CS217: Artificial Intelligence and Machine Learning (associated lab: CS240)

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Course website: very important

- https://www.cse.iitb.ac.in/~cs217/2025/

Perspective

Nobel Prizes in Physics and Chemistry in 2024 were for AI

1982
John Hopfield discovers the Hopfield network, an associative memory structure that can store and recreate patterns[5]

1985
Geoffrey Hinton uses the Hopfield network to build the Boltzmann machine, which resembles modern day artificial neural networks[6]

1988
Scientists begin to use artificial neural networks in protein structure prediction[41,42]

2010
Demis Hassabis co-founds DeepMind, an AI-focused company later sold to Google in 2014[43]

2018
Hassabis develops AlphaFold, which achieves a protein prediction accuracy of ~60%, an improvement on the ~40% accuracy that scientists previously achieved[44]

2020
John Jumper refines AlphaFold to develop AlphaFold2 using deep learning, achieving a protein structure prediction accuracy of ~90%, effectively solving the 50-year protein prediction challenge[15]

2024
The publicly available AlphaFold2 model has been used by more than 2 million people across 190 countries[2]

AI Perspective (post-web)

Robotics

NLP

IR

Planning

Search, Reasoning, Learning

Expert Systems

Computer Vision
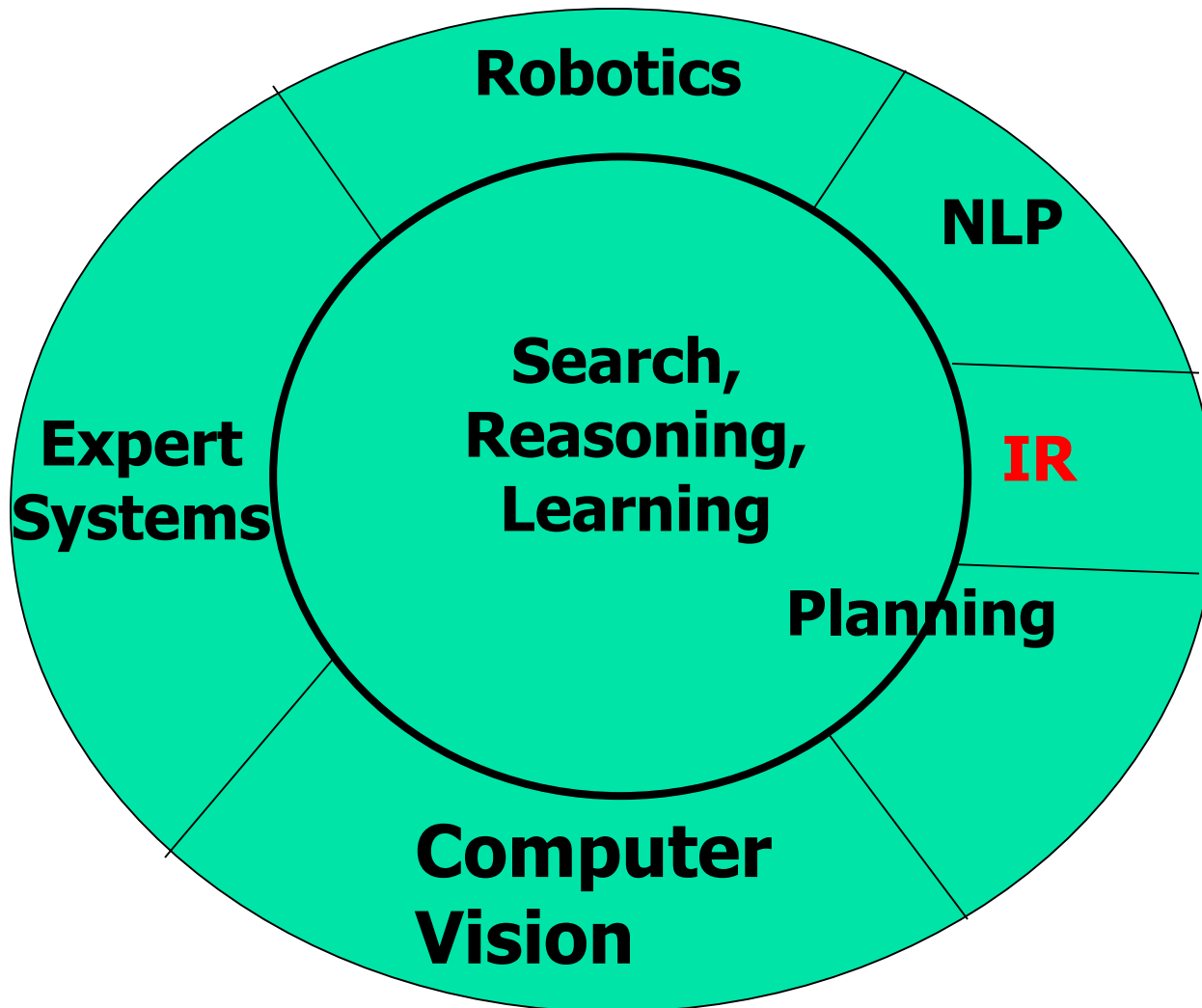
From Wikipedia

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]
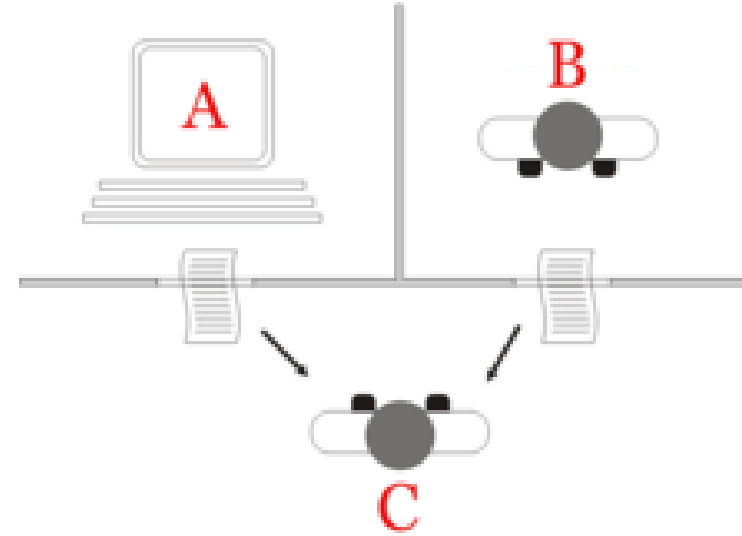
Topics to be covered: see the website

- **https://www.cse.iitb.ac.in/~cs217/2025/**

# Is AI Possible: theoretically, Philosophically?

Turing Test *(wikipedia)*

- The **Turing test**, originally called the **imitation game** by Alan Turing in 1950

- Test of a machine's ability to exhibit intelligent behavior

- Equivalent to, or **indistinguishable** from, that of a human

The "standard interpretation" of the Turing test, in which player C, the interrogator, is given the task of trying to determine which player – A or B – is a computer and which is a human. The interrogator is limited to using the responses to written questions to make the determination

