FACULTY OF INFORMATION TECHNOLOGY

Artificial Intelligence Fundamentals (NM TTNT)

Semester 1, 2022/2023

Chapter 1. Introduction to AI

Content

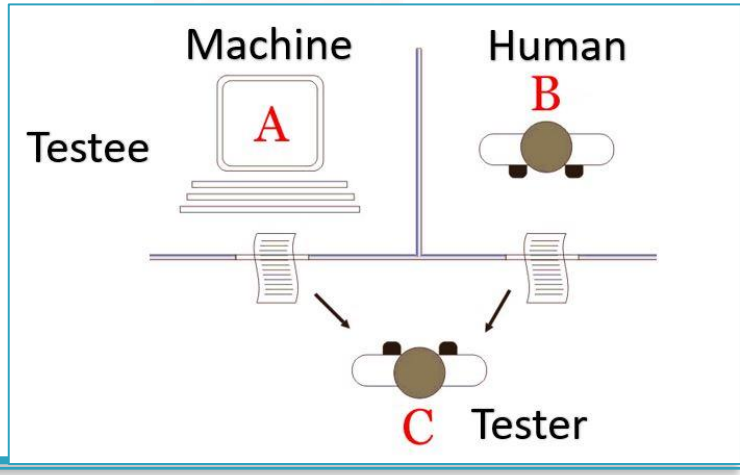
- What is AI?
- AI application areas
- The history of AI
- The state of the art
- Fundamental issues for AI problems

Turing Test

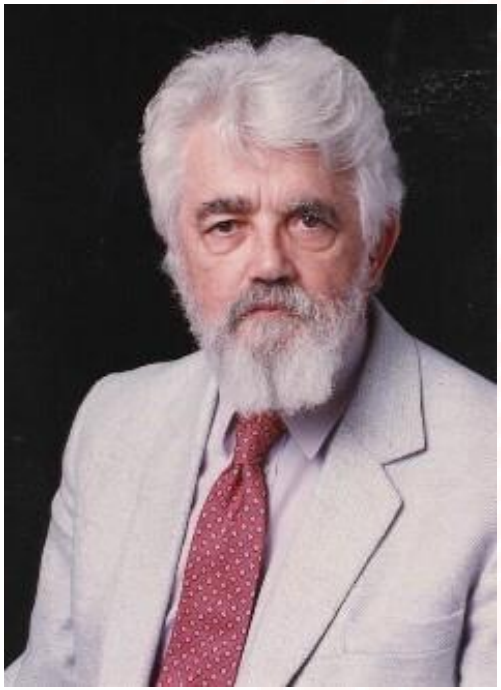
- In 1950, Alan Turing defined a test of whether a machine could "think"

- "A human judge engages in a natural language conversation with one human and one machine, each of which tries to appear human. If judge can't tell, machine passes the Turing test"

en.wikipedia.org/wiki/Turing_test



What is AI?



"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."

"Intelligence is the computational part of the ability to achieve goals in the world."

John McCarthy

What is AI?

"AI is
the design, study and
construction
of computer programs
that behave
intelligently."

Tom Dean

What is AI?

"AI is the study of complex information processing problems that often have their roots in some aspect of biological information processing.

The goal of the subject is to identify solvable and interesting information processing problems, and solve them."

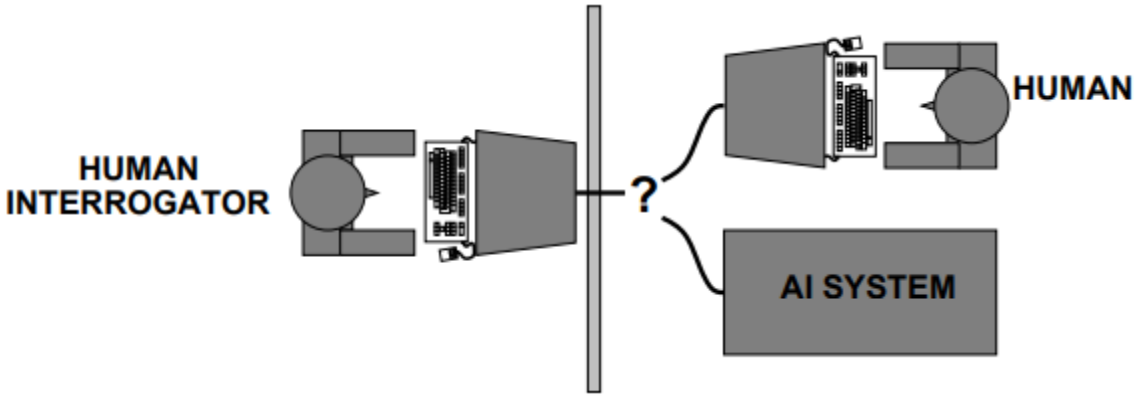
David Marr (1945–1980)

What is AI? (Approaches)

Thinking Humanly	**Thinking 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)
Acting Humanly	**Acting 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)	"Computational Intelligence is the study of the design of intelligent agents." (Poole *et al.*, 1998) "AI . . . is concerned with intelligent behavior in artifacts." (Nilsson, 1998)

Acting Humanly: The Turing Test approach

- Turing (1950) "Computing machinery and intelligence":
  - "Can machines think?" → "Can machines behave intelligently?"
  - Operational test for intelligent behavior: the Imitation Game



  - Suggested major components of AI: knowledge, reasoning, language understanding, learning

➔**Problem**: Turing test is not reproducible, constructive, or amenable to mathematical analysis

Thinking humanly: The cognitive modeling approach

- 1960s "cognitive revolution": information – processing psychology replaced prevailing orthodoxy of behaviorism
- Requires scientific theories of internal activities of the brain
  - What level of abstraction? "**Knowledge**" or "**circuits**"?
  - How to validate? Requires
    - 1) Predicting and testing behavior of human subjects (top-down) or
    - 2) Direct identification from neurological data (bottom-up)
- Both approaches (roughly, Cognitive Science and Cognitive Neuroscience) are now distinct from AI

Thinking rationally: The "laws of thought" approach

- Normative (or prescriptive) rather than descriptive
- **Example:** "Socrates is a man; all men are mortal; therefore, Socrates is mortal."
- Several Greek schools developed various forms of *logic notation* and *rules of derivation* for thoughts; may or may not have proceeded to the idea of mechanization
- Direct line through mathematics and philosophy to modern AI
- Problems:
  - Not all intelligent behavior is mediated by logical deliberation
  - What is the purpose of thinking? What thoughts should I have out of all the thoughts (logical or otherwise) that I could have?

Acting rationally: The rational agent approach

- Rational behavior: doing the right thing
- The right thing: that which is expected to maximize goal achievement, given the available information
- Doesn't necessarily involve thinking—e.g., blinking reflex—but thinking should be in the service of rational action
- Aristotle (Nicomachean Ethics):

  Every art and every inquiry, and similarly every action and pursuit, is thought to aim at some good

Rational Agents

- An agent is an entity that *perceives* and *acts*
- This course is about designing rational agents
- Abstractly, an agent is a function from percept histories to actions:

$$f : P^* \longrightarrow A$$

- For any given class of environments and tasks, we seek the agent (or class of agents) with the best performance

- **Caveat**: computational limitations make perfect rationality unachievable

➔ design best program for given machine resources

What is intelligent behavior?

- Perceiving one's environment
- Acting in complex environments
- Learning and understanding from experience
- Using reasoning to solve problems and to discover "hidden" knowledge
- Applying knowledge successfully in new situations
- Thinking abstractly, using analogies
- Communicating with others

AI prehistory

Philosophy	
Mathematics	
Economics	
Neuroscience	
Psychology	
Computer engineering	
Control theory	
Linguistics	

AI prehistory (cont.)

Philosophy	Logic, methods of reasoning, mind as physical system foundations of learning, language, rationality
Mathematics	Formal representation and proof algorithms, computation, (un)decidability, (in)tractability, probability
Economics	utility, decision theory
Neuroscience	physical substrate for mental activity
Psychology	phenomena of perception and motor control, experimental techniques
Computer engineering	building fast computers
Control theory	design systems that maximize an objective function over time
Linguistics	knowledge representation, grammar

