Acting outside the box
Lessons learned when embodiment is the only option.

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Modeling Embodiment
ACT-R/Embodied

Modified ACT-R implementation

Mostly at /PM level

Uses jACT-R

Older version using Lisp
Visual: What does ACT-R have?

- Full FOV foveal vision / no peripheral
- Saccades merely direct attention
- Doesn't change visual field
- Screen-based vision
  - *screen-x, screen-pos*
- Tuned to static displays
  - +visual> isa track-object
- Limited error checking/handling
Visual: What do we need?

- Foveal & peripheral vision
- More *natural* visual-locations
- Dynamic vision needs to be automatic
- Richer error information
Visual : What we’ve done

Everything is moving
  Motion tolerances dramatically increased (x10)
  Tracking is automatic
Moving eyes & visual-locations
  retinotopic visual angles (feeds directly to motor)
  Transient (and recycled)
FINSTs
  Object, not location, based
Fine-grained errors/states
  nothing-matches, nothing-to-match, out-of-fovea, object-disappeared, object-changed
Visual : What do we still need?

- Peripheral vision
- Change-blindness
  - Smoothing of sensor noise
- Capacity buffer
  - Subsumes FINSTs
- Temporal ejection (decay)
Manual: What does ACT-R have?

Keyboard & mouse focus

Limited, style-based movements

Serial preparation* & execution (at the style level)

* Thank you Kieras for exorcising preparation
Manual: What do we need?

- Parallel movements
- Proprioception
- Complex, coordinated, multi-joint movements
- Not manual but motor
Motor : What we’ve done

- Muscle-level parallelism execution & preparation
- Scope queries & requests with muscle slot
  - Provides state & proprioception
  - w/o muscle, queries operate globally

(p clap-hands
  ?motor>
  muscle left-hand
  state free
?motor>
  muscle right-hand
  state free
==>
+motor>
isa hand-to-center
  muscle left-hand
+motor>
isa hand-to-center
  muscle right-hand)
Motor : What we’ve done

Motor buffer is an interface and a container

Perceptual integration

Permits production-level composition of movements

(p start-tracking
  ?motor>
  buffer empty
  =visual>
  isa face
  ==> +motor>
  isa track-object
  target =visual
  =visual>)

(p target-outside-fixation
  =visual>
  isa visual-object
  screen-pos =loc
  =motor>
  isa track-object
  target =visual
  ?motor>
  muscle eyes
  state free
  x =x
  y =y
  !eval! (....)
  ==> +motor
  isa move-eyes
  rel-x =dx
  rel-y =dy)
Motor : What we still need

Motor learning & refinement

Internal body model

Much more detailed error states

collision? self-collision? broken/aching limb?
Things to come...

More integrated perception than embodied cognition

Perceptual priming

Percept $\rightarrow$ Chunk

generalized ACT-R 4 associative-learning mechanism

Chunk $\rightarrow$ Percept

Contextual feedback for sensors

activation & task
Aside..

Scale & Reuse

Scale

Long term robot engagement

100k chunks + productions in an hour

Reuse

Beyond the Roomba
Collaborators & Funders
Thanks for the WiFi