Attractor dynamics approach to behavior generation: vehicle motion

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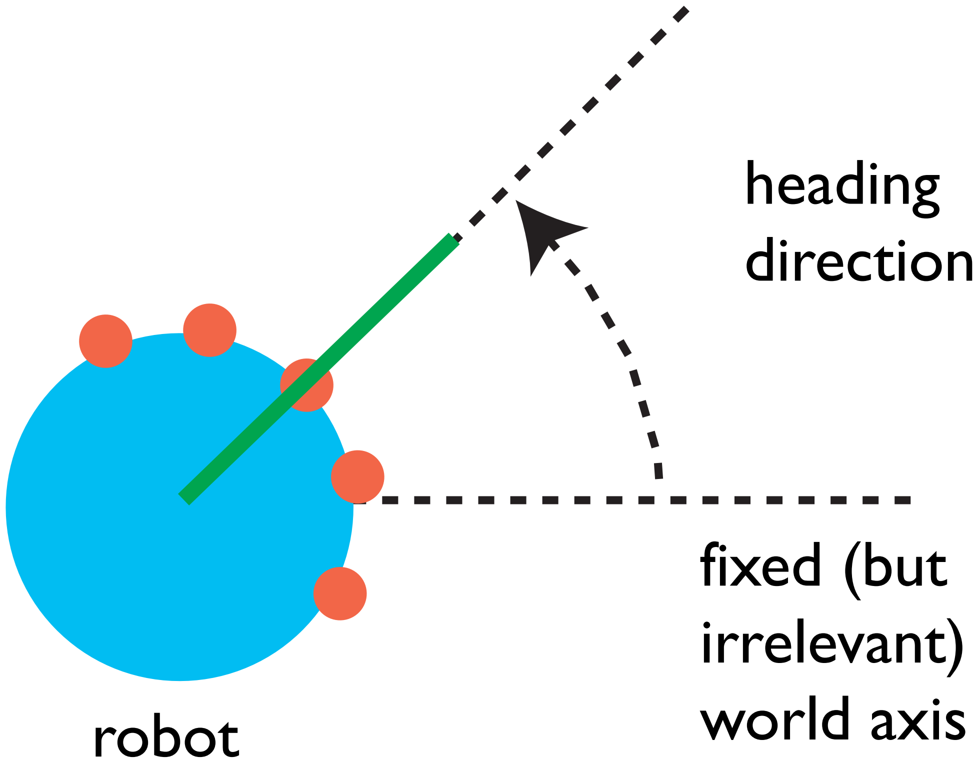
Basic ideas of attractor dynamics approach

- behavioral variables
- time courses from dynamical system: attractors
- tracking attractors
- bifurcations for flexibility

