# Review Session

CMSC 373 Artificial Intelligence
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## The Beginnings of AI

1956 Dartmouth Summer School
What is AI?
Scientific Agenda
Practical Agenda
Alan Turing/Turing Test
Dichotomies of AI: understanding *versus* simulating
Strong *versus* Weak AI
ELIZA
Winograd Schemas
AGI *versus* Narrow AI
Dichotomies of AI: Symbolic AI *versus* Subsymbolic AI
Seasons of AI: Spring, Winter
Movie: The Thinking Machine

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# Early Days of AI (1960s)

Perception
Problem Solving
Planning
Reasoning
Natural Language Understanding
Machine Learning
SHRDLU
Microworld
Procedural Knowledge
Declarative Knowledge
SHAKEY
STRIPS
State
Goal
Actions/Operators/Schema
Closed World
Frame Problem

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# Search in AI

**Problem Solving as Search**
State
Initial State
Goal State
Search Algorithms
State Space
Search Trees
Branching Factor
Search Depth
Search Complexity
Combinatorial Explosion
Complexity Barrier

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# Search Algorithms

- **Blind Search**
  - Depth-First Search
    *frontier* is a stack
  - Breadth-First Search
    *frontier* is a Queue
- **Informed Search**
  - Uniform-Cost/Best-First/Dijkstra's Search
    *frontier* is ordered by $g()$
  - Greedy Best-First Search
    *frontier* is ordered by $h()$
  - A* Search
    *frontier* is ordered by $f() = g() + h()$

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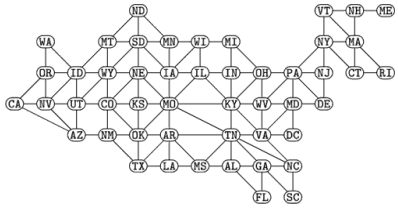
# A Generic Search Algorithm

- Uses a data structure, called ***frontier*** (a stack or a queue), to keep track of partially explored paths from initial state. Also uses a data structure (a set), ***explored*** to keep track of states/nodes already explored.

*frontier* ← a partial path containing the *start node*
*explored* ← { }
**repeat**
  *p* ← remove a partial path from the *frontier*
  **if** *p* ends in a goal node/state **return** the path *p* as answer
    *neighbors* ← neighbors of last node (*i*) in *p* that are not in explored
    *explored* ← last node (*i*) in *p*
    **for each** node *n* in *neighbors*
      *q* ← extend *p* to that neighbor, *n*
      *frontier* ← add *q*
**until** *frontier* is empty
**return** that there are no paths from initial state to goal state




Initial State: CA
Goal State: PA
Partial Path: CA-OR-ID-MT
Neighbors of MT: ID, ND, SD, WY

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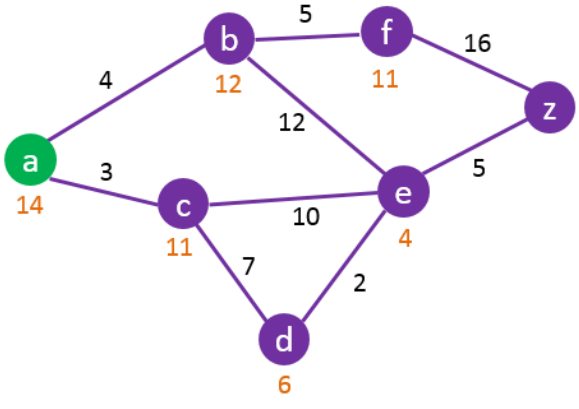
# Try on this...

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# Game Playing

2-Person Games
Zero Sum Games
Perfect Information
Minimax Algorithm
Game Ply
Backed-up Values
Static Evaluation Function
Heuristics
α-β Pruning
Move Ordering


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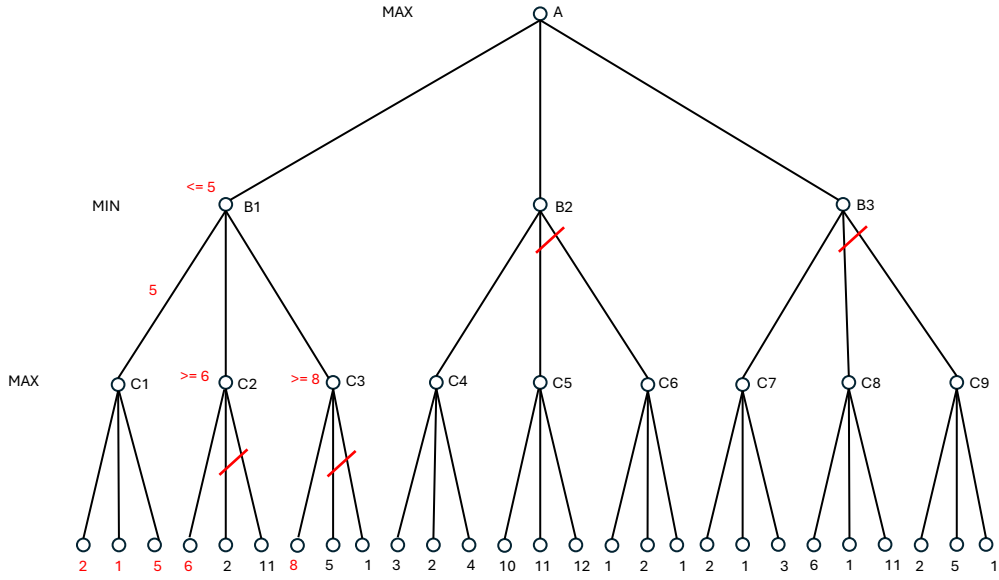
# Minimax with α-β Pruning

