Artificial & Computational Intelligence

AIML CLZG557

M1 : Introduction

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BITS Pilani
Pilani Campus

Agenda

- Course Administration
- Getting Started (with some definitions)
- Course Overview with example

Course Administration

About the course

- Focus on
  - principles of artificial intelligence
  - concepts, algorithms involved in building rational agents
  - topics covered like
    - (informed and uninformed) search & applications
    - (logical & probabilistic) knowledge representation
    - (logical & probabilistic) Reasoning & applications
  - topics not-covered like
    - Formal introduction to machine learning algorithms, neural networks etc., are covered as a ML course is running in parallel, Deep neural networks, which are part of AI as well.
    - Hardware aspects of the Design

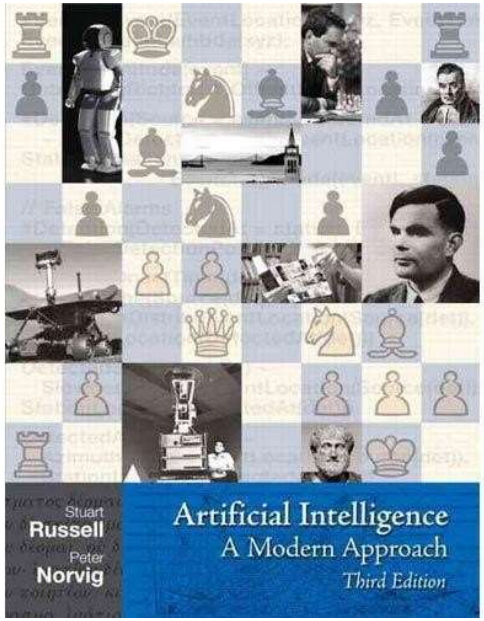
Course Outline

- **Pedagogy**
  - Weekly online live sessions
  - Webinars on lab implementation
  - Assignment:
    - 1 Quiz-5%,
    - 2 Assignments- 25%

- **Lab Modules**
  - Supported by 6 lab capsules for practical implementation and better understanding of the concepts learned in the live lecture sessions.

About the course

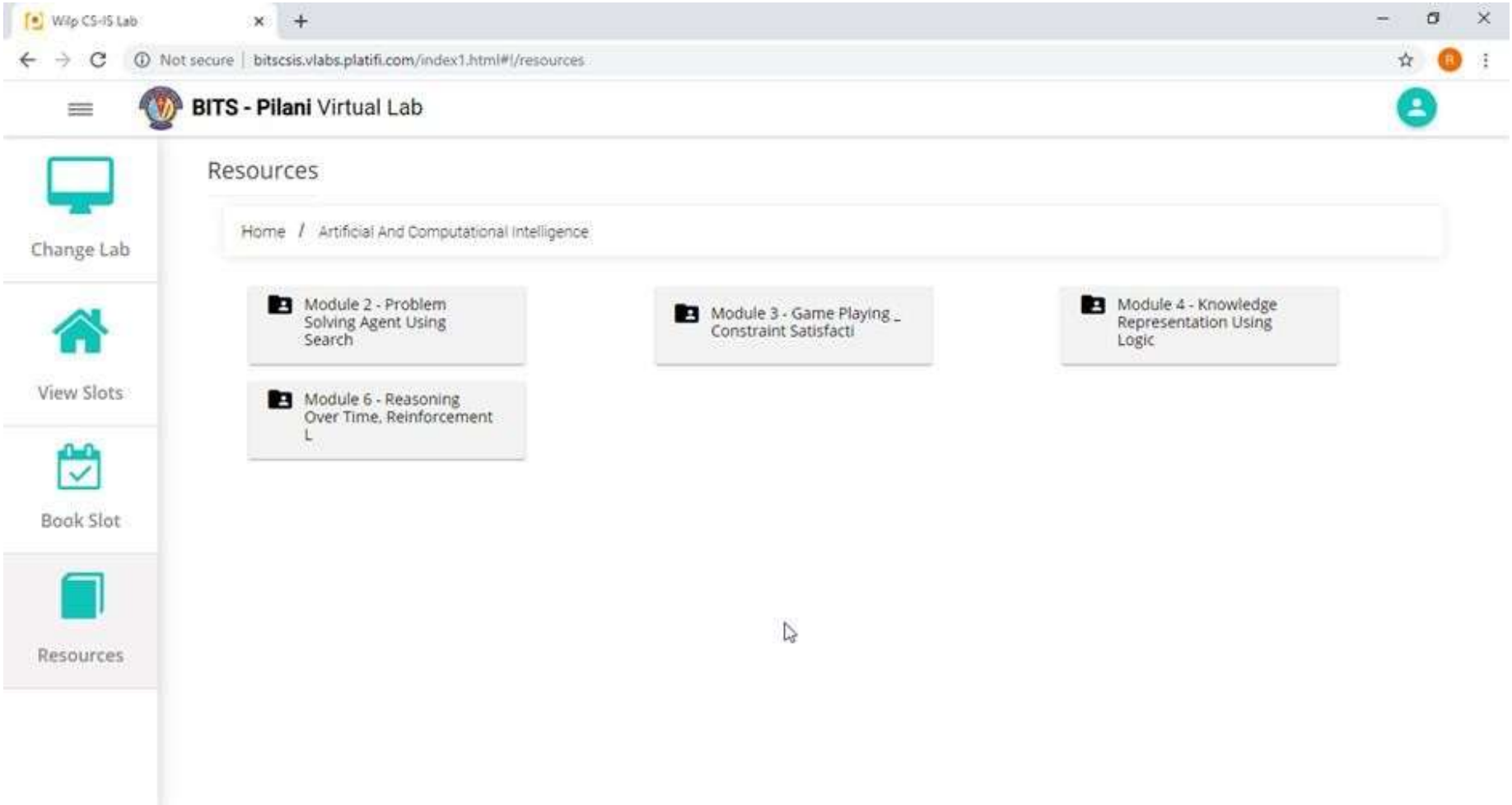
Text Book



Exercises : In Python & its libraries

Evaluation : 25% Assignment + 5% Quiz + 30% Mid Semester + 40% End Semester

About Labs



Exercises : In Python & its libraries

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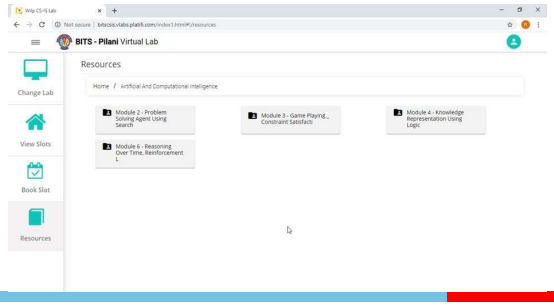

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BITS - Pilani Virtual Lab

Resources

Home / Artificial And Computational Intelligence / Module 2 - Problem Solving Agent Using Search

Exercise 1 - Uninformed Search

Exercise 2 - Informed Search

Exercise 3 - Local Search

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Resources

Home / Artificial And Computational Intelligence / Module 3 - Game Playing _ Constraint Satisfaction Problem

Exercise 4A - Adversarial Search - Game Playing

Exercise 4B - Constraint Satisfaction Problem

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Resources

Home / Artificial And Computational Intelligence / Module 4 - Knowledge Representation Using Logics

Representation In Logic

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Resources

Home / Artificial And Computational Intelligence / Module 6 - Reasoning Over Time, Reinforcement Learning

Exercise 7 - Experiment With HMM

Exercise 8 - Reinforcement Learning

Exercises : In Python & its libraries

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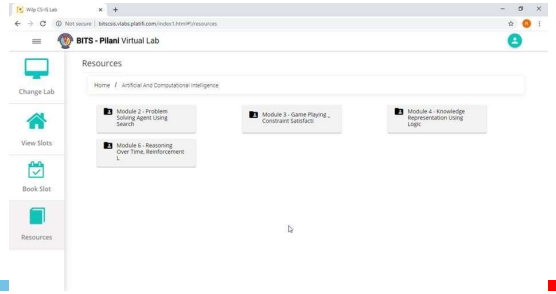

