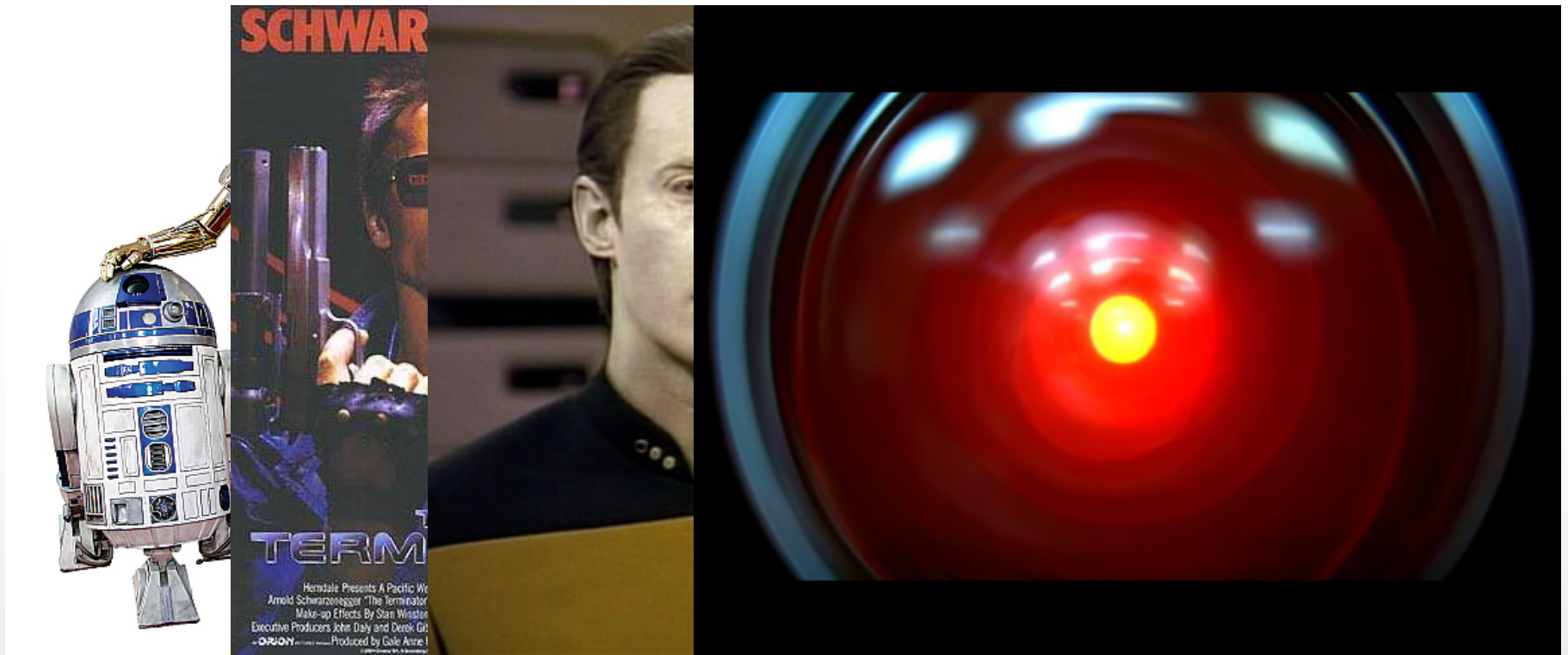# Overview of AI

WEBS6202

Slides by Richard Watson *MSc AI*
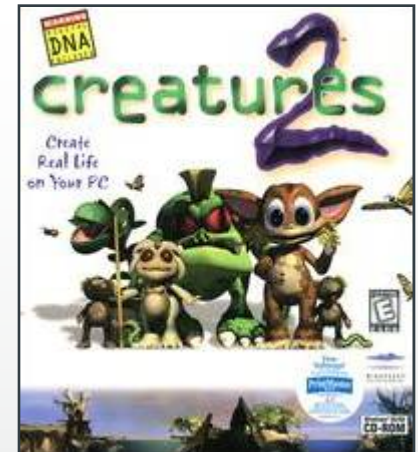
Heng Ji *RPI*

Imagined AI

Real AI?

