

# Testing AI and Smart Systems: The challenges of Self adaption

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# Plan: Testing AI & Self \*

- 7 principles of testing
- Background:
  - Decision Support Systems(DSS), Expert Systems (ES), Management Support Systems (MSS)
- AI, algorithms...
- High-level and low-level AI ; Testing AI tools
  - Autonomics , Self\* systems
  - DNA Computing
- Challenges of Self adaption

# 7 principles of testing

1. Testing shows the presence of bugs
2. Exhaustive testing is impossible
3. Early testing ... sooner the better
4. Defect clustering .... Pareto Principle 80:20 rule
5. The pesticide paradox ... systems evolve, so too should the testing data and cases
6. Testing is context dependent
7. Absence of errors fallacy ... if you don't find any, doesn't mean there aren't any!

(see for instance <https://www.testingexcellence.com/seven-principles-of-software-testing/>)

Plus other testing principles ...

And standards, eg. ISTQB/BCS; ISO/IEC/IEEE 29119 Software Testing an internationally agreed set of standards

- **But these are all stretched when it comes to AI testing**

# Some 'other' principles of testing

1. Usually done last (... Last in thinking about; last in the budget; last in the activity ...)
2. Usually seen as the unattractive part of development (just a must have element) ... Not as sexy as analysis, design or coding
3. Time, money and competition usually has an impact on *acceptable* testing
4. There is much innovation in other aspects of software and system compared to innovations in testing
5. The 'best' people often aren't interested in testing (they want the design and coding etc )
6. Users often don't know what they want so difficult for acceptance testing
7. Separation of roles doesn't always happen (developers and testers)

**& Probably a few other principles will emerge with AI testing**

# Testing AI ....Some background

- Decision Support Systems(DSS), Expert Systems (ES), Management Support Systems (MSS)
  - 1980s +
  - Developed using teams of experts
  - Experts involved in testing ....
    - Challenges of getting experts to agree!
    - Usually a rule-based approach
  - **Aim ... getting the 'right' or a good decision**
    - Also getting justification for decisions

# Testing AI

- Decision Support Systems(DSS), Expert Systems (ES), Management Support Systems (MSS)
  - *Aims ...were towards getting the ‘right’ or a good decisions*
  - **But the system aims changed/evolved**
    - Also changed from **decision support to decision making** (e.g. getting a loan from a bank) ... for consistency etc, and towards **Justifying** decisions
    - But (still) have to be wary of technology amelioration (e.g. mortgage calculations from banks)

# Testing AI

- AI algorithms, Neural nets, Simulated annealing .... **[Lots of 'testing' done]**
  - Focus on **'Trying to get the best algorithm'**
    - Lots of datasets ....
  - Training sets, particularly for Neural nets
    - ½ data for training ½ for actual applying
    - Looking for new patterns
      - E.g. classifying cork (found extra classification)
  - Simulated annealing ... coming up with a **'good' solution**, not (necessarily) optimal solution

# Testing AI

- AI algorithms, Neural nets, Simulated annealing  
....
  - Aims of tests/testing? [Lots of exploring, looking for something new]
  - Coming up with 'good' solution or better solutions than before
  - Coming up with something new [New = outside human created space; perhaps outside human comprehension]
  - Can we test for the 'best' solution or for outside of remit/scope?



# Testing AI

- High level and low level AI
  - **Low level** AI autonomies
    - Complex decisions, speed, self-control (e.g. Global network routers)
    - Self-management; local optimising & collaborating
  - **High level** AI autonomies
    - More Self\* systems
    - More strategy; longer term
    - AC (Artificial Consciousness), self-aware ....

# Testing AI

- AI autonomies
  - Lots of **Self\*** systems [**Self correcting, Self healing, Self modifying, perhaps Self-aware ...**]
  - **Moving outside human creation space and comprehension space; and dynamic**
  - **... a significant challenge in testing & scope of testing increases (... known-unknowns, unknown-unknowns)**

# Testing AI

- AI testing at high level and low level
  - What are the aims and scope of the testing?
  - Not always explicit; some of the aims and **hopes** of AI are fuzzy ... **so too are the testing aims**
  - Are they clear, and will they change/evolve (as per the examples in DSS / ES)?
    - **Expect some function creep**
    - Consider the Congestion Charging around London and automatic number plate recognition...

# Testing AI

- AI .... Autonomics
  - Working on its own
- **How to test?**
  - **Testing working scope**
  - **Testing unexpected example of dealing with uncertainty**
  - **What is a successful test outcome?**
    - **Finding bugs, meeting functions, not doing things outside of remit ...**

# Testing AI

- **AI .... Deep learning**
  - Going ‘deep’ ...looking beyond human ‘vision’ and understanding
  - Consider DeepMind’s Alpha Go success
  - In March 2016, it beat [Lee Sedol](#) in [a five-game match](#), the first time a computer Go program has beaten a [9<sup>th</sup> -dan](#) 4 to 1.... *And the inspirational move 37*
  - DeepMind created by Demis Hassabis – a child prodigy, chess master at 13, computer scientist and neuroscientist, ***a serious bright person – who is going to fully test his work?***
- **Again, many issues on how to test?**
  - Scope and What is a successful test outcome?
  - And who can ‘test’ beyond human understanding

# Testing AI – lots of variety!

- AI (Artificial Intelligence) ...
  - Decision Support Systems(DSS), Expert Systems (ES), Management Support Systems (MSS)
  - AI algorithms, Simulated annealing ....
  - High level and low level AI
  - Autonomics
  - Deep learning
  - Self\* systems
  - AC (Artificial Consciousness), self-aware ....
- **So likely multiple issues and aims in testing**