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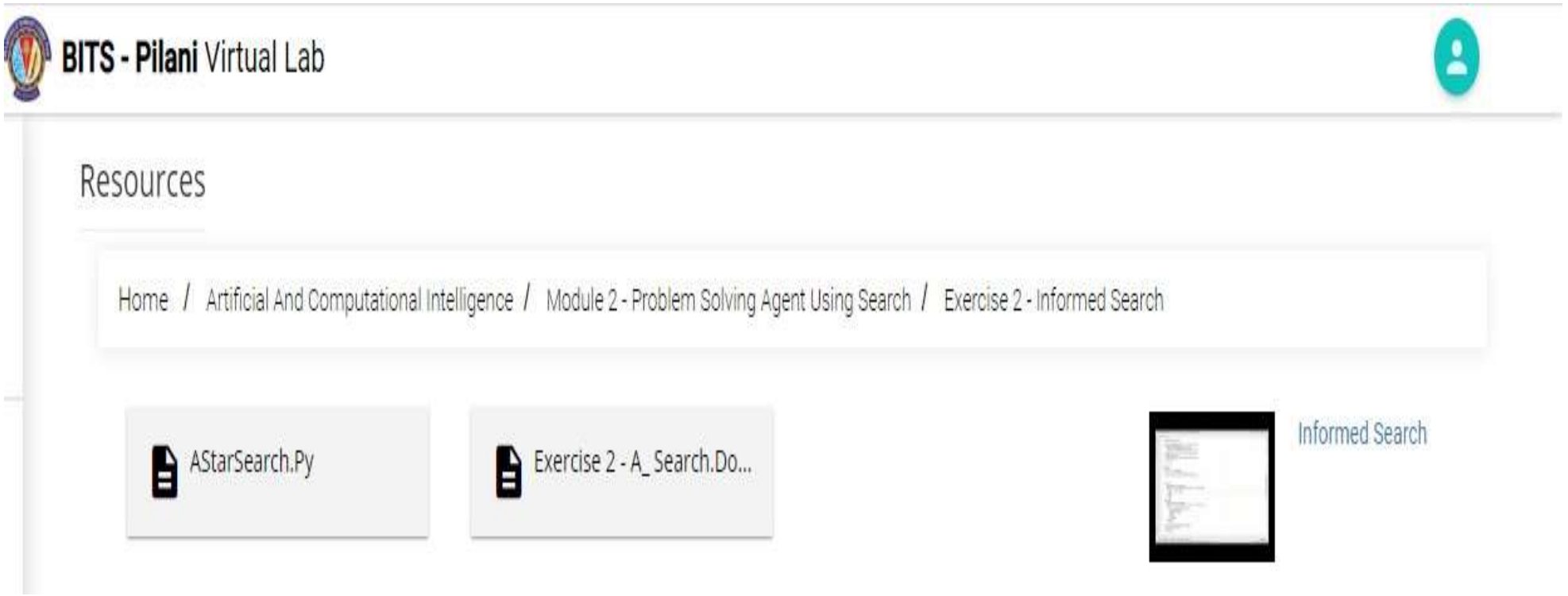

Exercises : In Python & its libraries

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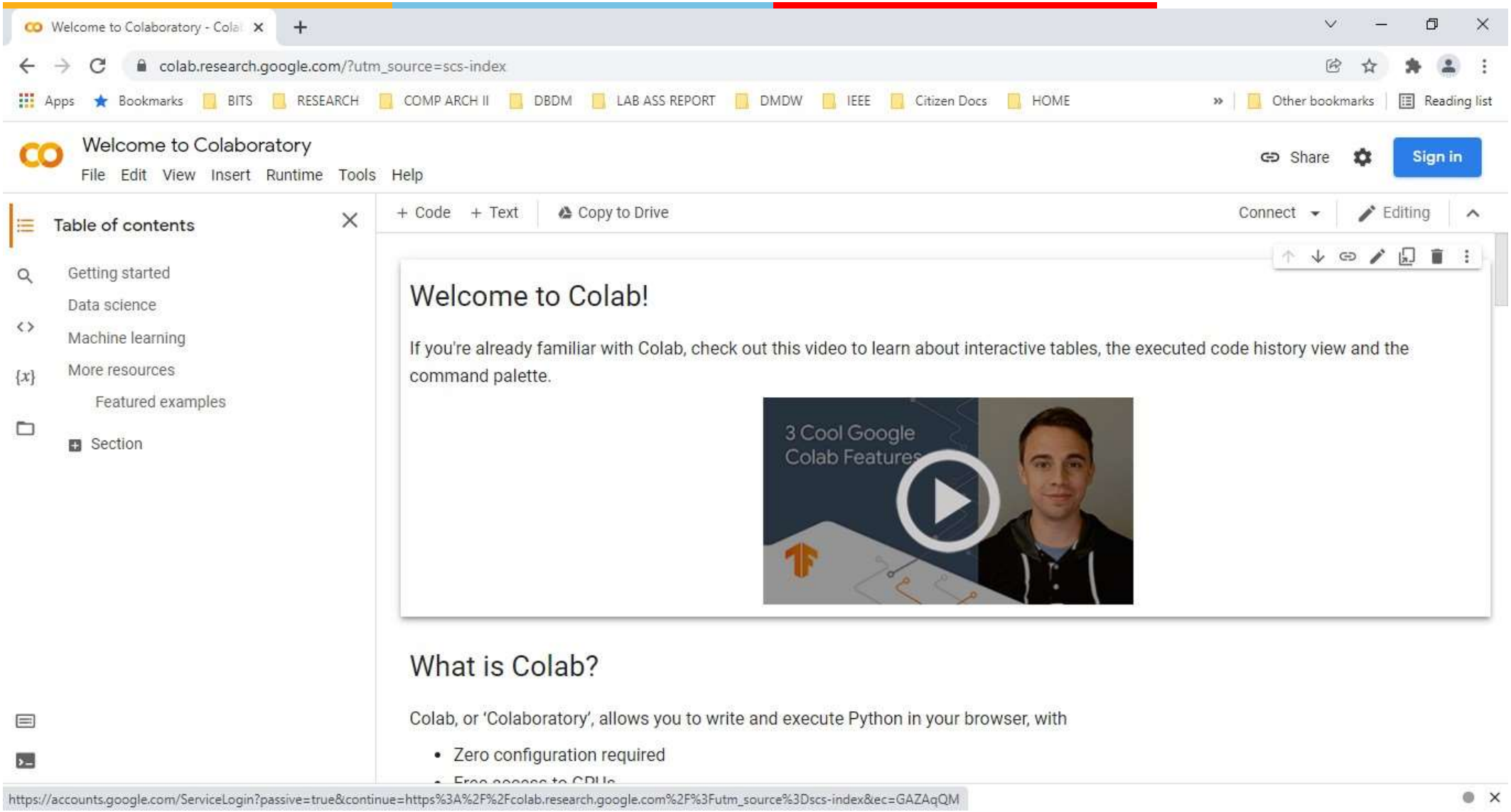

Exercises : In Python & its libraries

Artificial Intelligence

- Term coined by, *John McCarthy* (1955) & *Dartmouth Summer Research Project on Artificial Intelligence* (1956)

On September 2, 1955, the project was formally proposed by McCarthy, Marvin Minsky, Nathaniel Rochester and Claude Shannon. The proposal is credited with introducing the term 'artificial intelligence'.

The Proposal states[7]

> We propose that a 2-month, 10-man study of artificial intelligence be carried out during the summer of 1956 at Dartmouth College in Hanover, New Hampshire. The study is to proceed on the basis of the conjecture that every aspect of learning or any other feature of intelligence can in principle be so precisely described that a machine can be made to simulate it. An attempt will be made to find how to make machines use language, form abstractions and concepts, solve kinds of problems now reserved for humans, and improve themselves. We think that a significant advance can be made in one or more of these problems if a carefully selected group of scientists work on it together for a summer.

