CS344: Introduction to Artificial Intelligence (associated lab: CS386)

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Lecture–1: Introduction

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Basic Facts

- Faculty instructor: Dr. Pushpak Bhattacharyya (www.cse.iitb.ac.in/~pb)

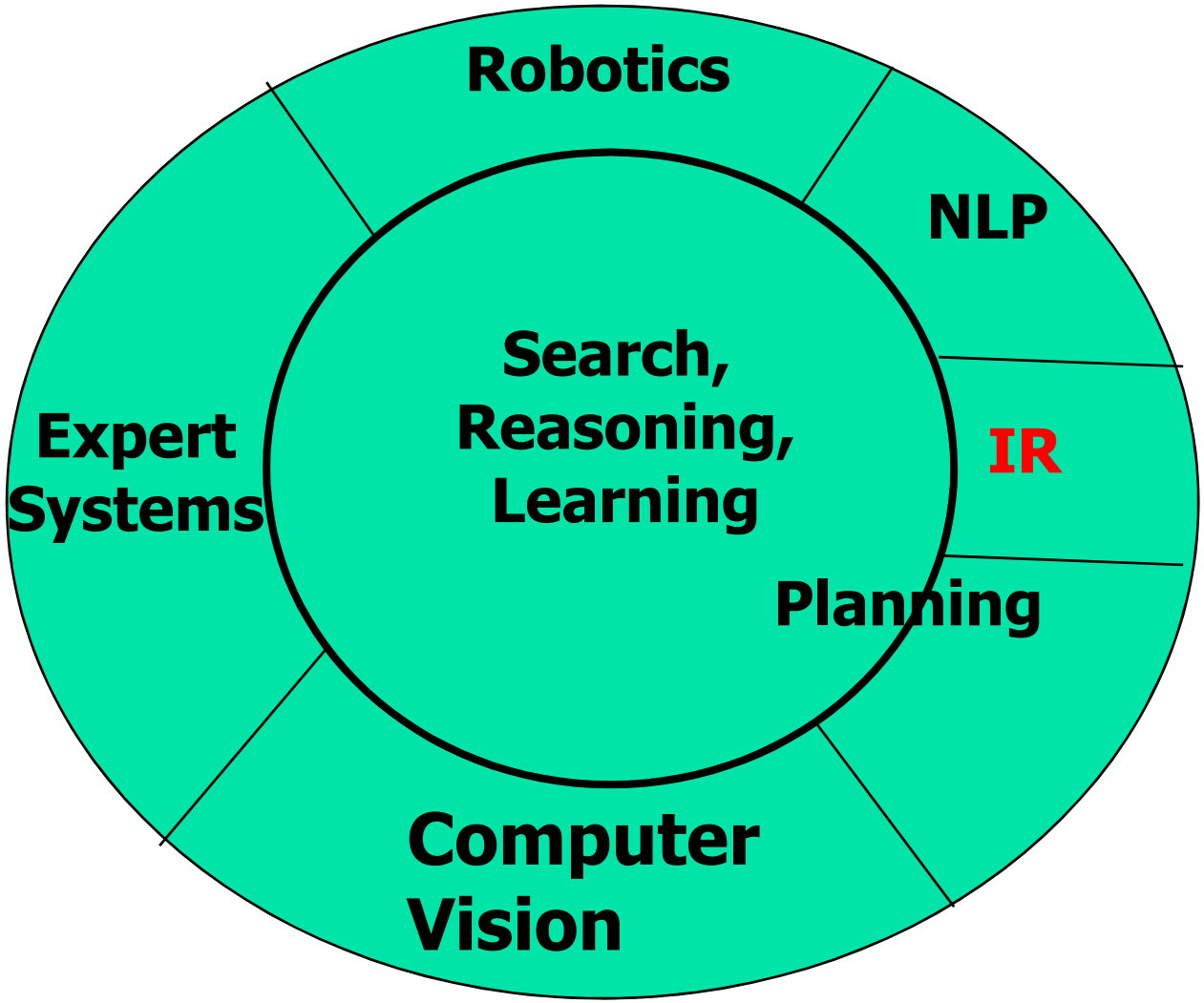
- TAs: *Ganesh, Kushal, Janardhan and Srijith "ganesh bhosale" <ganesh.bhosale.comp@gmail.com>, "Kushal Ladha" <kush@cse.iitb.ac.in>, <janardhan@cse.iitb.ac.in>, "Srijit Dutt" <srijitdutt@cse.iitb.ac.in>,*
- Course home page
  - www.cse.iitb.ac.in/~cs344-2011

