CS366: Artificial Intelligence

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Lecture–1: Introduction

THE MOST EXCITING DISCIPLINE in

Today's World

1/17/2024

Artificial Intelligence: Not merely a humanoid robot

- AI, as often portrayed, in science fiction is NOT only robots or other humanoid beings
  - **who are friendly and serve humans or,**
  - **turn evil and want to kill all humans to take control of our planet**

Fei-Fei Li, Director of Stanford AI lab, claims that the myth of the **terminator** *coming next door is, in fact, a real crisis for the development of the AI field as it highlights the public misreading of the technology but also reveals the fear of what are the intentions of the people behind the technology (2018)*
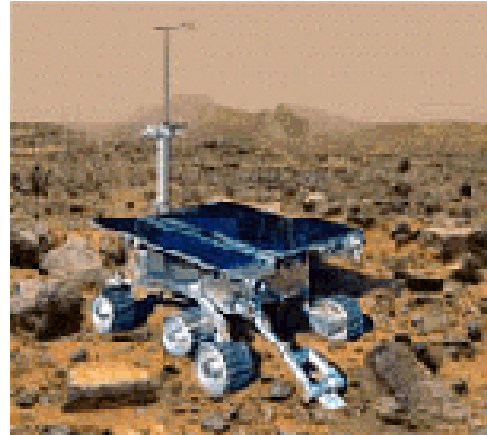
- AI is, in fact, an ever-evolving term which is one of the reasons that it means very different things to different people

- Artificial Intelligence is hard to define because the field has been redefined continuously with the advances of technology and the ambiguity of what we consider as "intelligent"

A better understanding of AI is crucial to its future development and progress
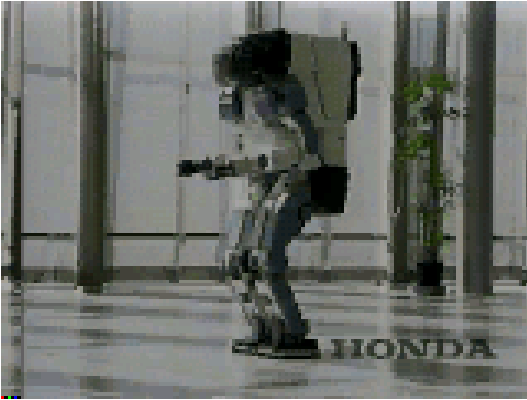
Why study AI?

Labor

Science

Search engines

Appliances

Medicine/
Diagnosis
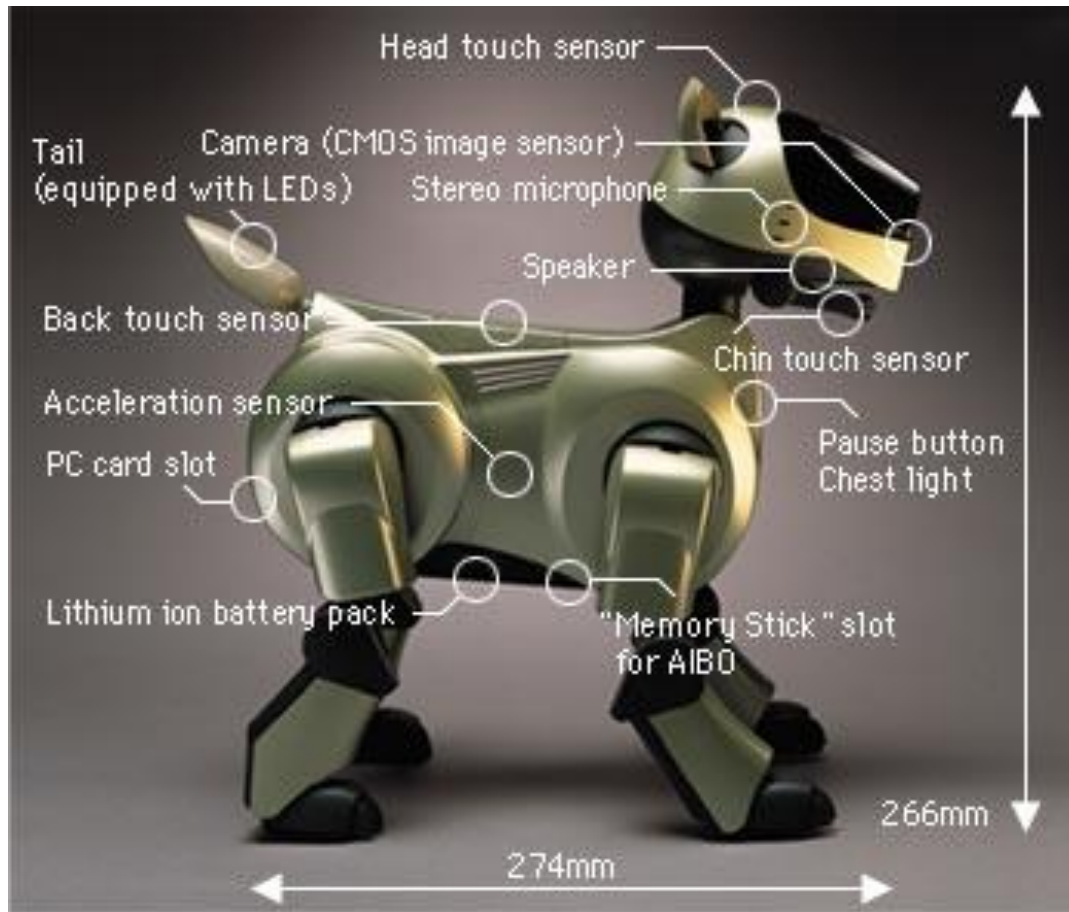
What else?

