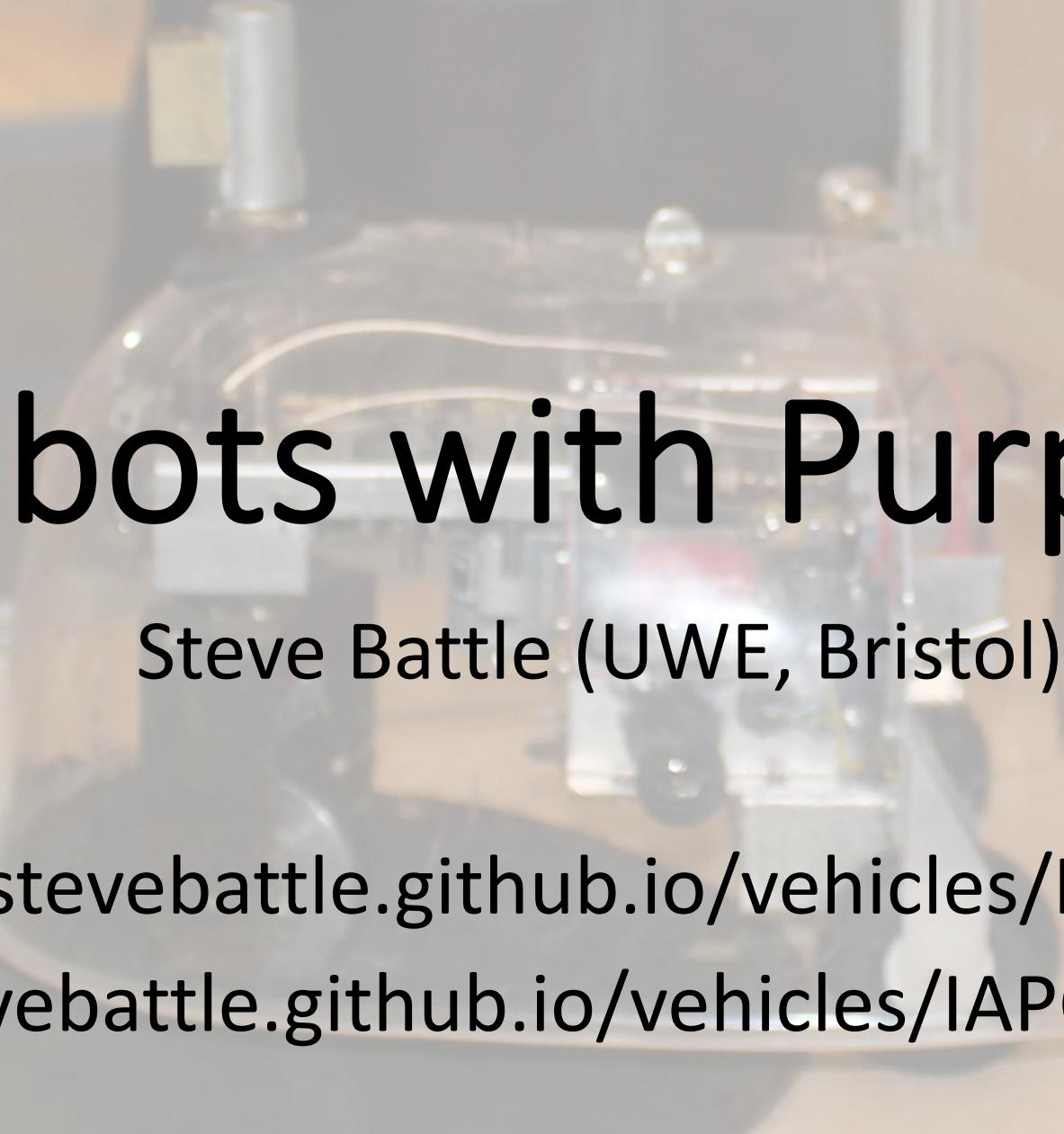


Robots with Purpose



Steve Battle (UWE, Bristol)