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# 1980s: Rise of Knowledge: Expert Systems

AI Winter
Knowledge in AI
Expert Systems
MYCIN
R1/XCON
Rules
Antecedent
Consequent
Rule-Based Systems
Forward Chaining
Backward Chaining
Explanability





# ZOOKEEPER – A Toy Rule-Based System

| | | |
|---|---|---|
| Z1 | IF | ?x has hair |
| | THEN | ?x is a mammal |
| Z2 | IF | ?x gives milk |
| | THEN | ? Is a mammal |
| Z3 | IF | ?x has feathers |
| | THEN | ?x is a bird |
| Z4 | IF | ?x flies |
| | THEN | ?x is a bird |
| Z5 | IF | ?x flies<br>?x lays eggs |
| | THEN | ?x is a bird |
| Z6 | IF | ?x is a mammal<br>?x has pointed teeth<br>?x has claws<br>?x has forward-pointing eyes |
| | THEN | ?x is a carnivore |
| Z7 | IF | ?x is a mammal<br>?x has hoofs |
| | THEN | ?x is an ungulate |
| Z8 | IF | ?x is a mammal<br>?x chews cud |
| | THEN | ?X is an ungulate |
| Z9 | IF | ?x is a carnivore<br>?x has tawny color<br>?x has dark spots |
| | THEN | ?x is a cheetah |
| Z10 | IF | ?x is a carnivore<br>?x has tawny color<br>?x has black stripes |
| | THEN | ?x is a tiger |
| Z11 | IF | ?x is an ungulate<br>?x has long legs<br>?x has long neck<br>?x has tawny color<br>?x has dark spots |
| | THEN | ?x is a giraffe |
| Z12 | IF | ?x is an ungulate<br>?x has white color<br>?x has black stripes |
| | THEN | ?x is a zebra |
| Z13 | IF | ?x is a bird<br>?x does not fly<br>?x has long legs<br>?x is black and white |
| | THEN | ?x is an ostrich |
| Z14 | IF | ?x is a bird<br>?x does not fly<br>?x swims<br>?x is black and white |
| | THEN | ?x is a penguin |
| Z15 | IF | ?x is a bird<br>?x is a good flyer |
| | THEN | ?x is an albatross |

Stretch has hair
Stretch chews cud
Stretch has long legs
Stretch has a long neck
Stretch has tawny color
Stretch has dark spots

## Knowledge Representation in Logic

Declarative Knowledge
Propositions
Entailment
Knowledge Representation
What is a logic?
Rules of Inference
Soundness
Completeness
First-Order Logic (FOPC)
Syntax
Semantics
Knowledge Representation & Reasoning Systems

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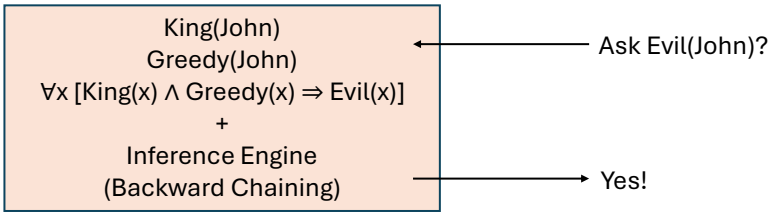
## KRR Systems

- Tell-Ask Systems

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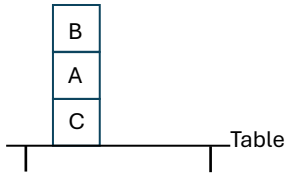
# Blocksworld

On(x, y) : x is on top of y
Clear(x) : x is clear
Block(x) : x is a block




On(B, A)
On(A, C)
On(C, Table)
Block(A)
Block(B)
Block(C)
∀x, y [ Block(x) ∧ Block(y) ∧ On(x, y) ⇒ ¬Clear(y) ]

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