Honda Humanoid Robot

Walk

Turn

Stairs

http://world.honda.com/ASIMO/

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Sony AIBO

Head touch sensor

Camera (CMOS image sensor)

Stereo microphone

Tail (equipped with LEDs)

Speaker

Back touch sensor

Chin touch sensor

Acceleration sensor

PC card slot

Pause button
Chest light

Lithium ion battery pack

"Memory Stick" slot for AIBO

266mm

274mm

Natural Language Question Answering
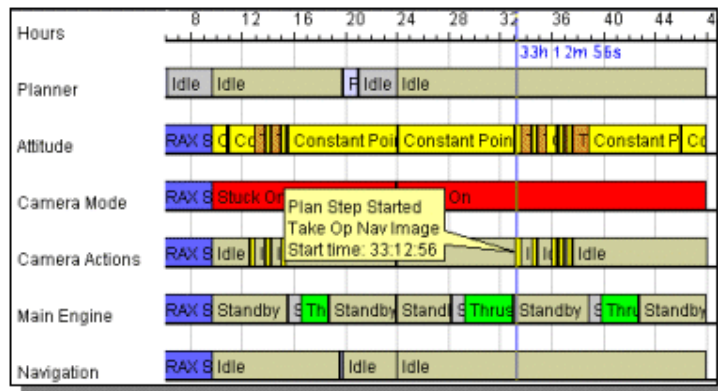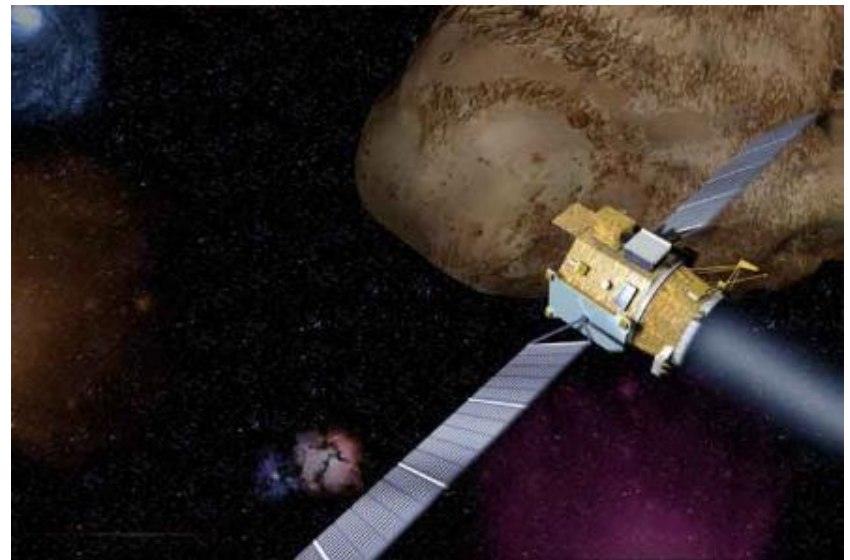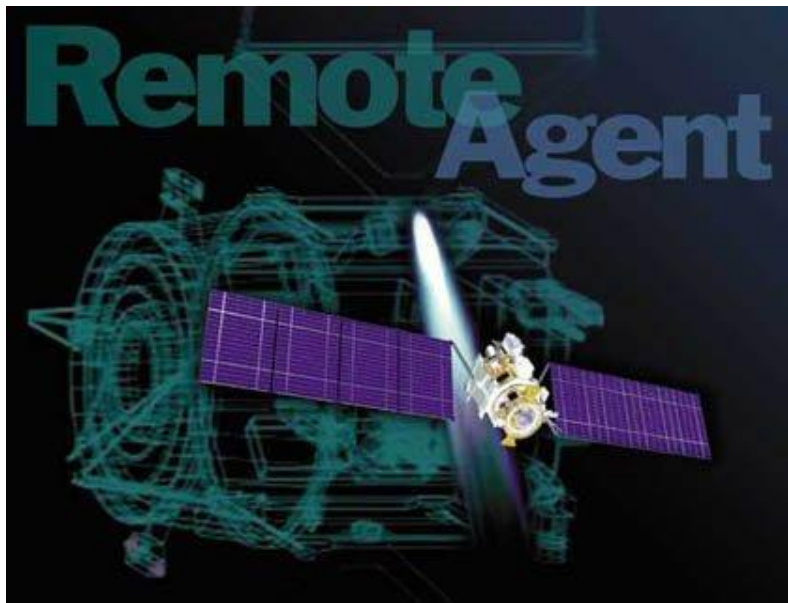
Example: AI at NASA
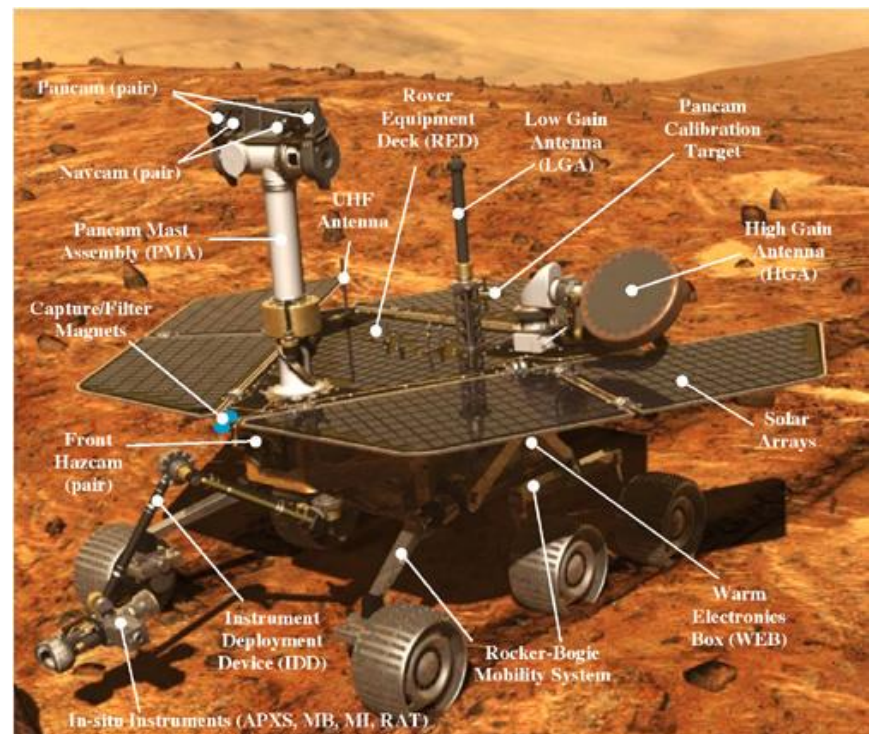
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Examples: AI at Google