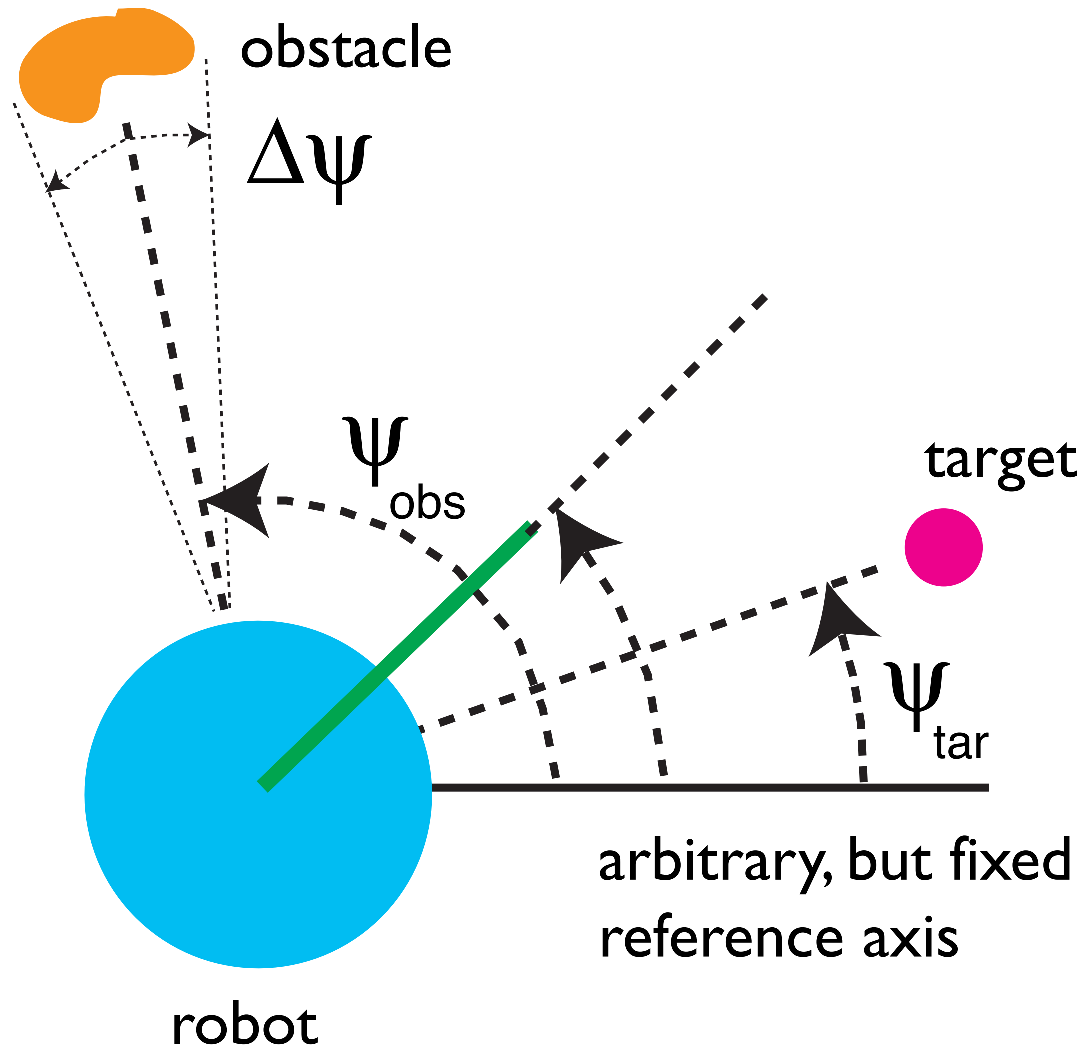
Behavioral variables: example

- vehicle moving in 2D: heading direction



Behavioral variables: example

- constraints: obstacle avoidance and target acquisition



Behavioral variables

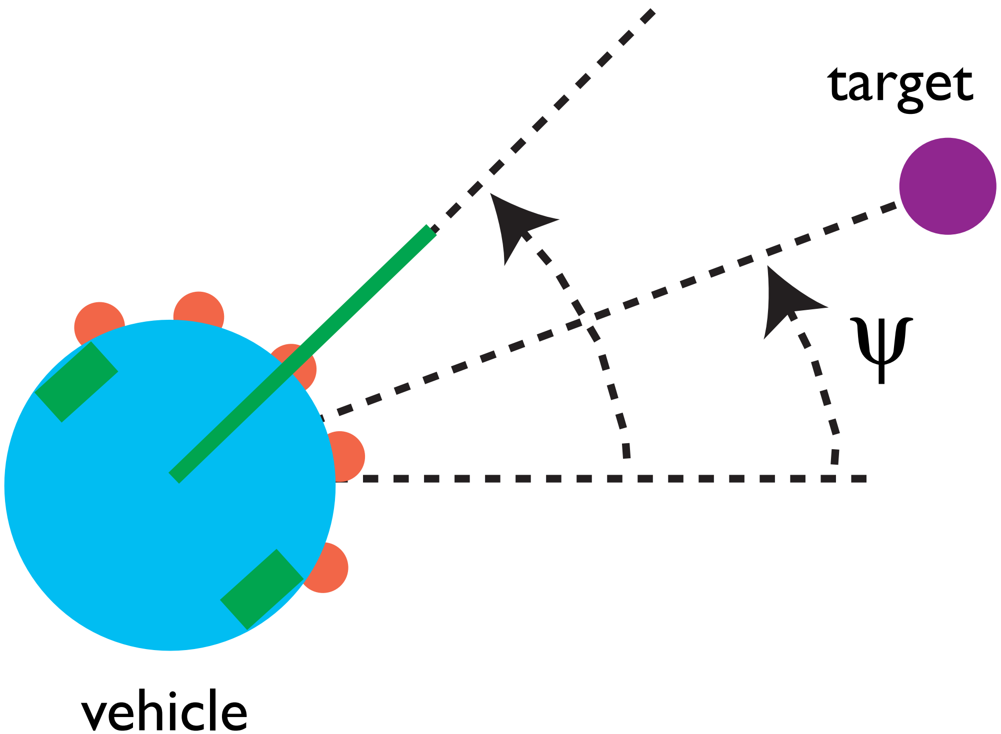
- describe desired motor behavior
- “enactable”
- express constraints as values/value ranges
- appropriate level of invariance

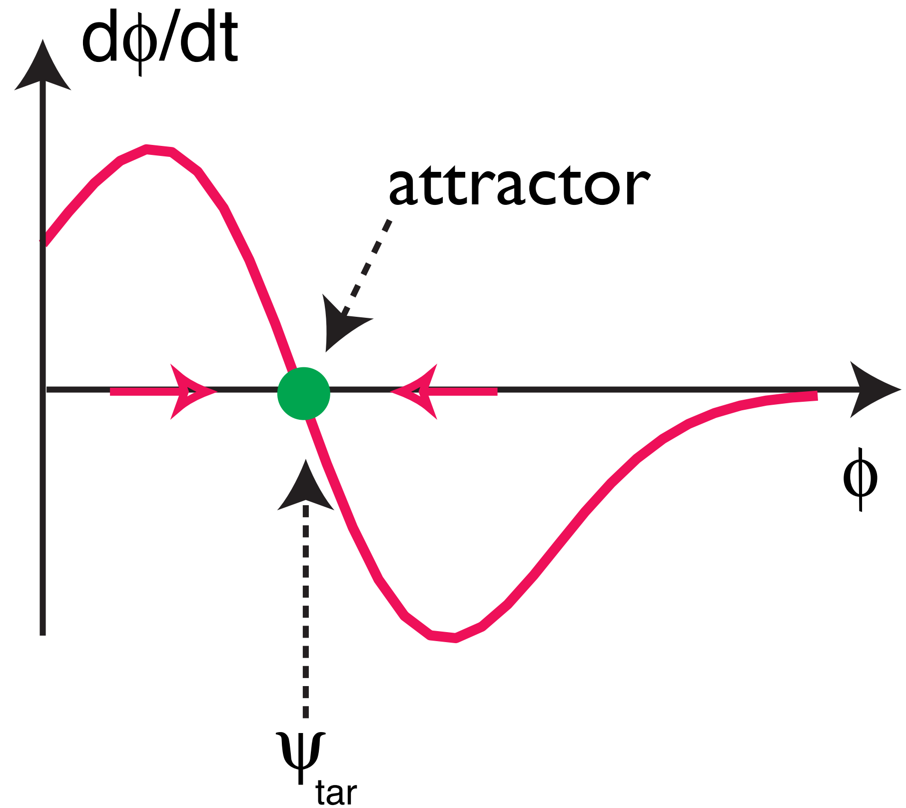
Behavioral dynamics

- generate behavior by generating time courses of behavioral variables
- generate time course of behavioral variables from attractor solutions of a (designed) dynamical system
- that dynamical system is constructed from contributions expressing behavioral constraints

Behavioral dynamics: example

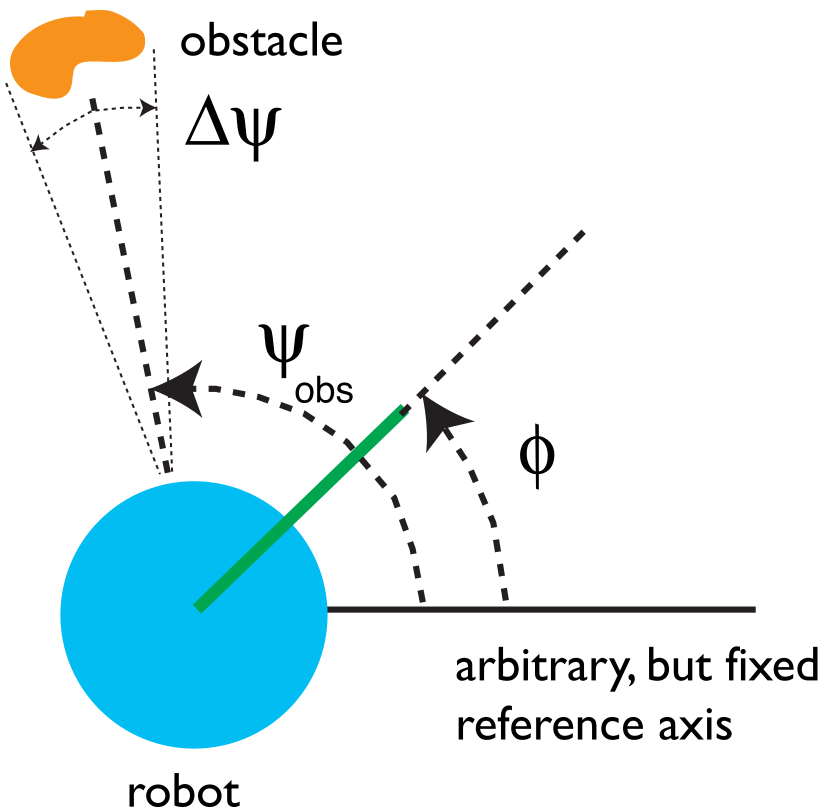
- behavioral constraint: target acquisition