Need help with our website? Need information about travelling by train? Just 'Ask Lisa', our new virtual assistant.
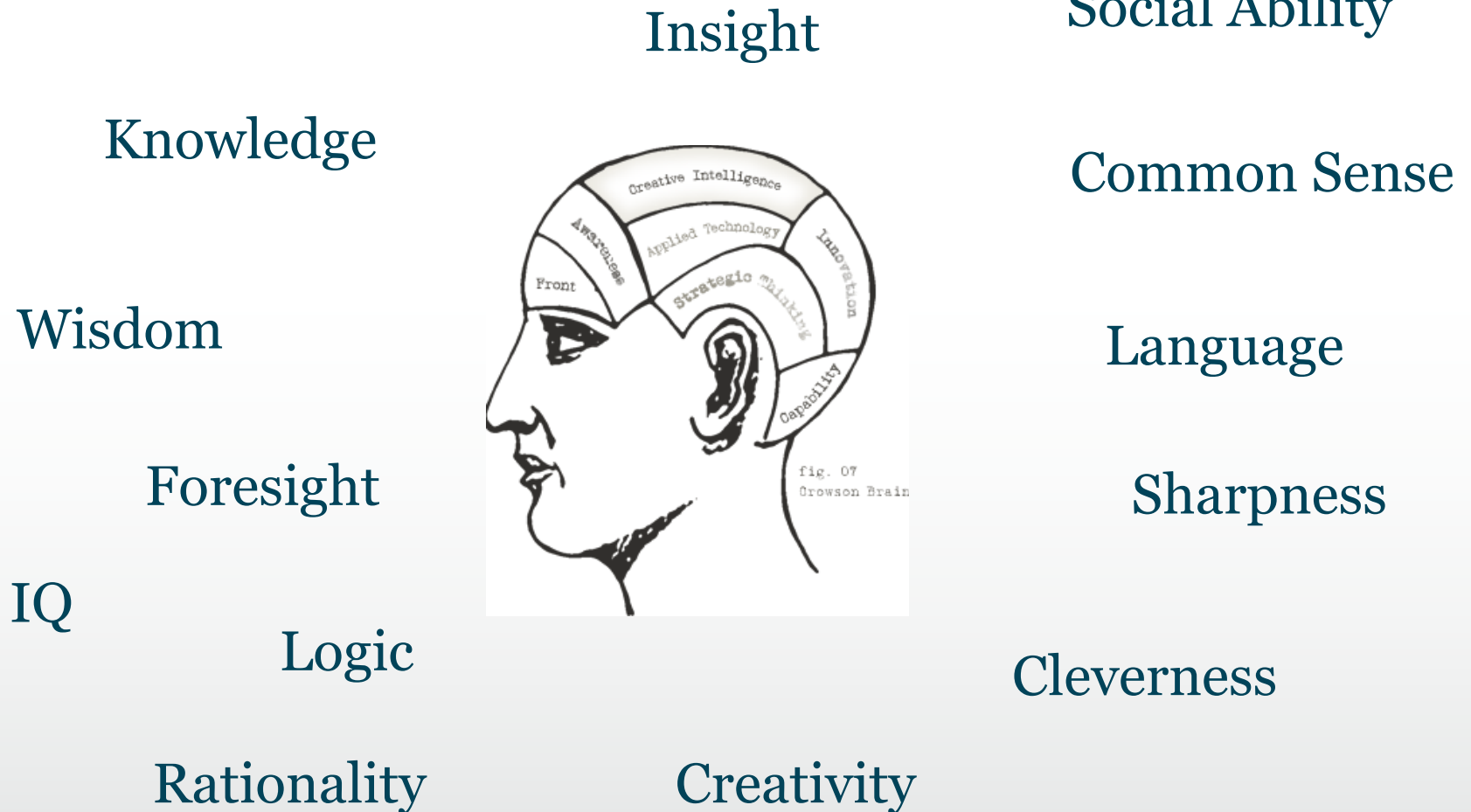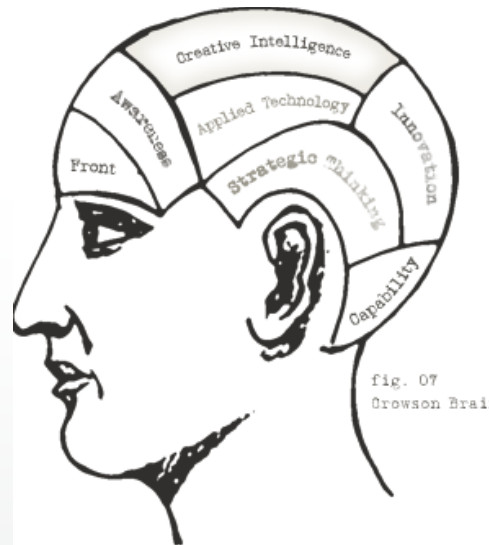
ASK

