Notes on cognitive robotics

1 Machine psychology (2002)

Jeff Krichmar is currently a professor in the departments of Cognitive Sciences and of Computer Science at the University College Irvine. This lecture is based on the paper by Krichmar and Edelman 2002[1]

- NOMAD=Neurally Organised Mobile Adaptive Device
- Darwin VII is a mobile robot that was used to simulate 14 experimental subjects.

Darwin was a series of robots developed at the Neurosciences Institute in CA, and has now progressed to the CARL series of robots at UCI[2]. The software to run CARL’s brain has been made available online as Carlsim 3 [3] see http://www.socsci.uci.edu/~jkrichma/CARLsim/

Figure 1: Darwin’s brain (left) and Darwin (right) From[1]fig 2

Figure 2: How the IT area classified objects. ‘Subject 4’ (left), ‘subject 5’ (middle). Response of IT to vertical lines - subject 4 and 5 overlayed (right) From[1]fig 5
### 1.1 Unconditioned

| R | Retinal area |
| VAP | Primary visual area |
| VAPB | Visual area for Blobs |
| VAPH | Visual area for Horizontal lines |
| VAPV | Visual area for Vertical lines |
| L Coch/ R Coch | Left and right Cochlear |
| A1 | Primary audio area |
| IT | Inferotemporal cortex (secondary visual area) |
| S | Value system |
| Mapp | Appetitive motor area |
| Mave | Aversive motor area |
| TappA | Appetitive taste (strongly conductive blocks) |
| Tave | Aversive taste (weakly conductive blocks) |
| C | Colliculus |
| R1 R2 R3 | Reflex response |

### 1.0.1 Brain areas

<table>
<thead>
<tr>
<th>Auditory (A1)</th>
<th>Cluster centres in IT</th>
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<tbody>
<tr>
<td>Top area is high f</td>
<td>Response of motor areas</td>
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<tr>
<td>mid area is low f</td>
<td>Left=Mave, right=Mapp</td>
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- Appetitive=satisfying bodily needs
- Aversive=something to avoid
- Blocks with blobs impart a bad taste and hence cause an aversive response
- Blocks with stripes impart a good taste and hence cause an appetitive response

#### 1.1 Unconditioned

Unlearned_combined.mpg

IT does not form a strong opinion on the objects. Takes the reward/aversion for confirmation.

#### 1.2 Conditioned visual

Learned_combined.mpg

Stripes are considered appetitive and the behaviour rewarded accordingly. Blobs are aversive and at this stage the robot can avoid the stimulus.

#### 1.3 Conditioned auditory

Beeping_combined.mpg

Blocks are neither blobs or stripes so are not recognised by the visual system, but give a tone when the robot is near by. The high frequency tone was associated with appetitive responses (rewards). The low tone was associated with the aversive response.

### 2 Resilient machines (2006)

Key paper is Bongard, Zykov and Lipson 2006[4]

Robot is the starfish. Fixed morphology

- 8 joint sensors,
- 2 tilt sensors and
- 8 joint actuators.

Most robotic systems get the humans to construct a mathematical model of the robot kinematics and/or dynamics and then plan movement against that model.

- Approach is expensive (time to construct a valid model), and requires calibration
- Robot does not have an explicit model of itself
  - Methods like SLAM model and adapt to change the environment
  - Very few robots allow adapt to changes to their own morphology
- Premise, create multiple internal models and use a system identification like approach to select the best
- Don’t freeze the system identification process during use
  - Rather look for disagreements between model and sensors (recall Kalman filters?)
Figure 3: Start at A, cycle A-C around 16 times to build the model. Evaluate walking in simulation, Best simulation is implemented on the robot. From[4]fig 1

- When disagreement is high, reinitiate the ‘model generation and evaluation’ cycles. Some info on the neural network based learning of movements is covered in[5] Internal model done with the Open Dynamics Engine (www.ode.org)

2.1 supplemental material

2.1.1 Video

Part I three cycles of model synthesis and action synthesis (Fig. 1A-C).
Part II locomotion synthesis using the best self-model (Fig. 1D).
Part III the physical robot executing the best behavior (Fig. 1E).
Part IV a sample experiment after the robot suffers damage. The robot is shown alternating self-modeling with exploratory action (Fig. 1A-C); then, the best compensatory gait is shown running on the self-model (Fig. 1D), after which it is executed by the physical robot (Fig. 1E).

REFERENCES

Figure 4: A and D try random actions, B,C,E,F try to fit a model. G,H,I try to walk in simulation. J,K,L try the walk on the robot. M Inflict damage, N,O, large errors therefore reinitiate modelling (this time only the limb lengths get changed), P,Q,R evaluate a new gait on model, S,T,U evaluate new gait on robot. From[4]fig 2
Figure 5: Evaluation of the ability the robot has to use its internal represent to survive in the real world. Red dots=random behaviour, Black dots=evaluation of movement from internal model, Blue dots=actual movement. From[4]fig 3