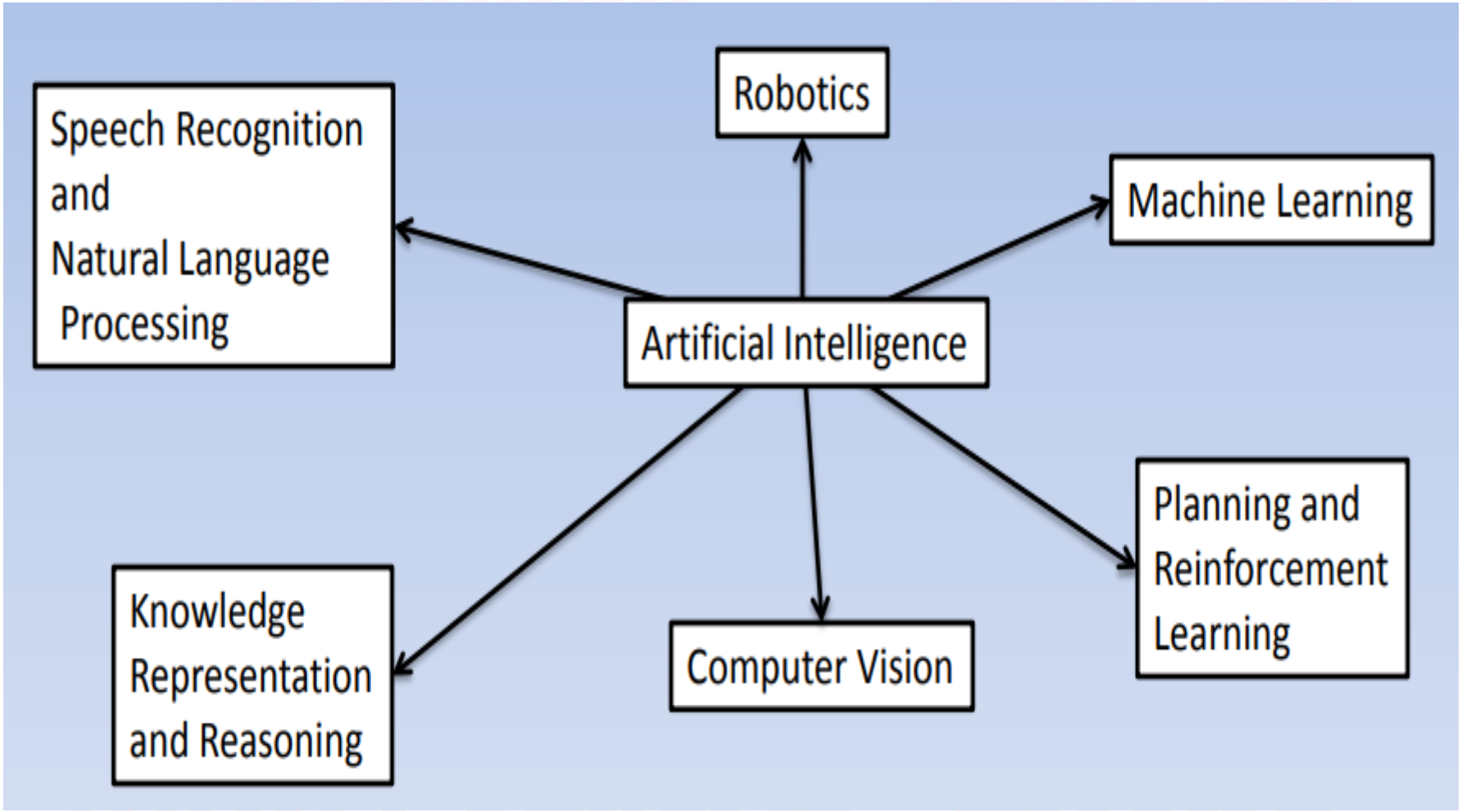
A Brief History of AI

- **1943**: McCulloch & Pitts: Boolean circuit model of brain
- **1950**: Turing's "Computing Machinery and Intelligence"
- **1952–69**: Look, Ma, no hands!
- **1950s**: Early AI programs, including Samuel's checkers program, Newell & Simon's Logic Theorist, Gelernter's Geometry Engine
- **1956: Dartmouth meeting: "Artificial Intelligence" adopted**
- **1965**: Robinson's complete algorithm for logical reasoning
- **1966– 74**: AI discovers computational complexity; Neural network research almost disappears
- **1969 – 79**: Early development of knowledge-based systems

A Brief History of AI (cont.)

- **1980 – 88**: Expert systems industry booms (the Japanese government aggressively funded AI with its fifth generation computer project)
- **1988 – 93**: Expert systems industry busts: "AI Winter"
- **1985 – 95**: Neural networks return to popularity
- **1988 – present**: Resurgence of probability; general increase in technical depth; "Nouvelle AI": ALife, GAs, soft computing
- **1995 – present**: Agents, agents, everywhere . . .
- **2003 – present**: Human-level AI back on the agenda
- **2011– present**: Deep learning, big data and artificial general intelligence (**strong AI**)

AI Subfields



AI Applications

1. Language translation services (Google)
2. News aggregation and summarization (Google)
3. Speech recognition (Nuance)
4. Song recognition (Shazam)
5. Face recognition (Recognizer)
6. Image recognition (Google Goggles)
7. Question answering (Apple Siri, IBM Watson)
8. Chess playing (IBM Deep Blue)
9. 3D scene modeling from images (Microsoft Photosynth)
10. Driverless cars (Google)
11. IBM Watson for oncology (applied in Vietnam)
12. …

AI Applications (cont.)

- Most recent success of AI based on *machine learning*

AI-based on Machine Learning

"Many developers of AI systems now recognize that, for many applications, it can be far easier to train a system by showing it examples of desired input-output behavior than to program it manually by anticipating the desired response for all possible inputs."

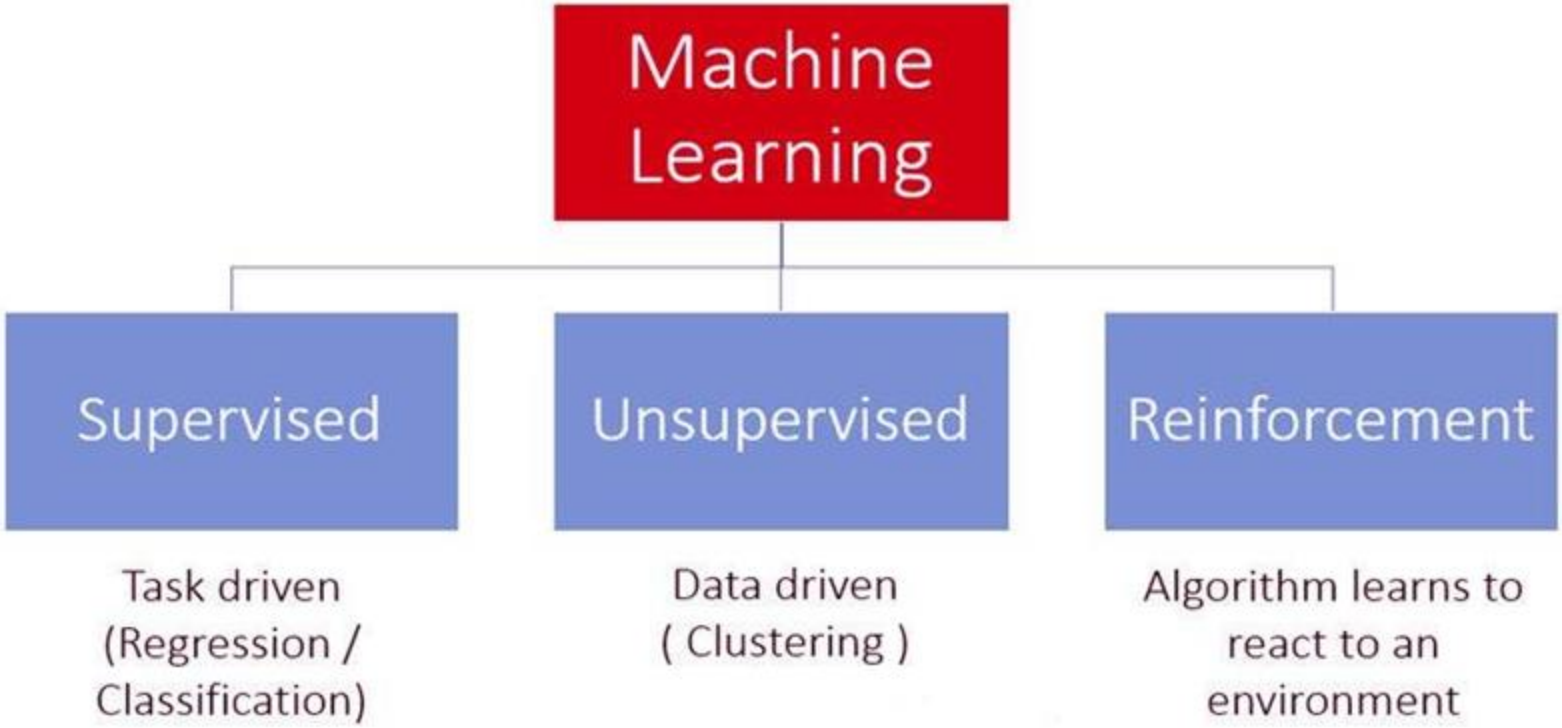
M.I. Jordan,T. Mitchell. Machine Learning: Trends, perspectives, and prospects. Science, 349 (6245), 255–260, 2015.

What is Machine Learning?

- Wikipedia: (ML introduced in 1980's)
  - *Machine learning is the subfield of computer science that "gives computers the ability to learn without being explicitly programmed"*

- Ability of computers to "learn" from "data" or "past experience"
  - learn: Make intelligent predictions or decisions based on data by optimizing a model
  - data: Comes from various sources such as sensors, domain knowledge, experimental runs, etc.