Definitions

- Q. What is artificial intelligence?

- A1. "It is the science and engineering of making intelligent machines, especially intelligent computer programs. It is related to the similar task of using computers to understand human intelligence, but AI does not have to confine itself to methods that are biologically observable."

  – John McCarthy, 2007.

- A2. It's aim is "to build intelligent entities".

  – Russell & Norvig, AIAMA2e

What is Intelligence?

Insight

Social Ability

Knowledge

Common Sense

Wisdom

Language

Foresight

Sharpness

IQ

Logic

Cleverness

Rationality

Creativity

What is Intelligence?

A Typology

Intelligent systems…

	Biological	Logical
Head	… think like us	… think rationally
World	… act like us	… act rationally

Think like us…

Intelligent systems…

	Biological	Logical
Head	**…think like us:** • 1960s cognitive revolution • computationalism • thought = information processing • cognitive neurosci. and psych. • AI systems shed light on our psychology	…think rationally
World	…act like us	…act rationally

Act like us…

Intelligent systems…

	…think like us	…think rationally
Head	**…act like us** • Prior to a mature psychological theory? • Does a machine think = does it *behave* intelligently • How to test for intelligent behavior? • Turing Test: we know it when we see it • Requires: knowledge, language, learning, but also mistakes, pauses, etc.	…act rationally
World		
	Biological	**Logical**

9

Think rationally…

Intelligent systems…

Head	…think like us	**…think rationally** • Aristotle: "laws of thought" • Inference, Argument, Logic • Notation and Derivation came early • Automation/Mechanisation came later • Problems of identifying relevance • Problems of interfacing with real world
World	…act like us	…act rationally
	Biological	Logical

Act rationally…

Intelligent systems…

	…think like us	…think rationally
Head		
World	…act like us	**…act rationally** • Rational action = "doing the right thing" • = that which is expected to maximise reward or goal achievement, given available information • Not necessarily driven by logic or deliberation

Biological   Logical

State of the Art

– Deep Blue

– AlphaGo   AlphaGo

– Boston Dynamics

– Waymo

– Medical Diagnosis

– DART

– PROVERB

• Wikipedia Entry: AI

DeepIndex: 357 Examples

DeepIndex

Keeping track of what AI can do, and where it is being applied.

Read on for 357 examples of AI in action.

Something missing? Email hello@deepindex.org

Legend
- Getting there
- Capable
- Crushing it

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Keeping track of what AI can do, and where it is being applied.
Read on for 357 examples of AI in action.

Games 15
- Play Atari 2600
- Play Battleship
- Play Doom
- Play Dota 2
- Play Go
- Play Jeopardy!
- Play Q*bert
- Play Scrabble
- Play Shogi
- Play Sokoban
- Play Sonic the Hedgehog
- Play StarCraft
- Play Super Mario Bros
- Play Texas Hold-Em
- Play chess

Creative 30
- Compose classical music
- Compose pop music
- Copy your handwriting
- Create a chatbot in your likeness
- Create anime characters
- Crop photos
- Design logos
- Design personalised clothing
- Direct a panel show
- Draw an image based on a description
- Draw creepy pictures
- Edit photos
- Fake a video of someone talking
- Fake your voice
- Generate an infinite podcast
- Generate photorealistic faces
- Identify authors of literary works
- Mimic famous artists
- Mix like a DJ
- Paint a masterpiece
- Play a piano duet with you
- Recognise doodles
- Restyle photos
- Spot forged artworks
- Teach you how to draw
- Write Harry Potter fanfiction
- Write a film
- Write a novel
- Write poetry
- Write songs

