PHILOSOPHY, EVOLUTION, IMPACT OF AI

Fundamentals of Artificial Intelligence

Session 02

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Agenda

- Philosophy & Computer Science
- Hardware, Software, Data – Why Now!
- Alan Turing
- Turing Test & Associated Questions
- Impact of AI

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What is Intelligence?

- Physics:
  - Branch of science concerned with the nature and properties of matter and energy.
- Chemistry:
  - Branch of science concerned with the substances of which matter is composed, the investigation of their properties and reactions, and the use of such reactions to form new substances.
- Intelligence:
  - Capacity to learn and solve problems - Webster dictionary
  - To learn, reason, understand and similar form of mental activity
  - The ability to act rationally
- Hmm… Not so easy to define

Homo sapiens— “human the wise”

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How do we think…

- Ever understood “how we think…”
  - How a mere handful of matter can perceive, understand, predict, and manipulate a world far larger and more complicated than itself
  - Is it possible for machines to act intelligently in the way that people do?
  - Would such machines have real, conscious minds?
  - Still a big question…
- Add couple of more questions
  - What are the ethical implications of intelligent machines in day to-day use?
  - Should machines be allowed to decide to kill humans?
  - Can algorithms be fair and unbiased?
  - What will humans do if machines can do all kinds of work?
  - Should machines become more intelligent than us, how do we control them?
- AI attempts not just to understand but also to build intelligent entities

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Philosophy and Computer Science

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Computer Science and Philosophy

"I don't see that human intelligence is something that humans can never understand."
- John McCarthy, March 1989

- Computer Science and Philosophy are coming together
  - Artificial intelligence (AI),
  - Logic,
  - Robotics,
  - Virtual reality, etc.

- Two disciplines share a broad focus on
  - The representation of information and rational inference,
  - Embracing common interests in
    - Algorithms,
    - Cognition,
    - Intelligence,
    - Language,
    - Models,
    - Proof and Verification

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Computer Science and Philosophy

- Philosophy of a Science
  - Philosopher analyze a concept
  - Comment on concepts being coherent or not!
- AI has closer connection with philosophy compared to any other science
- Shared concepts are:
  - Action
  - Consciousness
  - Epistemology
  - Free will
- AI Point of view
  - Use the philosophical theories without precluding human level AI
  - Do not obstruct development

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Think about a computer(Read AI System)!

- Epistemology:
  - What can we know about a Computer?
  - How can we justify our beliefs about Computer?
  - Can a Computer have Knowledge?
- Metaphysics:
  - What kind of thing a Computer is?
  - Does it have free will?
  - How does it relates to its parts?
  - Is it necessary or contingent?
- Ethics:
  - Is Computer Good or bad?
  - How can we use a Computer for good or bad?
- Philosophy of Mind:
  - Does Computer have consciousness?
- Philosophy of Art
  - Is it beautiful?
  - Is it sublime?

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Philosophical Criticisms of AI

- Two categories of criticism:
  - It cannot be done because ...
  - It cannot be done the way you are trying to do it…

Generative Pre-trained Transformer (GPTs) have arrived, would become better over time

- The danger of "*can't be done*" arguments…
  - Philosophers are forever telling scientists what they can't do, what they can't say, what they can't know, and so on and so forth

---

- In 1844 the philosopher August Compte said that if there was one thing man would never know it would be the composition of the distant stars and planets
- But three years after Compte died physicists discovered that an object's composition can be determined by its spectrum no matter how far off the object happens to be

- Simon Newcomb, who in October 1903 wrote "aerial flight is one of the great class of problems with which man can never cope"
  - Two months later, the Wright brothers' flew an aircraft at Kitty Hawk
- Air Travel arrived in 1903, of course took time to perfect it

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Computer Science and Philosophy

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- When it comes to philosophy of mind, AI offers advice to philosophers
- Key problem is `**Common Sense**`
- How to take decision in absence of complete picture
  - Without having access to full observation or
  - For ill-defined problems

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Computer Science and Philosophy

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- The study of Philosophy develops analytical, critical and logical rigor, and the ability to think through the consequences of novel ideas and speculations
- It stretches the mind by considering a wide range of thought on subjects as fundamental as the limits of knowledge, the nature of reality and our place in it, and the basis of morality
- Philosophers need to understand a world increasingly shaped by technology, in which a whole new range of enquiry has opened up, from the philosophy of AI, to the ethics of privacy and intellectual property
- Some of the greatest thinkers of the past – including Aristotle, Hobbes and Turing – dreamed of automating reasoning and what this might achieve
- Computer scientists need to be able to reflect critically and philosophically, as they push forward into novel domains
- The computer has now made it a reality, providing a wonderful tool for extending our speculation and understanding

Do no Harm!

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Limits of AI

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Limits of AI

- The argument from informality
  - Human behavior is far too complex to be captured by any formal set of rules
  - Humans must be using some informal guidelines that could never be captured in a formal set of rules
  - Thus could never be codified in a computer program
  - It turns out that argument was aimed against the simple reflex agent

- The argument from disability
  - A machine can never do a few things such as:
    - Be kind, resourceful, beautiful, friendly, have initiative, have a sense of humor, tell right from wrong, make mistakes, fall in love, enjoy Vada Pav, make someone fall in love with it, learn from experience, use words properly, be the subject of its own thought, have as much diversity of behavior as man, do something really new.
  - Today's machines can do a few of stuff
    - The one thing that it is clear they can't do is be exactly human

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Limits of AI

- The mathematical objection
  - Turing and Gödel proved that certain mathematical questions are in principle unanswerable by particular formal systems. Gödel's incompleteness theorem is the most famous example of this.
- Briefly, for any formal axiomatic framework powerful enough to do arithmetic, it is possible to construct a so-called Gödel sentence with the following properties:
  - G(F) is a sentence of F, but cannot be proved within G(F)
  - Imagine there is a village with a strict law against not shaving
    - The village has only one barber and only barber can shave another villager
    - The village barber must shave all men if they are incapable of shaving themselves
    - So who shaves the barber?
    - Barber cannot shave himself because barber is authorized to shave only people who do not shave themselves
    - But barber can shave himself
- A complete formal system of mathematics is not possible!

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Limits of AI

- Lack of Common Sense:
  - AI systems generate responses based on patterns in the data they were trained on,
  - Don't truly understand the context or have the ability to think critically.
- Data Dependency:
  - Require vast amounts of data to train effectively. Do not perform well on tasks or domains where sufficient training data is not available.
- Bias and Fairness:
  - Inherit biases present in their training data. Leads to biased and unfair outcomes, especially in applications like hiring, lending, and law enforcement.
- Lack of Creativity:
  - Creativity is often limited to patterns it has learned from training data. It cannot truly innovate or have genuine creative insights.
- Ethical Concerns:
  - AI can be used unethically, such as in deepfake creation or for malicious purposes.
- Interpretability:
  - AI models are "black boxes" , Challenging to understand how they arrive at their decisions.

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Limits of AI

- Resource Intensive:
  - Training and running AI models can be computationally expensive and energy-intensive
- Security Risks:
  - Can be vulnerable to attacks, including adversarial attacks where malicious inputs can fool the system into making incorrect decisions
- Scalability and Generalization:
  - While AI models can perform well in specific tasks they were trained on, they may struggle to generalize to new, unseen situations or tasks
- Human-AI Collaboration:
  - AI is often seen as a replacement for human jobs, but it can also create job displacement and challenges in integrating AI systems with human workers
- Legal and Regulatory Challenges:
  - The rapid development of AI has posed legal and regulatory challenges, including questions about liability and accountability when AI systems make errors or cause harm

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Objections to the AI

- The Theological Objection
  - "Thinking is a function of man's immortal soul. God has given an immortal soul to every man and woman, but not to any other animal or to machine. Hence no animal or machine can think."
- The "Head in the Sand" Objection
  - "The consequences of machines thinking are too dreadful to think about."
- The Argument for Consciousness
  - "A machine cannot write a sonnet or compose a concerto because of thoughts or emotions felt."
- Robotic Limitations:
  - Physical robots have limitations in terms of mobility, dexterity, and interaction with the physical world.
  - Still far from matching human capabilities in many real-world scenarios.

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Why Now!

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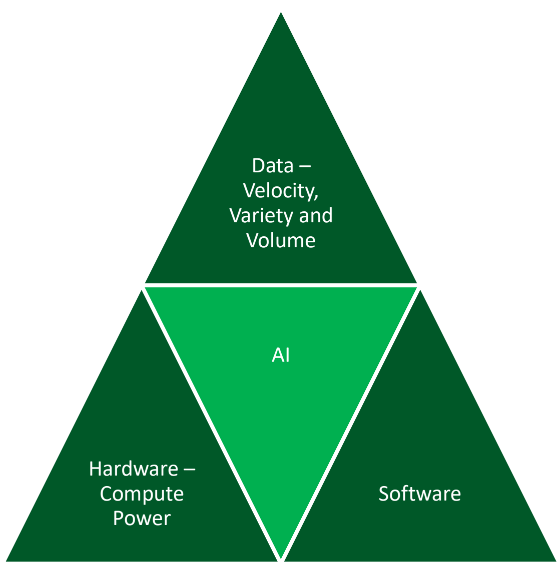
What has changed???



