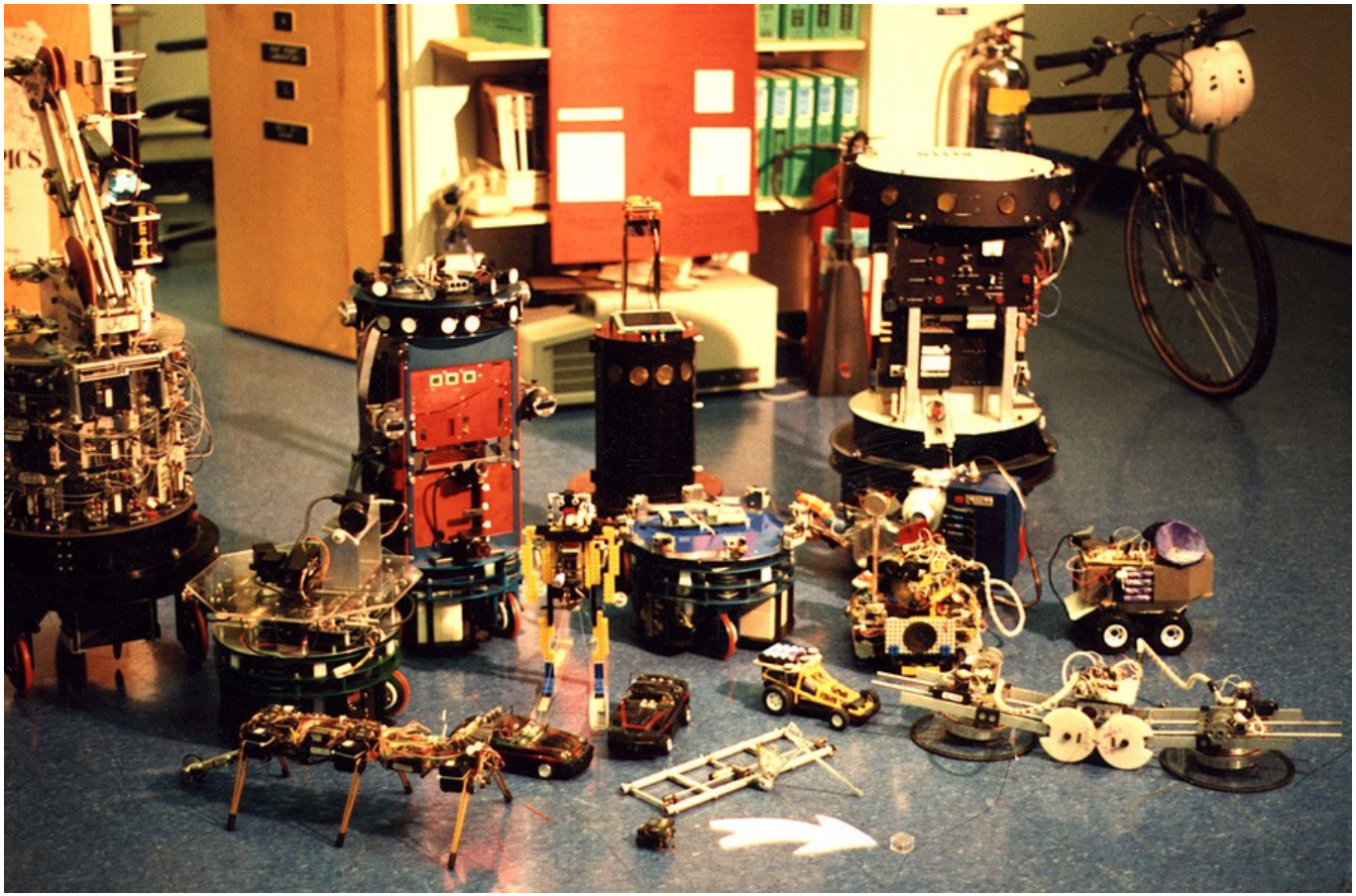
Subsumption:
Rodney Brooks, MIT AI Lab, 1980s



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Subsumption Philosophy

- Behaviours are grouped into *layers of competence.*
- Behaviour at a higher lever *subsume* behaviours at a lower level.
- Higher behaviour can also use computed percepts and intermediary or final output values of any lower lever behaviour.
- Layers of competence developed from bottom up
  - Starting with N=0, N layer behaviour developed and *debugged* before next layer is added