<https://stevebattle.github.io/vehicles/IAPCT20.pdf>

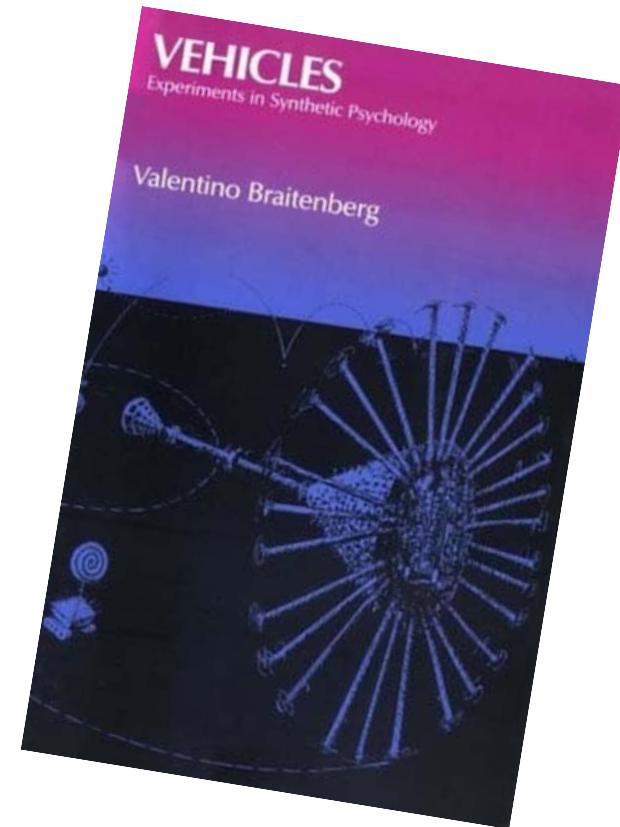
<https://stevebattle.github.io/vehicles/IAPCT20-slides.pdf>

S-R Vehicles

- A train of thought triggered by Marken's, 'Doing Research on Purpose.'

18 *Doing Research on Purpose*

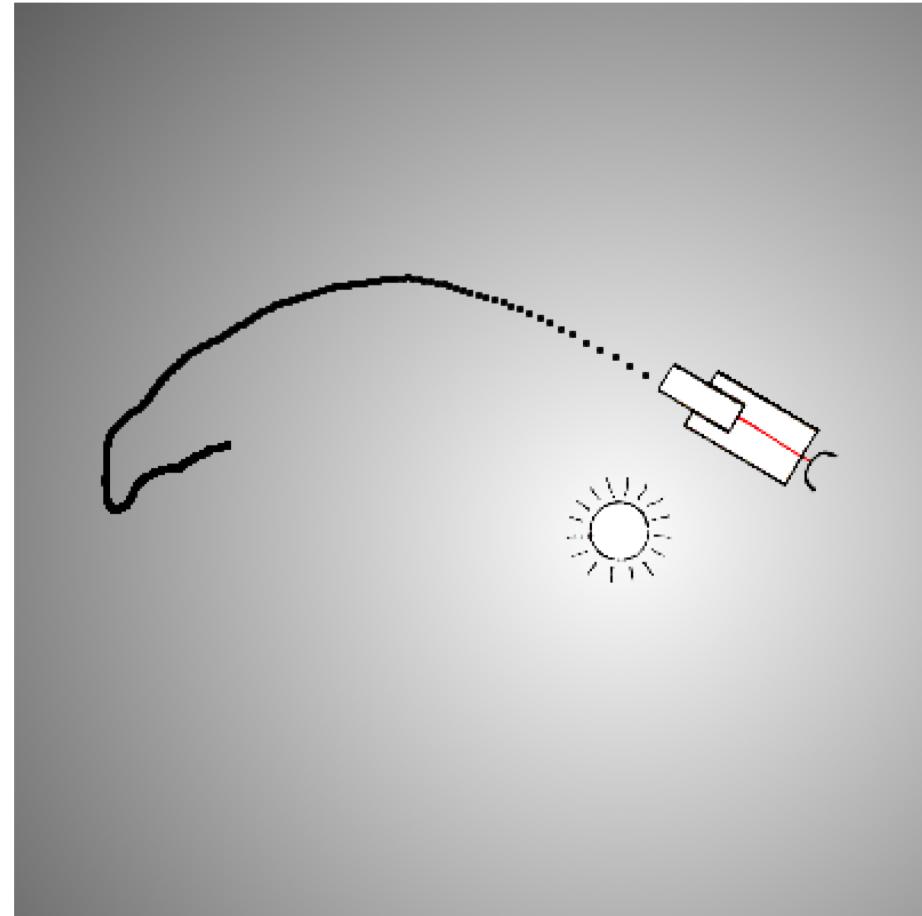
designed by Braitenberg (1986). Braitenberg vehicles have sensor inputs (S) connected by rules to motor outputs (R). The birds in animated computer simulations of flocking behavior are often described as though they were this kind of S-R vehicle, with the rules connecting S to R being quite complex (Wilhelms and Skinner, 1990). These S-R models of flocking birds, sometimes called "boids" (Reynolds, 1987), are clearly based on a concept of behavior that comes from looking at flocking birds through causal theory glasses. A computer model of flocking boids can be seen in action on the Internet⁴.