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Cambrian Explosion

- Current period of fervent innovation
- Range of innovative AI hardware-accelerator architectures continues to expand.
  - GPU is not the only one
- New AI-optimized chipset architectures:
  - New generations of GPUs
  - Neural network processing units (NNPUs)
  - Field programmable gate arrays (FPGAs),
  - Application-specific integrated circuits (ASICs), and
  - Various related approaches that go by the collective name of neurosynaptic architectures.

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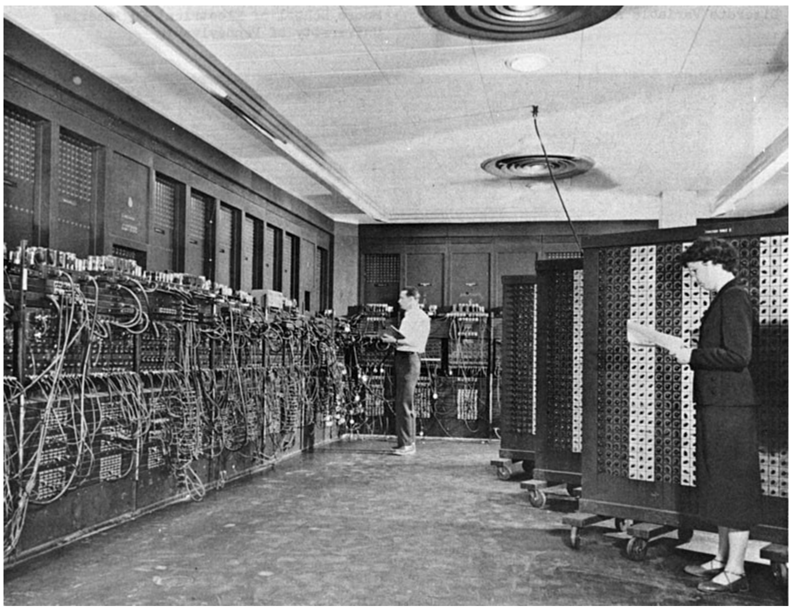
ENIAC - Electronic Numerical Integrator and Computer



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History of Computers

Model K

1937
George Stibitz

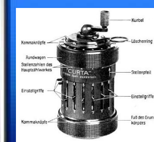
HP

1939
Bill Hewlett,
Dave Packard

Z3 Computer

1941
Konrad Zuse

Calculator



1944
Curt Herzstark

Manchester Baby

1948
University of
Manchester

ERA 1101

1950
Remington-Rand

UNIVAC 1

1951
Eckert–Mauchly
Computer Corporation

Defense Calculator

1954
IBM

Programmable
Computer

1957
MIT

Connected Sites

1958
SAGE Systems

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History of Computers

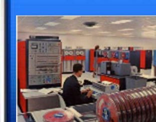
Minuteman I

1961
Flight Positioning

Atlas Computer

1962

System/360



1964
IBM

Programma 101

1965
Olivetti

Apollo Guidance
Computer

1968
MIT Instrumentation
Laboratory

4004 microprocessor

1971
Intel

Cray-1

1976

Apple-1

1976
Steve Wozniak

Tandy

1977
Radio Shack

Apple-II

1977
Apple Inc.

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History of Computers
Model 400/ Model 800
1979
Atari
Personal Computer
1981
IBM
C64 Computer
1982
Commodore
Lisa
1983
Apple Inc.
Macintosh
1984
Apple Inc.
Deskpro 386
1986
Compaq
NeXT Cube
1988
Steve Jobs
Powerbook
1991
Apple inc.
Newton
1993
Apple Inc.
Pentium
1993
Intel Corp
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History of Computers
Palm Pilot
1996
US Robotics
Vaio
1996
Sony
First Camera Phone
2000
Sharp Corp.
Earth Simulator
2002
Apple Inc.
ThinkPad
ThinkPad
ThinkPad becomes Lenovo
lenovo
2005
Lenovo
Kindle
2007
Amazon
iPhone
2007
Apple Inc.
MackBook Air
2008
Apple inc.
Retina Display
2010
Apple Inc.
First iPad
2010
Intel Corp
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History of Computers

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Better and Better Hardware

- Graphic processing units (GPU), in 2007, NVIDIA launched CUDA – It is Massively Parallelized
- Between 1990 and 2010, off-the-shelf CPU's became approx. 5000 times faster
- Around 2011, some researchers began to write CUDA implementations of neural nets
- NVIDIA TITAN X , a gaming GPU can deliver a peak of 6.6 TFLOPS in single precision: 6.6 trillion float32 operations per second.
  - 350 times more than what you can get out of a modern lap-top
- Beyond GPU ➔ TPU: specially designed hardware for neural networks about 10 times faster than GPU.
- 2016: The first reprogrammable quantum computer was created
- 2017: The Defense Advanced Research Projects Agency (DARPA) is developing a new "Molecular Informatics" program that uses molecules as computers

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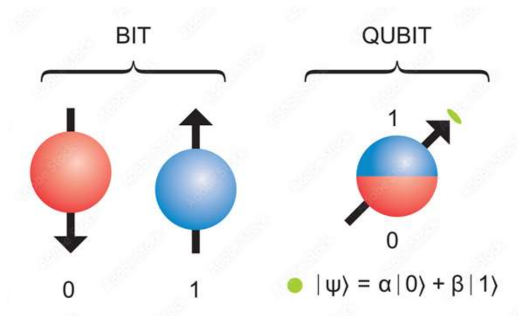
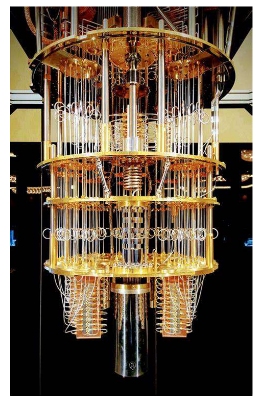
Quantum Computing

- Transistors cannot be reduced any further due to the laws of Quantum Mechanics
- What is special about Quantum Computer





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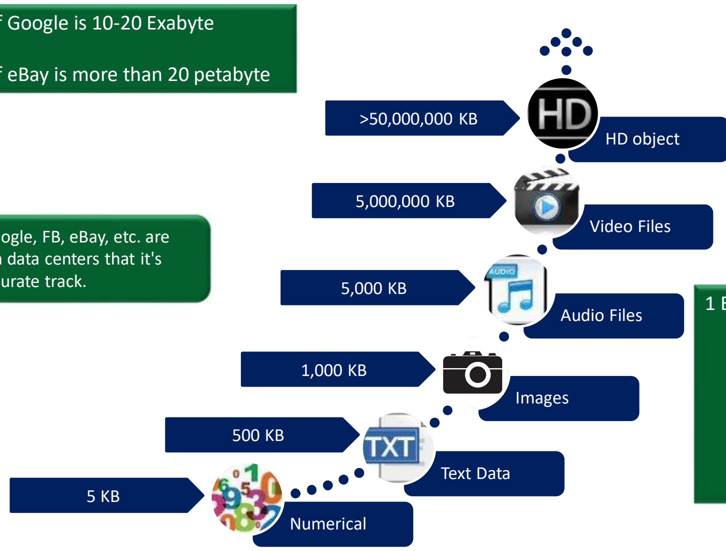
Size of data is increasing…

Estimated storage of Google is 10-20 Exabyte

Estimated storage of eBay is more than 20 petabyte

Google's First Setup
Stanford University – 1998

The reality is that Google, FB, eBay, etc. are investing so much on data centers that it's tough to keep an accurate track.



1 Exabyte
= 1024 Petabyte
= 1024^2 Terabyte
= 1024^3 Gigabyte
= 1024^4 Megabyte
= 1024^5 Kilobyte
= 1024^6 byte
= 1024^6 × 8 bit

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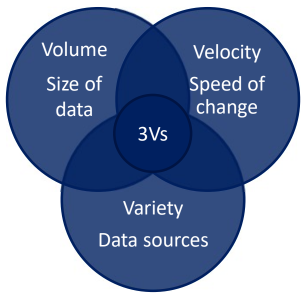
Big Data

- Big data is high-volume, high-velocity and/or high-variety information assets
  - that demand cost-effective, innovative forms of information processing
  - that enable enhanced insight, decision making, and process automation



- ✓ Enterprise resources
- ✓ Databases
- ✓ Data warehouse
- ✓ Enterprise Systems

Structured

- ✓ Phone Records
- ✓ Web logs
- ✓ Call center records
- ✓ XML, CSV, Json,
- ✓ Emails

Semi-Structured

- ✓ Social Media
- ✓ Facebook
- ✓ Twitter
- ✓ You Tube
- ✓ Analog data

Un-structured

Later Two more V's were added : Value and Veracity
Data has no use till it's value is discovered
And its true and accurate

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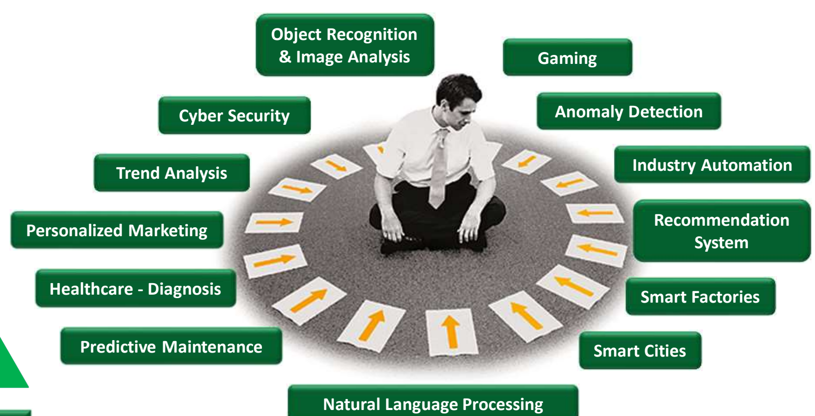
Variety Helps us Get More Questions!

