人工智慧

Artificial Intelligence

資訊工程學系 丁德榮

Course Information

- Email: deron@cc.ncue.edu.tw or deron@ms45.hinet.net
- 研究室：工學院大樓 237室
- 電話：04-7232105-8445
- Course Web Site:
  - 課程錄影 http://dlearn.ncue.edu.tw
- 助教：
  - 分機 8410
  - 實驗室：資工系1樓109室

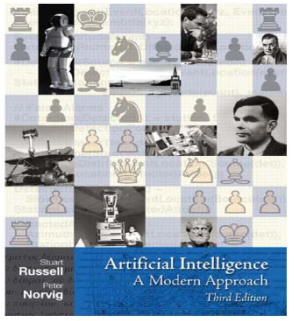
Office Hours

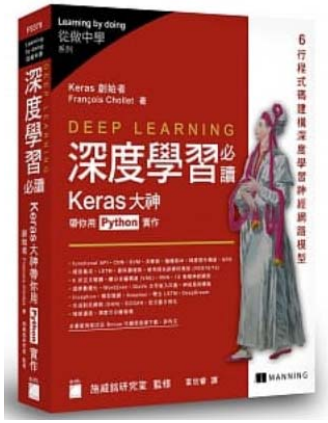
資訊工程學系 專任教師 丁德榮　　印表日期：2022/9/1

	星期一	星期二	星期三	星期四	星期五	星期六	星期日
第1節 08：10~09：00							
第2節 09：05~09：55				54016 資工三 計算機演算法 34304			
第3節 10：15~11：05			Office Hour 237研究室 分機:8445	54016 資工三 計算機演算法 34304			
第4節 11：10~12：00			Office Hour 237研究室 分機:8445	54016 資工三 計算機演算法 34304			
第14節 12：05~12：55							
第5節 13：10~14：00							
第6節 14：05~14：55		54019 資工物聯碩一 人工智慧 33401教室54020 資工三 人工智慧 33401教室	研究生開會	Office Hour 237研究室 分機:8445			
第7節 15：15~16：05		54019 資工物聯碩一 人工智慧 33401教室54020 資工三 人工智慧 33401教室	研究生開會	Office Hour 237研究室 分機:8445			
第8節 16：10~17：00		54019 資工物聯碩一 人工智慧 33401教室54020 資工三 人工智慧 33401教室					

Textbook and References

- 主要教科書：
  - B1. **Artificial Intelligence: A Modern Approach, Stuart Russell and Peter Norvig. (3nd ed), 2009 Chapter 1, 2, 18**
    - **人工智慧：現代方法(第三版),** 歐崇明, 時文中, 陳龍, 全華圖書, 2011
  - B2. Chollet, Deep Learning with Python, François, (First Edition) MANNING PUPLICATIONS, 2017. https://www.manning.com/books/deep-learning-with-python
    - **Deep learning 深度學習必讀：Keras 大神帶你用 Python 實作 葉欣睿譯 旗標**
  - **B3.** 小川雄太郎 (許郁文譯) 實戰人工智慧之深度強化學習：使用PyTorch X Python , 碁峯書局，台灣，2019/07, pp. 210-280 (Chapter 1-5)





參考書目或資源

- 參考書與資料
  - 深度學習必讀 旗標 施威銘研究室
  - Python 深度學習應用實務 陳允傑 旗標
  - Guido van Rossum, Python Tutorial Release 3.7.0 Python Software Foundation, 2018 version, download from:https://bugs.python.org/file47781/Tutorial_EDIT.pdf
  - **Read1**: YOLO: real-time object detection https://pjreddie.com/darknet/yolo/
  - **Read2**: Yolo V4 https://github.com/AlexeyAB
  - **Read3**: Yolo V5 https://github.com/ultralytics/yolov5
  - **Read4**: Pose estimation (TF-lite) https://github.com/tucan9389/PoseEstimation-TFLiteSwift
  - **Read5**: Jetson POSE https://github.com/NVIDIA-AI-IOT/trt_pose
  - **Read6**: Open_POSE https://github.com/CMU-Perceptual-Computing-Lab/openpose

Course Schedule

週次	上課日期	教學單元與進度	學生應預習之章節	作業評量與檢討
1	09/13	課程介紹、AI導論、PBL進行說明 智慧代理人		
2	09/20	智慧代理人		
3	09/27	Searching algorithm Genetic Algorithm Simulated Annealing		Genetic Algorithm 實作。
4	10/04	Introduction of learning： Learning from example， forms of learning，supervised learning，classification， regression，learning decision trees		Decision Tree
5	10/11	Regression and Classification with linear model， support vector machine（SVM） ， knn，clustering， kd－tree， Neural Networks		實作knn
6	10/18	Introduction to Deep learning，Keras， Tensorflow， MINST hand－written digits recognition		實作keras模式解 MINST 手寫數字辨識問題
7	10/25	期中測驗		
8	11/01	CNN		實作CNN 了解，動物影像分類問題
9	11/08	CNN 資料擴充技術		

Course Schedule

10	11/15	遞歸類神經網路（Recurrent Neural Networks， RNN） ， 長期記憶模型（Long Short Term Memory， LTSM）		實作LSTM做時序資料的預測
11	11/22	自編碼模型（Autoencoders） 生成對抗網路（Generative Adversarial Networks）		
12	11/29	強化學習（Reinforcement Learning）導論		實作Q－learning 解Carpole問題
13	12/06	AI 應用於物件辨識的基礎		測試Yolov4、安 裝、測試、物件辨識測試
14	12/13	物件辨識機與物件追蹤理論與實務		物件追蹤
15	12/20	人體活動辨識模型訓練		Gesture Recognition
16	12/27	業師演講		
17	01/03	期末專題報告		
18	01/10	期末專題報告與驗收		