Searl's Chinese Room Experiment
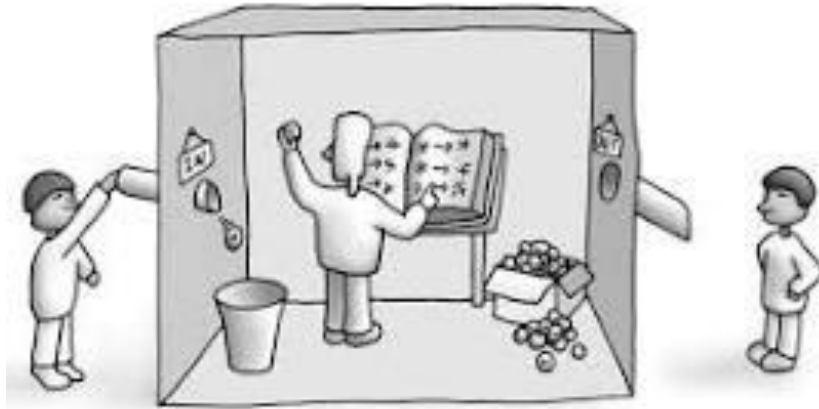
- A computer program cannot have a "mind", "understanding", or "consciousness", regardless of how intelligently or human-like the program may make the computer behave. Philosopher John Searle presented the argument in his paper "Minds, Brains, and Programs", published in *Behavioral and Brain Sciences* in 1980.

- **A human being sits in the room and does exactly as the program does, gives an impression of "knowing" Chinese, but in actuality does not understand Chinese.**

I gave this test to chatGPT (1/2)

Read this story and examine everything is right about this story: "once a ship was going from England to France. After a few days of journey, it was caught in a violent storm. The captain tried a lot to steer the ship clear from the eye of the storm, but the ship sped to a cliff and dashed against it. All those on board died and only the captain survived. With a binocular, he could spot a spot of jungle very far. With great difficulty, he took his articles near the jungle and after going there fell unconscious. He regained consciousness after 3 days. After becoming conscious, the captain felt very hungry. He fortunately found some potatoes amongst his articles. (cntd.)

I gave this test (2/2)

He managed to get a fire ignited by striking two pieces of stone. There were some dry pieces of wood which he lighted and boiled the potatoes on the fire and appeased his hunger. When he had slept for some time, he woke up and found some shining objects on the sand where the fire was burnt. He kept these objects with him. After several days, he spied a ship far away with the binocular. The ship rescued him from the island. The captain took those shining objects with him to England. Later they found interesting properties of these shining objects. These objects were transparent, but could be used to make containers. The material was given the name "glass". This is how glass was invented."

ChatGPT response (1/2)

There are several issues with this story, indicating that it is not entirely accurate.

Firstly, glass was not invented by a shipwrecked captain as described in the story. The history of glassmaking goes back thousands of years and involves the contributions of many different cultures.

Secondly, the story implies that glass is made from potatoes, which is completely false. Glass is made from a mixture of silica, soda ash, and limestone, among other materials.

ChatGPT response (2/2)

Thirdly, the story suggests that the captain discovered glass by chance, simply by finding some shiny objects on the sand. However, the process of making glass is complex and requires specialized knowledge and equipment.

Finally, the story is written in a somewhat simplistic and unconvincing manner, with several inconsistencies and unrealistic details, such as the captain managing to survive on a deserted island with only a few potatoes and no other resources for several days.

In summary, while the story may be entertaining, it is not a reliable source of information about the invention of glass.

There are a few issues with the story:

- The story describes the invention of glass, but glass was actually first produced by the ancient Mesopotamians around 3500 BCE, long before the time period in which the story is set.

- The story suggests that the captain single-handedly invented glass by discovering it on a deserted island. However, the invention of glass was a complex and gradual process that involved experimentation and refinement by many people over many centuries. (Cntd.)

Regenerate response (2/2)

Cntd.

- The story does not provide any specific details about the captain's journey or the location of the island, which makes it difficult to verify the accuracy of the events described.

- In conclusion, while the story may be an interesting work of fiction, it is not an accurate portrayal of the invention of glass.

Grading (Tentative)

- CS217
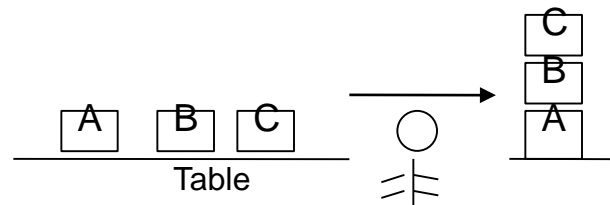 - Midsem: 30%
  - Endsem: 50%
  - Quizzes (2): 20%
- CS240
  - Weekly lab: each 10%
  - Modsem exam: 10%
  - Final Viva: 20%

AI Search: ubiquitous

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.