Get the right questions!



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Software

1952
Stochastic
Gradient Descent

1958
Perceptron
- Learning weight

...

1986
Back propagation
- Multilayer
Perceptron

1995
Deep
Convolutional
Neural Networks
- Digit Recognition

...

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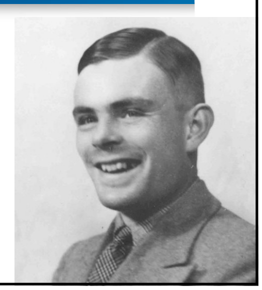
I propose to consider question: " Can machines think?"
- Alan Turing - 1950
Great 20th Century Mathematician



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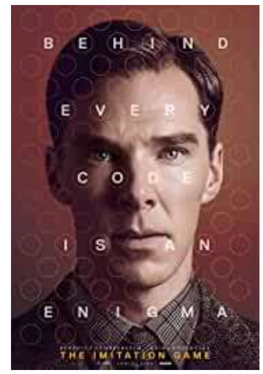
Alan Turing

- One of the rare figures in mathematics
- A mathematician, cryptographer, and a pioneer of computer science
- May best be known for his work at Bletchley Park during World War II, and his part in breaking the German Enigma code
- His idea of a 'Universal Machine', a hypothetical type of computer, resolved one of the most important problems in 20th century mathematics
- Movie “The Imitation Game”



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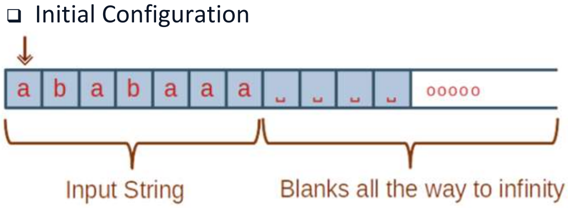
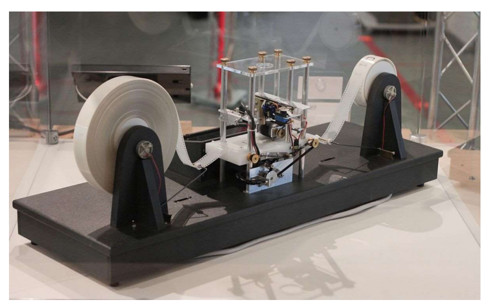
Turing Machine

- Tape Alphabets : Σ = {0, 1, a, b, x, Z0}
- The Blank ␣ is a special symbol and is not part of Σ and it is used to fill up the tape

- Initial Configuration





- Operations on the Tape
  - Read /Scan symbol at head location
    - Imagine that head is reading the tape
  - Update /Write a symbol using the head
  - Move Tape Head left or right
    - One space at a time

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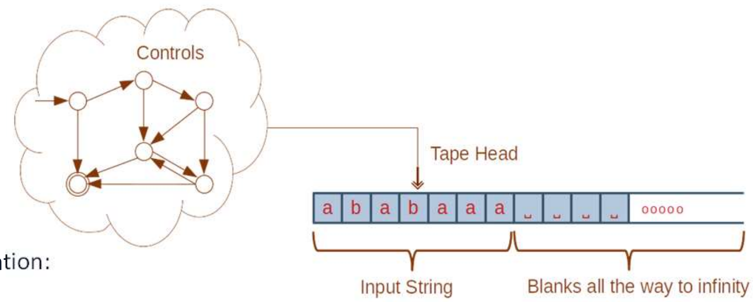
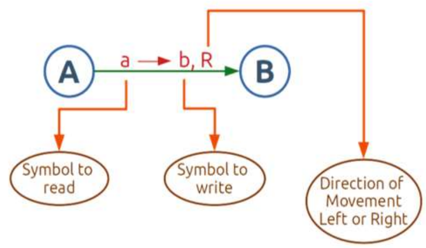
Turing Machine

- Controls are similar
  - Finite State Machine
  - Pushdown Automata
- It is deterministic
- Rule 1: At each step of the computation:
  - Read the current symbol
  - Update it and move exactly one step left or right
- Rule 2:
  - Start from initial state and reach final state
  - Two Final States – Accept State and Reject State
  - Computations can either:
    - Halt and Accept
    - Halt and Reject
    - Loop (fails to Halt)





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Turing Machine - Defined

- A Turing Machine can be defined as a tuple of seven
- The tuple is $(Q, \Sigma, \Gamma, \delta, q_0, b\ , F)$, where
  - Q : A finite set of States – Non-empty only {A, B, C, D,…},
  - Σ(sigma) : A finite set of non-empty Symbols {1, 0, x, y, …}
  - Γ(gamma) : A finite Tape Symbols
  - δ(delta) : The transition Function, $Q\ x\ \Sigma\ \rightarrow\ \Gamma\ x\ (L/R)\ x\ Q$
  - q_0 : Initial State,
  - b : Blank Symbol,
  - F : set of Final State (Accept or Reject)
- Production Rule can be written as:
  - δ (q_0, α) → (q_1, γ, R)

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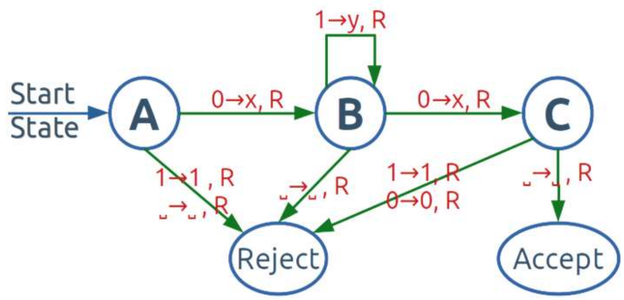
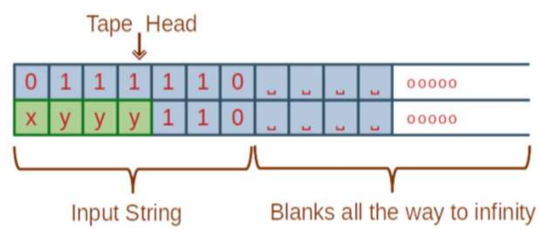
Turing Machine - Example

- Design a Turing Machine which recognizes language L = 01*0
  - Start with 0 thereafter there can be a number of 1s and end with 0





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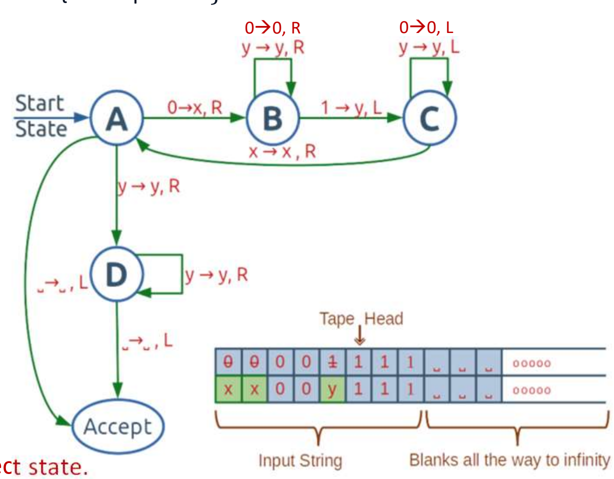
Turing Machine – Another Example

- Design a Turing Machine to recognize language L = { O^n1^n | n ∈ ℤ }

- Algorithm
  - Replace 0 by 'x'
  - Move right till you encounter 1
    - If None : "Reject"
  - Replace 1 to 'y'
  - Move left till you encounter 0
  - Repeat till all 0s have been replaced by 'x'
  - Validate if any 1 left still
    - No : "Accept"
    - Yes: "Reject"



- Practice: Complete the diagram by adding reject state.
- Note: if the first symbol is blank; it is accepted as n = 0.

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Turing Thesis

- Turing's Thesis states that any computation that can be carried out by mechanical means can be performed by some Turing Machine
- Explanation
  - Anything that can be done on existing digital computer can also be done by Turing Machine
  - No one has yet been able to suggest a problem solvable by what we consider an algorithm, for which a Turing Machine Program cannot be written

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PA_FAI_01: Construct a Turing Machine

Course & Batch : ____________________
Roll No: ____________________
Name: ____________________
Date of submission: 10 April 2024

- Construct a Turing Machine for the language $L = \{0^n1^n2^n\}$ where $n \geq 1$
- Answer to include
  - Algorithm
  - Representative transition diagram
  - Initial Tape and Final Tape
  - Similar to what you saw in slides 29 and 30
- Submission:
  - PDF or Image to be uploaded in the shared drive
  - Upload file Name: PRN_<*last 4 digits of PRN*>_<*name*>.<*ext*>

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Turing Test and Associated Questions

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What is Artificial Intelligence?