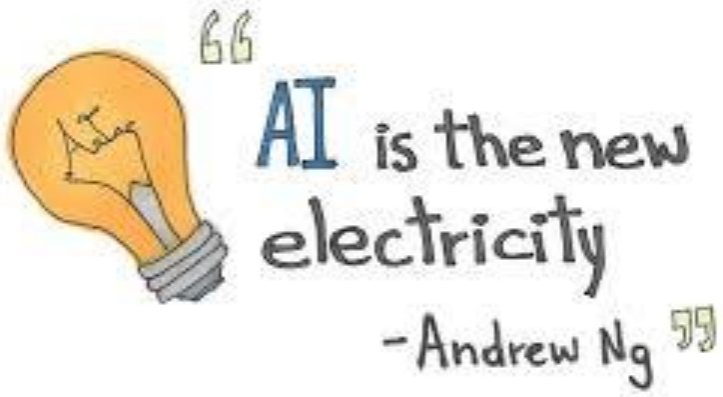
Types of Machine Learning



Artifical Intelligence vs Machine Learning vs Deep Learning

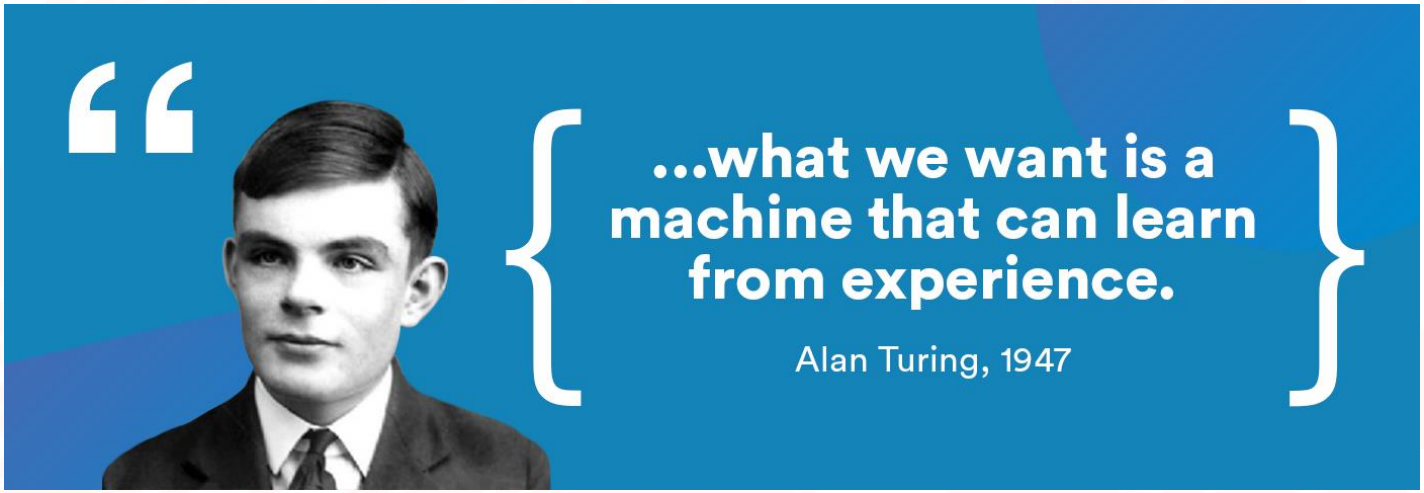
Artifical Intelligence

- Human intelligence exhibited by machines
  - empowers computers to mimic human intelligence such as decision making, text processing, and visual perception.



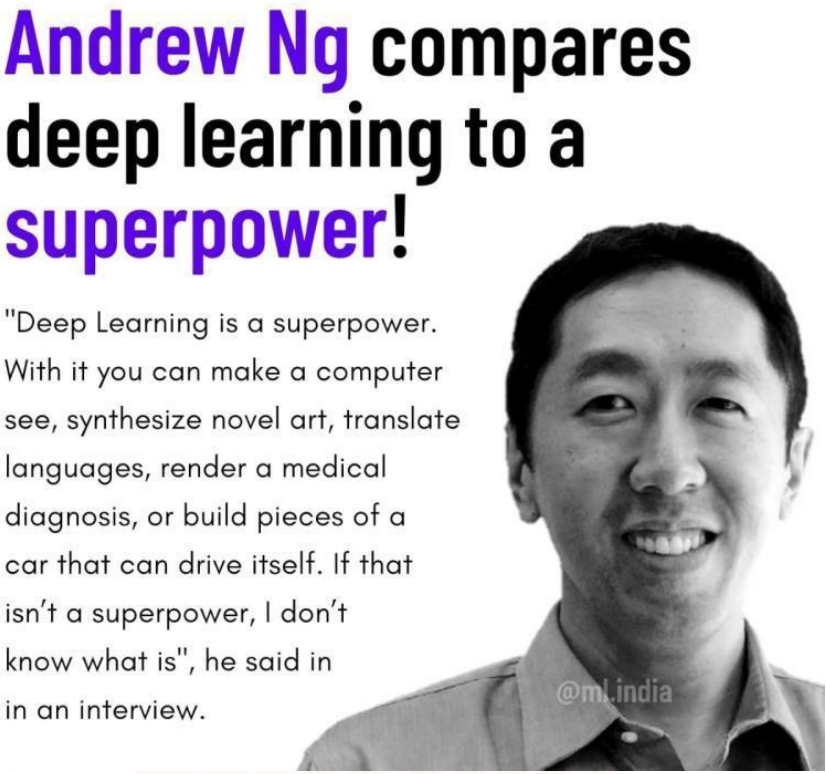
Machine Learning

- An approach to achieve Artificial Intelligence.
  - a subfield of Artificial Intelligence that enables machines to improve at a given task with experience



Deep Learning

- A technique for implementing machine learning
  - a specialized field of Machine Learning that relies on training of Deep Artificial Neural Networks (ANNs) using a large dataset such as images or texts

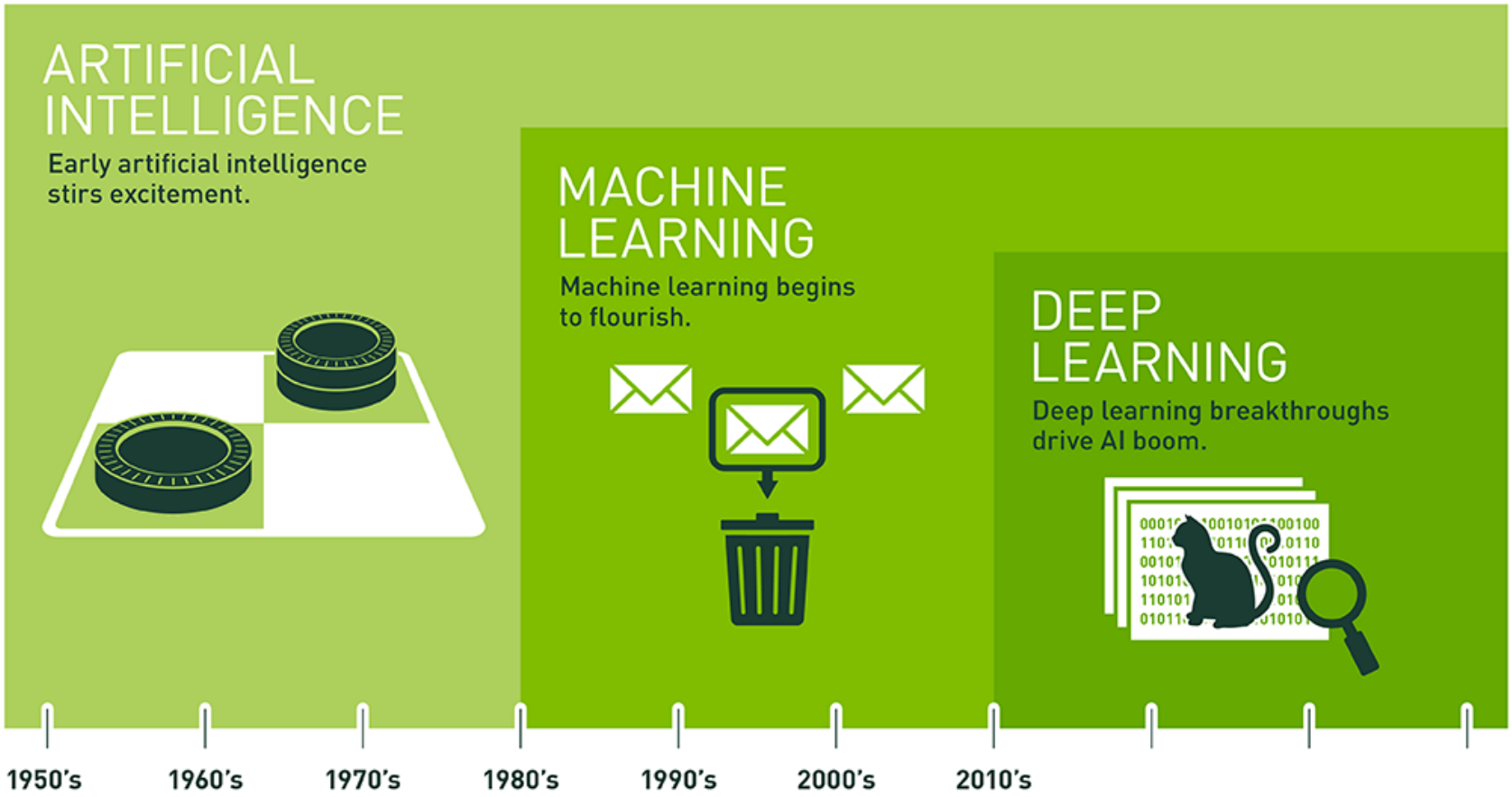


AI vs ML vs DL

- AI: Human intelligence exhibited by machines
  - empowers computers to mimic human intelligence such as decision making, text processing, and visual perception.
- ML: An approach to achieve Artificial Intelligence.
  - a subfield of Artificial Intelligence that enables machines to improve at a given task with experience
- DL: A technique for implementing machine learning
  - a specialized field of Machine Learning that relies on training of Deep Artificial Neural Networks (ANNs) using a large dataset such as images or texts

➔ Thanks to **Deep Learning**, AI has a bright future

AI vs ML vs DL (cont.)