Braitenberg Vehicle 1: Getting Around

“Once you let friction come into the picture, other amazing things might happen. As the vehicle pushes forward against frictional forces, it will deviate from its course.” Valentino Braitenberg

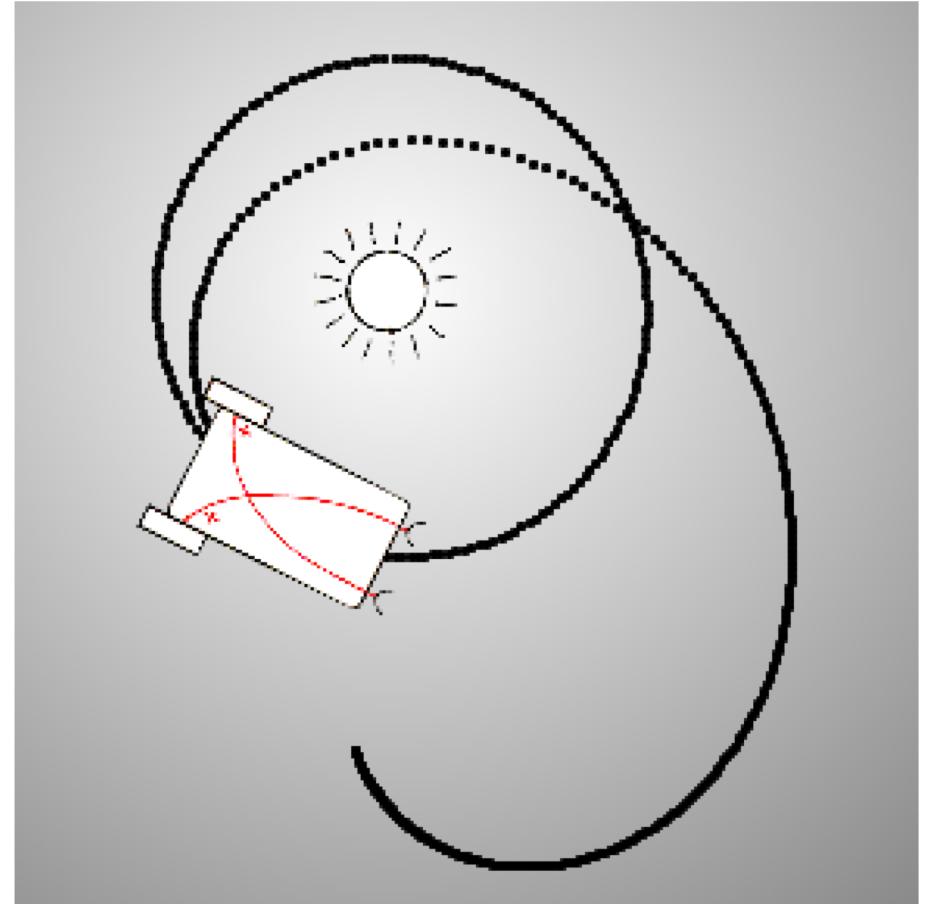
- stevebattle.github.io/vehicles/



