

Attractor dynamics approach to behavior generation: vehicle motion

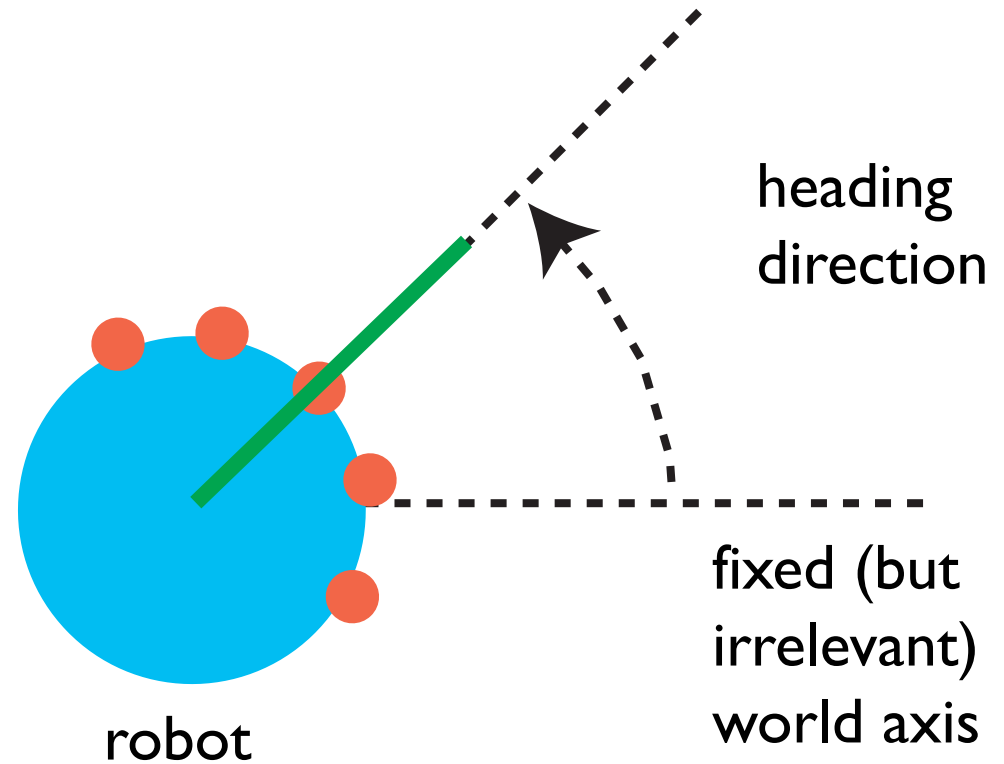
Gregor Schöner, INI, RUB

Basic ideas of attractor dynamics approach

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

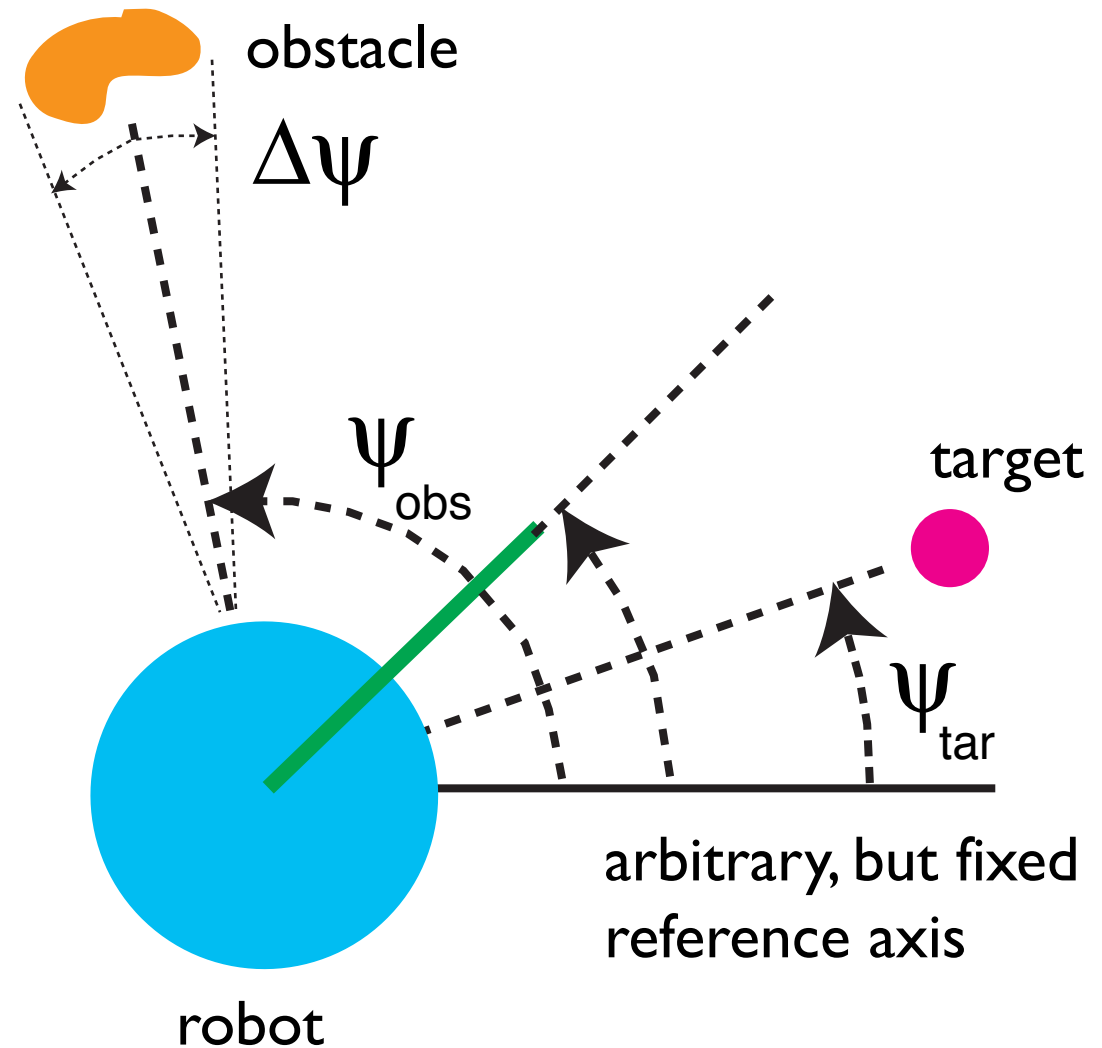
Behavioral variables: example

■ vehicle moving in
2D: heading
direction



Behavioral variables: example

- constraints:
obstacle avoidance
