## Non-Symbolic AI – Summer 2006

EASy

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Lectures:

- Tue 11:00 Thu 16:00 Fri 9:00 in ARUN-401

Seminars – split into groups – start in Week 2:

- Thu 09:00 in PEV1-1A3
- Fri 14:00 in PEV1-1A1



## Objectives

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- Familiarity with a broad range of non-symbolic AI
- NSAI for cognition – in robots or software
- Neural Nets (NNs) for cognition – eg robotics
- NNs for data-mining and applications
- Genetic Algorithms (GAs) for design
- GAs for data-mining and applications
- Ability to program GAs and NNs for these purposes



## Prerequisites

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It is assumed that you have some experience of background AI concepts to the course, eg from Further AI.

A lot of topics will be similar to Further AI, covered differently.

It is assumed that you can write programs in an appropriate language.

It is assumed that you can pursue topics through further reading, discussing with colleagues and asking questions in seminars!



## Seminars

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Seminars will start in week 2, and different seminars may be taken by different people.

Topic for week 2 will be based on a paper by

R. Pfeifer (1996): Building 'Fungus Eaters': Design Principles of Autonomous Agents. SAB96.

This paper will be made available this week, and you are expected to read it before hand, so that any of you can be called on to present the ideas in the paper.



## Seminar lists

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Your groupings into the different seminar slots will be announced shortly – and like everything else, will be kept up-to-date on

www.informatics.susx.ac.uk/users/inmanh/non-symb

Week 2: Seminar based on Reading

Week 3: GA exercise ***

Week 4: Backprop ANN exercise ***

Week 5: Seminar based on Reading



## Seminars -> Assessed Coursework

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Seminars in weeks 3 and 4 are GA and ANN exercises

You are expected to make a proper attempt on these before, and bring to the seminars, for feedback.

These exercises do not count towards the assessed coursework ***BUT*** by the time you have done them and put them together, you will find that most of the assessed coursework exercise is pretty much done already ***!!!!!!***

## Reading List

For Robotics and Autonomous Systems:

**Understanding Intelligence** Pfeiffer & Scheier, MIT Press 1999

For Genetic Algorithms

**An Introduction to Genetic Algorithms** Mitchell, MIT Pr 1996

For Neural Networks

**Neural Computing** Beale & Jackson, Adam Hilger 1990



## Other Reading

Designing Autonomous Agents, P. Maes (MIT)

Artificial Life, C. Langton (MIT)

An Intro to Neural Networks, J. Anderson (MIT)

Neural Networks for Pattern Recognition, CW Bishop (OUP)

Genetic Algorithms in Search … D. Goldberg (Addison-Wesley)

From Animals to Animats (Series of conference proceedings for SAB conferences).



## Lecture Notes

… can be got as a complete term pack from Celia in COGS Library

… and will also be posted on website

www.informatics.susx.ac.uk/users/inmanh/non-symb

These are **not**, however, a substitute for attending the lectures and seminars!



## Assessment

The course is assessed by 50% coursework and 50% unseen exam.

The **exam** will be some time in June – look out for announcements. You should answer 2 out of the 3 available questions within the 1.5 hours.

The **coursework** will be a programming exercise, with a short report (maximum 2000 words), that will be set in week 2, to be handed in by Thurs May 25 (Wk 6).

There are big penalties for handing in work late (10% up to 24 hrs late, **then 100% !!!**) so you should plan to complete in good time.



## Outline of lectures

Intro + 2 lectures on Genetic Algorithms

3 lectures on Alife and Robotics

3 lectures on Neural Networks (with some data-mining and more GAs)

2 lectures on this and that (coevolution, communication…)

Extra lectures at end – I will ask for suggestions as to either covering a new topic that you want, or returning and covering in more depth something previous – you will decide.



## Type of Lectures

Some lectures will cover tricky stuff, at a rather abstract and hand-wavy level. For these topics, you will be expected to pick up the general flavour without necessarily getting to grips with the detail (… unless of course you want to).

Other lectures will be covering topics such as GAs and Neural Networks at a low and simple level – for these topics you will be **expected** to be able to program some versions of these by the end of the course.

## What is Non-Symbolic AI?

1. What is AI ?
2. What is Symbolic AI ?
3. What is Non-Symbolic AI ?

The difference between 2 and 3 will be indicated by a rapid history of 2000 years of AI !



## What is AI ?

I am going to distinguish 2 (connected) parts to AI :-

1. Building hardware or software (robots or programs) that replicates (some aspects) of intelligent, adaptive behaviour as seen in humans or animals – e.g. trying to pass (some version of) the Turing test. Cognitive Science
2. Building tools to help humans tackle specific jobs in ways that need intelligence – e.g. data-mining, useful software tools, robots.

Crudely, these are **Science** and **Engineering.**



## AI and Alife

AI has tended to concentrate on **logic**, on **calculation**, on **formal systems** as the kind of intelligence to emulate in machines.

But recently – particularly with the new field of **Artificial Life** (Alife) – people have widened their ideas of what counts as 'intelligence'. The ability of a bird to navigate between N. Europe and S. Africa is amazing, displays some kind of adaptive intelligence – but does it use logic?

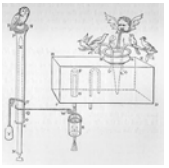


## Early Artificial Life

A whirlwind tour through 2 millennia.

*** Chapter 1 of Artificial Life, Chris Langton (ed), Addison Wesley 1989. Proc of First workshop on Artificial Life.

**Automata**
Started with the Ancient Greeks. 1st century AD, Hero of Alexandria described working models of animals and humans, using hydraulics and pneumatics.