R   L

Two eye
system

World
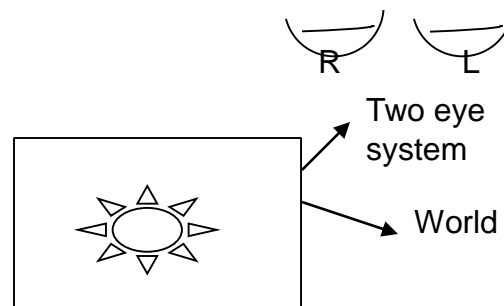
Robot Path Planning

- 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.
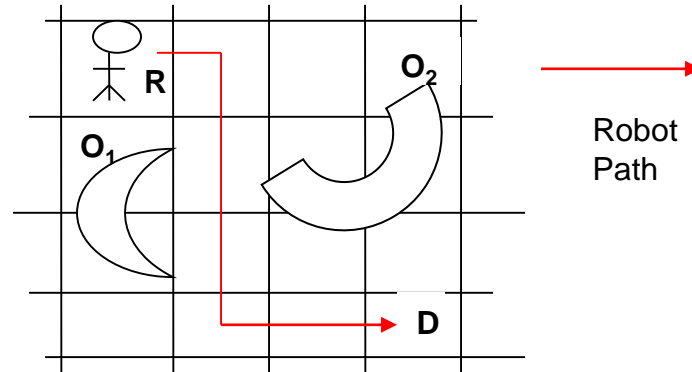
Natural Language Processing

- 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*.

The   man   would   like   to   play.

Noun   Verb   Preposition Verb   Noun   Verb
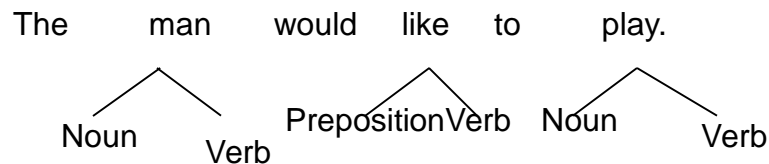
- Another sentence: *buffalo buffaloes buffalo buffaloes buffalo buffalo buffalo buffaloes* (buffalo as noun: *bison* or *city of buffalo*; as verb *to bully*); search space 3^8

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.
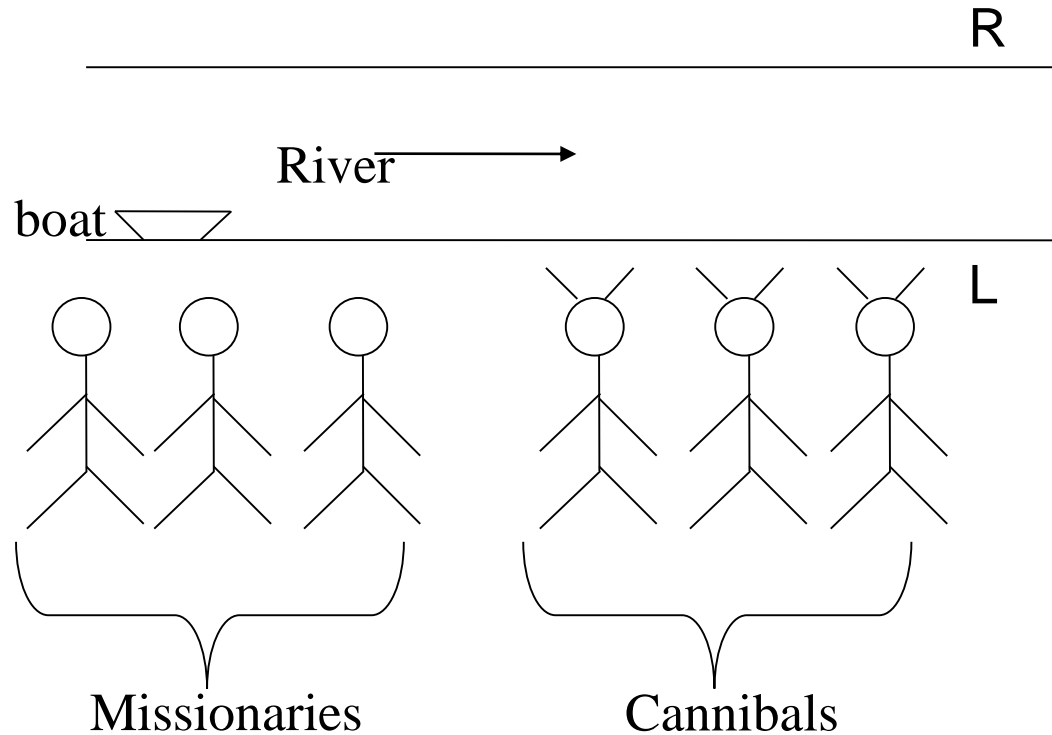
Operators:

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 : $\langle \#M, \#C, P \rangle$

$\#M$ = Number of missionaries on bank L

$\#C$ = Number of cannibals on bank L

P = Position of the boat

$S0 = \langle 3, 3, L \rangle$

$G = \langle 0, 0, R \rangle$
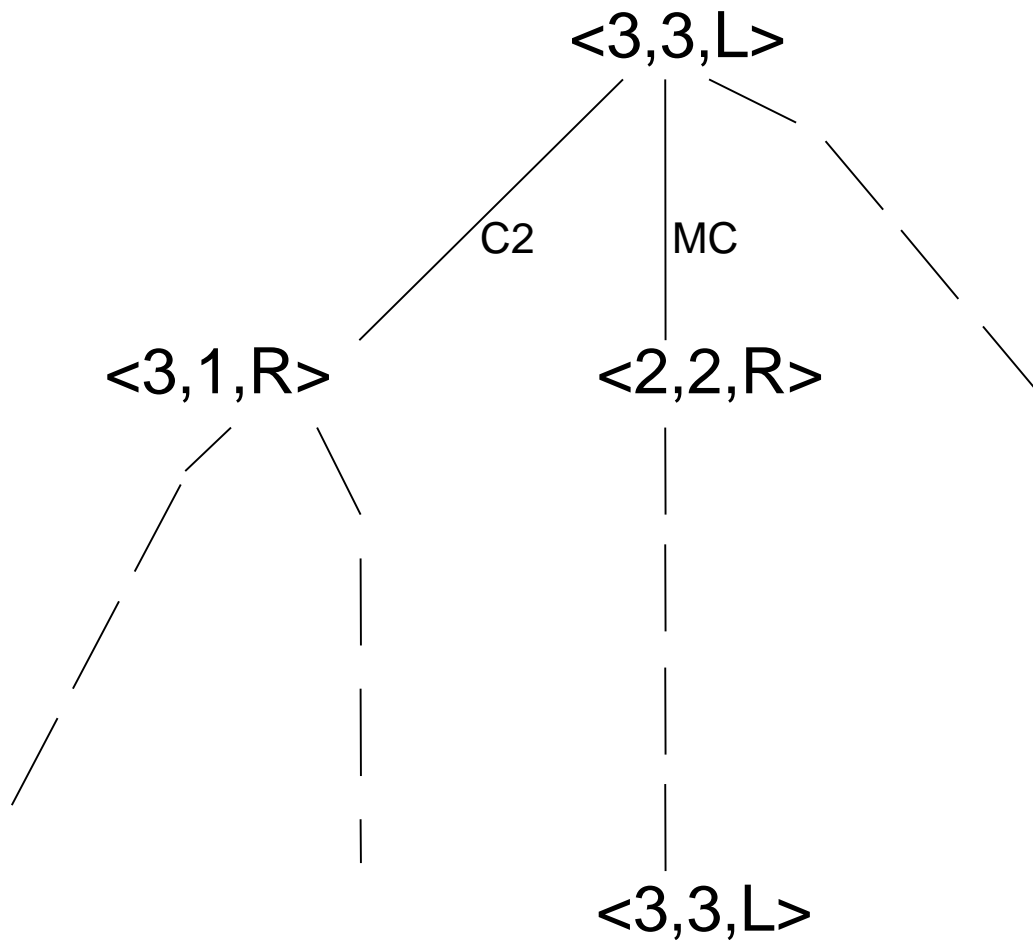
<u>Operations</u>