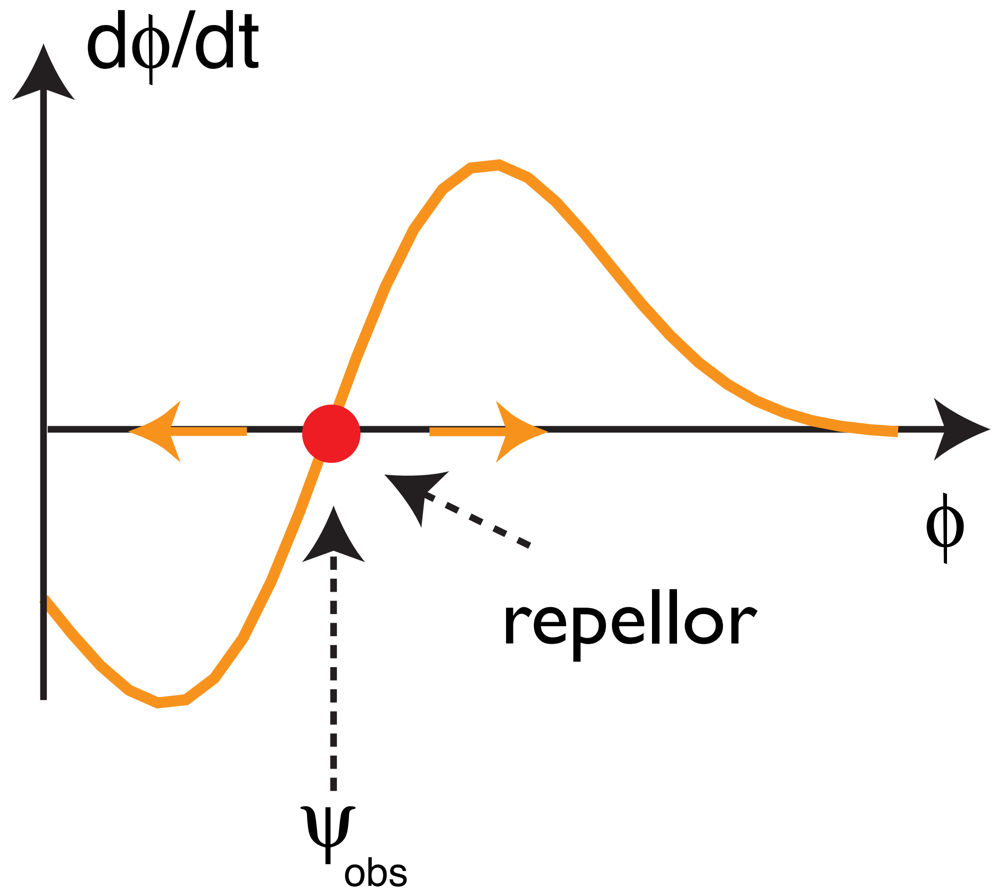




Behavioral dynamics: example

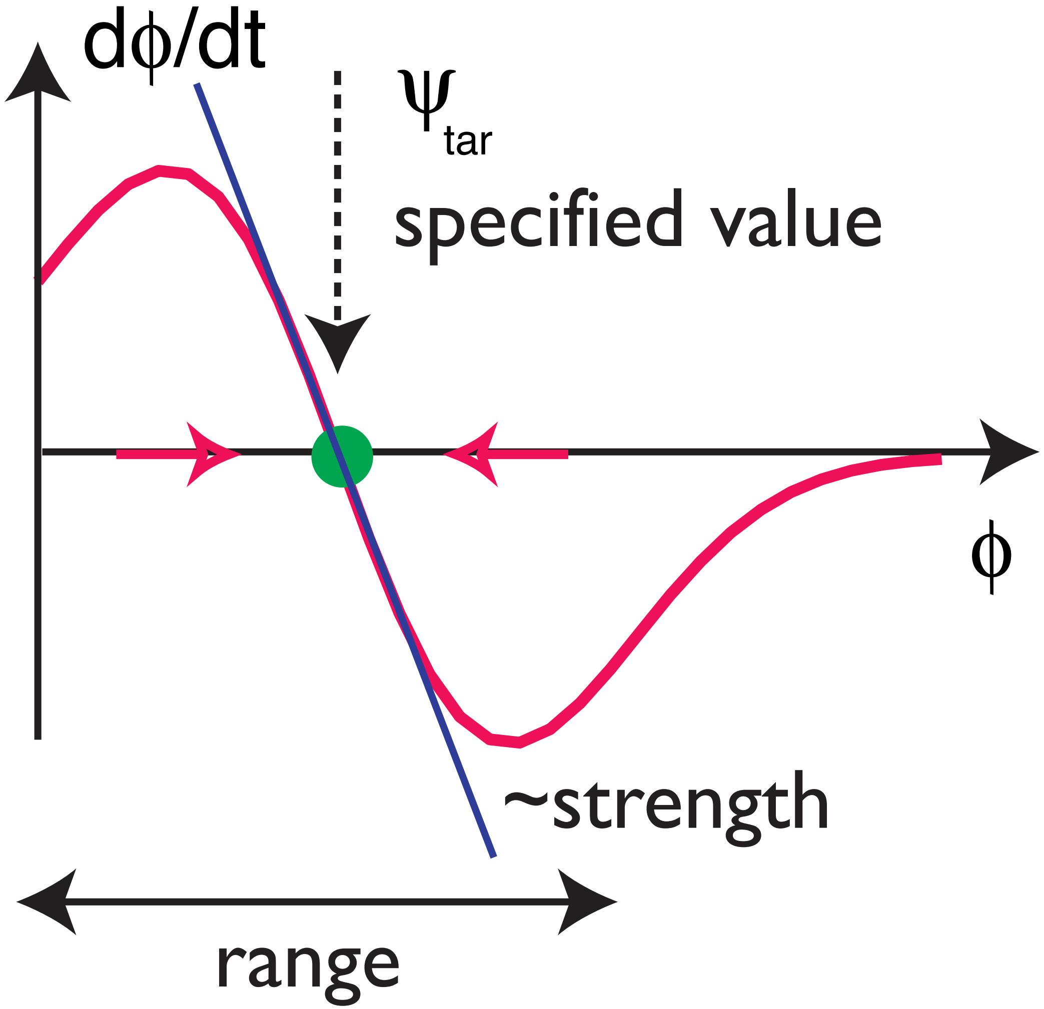
- behavioral constraint: obstacle avoidance





