Back to: Behaviors = (Poor Man's) Control Theory?!?!

yes and no…

some additional crucial issues:

- need for good system models for control theory
  - see example of underwater robot
  - decoupling to keep things manageable, e.g., considering diving control loop independent from motions in 2D plane
  - hence very good for designing single behaviors
- how to combine control-loops/behaviors
  - matters of architecture

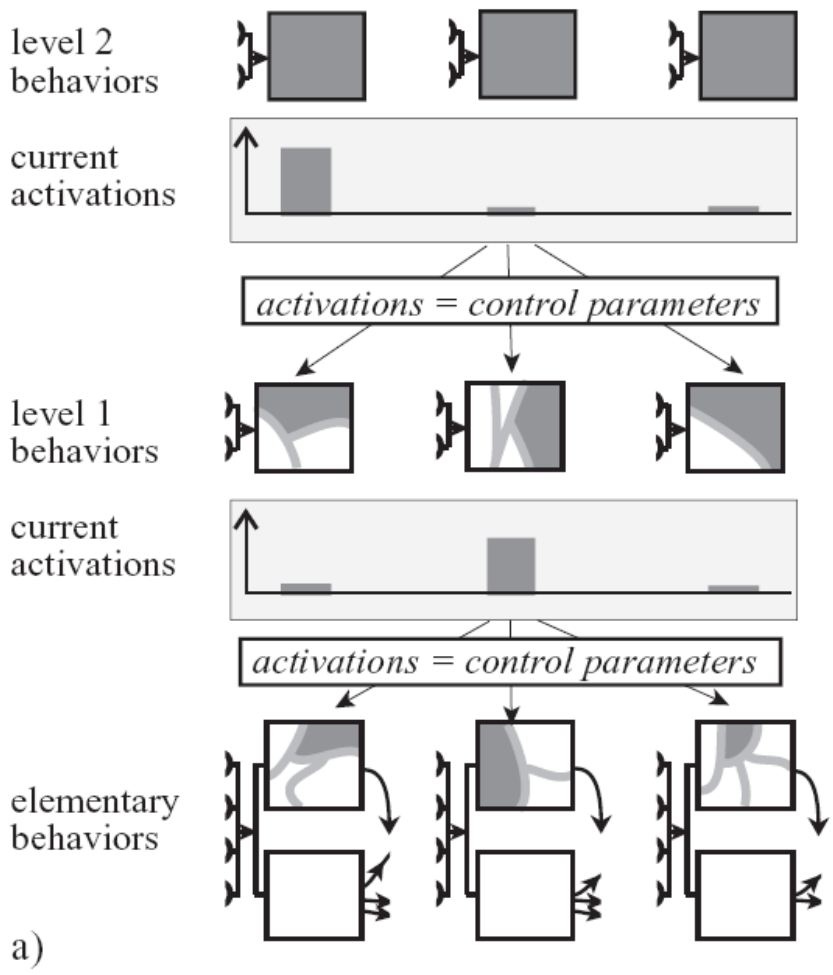
Hierarchical Programming with Behaviors

Dual Dynamics

- Herbert Jäger
- behaviors
  - as dynamical systems
  - using ordinary differential equations (ODEs)
- agents have modes
  - coherent, relatively stable “frames of mind"
  - used to tune into different situations and tasks
  - especially, different responses to sensory signals
- transitions between modes
  - "formally" a bifurcation (dynamical systems)
  - regulated by the ODEs
  - in contrast to FSM / subsumption architecture
  - naively speaking: sigmoid versus if (= step function)