and target
acquisition



Behavioral variables

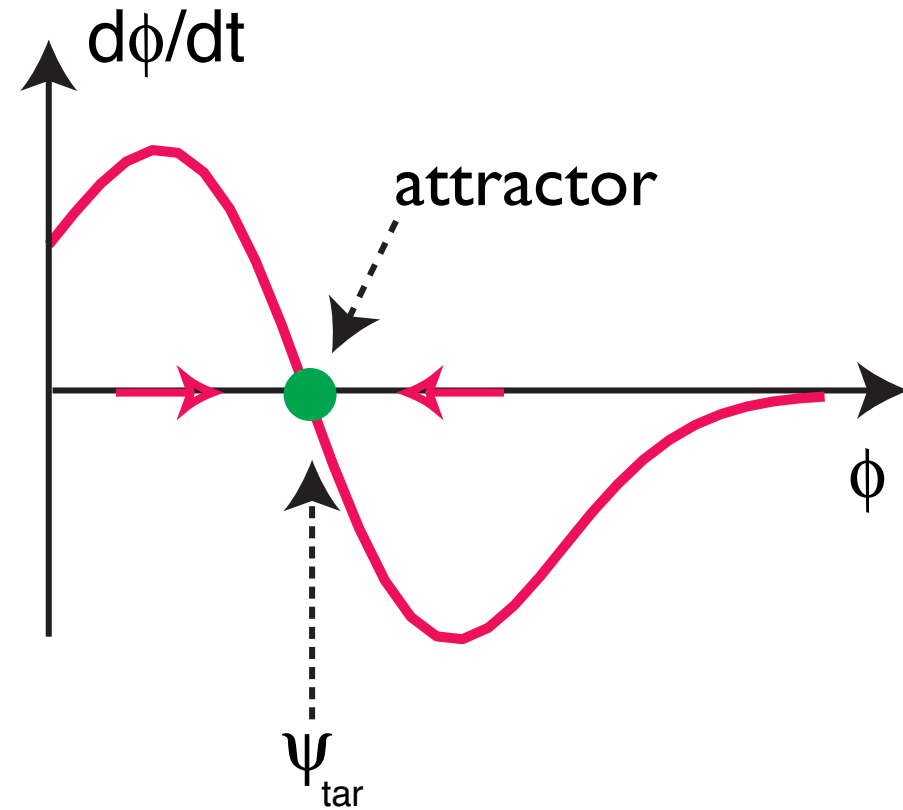
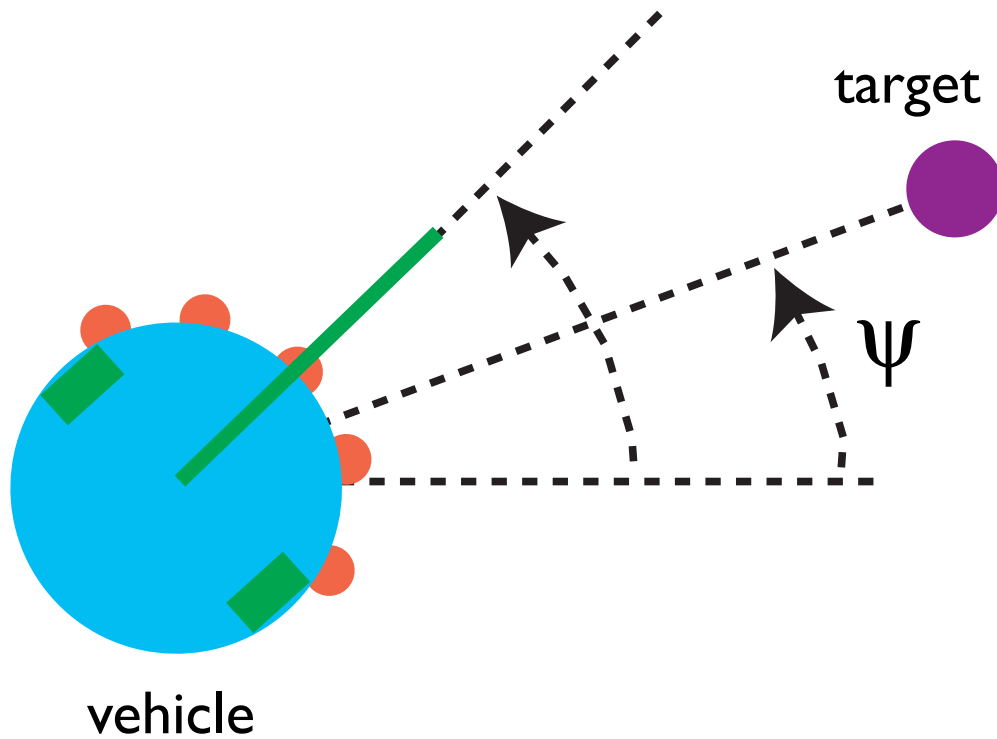
- describe desired motor behavior
- “enactable”
- express constraints as values/value ranges
- appropriate level of invariance

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

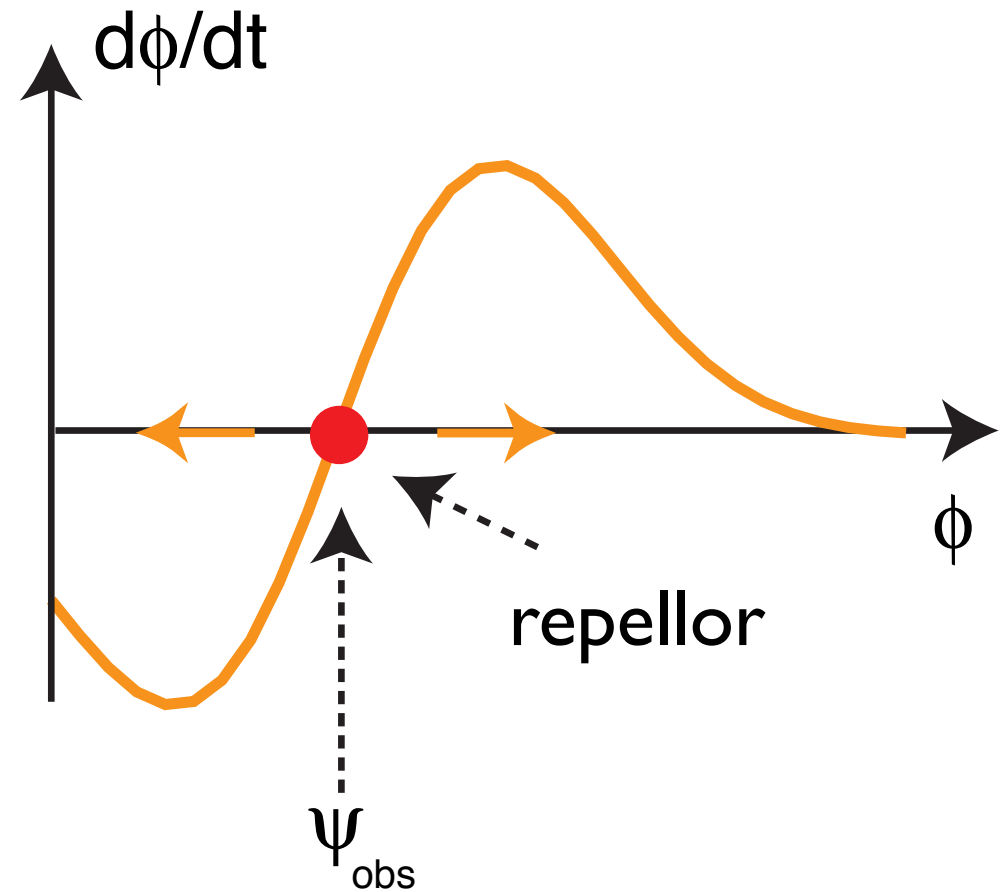
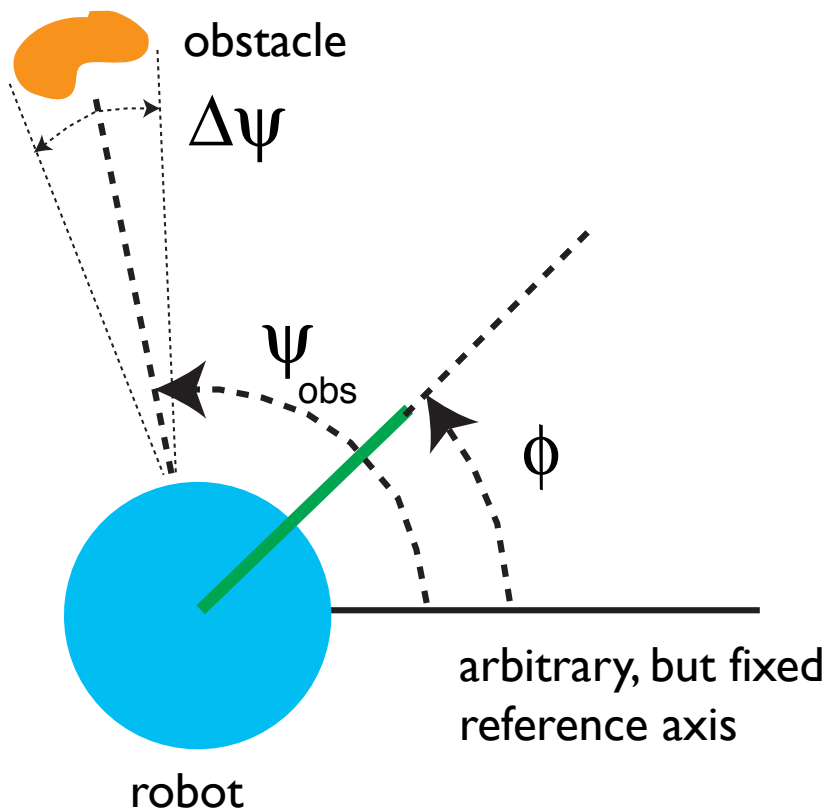
Behavioral dynamics: example