$M2$ = 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

<3,3,L>

C2   MC

<3,1,R>   <2,2,R>

<3,3,L>

Partial search
tree

Problem 3

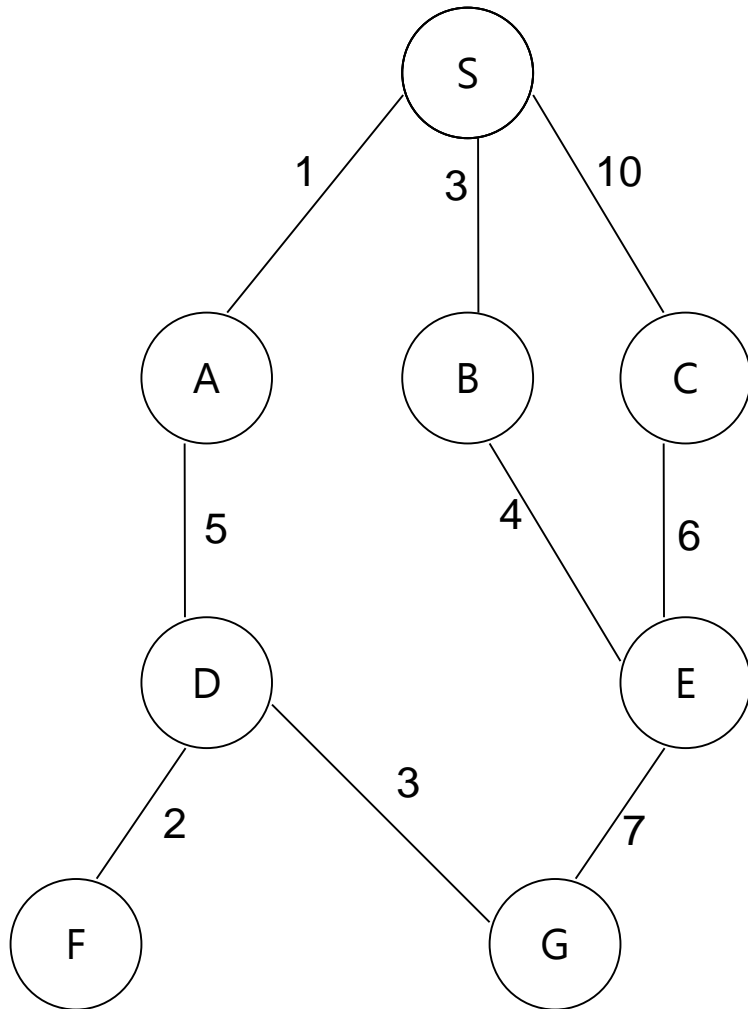| B	B	B	W	W	W	

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

Algorithmics of Search

General Graph search Algorithm

Graph G = (V,E)