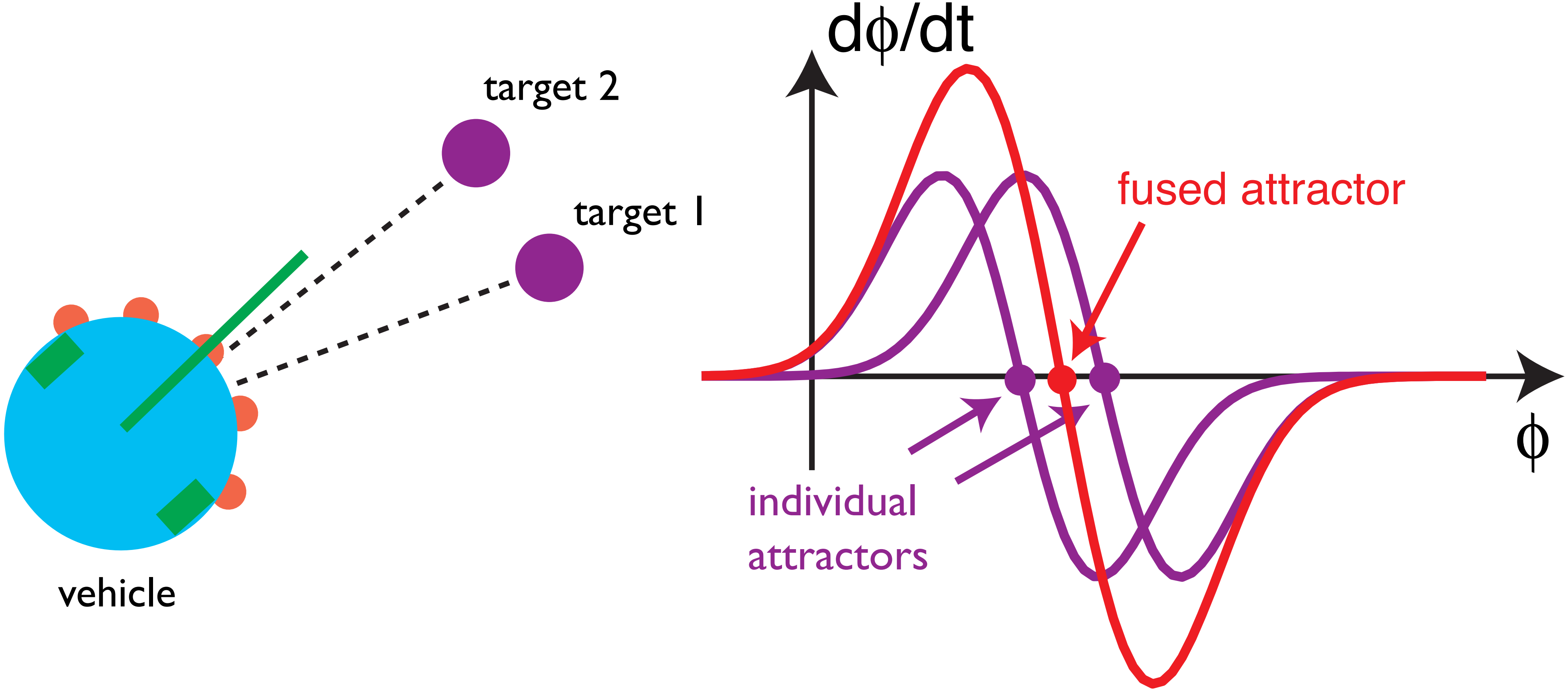
Behavioral dynamics

- each constribution is a “force-let” with
  - specified value
  - strength
  - range