Course overview

- Introduction, 2 weeks
  - PBL Introduction and Intelligent Agents (chapters 1, 2)
- Problem-solving (chapters 3-4) , 1 week
  - Solving Problems by Searching
  - genetic algorithm, simulated annealing algorithm
- Learning (chapters 18), 3 weeks
  - Learning from Examples, deep learning, neural network
  - Reinforcement Learning (Q-learning)
- Deep Learning, 4 weeks
  - CNN, RNN, LTSM, GAN, AE
- Object Detection, Object Tracking, 2 weeks
- Gesture recognition, Pose-estimation, 2 weeks
- Talk, Midterm, 2 weeks
- Final Project, 2 weeks

作業規劃

實驗一：實作基因演算法

實驗二：實作Learning Decision Tree 做資料分類

實驗三：實作knn做資料分類

實驗四：實作keras模式解MINST手寫數字辨識問題

實驗五：實作CNN 解動物影像分類問題

實驗六：應用資料擴充技術

實驗七：實作Q-learning 解Maze問題

實驗八：**LSTM, RNN 人體姿態訓練**

實驗九：測試Yolov4、安裝、測試、物件辨識測試

實驗十：人體活動辨識模型 Gesture Recognition or POSE_estimation

評估方式

- 期中考 ： 15%。
- 實驗完成作品 50%（共10個實驗，每實驗 5%） 。
- 期末專題 35% 。
- 專題競賽報名、參賽、獲獎加分 5%~10%

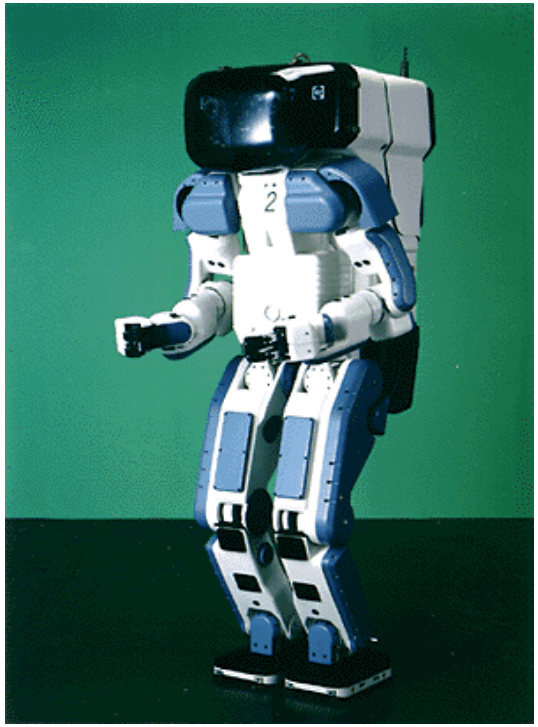
Introduction

學習目標

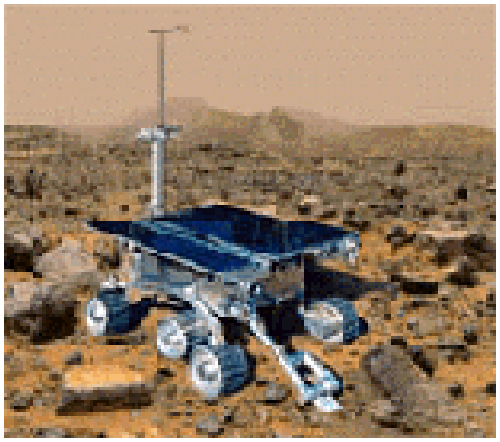
- 人工智慧定義。
- 人工智慧的基礎。
- 人工智慧的發展歷史。
- 人工智慧原理與應用。

Why study AI?
&
What is AI?

Why study AI?



Labor



Science

Appliances

Google

YAHOO!

Search engines

Medicine/
Diagnosis

What else?

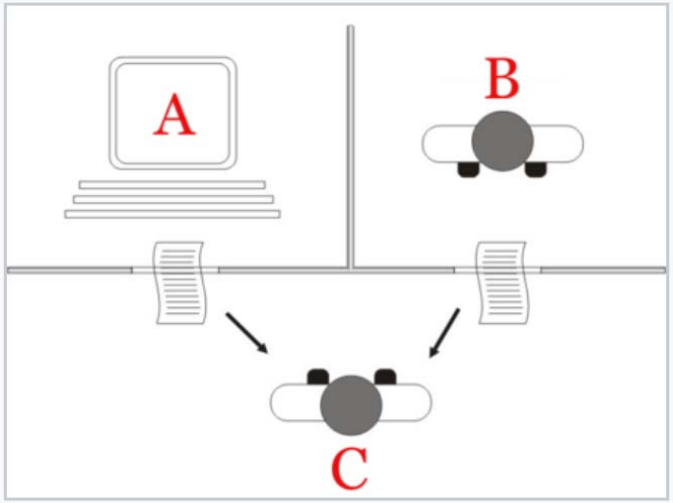
What is AI?

Systems that think like humans	Systems that think **rationally**
"The exciting new effort to make computers think . . . *machines with minds*, in the full and literal sense" (Haugeland, 1985) "[The automation of] activities that we associate with human thinking, activities such as decision-making, problem solving, learning . . ." (Bellman, 1978)	"The study of mental faculties through the use of computational models" (Charniak and McDermott, 1985) "The study of the computations that make it possible to perceive, reason, and act" (Winston, 1992)
Systems that act like humans	**Systems that act rationally**
"The art of creating machines that perform functions that require intelligence when performed by people" (Kurzweil, 1990) "The study of how to make computers do things at which, at the moment, people are better" (Rich and Knight, 1991)	"A field of study that seeks to explain and emulate intelligent behavior in terms of computational processes" (Schalkoff, 1990) "The branch of computer science that is concerned with the automation of intelligent behavior" (Luger and Stubblefield, 1993)

http://aima.cs.berkeley.edu/

Acting Humanly: The Turing Test

- **Alan Turing's** 1950 article *Computing Machinery and Intelligence* discussed conditions for considering a machine to be intelligent
- A computer passes the test if a human interrogator, after posing some **written questions**, cannot tell whether the written **responses** come from a person or from a computer.
  - "Can machines think?" ←→ "Can machines behave intelligently?"
  - The **Turing test** (The Imitation Game): **Operational definition** of intelligence (操作型定義).