Braitenberg Vehicle 2: Fear and Aggression

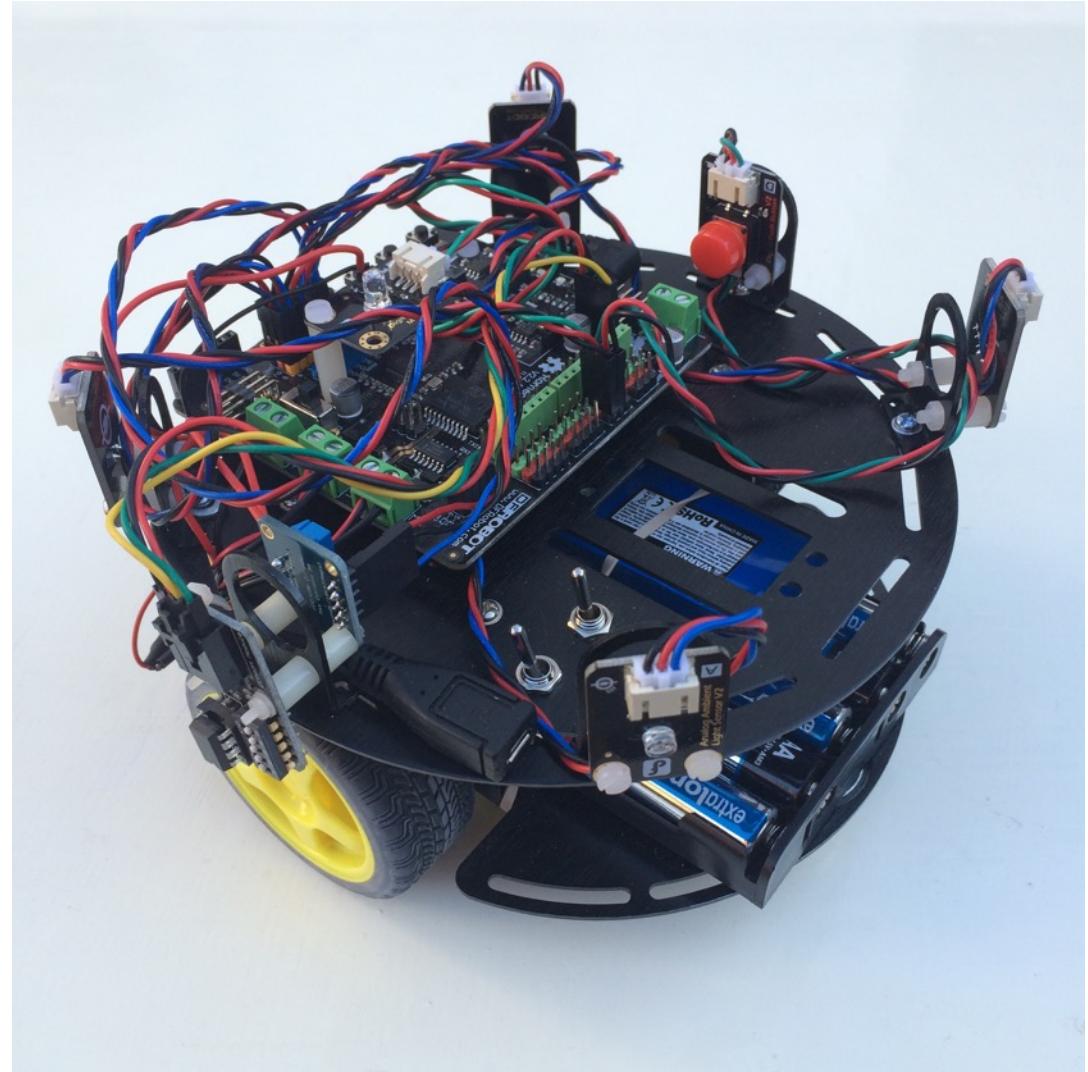
*“Vehicle 2b. It, too, is excited by the presence of sources, but resolutely turns toward them and hits them with high velocity, as if it wanted to destroy them. Vehicle 2b is **aggressive**, obviously.”* Valentino Braitenberg

