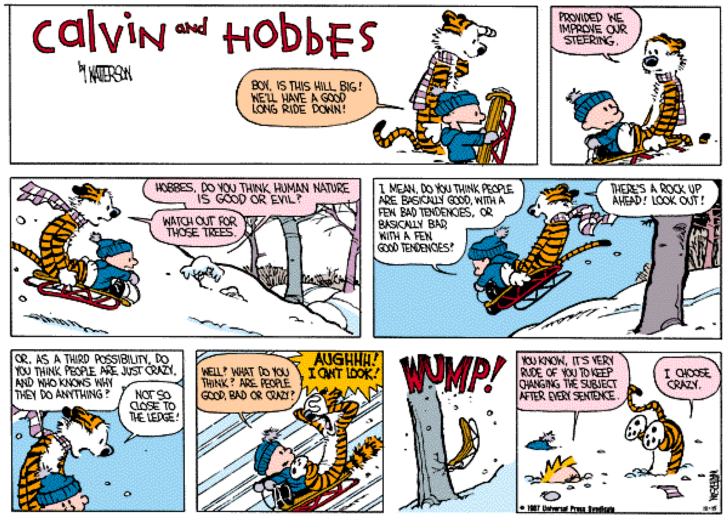
Review



How many AI researchers does it take to change a lightbulb?

The Problem Space Group

- One to define the goal state
- One to define the operators
- One to describe the universal problem solver
- One to hack the production system
- One to indicate about how it is a model of human lightbulb-changing behavior
- One to call the Lisp hackers

[Rich and Knight, 1991]

How many AI researchers does it take to change a lightbulb?

The Lisp Hackers

- One to bring up the network
- One to order the Chinese food
- Four to hack on the Lisp debugger, compiler, window system, and microcode
- One to write the lightbulb-changing program

How many AI researchers does it take to change a lightbulb?

The Logic Group

- One to figure out how to describe lightbulb changing in predicate logic
- One to show the adequacy of predicate logic
- One to show the inadequacy of predicate logic
- One to show that lightbulb logic is nonmonotonic
- One to show that it isn't nonmonotonic
- One to incorporate nonmonotonicity into predicate logic
- One to determine the bindings for the variables
- One to show the completeness of the solution
- One to show the consistency of the solution
- One to hack a theorem prover for lightbulb resolution
- One to indicate how it is a description of human lightbulb-changing behavior
- One to call the electrician

How many AI researchers does it take to change a lightbulb?

The Fuzzy Logic Group

- One to point out that, in the real world, a lightbulb is never "on" or "off", but usually somewhere in between

How many AI researchers does it take to change a lightbulb?

The Robotics Group

- One to build a vision system to recognize the dead bulb
- One to build a vision system to locate a new bulb
- One to figure out how to grasp the lighbulb without breaking it
- One to figure out the arm solutions that will get the arm to the socket
- One to organize the construction teams
- One to hack the planning system
- One to indicate how the robot mimics human motor behavior in lightbulb changing

How many AI researchers does it take to change a lightbulb?

The Game-Playing Group

- One to design a two-player game tree with the robot as one player and the lightbulb as the other
- One to write a minimax search algorithm that assumes optimal play on the part of the lightbulb
- One to build special-purpose hardware to enable 24-ply search
- One to enter the robot in a human lightbulb-changing tournament
- One to state categorically that lightbulb changing is "no longer considered AI"

How many AI researchers does it take to change a lightbulb?

The Learning Group

- One to collect thirty lightbulbs
- One to collect thirty "near misses"
- One to write a concept-learning program that learns to identify lightbulbs
- One to show that the program found a local maximum in the space of lightbulb descriptions

How many AI researchers does it take to change a lightbulb?

The Neural Network Group

- One to claim that lightbulb changing can only be achieved through massive parallelism
- One to build a backpropagation network to direct the robot arm
- One to assign initial random weights to the connections in the network
- One to train the network by showing it how to change a lightbulb (training shall consist of 500,000 repeated epochs)
- One to tell the media that the network learns "just like a human"
- One to compare the performance of the resulting system with that of symbolic learning approaches (optional)

Strong AI Position

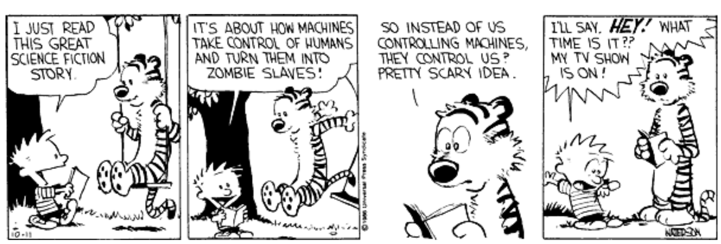
- Machines that act intelligently can have real, conscious minds
- Weak AI doubts can be refuted
  - Locate a task thought impossible, design a program to accomplish task
  - Helps identify and remove AI researcher assumptions
- Strong AI doubts are difficult to refute
  - Hard to define
  - Hard to prove or disprove

Weak AI Position

- Machines can be made to act *as if* they were intelligent
  - There are things that computers cannot do, no matter how we program them
  - Certain ways of designing intelligent programs are bound to fail in the long run
  - The task of constructing the appropriate programs is infeasible

What if we Succeed?

- Legal responsibility
- Should intelligent agents have rights?
- How some perceive the future of AI
  - HAL
  - Matrix
- What do you think?
- How should we use this technology?



Topics

- AI Overview and Intelligent Agents
  - Definition of AI
  - Types of agents
  - Classification of environments
- Search
  - Generic search algorithm
  - Uninformed Search: DFS, BFS, UCS, IDS
  - Informed Search: Best-FS, Hill Climbing, Beam Search, A*, IDA*
    - Heuristics
    - f(n), g(n), h(n)
  - Global (e.g. BFS) vs. Local Search (e.g. Hill-Climbing)

Topics

- Constraint Satisfaction Problems
  - Defining CSPs
  - General search for CSP
  - Backtracking
  - Forward checking
  - Heuristics
- Game Tree Search
  - Zero-Sum Games
  - Game Trees
  - Minimax, Alpha-Beta Minimax
  - Evaluation functions
  - Variations:
    - 3-player games
    - Nondeterministic games

Topics

- Representation and Reasoning
  - Types of formal logic
  - Entailment
  - Proof methods: model checking, inference
  - Propositional logic
  - Normal forms
  - First-Order Predicate Calculus (FOPC)
    - $\forall$ and $\exists$
    - Unification
    - Conversion to CNF and resolution
    - Green's trick

Topics

- Planning
  - Stanford Research Institute Problem Solver (STRIPS) Operators
  - State-space planning
  - Plan-space planning
  - Partial-order planning
  - Graphplan algorithm
  - Scheduling

Topics

- Uncertainty Reasoning
  - Dealing with uncertainty
  - Probability basics
  - Axioms of probability
  - Bayes' Rule
  - Normalization
  - Bayes' Networks
  - Independence and conditional independence
  - Solving Bayes' Networks
    - Inference by enumeration
    - Summing out
    - Variable elimination
    - Tree method
  - Inference through stochastic simulation

Topics

- Markov Decision Processes (MDPs)
  - Defining an MDP
  - Markov Assumption
  - Expected utility
  - Bellman equation for utility
  - Value iteration
  - Policy iteration
    - Policy evaluation
  - Difference between MDPs and reinforcement learning