The "standard interpretation" of the Turing test, in which player C, the interrogator, is given the task of trying to determine which player – A or B – is a computer and which is a human. The interrogator is limited to using the responses to written questions to make the determination.[1] website: http://www.aisb.org.uk/events/loebner-prize

Ref. https://en.wikipedia.org/wiki/Turing_test

Acting Humanly: The Turing Test

- **Computer needs to possess:**
  - **Natural language processing,**
  - **Knowledge representation,**
  - **Automated reasoning, and**
  - **Machine learning**
- Are there any problems/limitations to the Turing Test?
  - voided direct physical interaction between the interrogator and the computer
- **Total Turing Test**
  - It includes a video signal so that the interrogator can test the subject's perceptual abilities, as well as the opportunity for the interrogator to pass physical objects "through the hatch."
- To pass the total Turing Test, the computer will need
  - **computer vision** to perceive objects, and
  - **robotics** to manipulate objects and move about.

What tasks require AI?

- "AI is the science and engineering of making intelligent machines which can perform tasks that require intelligence when performed by humans …"
- **What tasks require AI?**
  - Solving a differential equation
  - Brain surgery
  - Inventing stuff
  - Playing Jeopardy (電視機智問答, IBM)
  - Playing Wheel of Fortune
  - What about walking?
  - What about grabbing stuff?
  - What about pulling your hand away from fire?
  - What about watching TV?
  - What about day dreaming?

Thinking Humanly: Cognitive Science (認知)

- 1960 "Cognitive Revolution": information-processing psychology replaced behaviorism
- Cognitive science brings together theories and experimental evidence to model **internal activities** of the brain
  - What level of abstraction? "Knowledge" or "Circuits"?
  - How to validate models?
    - Predicting and testing behavior of human subjects (top-down)
    - Direct identification from neurological data (bottom-up)
    - Building computer/machine simulated models and reproduce results (simulation)

Thinking Rationally: Laws of Thought (思維法則)

- Aristotle (~ 450 B.C.) attempted to codify "right thinking"
- 三段論證syllogisms ，邏輯推理(inference)
- P is True and P->Q ⇒ Q is True
  What are correct arguments/thought processes?
- E.g., "Socrates is a man, all men are mortal; therefore Socrates is mortal"
- Several Greek schools developed various forms of **logic**: notation plus rules of derivation for thoughts.

Thinking Rationally: Laws of Thought

- Problems:
  1) Uncertainty: Not all facts are certain (e.g., *the flight might be delayed). Fuzzy logic*
  2) Resource limitations:
     - Not enough time to compute/process
     - Insufficient memory/disk/etc.
     - NP-hard/complete problem,
     - Etc.

Acting Rationally: The Rational Agent (代理人)

- Rational behavior: Doing the right thing!
- The right thing: That which is expected to maximize the expected return
- Provides the most general view of AI because it includes:
  - Correct inference ("Laws of thought")
  - Uncertainty handling
  - Resource limitation considerations (e.g., reflex vs. deliberation)
  - Cognitive skills (NLP, knowledge representation, etc.)
- Advantages:
  1) More general
  2) Its goal of rationality is well defined

How to achieve AI?

- How is AI research done?
- AI research has both theoretical and experimental sides. The experimental side has both basic and applied aspects.
- There are two main lines of research:
  - One is biological(生物的), based on the idea that since humans are intelligent, AI should study humans and imitate their psychology or physiology.
  - The other is phenomenal(現象的), based on studying and formalizing common sense facts about the world and the problems that the world presents to the achievement of goals.
- The two approaches interact to some extent, and both should eventually succeed. It is a race, but both racers seem to be walking. [**John McCarthy]**

Branches of AI

- **Logical AI, Search**
- **Natural language processing**
- **Pattern recognition**
- **Knowledge representation**
- **Inference** From some facts, others can be inferred.
- **Automated reasoning**
- **Learning from experience**
- **Planning** To generate a strategy for achieving some goal
- **Epistemology(認識論)** Study of the kinds of knowledge that are required for solving problems in the world.
- **Ontology** (本體論) Study of the kinds of things that exist. In AI, the programs and sentences deal with various kinds of objects, and we study what these kinds are and what their basic properties are.
- **Learning, Genetic programming**

Foundations of AI

Foundations - Philosophy

- Aristotle (亞里斯多德)(384 B.C.E.)
  - Author of logical syllogisms
- da Vinci (達文西)(1452)
  - designed, but didn't build, first mechanical calculator
- Descartes (笛卡兒)(1596)
  - can human free will be captured by a machine?
  - Is animal behavior more mechanistic?
- Necessary connection between logic and action is discovered

Foundations - Mathematics

- What are the formal rules to draw valid conclusions?
- What can be computed?
- How do we reason with uncertain information?
- More formal logical methods
  - **Boolean logic** (Boole, 1847)
- Analysis of limits to what can be computed
  - **Intractability** (1965) – time required to solve problem scales exponentially with the size of problem instance
  - **NP-complete** (1971) – Formal classification of problems as intractable
  - **Turing Machine/Halting problem**
- **Uncertainty** (Cardano 1501)
  - The basis for most modern approaches to AI
  - Uncertainty can still be used in logical analyses

