



Artificial and Computational Intelligence

AIMLCZG557

Contributors & Designers of document content: Cluster Course Faculty Team

M1: Introduction

BITS Pilani

Pilani Campus

Presented by Faculty Name BITS Email ID

Artificial and Computational Intelligence

Disclaimer and Acknowledgement



- Few content for these slides may have been obtained from prescribed books and various other source on the Internet
- I hereby acknowledge all the contributors for their material and inputs and gratefully acknowledge people others who made their course materials freely available online.
- I have provided source information wherever necessary
- This is not a full fledged reading materials. Students are requested to refer to the textbook w.r.t detailed content of the presentation deck that is expected to be shared over e-learning portal - taxilla.
- I have added and modified the content to suit the requirements of the class dynamics & live session's lecture delivery flow for presentation
- Slide Source / Preparation / Review:
- From BITS Pilani WILP: Prof.Raja vadhana, Prof. Indumathi, Prof.Sangeetha
- From BITS Oncampus & External: Mr.Santosh GSK

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Agenda

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

Course Administration

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About the course

- Focus on
 - principles of artificial intelligence
 - o 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

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Course Outline

Pedagogy

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

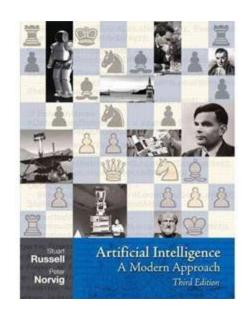
Lab Modules

O 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

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/Dartmout h
_workshop [01 June, 2019]

Larger Intent,
Dream,
Overconfidence ...

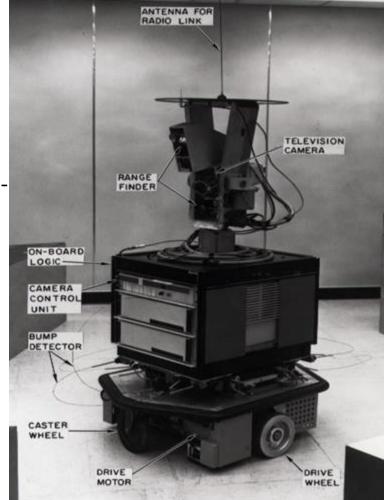
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Some Early successes of Dartmouth

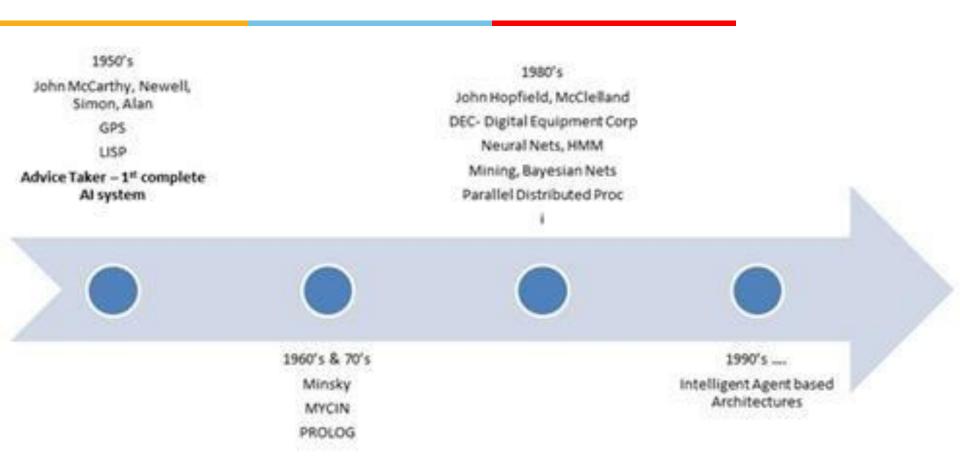
Many key projects were initiated after Dartmouth summer project.

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 Al



How is Al 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 Al





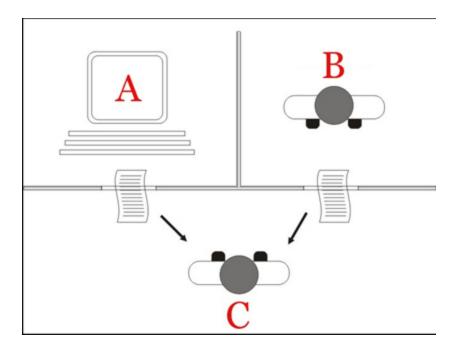
	Thought / Reasoning	Acting
	THINKING HUMANLY	ACTING HUMANLY
Human Performance	"[The automation of] activities that we associate with human thinking, activities such as decision-making, problem solving, learning, " (Bellman, 1978)	"The art of creating machines that perform functions that require intelligence 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)	"Computational intelligence is the study of the design of intelligent agents" (Poole et al., 1998)