## Middle Ages

**From around 14th Century AD**, development of clocks allowed more sophisticated automata.

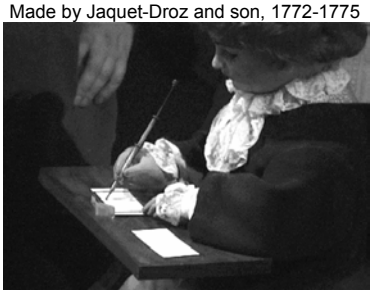
**Early Alife quote:**
"For seeing life is but a motion of Limbs, the beginning whereof is in the principal part within; why may we not say that all *Automata* (Engines that move themselves by springs and wheeles as doth a watch) have an **artificiall life**?"

Thomas Hobbes in *Leviathan* (1651)



## 18th C Automata

Made by Jaquet-Droz and son, 1772-1775



## 18th C Automata (2)



## 18th C Automata (3)



## 18th C Automata (4)



## 18th C Automata (5)



## Jump to 20 C

2nd World War – **Cybernetics** "the study of control and communication in the animal and machine" N Wiener. Aiming of anti-aircraft fire -- notion of **Feedback**

A lot of important early work in Cybernetics in 1940/50s that got rather forgotten in the rise of **Computing**.

Well worth searching for this early Cybernetics work -- I consider **Design for a Brain**, by **W Ross Ashby**, Wiley & Sons 1952, enormously important.



## And Computing

Then came computing ... ... the classical AI approach ... disembodied abstract reasoning.

Computing has been enormously successful for abstract problem solving, but led to this insidious popular view that humans and animals think and behave like problem-solving computers.

## Embodied behaviour before abstract rationality

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From several directions, particularly in the last decade, has come the realisation that humans are the product of 4 billion years of evolution, and only the last tiny fraction of this period has involved language and reasoning.

If we dont understand the capacities of simple organisms, how can we hope to understand human capacities?

Cf. Rod Brooks, robot subsumption architecture.
This is **one motive** for doing A-life. **(RB talk 14 May)**



## OK, so what is Artificial Life?

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"Artificial Life is the study of man-made systems that exhibit behaviors characteristic of natural living systems. It complements the traditional biological sciences concerned with the *analysis* of living organisms by attempting to *synthesize* life-like behaviors within computers and other artificial media. By extending the
empirical foundation upon which biology is based *beyond* the carbon-chain life that has evolved on Earth, Artificial Life can contribute to theoretical biology by locating *life-as-we-know-it* within the larger picture of *life-as-it-could-be."*

Chris Langton (in Proc. of first Alife conference)



## Alife as conscious echo of AI

EASy

Note 2 meanings of 'Artificial':
(1) = fake (eg artificial snow)
(2) = made by artifice, an artefact, but not fake
(eg artificial light)

Two positions you will come across:
Weak Alife: computer programs as useful simulations of real life
Strong Alife: ditto as **actually living**



## Non-Symbolic AI (1)

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So, one aspect of Non-Symbolic AI (maybe the 'Science' part) is an extension of ideas of Intelligence to include all sorts of adaptive behaviour, not just the 'rational' part of human behaviour.

After all, in the 4 billion year history of our species, rationality only 'turned up' fairly recently, and even now we mostly get by without using logic!

This part of Non-Symbolic AI is demonstrated in Alife, in situated embodied robotics, etc.



## Non-Symbolic AI (2)

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But there is a 2nd aspect to n-sAI (maybe the Engineering part).

This comes from recognising that symbolic AI approaches to eg pattern recognition are useless in comparison to the ability of a migrating bird (that does not use symbols or logic)

… that the most complex bit of machinery humans have designed is trivial (in performance, in efficiency, in robustness) compared to even the simplest natural organism.

So let's try and understand and borrow some of Nature's tricks.



## Nature's tricks (1)

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In particular, for jobs such as pattern-recognition (is that where I turn left to go home? Is that a crack in the wing? Is that a tumour on this X-ray? Is that a sign that the stock-market is about to crash?), maybe we can get some ideas from Neural Networks.

Artificial Neural Networks (ANNs) come in all sorts of varieties, and one class (which may or may not be similar to natural NNs) is potentially useful for pattern-recognition tasks.

Feedforward, multilayer perceptrons, backprop etc

## Nature's tricks (2)

EASy

Another class of ANNs borrows from the role of real NNs in **control** – how sensors and motors are coordinated in action and perception.

Dynamic Recurrent NNs

Evolutionary Robotics

Brooks' subsumption architecture, though not usually described as an ANN, actually has some similarities with this sort of approach.



## Nature's tricks (3)

EASy

Evolution is Nature's trick for designing complex interacting creatures – hence Evolutionary Robotics borrows directly from this.

More generally, Genetic Algorithms (GAs) are efficient search methods for finding design solutions to intricate problems (how can I organise the lecture timetable without clashes? How can I design an ANN for a robot brain? How can I find a simple formula to predict the weather, the horse that will win the 2:30 race at Newmarket?)

Next lecture will be on GAs.



## Non-Symbolic AI

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More generally, (and with prejudice!):

- Symbolic AI has its place, is crucially6 important for many machine learning techniques -- but has its limits as a model for how humans and animals actually behave
- Non-Symbolic AI, Alife, Evolutionary and Adaptive Systems, -- this is where currently much of the interesting new ideas and research is
- This is where there is currently a large demand for people with experience and skill.