1) Open List : S $^{(\varnothing,\ 0)}$
   Closed list : $\varnothing$

2) OL : A$^{(S,1)}$, B$^{(S,3)}$, C$^{(S,10)}$
   CL : S

3) OL : B$^{(S,3)}$, C$^{(S,10)}$, D$^{(A,6)}$
   CL : S, A

4) OL : C$^{(S,10)}$, D$^{(A,6)}$, E$^{(B,7)}$
   CL: S, A, B

5) OL : D$^{(A,6)}$, E$^{(B,7)}$
   CL : S, A, B , C

6) OL : E$^{(B,7)}$, F$^{(D,8)}$, G$^{(D,\ 9)}$
   CL : S, A, B, C, D

7) OL : F$^{(D,8)}$, G$^{(D,9)}$
   CL : S, A, B, C, D, E

8) OL : G$^{(D,9)}$
   CL : S, A, B, C, D, E, F

9) OL : $\varnothing$
   CL : S, A, B, C, D, E,
        F, G

Steps of GGS
(*principles of AI, Nilsson,*)

- 1. Create a search graph G, consisting solely of the start node S; put S on a list called *OPEN.*

- *2.* Create a list called *CLOSED* that is initially empty.

- 3. Loop: if *OPEN* is empty, exit with failure.

- 4. Select the first node on *OPEN*, remove from *OPEN* and put on *CLOSED*, call this node n.

- 5. if n is the goal node, exit with the solution obtained by tracing a path along the pointers from n to s in G. (ointers are established in step 7).

- 6. Expand node n, generating the set M of its successors that are not ancestors of n. Install these memes of M as successors of n in G.

GGS steps (contd.)

- 7. Establish a pointer to *n* from those members of *M* that were not already in *G* (*i.e.*, not already on either *OPEN* or *CLOSED*). Add these members of *M* to *OPEN*. For each member of *M* that was already on *OPEN* or *CLOSED*, decide whether or not to redirect its pointer to *n*. For each member of M already on *CLOSED*, decide for each of its descendents in *G* whether or not to redirect its pointer.

- 8. Reorder the list *OPEN* using some strategy.

- 9. Go *LOOP.*

GGS is a general umbrella

OL is a
queue
(BFS)

OL is
stack
(DFS)

OL is accessed by
using a functions
$f = g + h$
(Algorithm A)

S ○

n$_1$ ○

C(n$_1$,n$_2$)

h(n$_1$)

n$_2$ ○

h(n$_2$)

g ○
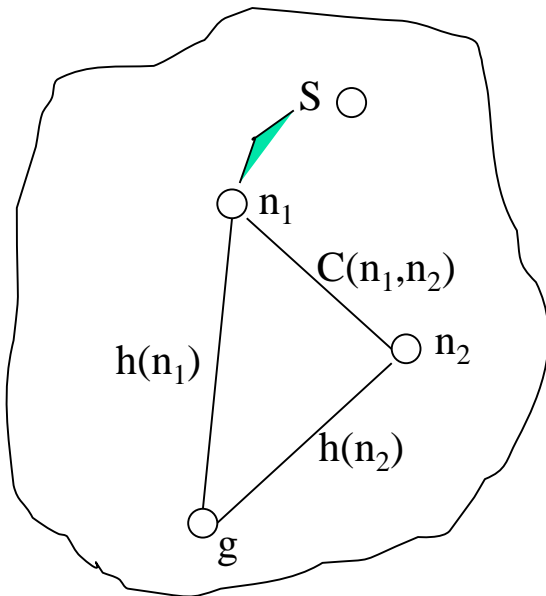
$$h(n_1) \leq C(n_1, n_2) + h(n_2)$$

Algorithm A

- A function f is maintained with each node

  $f(n) = g(n) + h(n)$, n is the node in the open list

- Node chosen for expansion is the one with least f value

- For BFS: $h = 0$, $g =$ number of edges in the path to S

- For DFS: $h = 0$, $g = \dfrac{1}{\text{No of edges in the path to S}}$

Algorithm A*

- One of the most important advances in AI

- *g(n)* = least cost path to n from S found so far

- *h(n) <= h*(n)* where *h*(n)* is the actual cost of optimal path to G(node to be found) from *n*