■ behavioral constraint: target acquisition



Behavioral dynamics: example

■ behavioral constraint: obstacle avoidance



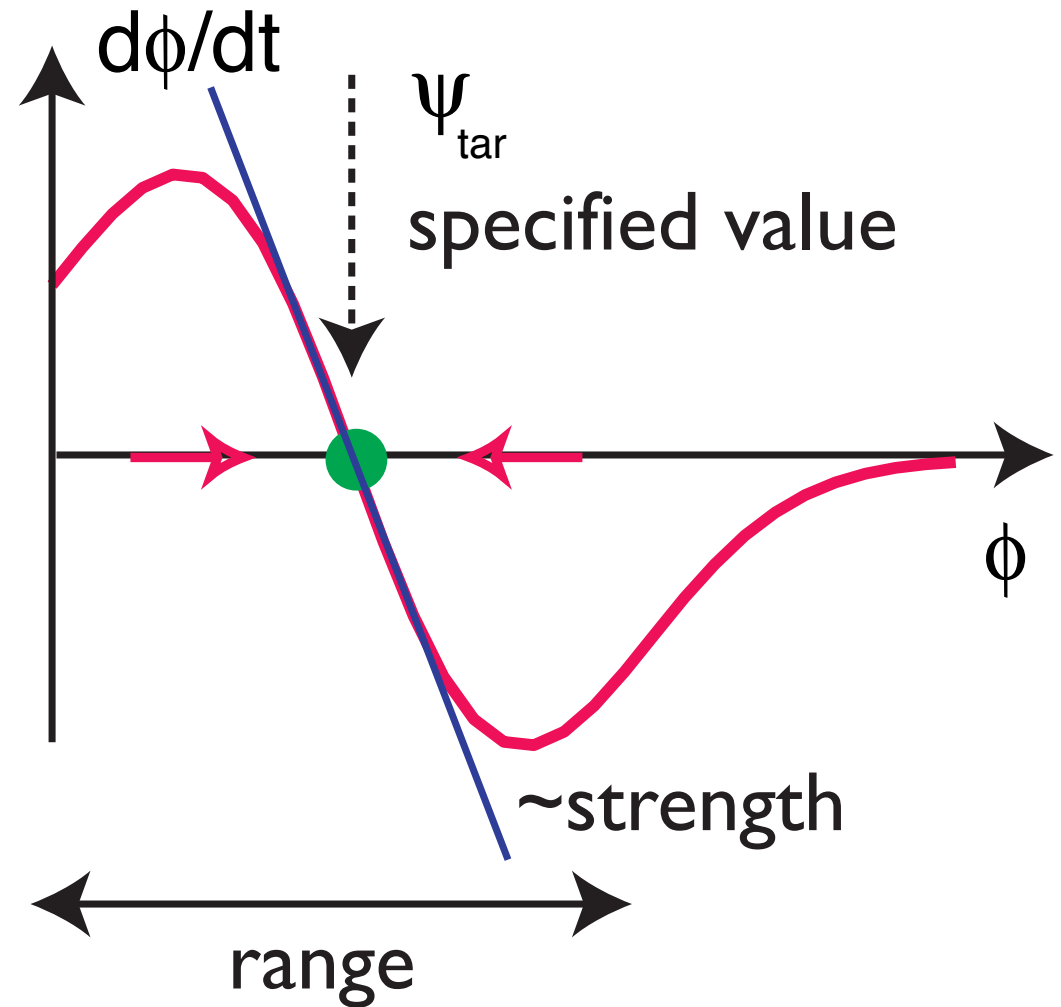
Behavioral dynamics

■ each contribution is a “force-let” with

■ specified value