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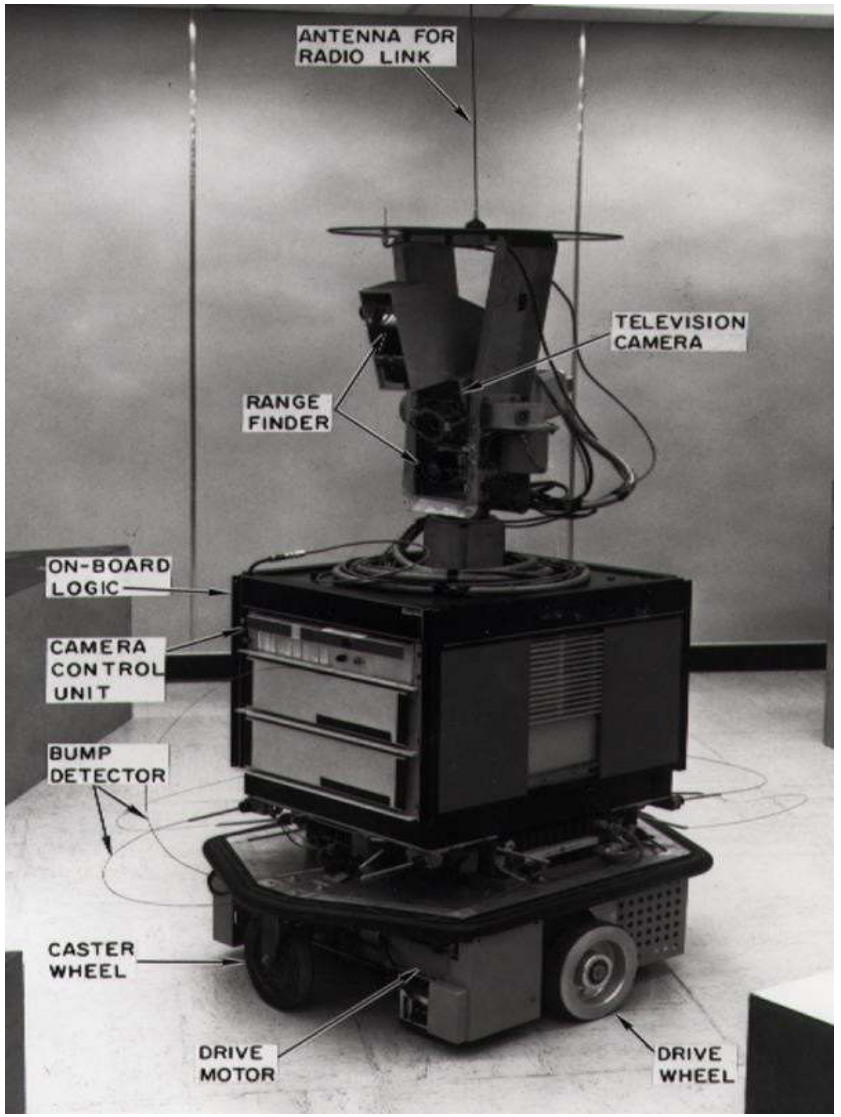
https://en.wikipedia.org/wiki/Dartmouth_workshop [01 June, 2019]

Larger Intent, Dream, Overconfidence ...

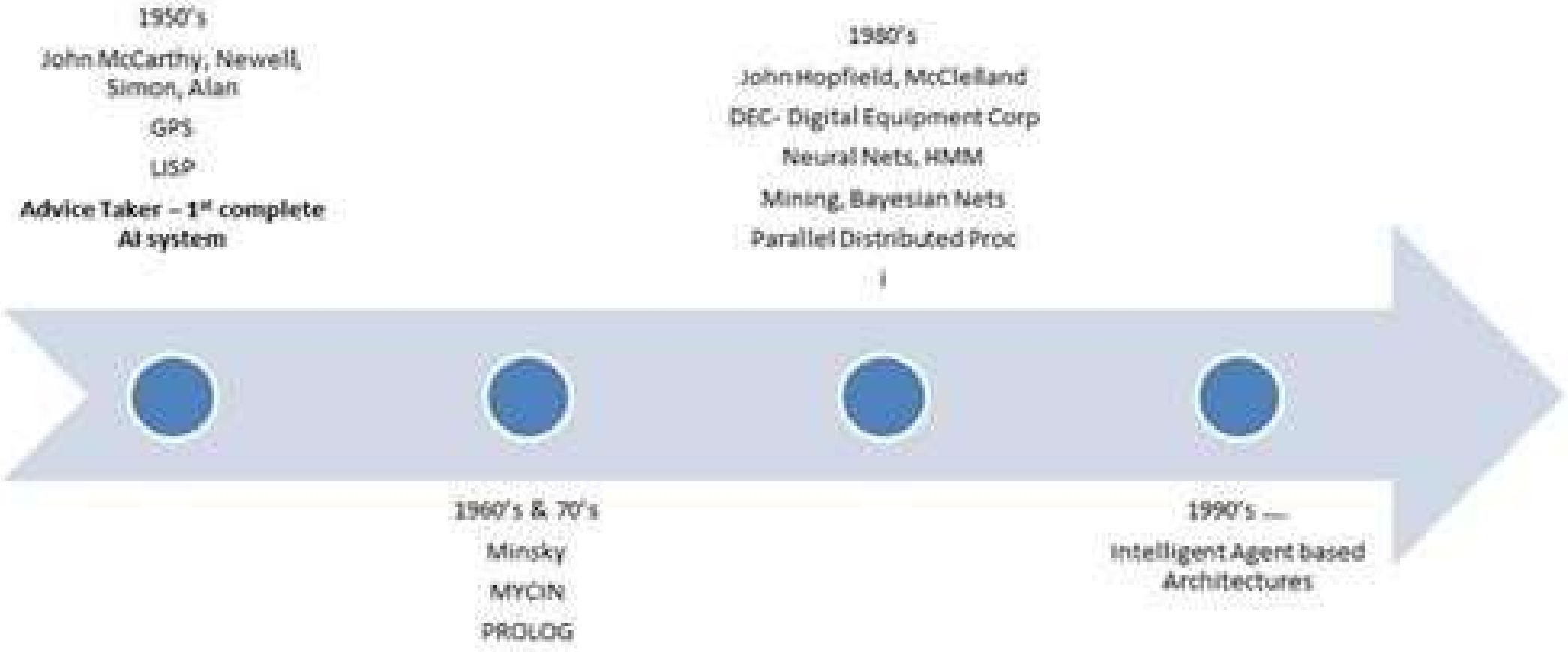
Some Early successes of Dartmouth

Many key projects were initiated after Dartmouth summer project.

Shakey robot - First mobile robot to perceive environment & reason about surroundings, actions - Introduced A* algorithm to find paths - Hough Transform for image analysis - Used Lisp for programming - visibility graph used for finding shortest paths in the presence of obstacles...



A brief history of AI



How is AI unique or in other words different from Applied Math?

Some Early successes of Dartmouth

DENDRAL -

Attempted to encode the domain expertise in molecular biology as an expert system

Led to the creation of expert systems for various other domain, including medical.

A milestone worship in the history of AI !!!

Perspectives of AI

Definitions

	Thought / Reasoning	Acting
Human Performance	THINKING HUMANLY "[The automation of] activities that we associate with human thinking, activities such as decision-making, problem solving, learning, ... " (Bellman, 1978)	ACTING HUMANLY "The art of creating machines that perform functions that require intelligence when performed by people" (Kurzweil, 1990)
Rational Performance	THINKING RATIONALLY "The study of computations that make it possible to perceive, reason, and act" (Winston, 1992)	ACTING RATIONALLY "Computational intelligence is the study of the design of intelligent agents" (Poole et al., 1998)

Acting Humanly

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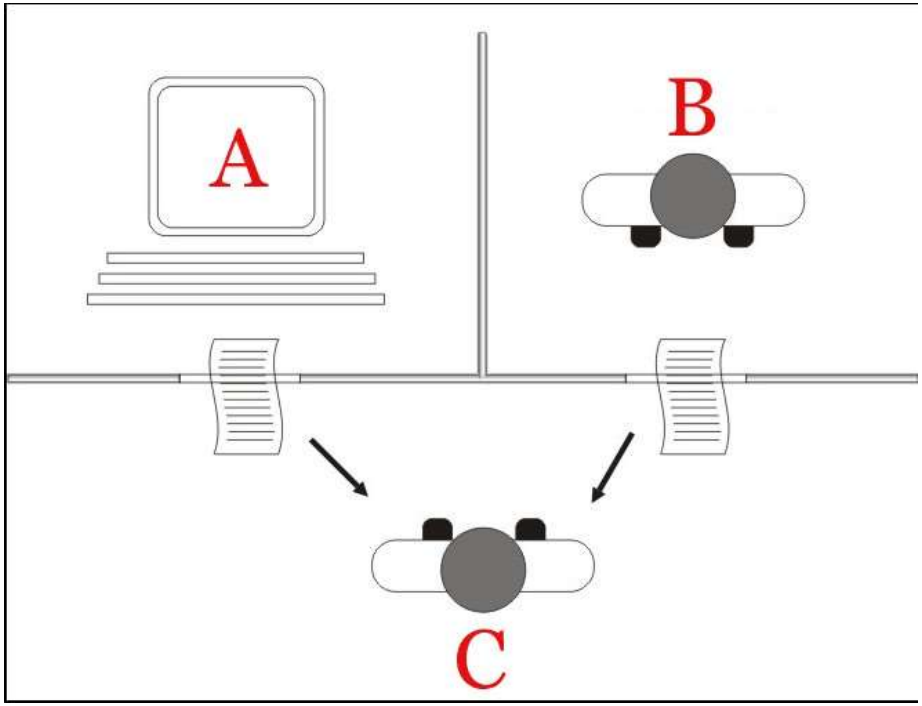
Turing Test Approach