Finding Canonical Images

Compare low-level features
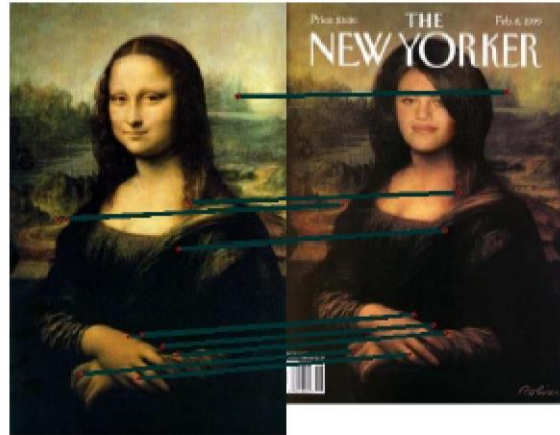
(a) A v.s. B
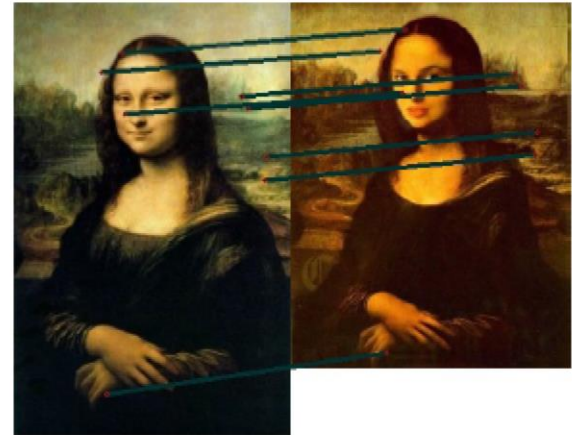
(b) A v.s. C
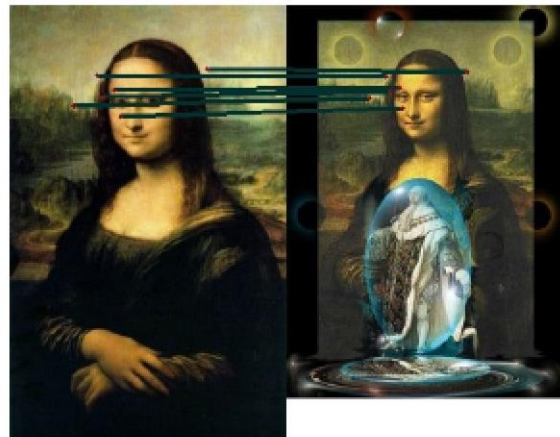
(c) A v.s. D
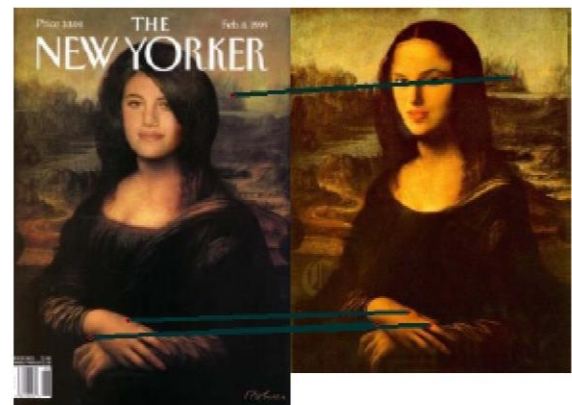
(d) B v.s. C