- Systems that think like humans
- Systems that act like humans
- Systems that think rationally
- Systems that act rationally

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What is AI?

- Views of AI fall into four different perspectives --- two dimensions:
  - Thinking versus Acting
  - Human versus Rational

	Human-like Intelligence	"Ideal" Intelligent/ Pure Rationality
Thought/ Reasoning ("modeling thought" "brain")	**2. Thinking Humanly**	**3. Thinking Rationally**
Behavior/Actions "behaviorism", "mimics behavior"	**1. Acting Humanly**	**4. Acting Rationally**

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Acting Humanly

- Views of AI fall into four different perspectives --- two dimensions:
  - Thinking versus Acting
  - Human versus Rational

	Human-like Intelligence	"Ideal" Intelligent/ Pure Rationality
Thought/ Reasoning ("modeling thought" "brain")	**2. Thinking Humanly**	**3. Thinking Rationally**
Behavior/Actions "behaviorism", "mimics behavior"	**1. Acting Humanly**	**4. Acting Rationally**

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Acting Humanly: The Turing Test

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

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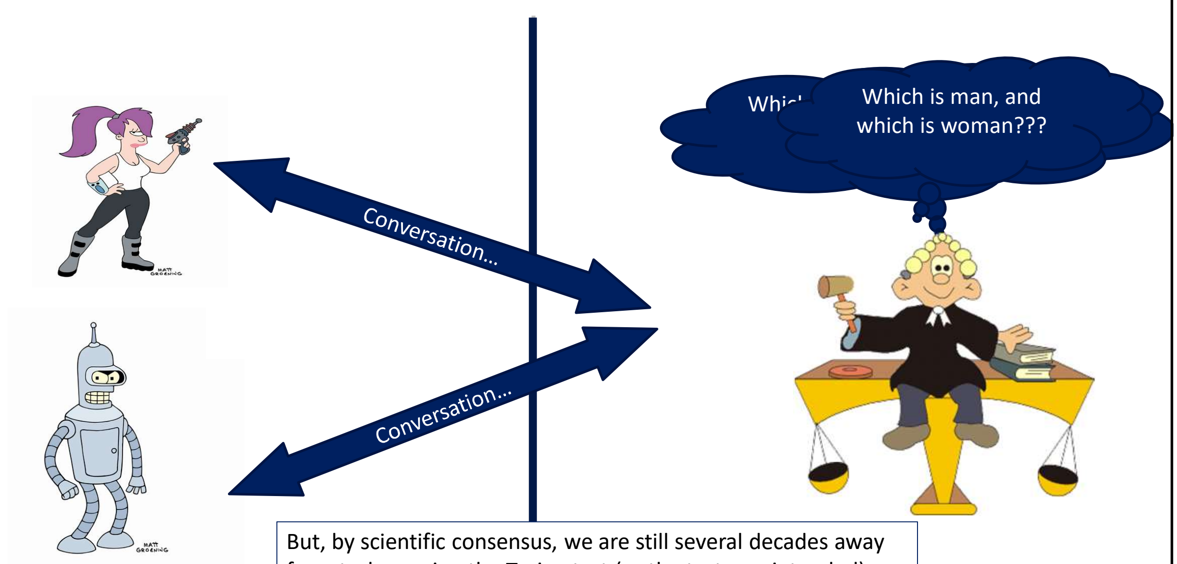
The Imitation Game



But, by scientific consensus, we are still several decades away from truly passing the Turing test (as the test was intended).

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Acting Humanly: The Turing Test

- "Imitation Game"
  - Method
    - Three people play (man, woman, and interrogator)
    - Interrogator determines which of the other two is a woman by asking questions
      - Example: How long is your hair?
    - Questions and responses are typewritten or repeated by an intermediary
    - Turing Test: Machine takes the part of the man
  - AI system passes if interrogator cannot tell which one is the machine.
  - No computer vision or robotics or physical presence required!
  - Predicted that by 2000, a machine might have a 30% chance of fooling a lay person for 5 minutes

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Predictions

- In 1950, Turing predicted that 50 years later it will be possible to program a computer with ~100 Mb memory to pass TT 70% of the time, with 5 minute conversations.
- It will be natural to speak of computers 'thinking'.
- "[The machine] may be used to help in making up its own programs, or to predict the effect of alterations in its own structure."
- "We may hope that machines will eventually compete with men in all purely intellectual fields."

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Trying to pass the Turing test: Some Famous Human Imitation "Games"

- 1960s ELIZA (http://www-ai.ijs.si/eliza/eliza.html)
  - Joseph Weizenbaum - Rogerian psychotherapist

- Still, passing Turing test is of somewhat questionable value.
- Because, appears deception is required and allowed!
  - Consider questions:
    - Where were you born?
    - How tall are you?

- 1990s ALICE
- George (http://www.jabberwacky.com/chat-george)

- See: The New Yorker, August 16, 2013
- Why Can't My Computer Understand Me? Posted by Gary Marcus (http://www.newyorker.com/online/blogs/elements/2013/08/why-cant-my-computer-understand-me.html)

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AI and music: will we be slaves to the algorithm? – The Guardian


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The Observer
Artificial intelligence (AI)

AI and music: will we be slaves to the algorithm?

Tech firms have developed AI that can learn how to write music. So will machines soon be composing symphonies, hit singles and bespoke soundtracks?

Stuart Dredge
@stuartdredge
Sun 6 Aug 2017 07.30 BST

470 99

Pioneers of sound (left to right): George Philip Wright, Jon Eades and Siavash Mahdavi at Abbey Road Studios, London. Photograph: Sonja Horsman/The Observer

From Elgar to Adele, and the Beatles or Pink Floyd to Kanye West, London's Abbey Road Studios has hosted a storied list of musical stars since opening in 1931. But the man playing a melody on the piano in the complex's Gatehouse studio when the Observer visits

It kind of passed Turing Test but for music as published in The Guardian in Aug2017..

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Thinking Humanly

	Human-like Intelligence	"Ideal" Intelligent/ Pure Rationality
Thought/ Reasoning ("modeling thought" "brain")	**2. Thinking humanly** ➢ **Cognitive Modeling**	**3. Thinking Rationally**
Behavior/Actions "behaviorism", "mimics behavior"	**1. Acting Humanly**	**4. Acting Rationally**

- Requires scientific theories of internal activities of the brain.
- Cognitive Science (top-down) computer models + experimental techniques from psychology
  - Predicting and testing behavior of human subjects
- Cognitive Neuroscience (bottom-up) : Direct identification from neurological data

Cognitive Science and Cognitive Neuroscience distinct disciplines
Cognitive Neuroscience has become very active.

Connection to AI: Neural Nets. (Large Google / MSR / Facebook AI Lab efforts.)

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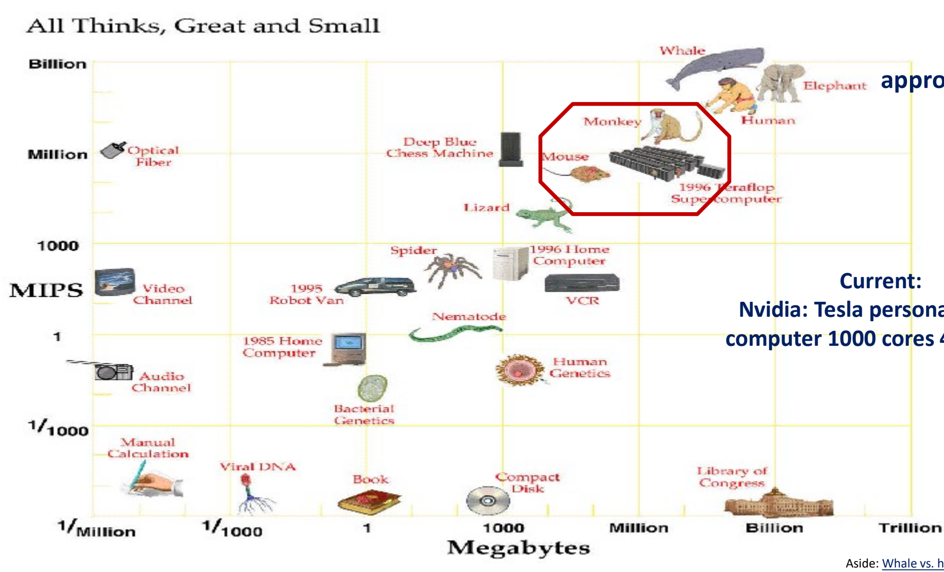
Computer vs. Brain



approx. 2025

Current:
Nvidia: Tesla personal super-computer 1000 cores 4 teraflop

Aside: Whale vs. human brain

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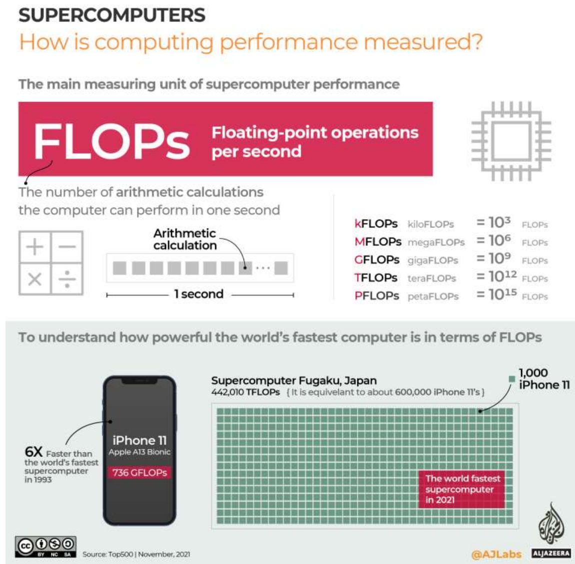
Super Computer