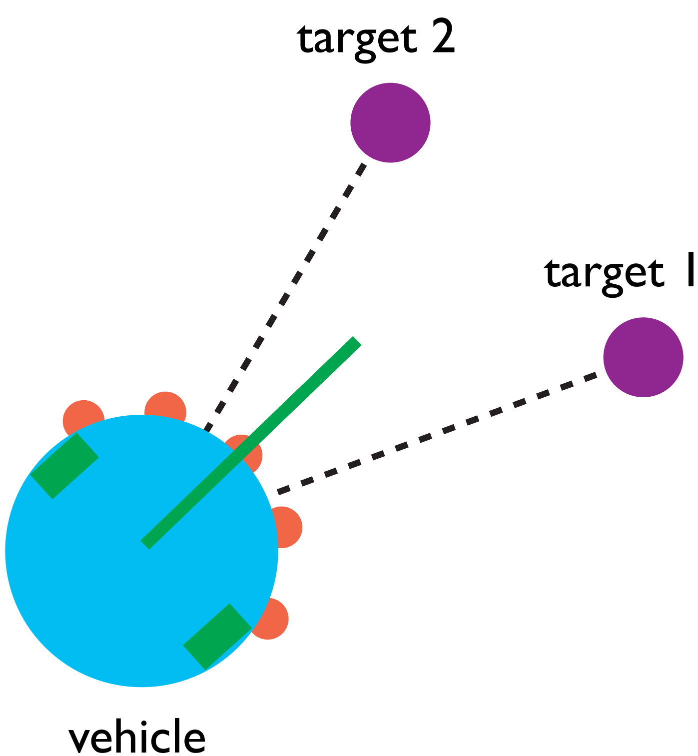
Behavioral dynamics

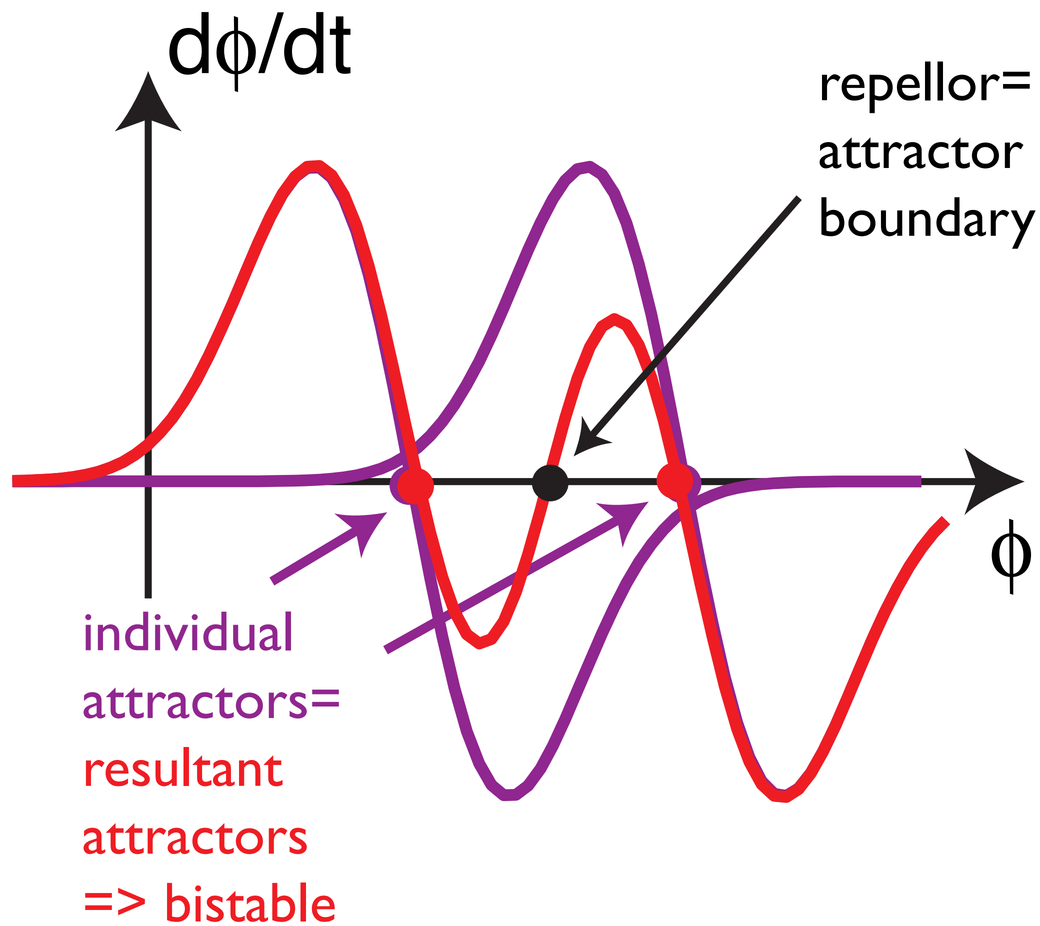
- multiple constraints: superpose “force-lets”
- fusion