Since an early flush of optimism in the 1950s, smaller subsets of artificial intelligence – first machine learning, then deep learning, a subset of machine learning – have created ever larger disruptions.

State of the Art (STOA)

STOA

- AI Applications:
  - Robotic vehicles
  - Speech recognition
  - Autonomous planning and scheduling
  - Game playing
  - Spamfighting
  - Logistics planning
  - Robotics
  - Machine Translation
  - …

STOA: Robotic Vehicles

- 2006, a driverless robotic car – STANLEY won in DARPA Grand Challenge (dessert)
- 2007, a driverless robotic car – CMU's BOSS won in Urban Challenge
- Tesla Autopilot

STOA: Speech Recognition

- PEGASUS allows users to obtain flight info and make reservations by speaking over the phone

STOA: Speech Recognition (cont.)

- Google Assistant: (by voice, text)
  - 06/05/2019 officially available in Vietnamese.
  - Tasks can be undertaken by Google Assistant: reminders, alarms, timers, weather forecasts and directions

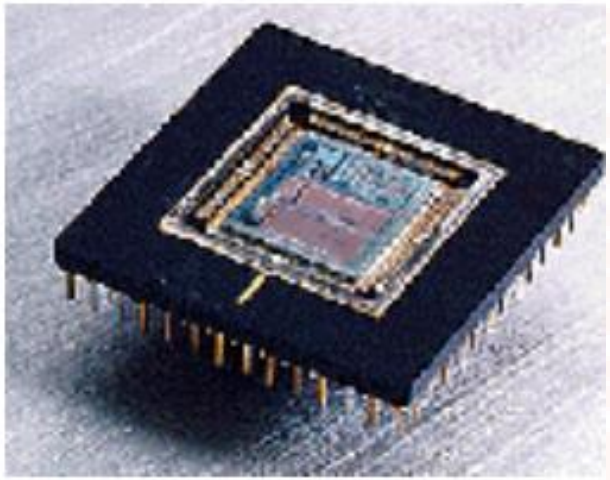
STOA: Autonomous Planning and Scheduling

- NASA's Remote Agent program (2000): controls the scheduling of operations for a spacecraft.
- MAPGEN (2004): plans the daily operations for NASA's Mars Exploration Rovers
- MEXAR2 (2007): logistics and science planning—for the European Space Agency's Mars Express

STOA: Game Playing – Chess

- 1997, Deep Blue (IBM) has defeated Garry Kasparov

won 3 games,
lost 2,
tied 1



Deep Blue chip

STOA: Game Playing – Go

- 2016, AlphaGo (Deepmind, Google) has defeated Lee Sedol.

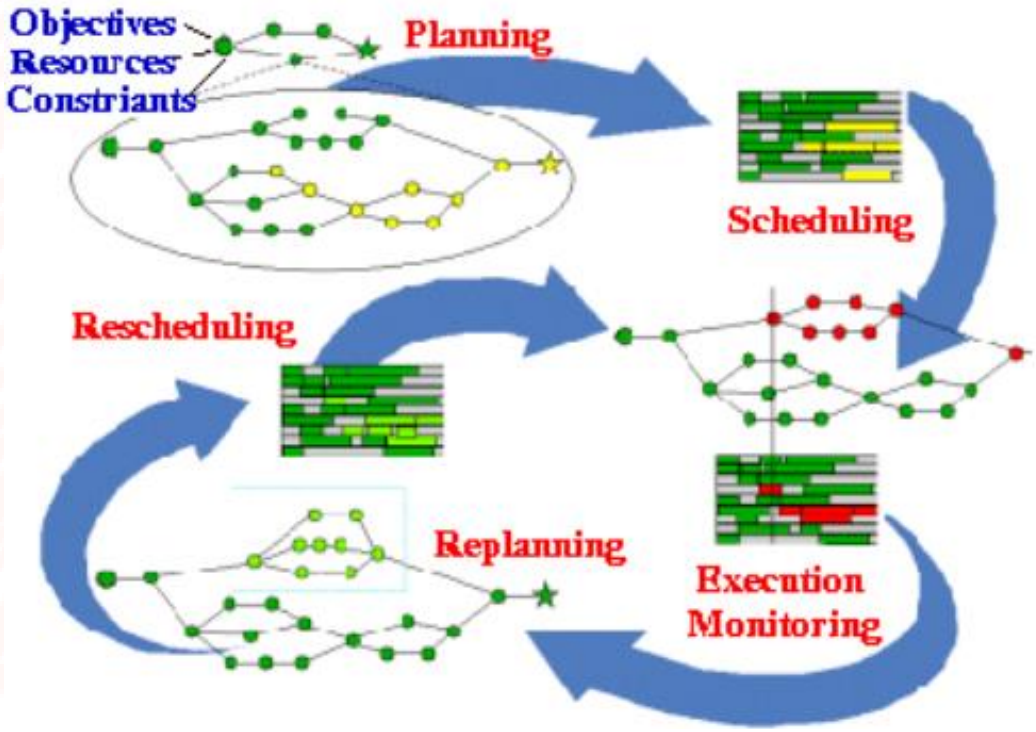
won 4 games,
lost 1

STOA: SpamFighting

- Learning algorithms classify over a billion messages as spam

STOA: Logistics Planning

- In 1991, U.S. forces deployed a **D**ynamic **A**nalysis and **R**eplanning **T**ool, DART to do:
  - automated logistics planning and scheduling for transportation.



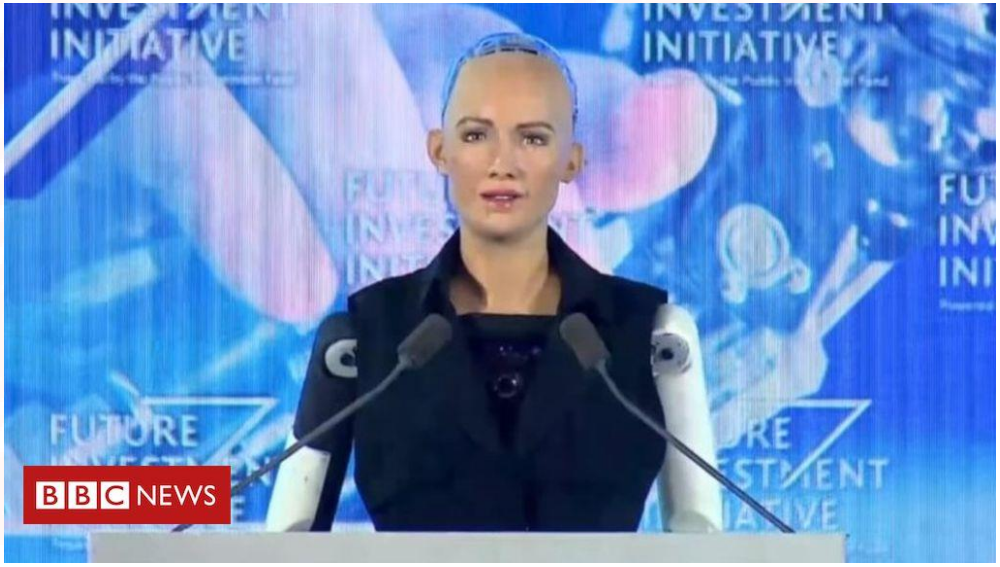
STOA: Robotics

- iRobot Corporation: has sold millions of Roomba robotic vacuum cleaners

- iRobot: also deployed PackBot to Iraq and Afghanistan for handling:
  - hazardous materials,
  - clear explosives, and
  - identify the location of snipers.

STOA: Robotics (cont.)

- Sophia: a social humanoid robot
  - developed by Hong Kong based company Hanson Robotics.
  - activated on February 14, 2016
  - 10/2017, became a Saudi Arabian citizen – the first robot to receive citizenship of any country

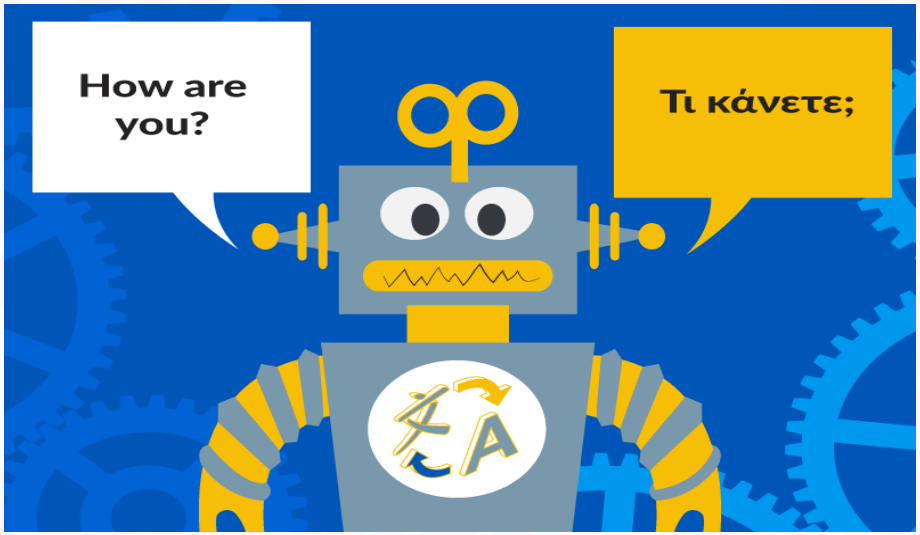


STOA: Robotics (cont.)