Home & lifestyle 22
- Adjust your lights
- Buy stuff on your behalf
- Choose your clothes
- Clean your windows
- Control your entire house
- Cook your meals
- Give you fashion advice
- Guess who you know
- Help you choose a hair dye
- Invent recipes
- Learn your weekly shop
- Mix cocktails
- Mow your lawn
- Optimise your heating
- Predict how long your relationship will last
- Predict your lifespan
- Recommend movies
- Recommend music
- Recommend stuff to buy
- Reduce your water bills
- Tell you if you have spots or wrinkles
- Vacuum your floors

Industrial 14
- Assist the crew of the ISS
- Audit what's on a store's shelves
- Clean floors
- Customise hair care products
- Help deliver the mail
- Manage construction projects
- Pick up fruit and vegetables
- Predict maintenance tasks
- Reduce industrial energy consumption
- Run a factory
- Run a supermarket
- Run a warehouse
- Sort parcels
- Track supply chains from space

Agriculture 13
- Boost greenhouse productivity
- Detect crop diseases
- Detect poachers
- Harvest strawberries
- Help farmers work more efficiently
- Pick apples
- Pollinate crops
- Predict crop yields
- Reduce the cost of fish farming
- Seed, water and care for plants
- Sort cucumbers
- Spray pesticides
- Thin lettuces

Transport 15
- Alert distracted or drowsy drivers
- Deliver pizza
- Design a sports car
- Dispatch taxis
- Drive a car
- Drive a truck
- Fly an F-16 fighter jet
- Give you driving directions
- Help pilots cope with emergencies
- Land a passenger aeroplane
- Pilot a drone
- Predict airline delays
- Predict how long you'll wait for a taxi
- Predict parking availability
- Predict where you want to go

Science 24
- Build models for new artificial life forms
- Classify extreme weather events
- Design better batteries
- Design more efficient OLEDs
- Design organic syntheses
- Detect and locate earthquakes
- Discover new models in biology
- Discover new planets
- Discover unknown species of virus
- Draft research papers
- Enhance atomic imaging
- Explore Mars
- Find new uses for existing drugs
- Hunt for subatomic particles
- Identify bacteria
- Improve the accuracy of gene editing
- Invent alternatives to meat
- Predict disruptions in fusion reactions
- Predict earthquakes
- Predict life on other planets
- Predict molecular properties
- Simulate quantum systems
- Survey and classify biological data
- Track mosquitos by their sound

Security 26
- Detect ISIS propaganda
- Detect child abuse images
- Detect compromised user accounts
- Detect drug smuggling
- Detect malware
- Direct drone surveillance
- Drive a police car
- Drive a tank
- Enhance pixellated images
- Enhance real-time police surveillance
- Flag suspicious people at border crossings
- Follow a person without human interaction
- Help run a nuclear submarine
- Identify objects of interest in drone footage
- Identify surface-to-air missile sites
- Make surveillance footage searchable in real time
- Monitor the border
- Operate a sentry gun
- Patrol shopping malls
- Predict protests and riots
- Predict who is going to commit a crime
- Spot burglars
- Spot trolls on Twitter
- Staff a police station
- Threaten our digital, physical and political security
- Verify your identity from a selfie

Computing 12
- Block spam emails
- Deliver search results
- Improve your UX design
- Improve your WiFi performance
- Learn how to use a computer
- Learn how to use encryption
- Organise your Facebook news feed
- Perform functional software testing
- Predict hard drive failures
- Turn wireframes into working apps
- Write AI software
- Write unit tests

Government & nonprofit 12
- Detect benefit fraud
- Detect illegal logging in the rainforest
- Find the best place to resettle refugees
- Help cities get feedback from their residents
- Help police make custody decisions
- Predict court cases
- Predict crime hotspots
- Predict government corruption
- Rate school performance
- Reduce urban congestion
- Suggest ways to reduce pollution
- Triage natural disaster aerial imagery

Education 6
- Be a teaching assistant
- Create custom textbooks
- Create personalised learning plans
- Help deaf students learn
- Mark essays
- Tutor kids in maths