Acting Humanly



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?
 - O Introspection
 - O Psychological Experiments
 - O Brain Imaging
- System: "General Problem Solver" (Newell and Simon, 1961)
 - O Designed to work as a universal problem solver
 - O Problems represented by horn clauses
 - O First Al Machine which has KB + Inference separation
 - O 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



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

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

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:

 $[f: P^* \rightarrow A]$

- 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

"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)

Acting Humanly

"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 Rationally

"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)

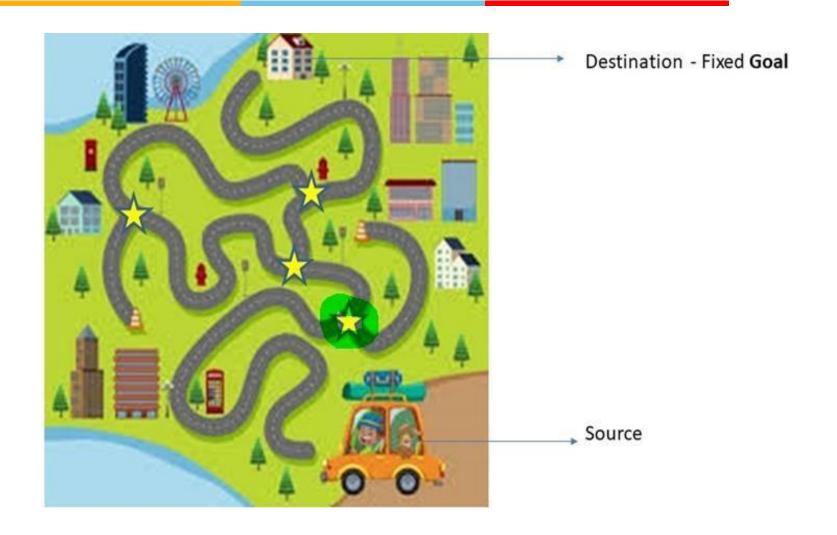
Acting Rationally

"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









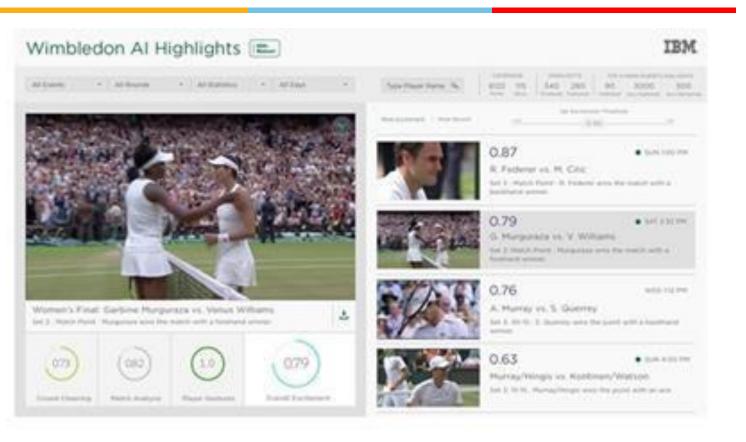
Spyce





Al in NLS IBM Watson





Computer Vision
NLP
ML
Speech Recognition
Automation

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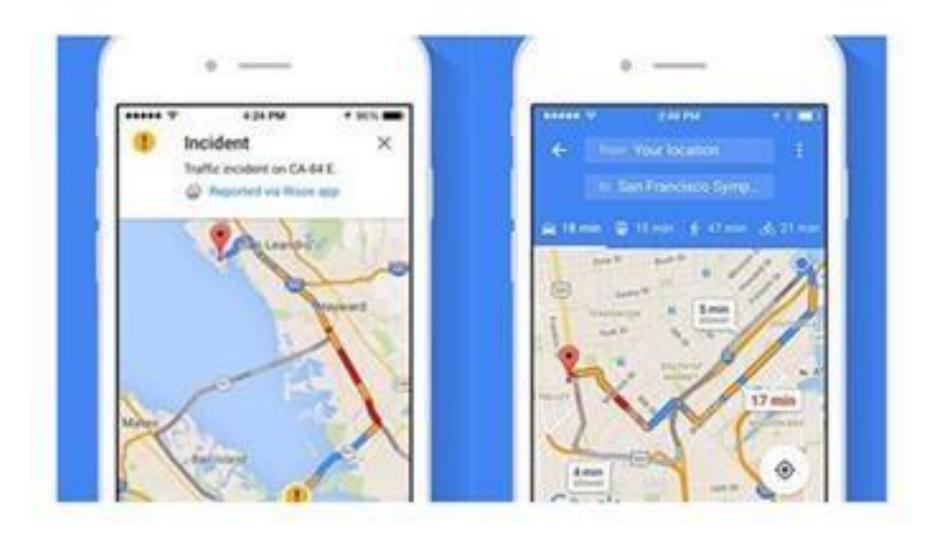
Al in Transportation