- Industrial robots
  - Robots are used in manufacturing to take on repetitive tasks, which streamlines the overall assembly workflow

STOA: Machine Translation

- Brants et al., 2007: developed a computer program automatically translates from Arabic to English



STOA: Computer Vision

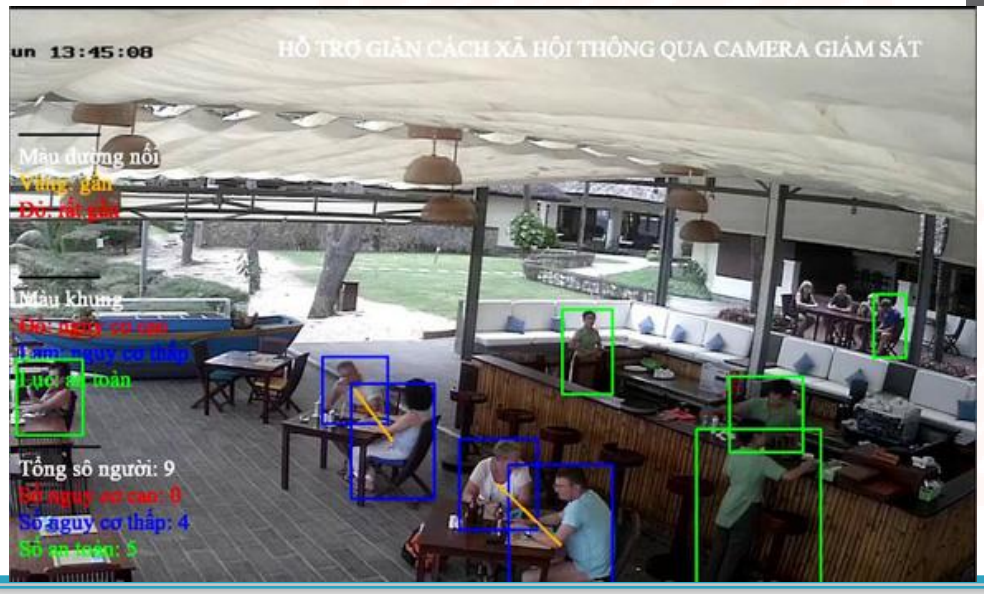
- Face recognition programs:
  - banks, casinos, police

- CMU's ALVINN:
  - autonomously drove a van from Washington, D.C. to San Diego, averaging 63 mph day and night, in all weather conditions

- Handwriting recognition, electronics and manufacturing inspection, photo-interpretation, baggage inspection, etc.

STOA: Computer Vision (cont.)

- A monitoring system for ensuring safe distance in **COVID-19** pandemic (by MMLab, VNU-HCM)



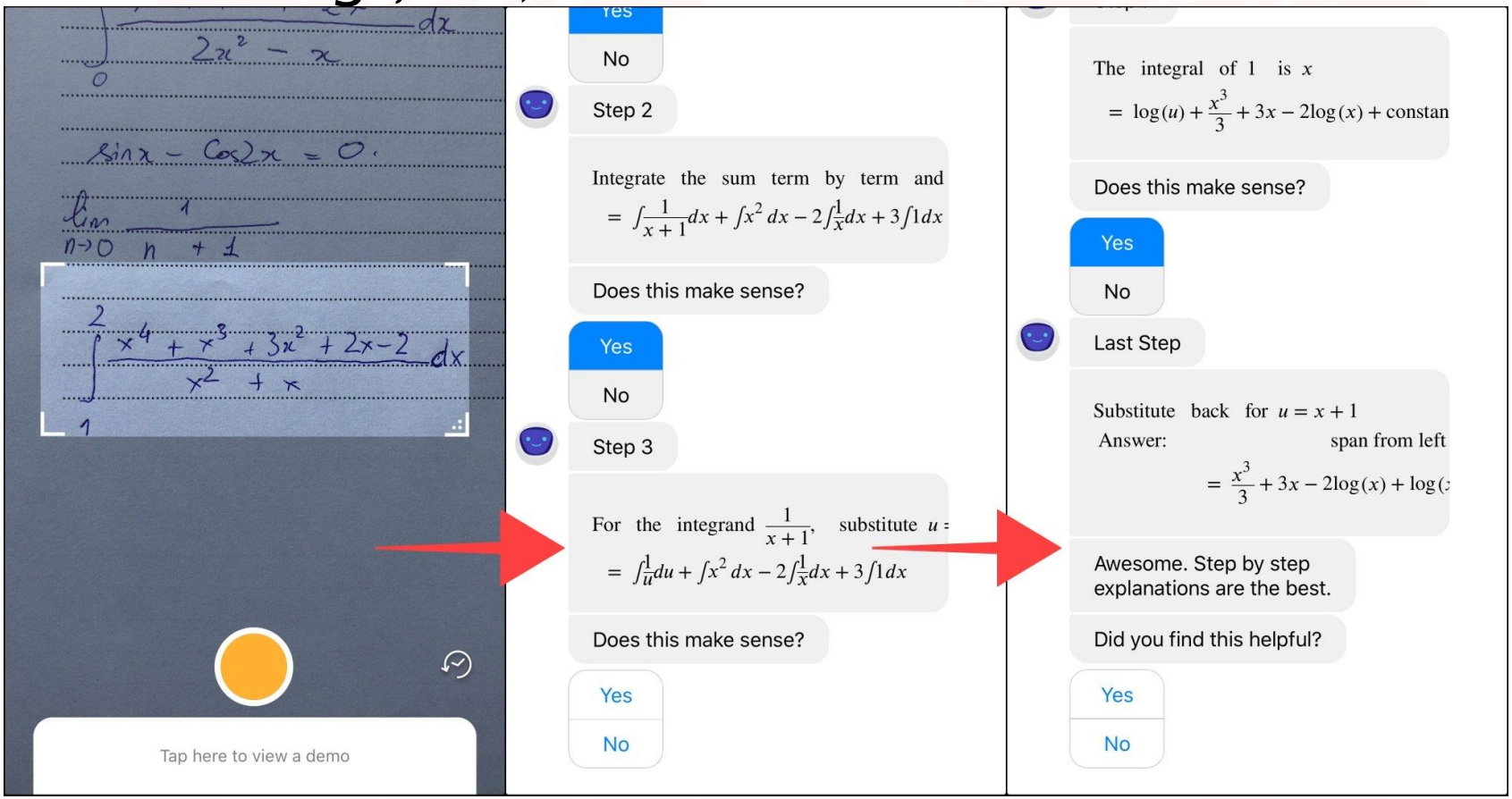
http://mmlab.uit.edu.vn/

STOA: Computer Vision (cont.)

- Information Extraction from ID Cards by FPT.AI (accuracy up to 99%)

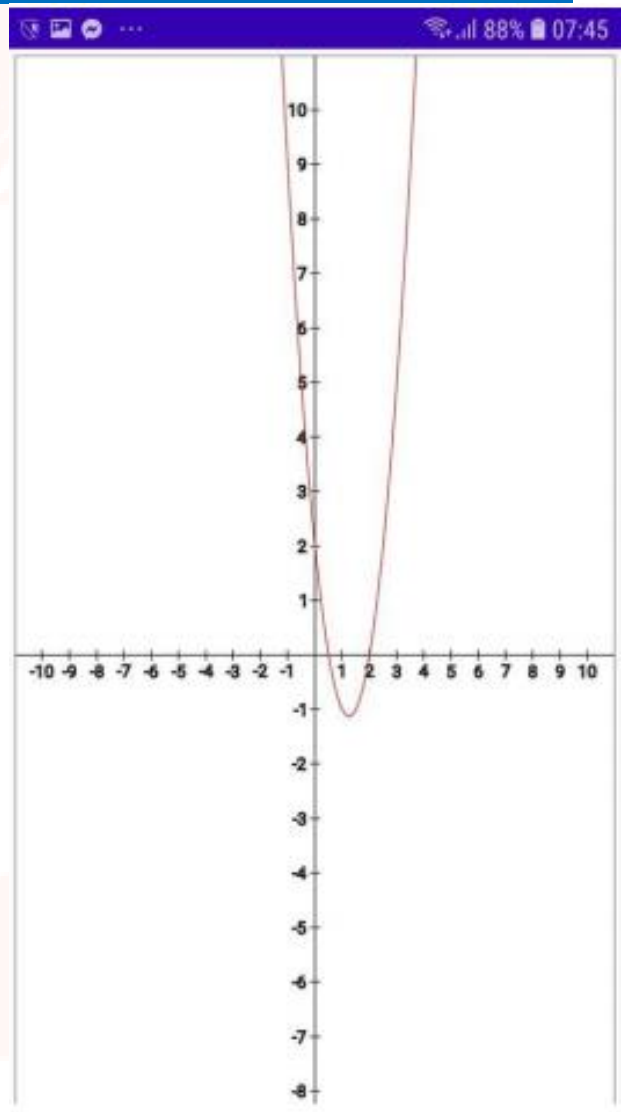
STOA: Computer Vision (cont.)