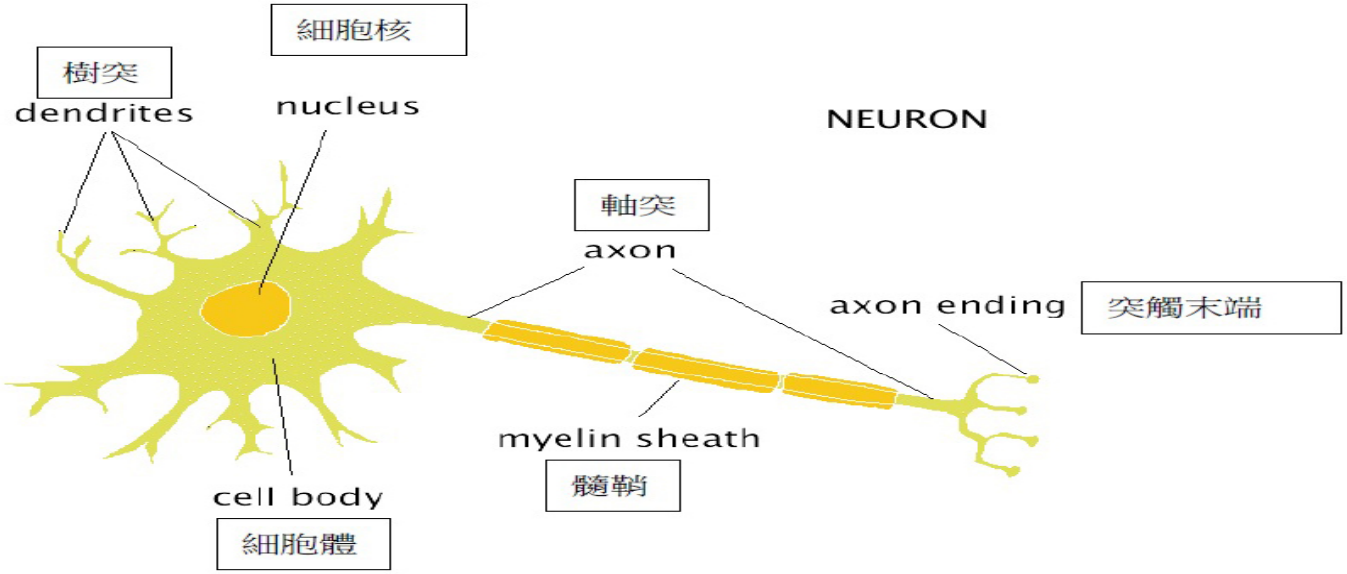
Foundations - Economics

- How should we make decisions so as to maximize payoff?
- How should we do this when others may not go along?
- How should we do this when the payoff may be far in the future?
- Humans are peculiar so define generic happiness term: utility
  - Decision Theory
  - Game Theory – study of rational behavior in small games
  - Operations Research – study of rational behavior in complex systems
  - Markov decision process
  - Herbert Simon (1916 – 2001) – AI researcher who received Nobel Prize in Economics for showing people accomplish **satisficing** solutions(non-optimal solution), those that are good enough

Foundations - Neuroscience

- How do brains work?
  - Early studies (1824) relied on injured and abnormal people to understand what parts of brain do
  - More recent studies use accurate sensors to correlate brain activity to human thought
    - By monitoring individual neurons, monkeys can now control a computer mouse using thought alone
  - **Moore's law** states computers will have as many gates as humans have neurons in 2020
  - How close are we to having a mechanical brain?
    - Parallel computation, remapping, interconnections, binary vs. gradient…

神經元 nerve cell or neuron



	Supercomputer	Personal Computer	Human Brain
Computational units	10^4 CPUs, 10^{12} transistors	4 CPUs, 10^9 transistors	10^{11} neurons
Storage units	10^{14} bits RAM	10^{11} bits RAM	10^{11} neurons
	10^{15} bits disk	10^{13} bits disk	10^{14} synapses
Cycle time	10^{-9} sec	10^{-9} sec	10^{-3} sec
Operations/sec	10^{15}	10^{10}	10^{17}
Memory updates/sec	10^{14}	10^{10}	10^{14}

http://webspace.ship.edu/cgboer/theneuron.html

Foundations - Psychology

- Helmholtz and Wundt (1821) – started to make psychology a science by carefully controlling experiments
- The brain processes information (1842)
  - stimulus converted into mental representation
  - cognitive processes manipulate representation to build new representations
  - new representations are used to generate actions
- Cognitive science started at a MIT workshop in 1956 with the publication of three very influential papers

Foundations – Control Theory

- Machines can modify their behavior in response to the environment (sense / action loop)
  - Water-flow regulator (250 B.C.E), steam engine governor, thermostat
- The theory of **stable feedback systems** (1894)
  - Build systems that transition from initial state to goal state with minimum energy
  - In 1950, control theory could only describe **linear systems** and AI largely rose as a response to this shortcoming