Medicine 38
- Create holograms of cervical smears
- Detect falls in the home
- Detect potassium in your blood
- Detect suicidal thoughts
- Diagnose cataracts
- Diagnose common conditions
- Diagnose nail fungus
- Diagnose osteoarthritis of the knees
- Diagnose pneumonia
- Diagnose prostate cancer
- Diagnose skin cancers
- Enhance cancer pathology reports
- Generate oncology treatment plans
- Identify diabetic retinopathy
- Identify inter-cranial haemorrhages
- Identify malaria parasites in blood
- Improve palliative care
- Interpret echocardiograms
- Make precise incisions
- Monitor outpatients
- Organise clinical trials
- Pass a medical licensing exam
- Predict Alzheimer's disease
- Predict autism
- Predict cardiovascular risk from retina scans
- Predict epileptic seizures
- Predict heart attack and stroke risk
- Predict high blood pressure
- Predict hospital readmissions
- Predict hypoglycemic events
- Predict imminent cardiac arrest
- Predict leukaemia relapse
- Predict schizophrenia
- Predict sepsis
- Predict sleep apnea
- Screen for cervical cancer
- Suture a wound
- Talk to people with depression

Professional 30
- Analyse red carpet fashions
- Build project teams
- Buy advertising inventory
- Check commercial loan agreements
- Coach call centre staff
- Conduct M&A due diligence
- Conduct legal case research
- Design a pricing strategy
- Evaluate the performance of sportspeople
- Guide visitors to a museum
- Handle customer support
- Made ad placement decisions
- Match art to potential buyers
- Match candidates with job vacancies
- Optimise retail inventory
- Personalise customer experiences
- Predict box office performance
- Predict fashion trends
- Price property insurance accurately
- Review legal contracts
- Review motor insurance claims
- Review theft insurance claims
- Rewrite the news to remove bias
- Run a hotel reception desk

Finance 14
- Detect payment fraud
- Do your accounts
- Find cheap flights
- Get invoices paid instantly
- Give financial planning advice
- Give investment advice
- Help you look after your money
- Make lending decisions
- Manage a hedge fund
- Optimise your spending
- Price risk
- Suggest venture capital investments
- Trade cryptocurrencies
- Trade equities

Administrative 11
- Be your personal assistant
- Do data entry
- Get parking tickets cancelled
- Improve your writing
- Make a staffing rota
- Make your Slack workspace more productive
- Organise your photos
- Schedule your meetings
- Spy on you at work
- Suggest a room for your meeting
- Take notes in a meeting

Speech & language 21
- Classify sentiment in text
- Decipher an ancient manuscript
- Detect toxic comments in online discussions
- Exchange banter with humans
- Fool a speech-to-text system
- Interpret orders from a Starfleet captain
- Learn to speak like someone else
- Pass a reading comprehension test
- Pick a single voice out of a crowd
- Read your lips
- Recognise emotions in speech
- Resist creepy laughing
- Speak naturally
- Spot fake news
- Tell British and American accents apart
- Track stereotypes about women and minorities
- Transcribe a conversation
- Translate in real time
- Translate like a native speaker
- Translate over 100 languages
- Write convincing reviews

Vision 30
- Answer questions about an image
- Categorise ramen by shop
- Change faces in videos
- Change people's clothes in a video in real time
- Change the weather in a video
- Convert flat images to 3D
- Describe what's happening in a picture
- Find pictures capturing similar moods
- Fool an image classifier system
- Guess your age
- Identify hotdogs or not hotdogs
- Identify objects for the visually impaired
- Identify plant and animal species
- Identify you from your face
- Identify you from your walk
- Locate emoji in the real world
- Match selfies to famous paintings
- Rank photos by aesthetic appeal
- Recognise emotions in pictures
- Recognise partially concealed faces
- Remove Henry Cavill's mustache
- See in the dark
- See through walls
- Tag your friends in photos

Robotics 14
- Anticipate human movements
- Dance Gangnam Style
- Dance to any music
- Design better artificial limbs
- Do a backflip
- Give you superhuman strength
- Help robots teach themselves
- Juggle balls in mid-air
- Learn to mimic human movement
- Move like a fish
- Open doors
- Play table tennis
- Roll on any terrain
- Ski an alpine slalom course

Pre-History: Tributaries of AI

- Philosophy   Logic, methods of reasoning, phil. of mind, learning, language, rationality

- Mathematics   Formal notation & proof, algorithms, computation, undecidability, intractability

- Neuroscience   Physical substrate for mental activity

- Psychology   Perception, motor control, experimentation

- Engineering   Building (fast) computing devices

- Control Theory   Feedback, homeostasis, stability, optimality

- Linguistics   Knowledge representation, grammar

- Economics   Utility, decision theory

Turing and Bletchley Park

- During WWII, Alan Turing worked on code-breaking at Bletchley Park.

