Outline

1. History of the AI dream
2. How do brains work?
3. Connectionism
   - Image Processing
   - Learning to ‘talk’
4. Fantasy Machines
   - Finding the Burglar
   - Spelling correction
   - Speech recognition
   - Medical diagnosis
5. Physical Interaction and Commonsense
6. Current Research in Machine Learning
7. Outlook
Engineering Intelligence

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1948 Turing and Champernowne ‘paper and pencil’ chess.
1951 Prinz mate-in-two moves chess machine.
1952 Strachey programs first computer draughts algorithm.
Learning Machines

1951 Oettinger makes first program that ‘learns’.
1955 Samuel adds ‘learning’ to his draughts algorithm.
Logical Intelligence

1968  Risch’s algorithm for integration in calculus
1972  Prolog for general logical reasoning
1997  Deep Blue defeats Kasparov
Other forms of intelligence

But is this getting us to where we’d like to be?

- Speech Recognition
- Visual Processing
- Natural Language modelling
- Planning and decision in uncertain environments

Perhaps a different approach would be useful.
“A person’s mental activities are entirely due to the behaviour of nerve cells and the molecules that make them up and influence them.”
Neurons
Information Processing in Brains

Real World

Layer 1

Layer 2

High-level Concepts

Hierarchical; Modular; Binary; Parallel; Noisy
Engineering Intelligence

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McCulloch and Pitts Network (1943)
Artificial Neuron (Perceptron)
Training an artificial neural network

- Want to generalise to new images with high accuracy.
Artificial Network

1957 Rosenblatt’s perceptron

▶ perceptron film clip
1960 Realised a perceptron can only solve simple tasks.
1970 Decline in interest.
1980 New computing power made training multilayer networks feasible.
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Computer makes error less than $1/1000$. 
Digit recognition using a neural network
Feature neurons in the first layer
Feature neurons in a real brain
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NETtalk: Sejnowski and Rosenberg (1986)

This is the input

Output units (phoneme code)

Hidden units
Limitations of forward reasoning

- Recognising patterns (perceptron style) is only one form of intelligence.
- Solving chess problems is another and requires complex reasoning using some form of internal model.
- The world is noisy and information may be conflicting.
- Recognised that new approaches are required.
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Models help us to fantasise about the world.
Models
Models
Models

Real World

High-level Concepts
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Burglar Problem
Creaks and Bumps

Creak

Bump
Burglar Model

\[ pos_1 \rightarrow pos_2 \rightarrow pos_3 \rightarrow pos_4 \]

\[ snd_1 \rightarrow snd_2 \rightarrow snd_3 \rightarrow snd_4 \]

*pos* - position in kitchen

*snd* – sound
<table>
<thead>
<tr>
<th>creak!</th>
<th>creak!</th>
<th>creak!</th>
<th>creak!</th>
<th>creak!</th>
<th>creak!</th>
<th>creak!</th>
<th>creak!</th>
<th>creak!</th>
<th>creak!</th>
</tr>
</thead>
<tbody>
<tr>
<td>bump!</td>
<td>bump!</td>
<td>bump!</td>
<td>bump!</td>
<td>bump!</td>
<td>bump!</td>
<td>bump!</td>
<td>bump!</td>
<td>bump!</td>
<td>bump!</td>
</tr>
</tbody>
</table>
Finding the Burglar

creak! creak! creak! creak! creak!
bump! bump! bump! bump! bump! bump! bump!
Finding the Burglar

creak! creak! creak! creak! creak!
bump! bump! bump! bump! bump! bump!
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Stubby Fingers

```
int_1 → int_2 → int_3 → int_4

hit_1 → hit_2 → hit_3 → hit_4

int  - intended key
hit  - hit key
```
Stubby Fingers: errors
| a | b | c | d | e | f | g | h | i | j | k | l | m | n | o | p | q | r | s | t | u | v | w | x | y | z |
| a | b | c | d | e | f | g | h | i | j | k | l | m | n | o | p | q | r | s | t | u | v | w | x | y | z |

0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9

Stubby Fingers: language
Given the typed sequence kezrninh what is the most likely word that this corresponds to?

- Listing the 200 most likely hidden sequences
- Discard those that are not in a standard English dictionary
- Take the most likely proper English word as the intended typed word

... and the answer is ...
Given the typed sequence `kezrninh` what is the most likely word that this corresponds to?

- Listing the 200 most likely hidden sequences
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... and the answer is ... learning

What about `cwsykcak`?
Engineering Intelligence

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Speech Recognition: raw signal
‘neural’ representation
Speech Recognition

\[ \text{pho}_1 \rightarrow \text{pho}_2 \rightarrow \text{pho}_3 \rightarrow \text{pho}_4 \]

\[ \text{aud}_1 \rightarrow \text{aud}_2 \rightarrow \text{aud}_3 \rightarrow \text{aud}_4 \]

\text{pho}: \text{phoneme (letter)}
\text{aud}: \text{audio signal (neural representation)}
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Medical Diagnosis

Combine known medical knowledge with patient specific information.
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Robots
Recognising an object based on its features is useful (but limited).

Understanding what ‘fetch me a teacup’ means is hard.

Something that can contain hot water that a human can drink comfortably from.

“Mary saw the dog in the shop window. She wanted it.”

Machines ultimately need to understand more about what it means to be human.
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Automatic car navigation.

Monitoring behaviour of plants/machines, surveillance.

Search:
‘What is the tallest building in the world?’
versus
‘Does the same person appear in both these videos?’

Translation.

Scientific reasoning.

Medical diagnosis.
Speech recognition

How Speech Recognition Works

POTATO

Markov Model

2006@HowStuffWorks.com
Mike saw the man with the telescope.
Face Recognition
Robot Control
Game Playing
Object Recognition
Bio-informatics
Personalised Medicine

It’s all about your genome, and we have something JUST for you.
Prediction

- stock market
- consumer demand e.g. newspapers
- engine failure
We’re only just beginning...

- AI is hard!

Machines can do amazing things – beat us at chess, navigate autonomously, recognise our speech. Tremendous progress has been made in these extremely difficult problems. Need to develop algorithms that work physically in parallel, like brains do and harness true power of parallel computing. Need continued progress in processing of complex signals, modelling of environment, understanding what it means to be human. Need continued insights from biology about how natural organisms solve some of these complex tasks.
We’re only just beginning...

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www.cs.ucl.ac.uk/staff/D.Barber