Foundations - Linguistics

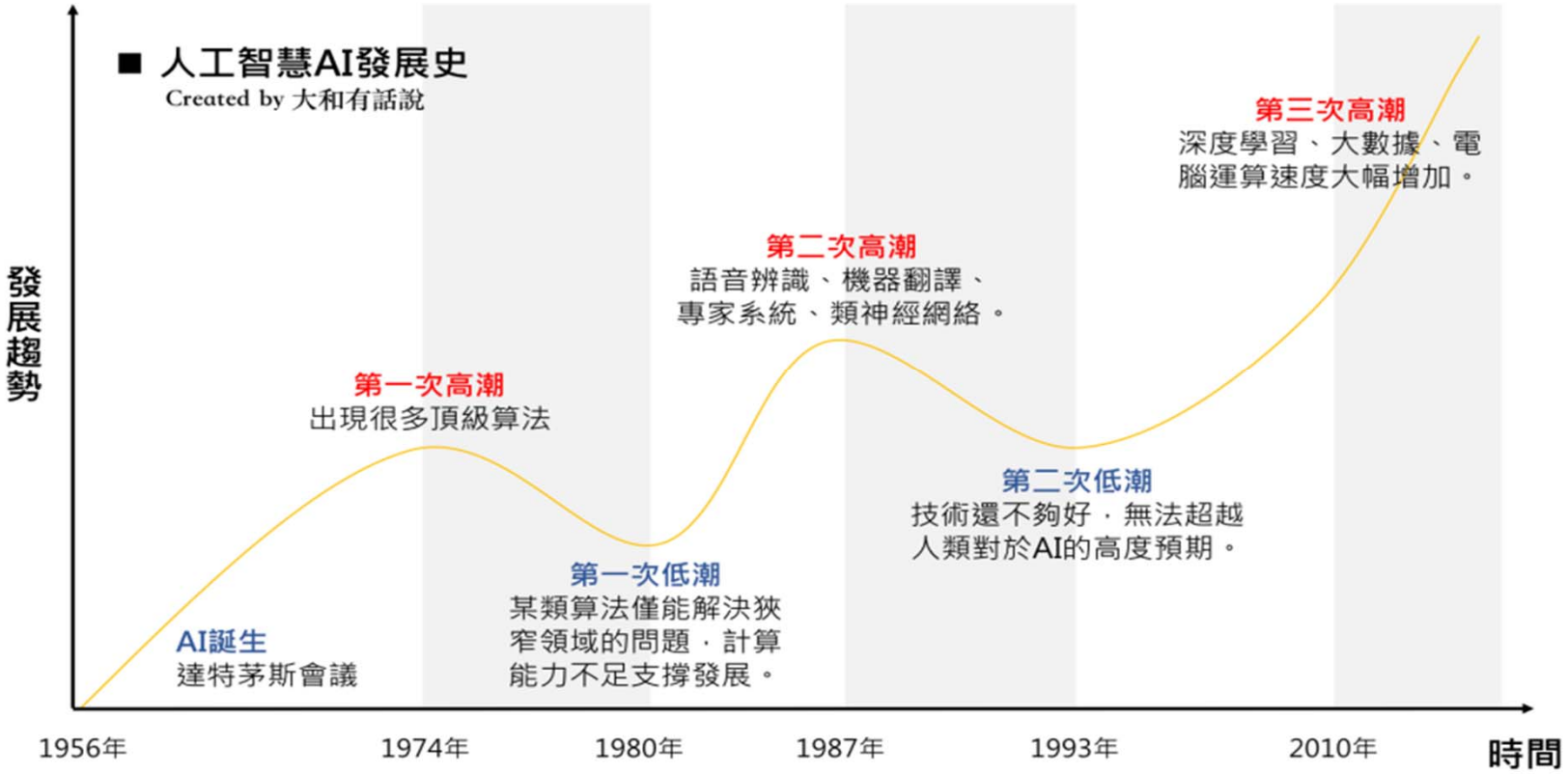
- Speech demonstrates so much of human intelligence
  - Analysis of human language reveals thought taking place in ways not understood in other settings
    - Children can create sentences they have never heard before
    - Language and thought are believed to be tightly intertwined

History of AI

A (Short) History of AI

- 1940-1950: Early days
  - 1943: McCulloch & Pitts: Boolean circuit model of brain (neural network)
  - 1950: Turing's "Computing Machinery and Intelligence"
- 1950—70: Excitement: Look, Ma, no hands!
  - 1950s: Early AI programs, GPS(general problem solver), including Samuel's checkers program, Newell & Simon's Logic Theorist , Gelernter's Geometry Engine, LISP, First-order Logic
  - 1956: Dartmouth meeting: "Artificial Intelligence" adopted
  - 1965: Robinson's complete algorithm for logical reasoning/proception
- 1970—90: **Knowledge-based approaches**
  - 1969—79: Early development of knowledge-based systems
  - 1980—88: Expert systems industry booms
  - 1988—93: Expert systems industry busts: "AI Winter"
- 1990—: **Statistical approaches**
  - Resurgence of probability, focus on uncertainty
  - General increase in technical depth
  - Agents and learning systems… "AI Spring"?
- 2000—: Where are we now?

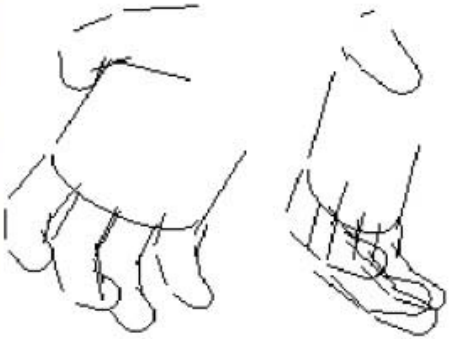
AI 的三次浪潮

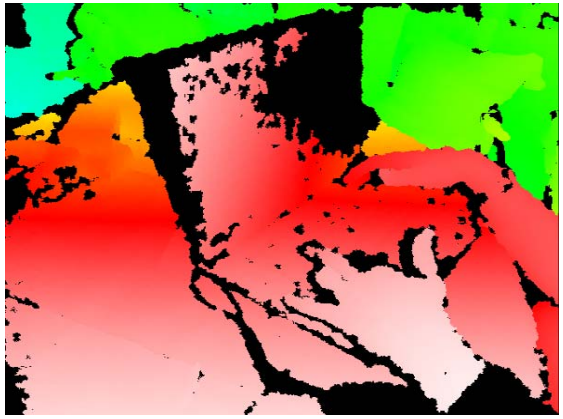


https://dahetalk.com/2018/04/08/完整解析ai人工智慧%EF%BC%9A3大浪潮%EF%BC%8B3大技術%EF%BC%8B3大應用%EF%BD%9C/

Vision (Perception)

- Object and face recognition
- Scene segmentation
- Image classification





Images from Erik Sudderth (left), wikipedia (right)

Game Playing

- Classic Moment: May, '97: **Deep Blue** vs. Kasparov
  - First match won against world champion
  - “Intelligent creative” play
  - **200 million** board positions per second
  - Humans understood 99.9 of Deep Blue's moves
  - Can do about the same now with a PC cluster
- Open question:
  - How does human cognition deal with the search space explosion of chess?
  - Or: how can humans compete with computers at all??
- Huge game-playing advances recently, e.g. in Go!