- stevebattle.github.io/vehicles/



Sensors & Motors

- Vehicle sensors are directional
- Light sensitive, but could sense chemical gradient.
- Motor could easily represent flagella on a bacterium.
- An ‘eye’ functions according to Lambert’s cosine law.
- Wrap-around eyes provide full (unrectified) cosine function.



Experiments

Organisms control their
perceptions

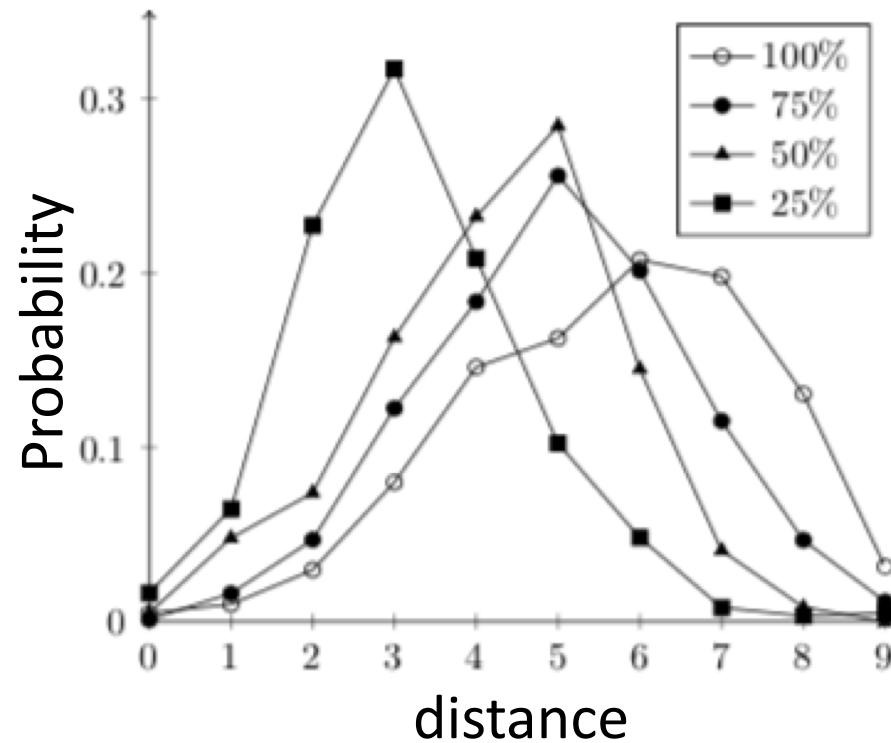
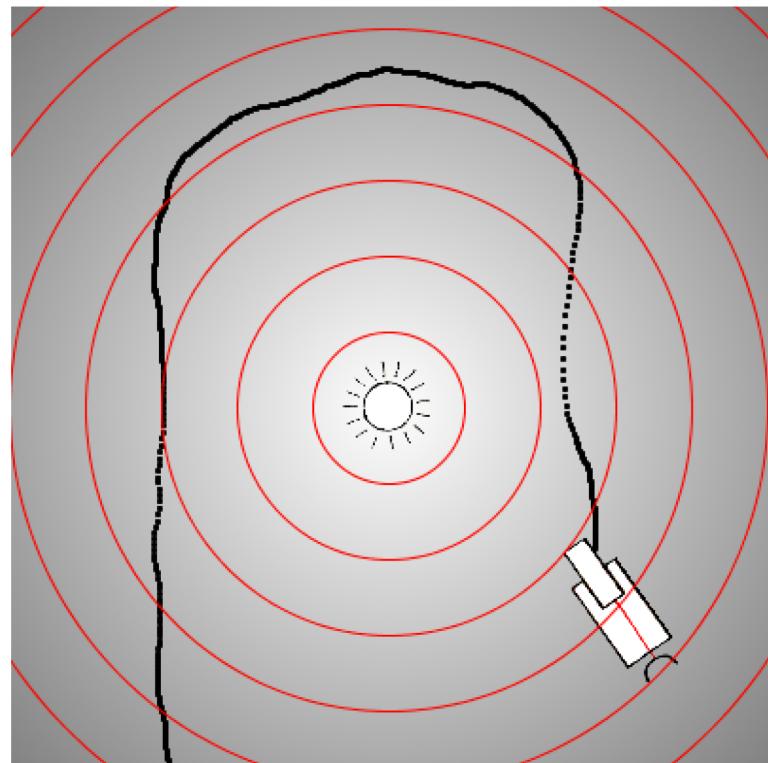
- V1 percepts
 - Distance **X**
 - Angle (bearing) **X**
 - Apparent brightness ✓
- V2 percepts
 - Distance **X**
 - Angle (bearing) ✓
 - Apparent brightness ✓