- Venue: SIC 301, KR bldg

- 1 hour lectures 3 times a week: Mon-9.30, Tue-10.30, Thu-11.30 (slot 2)

Perspective

AI Perspective (post-web)



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]

Topics to be covered (1/2)

- **Search**
  - **General Graph Search, A*, Admissibility, Monotonicity**
  - **Iterative Deepening, α-β pruning, Application in game playing**
- **Logic**
  - **Formal System, axioms, inference rules, completeness, soundness and consistency**
  - **Propositional Calculus, Predicate Calculus, Fuzzy Logic, Description Logic, Web Ontology Language**
- **Knowledge Representation**
  - **Semantic Net, Frame, Script, Conceptual Dependency**
- **Machine Learning**
  - **Decision Trees, Neural Networks, Support Vector Machines, Self Organization or Unsupervised Learning**

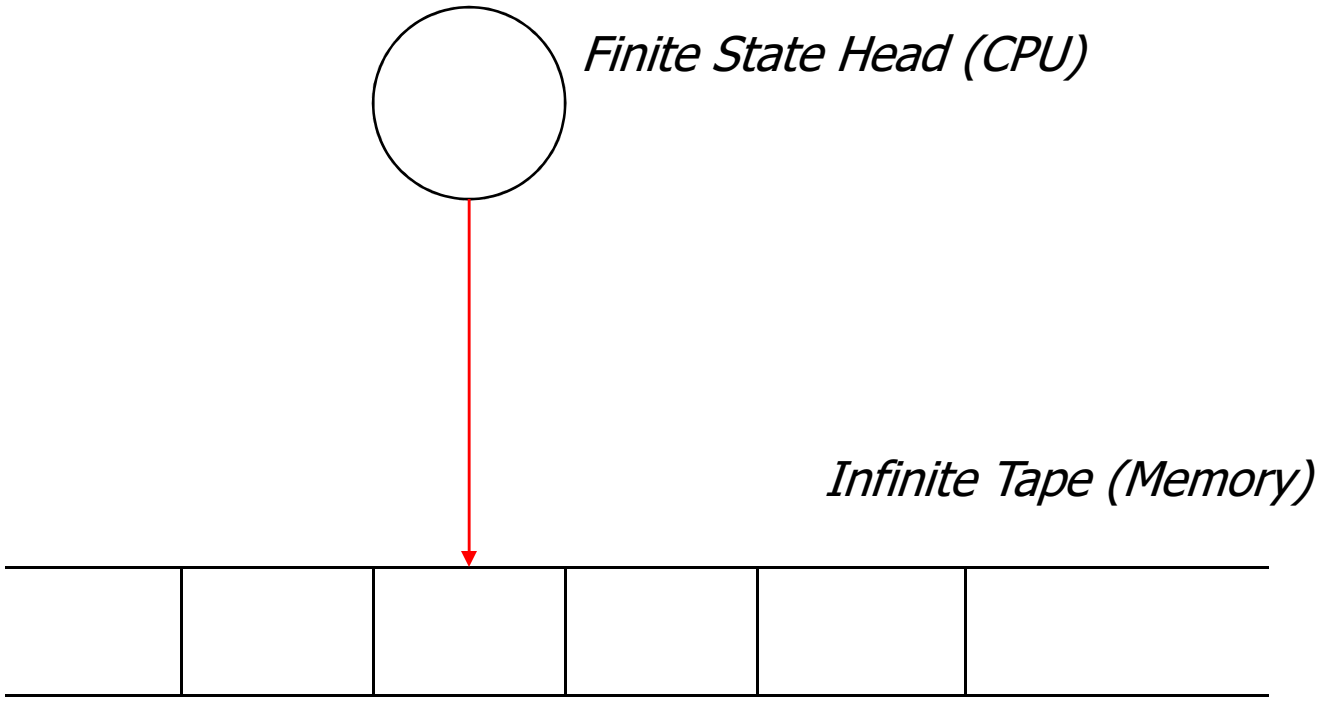
Topics to be covered (2/2)

- **Evolutionary Computation**
  - **Genetic Algorithm, Swarm Intelligence**
- **Probabilistic Methods**
  - **Hidden Markov Model, Maximum Entropy Markov Model, Conditional Random Field**
- **IR and AI**
  - **Modeling User Intention, Ranking of Documents, Query Expansion, Personalization, User Click Study**
- **Planning**
  - **Deterministic Planning, Stochastic Methods**
- **Man and Machine**
  - **Natural Language Processing, Computer Vision, Expert Systems**
- **Philosophical Issues**
  - **Is AI possible, Cognition, AI and Rationality, Computability and AI, Creativity**