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Super Computers

- The US has retaken the top spot in the race to build the world's fastest supercomputer
- 'Frontier' is capable of more than a billion - billion operations a second, making it the first exascale supercomputer.
- Supercomputers have been used to discover more about diseases including COVID-19 and cancer.
- **Fun fact**: *there might be faster supercomputers out there whose operators didn't submit their systems to be ranked.*

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Super Computers

- Frontier: Built by Hewlett Packard Enterprise (HPE) and housed at the Oak Ridge National Laboratory (ORNL) in Tennessee, USA
- Fugaku: Previously held the top spot, is installed at the Riken Center for Computational Science in Kobe, Japan. It is three times faster than the next supercomputer in the top 10
- LUMI: New number 3, crunching the numbers in Finland
- Summit (IBM): is also at ORNL in Tennessee
- Sierra: Installed at the Lawrence Livermore National Laboratory in California, which is used for testing and maintaining the reliability of nuclear weapons
- Sunway TaihuLight: A system developed by the National Research Center of Parallel Computer Engineering and Technology and installed in Wuxi, Jiangsu
- Perlmutter: another top 10 entry based on HPE technology
- Selene : currently running at AI multinational NVIDIA in the US
- Tianhe-2A : developed by China’s National University of Defence Technology and installed at the National Supercomputer Center in Guangzhou
- France’s Adastra is the second-fastest system in Europe and has been built using HPE and AMD technology

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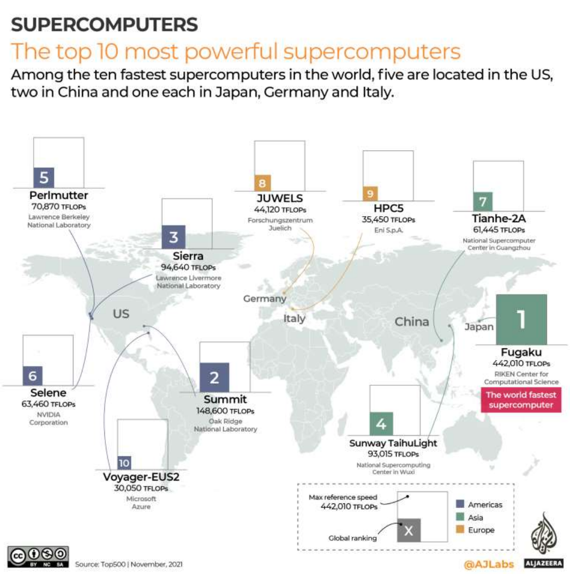
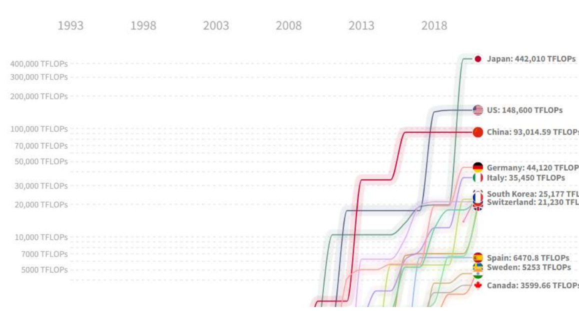
Top 10 Super – Computer





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Super Computers - India

- AIRAWAT
  - Ranked 75th in the Top 500 Global Supercomputing List. The rankings were announced at the 61st edition of the International Supercomputing Conference (ISC 2023) held in Germany.
  - Speed of 13,170 teraflops (Rpeak). The AI system was installed as part of the government's National Program on Artificial Intelligence

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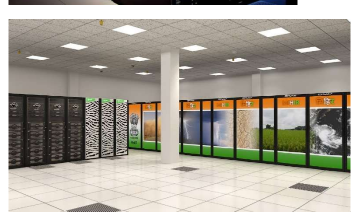
Three More - Super Computers India

- PARAM Siddhi-AI supercomputer which has been ranked 131st on the list is Installed at the C-DAC, Pune.

- The Pratyush supercomputer at the Indian Institute of Tropical Meteorology has secured the 169th position

- Mihir supercomputer at the National Centre for Medium-Range Weather Forecasting has been ranked 316th on the list



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Super Computers - India

PARAM Utkarsh is a High Performance Computing System setup at C-DAC, Bangalore under the National Supercomputing Mission (NSM), Government of India.

- This system offers Artificial Intelligence over Machine Learning & Deep Learning frameworks, Compute and Storage as a cloud service.
- This leads to reduced turnaround time to market of MSMEs and Startup India, thereby increasing their innovation potential.
- PARAM Utkarsh is based on Intel Cascade Lake processor and NVIDIA Tesla V100 GPU with 100Gbps infiniband non-blocking interconnect.
- Equipped with 50,000+ compute cores (CPU & GPU) and liquid cooling system for efficient PUE, PARAM Utkarsh offers peak computing power of 838 Teraflops.

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Safe to assume

- In near future, we can have computers with as many processing elements as our brain, but:
  - Far fewer interconnections (wires or synapses)
  - Then again, much faster updates

- Fundamentally different hardware may be require → fundamentally different algorithms!
  - Still an open question.
  - Neural net research - Can a digital computer simulate our brain?

Likely: Church-Turing Thesis
(But, might we need quantum computing?)
(Penrose; consciousness; free will)

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Thinking Rationally

	Human-like Intelligence	"Ideal" Intelligent/ Pure Rationality
Thought/ Reasoning ("modeling thought" "brain")	2. Thinking humanly	3. Thinking Rationally ➢ formalizing "Laws of Thought"
Behavior/Actions "behaviorism", "mimics behavior"	1. Acting Humanly	4. Acting Rationally

- Logic: Making the right inferences!
  - Remarkably effective in science, math, and engineering.
- Several Greek schools developed various forms of logic: notation and rules of derivation for thoughts.
- Aristotle: what are correct arguments/thought processes? (characterization of "right thinking").
  - Socrates is a man, All men are mortal ➔ Therefore, Socrates is mortal

Can we mechanize it? (syntactic; strip interpretation)
Use: legal cases, diplomacy, ethics etc. (?)

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Acting Rationally

	Human-like Intelligence	"Ideal" Intelligent/ Pure Rationality
Thought/ Reasoning ("modeling thought" "brain")	2. Thinking humanly	3. Thinking Rationally
Behavior/Actions "behaviorism" "mimics behavior"	1. Acting Humanly	4. Acting Rationally

- An agent is an entity that perceives and acts in the world (i.e. an "autonomous system" (e.g. self-driving cars) / physical robot or software robot (e.g. an electronic trading system))
- Current focus of AI is about designing rational agents
- For any given class of environments and tasks, we seek the agent (or class of agents) with the best performance

Caveat: computational limitations may make perfect rationality unachievable design best program for given machine resources
"Limited rationality"

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Building Intelligent Machines

Focus I
Building exact models of human cognition view from psychology, cognitive science, and neuroscience

Focus II
Developing methods to match or exceed human performance in certain domains, possibly by very different means

Main focus of current AI.

But, Focus I often provides inspiration for Focus II. Also, Neural Nets blur the separation.

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Acting Rationally

Good judgment comes from experience, and a lot of that comes from bad judgment.

- For **each percept sequence** does whatever action is expected to maximize its performance measure **on the basis of evidence perceived so far** and built-in knowledge.
- Were all your past decisions correct?
- Do you regret them?
- Includes acting on the basis of what you know and what you have learnt!

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Turing Test – Loebner prize

Loebner Prize Judges Could Easily Identify Chatbots

Written by Sue Gee
Friday, 18 May 2012 08:36

The 2012 Loebner Prize for the best chatbot has been awarded to Chip Vivant, created by Mohan Embar, a software consultant based in Milwaukee.

There were four contestants in the final round of this competition which took place at Bletchley Park on May 15, 2012 and none of them were likely to fool the judges into mistaking them for a human as required to win the Loebner Prize Gold Medal. So instead the Bronze Medal and $5,000 was awarded to the chatbot with the most impressive conversational abilities.

Now Defunct

Alan Turing depicted on the Loebner Prize Gold Medal

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What is AI?

