

# Artificial Intelligence- An Introduction



# Obvious question

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- What is AI?
  - Programs that behave externally like humans?
  - Programs that operate internally as humans do?
  - Computational systems that behave intelligently?
  - Rational behaviour?

# Turing Test

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- Human beings are intelligent
- To be called intelligent, a machine must produce responses that are indistinguishable from those of a human



Alan Turing

# Does AI have applications?

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- ❑ Autonomous planning and scheduling of tasks aboard a spacecraft
- ❑ Beating Gary Kasparov in a chess match
- ❑ Steering a driver-less car
- ❑ Understanding language
- ❑ Robotic assistants in surgery
- ❑ Monitoring trade in the stock market to see if insider trading is going on

# A rich history

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- ❑ Philosophy
- ❑ Mathematics
- ❑ Economics
- ❑ Neuroscience
- ❑ Psychology
- ❑ Control Theory
- ❑ John McCarthy- coined the term- 1950's

# Philosophy

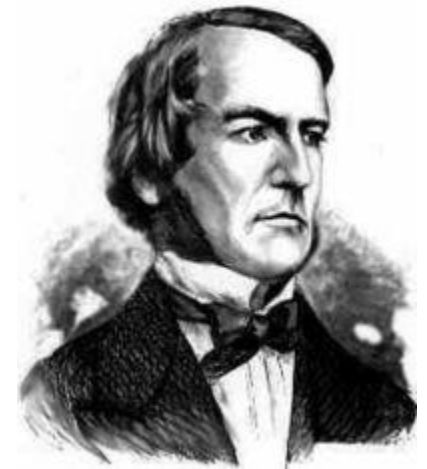
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- ❑ Dealt with questions like:
  - Can formal rules be used to draw valid conclusions?
  - Where does knowledge come from? How does it lead to action?
- ❑ David Hume proposed the principle of induction (later)
- ❑ Aristotle-
  - Given the end to achieve
  - Consider by what means to achieve it
  - Consider how the above will be achieved ...till you reach the first cause
  - Last in the order of analysis = First in the order of action
  - If you reach an impossibility, abandon search

# Mathematics

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- ❑ Boolean Logic(mid 1800's)
- ❑ Intractability (1960's)
  - Polynomial Vs Exponential growth
  - Intelligent behaviour = tractable subproblems, not large intractable problems.
- ❑ Probability
  - Gerolamo Cardano(1500's) - probability in terms of outcomes of gambling events



George Boole



Cardano

# Economics

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- ❑ How do we make decisions so as to maximize payoff?
- ❑ How do we do this when the payoff may be far in the future?
- ❑ Concept of utility (early 1900's)
- ❑ Game Theory (mid 1900's)



Leon Walras



# Neuroscience

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- ❑ Study of the nervous system, esp. brain
- ❑ A collection of simple cells can lead to thought and action
- ❑ Cycle time: Human brain- microseconds  
Computers- nanoseconds
- ❑ The brain is still 100,000 times faster

# Psychology

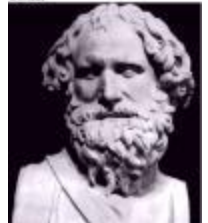
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- ❑ Behaviourism- stimulus leads to response
- ❑ Cognitive science
  - Computer models can be used to understand the psychology of memory, language and thinking
  - The brain is now thought of in terms of computer science constructs like I/O units, and processing center

# Control Theory

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- ❑ Ctesibius of Alexandria- water clock with a regulator
- ❑ Purposeful behaviour as arising from a regulatory mechanism to minimize the difference between goal state and current state ("error")



# Does AI meet EE?

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- ▣ Robotics- the science and technology of robots, their design, manufacture, and application.
- ▣ Liar! (1941)



Isaac Asimov

- Mechatronics- mechanics, electronics and computing which, combined, make possible the generation of simpler, more economical, reliable and versatile systems.