■ strength

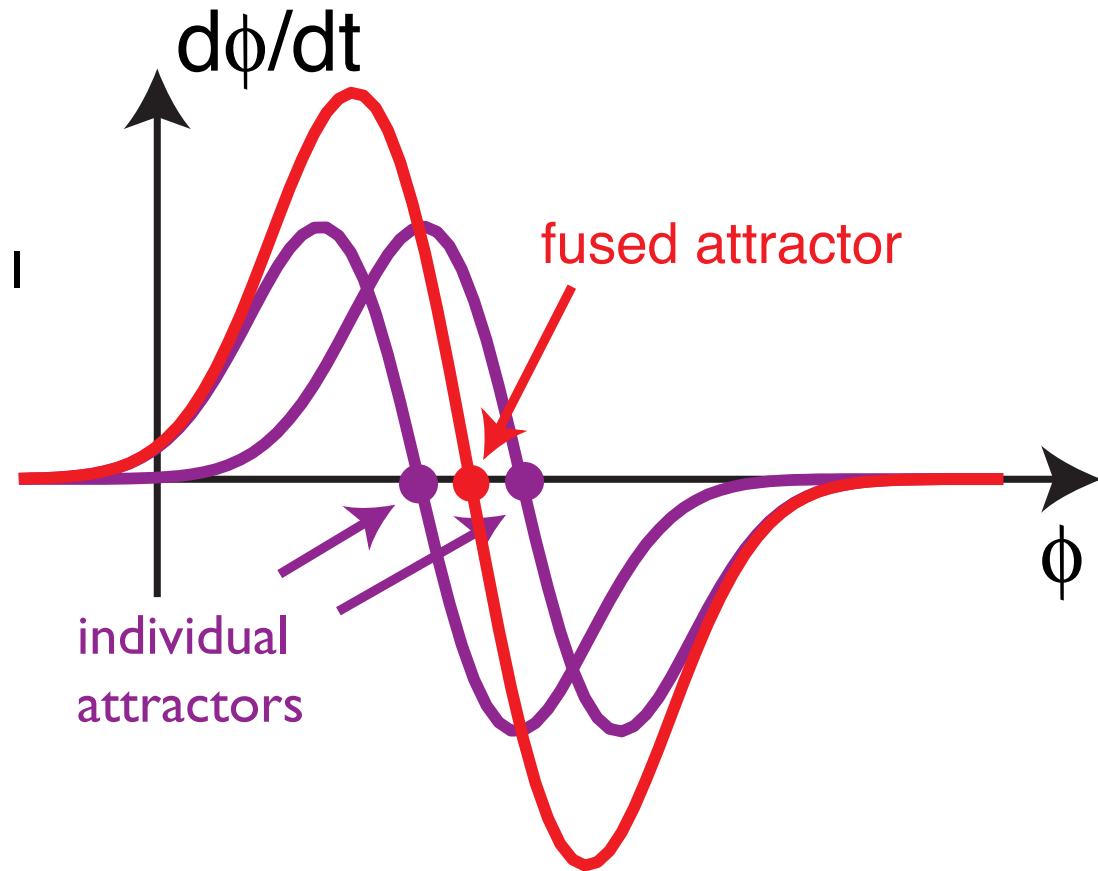
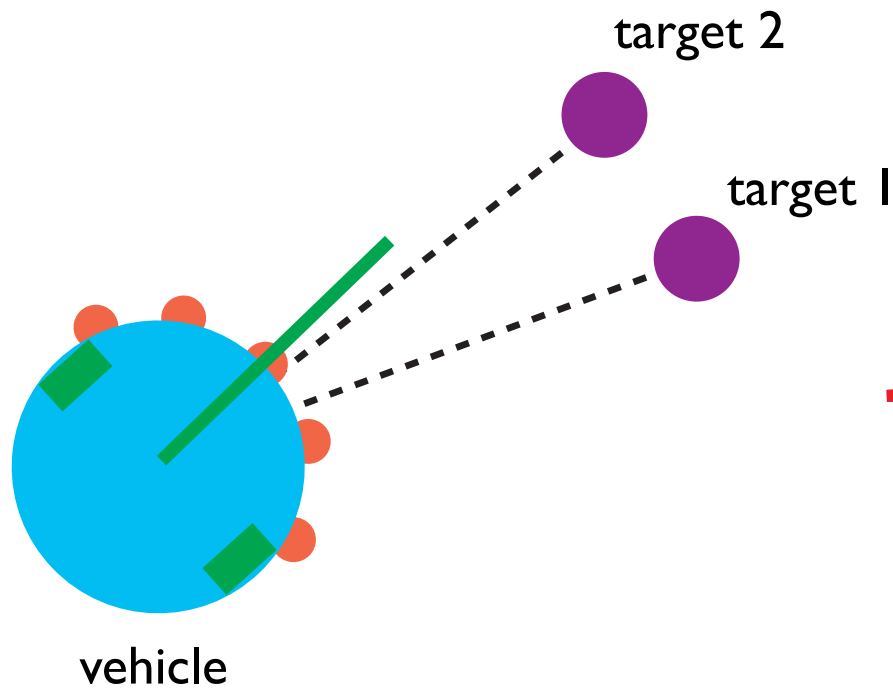
■ range



Behavioral dynamics

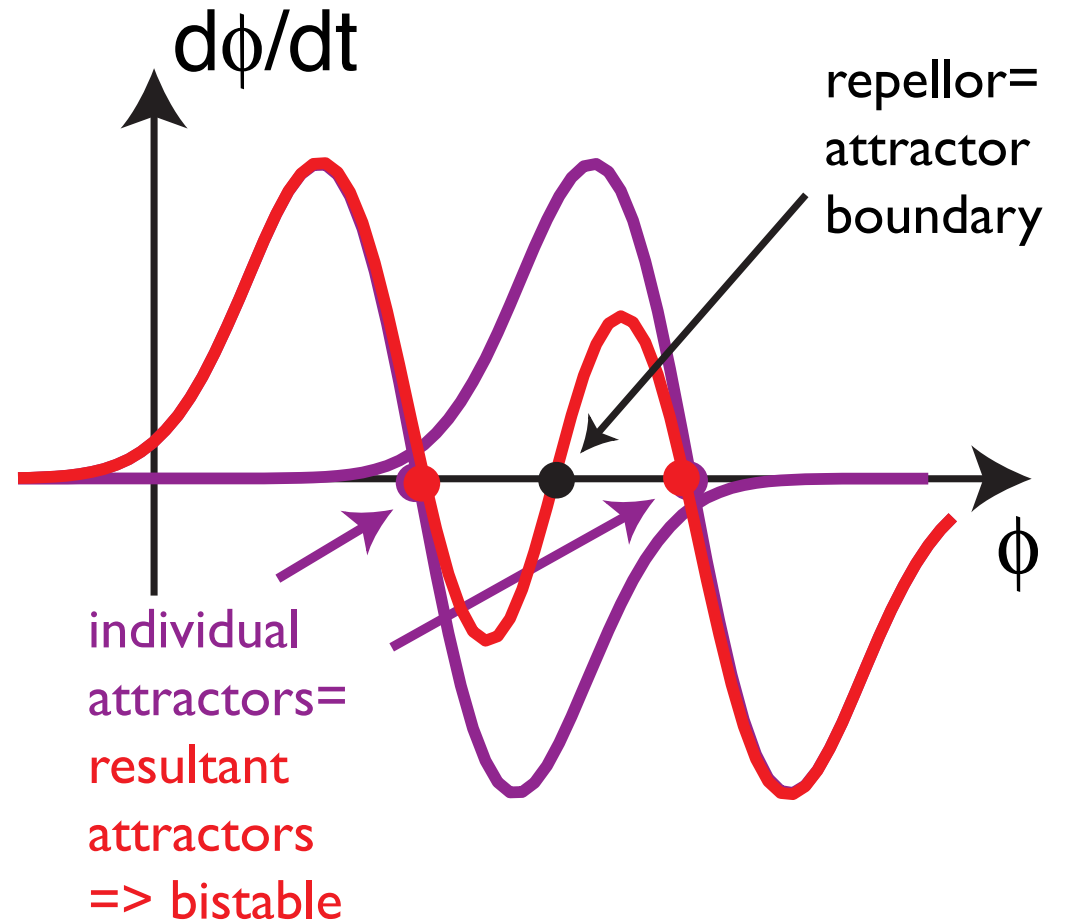
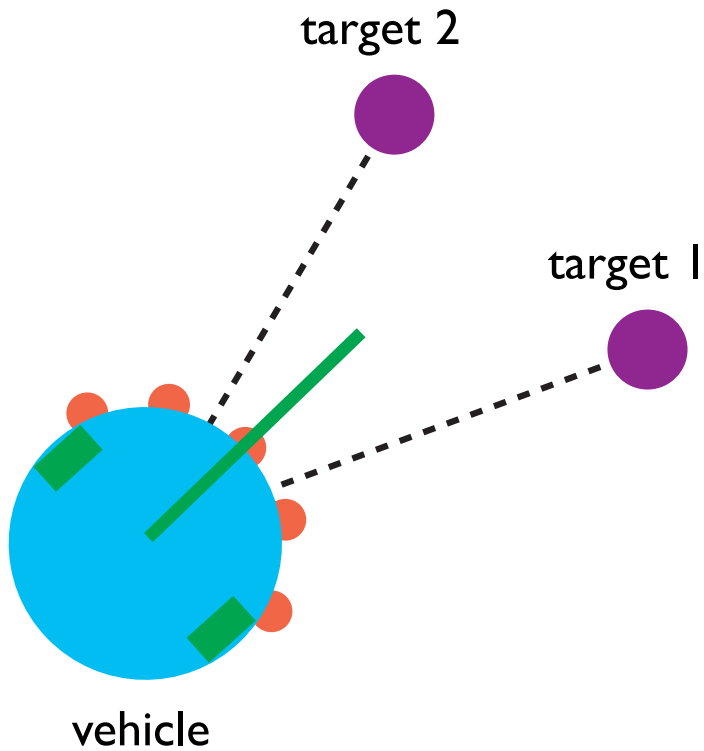
■ multiple constraints: superpose “force-lets”