- PhotoSolver developed by GotIt (2018, Tran Viet Hung , VN)



STOA: Computer Vision (cont.)

- NLUMath



STOA: Natural Language Chatbots

- **Audiotory:**
  - Siri (Apple)
  - Google Assistant (Google)
  - Cortana (Microsoft)
  - Kiki (Zalo , VN)
- **Textual:**
  - personal stylist (Sephora)
  - order pizza (Dominos Pizza)
  - Fashion- ecommerce- chatbots (H&M)

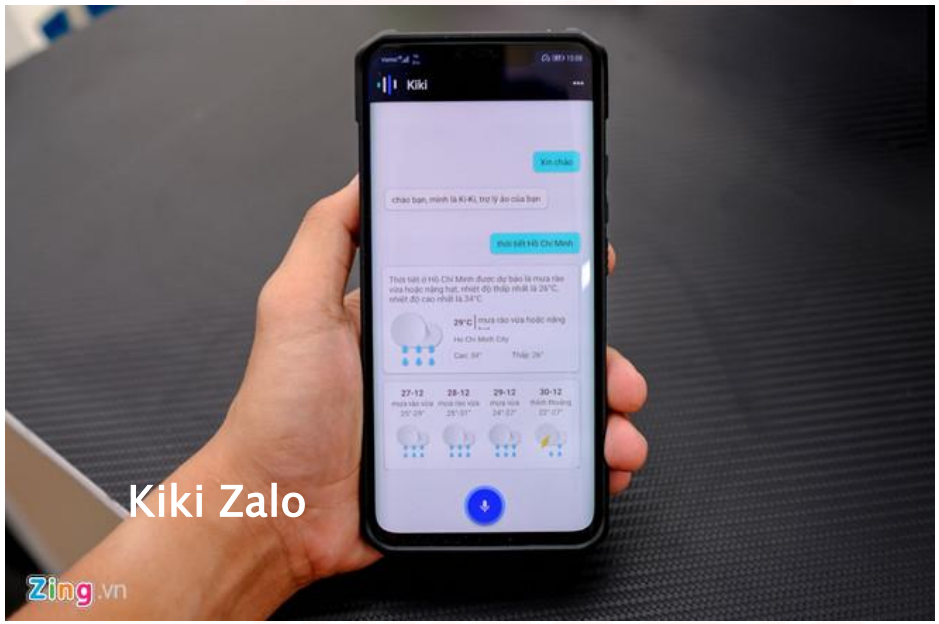
- **ALICE**: 2004 Loebner Prize winner
  - Loebner Prize gold medal, awarded annually to best AI program
- **ELIZA**: psychotherapist
- **Valerie**: CMU (Carnegie Mellon University) Robot Receptionist

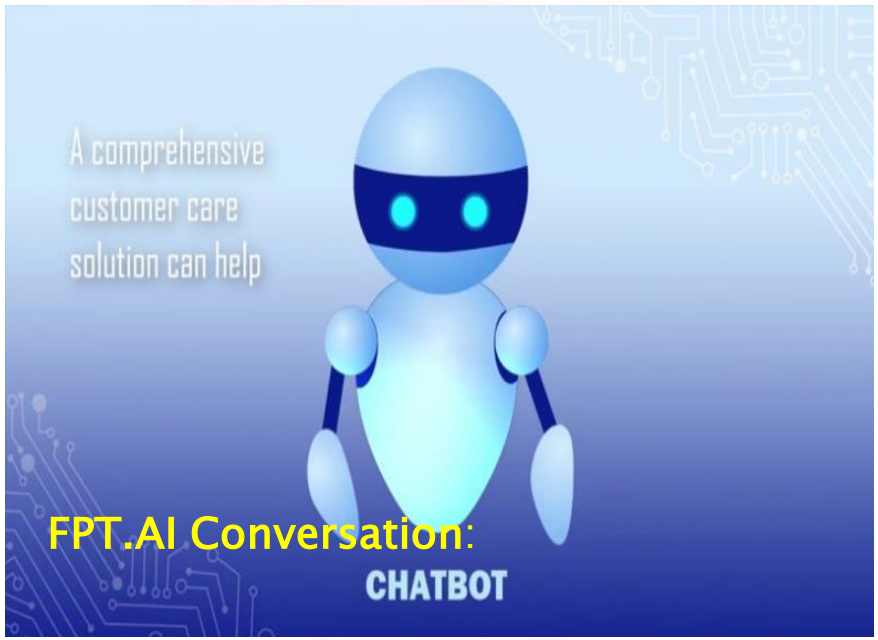
(ALICE) Pandorabots

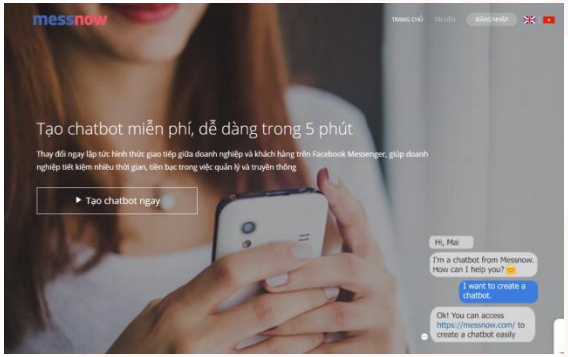
Jerry: my name is jerry.
ALICE: Hey jerry.
Jerry: Do you know Turing?
ALICE: A brilliant and tragic figure in the history of computer science.
Jerry: Who else do you know?
ALICE: Hugh Loebner, Robby Garner, and Steven Spielberg
Jerry: Which film do you like?
ALICE: My favorite movie is Teknolust. Have you seen it?
Jerry: No.
ALICE: I would recommend you check it out.
Jerry: What is it about?
ALICE: Science fiction.
Jerry: Do you remember my name?
ALICE: Your name is jerry, seeker.