Image from IBM’s Deep Blue pages

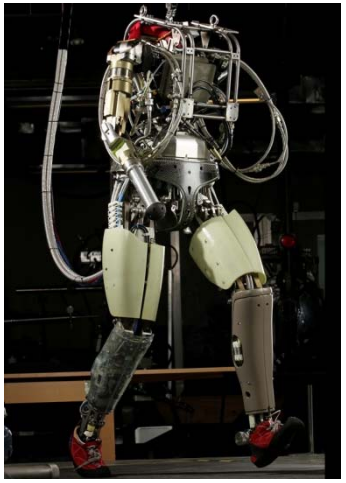
Robotics

- Robotics
  - Part mech. eng.
  - Part AI
  - Reality much harder than simulations!

- Technologies
  - Vehicles
  - Rescue
  - Soccer!
  - Lots of automation…

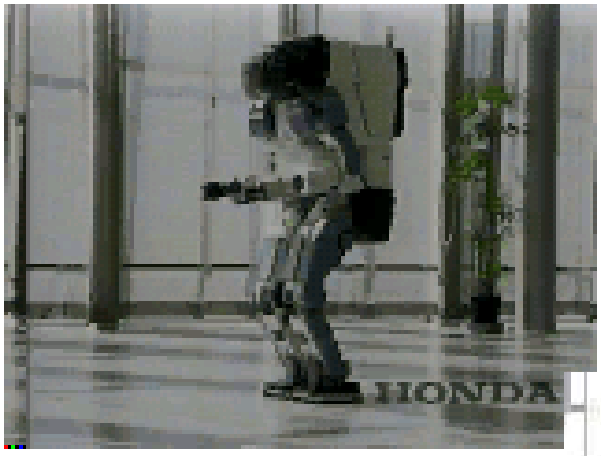
- In this class:
  - We ignore mechanical aspects
  - Methods for planning
  - Methods for control

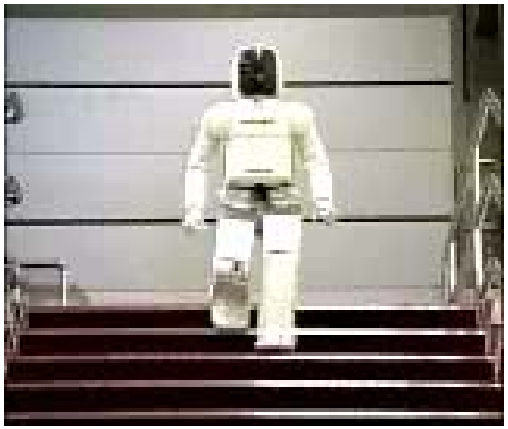
Demo 1: ROBOTICS – soccer.avi
Demo 2: ROBOTICS – soccer2.avi
Demo 3: ROBOTICS – gcar.avi
Demo 4: ROBOTICS – laundry.avi
Demo 5: ROBOTICS – petman.avi