■ fusion



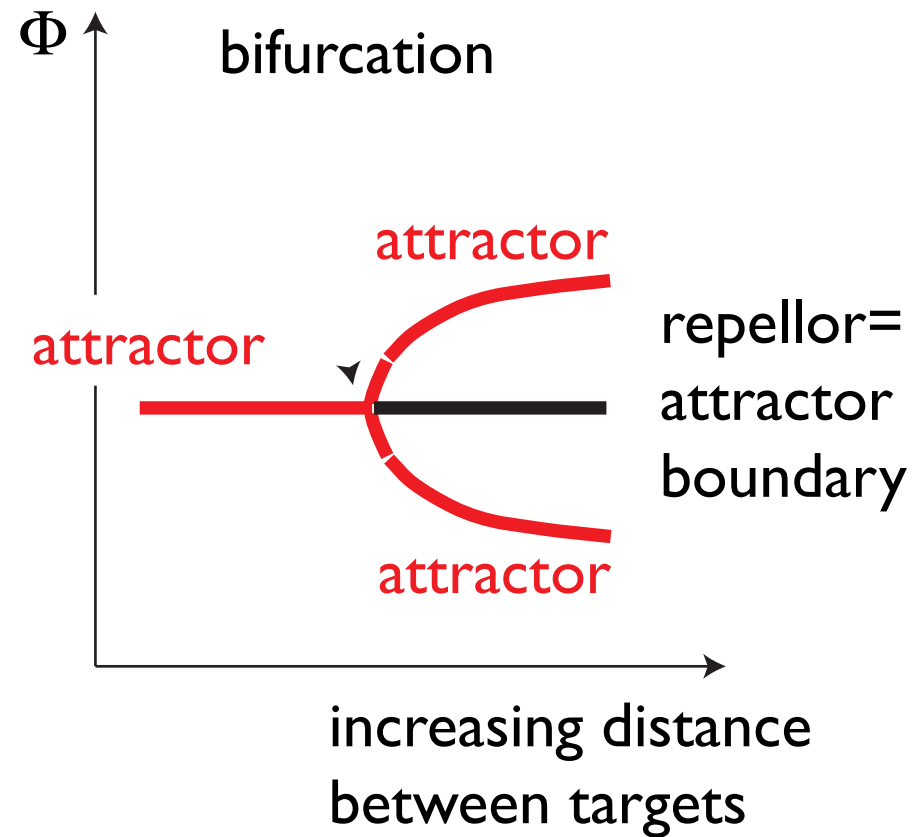
Behavioral dynamics

■ decision making



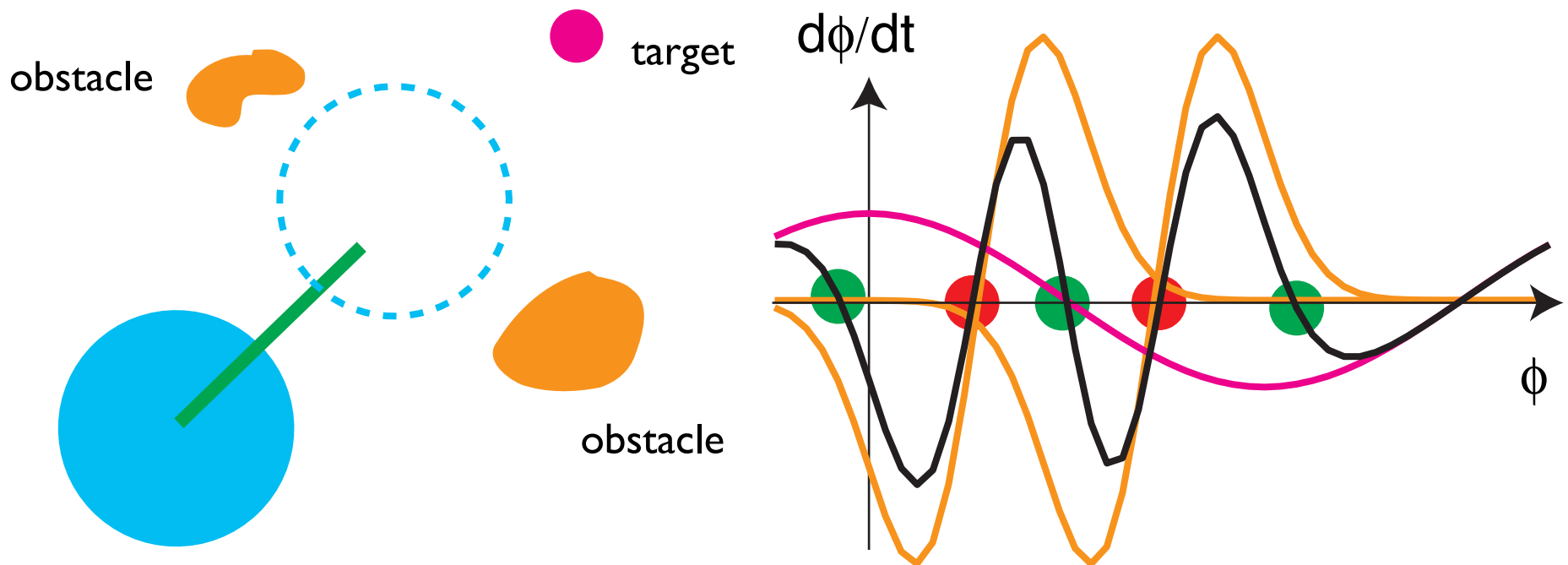
Behavioral dynamics

- Bifurcations switch between fusion and decision making



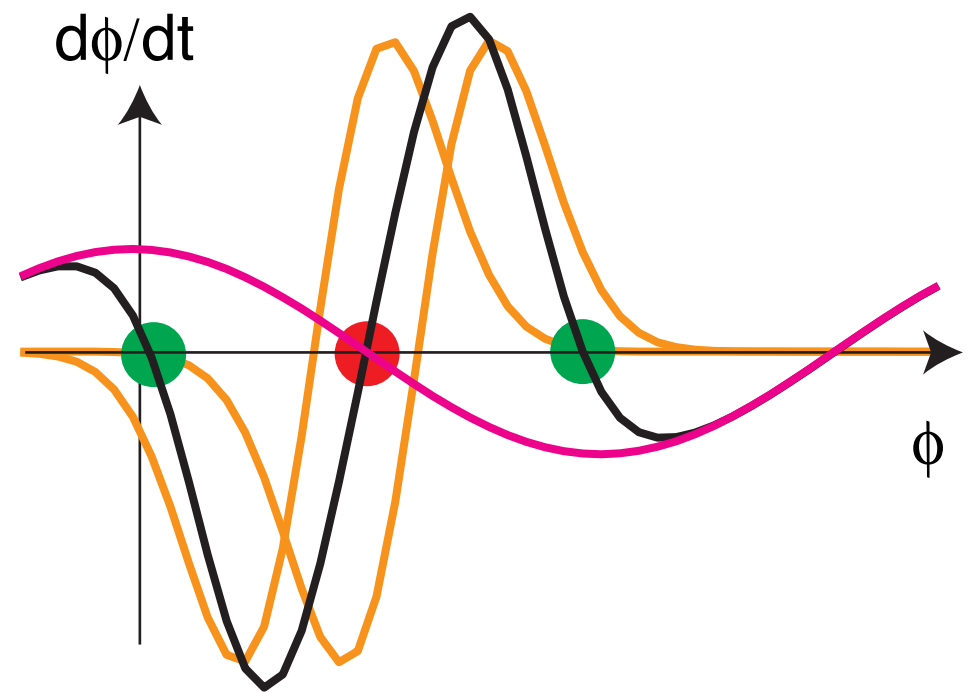
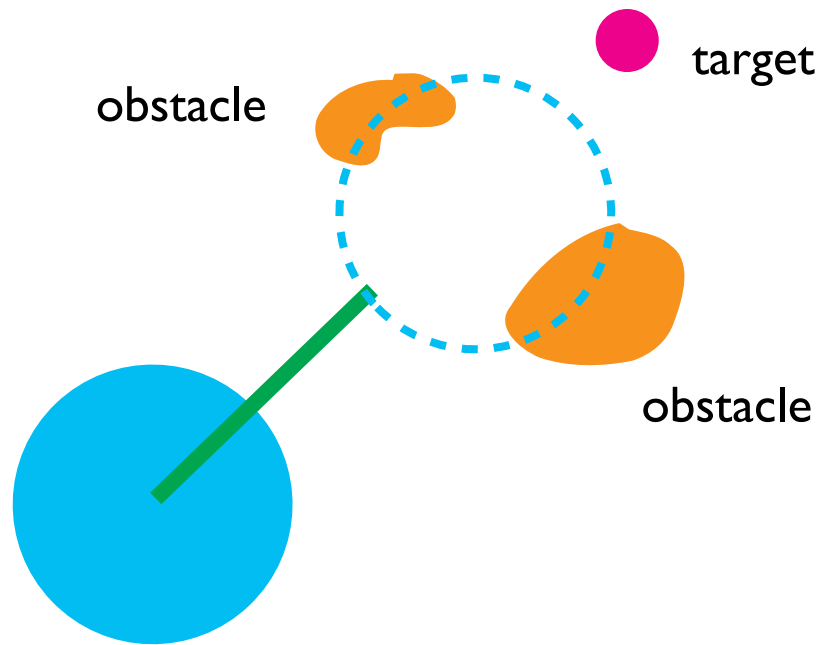