- *Turing Test* & *Total Turing test* (operational test to determine an entity is intelligent / not) [50's]

- Skills necessary to pass these tests
  - NLP, Knowledge Representation, Automated Reasoning, ML + Computer Vision & Robotics(for total turing test)



Pictorial Representation of Turing Test from https://en.wikipedia.org/wiki/Turing_test

Acting Humanly

Turing Test Approach

Some Definitions of AI:

"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)

Thinking Humanly

Cognitive Modelling Approach

- How do we capture human thinking to implement?
  - Introspection
  - Psychological Experiments
  - Brain Imaging

- System : *"General Problem Solver"* (*Newell and Simon, 1961*)
  - Designed to work as a universal problem solver
  - Problems represented by horn clauses
  - First AI Machine which has KB + Inference separation
  - Authors focus on this is on comparing the trace of its reasoning steps to traces of human subjects solving the same problems

- Growth of Cognitive science and AI supports each other

Passing the Turing Test

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Transcript of a chat

EUGINE - a thirteen-year-old Ukrainian boy, chats

JUDGE: Hello.
EUGENE: Hello, I'm really glad to have the chance to chat with you! My guinea pig Bill sends his regards too!
JUDGE: Is Bill a male or a female?
EUGENE: Ask Bill personally, please.
JUDGE: Well I'd rather talk to you. What is your name?
EUGENE: Call me Eugene. I am glad to talk to you!
JUDGE: My name is Jane and I am female. How about you? What's your gender?
EUGENE: I'm a male. A "guy' I'd say.
JUDGE: Pleased to meet you Eugene. What's the weather like where you are?
EUGENE: Let's get on with our conversation!
JUDGE: Don't you like talking about the weather?
EUGENE: All these talks about weather is a waste of time.
JUDGE: What would you like to discuss?
EUGENE: I don't know. Better tell me more about yourself!

Passing the Turing Test

- 2014 - Royal Society (London) - Sixteenth Anniversary of Alan Turing -
- Chabot - Eugene Goostman - Pretended to be a thirteen-year-old Ukrainian boy
  - Passed the turing test for the first time
  - 10/30 Judges believed the response is from human

- *Turing predicted in 50 years time, computers can be programmed to play imitation game in which an average interrogator fails to identify the machine 70% time in a 5 mins questioning*

Thinking Humanly

Cognitive Modelling Approach

Some Definitions of AI:

"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)

Thinking Rationally

"Laws of Thought" Approach

- Invention of Formal Logic, Greek Philosopher **Aristotle**, Third century BC.
- Introduced syllogisms, providing argument structures

In all boring classes, students sleep

It is a boring class

Students sleep in this class [Are you ?]

- Field of Logics gave rise to codifying rational thinking
    - When elements are '*things*', we reason about things

Hurdles to the idea : (1) Not everything can be logically coded (2) no provably correct action at a moment (3) Exhaustive computational resources

Acting Rationally

The Rational Agent Approach

- 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* → A]

- For any given class of environments and tasks, we seek the agent (or class of agents) with the best performance
- Computational limitations make perfect rationality unachievable
- Design best program for given machine resources

Acting Rationally

The Rational Agent Approach

- Rational behaviour: doing the *right thing*
- The *right thing:* that which is expected to maximize goal achievement, given the available information
- Rational behaviour is not just about correct inference / thinking, skills needed to pass turing test etc.

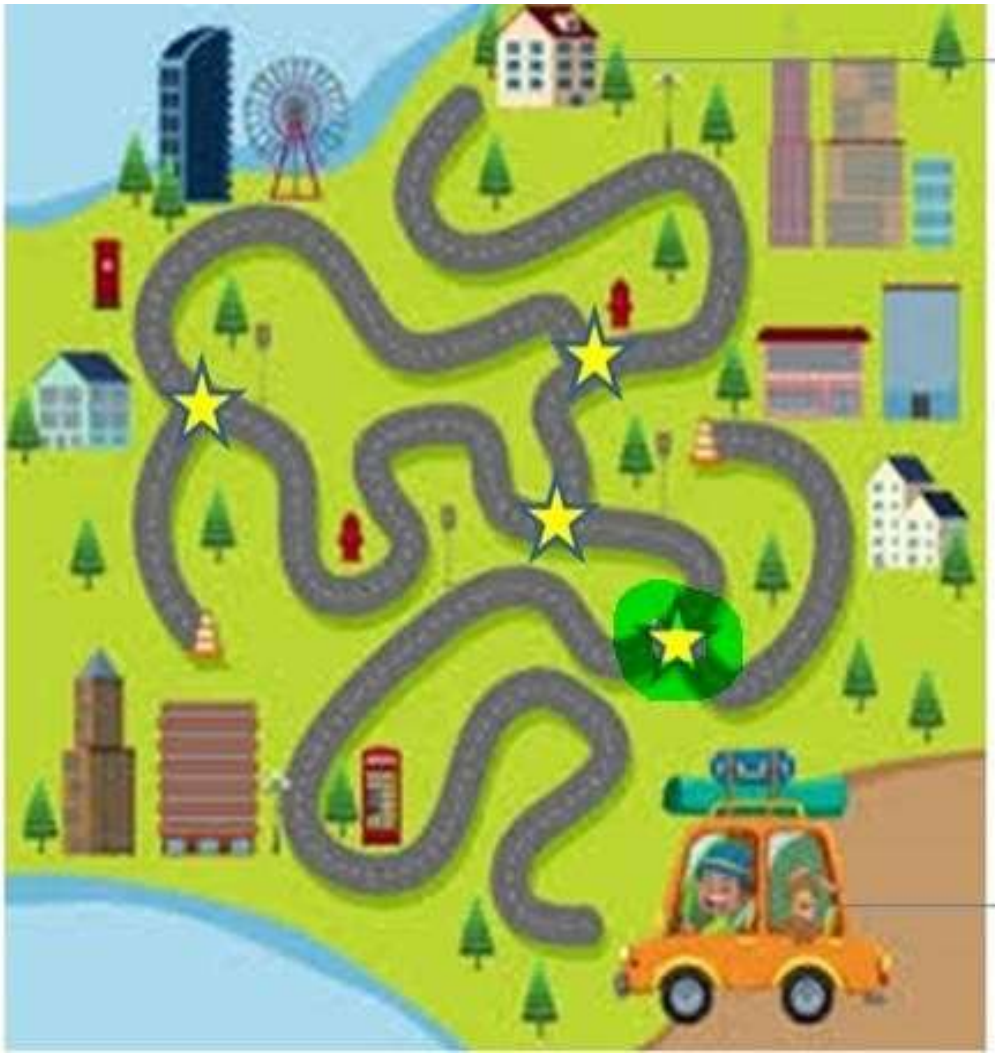
(adv) : More General - Correct inference is just a thing

(adv) : More amenable for scientific developments, as the rational behaviour is better defined than human thinking and behaviour

Definitions

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)