Foundational Points

- Church Turing Hypothesis
  - Anything that is computable is computable by a Turing Machine
  - Conversely, the set of functions computed by a Turing Machine is the set of ALL and ONLY computable functions

Turing Machine



Foundational Points *(contd)*

- Physical Symbol System Hypothesis (Newel and Simon)
  - *For Intelligence to emerge it is enough to manipulate symbols*

Foundational Points *(contd)*

- Society of Mind (Marvin Minsky)
  - *Intelligence emerges from the interaction of very simple information processing units*
  - *Whole is larger than the sum of parts!*

Foundational Points *(contd)*

- Limits to computability
  - *Halting problem: It is impossible to construct a Universal Turing Machine that given any given pair <M, I> of Turing Machine M and input I, will decide if M halts on I*
  - What this has to do with intelligent computation? *Think!*

Foundational Points *(contd)*

- Limits to Automation
  - *Godel Theorem: A "sufficiently powerful" formal system cannot be BOTH complete and consistent*
  - "Sufficiently powerful": at least as powerful as to be able to capture Peano's Arithmetic
  - Sets limits to automation of reasoning

Foundational Points *(contd)*

- Limits in terms of time and Space
  - *NP-complete and NP-hard problems: Time for computation becomes extremely large as the length of input increases*
  - *PSPACE complete*: Space requirement becomes extremely large
  - Sets limits in terms of resources

Two broad divisions of Theoretical CS

- Theory A
  - Algorithms and Complexity
- Theory B
  - Formal Systems and Logic

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

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, Neural Nets
Physics	Learning, Information Theory & AI, Entropy, Robotics
Computer Sc. & Engg.	Systems for AI

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

Resources

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

Positively attend lectures!

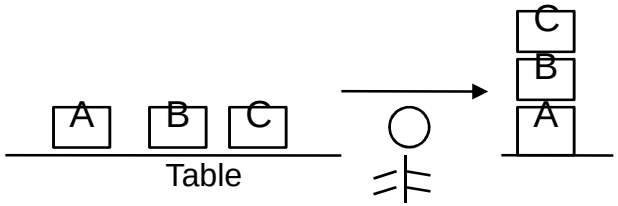
Grading

- Midsem
- Endsem
- Group wise assignments (closely follows lectures)
- Paper reading (possibly seminar)
- Quizzes

Search: Everywhere

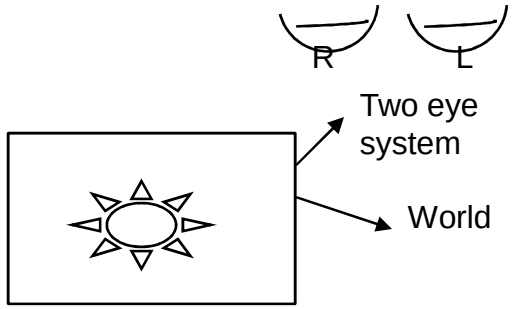
Planning

- (a) which block to *pick*, (b) which to *stack*, (c) which to *unstack*, (d) whether to *stack* a block or (e) whether to *unstack* an already stacked block. These options have to be searched in order to arrive at the right sequence of actions.



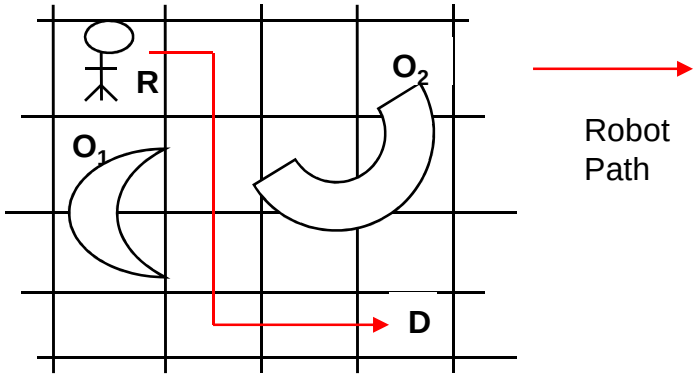
Vision

- A search needs to be carried out to find which point in the image of *L* corresponds to which point in *R*. Naively carried out, this can become an *O(n2)* process where *n* is the number of points in the retinal images.



