# Lecture 6
# A Brief History of AI:
# New Paradigms, Scientific Method, Big Data (1986-present)

Rob Gaizauskas

# Lecture Outline

- Historical Overview
  - Precursors (… – 1943)
  - Gestation and Birth (1943 – 1956)
  - Golden Early Years (1956-1969)
  - The First "AI Winter" (1966-73)
  - Rise of Knowledge-based and Expert Systems (1969-1989)
  - New Paradigms: Connectionism; Intelligent Agents; Embodied AI (1986 – present)
  - Scientific Method and Big Data (1987 – present)
- Reading:
  - Russell and Norvig (2010), Chapter 1 "Introduction"
  - Wikipedia: History of Artificial Intelligence. http://en.wikipedia.org/wiki History_of_artificial_intelligence

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# New Paradigms: Connectionism; Intelligent Agents; Embodied AI (1986 – present)

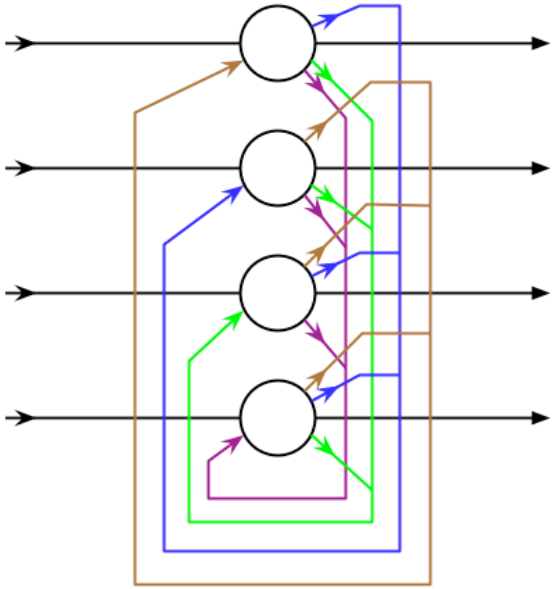
- Despite commercial successes of expert systems, growing frustration amongst AI researchers about whether current approaches could achieve long term goals of truly intelligent systems
  - Dreyfus analogy of climbing a tree to get to the moon: can report steady progress – all the way to the top of the tree!
  - Was traditional AI and its emphasis on logic, knowledge representation and reasoning (and its assumption of the physical symbol system hypothesis) the correct way to go?
  - expert systems successful within their domains but clearly not generalisable
  - Moravec's paradox: why were the intelligent behaviours of the child still so far beyond reach?
  - AI was fissuring into disconnected subareas

# New Paradigms: Connectionism; Embodied AI; Intelligent Agents; (1986 – present)

- These concerns led to the emergence of a number of different paradigms from about the mid 1980's
  - Connectionism – neural network research reborn
  - Embodied or situated AI – emphasis on importance of having a body/perceptual system for intelligence
  - Intelligent agents – emphasis on acting in an environment

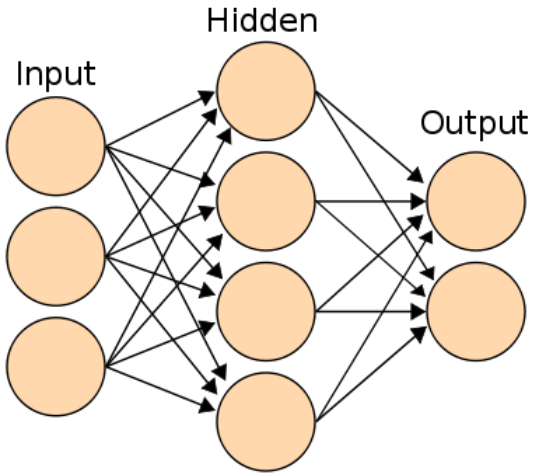
# New Paradigms: Connectionism

- 1980's saw two key developments that led to revival of neural networks research
- 1n 1982 John Hopfield proposed a new form of neural net and demonstrated that it had new learning and information representation possibilities



- Key features of these "Hopfield nets" is that they are recurrent
  - Output from a unit can fed back into itself via other units
- Recurrent neural networks (RNNs) effectively have an internal memory and can exhibit dynamic temporal behavior
  - can use their internal memory to process arbitrary sequences of inputs
  - can be used for tasks such as unsegmented connected handwriting recognition, where they have achieved the best known results