Behavioral dynamics

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



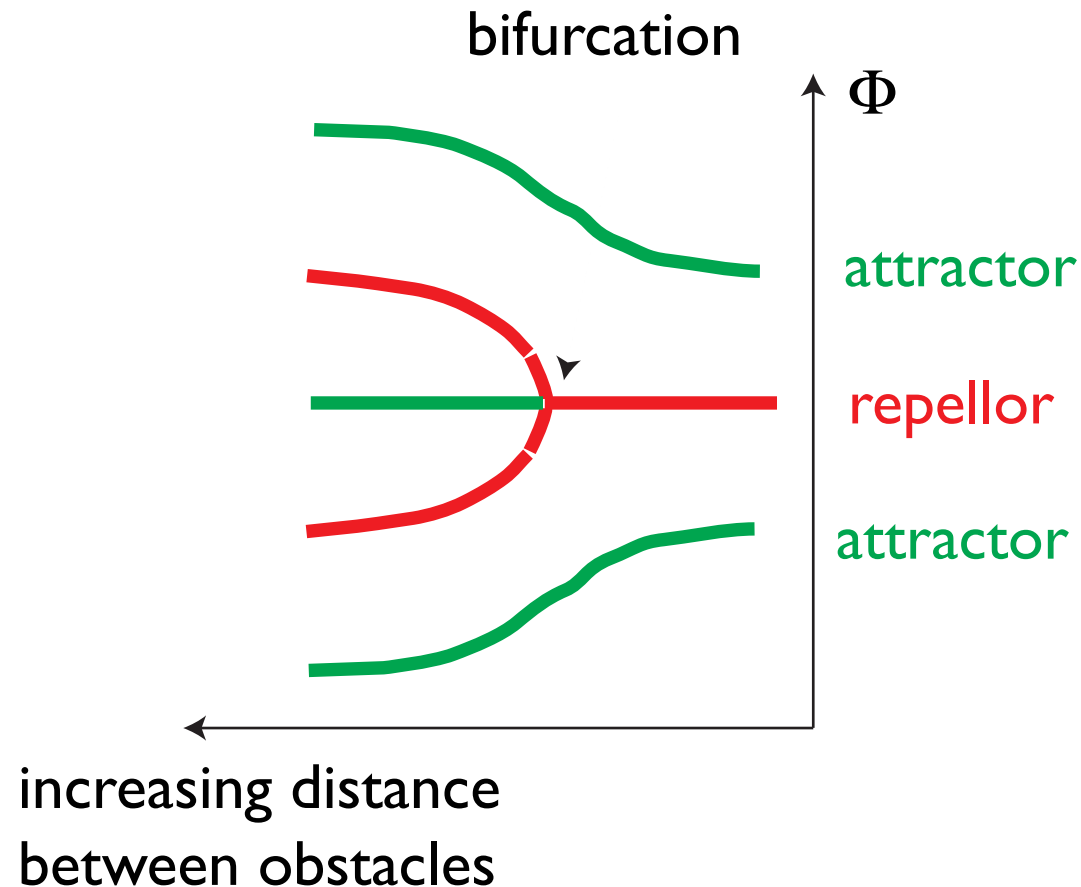
Behavioral dynamics

■ constraints in conflict



Behavioral dynamics

- transition from “constraints not in conflict” to “constraints in conflict” is a bifurcation