Dual Dynamics

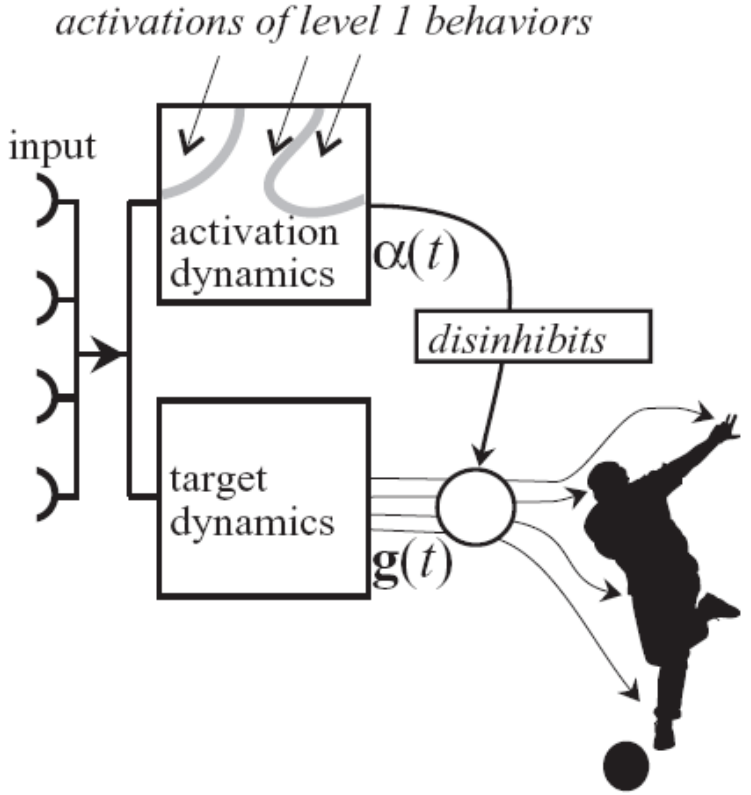
- behaviors
  - main building blocks of a DD robot architecture
  - ordered in levels
- bottom level
  - elementary behaviors
  - sensomotoric
  - direct access to sensor data and actuators
- higher levels
  - increasingly comprehensive
  - also access to sensors
  - cannot activate actuators
  - regulate modes



from: "Behavior engineering with dual dynamics models and design tools"

Dual Dynamics

- elementary behaviors
  - are different from higher-level behaviors
  - made from two subsystems
  - target & activation dynamics

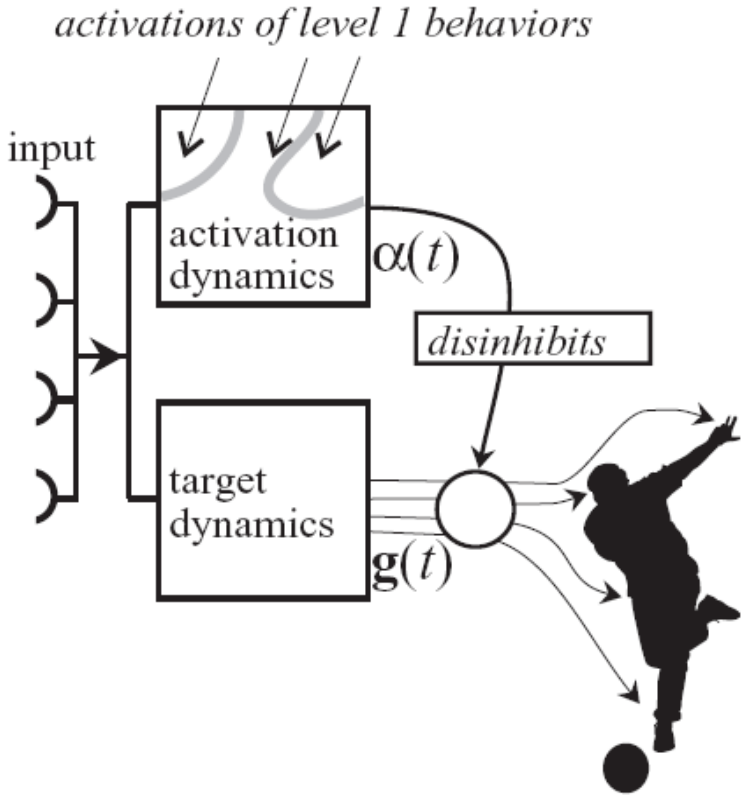


b)

from: "Behavior engineering with dual dynamics models and design tools"

Dual Dynamics

- target dynamics
  - calculates target trajectories for all actuators
  - which are relevant for the behavior
  - target dynamics should not undergo bifurcations
  - naively speaking: simple control functions