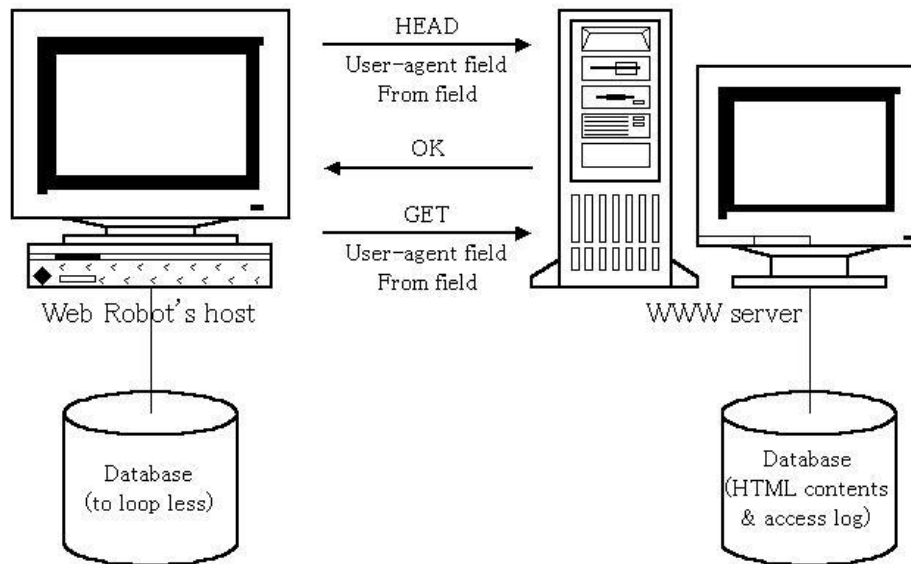


Norbert Wiener

- Cybernetics- the study of communication and control, typically involving regulatory feedback, in living organisms, in machines, and in combinations of the two.

# An Agent

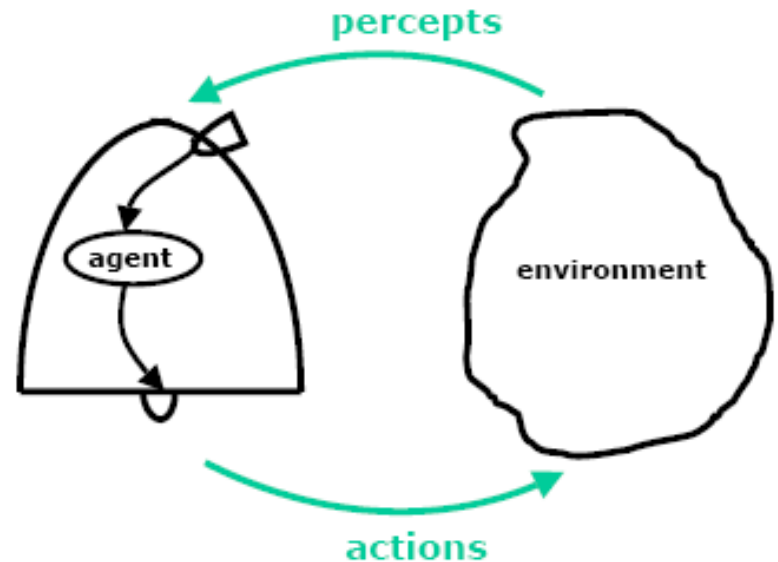
- 'Anything' that can gather information about its environment and take action based on that information.



# The Environment

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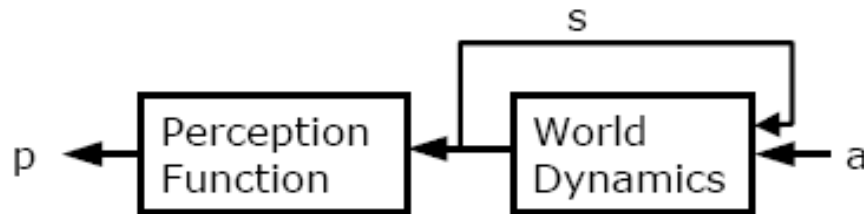
- What all do we need to specify?
  - The action space
  - The percept space
  - The environment as a string of mappings from the action space to the percept space



# The World Model

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- ❑ Perception function
- ❑ World dynamics / State transition function



- ❑ Utility function- how does the agent know what constitutes “good” or “bad” behaviour



# What is Rationality?

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- Goal
- Information / Knowledge
- The purpose of action is to reach the goal, given the information/knowledge possessed by the agent
- Is not omniscience
- The notion of rationality does not necessarily include success of the actions chosen

# Environments

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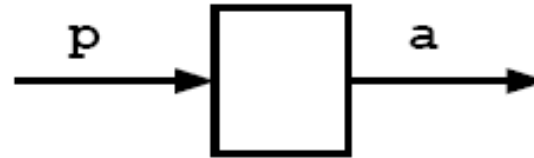
- ❑ Accessible/Inaccessible
- ❑ Deterministic/Non-deterministic
- ❑ Static/Dynamic
- ❑ Discrete/Continuous
- ❑ E.g. Driving a car, a game of Chinese-checkers