Images from UC Berkeley, Boston Dynamics, RoboCup, Google

Honda Humanoid Robot





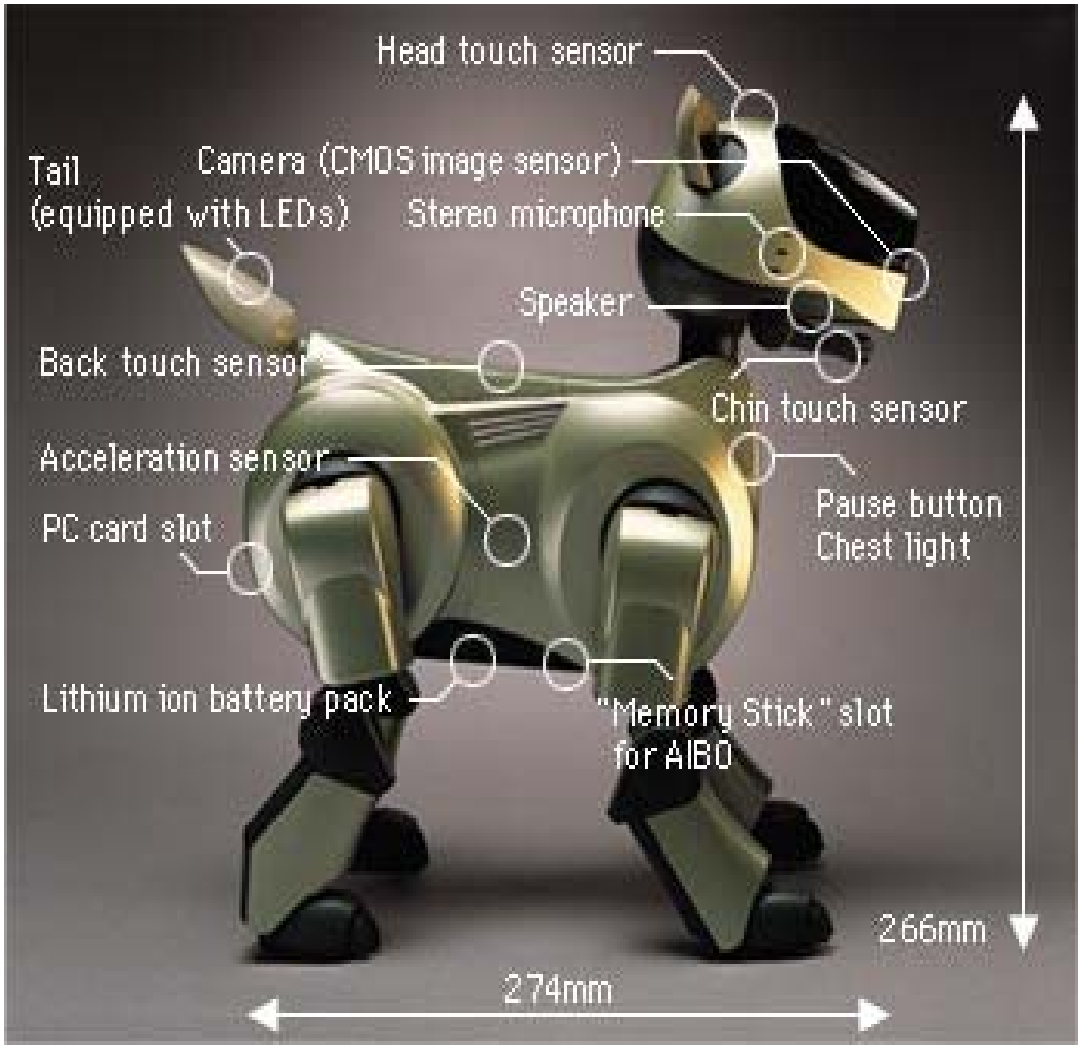
Walk

Turn

Stairs

http://world.honda.com/robot/

Sony AIBO

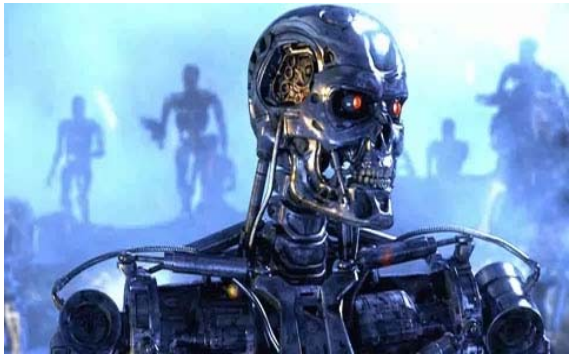


http://www.aibo.com

Natural Language Question Answering

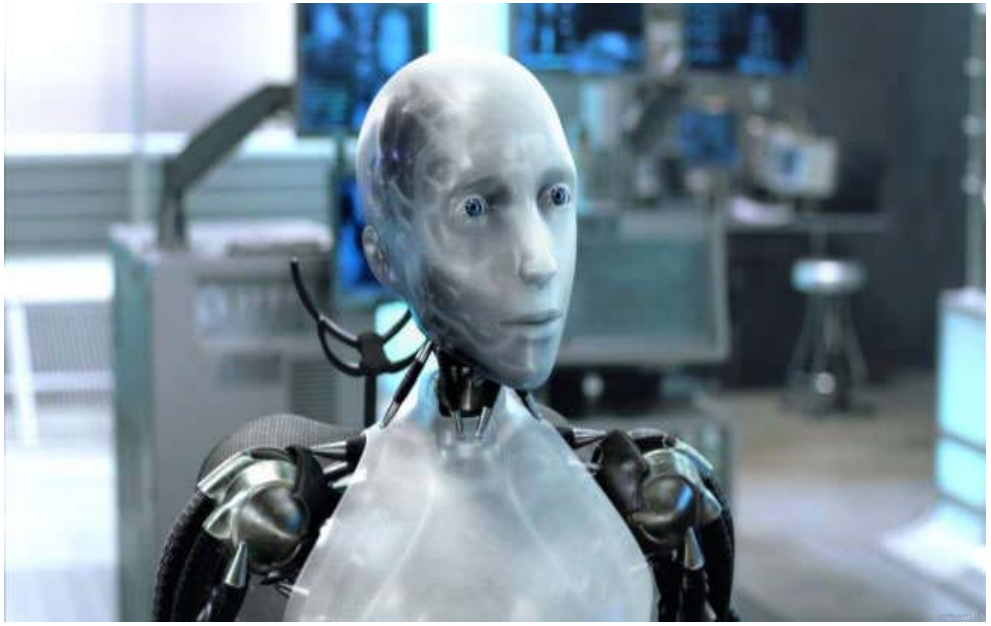
http://aimovie.warnerbros.com http://www.ai.mit.edu/projects/infolab/

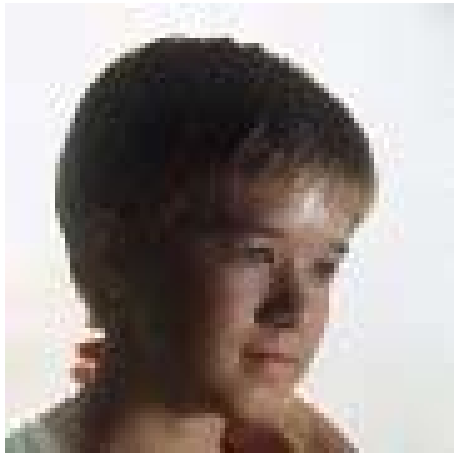
Sci-Fi AI?