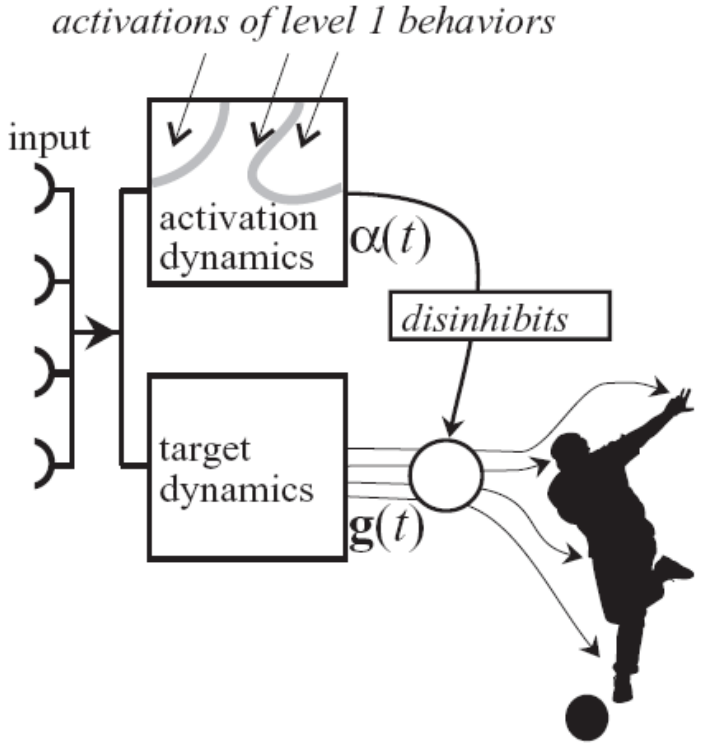


b)

from: "Behavior engineering with dual dynamics models and design tools"

Dual Dynamics

- activation dynamics
  - regulates a single variable,
  - the behavior's activation
  - should have a dynamic range between 0 and 1
  - i.e, ranging from inhibited to fully active
- are allowed to undergo bifurcations
  - control parameters which induce these bifurcations
  - are the activation variables of higher-level behaviors

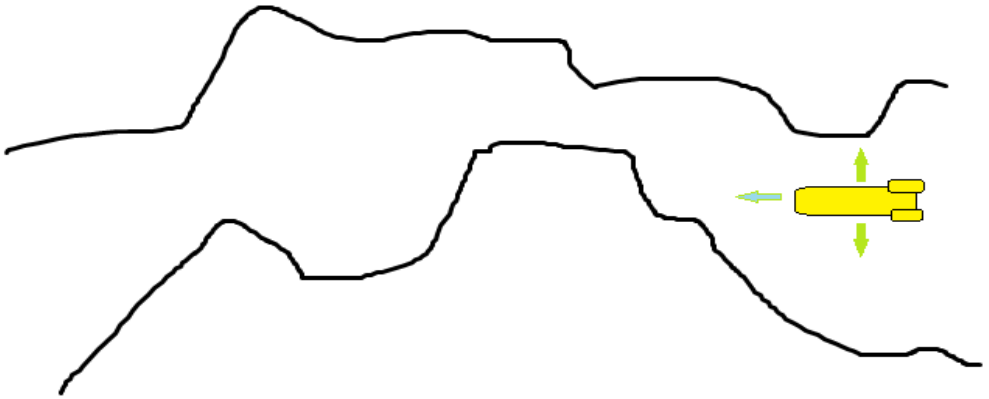


b)

from: "Behavior engineering with dual dynamics models and design tools"

Example

- AUV diving through cave
  - fully actuated, i.e., surge, sway, heave
  - 5 pencil beam sonars: forward, left, right, down, up
- 4 processes
  - forward
  - obstacle avoid. (slow forward down on forward-sonar reading)
  - vertical alignment (center AUV between up/down readings)
  - horizontal alignment (center AUV between left/right readings)
- with Dual Dynamics
  - use of the alignment errors
  - to damp forward activation



(you can also think about using PDL processes to program this)

Modern AI Architectures

- typically ***hybrid***, i.e., combine aspects of behaviors (low-level control) and higher level action-oriented planning (aka cognitive control)
- higher levels simply activate/deactivate behaviors
- no exploitation of side-effects – in contrary, avoiding them

Hierarchies with Actions and Behaviors

hybrid architectures

- “lower” level(s): behaviors
- „higher“ levels: world-modeling & planning
  - „cognitive“ functions (e.g., problem solving, reasoning)
  - „actions“ as activations and deactivations of behaviors (can be also layered, e.g., via Dual Dynamics)
  - plus continuous behaviors, e.g., for safety fct‘s etc.

Hierarchies with Actions and Behaviors

roughly speaking

- ***behaviors*** take care of the “here and now”
- ***actions*** are a good basis for „long-term“ goal-oriented guidance of the system