# New Paradigms: Connectionism




- The problems identified with neural nets in the late 1960s were to do with representational limitations of perceptrons which were single layer networks
- Multi-layer networks with internal "hidden layers" are potentially much more powerful – but it was not clear how to train them
- A new approach to training such networks called back-propagation, while initially discovered in the 1960's, was popularized in the 1980s by Rumelhart and McClelland in *Parallel and Distributed Processing* (1986)
- Led to a renaissance of work in neural networks
- Current view is that NNs and symbolic approaches are complementary not competing …

# New Paradigms: Embodied AI

- In the late 80s, several researchers advocated a completely new approach to AI based on robotics
  - believed that, to show real intelligence, a machine needs to have a body — it needs to perceive, move, survive and deal with the world
  - argued that these sensorimotor skills are essential to higher level skills like commonsense reasoning and that abstract reasoning was actually the least interesting or important human ability
- Robotics researcher Rodney Brooks in "Elephants Don't' Play Chess" (1990) directly attacked physical symbol system hypothesis
  - argued symbols not always necessary since

    "the world is its own best model. It is always exactly up to date. It always has every detail there is to be known. The trick is to sense it appropriately and often enough."
- Many cognitive scientists also rejected the symbol processing model of the mind and argued that the body was essential for reasoning – the "embodied mind thesis"

# New Paradigms: Embodied AI

- Brooks: for robots to accomplish everyday tasks in an environment shared by humans, their higher cognitive abilities (abstract thinking) need to be based on the primarily sensor-motor interaction ("action") with the environment, complemented by proprioceptive sense which is a key component in hand-eye coordination

  (http://en.wikipedia.org/wiki/Rodney_Brooks)

- He pointed out that:

  Over time there's been a realization that vision, sound-processing, and early language are maybe the keys to how our brain is organized.

- His company Rethink Robotics produces Baxter

# New Paradigms: Intelligent Agents

- Given progress in sub-areas of AI, some researchers started looking at the "whole agent" problem again
  - "In artificial intelligence, an intelligent agent (IA) is an autonomous entity which observes through sensors and acts upon an environment using actuators (i.e. it is an agent) and directs its activity towards achieving goals (i.e. it is rational)"

    (Russell & Norvig, 2010, Chp 3 – more next week)
  - i.e. focus is not on vision or language or learning but on integrating all of these in a single entity (the agent) that can perceive and act in an uncertain, dynamic environment
- Had been considered in early days of AI (e.g. Shakey), but put aside to address problems of making progress in sub-areas
- The internet has provided a new environment for agents
  - Now a host of "internet bots" aka "web robots" or just "bots"

# New Paradigms: Intelligent Agents

Focussing on building whole agents has a number of consequences

- Now apparent that sensory systems – vision, sonar, speech recognition – cannot deliver perfect information about the environment
  - So, planning/reasoning systems need to be able to deal with noise/uncertainty
- Agent perspective has suggested connections with related fields that also deal with agents
  - Control theory (e.g. control of robotic cars)
  - Economics (decision theory, game theory, operations research)

# Other Trends: Scientific Method and Big Data (1987 – present)

- Two major trends in past two decades:
  1. AI has moved more into the mainstream of computer science and has embraced the traditional scientific method
  2. Very big datasets have become available and methods to exploit them have become a major focus of attention

# Scientific Method in AI

- Early AI was filled with brilliant intellectual mavericks who thought they were creating a entirely new field with new problems for which new theories/methods were required
- With time has come the realisation that there is much to be gained from other areas and from a more rigorous empirical approach