"Optimism leads to optimality"
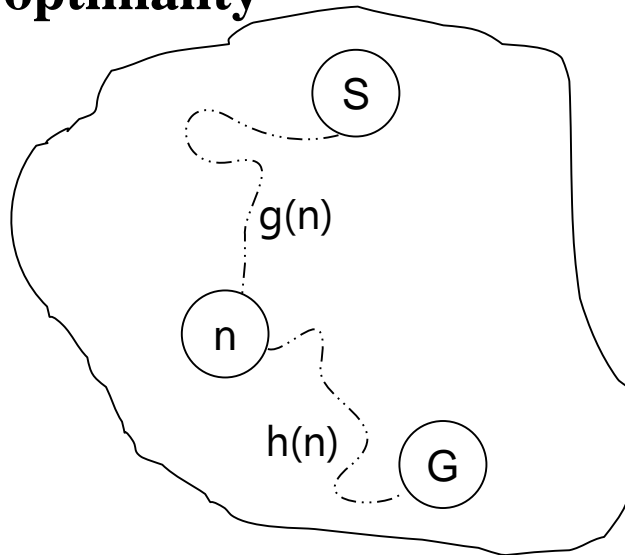
A* Algorithm – Definition and Properties

- *f(n) = g(n) + h(n)*
- The node with the least value of *f* is chosen from the *OL*.

- *f*(n) = g*(n) + h*(n),* where,

  g*(n) = actual cost of the optimal path *(s, n)*
  h*(n) = actual cost of optimal path *(n, g)*

- *g(n) ≥ g*(n)*

- By definition, *h(n) ≤ h*(n)*
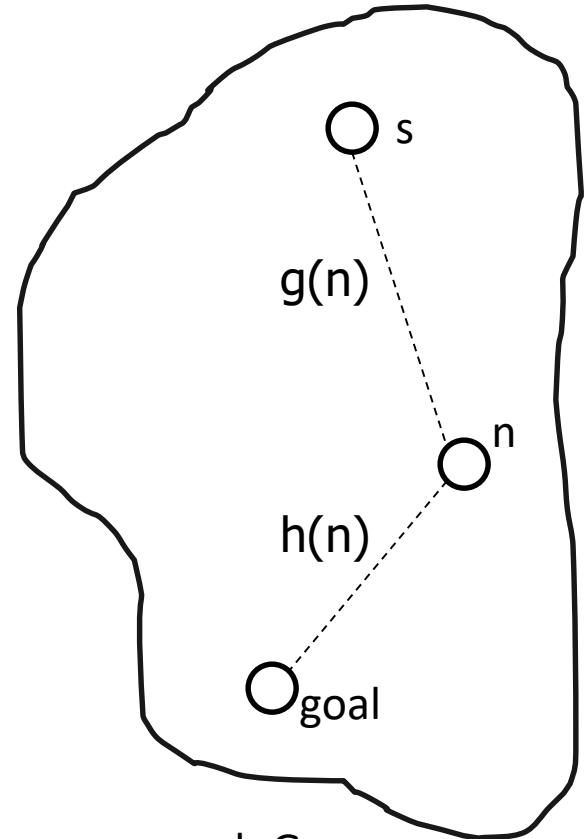
State space graph G

8-puzzle: heuristics

Example: 8 puzzle

2	1	4
7	8	3
5	6	

s

1	6	7
4	3	2
5		8

n

1	2	3
4	5	6
7	8	

g

$h*(n)$ = actual no. of moves to transform n to g

1. $h_1(n)$ = no. of tiles displaced from their destined position.
2. $h_2(n)$ = sum of Manhattan distances of tiles from their destined position.

$h_1(n) \leq h*(n)$ and $h_1(n) \leq h*(n)$

$h*$

h_2

h_1

Comparison