# Agents

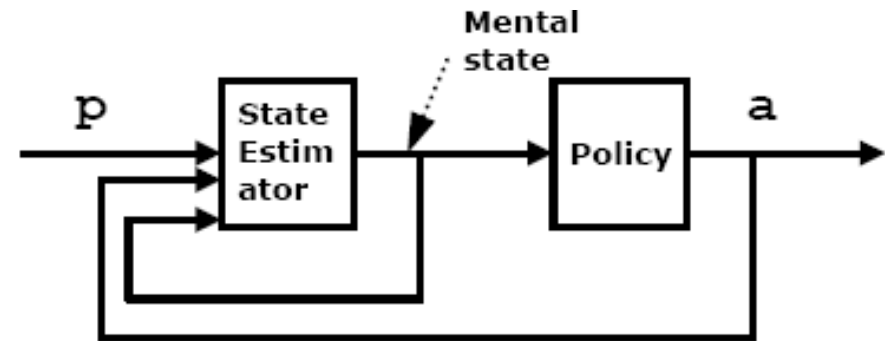
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## □ Reactive agents

- No memory

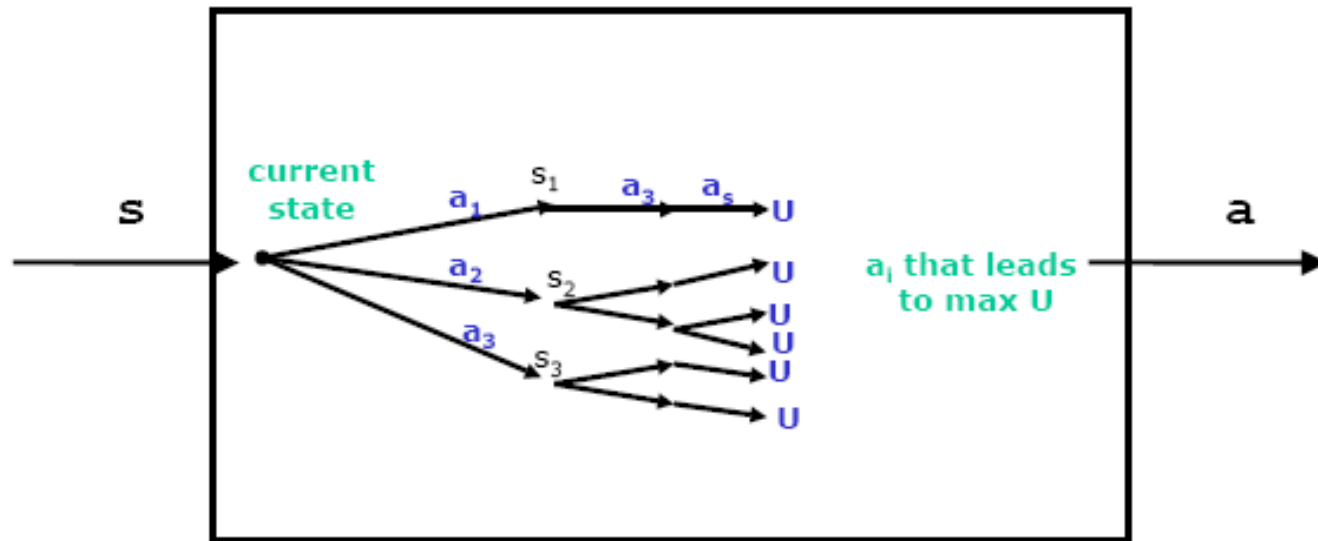


## □ Agents with memory



# Planning

- Planning a policy = considering the future consequences of actions to choose the best one



# Seems okay so far?

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- ❑ Computational constraints
- ❑ Can we possibly specify EXACTLY the domain the agent will work in?
- ❑ A look-up table of reactions to percepts is far too big
- ❑ Most things that could happen, don't

# Learning

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- ❑ Incomplete information about the environment
- ❑ A changing environment
- ❑ Use the sequence of percepts to estimate the missing details
- ❑ Hard for us to articulate the knowledge needed to build AI systems – e.g. try writing a program to recognize visual input like various types of flowers

# What is Learning?

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## □ Herb Simon-

“Learning denotes changes in the system that are adaptive in the sense that they enable the system to do the tasks drawn from the same population more efficiently and more effectively the next time.”

## □ But why do we believe we have the license to predict the future?

# Induction

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- David Hume- Scottish philosopher, economist
- All we can say, think, or predict about nature must come from prior experience
- Bertrand Russell-

"If asked why we believe the sun will rise tomorrow, we shall naturally answer, 'Because it has always risen everyday.' "



David Hume



# Classifying Learning Problems

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- ❑ Supervised learning- Given a set of input/output pairs, learn to predict the output if faced with a new input.
- ❑ Unsupervised Learning- Learning patterns in the input when no specific output values are supplied.
- ❑ Reinforcement Learning- Learn to interact with the world from the reinforcement you get.

# Functions

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- Given a sample set of inputs and corresponding outputs, find a function to express this relationship
  - Pronunciation= Function from letters to sound
  - Bowling= Function from target location (or trajectory?) to joint torques
  - Diagnosis= Function from lab results to disease categories

# Aspects of Function Learning

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- Memory
- Averaging
- Generalization