- Views of AI fall into four different perspectives --- two dimensions:
  - Thinking versus Acting
  - Human versus Rational

	Human-like Intelligence	"Ideal" Intelligent/ Pure Rationality
Thought/ Reasoning ("modeling thought" "brain")	**2. Thinking humanly**	**3. Thinking Rationally**
Behavior/Actions "behaviorism" "mimics behavior"	**1. Acting Humanly**	**4. Acting Rationally**

Seems to be a Good Idea

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Rational Agent

- An agent should strive to do right thing,
  - Based on what it can perceive and the actions it can perform
- Right action is one which makes agent to be most successful
- Performance measure: An objective criterion for success of an agents behavior
- Imagine you are trying to design a vacuum-cleaner
  - Amount of dirt gathered
  - Time taken in doing so
  - Electricity consumed
  - Noise generated
  - etc…

We will circle back to Agents later…

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Reflect…

- Fine-tuned model from one field may not work in other field
  - True
  - False
  - Don't know
- A.M. Turing developed a technique for determining whether a computer could or could not demonstrate the artificial Intelligence, Presently, this technique is called ___________
  - Turing Test
  - Algorithm
  - Boolean Algebra
  - Logarithm
- What was originally called the "imitation game" by its creator?
  - The Turing Test
  - LISP
  - The Logic Theorist
  - Cybernetics
- Which programming language is most used for AI?
  - Python
  - Java
  - Lisp
  - R
  - Prolog

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Reflect…

- Bottom Up Approach focuses on ____
  - on action and behavior
  - on action and function
  - on representation and function
  - on representation and behavior

- Recursively Enumerable Language
  - A language L with a set of input symbols Σ, is said to be recursively enumerable if there exists a Turing Machine that accepts it

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Next Session…

- AI – Should I worry about its ramification?
- Technology is not neutral!
- Type of Machine Learning
- AI Trends

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ADDITIONAL MATERIAL

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Impact of AI

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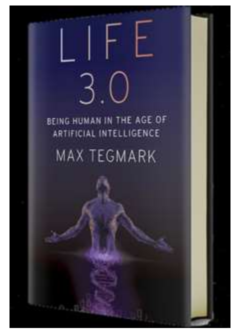
Impact of AI

- How will Artificial Intelligence affect
  - Crime, war, justice, jobs, society
  - And our very sense of being human?
- The rise of AI has the potential to transform our future more than any other technology?

- Life 3.0
  - Written by Swedish-American cosmologist Max Tegmark from MIT.
  - Discusses Artificial Intelligence (AI) and its impact on the future of life on Earth and beyond
  - Discusses a variety of societal implications, what can be done to Maximize
    - the chances of a positive outcome
    - Potential futures for humanity, technology and combinations thereof



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How job Scenario will change?

- How can we grow our prosperity through automation without leaving people lacking income or purpose?
- What career advice should we give today?

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Where we are!

- First phase of Life - biological origins,
- Second Phase - cultural developments in humanity,
  - Customs, cultures, social norms
- This is technical age of humans
- Emerging technology such as artificial general intelligence that may someday, in addition to being able to learn, be able to also redesign its own hardware and internal structure
- Short-term effects of the development of advanced technology
  - Technological unemployment,
  - AI weapons,
  - Quest for human-level AGI (Artificial General Intelligence).
- Examples
  - Deepmind and OpenAI, self-driving cars, and AI players that can defeat humans in Chess, Jeopardy and Go.

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Limitations

- Not all intelligent behavior is mediated by logical deliberation (much appears not…)
- (Logical) representation of knowledge underlying intelligence is quite non-trivial.
- Studied in the area of "knowledge representation."
- Also brings in probabilistic representations. E.g. Bayesian networks and graphical models.
- What is the purpose of thinking?
- What thoughts should I have?
- Seems to require some connection to "acting in the world."
- We ("agents") want/need to affect our environment (in part for survival)

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Computer Science vs. Philosophy

Computer Science

Functional programming	Object-oriented programming
Probability & Algorithms	Computational complexity
Imperative programming	Computer-aided verification
Discrete mathematics	Knowledge representation and reasoning
Models of computation	Advanced security
Compilers	Computational game theory
Concurrent programming	Concurrent algorithms and data structures
Databases	Computational Learning Theory
Intelligent systems	Quantum Computer Science
Machine learning	

Philosophy

General philosophy	Ethics
Elements of deductive logic	Philosophical logic
Turing on computability and intelligence	Philosophy of cognitive science
Knowledge and reality	Philosophy of mathematics
Early Modern philosophy	Philosophy of logic and language and many others
Philosophy of science	Advanced options in Philosophy
Philosophy of mind	Computers in society

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Theory of Computation

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Introduction to Theory of Computation

- Fundamentals of computer science
- What can be computed mechanically and how much space will it take
- There are computations that computers can do!
  - Does given binary string ends with 0?
  - Is it a valid Python script?
- There will always be tasks computers will not be able to perform
  - Will this code run forever (infinite loop)?

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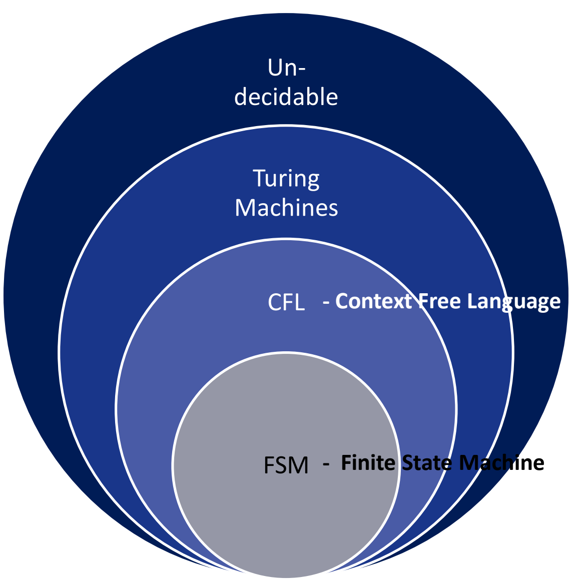
TOC - Layers



- Language means any set of strings
- Un-decidable – something which cannot be solved mechanically

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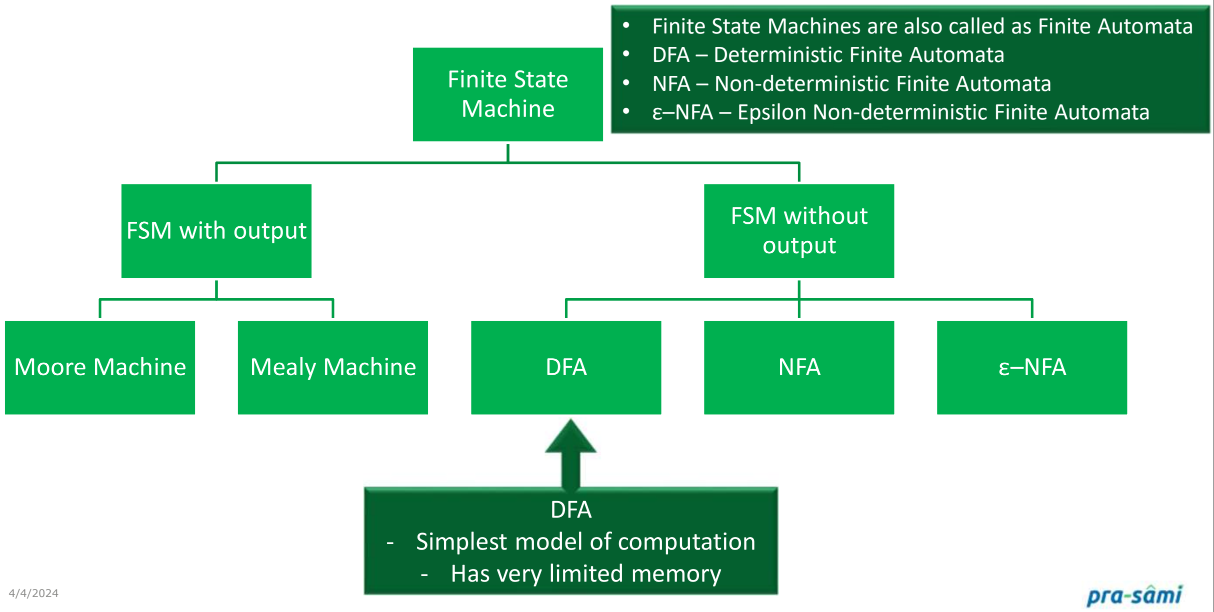
Finite State Machine



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Grammar

- Noam Chomsky gave a mathematical model of Grammar which is effective for writing computer languages
  - For details : https://en.wikipedia.org/wiki/Chomsky_hierarchy
- The four type of grammars are:

Type	Grammar	Language	Automata
Type – 0	Unrestricted	Recursively Enumerable	Turing Machine
Type – 1	Context Sensitive	Context Sensitive	Linear Bounded
Type – 2	Context Free	Context Free	Push Down
Type – 3	Regular	Regular	Finite State

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Some definitions!