- Used heuristic search to translate Nazi messages in real time

- With others, e.g., Jack Good and Don Michie, he speculated on machine intelligence, learning…

- Much of this remained secret until after the war.

- The military has retained a strong interest in AI ever since…
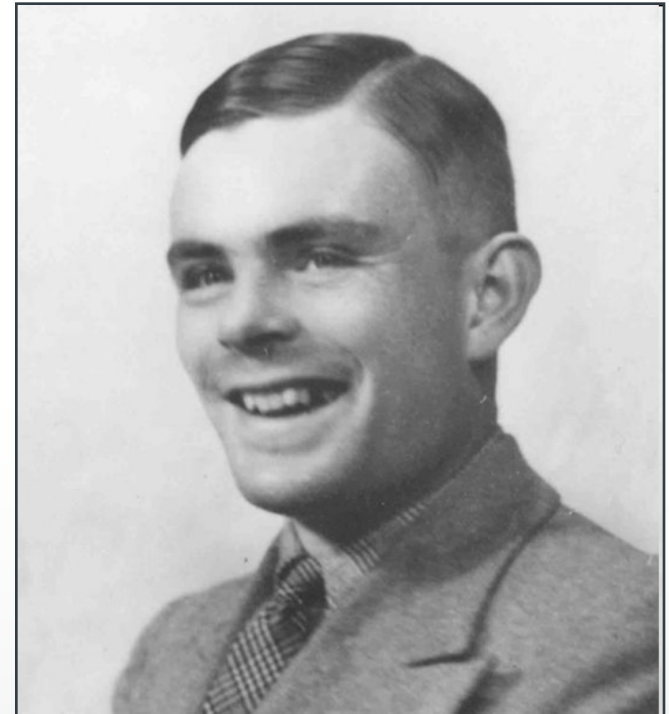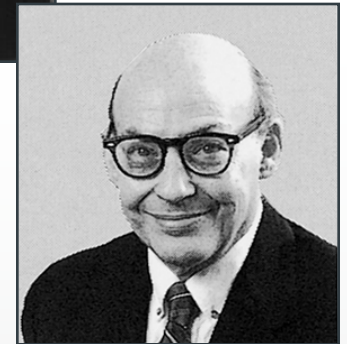
After WWII

- 1943: McCulloch & Pitts model of artificial boolean neurons.

- First steps toward connectionist computation and learning

- 1951: Marvin Minsky builds the first neural network computer

- 1950: Turing's "Computing Machinery and Intelligence" is published.

    – First complete vision of AI.
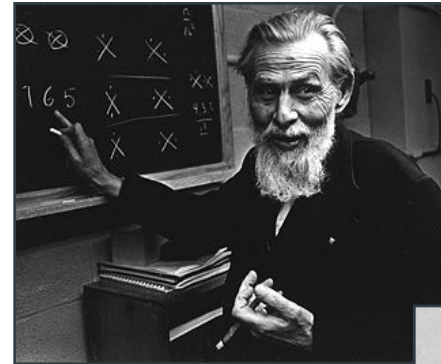
Warren McCulloch (1899-1969

Marvin Minsky (1927-)

The Birth of AI (1956)

The Dartmouth Workshop brings together 10 top minds on automata theory, neural nets and the study of intelligence.

- Conjecture: "every aspect of learning or any other feature of intelligence can in principle be so precisely described that a machine can be made to simulate it"

- Ray Solomonoff, Oliver Selfridge, Trenchard More, Arthur Samuel, John McCarthy, Marvin Minsky, etc.

- Allen Newell and Herb Simon's Logic Theorist

- For the next 20 years the field was dominated by these participants.