Behavioral dynamics

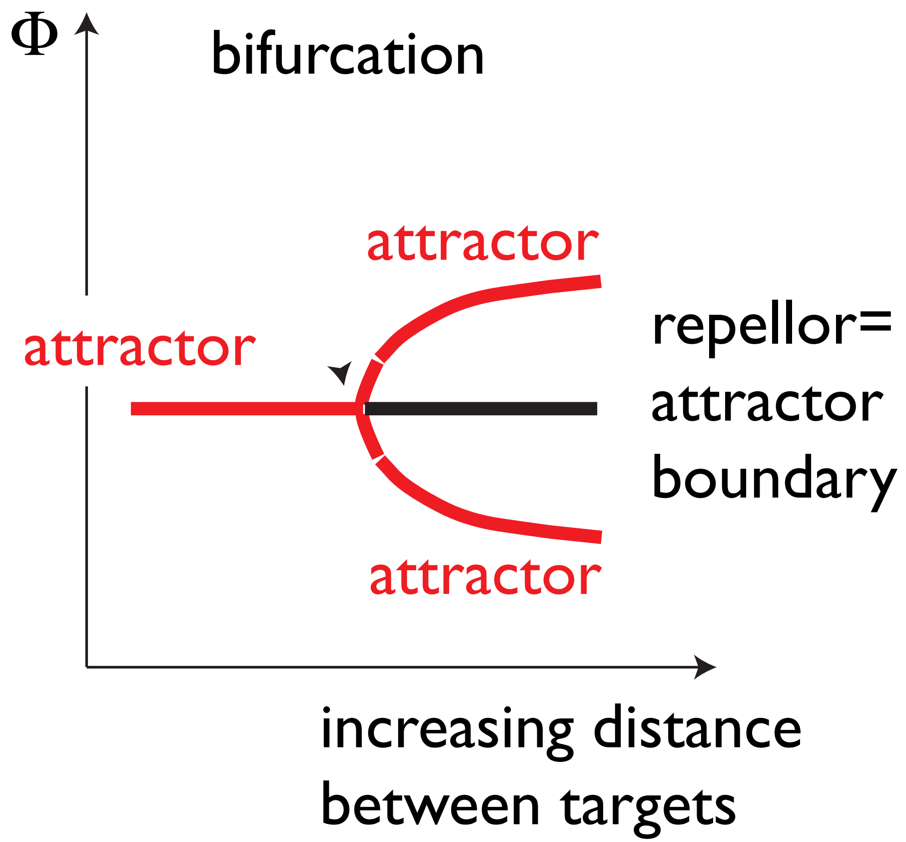
- decision making





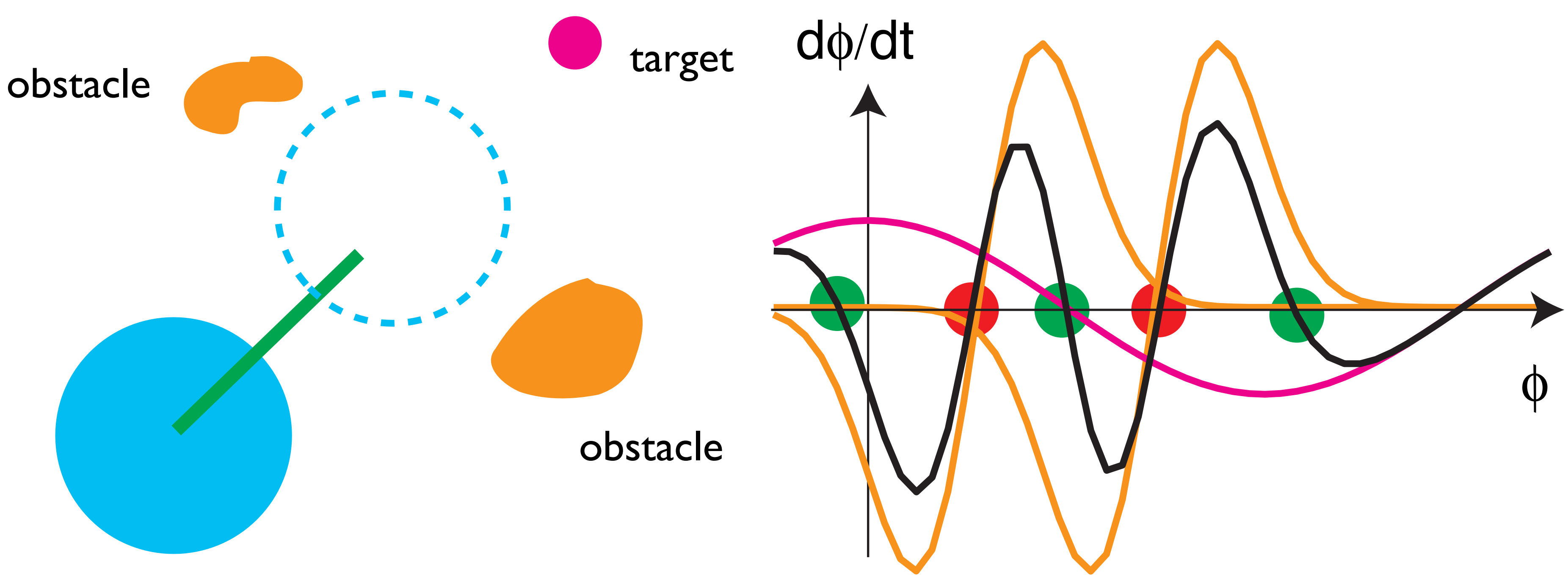
Behavioral dynamics

- Bifurcations switch between fusion and decision making



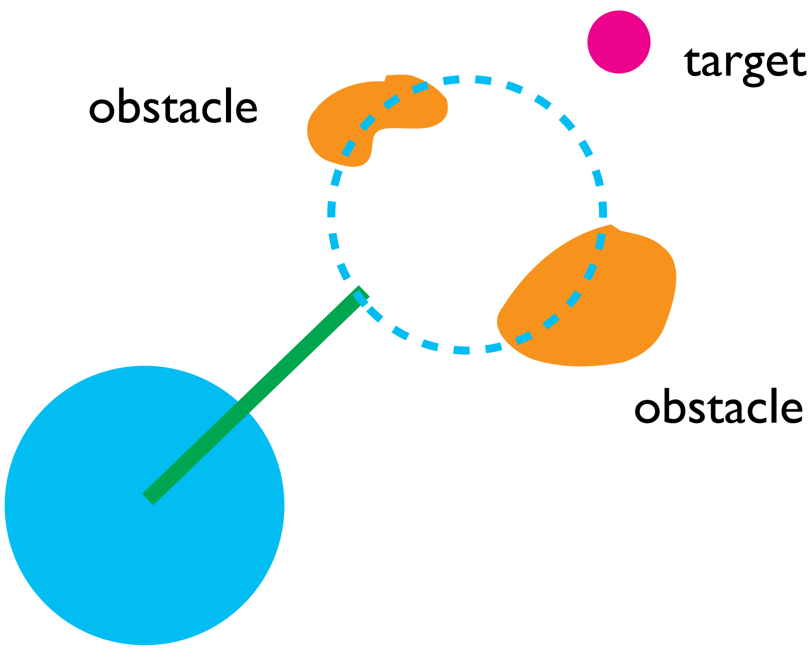
Behavioral dynamics

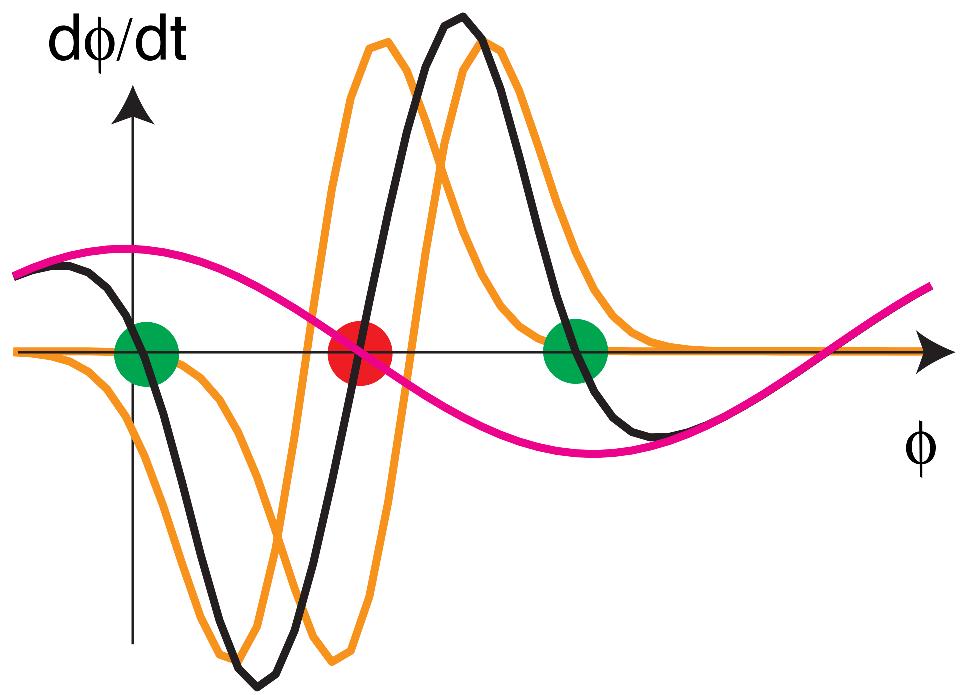
- an example closer to "real life": bifurcations in obstacle avoidance and target acquisition
- constraints not in conflict



