Agents, Emergence, Representation and Emotion

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Overview

• Extends SMC99 Presentation
  – Computational Emergence and Computational Emotion

• Places work firmly in ongoing research
  – agents and a-life architectures

• Step Through Design of A-life Architecture
  – Combination of CAs and Beehive Analogy
  – Activity at one level is represented elsewhere
  – Emotion as overall guidance of processing
History of this Research

• Starting point was Sloman
  – emotion and cognition highly inter-linked

  – Gibson - ecological perspectives on psychology
    • drives not necessarily cognitive - conative
  – Simon - control state theory for cognition
    • animate beings and synthetic systems
  – Newell - united theory of cognition
    • needs to be an explanation that
    • unifies all possible cognitive acts, states, processes
META-MANAGEMENT or REFLECTIVE processes

Inner Perception

Inner Action

RESOURCE-LIMITED DELIBERATIVE MANAGEMENT PROCESSES
(Planning, deciding, memory recall, scheduling etc.)

Motive activation

Automatic (pre-attentive) processes

Reflexes (some learnt)

THE ENVIRONMENT
Earlier Work

• Earlier work on Cognition and Affect
  – ill specified 2D designs
  – ill specified internal communication
  – ill formed ideas of reflective layer
• Here address some of these inadequacies
• Recent work based on Cellular Automata
  – game of go
• Develop these ideas in a new direction
Design Overview

Reflective agencies

Inner Perception
Inner Action

Deliberative contexts

Abstract agencies

Surfaced or emergent goals

Tightly coupled agencies

Loosely coupled agencies

Attentional Filters

Reactive community of reflexive agents

Reactive and a-life agents

JSPS - KYOTO - 1999

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CA-Reflexive Level

- Insect community approach to A-life
- Hive - static heterogeneous CA agency

```
G—W—G—W—G
W—W—D—W—W
G—D—Q—D—G
W—W—D—W—W
G—W—G—W—G
```
CA-Reflexive Level - II

- Mobile - heterogeneous CA agency

- Plus alien - non-hive (external) data

- Reflexive $\equiv$ synthetic-chemical communication
CAs and Communication

• 5 categories of CA here - all 4 neighbourhood
  – G - insect guards
  – W - insect workers
  – D - the insect drones
  – Q - the insect queen
  – A - the alien worker

• Communication
  – within hive (5), within mobile (2)
  – hive with mobile, alien with mobile, alien with hive
Reactive Level - CA Behaviours

- b1 - \{ 1W_i-W_j, \ldots, kW_i-W_j \} - worker and worker
- b2 - \{ 1G_i-G_j, \ldots, mG_i-G_j \} - guard and guard
- b3 - \{ 1G_i-D_j, \ldots, nG_i-D_j \} - guard and drone
- b4 - \{ 1D_i-G_j, \ldots, pD_i-G_j \} - drone and guard
- b5 - \{ 1D_i-Q_j, \ldots, rD_i-Q_j \} - drone and queen
- b6 - \{ 1Q_i-W_j, \ldots, sQ_i-W_j \} - queen and worker
- b7 - \{ 1A_i-G_j, \ldots, tA_i-G_j \} - alien and guard
- b8 - \{ 1A_i-W_j, \ldots, vA_i-W_j \} - alien and worker
- b9 - \{ 1H_i-M_j, \ldots, xH_i-M_j \} - hive and mobile
Computational Emergence

• Gestalt Emergence
  – patterns of behaviour or signals
• Diachronic Emergence
  – develops over evolutionary time
• Representational Emergence
  – emergence of representational forms and structures
• Functional Emergence
  – unexpected or not-designed-for behaviours
Deliberative Level

• D1 - tightly coupled
  – deliberative agency responsible for hive
• D2 - tightly coupled
  – deliberative agency responsible for mobile
• D3 - loosely coupled - representation transformer
• D4 - tightly and loosely coupled
  – memory management
• D5 - tightly coupled
  – threshold and process observer and control
Nature of Communication

- Communication within and between layers

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Psychology and Basic Emotions

• Based on Power and Dalgleish

• Fear
  – Physical or social threat to self or valued role or goal

• Anger
  – Blocking or frustrations of a role or goal through perceived other agent

• Disgust
  – Elimination or distancing from person, object, or idea repulsive to self and to valued roles and goals
• Sadness
  – Loss or failure (actual or possible) of valued role or goal
• Happiness
  – Successful move towards or completion of a valued role or goal
• Provides 4 dimensional model
  – Sadness-Happiness are extremes on one dimension
  – computationally tractable as hybrid ANN of some type
• Suitable model for reflective level agency
Design at its simplest

Memory

Tightly Coupled

H I V E

M O B I L E

Reactive

Reflexive
Implementation?

• Partial implementations of some components
  – Some CA work on GO
    • Multiple CA communities - reflexive and deliberative
  – Multi-layer Agents for simulating robot factory
    • Deliberative, reactive and reflexive layers integrated
  – Mobile agents for e-commerce
    • KQML and KIF

• Hybrid Artificial Neural Network
  – Reflective computational model of emotion
And The Future?

• Early days in this research
  – Need to develop fully integrated agencies

• No particular application but
  – Go - already multiple levels and communities of CAs
  – Computational models of synthetic mind
    • Perturbation as emergent emotional states
  – Creativity
    • Music, Art?
  – Virus checking over heterogeneous networks?

• Can always keep it completely theoretical
References - I


References - II

References - III