Induced Graph
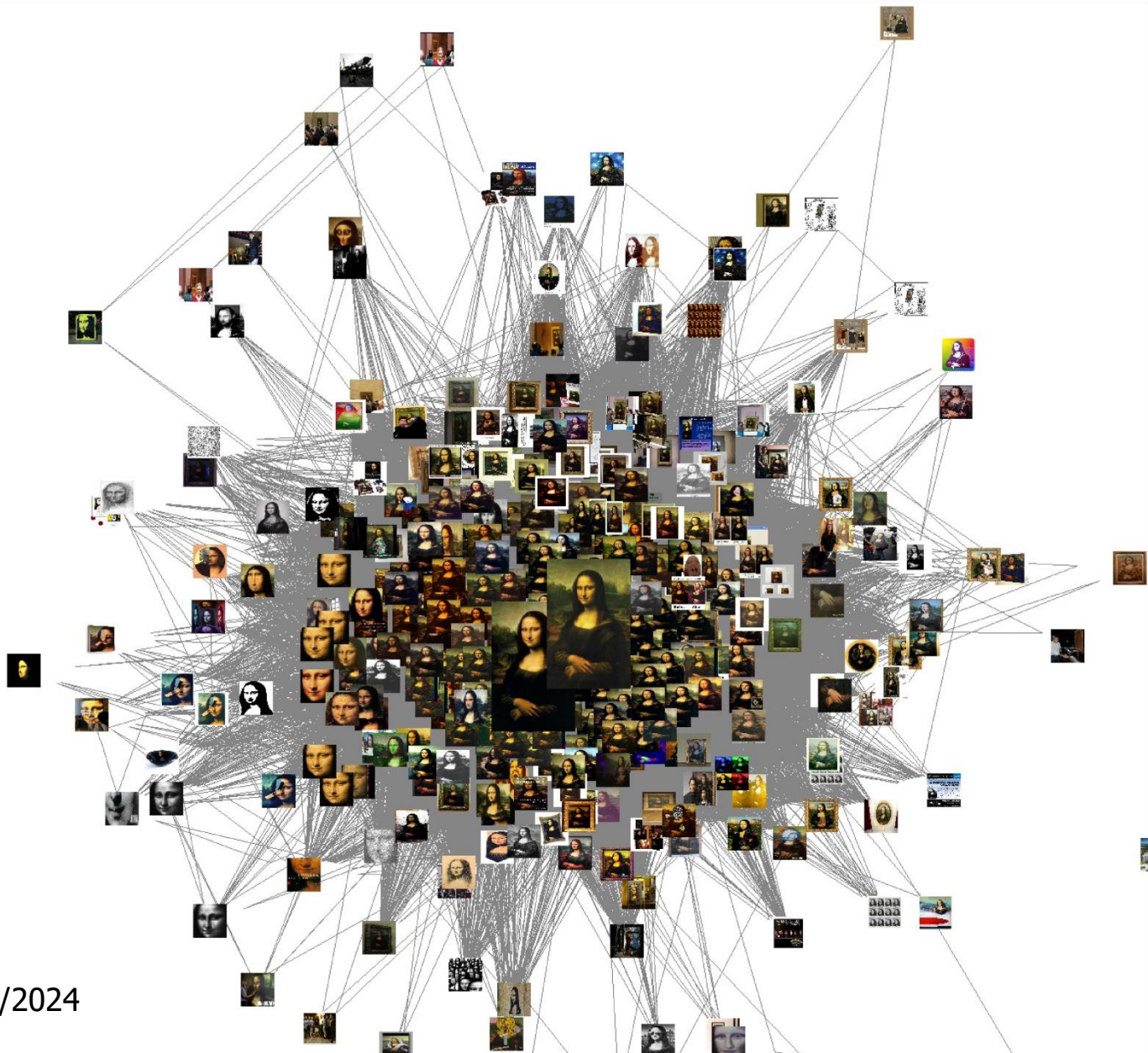
Route Finding

↰ 2. Turn left

— 210 m

⚲ 3. At the roundabout, take the 2nd exit onto IIT Main Rd

— 250 m

Take NH922 to Anisabad Post Office Rd/Dhira Chak Main Rd/Khagaul Rd/Mithapur - Anisabad - Khagaul Rd in Anisabad, Patna

— 53 min (28.8 km)

↰ 4. Turn left at Singh Da Dhaba onto Bihta Kanpa Rd

ⓘ Pass by SURAJ Hotel (on the right in 450 m)

— 1.4 km

↑ 5. At Pradip Communnication, continue onto Bihta Rd/Bikram - Bihta Rd

ⓘ Continue to follow Bikram - Bihta Rd

ⓘ Pass by Hanuman Mandir (on the left)

— 2.3 km

Take IIT Main Rd to Bihta Kanpa Rd

— 2 min (550 m)

↑ 1. Head northeast

ⓘ Pass by SBI ATM (on the left)

— 88 m

↰ 2. Turn left

— 210 m

⚲ 3. At the roundabout, take the 2nd exit onto IIT Main Rd

— 250 m

Take NH922 to Anisabad Post Office Rd/Dhira Chak Main Rd/Khagaul Rd/Mithapur - Anisabad - Khagaul Rd in

Google Maps

Indian Institute of Technology Patna to Jay Prakash Narayan International Airport

Drive 32.2 km, 1 h 15 min
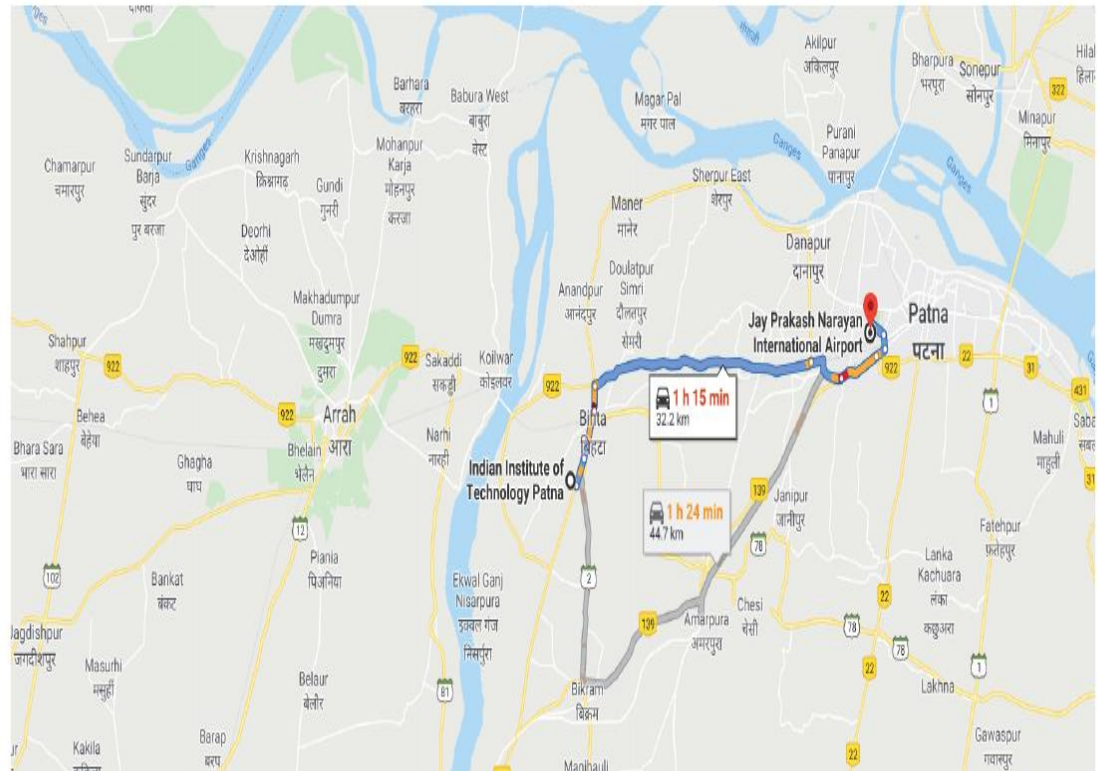
COVID-19 Trend
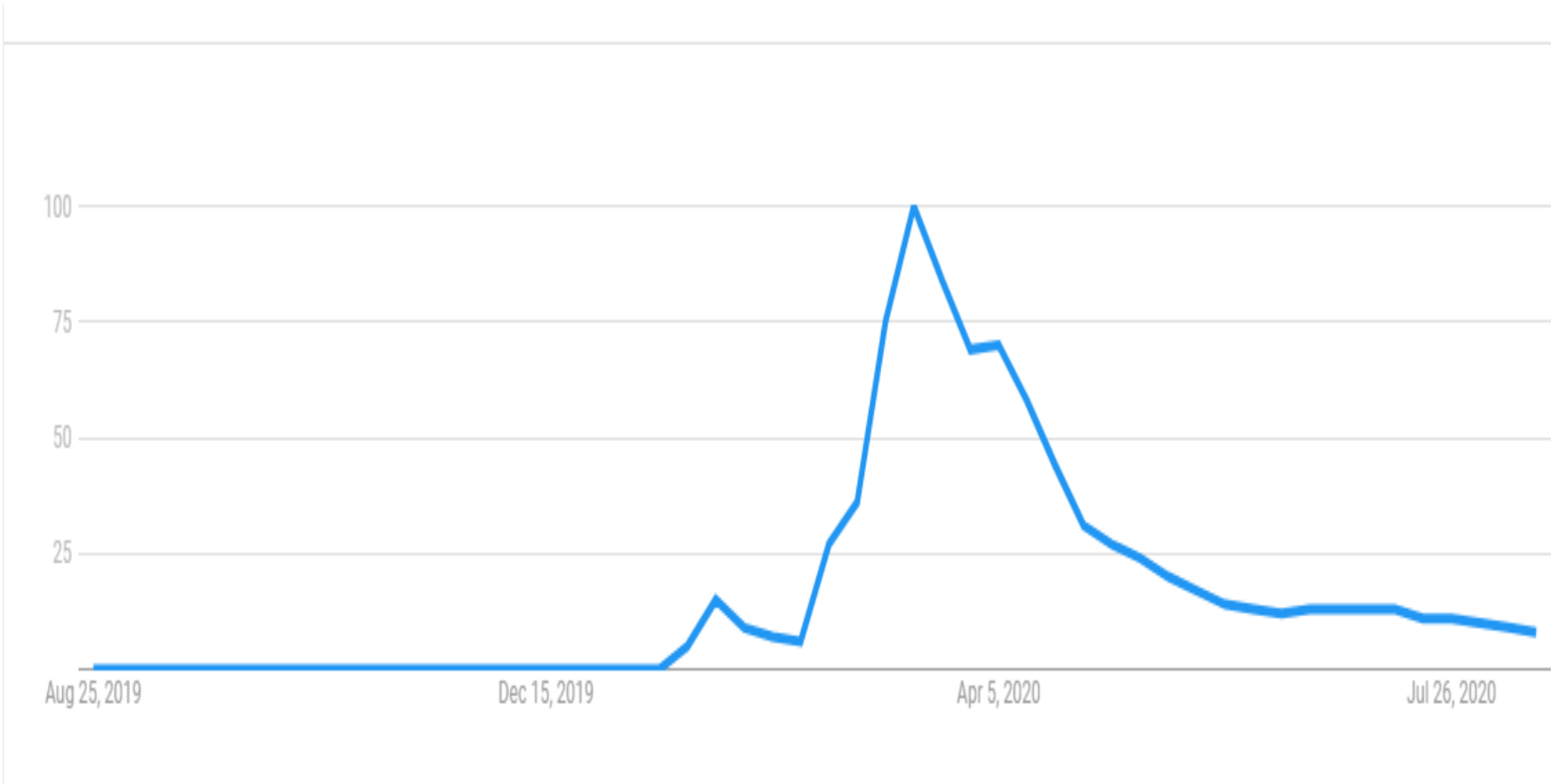
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Google™ Sets