Disturbance is the **Luminosity** of the light source

TCV experimental protocol:

1. Record variables without disturbance (**reference**)
2. Record variables with different % of disturbance.

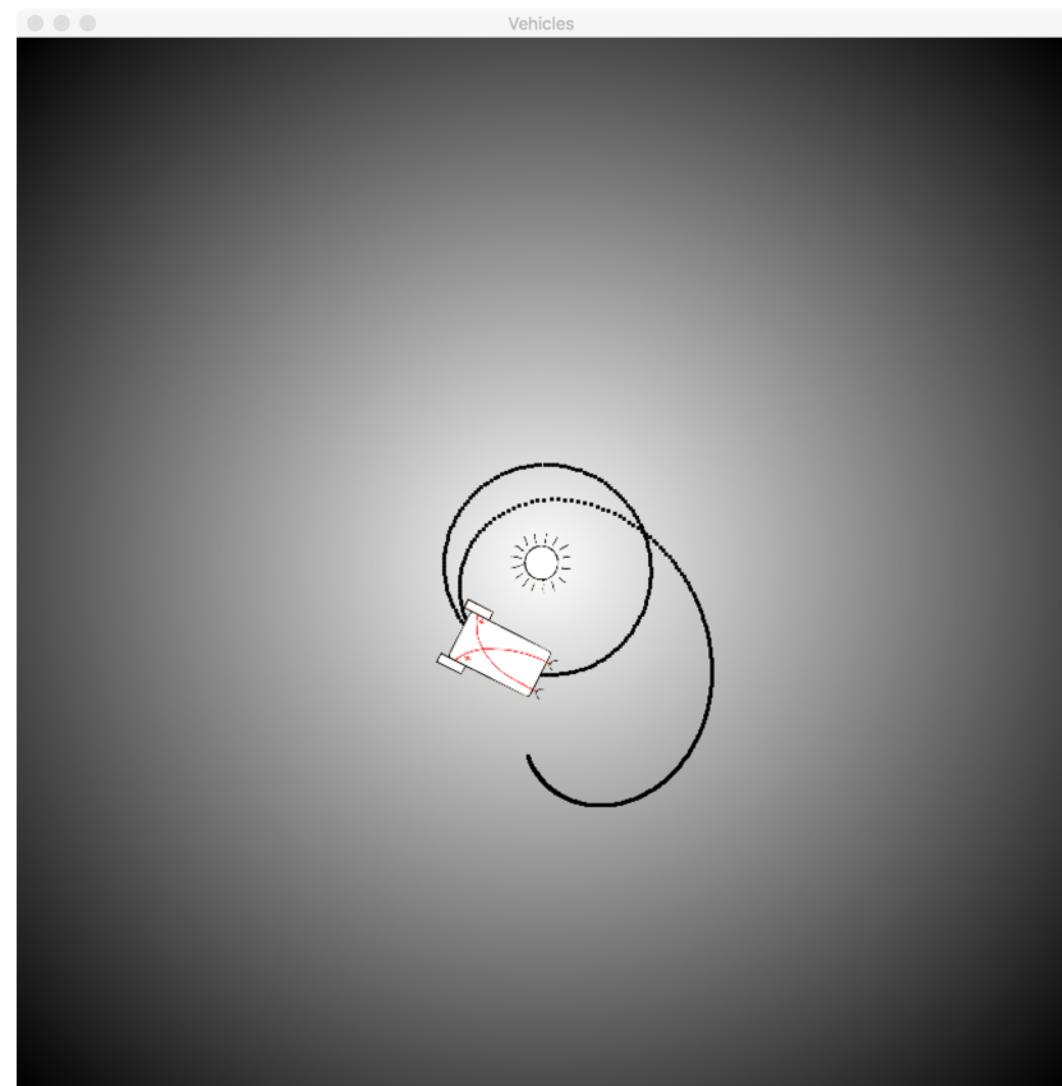
Vehicle 1 results



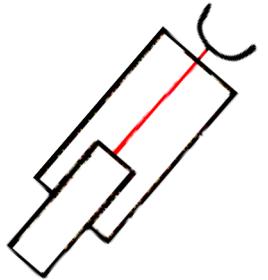
reference	H1 (brightness)
	0.1698
luminosity	
100%	0.1646
75%	0.1562
50%	0.1382
25%	0.1124
mean	0.1428
RMSD	0.0336
NRMSD %	0.2349

Vehicle 2 Results

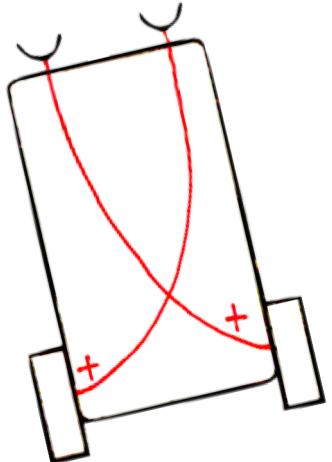
	H1 (brightness)	H2 (angle)
reference	1.8173	1.6407
luminosity		
100%	1.8173	1.6407
90%	1.6195	1.6331
80%	1.4255	1.6257
70%	1.2352	1.6184
60%	1.0486	1.6112
50%	0.8656	1.6042
40%	0.6860	1.5972
30%	0.5097	1.5905
20%	0.3367	1.5838
10%	0.1668	1.5772
mean	0.9711	1.6082
RMSD	0.9967	0.0383
NRMSD %	1.0264	0.0238



Surprises



- Vehicle 1 appears to be goal-directed
 - Its purpose is to maintain level of **brightness**
 - An emergent property



- Vehicle 2 *maintains* its distance
 - But cannot perceive distance, nor *control* it
 - Contingent to control over **angle**

Questions

- RMS criteria? (my working criteria is to reject $\text{RMSD} \geq 1$)
- Experimental protocol OK?
- Is this cybernetics?
 - *“Cybernetics is a branch of mathematics dealing with control, recursiveness, and information”* Gregory Bateson