Traveller's Problem



Traveller's Problem

AI in HealthCare

Lyrebird's Project Re-Voice

AI in Culinary Field

Spyce

AI in NLS

IBM Watson

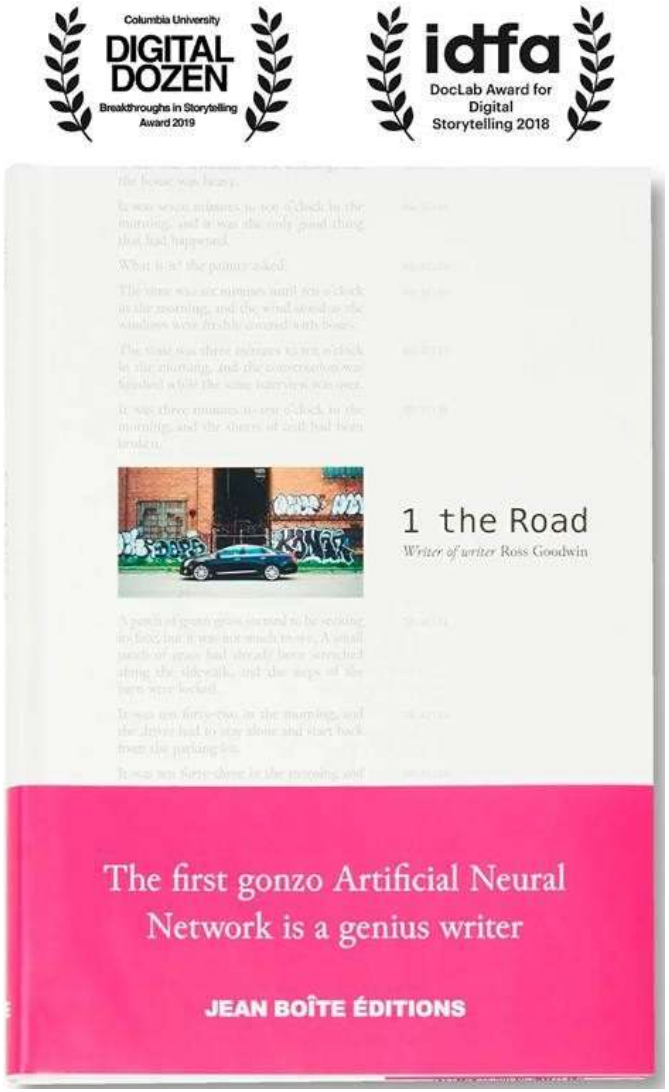
Computer Vision
NLP
ML
Speech Recognition
Automation

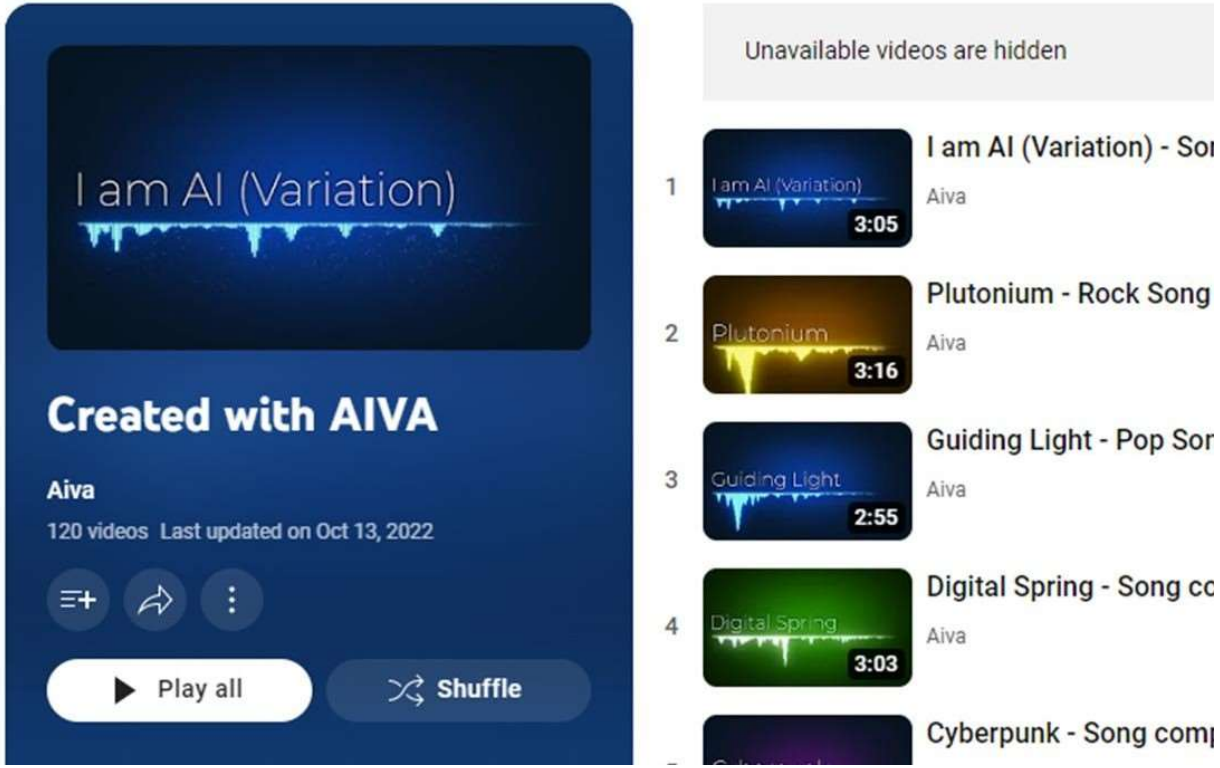
AI in Transportation

AI in HCI

Google Map Navigation Assistant

AI in Literacy & Music





Application Domain

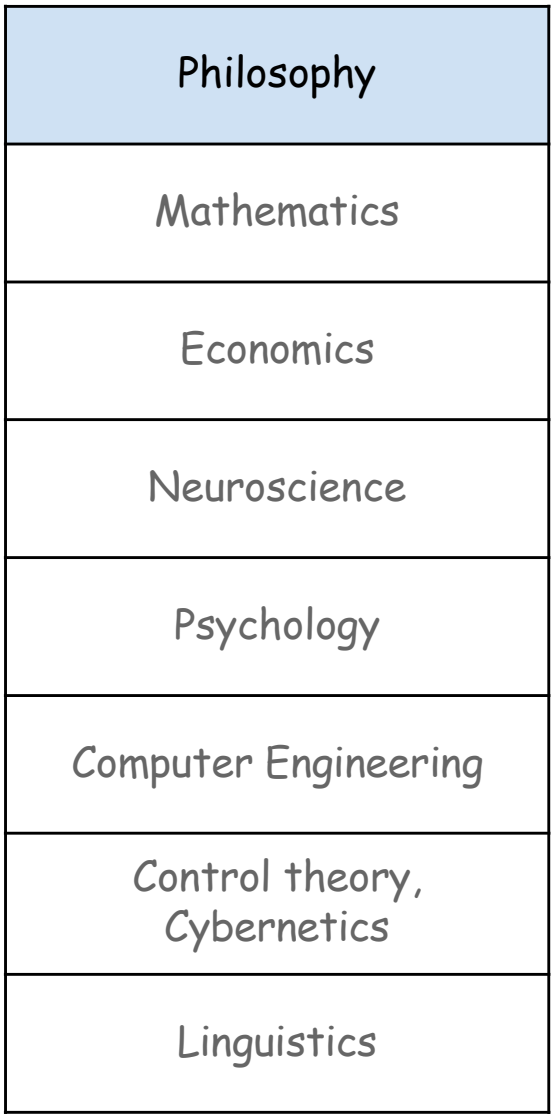
(Additional Notes added from the textbook for self read)

Areas Contributing to AI

Philosophy
Mathematics
Economics
Neuroscience
Psychology
Computer Engineering
Control theory, Cybernetics
Linguistics

- Can formal rules be used to draw valid conclusions?
- How does the mind arise from a physical brain?
- Where does knowledge come from?
- How does knowledge lead to action?

Areas Contributing to AI



Aristotle (384–322 B . C .) : first to formulate precise set of laws to govern rational part of brain

Ramon Lull (d. 1315) : useful reasoning could actually be carried out by a mechanical artifact

Hobbes (1588–1679) : "we add

and subtract in our silent thoughts."