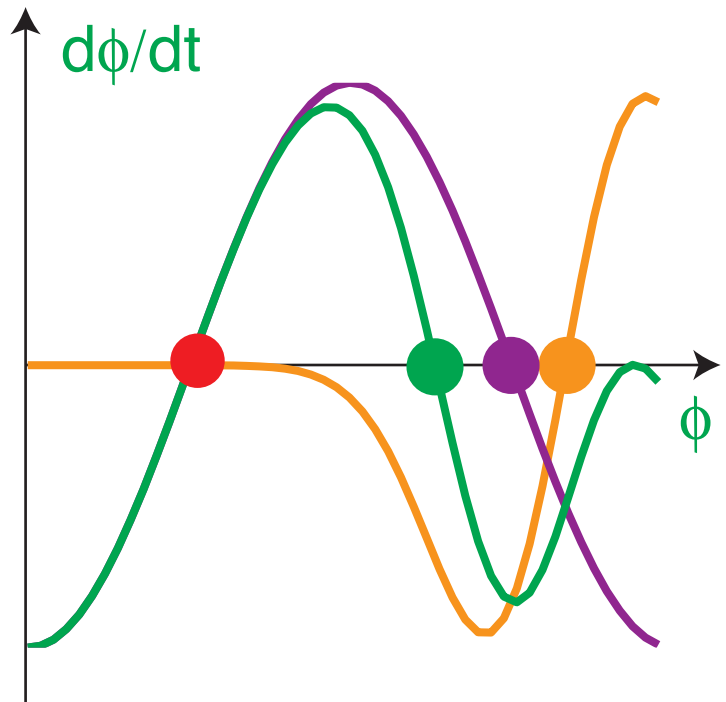
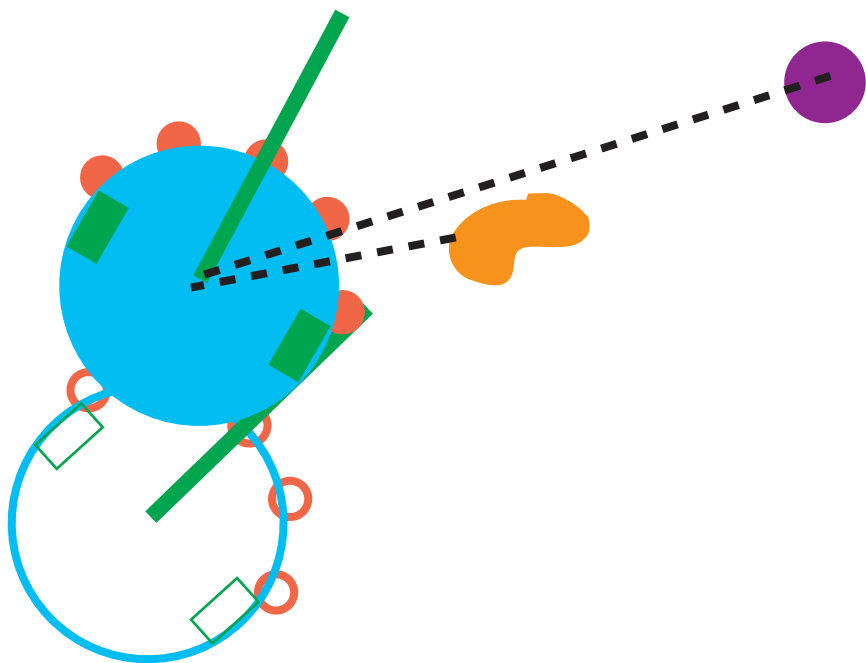
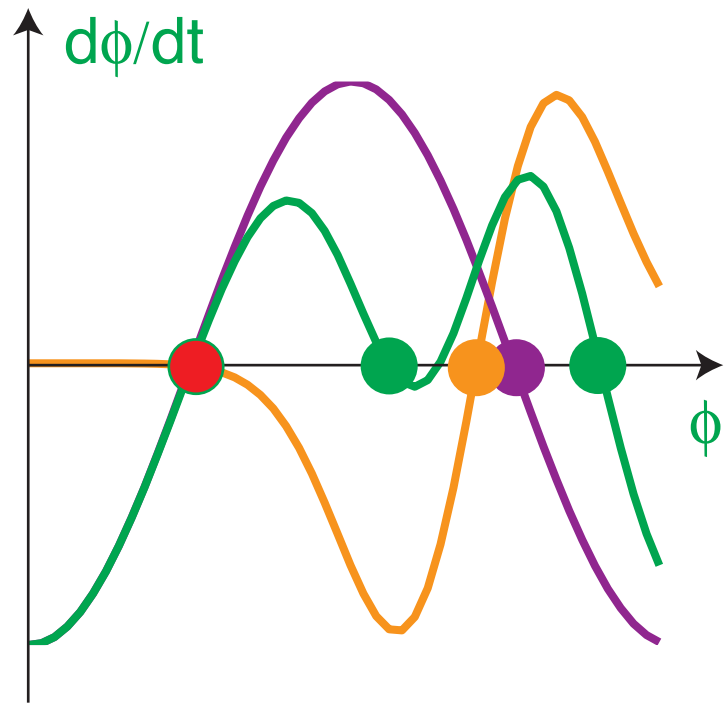
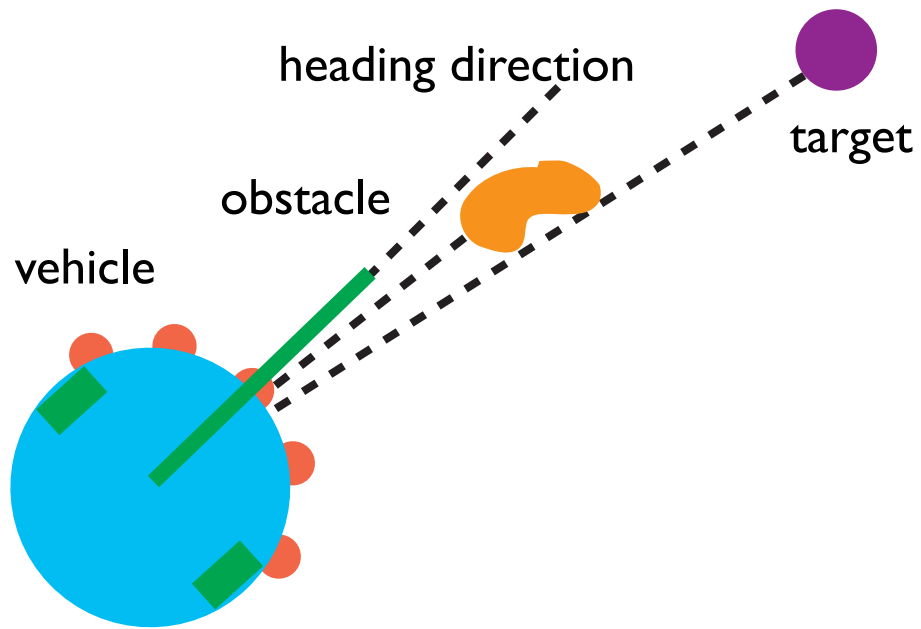