Automatically create sets of items from a few examples.

Enter a few items from a set of things. (example)
Next, press *Large Set* or *Small Set* and we'll try to predict other items in the set.

- pablo picasso
- henri matisse
-
-
-

(clear all)

Large Set   Small Set (15 items or fewer)

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Google

sets | labs

Automatically create sets of items from a few examples.

Enter a few items from a set of things. (example)
Next, press *Large Set* or *Small Set* and we'll try to predict other items in the set.

- lions
- tigers
- bears
-
-

(clear all)

(Large Set) (Small Set (15 items or fewer))

Examples:

green, purple, red   chicken dance, macarena, ymca   alexander, gladiator, troy   hilary duff, kelly clarkson   more...

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Google Sets

tigers, lions, bears, cats, dogs, birds, horses, reptiles, fish, pet breeders, rabbits, *pet health, pet food, pet supplies*, exotic pets, small mammals, iguanas, *animal medications*, pet rescue, *pet adoption*, *veterinary jobs*, pets general, elephants, livestock, insects, other, small pets, marine life, spiders, amphibians, aquariums, pets, wolves, monkeys, flowers, pigs, wildlife, dolphins, frogs, giraffes, turtles, butterflies, sheep, ferrets, dinosaurs, farm animals

Statistical Machine Translation

SEHR GEEHRTER GAST!
KUNST, KULTUR UND
KOMFORT IM HERZEN
BERLIN.

↔

DEAR GUESTS,
ART, CULTURE AND
LUXURY IN THE HEART
OF BERLIN.

DIE ÖRTLICHE
NETZSPANNUNG
BETRÄGT 220/240 VOLT
BEI 50 HERTZ.

↔

THE LOCAL VOLTAGE
IS 220/240 VOLTS 50 HZ.

EN

DE

Statistical Machine Translation

- Align

KUNST, KULTUR UND KOMFORT IM HERZEN BERLINS.

ART, CULTURE AND LUXURY IN THE HEART OF BERLIN.

Statistical Machine Translation

- Align

KUNST, KULTUR UND KOMFORT IM HERZEN BERLINS.

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Statistical Machine Translation

- ■ Align

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ART, CULTURE AND LUXURY IN THE HEART OF BERLIN.

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Statistical Machine Translation

- Align

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Statistical Machine Translation

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ART, CULTURE AND LUXURY IN THE HEART OF BERLIN.
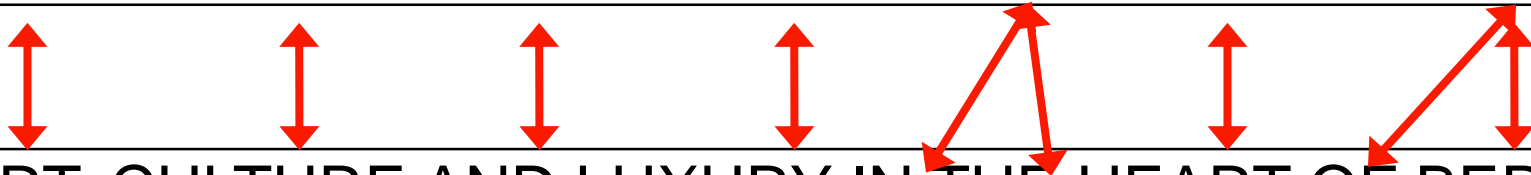
English-Hindi and Challenges

- *The grandfather <u>kicked the bucket after</u> suffering from cancer.*
- *This job is a <u>piece of cake</u>*
- *<u>Put</u> the sweater <u>on</u>*
- *He is the <u>dark horse</u> of the match*

Google Translations of above sentences:

दादा कैंसर से पीड़ित होने के बाद बाल्टी लात मारी.
इस काम के केक का एक टुकड़ा है.
स्वेटर पर रखो.
वह मैच के अंधेरे घोड़ा है.