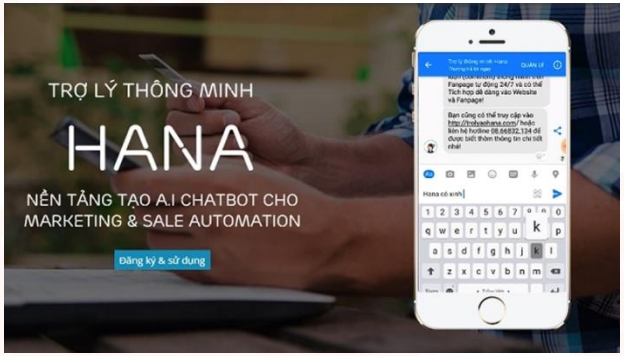
https://home.pandorabots.com

Chatbots


Kiki
Kiki Zalo
Zing.vn


A comprehensive customer care solution can help
FPT.AI Conversation:
CHATBOT


messnow
Tạo chatbot miễn phí, dễ dàng trong 5 phút
Tạo chatbot ngay


TRỢ LÝ THÔNG MINH
HANA
NỀN TẢNG TẠO A.I CHATBOT CHO MARKETING & SALE AUTOMATION
Đăng ký & sử dụng

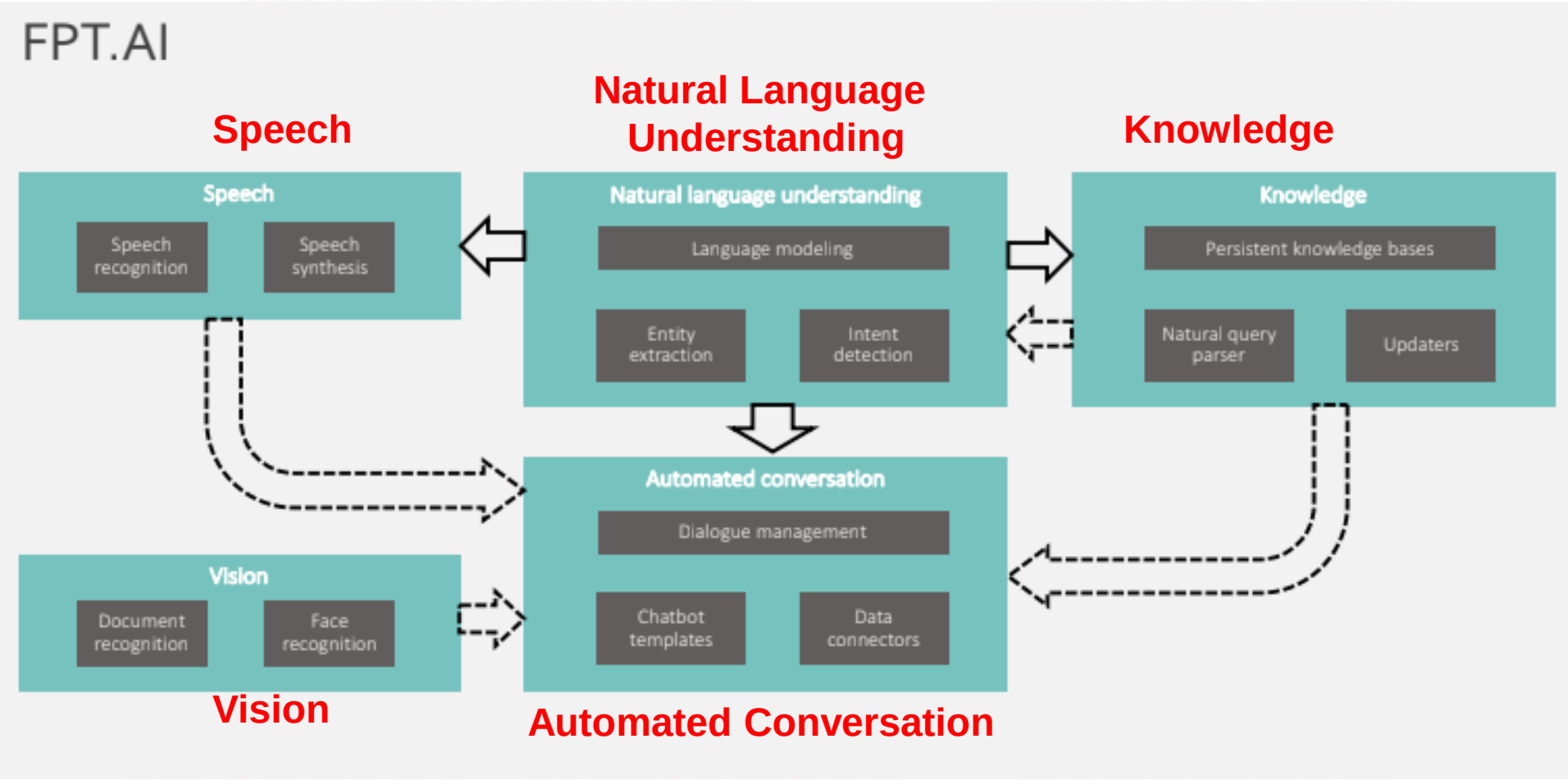

haravan
Facebook đã mở API
Tạo Chatbot hoàn toàn miễn phí
API

Chatbot (cont.)

H&M Chatbot

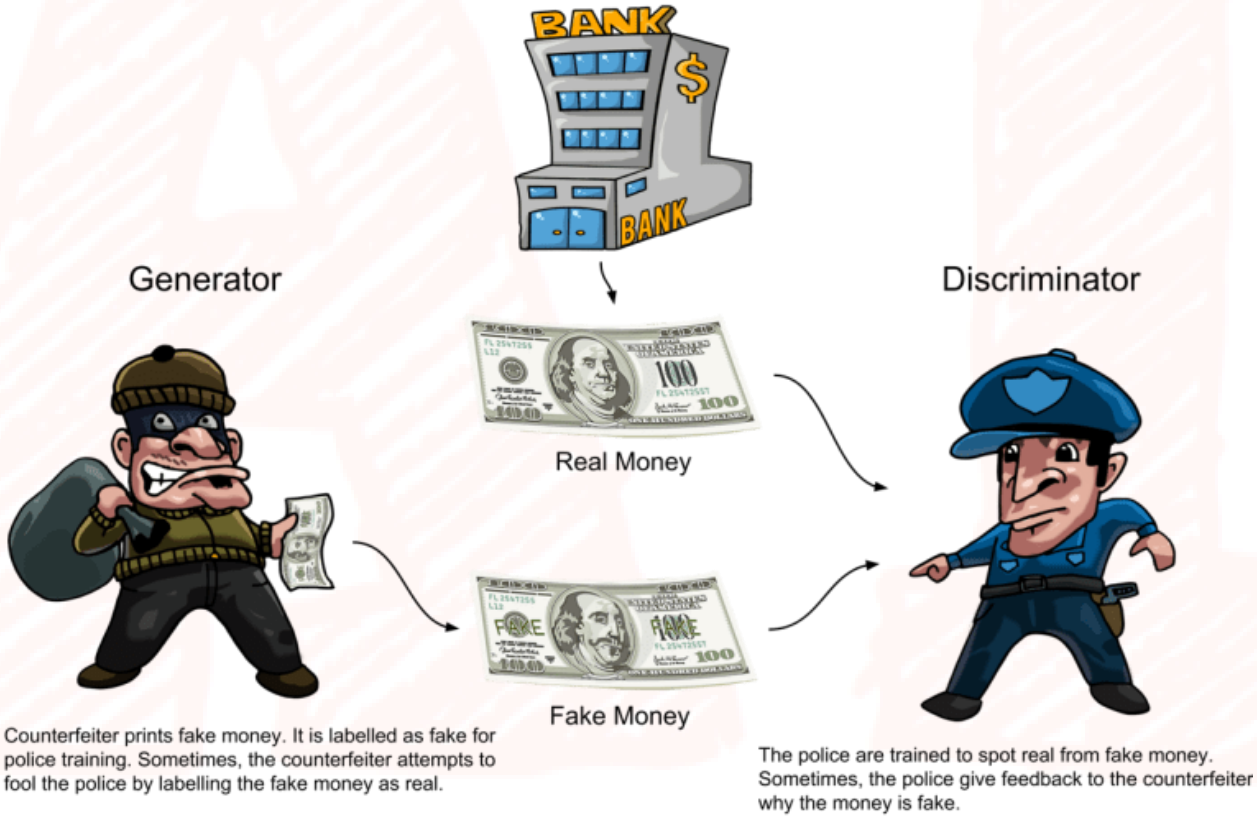
"Smart virtual lawyer" in the legal industry

FPT.AI Architecture

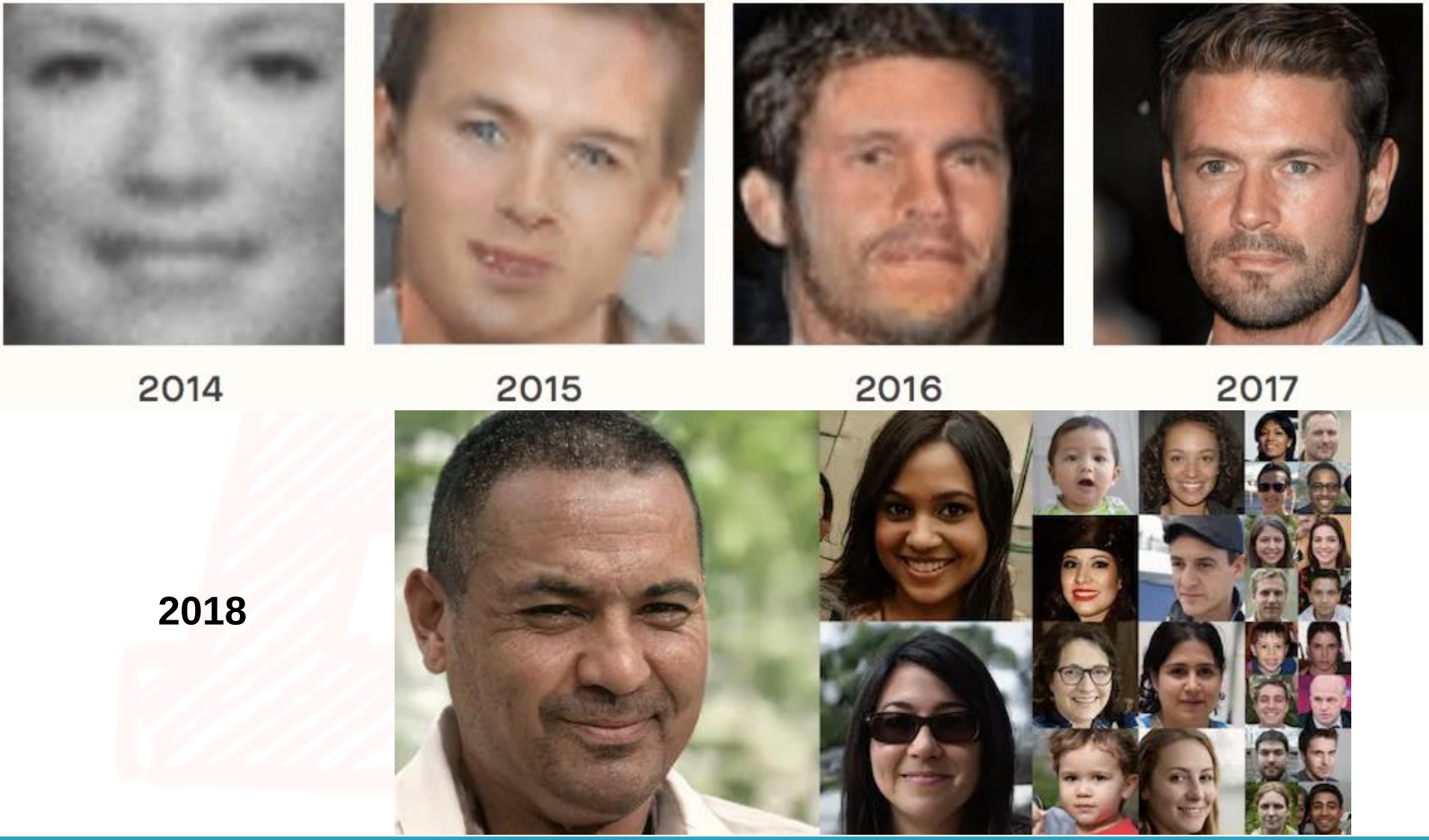


GAN: Generative Adversarial Networks

- GAN: learn to model the input distribution by training two competing (and cooperating) networks called **generator** and **discriminator**



GAN (cont.)