Behavioral dynamics

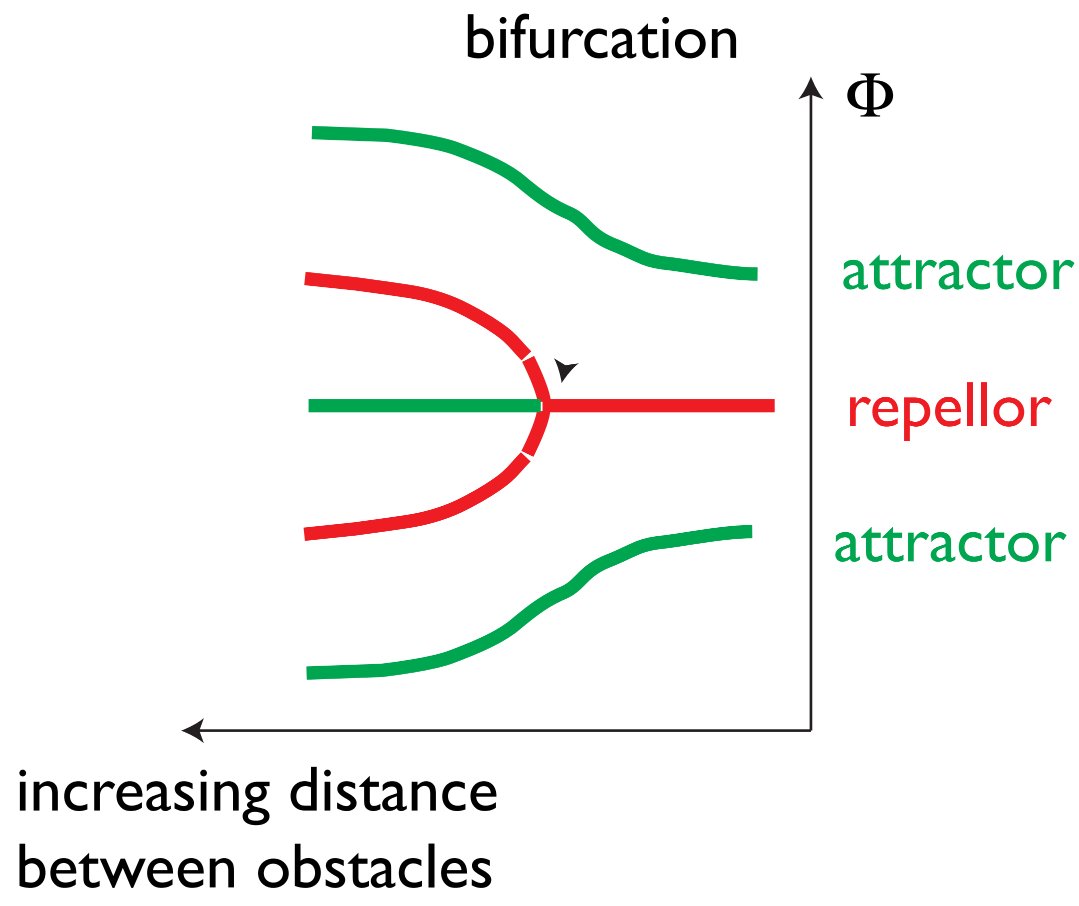
- constraints in conflict





Behavioral dynamics

- transition from "constraints not in conflict" to "constraints in conflict" is a bifurcation