English-Hindi and Challenges

- Bengali: *চঞ্চল সরকার বাড়িতে আছে*
  English: *Government is restless at home*. (*)
  Chanchal Sarkar is at home

  Amsterdam airport: "Baby Changing Room"

- Hindi: *दैनिक दबंग दुनिया*
  English: Daily domineering world

Actually name of a Hindi newspaper in Indore

- High degree of overlap between NEs and MWEs
- Treat differently - transliterate do not translate

What Else is AI?

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0 MPH
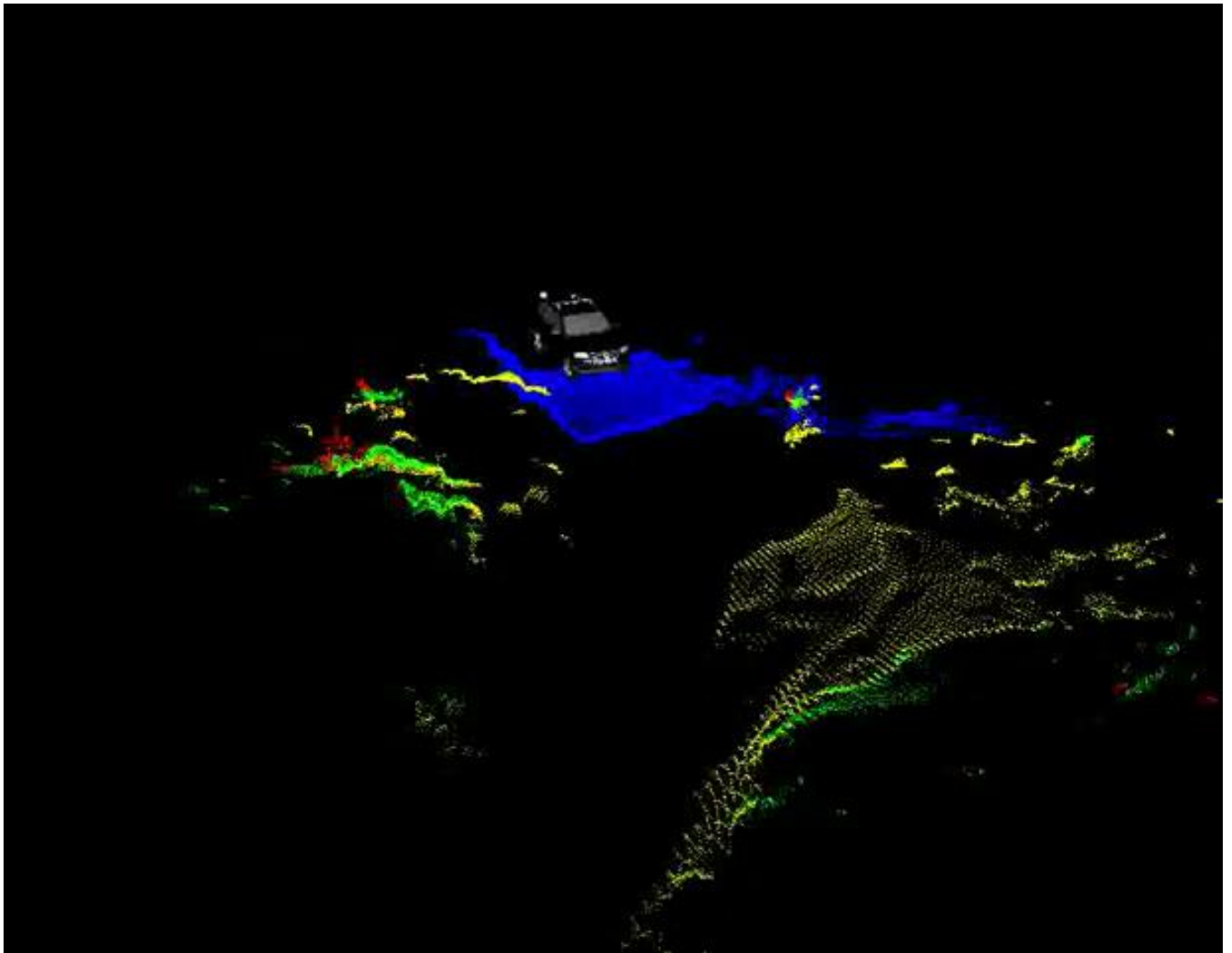
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AI as the forcing function

- Time sharing system in OS
  - Machine giving the illusion of attending simultaneously with several people

- Compilers
  - Raising the level of the machine for better man-machine interface
  - Arose from Natural Language Processing (NLP)
    - NLP in turn called the forcing function for AI

AI is Real Fun!

What is AI?

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

Figure 1.1   Some definitions of AI. They are organized into four categories:

Systems that think like humans.	Systems that think rationally.
Systems that act like humans.	Systems that act rationally.