Great Expectations (1952-1969)

- Newell & Simon imitated human problem-solving

  – General Problem Solver.

- Arthur Samuel (1952-)

  – Had success with checkers.

- John McCarthy (1958-) invented Lisp (2nd high-level lang.)

  – Advice Taker

- Marvin Minsky introduced "microworlds"

  – "Society of Mind"

AI Winter

- Collapse in AI research (1966 - 1973)

    – Progress was slower than expected.

        • Unrealistic predictions.

    – Some systems lacked scalability.

        • Combinatorial explosion in search.

    – Fundamental limitations on techniques and representations.

   • Minsky and Papert (1969) Perceptrons.
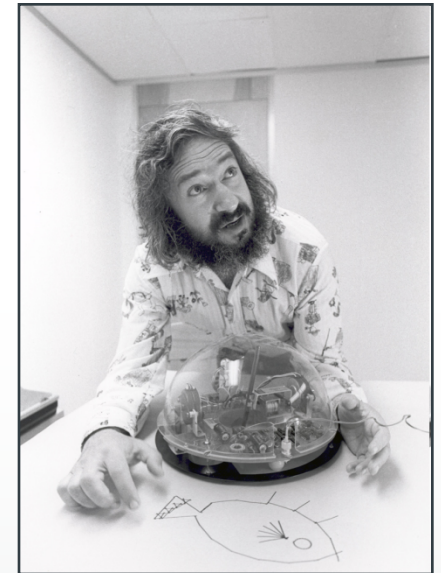
Seymour Papert (1928-)

AI Revival (1969-1970s)

- Exploiting encoded domain knowledge

  - DENDRAL (Buchanan et al. 1969)
    - First successful knowledge intensive system.

  - MYCIN diagnosed blood infections (Feigenbaum et al.)
    - Introduction of uncertainty in reasoning.

- Increase in knowledge representation research.

  - Logic, frames, scripts, semantic nets, etc., ...

Connectionist Revival (1986-)

- Parallel distributed processing (Rumelhart & McClelland '86)

- Multi-level perceptrons and backpropagation learning

- Language, reasoning, perception, control + a little mystery

- Robust behaviour, graceful degradation

- No representations? Sub-symbolic AI...

- 90s: Elman pioneers layered recurrent nets

- 90s: Fully recurrent networks and robot control (e.g., Beer)

- Ultimately... "neural" networks as data-mining, statistics...
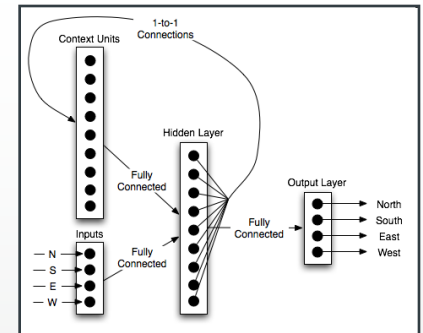
Nouvelle AI (1988-)

- Rodney Brooks and other roboticists challenge the formalist, "representational" orthodoxy

    – Elephant don't play chess, Brooks

    – Why not the whole iguana?, Dennett

    – Nevermind the blocksworld, Cliff

- Situated, Embedded, Embodied cognition

- Inspired by simple insects, rather than chess and logic

- Anti-representationalist, anti-reasoning, anti-generality

- Evolutionary robotics, artificial life, "the new cybernetics"

Intelligent Agents (1995-)

- Combined whole organism perspective with a rational utility-maximising framework borrowed from economics.

- A response to nouvelle AI?

- An empty label?

- A hybrid? A bolt-hole for formalists? A revolution?

  – "How does an agent act/behave embedded in real environments with continuous sensory inputs"

Data, Data, Everywhere (2000-)

- Massive amounts of raw power and raw data fuel advances in machine learning:

  – Eigenfaces

  – Corpus linguistics

  – Kernel methods

  – Computational learning theories
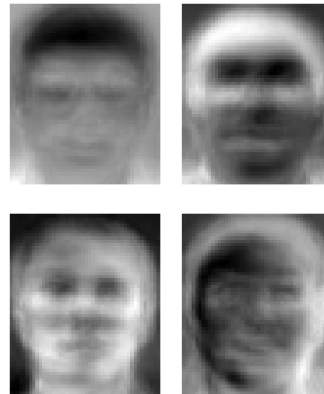
- Offline vs. Online AI?