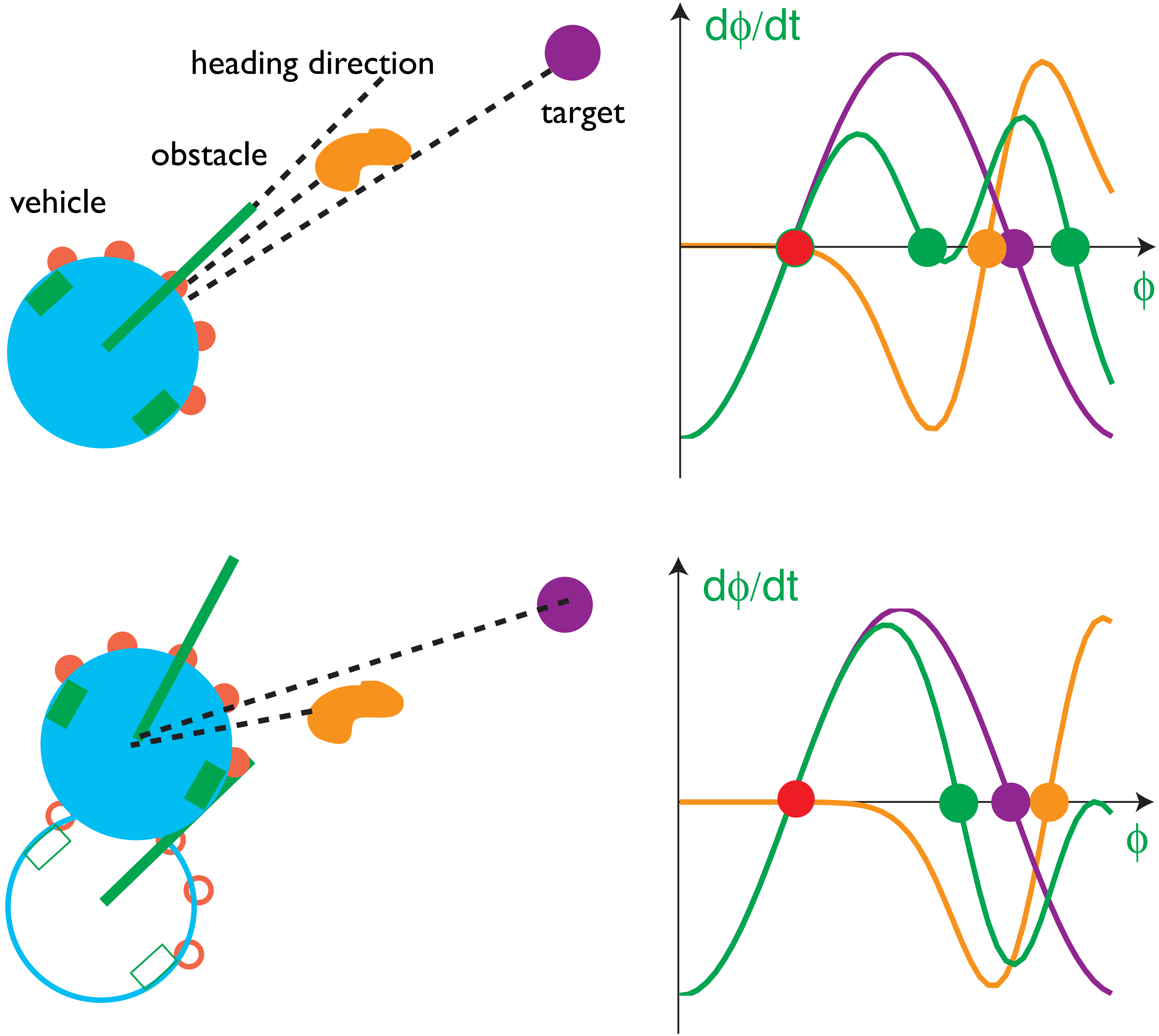


Behavioral dynamics

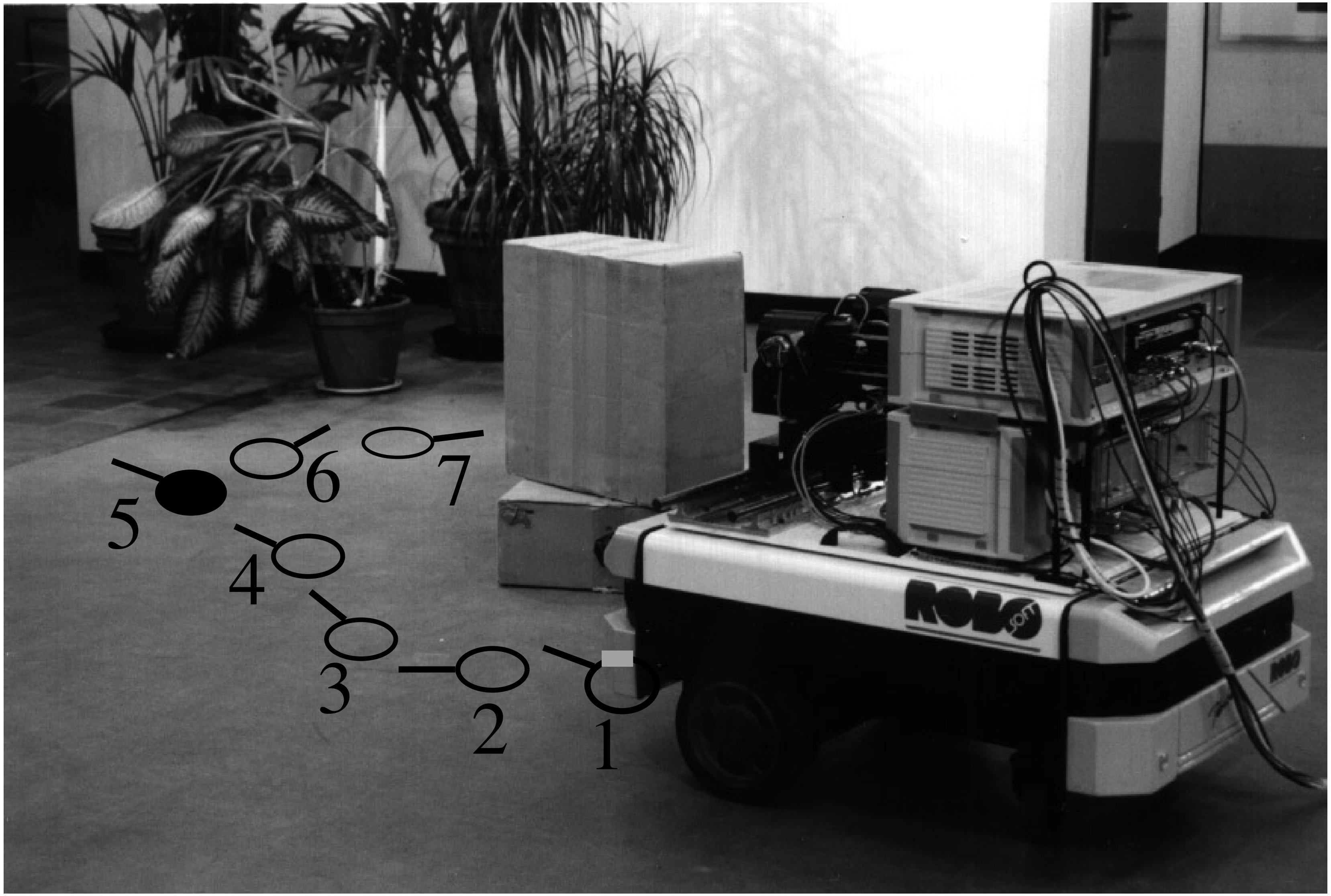
- Such design of decision making is only possible because system “sits” in attractor.
- This reduces the difficult design of the full flow (ensemble of all transient solutions) of non-linear dynamical systems to the easier design of attractors (bifurcation theory).

Behavioral dynamics

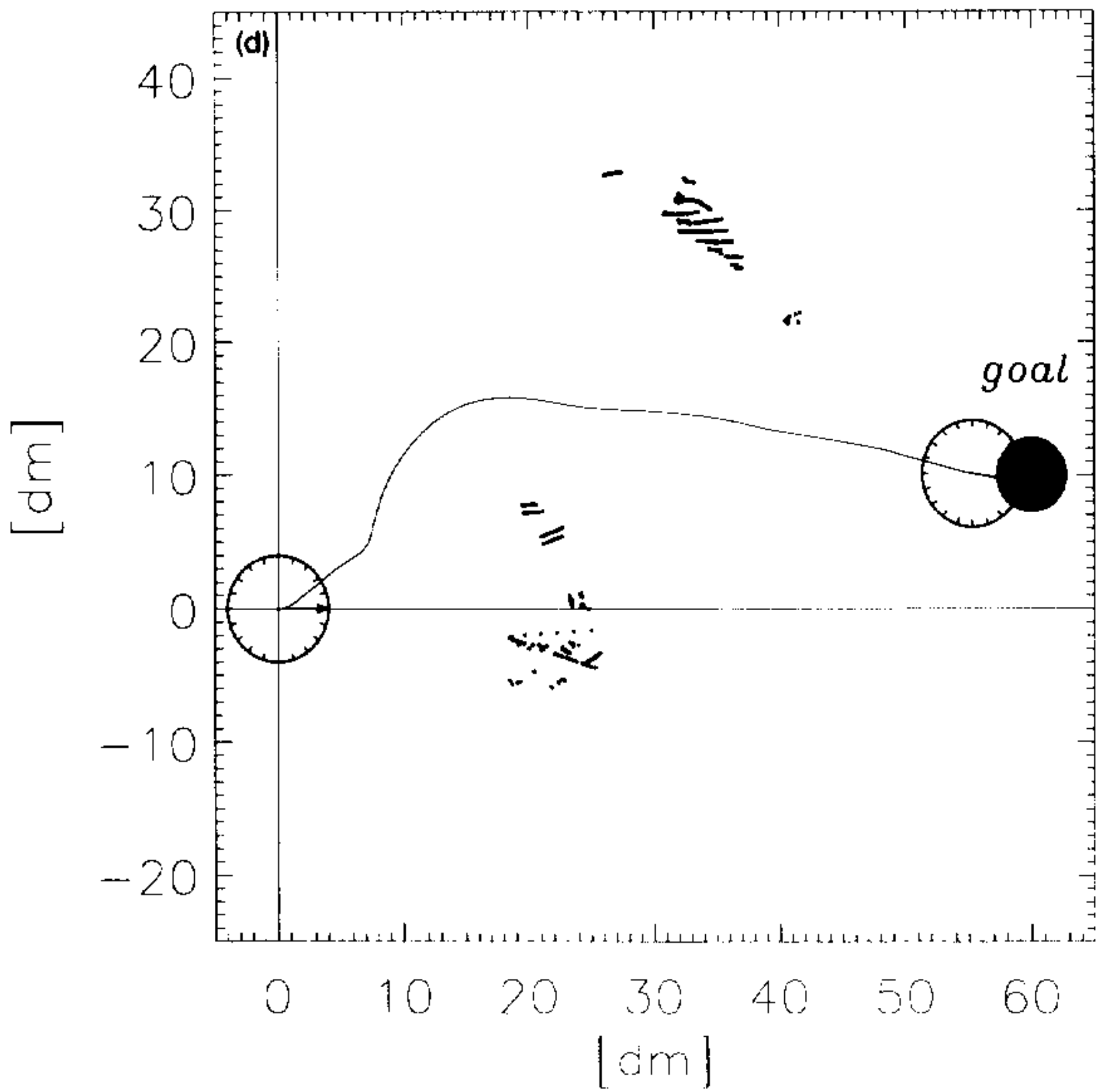
- But how may complex behavior be generated while "sitting" in an attractor?
- Answer: force-lets depend on sensory information and sensory information changes as the behavior unfolds



heading direction
target
obstacle
vehicle
dϕ/dt
ϕ
dϕ/dt
ϕ



[Schöner, Dose, 1992]



[Schöner, Dose, Engels, 1995]

… this is a “symbolic” approach

- in the sense that we talk about “obstacles” and “targets” as objects, that have identity, preserved over time…
- making demands on perceptual systems…
- in the implementation we see that these demands can be relaxed…
- so next we’ll look at how a “sub-symbolic” attractor dynamics approach may work