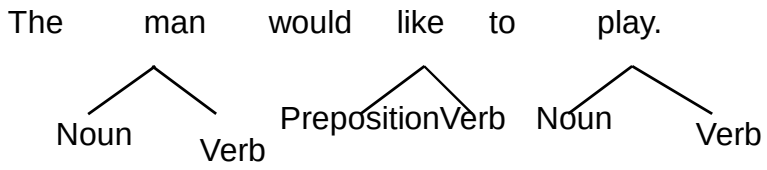
Robot Path Planning

- searching amongst the options of moving ***L***eft, ***R***ight, ***U***p or ***D***own. Additionally, each movement has an associated cost representing the relative difficulty of each movement. The search then will have to find the *optimal*, *i.e.*, the *least cost* path.



Natural Language Processing

- search among many combinations of parts of speech on the way to deciphering the meaning. This applies to every level of processing- *syntax, semantics, pragmatics* and *discourse*.



Expert Systems

Search among rules, many of which can apply to a situation:

If-conditions

the infection is primary-bacteremia
AND the site of the culture is one of the sterile sites
AND the suspected portal of entry is the gastrointestinal tract

THEN

there is suggestive evidence (0.7) that infection is bacteroid

(from MYCIN)

Search building blocks

- State Space : Graph of states (Express constraints and parameters of the problem)
- Operators : Transformations applied to the states.
- Start state : S_0 (Search starts from here)
- Goal state : $\{G\}$ - Search terminates here.
- Cost : Effort involved in using an operator.
- Optimal path : Least cost path

Examples

Problem 1 : 8 – puzzle

4	3	6
2	1	8
7		5

S

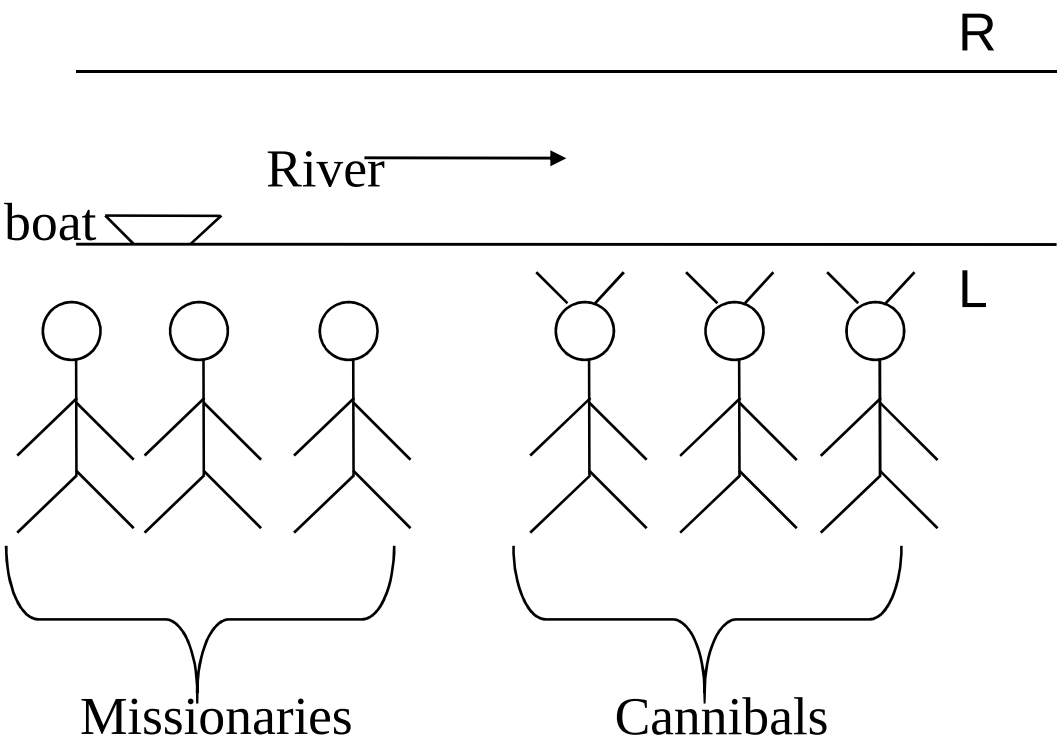
1	2	3
4	5	6
7	8	

G

Tile movement represented as the movement of the blank space.
Operators:
L : Blank moves left
R : Blank moves right
U : Blank moves up
D : Blank moves down