Al in HCl Google Map Navigation Assistant



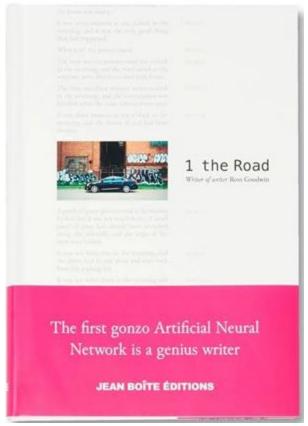


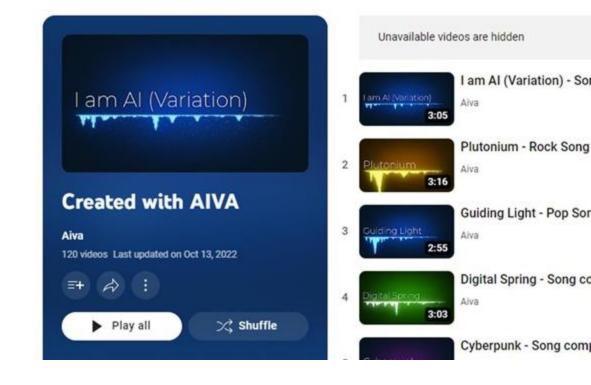
Al in Literacy & Music











Application Domain

(Additional Notes added from the textbook for self read)



Areas Contributing to Al

Philosophy Mathematics **Fconomics** 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 Al

Phil	loso	phy

Mathematics

Economics

Neuroscience

Psychology

Computer Engineering

Control theory, Cybernetics

Linguistics

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

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Cybernetics

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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 Al

Philosophy

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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

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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



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

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



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

What are the formal rules to draw valid conclusions?

George Boole (1815–1864): Propositional Logic

Gottlob Frege (1848–1925): First order logic



Philosophy Mathematics **Fconomics** Neuroscience Psychology Computer Engineering Control theory, Cybernetics Linguistics

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

Areas Contributing to Al

Phi	loso	phy
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Mathematics

Economics

Neuroscience

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Linguistics

 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



Phi	loso	phy
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Mathematics

Economics

Neuroscience

Psychology

Computer Engineering

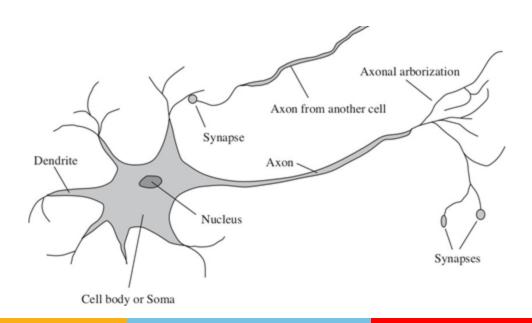
Control theory, Cybernetics

Linguistics

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"



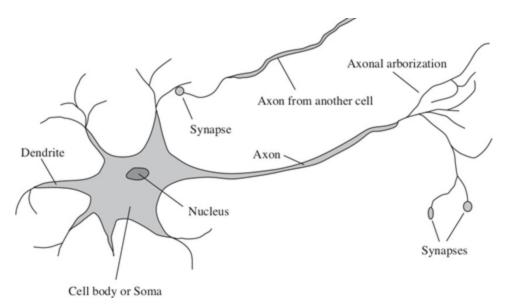


lead

Areas Contributing to Al

Philosophy
Mathematics
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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	$10^{-9} {\rm sec}$	$10^{-9} { m sec}$	$10^{-3} { m sec}$
Operations/sec	10^{15}	10^{10}	10^{17}
Memory updates/sec	10 ¹⁴	10^{10}	10^{14}



Areas Contributing to Al

Philosophy
Mathematics
Economics
Neuroscience
Psychology
Psychology Computer Engineering
, 3,

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);



Philosophy

Mathematics

Economics

Neuroscience

Psychology

Computer Engineering

Control theory, Cybernetics

Linguistics

Computers & Programming Languages

Areas Contributing to Al

Philosophy
Mathematics
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Neuroscience
Psychology
Computer Engineering
Control theory, Cybernetics
Linguistics

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

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

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 Al
 - 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:

- O a solid foundation for designing intelligent agents
- O to represent and use the knowledge learnt for inferencing
- O to model agents operating in uncertain environments
- O optimization models of computation and processing in real world application

Modules:

- O Problem Solving Agent using Search
- O Game Playing
- O Probabilistic Representation and Reasoning
- O 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