

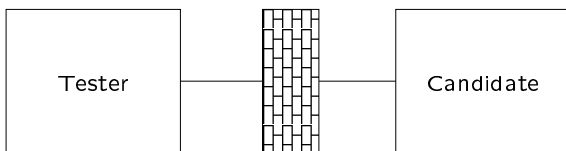
# Advanced Symbolic Artificial Intelligence

1. text editor
2. searching for a name/address/occupation record in a database
3. displaying and manipulating 3D objects on monitor (CAD)
4. simulating biological metabolisms
5. chess and go playing programs
6. language translation
7. speech recognition
8. robot control
9. theorem provers
10. puzzle solvers
11. diagnosis systems
12. Turing test contenders

1

## Towards a Concept of AI

### The Turing Test



- terminal communication with unknown partner
- no way of identifying partner
- **Question:** is partner human or not?
- **See:** e.g. [Saygin et al., 2000]

*On the internet, nobody knows you are a dog!*

*New Yorker Magazine, July 1993*

**Questions:** does AI require machines to have equivalent capabilities to human intelligence?

**Consider Here:**

- are animals intelligent?
- does reasoning require intelligence?
- do mathematic puzzles require intelligence?
- does chess require intelligence?
- do robots require intelligence?
- what about speech or image processing?

**Transfer to computers:** what about regular software?

## When does AI begin?

**Bottom-Line:** pragmatic approach

- straightforward algorithmic approaches where all substeps are “evident” are not “intelligent”
- AI originally dealt with problems for whom algorithmic solutions were not obvious
- computational systems emulating “intelligence” [Schalkoff, 1990]

**Nota Bene:** What is obvious and what “intelligent” changes with time

4

## Examples for AI Applications

**Abstract Worlds:**

- board games
- puzzle solving
- theorem proving
- reasoning

**But Also:**

- speech and image processing
- robot control

**Question:** what is the difference?

5

## Symbols

**Observation:**

- humans communicate in symbols
- symbols form central basis of human culture
  - via language
  - via writing
  - via scripture
  - via mathematics

**Question:** is use of symbols limited to humans?

**Hypothesis:** if so, human intelligence linked to use of symbols?

6

## The Power of Symbols

He that saw the abyss, the bottom of our land  
That knew the sea and knew what was to know  
He that saw the circumference of Earth, land  
by land

He whom the deepest foundations of things  
were revealed to

He that discovered secrets and experienced the  
mysteries

He brought a legend back from the time before  
the Flood.

*Gilgamesh Epic, approx. 2600 BC  
(Transl. Raoul Schrott)*

In the Beginning Was the Word.

*John 1,1*

Ich bin ein Berliner.

*John F. Kennedy*

7

**The Role of Symbols**

**Observations:**

- symbols are connected with knowledge
- symbols survive for millenia
- symbols preserve information
- symbols connect the past with the future

**Bottom Line:** importance of symbols for human culture

**But:** ambiguity

**Disambiguation:** language of mathematics

**Goal:** connection with physical world

**Examples:**

$$E = mc^2 \quad \text{energy-mass relation}$$

$$8\pi G = T \quad \text{Einstein equation}$$

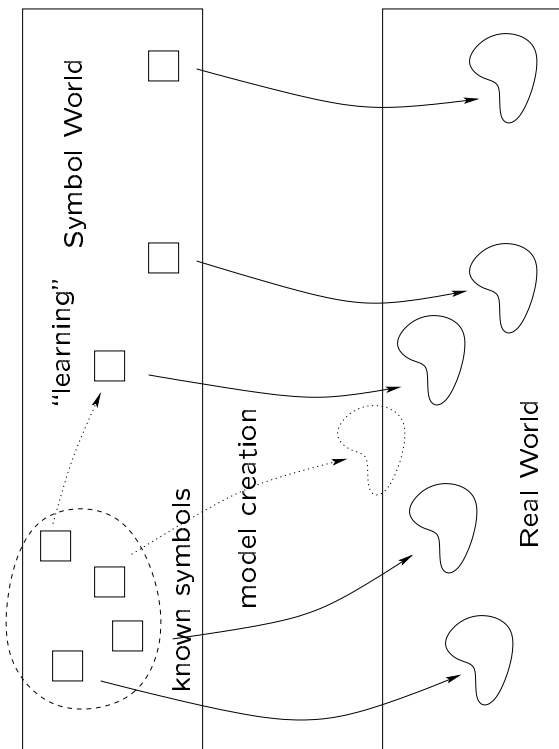
$$(\hat{p}_0 - \alpha \hat{p} - \beta mc) = 0 \quad \text{Dirac equation}$$