$$C(L) = C(R) = C(U) = C(D) = 1$$

Problem 2: Missionaries and Cannibals



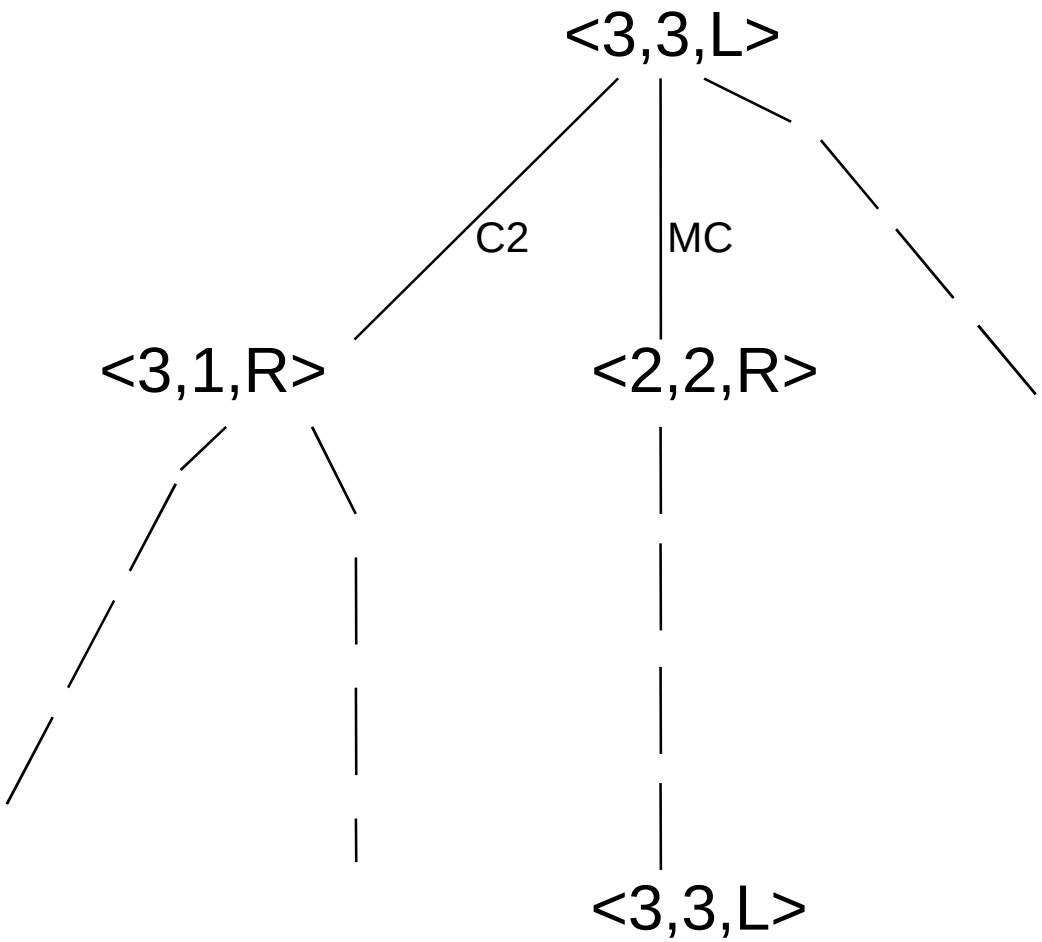
Constraints

- The boat can carry at most 2 people
- On no bank should the cannibals outnumber the missionaries

State : *<#M, #C, P>*
#M = Number of missionaries on bank *L*
#C = Number of cannibals on bank *L*
P = Position of the boat

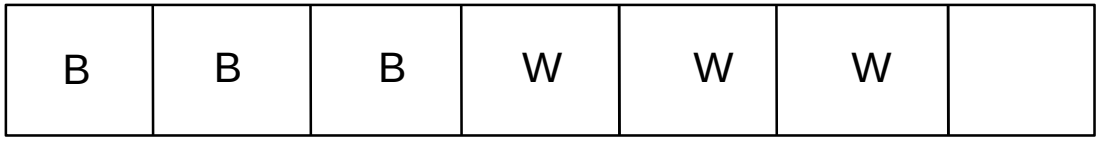
S0 = <3, 3, L>
G = < 0, 0, R >

Operations
M2 = Two missionaries take boat
M1 = One missionary takes boat
C2 = Two cannibals take boat
C1 = One cannibal takes boat
MC = One missionary and one cannibal takes boat



Partial search tree

Problem 3



G: States where no **B** is to the left of any **W**

Operators:

1) A tile jumps over another tile into a blank tile with cost 2

2) A tile translates into a blank space with cost 1