Power of Sigma (Σ)

- For sigma (Σ) = { 0, 1}
  - $\Sigma^0 = \{ \varepsilon \}$
  - $\Sigma^1 = \{ 0 , 1 \}$
  - $\Sigma^2 = \{ 00, 01, \ 10, 00\}$
  - $\Sigma^3 = \{ 000, 001, 010, 100, 011, 101, 110, 111 \}$
  - $\Sigma^n = \{ 00 \ldots n \ times, \ldots \ldots .. \ 2n \ terms \} =$ $Set \ of \ strings \ of \ length \ n$

Cardinality

- $\Sigma^0 \rightarrow Cardinality = 1 = 2^0$
- $\Sigma^1 \rightarrow Cardinality = 2 = 2^1$
- $\Sigma^2 \rightarrow Cardinality = 4 = 2^2$
- $\Sigma^3 \rightarrow Cardinality = 8 = 2^3$
- $\Sigma^n \rightarrow Cardinality = 2^n$

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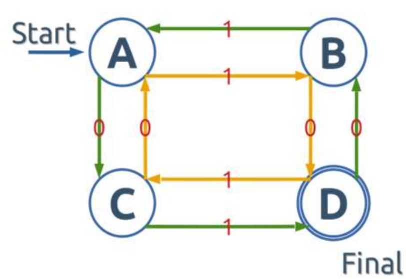
Finite State Machine (Finite Automata)

- Q : Set of all states = {A, B, C, D},
- Σ: inputs = {0, 1},
- q_0 : Start State / Initial State= A,
- F: Final State(s) = {D},
- δ = transition function from Q x Σ ➔ Q

Current State \ Input	0	1
A	C	B
B	D	A
C	A	D
D	B	C

State Transition Diagram



Finite state machine is defined by a tuple (Q, Σ, q_0, F, δ)

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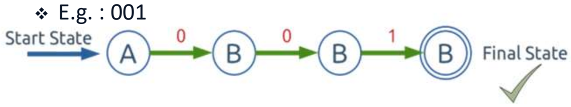
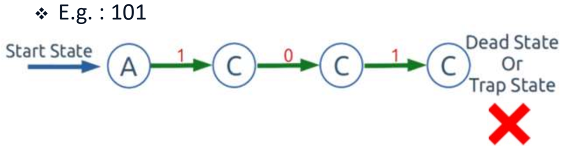
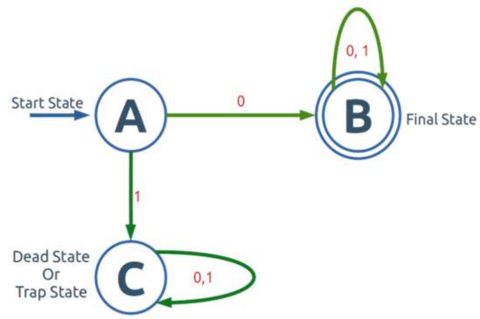
Deterministic Finite Automata - DFA

- Example 1
  - L1 = Set of all strings that start with '0'
    - { 0, 00, 01, 000, 001, 010, 011,0000, ….}
  - E.g. : 001



  - E.g. : 101





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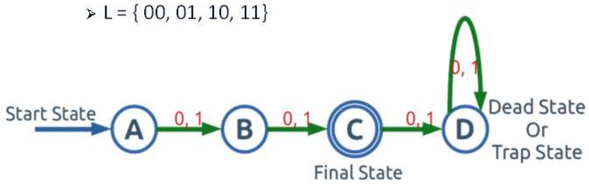
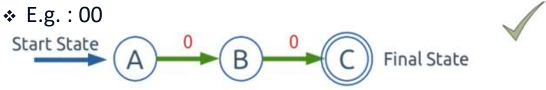
Deterministic Finite Automata - DFA

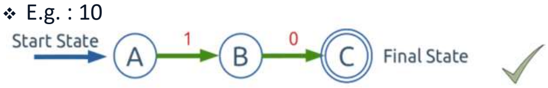
- Example 2
  - Construct a DFA that accepts all strings over {0,1} of length 2
    - Σ = { 0, 1}
    - L = { 00, 01, 10, 11}



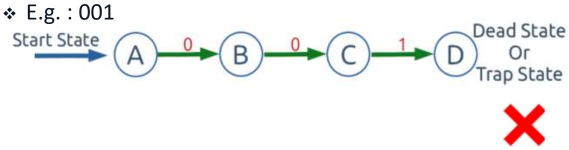
- E.g. : 00



- E.g. : 10



- E.g. : 001



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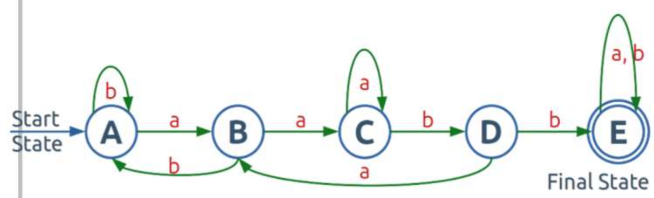
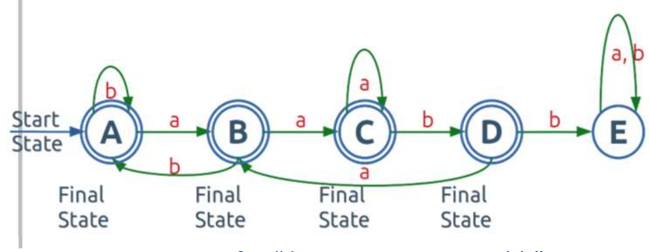
Deterministic Finite Automata - DFA

- Example 3
  - Construct a DFA that accepts all strings over { a, b } that **does not contain** 'aabb' in it.
  - It will be simpler to construct a DFA that **contains** 'aabb'!
    - Σ = { a, b}
  - Thereafter, flip the DFA to represent 'Does not contain' condition
  - Final stage becomes non-final and non-final stages become final stage



DFA for "contains aabb"



DFA for "does not contains aabb"

Regular Languages

- A language is said to be REGULAR LANGUAGE if and only if some Finite State Machine recognizes it
- Irregular languages (read set of strings)???
- The languages which
  - Are not recognized by FSM
  - Require memory
- Memory of FSM is very limited
  - It cannot **store** or **count** strings
- E.g.: ababbababb
- E.g. : $a^n b^n$ ➔ for n = 3, it becomes 'aaabbb' and for n = 5, it is 'aaaaabbbbb'
  - We need to keep count of how many times 'a' has appeared and compare it with count of 'b'

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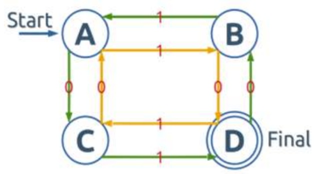
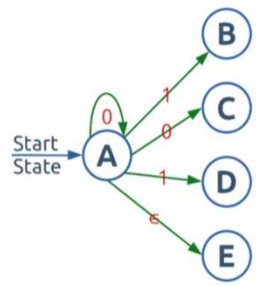
NFA – Nondeterministic Finite Automata

Deterministic Finite Automata	Nondeterministic Finite Automata
Given the current state and input, next state is fixed It has only one unique next state It has no choices or randomness Its simplest of all and easy to design	For given current state and input, there could be multiple next states The next state could be chosen at random All the next states may be chosen in parallel





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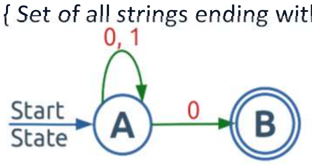
NFA - Example

- L = { *Set of all strings ending with 0*}



- Defined using a tuple of (Q, Σ, q_0, F, δ)
  - Q : Set of all states = {A, B},
  - Σ: inputs = {0, 1},
  - q_0 : Start State / Initial State= A,
  - F: Final State(s) = {B},
  - δ = transition function from Q x Σ ➔ __ ????
- State A on getting any input where all can it go?
  - A x 0 ➔ A
  - A x 0 ➔ B
  - A x 1 ➔ A
  - B x 0 ➔ ϕ
  - B x 1 ➔ ϕ
  - A on getting input 0 can go to A as well as B
  - In this case Total possibilities are { A, B, AB, ϕ} ➔ 4 Nos.
- What happens if there are three states?
  - Total possibilities are {A, B, C, AB, AC, BC. ABC, ϕ} ➔ 8 nos.
- In general, we can say total possibilities are 2^Q

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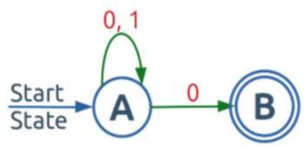
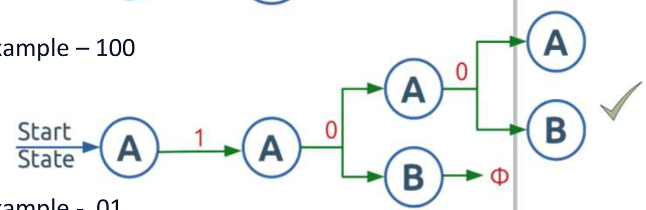
NFA – Example

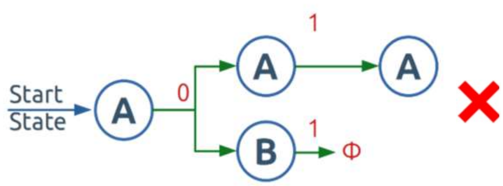
- L = { Set of all strings ending with 0}



- Example – 100



- Example - 01



- If there is a way to run the machine that ends with states out of which at least one state is a final state, NFL accepts the language (strings)

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Pushdown Automata

- A Pushdown automata is a way to implement a context Free Grammar in a similar way we design Finite Automata for Regular Grammar
  - More powerful than FSM
  - More memory than FSM
  - PDA is FSM plus a Stack (Arrangement of elements on one on top of another)
    - Example : pile of books
    - Push : add on top of the stack
    - Pop : remove from the top

