Artificial Intelligence:
An Introduction

Mohsen Afsharchi
Strong AI

• An autonomous self-moving machine that acts and reasons like a human
AI: a brief history

- 1950: Alan Turing. The Turing test.
  - Can machines think? → Can we tell it’s a machine from conversation?
  - text in / text out
  - it also contains things like genetic algorithm, human cloning …

![Turing test timeline](image-url)
AI: a brief history

- 1956: Dartmouth summer workshop
  - AI named
  - big players introduced
  - no consensus
AI: a brief history

  - X = solve puzzles, prove geometry theorems, play checker, Lisp, block world, ELIZA, perceptron…
  - but many are toy problems
AI: a brief history

- 1966-1973: a dose of reality
  - syntactic without domain knowledge doesn’t work
    - The spirit is willing but the flesh is weak
    - The vodka is good but the meat is rotten (US→RU→US)
    - US gov canceled funding for machine translation
  - intractability: exponential complexity
    - British gov ended AI support based on the Lighthill report
  - theoretic limit: perceptron can’t do XOR
    - Neural network research halted
AI: a brief history

- **1969-1988: Knowledge-based systems**
  - Add domain-specific knowledge to guide search
  - CYC: world = millions of rules.  
    ([cyc.com](http://cyc.com))
  - Expert systems commercialized in the 80’s
    - One AI group in every major US company
    - Billions of $$$ industry
AI: a brief history

- 1988 – not long ago: **AI winter**
  - Expert systems
    - Massive investment from venture capitalists
    - Extravagant promises
  - Bubble burst
    - AI funding dried up
    - AI companies down
AI: a brief history

- 1986 – not long ago: neural networks
  - Multi-layer perceptron
  - Back propagation training algorithm rediscovered
  - Connectionists vs.
    - Symbolic models (Newell, Simon)
    - Logicist (McCarthy)
  - What it really is: statistical machine learning
AI: a brief history

- present: statistics
  - machine learning
    - Hidden Markov models (HMM), support vector machines (SVM), Gaussian processes, graphical models (Bayes networks, conditional random fields)
  - data mining
The Reality

• In the early period of AI it seemed plausible that new forms of symbolic computation, e.g., frames and semantic networks, made much of classical theory obsolete. This led to a form of isolationism in which AI became largely separated from the rest of computer science. This isolationism is currently being abandoned. There is a recognition that machine learning should not be isolated from information theory, that uncertain reasoning should not be isolated from stochastic modeling, that search should not be isolated from classical optimization and control, and that automated reasoning should not be isolated from formal methods. David McAllester 1998
Weak AI

• Machines *can* demonstrate intelligence, but do not necessarily have a *mind*, *mental states* or *consciousness*

• weak AI refers to the use of software to study or accomplish specific *problem solving* or *reasoning* tasks that do not encompass the full range of human cognitive abilities.
AI today

• Don’t know how to do 98% of the intelligent things
• But the rest 2% can do quite well

There’s no magic in AI.
It’s all about optimization, probability, algorithms.
Valerie: CMU Robot Receptionist in Newell-Simon hall.

ALICE: 2004 Loebner Prize winner

ELIZA: psychotherapist

Shallow natural language processing, pattern matching
AI today: natural language: speech recognition

- “speak or touch tone your card number” (tiny vocabulary, high accuracy needed)
- call routing: “how can I help you?” (large voc, low acc)
- dictation (large voc, high acc)

- Hidden Markov Model, A* search, …
The spirit is willing but the flesh is weak. (2005/6/29)

Дух охотно готов но плоть слаба
精神是愿意的但骨肉是微弱的
精神は喜んでであるが、肉は弱い

Spirit is willingly ready but flesh it is weak
The spirit is wants but the flesh and blood is weak
Mind is rejoicing,, but the meat is weak

El alcohol está dispuesto pero la carne es débil

The alcohol is arranged but the meat is weak

الcohol مستعدة غير أن اللحم ضعيفة.
The alcohol is ready nevertheless the meat is weak.

• IBM statistical machine translation models
• US gov major consumer
  - Why Vodka (Russian)?
  - Now?
AI today: natural language: question answering

- What happened to Gagarin?
- Shallow natural language processing, heuristics
AI today: game: chess

- IBM Deep Blue vs. Kasparov, 1997/5
- 6 games: K, D, draw, draw, draw, D
- IBM stock up $18 billion.