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From Wikipedia

Artificial intelligence (**AI**) is the intelligence of machines and the branch of computer science that aims to create it. Textbooks define the field as "the study and design of intelligent agents"[1] where an intelligent agent is a system that perceives its environment and takes actions that maximize its chances of success.[2] John McCarthy, who coined the term in 1956,[3] defines it as "the science and engineering of making intelligent machines."[4]

The field was founded on the claim that a central property of humans, intelligence—the sapience of *Homo sapiens*—can be so precisely described that it can be simulated by a machine.[5] This raises philosophical issues about the nature of the mind and limits of scientific hubris, issues which have been addressed by myth, fiction and philosophy since antiquity.[6] Artificial intelligence has been the subject of optimism,[7] but has also suffered setbacks[8] and, today, has become an essential part of the technology industry, providing the heavy lifting for many of the most difficult problems in computer science.[9]

AI research is highly technical and specialized, deeply divided into subfields that often fail to communicate with each other.[10] Subfields have grown up around particular institutions, the work of individual researchers, the solution of specific problems, longstanding differences of opinion about how AI should be done and the application of widely differing tools. The central problems of AI include such traits as reasoning, knowledge, planning, learning, communication, perception and the ability to move and manipulate objects.[11] General intelligence (or "strong AI") is still a long-term goal of (some) research.[12]

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Acting Humanly: The Full Turing Test

- Alan Turing's 1950 article *Computing Machinery and Intelligence* discussed conditions for considering a machine to be intelligent
    - "Can machines think?" $\longleftrightarrow$ "Can machines behave intelligently?"
    - The Turing test (The Imitation Game): Operational definition of intelligence
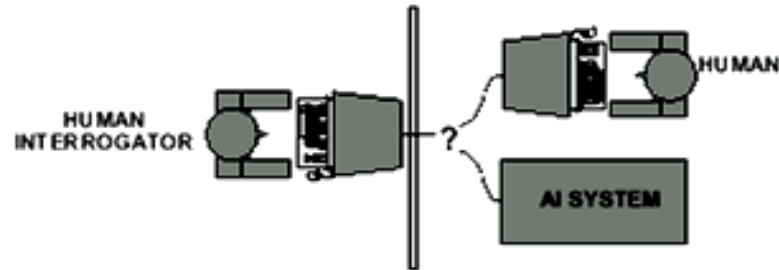
- Computer needs to posses: Natural language processing, Knowledge representation, Automated reasoning, and Machine learning
- Problem: 1) Turing test is not reproducible, constructive, and amenable to mathematic analysis. 2) What about physical interaction with interrogator and environment?
- Total Turing Test: Requires physical interaction and needs perception and actuation.

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What would a computer need to pass the Turing test?

- **Natural language processing:** to communicate with examiner
- **Knowledge representation:** to store and retrieve information provided before or during interrogation
- **Automated reasoning:** to use the stored information to answer questions and to draw new conclusions

- **Machine learning:** to adapt to new circumstances and to detect and extrapolate patterns

- **Vision** : to recognize the examiner's actions and various objects presented by the examiner
- **Motor control**: to act upon objects as requested
- **Other senses**: such as audition, smell, touch, etc.

Thinking Humanly: Cognitive Science

- 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)

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Thinking Rationally: Laws of Thought

- Aristotle (~ 450 B.C.) attempted to codify "right thinking"
  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

- Problems:
  1) Uncertainty: Not all facts are certain (e.g., *the flight might be delayed*)
  2) Resource limitations: There is a difference between solving a problem in principle and solving it in practice under various resource limitations such as time, computation, accuracy etc. (e.g., *purchasing a car*)

Acting Rationally: The Rational Agent

- 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, AR, knowledge representation, ML, etc.)

- Advantages:
  1) More general
  2) Its goal of rationality is well defined

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How to achieve AI?

- How is AI research done?

  - AI research has both <u>theoretical</u> and <u>experimental</u> sides. The experimental side has both basic and applied aspects

- There are two main lines of research:
  - One is <u>biological</u>, based on the idea that since humans are intelligent, AI should study humans and imitate their psychology or physiology
  - The other is <u>phenomenal</u>, 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]**

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Disciplines which form the core of AI- inner circle
 Fields which draw from these disciplines- outer circle

Robotics

NLP

Search,
Reasoning,
Machine Learning

Expert
Systems

Planning

Computer
Vision

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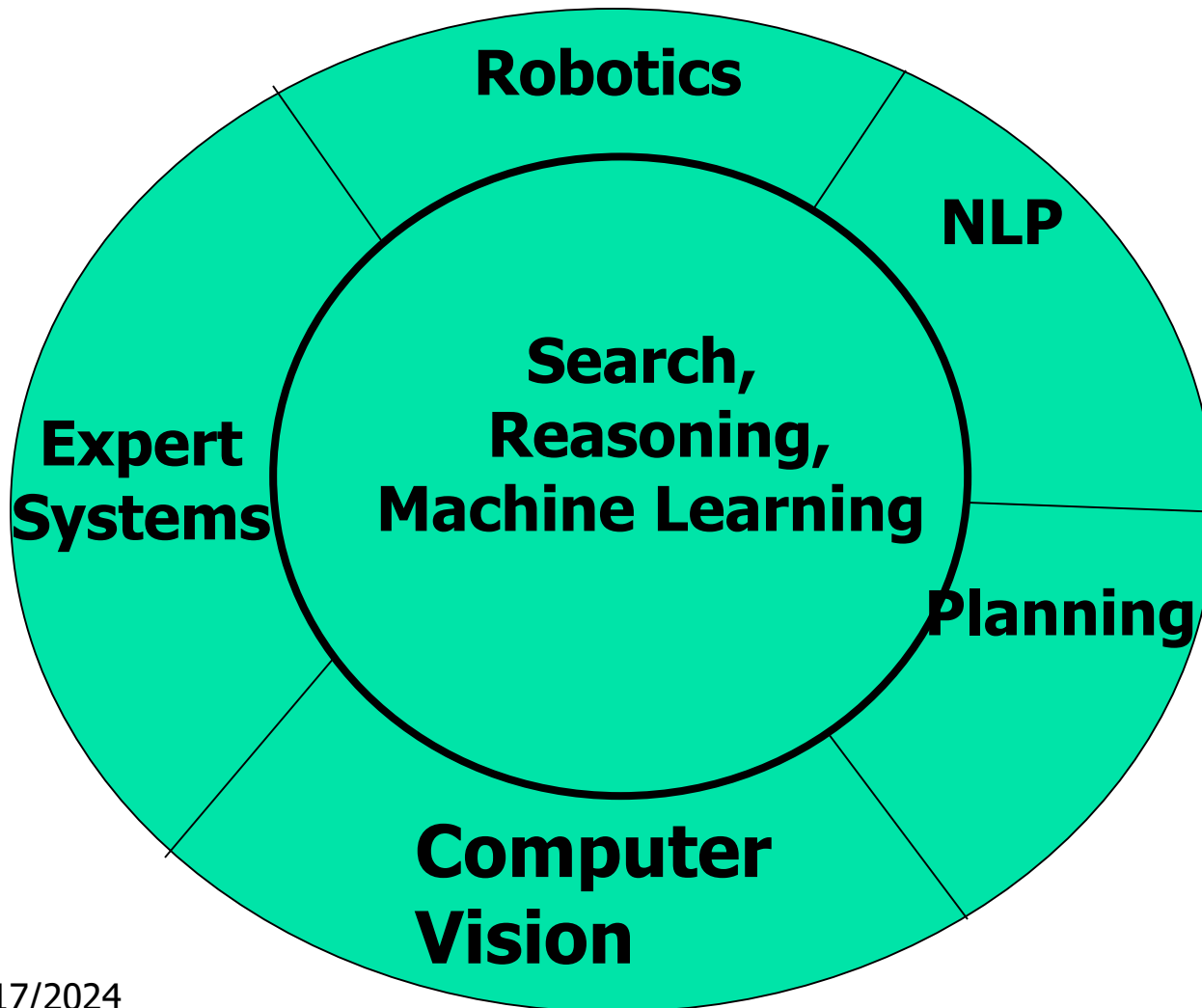
Allied Disciplines