Leibniz (1646–1716) : Built a mechanical device intended to carry out operations on concepts rather than numbers

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Some *'isms* on the working of minds :

Rationalism - Correct Reasonings (Aristotle, Descartes …)

Dualism - A part of the human mind (or soul or spirit) that is outside of nature

Materialism - Alternative to dualism - holds that the brain's operation according to the laws of physics constitutes the mind

Areas Contributing to AI

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Obtaining Knowledge

David Hume's (1711–1776) : First principles of induction

Logical positivism- Rudolf Carnap : Every knowledge obtained has a logical connection

Carnap (1905–1997) : A book "*The Logical Structure of the World*" (1928) defined an explicit computational procedure for extracting knowledge from elementary experiences

Areas Contributing to AI

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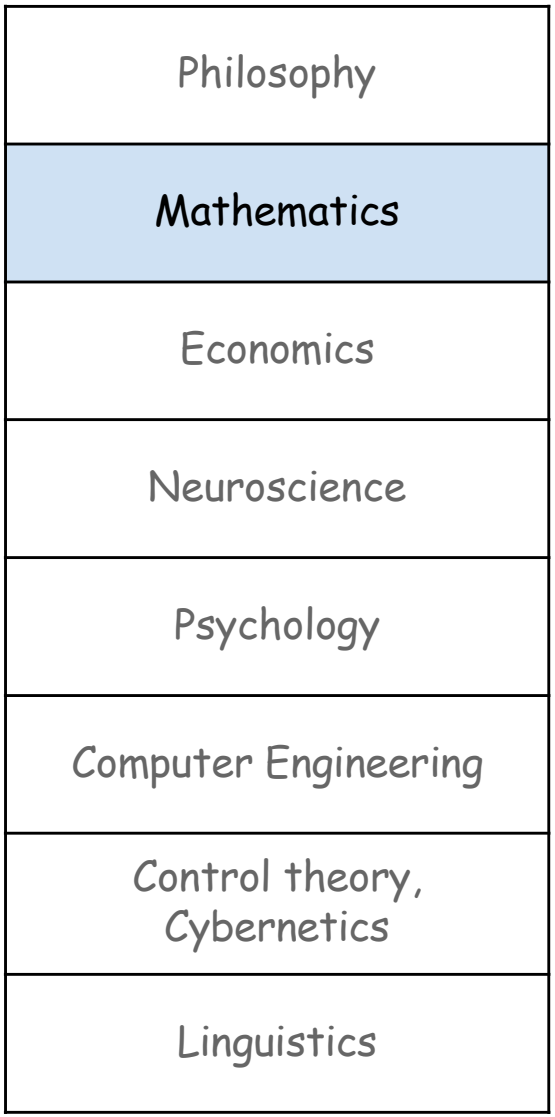
Connection between knowledge and action:

Aristotle - (in *De Motu Animalium*) that actions are justified by a logical connection between goals and knowledge of the action's outcome

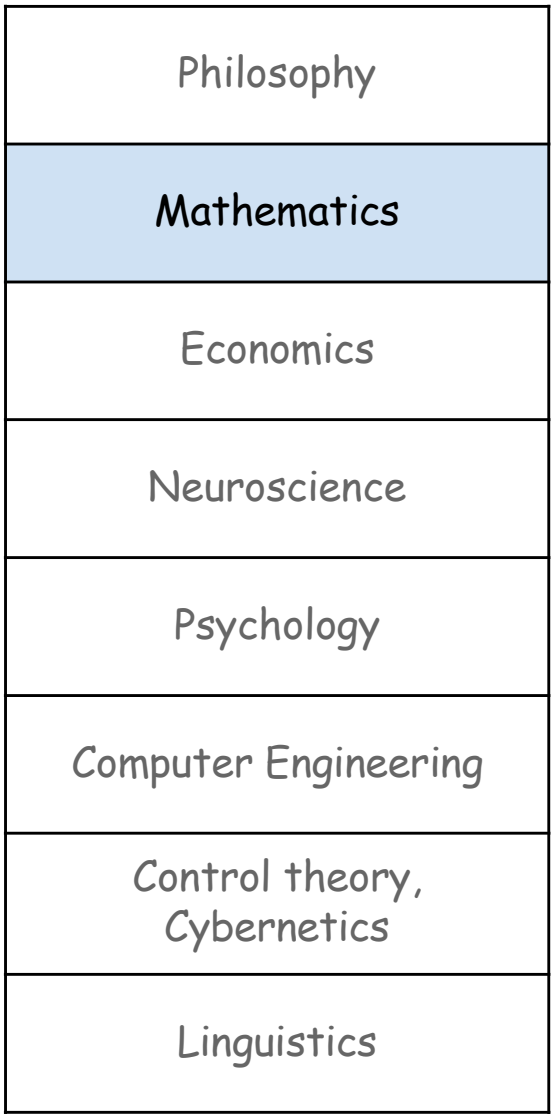
```
I need covering;
a cloak is a covering.
I need a cloak.
What I need, I have to make;
I need a cloak.
I have to make a cloak.
And the conclusion, "I have to make a cloak" is an action
```

Areas Contributing to AI



- What are the formal rules to draw valid conclusions?
- What can be computed?
- How do we reason with uncertain information?

Areas Contributing to AI

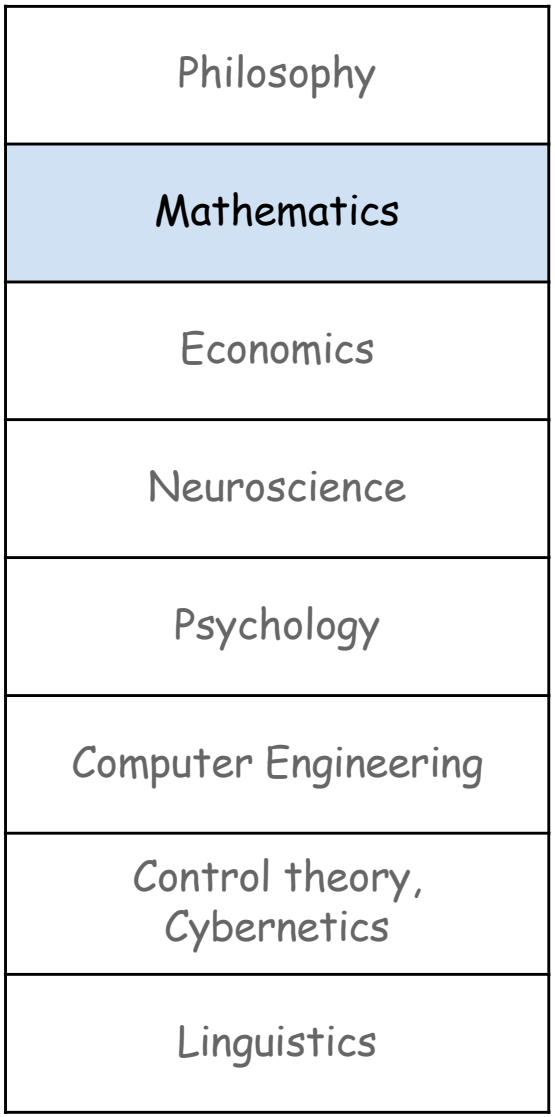


- What are the formal rules to draw valid conclusions?

George Boole (1815–1864) : Propositional Logic

Gottlob Frege (1848–1925): First order logic

Areas Contributing to AI



- What can be computed?