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Pushdown Automata

- 3 components
  - An input tape
  - Finite control unit
  - Stack of infinite size
- Defined by a tuple of $(Q, \Sigma, \Gamma, \delta, q_0, z_0, F)$, where
  - Q : A finite set of States
  - Σ(sigma) : A finite set of Input Symbols
  - Γ(gamma) : A finite Stack Alphabet
  - δ(delta) : The transition Function,
  - q_0 : start state,
  - z_0 : The Start Stack Symbol,
  - F : set of Final / Accepting State

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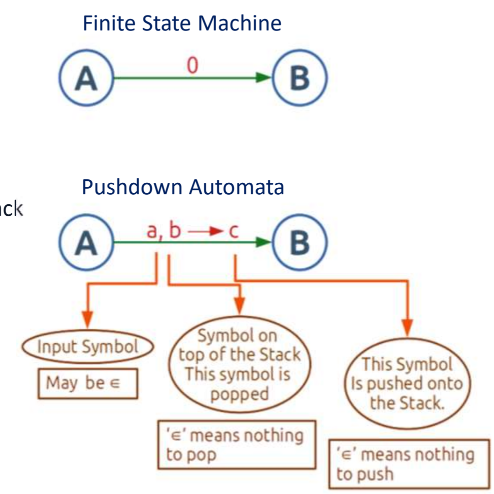
Pushdown Automata

- δ takes a tuple as argument (q, α, X)
  - q is a State in Q
  - α is either an Input Symbol in Σ or ε
  - X is a Stack Symbol which is part of Γ
- The output of δ is a tuple (p, γ) where
  - p is new state
  - γ is a string of stack symbol that replaces X at the top of the stack
  - If γ = ε → stack is empty
  - If γ = X → stack is unchanged
  - If γ = YZ → X is replaced by Z and Y is pushed onto the stack



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Example Pushdown Automata

- A PDA that accepts L = { 0^n1^n | n ≥ 0 } i.e. L = 000111
  - All 0s and 1s need to be together

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Example Pushdown Automata

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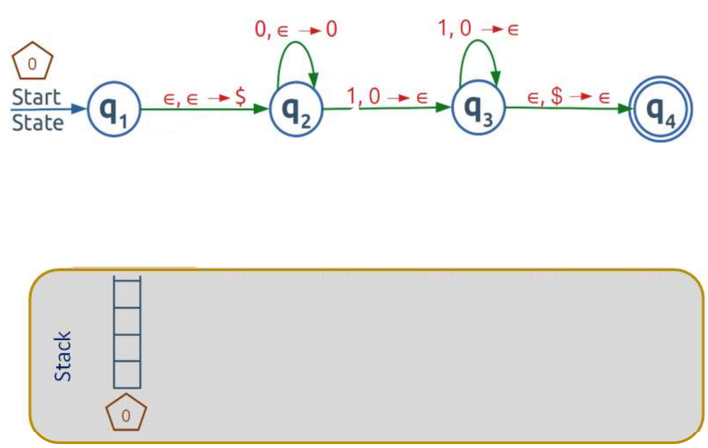

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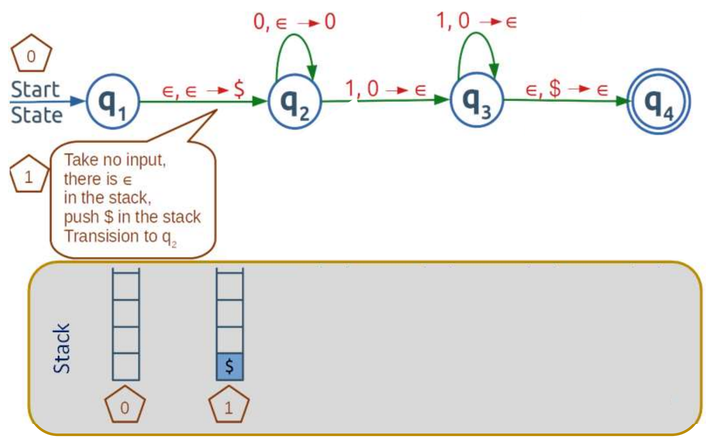

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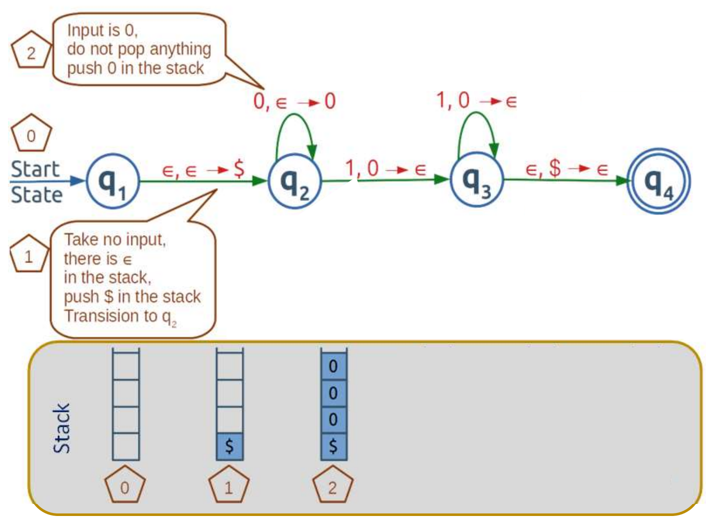

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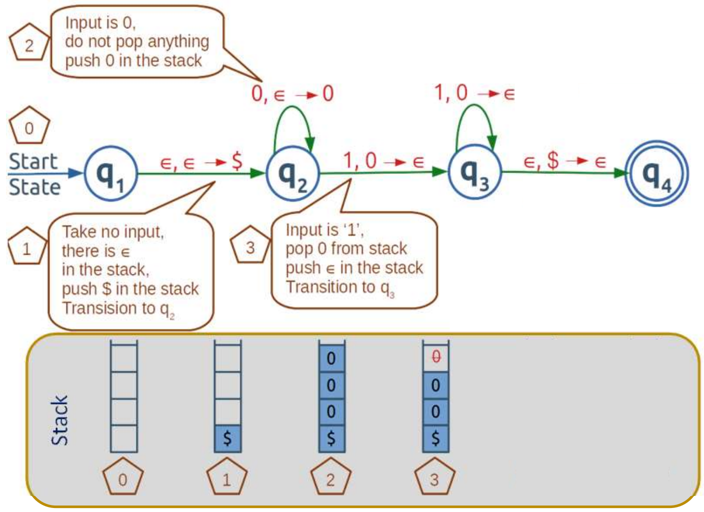

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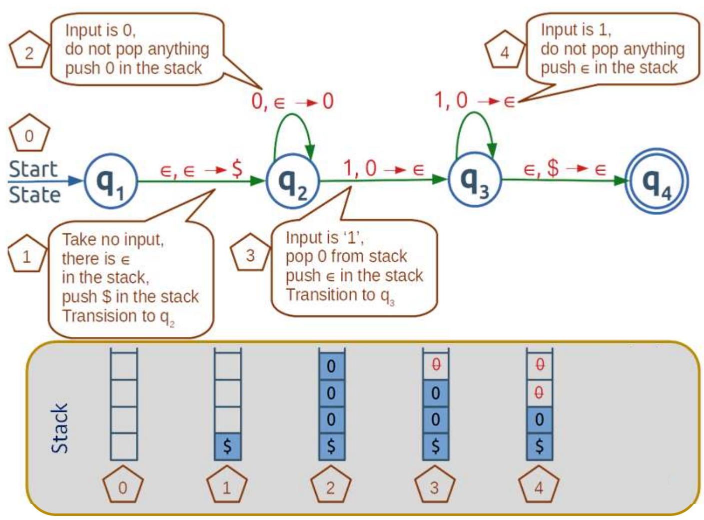

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Example Pushdown Automata

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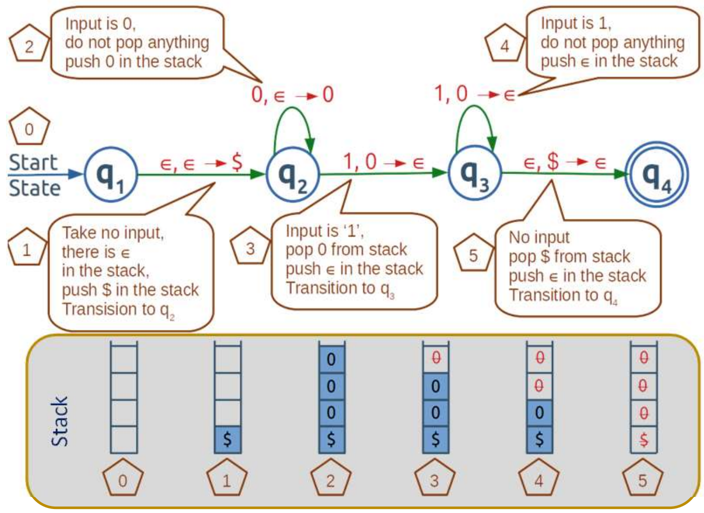

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