# Testing AI – big challenges!

- AC (**Artificial Consciousness**), self-aware ....
  - Turing test  
[https://en.wikipedia.org/wiki/Turing\\_test](https://en.wikipedia.org/wiki/Turing_test)
  - Behaviour of intelligence
  - Self \* (self aware, self healing, self correcting ...)
  - Autonomous/Autonomic systems (e.g. a Mars rover/explorer – a scenario approach)

# Testing AI

- AC, AI, Self-aware ....
  - **How to test and what will be the aims of the test?**
- Can follow
  - Rule approach, heuristics approach (e.g. [highway code approach](#))
  - An ethics approach (e.g. as per police in the ACPO guidelines ... <https://www.npcc.police.uk/>)
- Self \* ... doing more that humans do, so follow human/society bases for testing and conforming
  - Will we have rights and responsibilities for 'robots'/AI; criminal robots; Prisons for robots?)



# Testing AI – Some tools

## Current research projects

- **Affordances Mapping**
  - Metadata on attributes; in a LOM format
- **Bounds of Applicability**
  - addressing the gaps of ‘exception testing’, allows reuse of AI items

# Testing AI

## Current research projects ..

- Scenario modeling / testing - TSEA toolset
- Keeping the expert in the loop
  - Intelligent content creation; e.g. AI e+Cookbook
  - Workflows and content creation – case studies for AI testing workshop (AI-BCS SiG 2023 conference)

# Testing AI & Auditing

- Need to audit testing and providence
  - A Metadata approach
    - Using LOM – Learning Object Metadata standard
      - IEEE 1484.12.1-2020 standard
      - New AI-LOM system

# Testing AI & Auditing

- Need to audit testing and providence
  - A Metadata approach
  - Using LOM – Learning Object Metadata standard
    - Affordances Mapping
    - Bounds of Applicability
    - (Temporal) Scenario modeling / testing
  - Supports reuse , recognising IP, passing across testing/providence

# Testing AI – further dimensions

## Consider Self-aware AI....

– what will be the aims of the test?

- Proving consciousness
- Proving the application works (doing as good as/better than/cheaper than humans?)

– What should be the scope of testing?

- Just the application or wider societal issues

- **Is also relevant to other areas of science / computing**

# Testing AI – further dimensions

- Need more resources to support AI testing
- **Open call:- Looking for contributions to a book; contributed chapters on approaches, models, case studies on AI testing**
- Interested send email to [ca.mobipublishing@gmail.com](mailto:ca.mobipublishing@gmail.com) with AI testing Book in header

# Testing AI Self \* ... similar to DNA comp

- **DNA Computing** = lots of Self \*, including Self assembly
- Many similar testing issues to AI  
(**Particularly challenges of Self adaption**)
- Some background ...

# DNA Computing

A land mark paper and works

- LM Adleman (1994) Molecular computation of solutions to combinatorial problems. Science. Vol. 266 no. 5187 pp. 1021-1024. ...you can do Computing stuff with DNA!

And work by Eric Drexler

- (1993 Nanosystem: Molecular machinery, manufacturing and computation. Wiley publishing) ...also known for the 'nano grey goo'



# DNA Computing

Building on previous land mark works

- 1953 **Watson and Francis Crick's** paper in *Nature*. [<http://www.nature.com/nature/dna50/archive.html>]
- the structure of the DNA-helix (Deoxyribonucleic acid) ... the hereditary material present in the cells of all living organisms; the blueprint or code instructions of living organisms (self assembly instructions)

And

- 1959 famous lecture by physicist **Richard Feynman**, 'There's Plenty of Room at the Bottom', [[http://www.pa.msu.edu/~yang/RFeynman\\_plentySpace.pdf](http://www.pa.msu.edu/~yang/RFeynman_plentySpace.pdf)] ... The opportunity of nano

# DNA Computing

- Started to see the birth or emergence of DNA computing
- Computing at the nano level
- Different models of 'development' and design (more self assembly; more simulation; more science ...), **and of course testing**

# DNA Computing

- But DNA/Nana stuff coming from many disciplines ...
- Physics, biology, mathematics, engineering, material sciences, epigenetics (and other sub fields), .... And computing
- **[all with very different thinking for testing!]**

# DNA Computing

- Nano scale devices (and thinking)
  - very small , a few nanometers to a few hundred nanometers (nm),
  - .... the scale of just a collection of atoms and molecules.
- Nanotechnologies (nano-materials, nano-devices and nanomachines)
- Wet and Dry options
  - With different thinking on testing

# DNA Computing

- (My) Earlier thinking / experience ... self modifying code (1980's)
- My own paper/work
  - ... trying to make it simple
  - Considering testing issues, ethical issues, innovation issues

# AI and DNA Computing testing

## Challenges?

- We don't know all the challenges yet
- My own paper/work ... throws up more questions than answers
  - Seem to be at a schism (division or disunion, especially into mutually opposed parties) between fields

# AI & DNA Computing testing

- We need a different mindset for development and for testing, both in AI and in DNA Computing

## Some emergent themes

- Lots of simulation and theoretical
- Lots of self organising (for development and testing)
- Need off 'buttons', reset 'buttons'
  - Consider Blowflies and corpses  
<https://bekkabrodie.com/2014/10/29/the-beginning-of-the-end-how-blow-flies-find-corpse/>
  - There seems to be 'off' switches in living things

# AI and DNA Computing testing

- We need a different mindset for development and for testing
- Need to design for Self \* testing
- Need to design for testing functionality beyond human comprehension (at least in the short term)
- Need the best people involved!



# Testing AI – further dimensions

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Any questions