GAN (cont.)

- Generate Anime characters

Towards the Automatic Anime Characters Creation with Generative Adversarial Networks

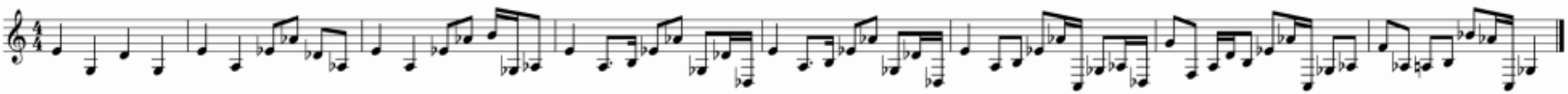
GAN (cont.)

- Text to image

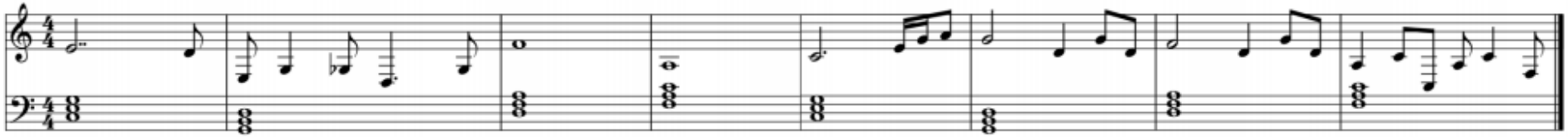
StackGAN: Text to Photo-realistic Image Synthesis with Stacked Generative Adversarial Networks

GAN (cont.)

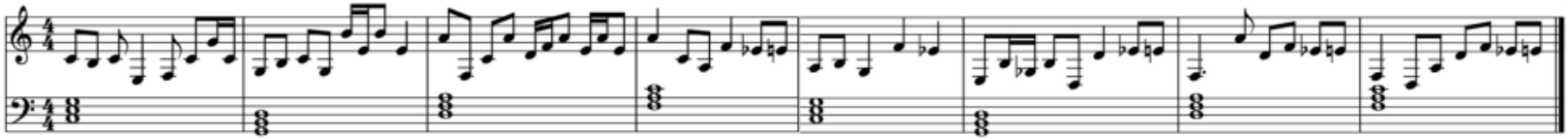
- Music generation



(a) MidiNet model 1



(b) MidiNet model 2



(c) MidiNet model 3

Figure 3. Example result of the melodies (of 8 bars) generated by different implementations of MidiNet.

MidiNet: A Convolutional Generative Adversarial Network for Symbolic-domain Music Generation

Some AI "Grand Challenge" Problems

- Intelligent Agents
- Smart Clothes
- Aids for the Disabled
- Tutors
- Accident-avoiding Vehicles
- Self-Organizing Systems
- Translating Telephone Conversations
- Extracting and representing information from lots of data
  - Neural networks, hidden Markov models,
  - Bayesian networks, heuristic search, logic, …

Issues for AI Problems

Fundamental Issues for AI Problems

- Representation
- Search
- Inference
- Learning
- Planning

Representation

Facts about the world are remembered:

- How do we represent facts?
- What should we store?
- How do we structure this knowledge?
- What is explicit? What is inferred?
- How are inference rules encoded?
- How should inconsistent, incomplete, and probabilistic knowledge be dealt with?

Representation (cont.)

- Example:
  "The fly buzzed irritatingly on the window pane".

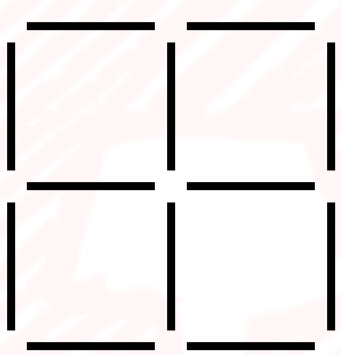
"Jill quickly picked up a newspaper".

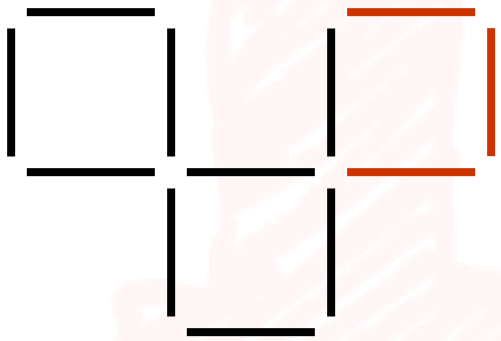
- What is the inference?
  - Jill is going to start a fire?
  - Jill is going to start a papier mache project?
  - Jill is going to exterminate the fly?

Representation (cont.)

- Example:

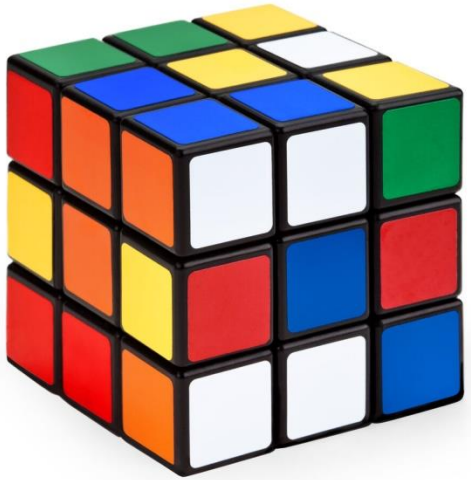
"Given 12 sticks in a 2 by 2 grid, move 3 to leave exactly 3 boxes."





Search

- A problem space is searched for a solution
  - Checkers: 10^{40} states
  - Chess: 10^{120} states
  - Tic-Tac-Toe: 3^9 states
  - Rubik's Cube: 10^{19} states



- How do limit the search space?
- How do we find an optimal solution?
- How are heuristics and constraints used?

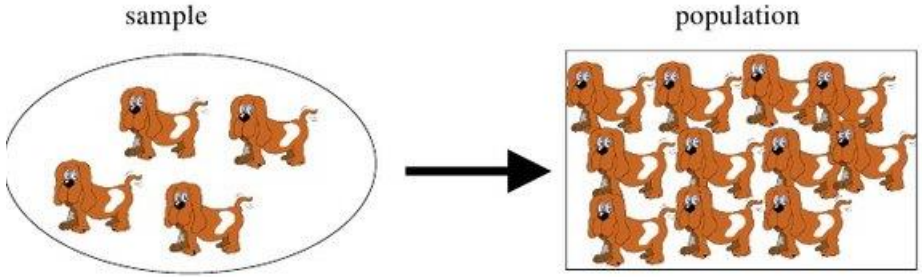
Inference

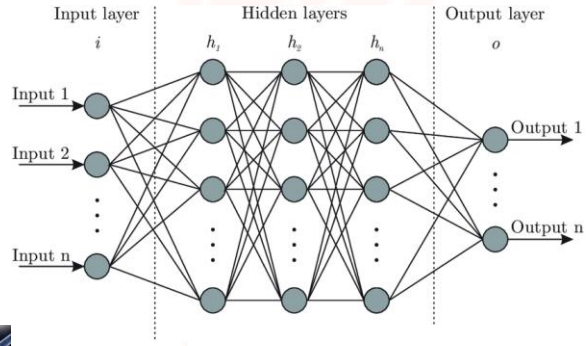
- New facts are determined from a set of existing facts
  - deduction
  - abduction non-monotonic reasoning
  - reasoning under uncertainty

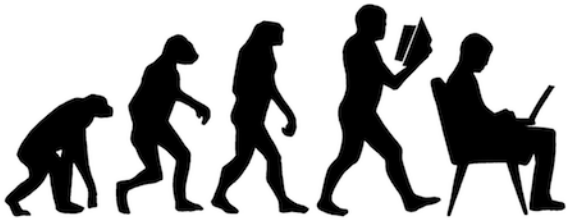
- Example: All elephants have trunks. Clyde is an elephant.
  - Does Clyde have a trunk?
  - Willy has a trunk. Is Willy an elephant?

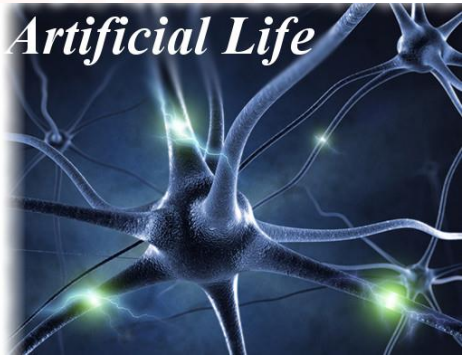
Learning

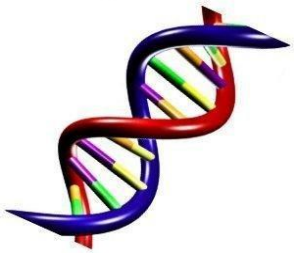
- New knowledge is acquired:
  - inductive inference
  - neural networks
  - genetic algorithms
  - artificial life
  - evolutionary approaches











Planning

A strategy for achieving a goal in terms of a sequence of primitive actions is generated

- What general facts about the world are needed?
- What facts about the specific situation are needed?
- What facts are needed about the effects of actions?
- How do you state the goal?
- How do you know the goal has been reached?

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