Disney · PIXAR
WALL·E


© Disney





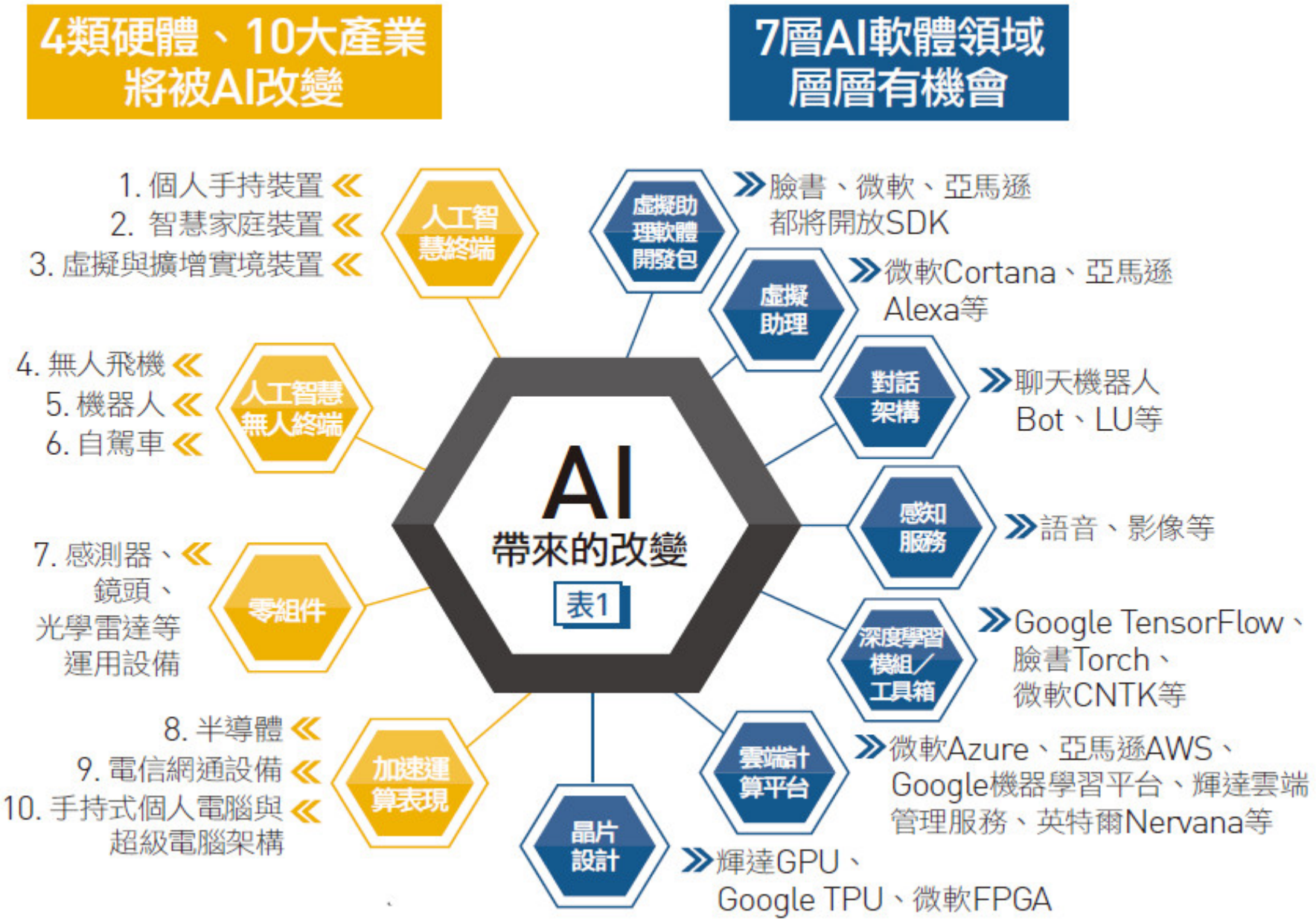
State of the art

- Proved a mathematical **conjecture** (Robbins conjecture) unsolved for decades
- **AutoCar**: No hands across America (driving autonomously 98% of the time from Pittsburgh to San Diego)
- During the 1991 Gulf War, US forces deployed an **AI logistics planning and scheduling program** that involved up to 50,000 vehicles, cargo, and people
- **NASA's** on-board **autonomous planning** program controlled the scheduling of operations for a spacecraft
- DARPA grand challenge: Autonomous vehicle navigates across desert and then urban environment.
- iRobot Roomba automated vacuum cleaner, and PackBot used in Afghanistan and Iraq wars.
- **Proverb** solves crossword puzzles better than most humans

State of the Art

- Automated speech/language systems for airline travel.
- **Spam filters** using machine learning.
- Question answering systems automatically answer factoid questions.
- Usable **machine translation** thru Google.
- 2008年 機器學習 (machine learning)、
- 2009年 Siri、
- 2013年 深度學習(deep learning)、
- 2014年 神經形態晶片 、
- 2016年 語音介面與知識分享型機器人，
- 2016 Alpha Go
- 2017年 自動駕駛卡車與強化學習 。

https://www.mirrormedia.mg/story/20180222int001/


4類硬體、10大產業
將被AI改變
7層AI軟體領域
層層有機會
1. 個人手持裝置
2. 智慧家庭裝置
3. 虛擬與擴增實境裝置
人工智慧終端
4. 無人飛機
5. 機器人
6. 自駕車
人工智慧無人終端
7. 感測器、鏡頭、光學雷達等運用設備
零組件
8. 半導體
9. 電信網通設備
10. 手持式個人電腦與超級電腦架構
加速運算表現
晶片設計
AI
帶來的改變
表1
虛擬助理軟體開發包
臉書、微軟、亞馬遜都將開放SDK
虛擬助理
微軟Cortana、亞馬遜Alexa等
對話架構
聊天機器人Bot、LU等
感知服務
語音、影像等
深度學習模組／工具箱
Google TensorFlow、臉書Torch、微軟CNTK等
雲端計算平台
微軟Azure、亞馬遜AWS、Google機器學習平台、輝達雲端管理服務、英特爾Nervana等
輝達GPU、Google TPU、微軟FPGA