Philosophy	Knowledge Rep., Logic, Foundation of AI (is AI possible?)
Maths	Search, Analysis of search algos, logic
Economics	Expert Systems, Decision Theory, Principles of Rational Behavior
Psychology	Behavioristic insights into AI programs
Brain Science	Learning, cognitive science, Neural Nets
Physics	Learning, Information Theory & AI, Entropy, Robotics
Computer Sc. & Engg.	Systems for AI

AI History

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

1980–88   Expert systems industry booms

1988–93   Expert systems industry busts: "AI Winter"

1985–95   Neural networks return to popularity

1988 – Resurgence of probability; general increase in technical depth "Nouvelle AI": ALife, GAs, soft computing

1995 – Agents, agents, everywhere . . . Machine learning comes to age, web intelligence, smart machines

2003 – Human-level AI back on the agenda

AI State-of-the-art

- Have the following been achieved by AI?
    - World-class chess playing
    - Playing table tennis
    - Solving mathematical problems
    - Discover and prove mathematical theories
    - Engage in a meaningful conversation
    - Understand spoken language
    - Observe and understand human emotions
    - Express emotions
    - …

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AI, NLP and ML: From Past to Present

- AI/NLP based systems have enabled wide-range of applications
  - Google's powerful search engines
  - Alexa, Google's MT
  - Several systems related to healthcare, mental health, processing social media texts etc.
  - Fake news detector and so on
  - Chess playing
- Shallow ML algorithms (corresponds to Statistical NLP)
  - Used extensively (HMM, MaxEnt, CRF, SVM, Logistic Regression etc.)
  - Requires handcrafting of features
  - Time-consuming
  - Curse of dimensionality (because of joint modeling of language models)

48

AI, NLP and ML: From Past to Present

- Deep Learning algorithms
  - No feature engineering
  - Success of distributed representations (Neural language models)
- Some recent developments
  - The rise of distributed representations (e.g., Word2vec, GLOVE, ELMO, BERT etc)
  - Convolutional, recurrent, recursive neural networks, Transformer, Reinforcement learning
  - Unsupervised sentence representation learning
  - Combining deep learning models with memory-augmenting strategies
- Explainable AI

AI, NLP and ML: Future

- Artificial General Intelligence :
    able to exhibit human intelligence

- Artificial Super Intelligence :
    surpasses human intelligence in many aspects

    from creativity to general wisdom to problem-solving —
    will require machines to experience consciousness

News: March 27, 2019

Yoshua Bengio, Geoffrey Hinton, and Yann LeCun received the

Turing Award-2018 (equivalent to Nobel Prize of Computing)

- *for Modern AI (specifically for deep learning research)*

Bengio- University of Toronto and Google

Hinton- University of Montreal

LeCun- Facebook's chief AI scientist and a professor at NYU

Topics to be covered (1/2)

- **Search**
  - General Graph Search, Uninformed search, informed search and local search

- **Logic**
  - Propositional Calculus and Predicate Calculus
- Planning

- **Machine Learning**
  - Basic Ideas, Decision Trees, Bayes Networks, Text Classification, Neural Networks
- **Deep Learning**
  - CNN, RNN, LSTM

Topics to be covered (2/2)

- **Evolutionary Computation**
    - Genetic Algorithm, Multiobjective Optimization, Differential Evolution, Particle Swarm Optimization

- **Probabilistic Methods**
    - Hidden Markov Model, Maximum Entropy Markov Model

- Introduction to NLP

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Goal of Teaching the course

- **Concept building**: firm grip on foundations, clear ideas

- **Coverage**: grasp of good amount of material, advances

- **Inspiration**: get the spirit of AI, motivation to take up further work

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Resources

- **Main Text:**
  - Artificial Intelligence: A Modern Approach by Russell & Norvig, Pearson, 2003.
- **Other Main References:**
  - Principles of AI - Nilsson
  - AI - Rich & Knight
  - Knowledge Based Systems – Mark Stefik
- **Journals**
  - AI, IEEE Expert, TPMII, IEE TKDE etc..
  - Area Specific Journals e.g, Computational Linguistics etc.
- **Conferences**
  - IJCAI, AAAI, ACL etc.

Positively attend lectures!

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Teaching Assistants

- **Theory**
  - Soumitra Ghosh (3rd Year PhD Student, CSE): ghosh.soumitra2@gmail.com
  - Deeksha Vershney (3rd Year PhD student, CSE): deeksha.varshney2695@gmail.com
  - Mamta Kumari (2nd Year PhD Student, CSE): mamta20118@gmail.com
  - Prashant Kapil (4th Year PhD Student, CSE): prashant.juse2014@gmail.com

- **Laboratory**
  - Zishan Ahmad (3rd Year PhD Student, CSE): zeeman.zishan@gmail.com
  - Kshitij Misra (2nd Year PhD Student, CSE): kmishra.kings@gmail.com
  - Aizan Zafar (2nd Year PhD Student, CSE): aizanzafar@gmail.com
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Thank you for your attention!

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