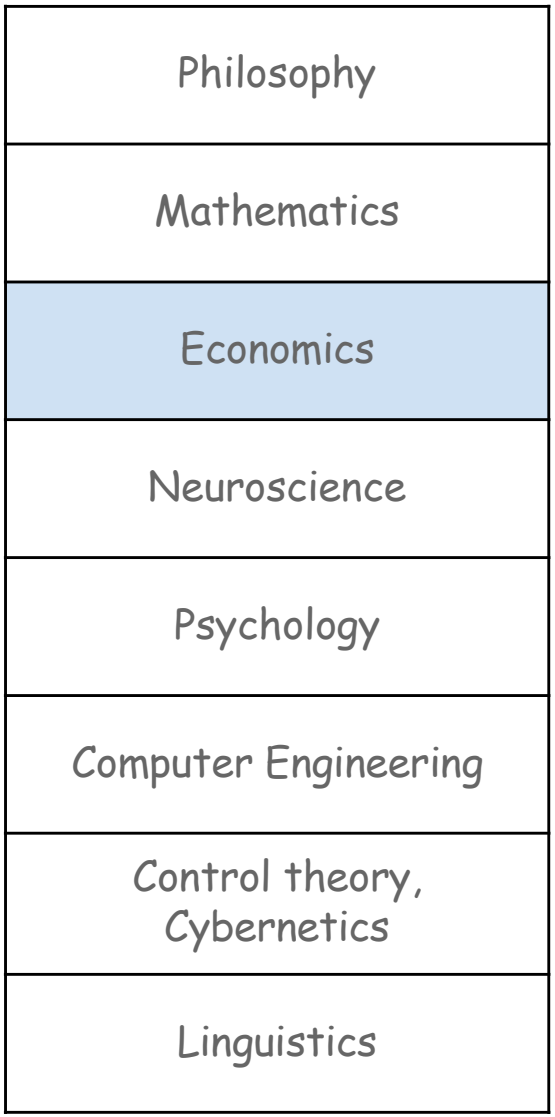
Kurt Gödel (1906–1978) : In any formal theory as strong as Peano arithmetic #(the elementary theory of natural numbers), there are true statements that are undecidable in the sense that they have no proof within the theory

Computability, tractability, NP-completeness

Probability theory & inference mechanisms

- https://en.wikipedia.org/wiki/Peano_axioms

Areas Contributing to AI



- How should we make decisions so as to maximize payoff?

Utility / preferred outcomes

Decision theory -Probability & utility theory

Game theory

- How to make decisions when payoffs are not immediate?
  - MDP

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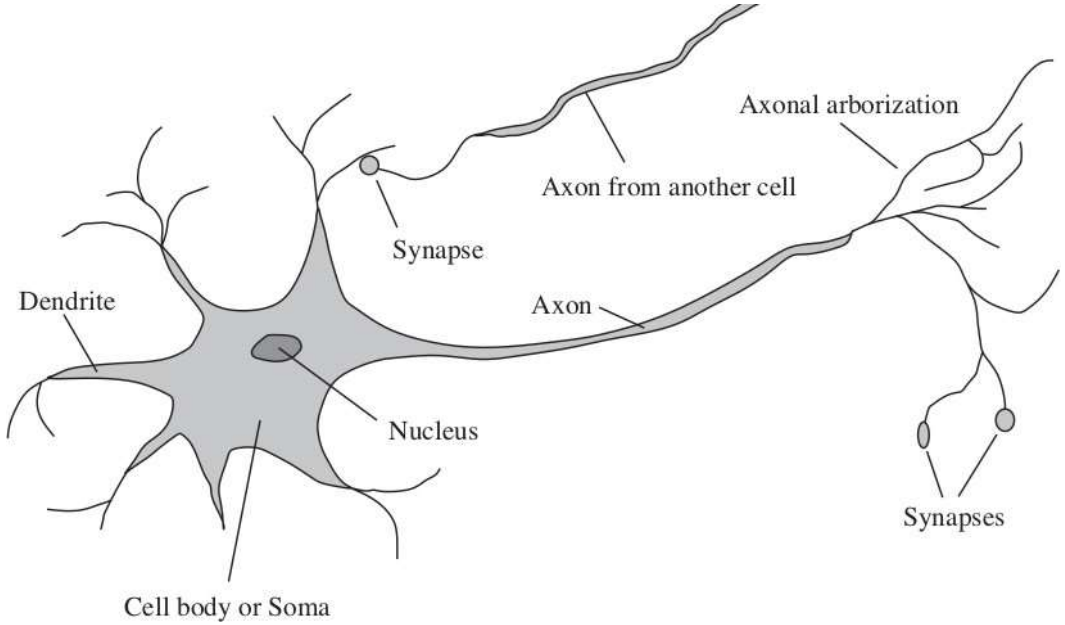
How do brains process information?

- Study of the nervous system / brain
- How does brain enables thoughts - Mystery Still

Aristotle , "*Of all the animals, man has the largest brain in proportion to his size*"



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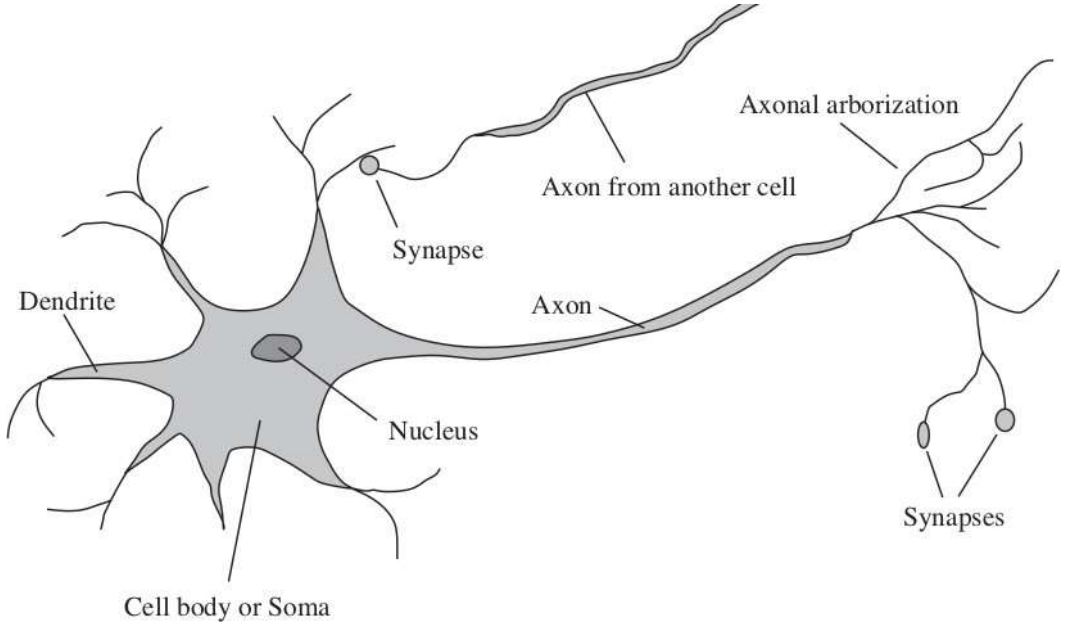
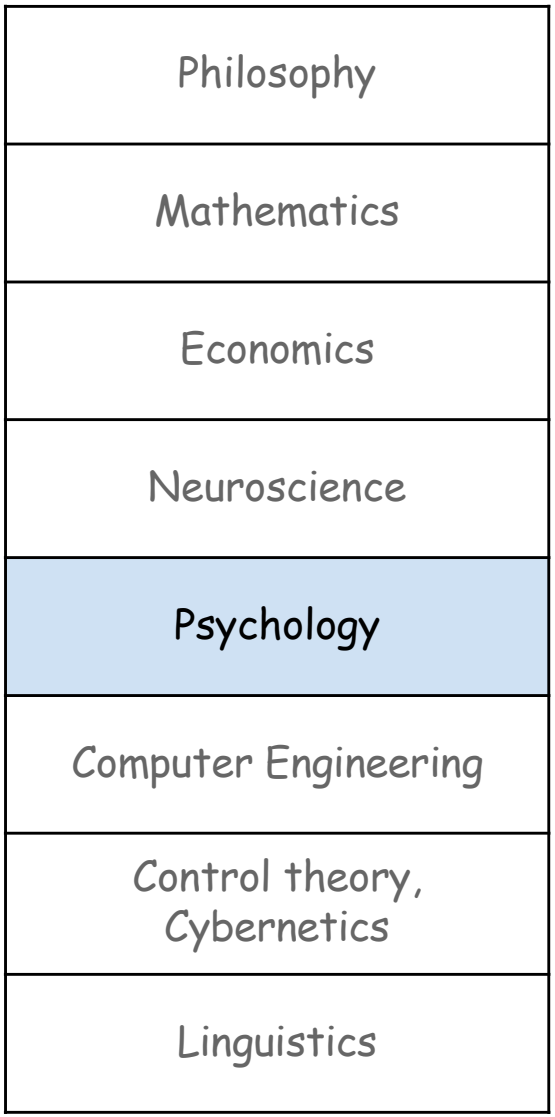
	Supercomputer	Personal Computer	Human Brain
Computational units	10^4 CPUs, 10^{12} transistors	4 CPUs, 10^9 transistors	10^{11} neurons
Storage units	10^{14} bits RAM	10^{11} bits RAM	10^{11} neurons
	10^{15} bits disk	10^{13} bits disk	10^{14} synapses
Cycle time	10^{-9} sec	10^{-9} sec	10^{-3} sec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