- Pattern Recognition in a Bucket?

Machine Learning

- So far we have assumed we know how the world works

  – Rules of queens puzzle

  – Rules of chess

  – Knowledge base of logical facts

  – Actions' preconditions and effects

  – Probabilities in Bayesian networks

- At that point "just" need to solve/optimize

- In the real world this information is often not immediately available

- AI needs to be able to learn from experience

Different kinds of learning…

- **Supervised learning**:

  - Someone gives us examples and the right answer for those examples

  - We have to predict the right answer for unseen examples

- **Unsupervised learning**:

  - We see examples but get no feedback

  - We need to find patterns in the data

- **Reinforcement learning**:

  - We take actions and get rewards

  - Have to learn how to get high rewards

Inductive Reasoning

- Learning in humans consists of (at least):

  - memorisation, comprehension, learning from examples

- Learning from examples

  - Square numbers: 1, 4, 9 ,16
  - 1 = 1 * 1; 4 = 2 * 2; 9 = 3 * 3; 16 = 4 * 4;
  - What is next in the series?
  - We can learn this by example quite easily

- Machine learning is largely dominated by

  - Learning from examples

Machine Learning Tasks

- Categorisation

  – Learn why certain objects are categorised a certain way

  – E.g, why are dogs, cats and humans mammals, but trout, mackeral and tuna are fish?

    - Learn attributes of members of each category from background information, in this case: skin covering, eggs, homeothermic,...

- Prediction

  – Learn how to predict how to categorise unseen objects

  – E.g., given examples of financial stocks and a categorisation of them into safe and unsafe stocks

Potential for Machine Learning

- Agents can learn these from examples:

    – which chemicals are toxic (biochemistry)

    – which patients have a disease (medicine)

    – which substructures proteins have (bioinformatics)

    – what the grammar of a language is (natural language)

    – which stocks and shares are about to drop (finance)

    – which vehicles are tanks (military)

    – which style a composition belongs to (music)

Performing Machine Learning

- Specify your problem as a learning task

- Choose the representation scheme

- Choose the learning method

- Apply the learning method

- Assess the results and the method

Constituents of Learning Problems

1. The example set

2. The background concepts
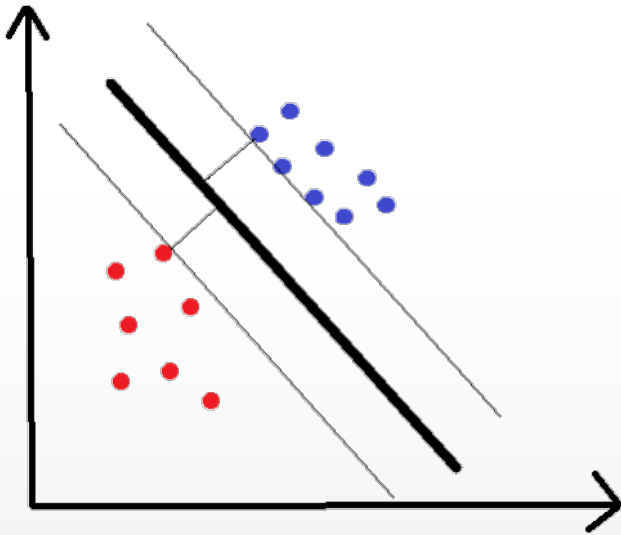
3. The background axioms

4. The errors in the data

Problem constituents:
1. The Example Set

- Learning from examples

  – Express as a **concept learning** problem

  – Whereby the concept solves the categorisation problem

- Usually need to supply pairs (E, C)

  – Where E is an example, C is a category

  – Positives: (E,C) where C is the <u>correct</u> category for E

  – Negatives: (E,C) where C is an <u>incorrect</u> category for E

- Questions about examples:

  – How many does the technique need to perform the task?

Classification and Regression

- Red or blue? Mammal or reptile? Cat or dog? Good investment or not?

- Predicted rates of return?

Income

https://medium.com/machine-learning-for-humans