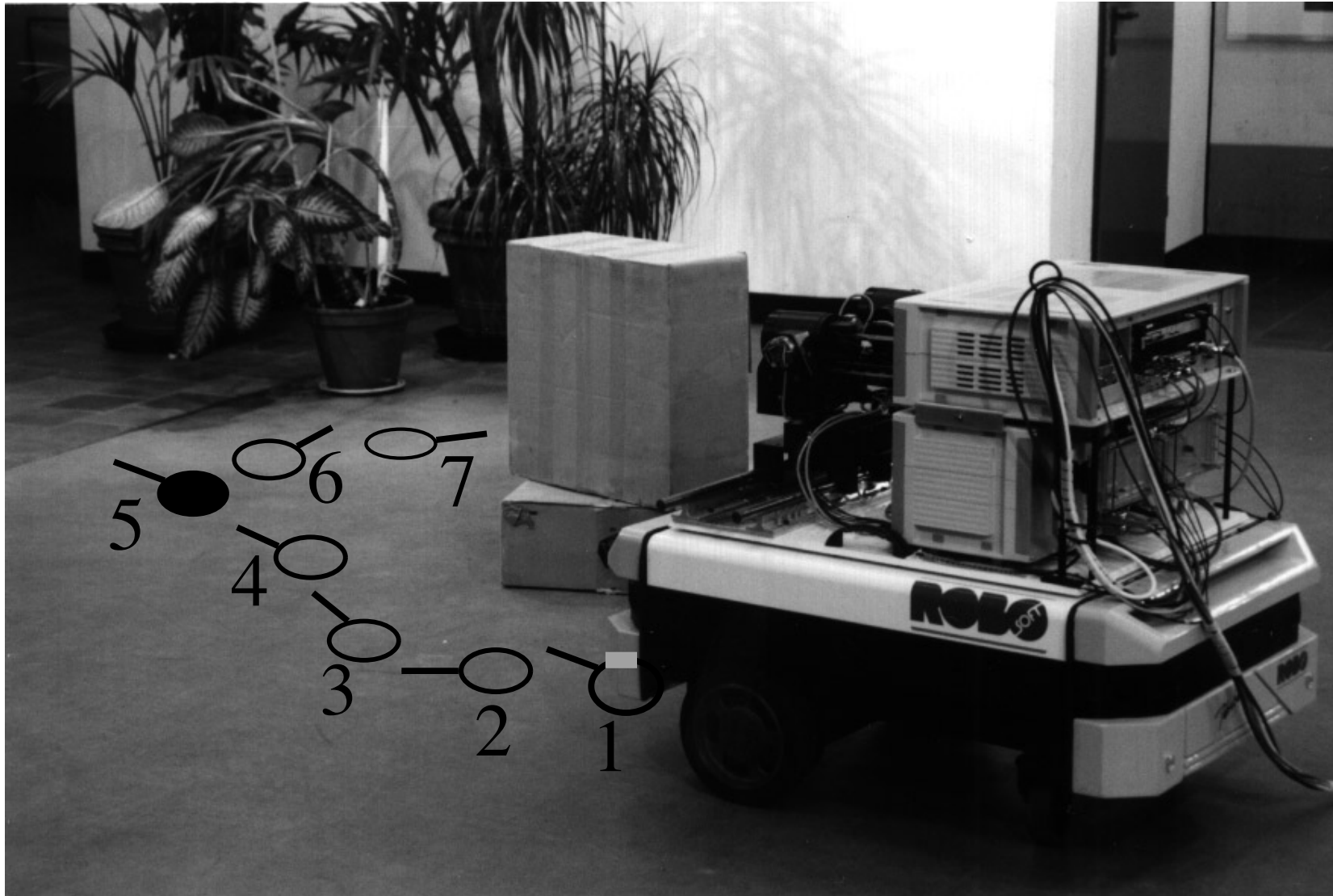
Behavioral dynamics

- 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).

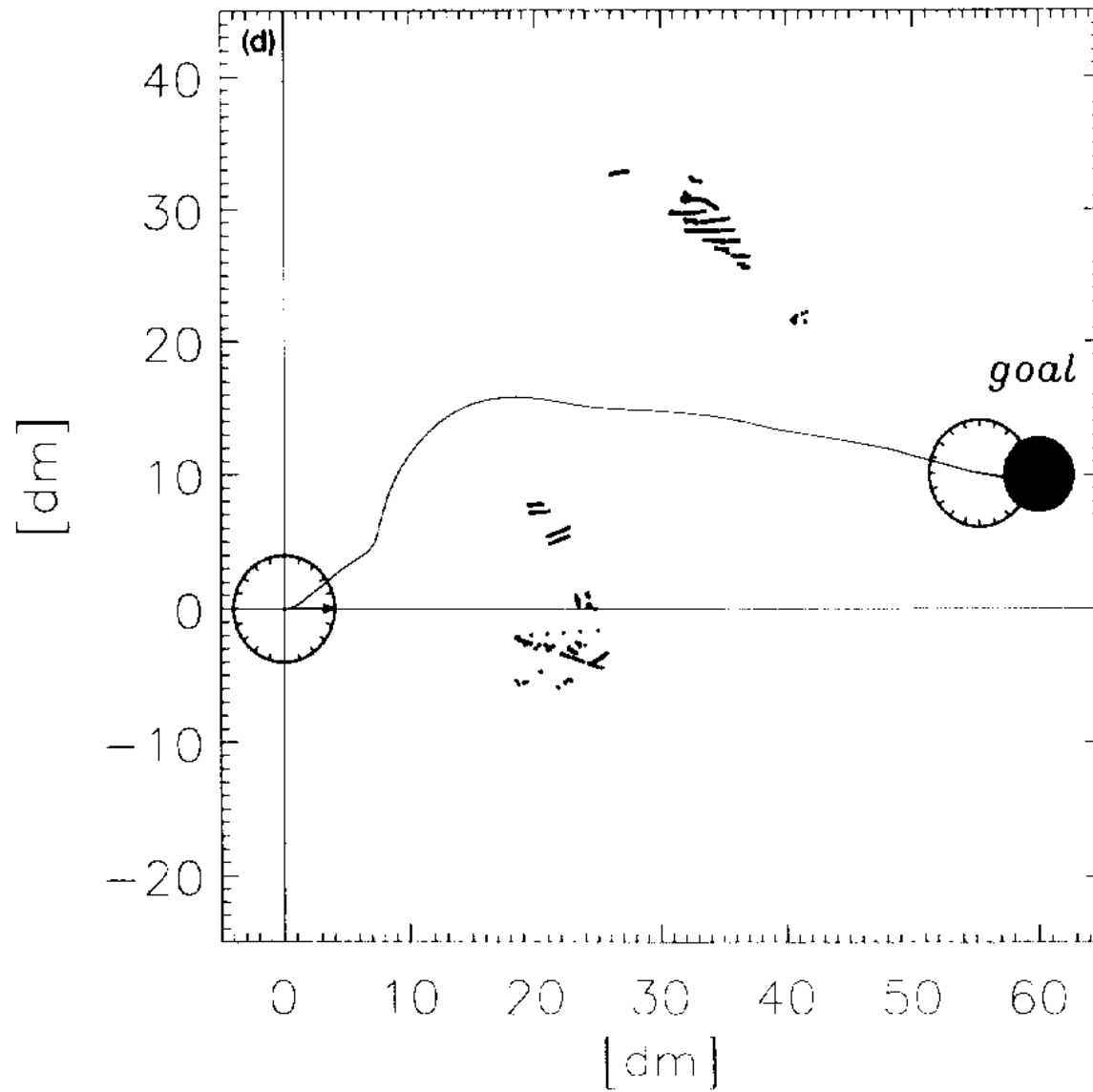
Behavioral dynamics

- 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





[Schöner, Dose, 1992]



[Schöner, Dose, Engels, 1995]

Behavioral dynamics

- may generate behaviors that go beyond simple control (achieving one particular set-point or goal), but include decision making...
- next questions
 - where do constraints come from ?
 - what are other approaches to behavior generation ?
 - in which sense is the approach analogous to human movement behavior?
 - how does the approach scale with the number of constraints?
 -

... 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