Areas Contributing to AI

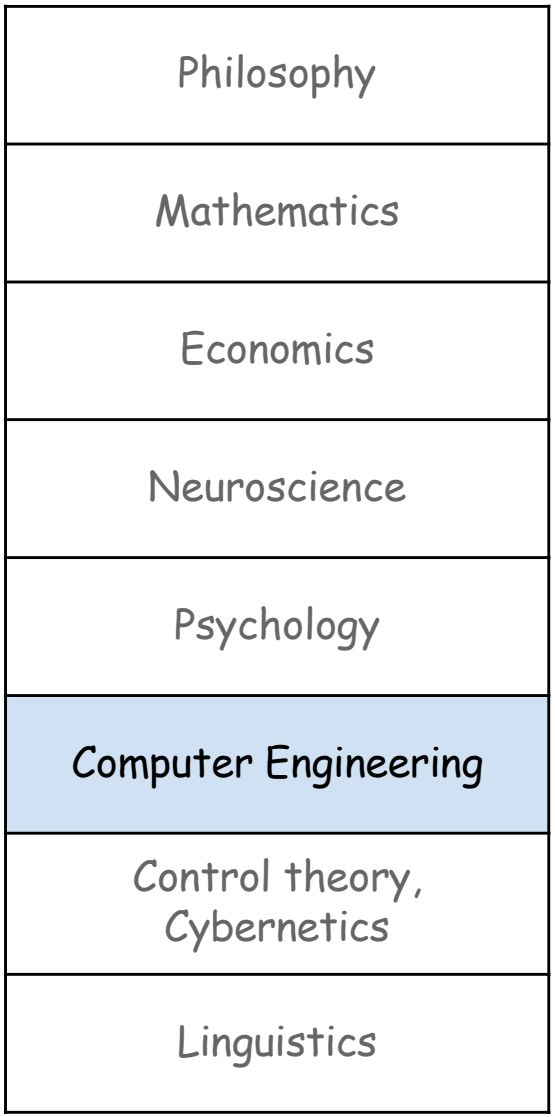


How do humans and animals think and act?

- *Cognitive Psychology* - Brain as an information-processing device
- Two months after the dartmouth workshop, a workshop in MIT gave birth to *Cognitive Science*
  - George Miller, Noam Chomsky, Allen Newell and Herbert Simon - roles of computer models to address the psychology of memory, language, and logical thinking, issues..

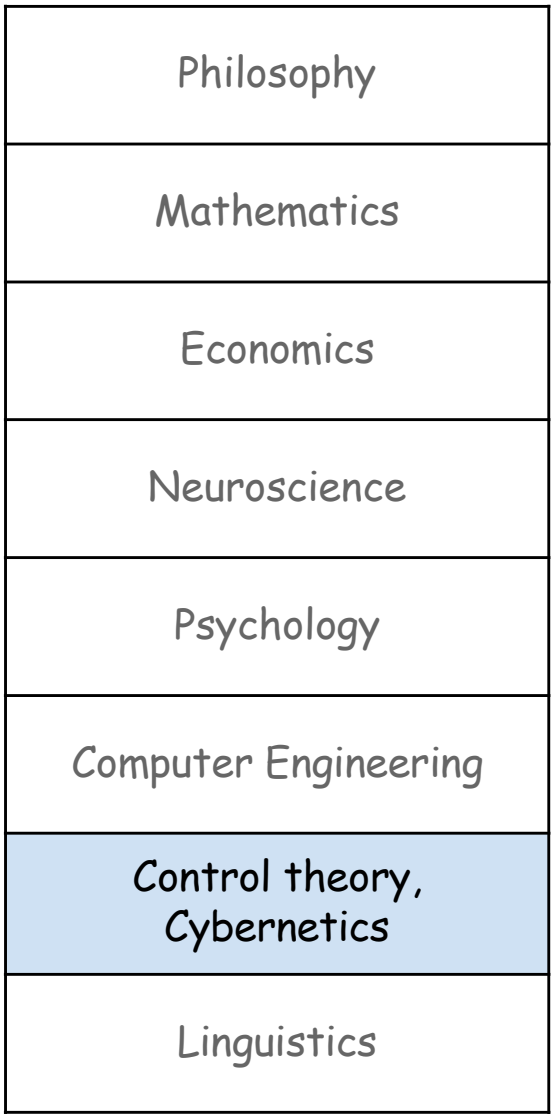
"*a cognitive theory should be like a computer program*" (Anderson, 1980);

Areas Contributing to AI



Computers & Programming Languages

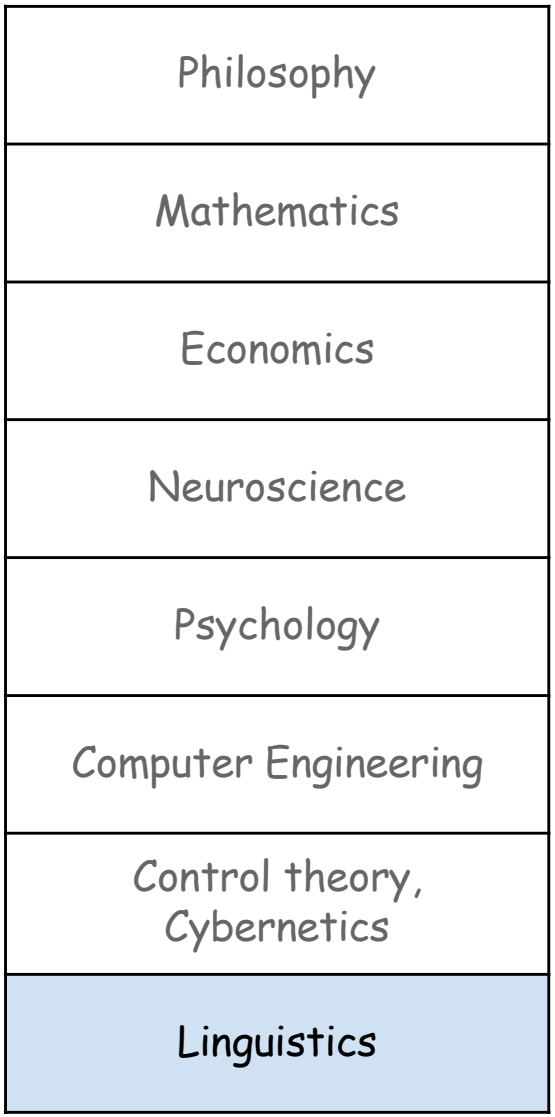
Areas Contributing to AI



Control theory

- Deals with the behaviour of dynamic systems
  - behaviour must ensure the error between the current state and goal state is minimized
- Cybernetics - Book by Wiener
  - (Norbert Wiener, 1948) : Scientific study of control and communication in the animal and the machine
- Ashby's Design for a Brain (1948, 1952):
  - Intelligence could be created by the use of homeostatic devices containing appropriate feedback loops to achieve stable adaptive behavior
  - Led to the idea of *design of systems that maximize an objective function over time*

Areas Contributing to AI



How does language relate to thought?

Verbal Behavior (1957, B. F. Skinner) :

- Behaviorist approach to language learning
- Reviewed by Noam Chomsky
  - criticised lack of notion of creativity in language

Syntactic Structures (1957, Noam Chomsky)

- Computational linguistics / natural language processing as a part of AI
  - Understanding a language is realized as more complex than ever
  - Context, subject matter knowledge complicated it further
  - Representing language consumed volume of work done in NLP, in early times

Course Outline

- **In this course, you will learn :**
  - a solid foundation for designing intelligent agents
  - to represent and use the knowledge learnt for inferencing
  - to model agents operating in uncertain environments
  - optimization models of computation and processing in real world application
- **Modules :**
  - Problem Solving Agent using Search
  - Game Playing
  - Probabilistic Representation and Reasoning
  - Reasoning over time

Required Reading: AIMA - Chapter #1

AIMA is the first prescribed text book

Thank You for your active participation

Note : Some of the slides are adopted from AIMA TB materials

Next Class Plan

- Agent Design
- Environment
- Agent Architecture
- Problem Solving Agent Formulation