# Scientific Method in AI

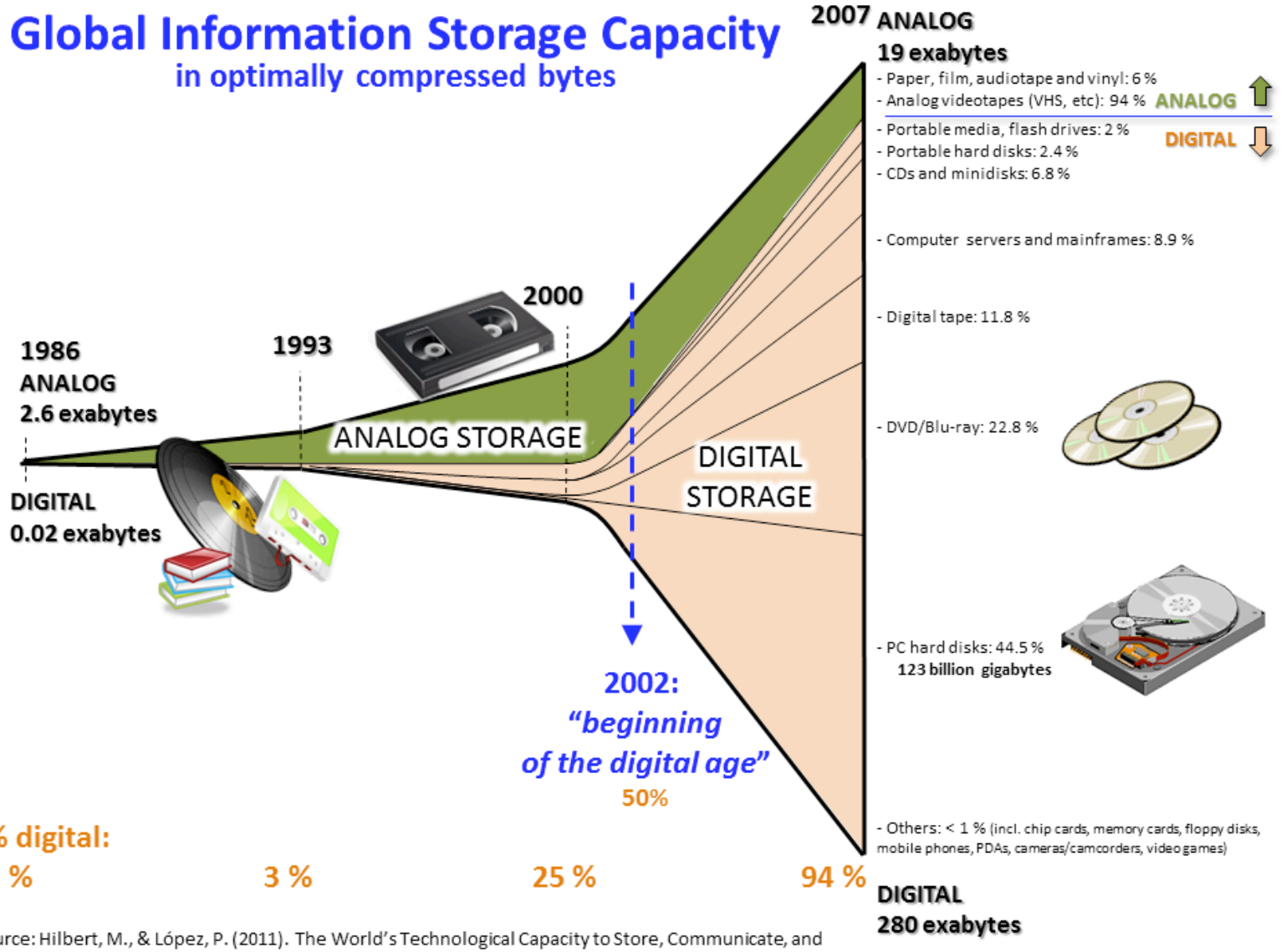
- Trends include:
  - Building on existing theories – e.g. information theory, probability theory, statistical modelling – with solid mathematical foundations
  - Experimentation on real world data rather than "blocks world" data to get hard experimental evidence
  - Experiments must be replicable and results significant
    - Rise of "shared task evaluations" with shared tasks, data sets, evaluation/performance measures in e.g. speech recognition, language processing, robotics, vision, etc. – anyone can test claims against these datasets
    - Increasingly experimental code and data must be submitted alongside results are when papers are submitted for publication
    - Inclusion of standard statistical significance testing to ensure experimental results are sufficient to support conclusions being drawn

# Big Data

- Very big datasets have become available, offering challenges and opportunities
  - Text corpora of trillions of words
  - Social media streams (Twitter, Facebook, on-line comment)
  - Image collections of billions of images and videos
  - Terabytes of sensor data
  - Billions of base pairs of genomics sequences
  - …

Other Trends: Scientific Method and Big Data (1987 – present)

# Big Data




Source: Hilbert, M., & López, P. (2011). The World's Technological Capacity to Store, Communicate, and Compute Information. *Science*, 332(6025), 60 –65. http://www.martinhilbert.net/WorldInfoCapacity.html

# Big Data in AI

- Traditional data processing applications are inadequate to cope with this mass of data
- Challenges in:
  - analysis, capture, data curation, search, sharing, storage, transfer, visualization, and information privacy.
- Huge interest in the AI/Computing Commmunity – new conferences and funding calls for proposals are going out under the heading of "Big Data"
- Immense potential for machine learning and data mining
  - Discover/learn patterns in data to help make sense of it
  - Massive amounts of data to learn from

# Summary

- AI is a very new field (b. 1956)
- Its history may be divided in various ways, but one way to do so is as follows:
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- Most of its history is still to be written …

# References


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