- Search, two-player zero-sum discrete finite games with perfect information.
AI today: WWW: web search

- Ranking is everything
  - Dozens to thousands of smart people in Google, Yahoo!, MSN, etc.
  - e.g. Peter Norvig
- Google: PageRank (graph theoretic) and tons of secrets.
- A whole Search Engine Optimizer (SEO) industry
  - Promote your webpage’s rank in search engines
  - Some bad reputations (spam the search engines)
  http://www.google.com/webmasters/seo.html
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AI today: WWW: Google news

- Automatically selects / arranges news from multiple sources
- c.f. CNN

- Unsupervised machine learning: clustering
AI today: WWW: ad

- “Sponsored links”
- Show ad based on relevance and money. Big business.
- Online algorithm, game, auction, multiple agents
AI today: WWW: driving directions

• From UW CS to state street

• search
AI today: WWW: information extraction

- Extract job info, free web text $\rightarrow$ DB

- Machine learning: classification
AI today: WWW: collaborative filtering

- Recommendation based on other users’ behavior
- e.g. Amazon.com

- Unsupervised learning
AI today: robotics: ‘intelligent’ shoes

- Adjust cushioning by speed, road surface (adidas_1)

- Probably simple regression
AI today: robotics: robosoccer

- Robocup (http://www.robocup.org/)

- Markov decision process, reinforcement learning
AI today: robotics: humanoid

- Bipedal, human-like walking

Asimo (Honda)  QRIO (Sony)
Al today: robotics: Hubble telescope

• Scheduling: who gets to see what when
  ▪ 30,000 observations per year
  ▪ Many constraints, including
    • Earth blocks view every 95 minutes
    • Halts when in South Atlantic Ocean radiation belt
    • Avoid bright Sun, Moon, illuminated Earth
    • Disruption of plan for e.g. a supernova

• Search: Constraint satisfaction problem
AI today: robotics: Mars Rovers

- Autonomous driving on Mars (part time)
- Robot motion planning

not always autonomously...
AI today: art

- AARON (http://www.kurzweilcyberart.com/)
Are these intelligence?
## AI defined

- Which one do you like?

<table>
<thead>
<tr>
<th></th>
<th>act</th>
<th>think</th>
</tr>
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<tbody>
<tr>
<td><strong>humanly</strong></td>
<td>e.g. Turing test</td>
<td>How DO we think?</td>
</tr>
<tr>
<td><strong>rationally</strong></td>
<td>agent</td>
<td>Logic</td>
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rational agent

- Sensors can be noisy or missing
- Actuators
  - may change the environment
  - can be inaccurate
- Performance measure
- Rational = optimize the performance measure
  - May not be perfect or even useful
  - e.g. “pick up as much dirt as possible”
Natural intelligence
How do we think? Mind reading

- Polygraph

http://people.howstuffworks.com/lie-detector2.htm
How do we think? Mind reading

- Brain-computer interface

The Berlin Brain-Computer Interface
How do we think? Mind reading

- fMRI
  - Neuronal activity requires oxygen
  - The vascular system responds to increased activity by sending more oxygen
  - The increase in oxygen is visible in the MRI signal

[Francisco Pereira, CMU Ph.D. thesis]
How do we think? Mind reading

- Which picture is seen? high accuracy [Cox & Savoy, *Neuroimage* 2003]

- Also word meaning, picture vs. sentence, sentence ambiguity [Francisco Pereira, CMU Ph.D. thesis]

[Images of brain scans showing activation differences]
Harvest human intelligence:
Captcha and the ESP game
AI is hard

- Some AI problems are very hard
  - Vision, natural language understanding, ...
- “AI-complete”
  - If you solve one, you solve AI
- What do you do?
  - Give up?
  - Bang your head really hard?
  - Important lesson in life:
    - turn hardness into something useful
- Very hard for machine, trivial for human
Captcha

- Yahoo!
- Google
Captcha

- The “anti-Turing test”
- Tell human and machines apart, automatically
  - Deny spam-bots free email registration
  - Protect online poll from vote-bots
- By asking an “AI-complete” question

Random string  Distorted image  What do you see?
 oamg  [Image]  

- Also audio Captcha, e.g. superimposed speakers
- http://www.captcha.net/

[Luis von Ahn, IAAI/IJCAI 2003 keynote]
The ESP game

- Real intelligence is here (for now)

- We waste it in computer games, anyway

- Harvest it (http://www.espgame.org/)
The ESP game

• Task: label all images on the web with words

  ➔ car, boy, hat, …

• Why: current image search engines
  ▪ use the image filename and surrounding text
  ▪ do not really understand the image

• How: two separate players try to find a common description of the image.
The ESP game

PLAYER 1

GUESSING: CAR
GUESSING: HAT
GUESSING: KID
SUCCESS!
YOU AGREE ON CAR

PLAYER 2

GUESSING: BOY
GUESSING: CAR
SUCCESS!
YOU AGREE ON CAR

[Luis von Ahn, IAAI/IJCAI 2003 keynote]