**Problem:** "meaning" of symbols

**Note:** mathematical/physical symbols defined by means of everyday language (i.e. symbolism)

**Question:** how to bootstrap?

**The Big Slide**



**AI Symbolism**

**Important:** interplay between model world, real world and world model

**Doctrine:** in classical symbolic AI

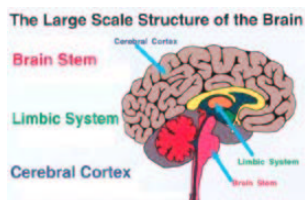
- symbol manipulation achieves all world relevant symbols
- symbol manipulation travels quickly and effectively through relevant symbol space
- symbols represent *crisp* concepts
- strong view says human thinking uses exclusively symbols

**Question:** is this so?

## Neuroscience

**Experiments:** study of brain mechanisms

**Results:** [Firstscience, 2002]



**Stem:** instinctive functions, breathing and heartbeat

**Limbic System:** emotions, sexuality, memory

**Cortex:** sensing, deliberation, speech

12

## Symbolism vs. Nonsymbolism

**Dilemma:** if brains do not work this way, why do symbolic AI?

**Possible Reasons:**

- philosophical reasons (see next unit)
- because we understand math, but not the world
- because it is closer to the von Neumann/Turing concept
- algorithmic realisability

14

**Classical AI Hypothesis:**

- language perceived is symbolic
- it reflects state of mind
- deliberations can be followed using language
- ergo: human thinking is symbolic

**But:** is this true?

**Neuroscience Results:**

- parallel processing
- asynchronous processing
- imprecise, non-crisp, fuzzy
- robust

**Bottom Line:** natural brains most probably do *not* work symbolically

13

## Symbolism vs. Nonsymbolism II

**Deep Reason:**

- language compresses subsymbolic (fuzzy) concepts into tight channels
- “compactification” creates crisp structures
- “emergence” of structural concepts
- crisp “ideal” concepts condense from fuzzy “real” ones
- concepts may decompose into separate abstract subconcepts

**Now:** symbols are easy to manipulate

**Bottom Line:**

- symbolic concepts useful to capture certain aspects of the “essence” of things
- symbols allow algorithmic manipulation of this aspects

15

## Caveats

### Do Not:

- be deluded
- confuse a symbol with a thing



Ceci n'est pas un pipe  
(René Magritte)

(see also [Hofstadter, 1999])

- forget that a symbol compresses a thing into *one concept*
- forget that a symbol extracts only one specific aspect

16

**Artificial Intelligence:** computers as models for human intelligent thinking

### Symbolic AI:

- symbolism believed to be important factor in human intelligence
- symbols form “essence” of objects
- symbols easy to manipulate
- **world is formalisable**

### Nonsymbolic AI:

- simplistic symbolic view is fundamentally incomplete
- symbolic view captures only partial aspect of objects
- cybernetics/embodiment/“holism”

**Modern AI:** blurring borders between symbolism and nonsymbolism

17

## The Power of Symbolic AI

### Strengths:

- crisp concepts
- explainability
- transparency and reproducibility
- expressivity and communicability

### Applications:

- intelligent modelling
- learning
- problem-solving
- decision making
- reasoning

18

## Methods and Languages

- predicate logics
- Prolog
- LISP
- data structures
- search
- logic and resolution
- deduction

19

## Tasks

1. On [CMU Artificial Intelligence Repository, 2002], check the definition of Artificial Intelligence. Can you live with it as stated? Elaborate.
2. Check on the web for the word "emergence". It is a very important term in nonsymbolic AI approaches. Why do you think does it not appear in the context of symbolic AI?
3. on slide 18, which application directions do you think are best suited for Symbolic AI?
4. Install Prolog  
(<http://www.swi-prolog.org/>)

## References

- CMU Artificial Intelligence Repository, [2002]. CMU Artificial Intelligence Repository.  
<http://www-2.cs.cmu.edu/afs/cs.cmu.edu/project/ai-repository/ai/html/air.html>, 2. Oct 2002
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[http://www.firstscience.com/SITE/review\\_radiant.asp](http://www.firstscience.com/SITE/review_radiant.asp), 3. Oct 2002
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