Artificial Intelligence

- Course Overview
- Introduction
- Roots
- Applications

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- You are told to find a large Phillips screwdriver in a cluttered workroom. You enter the room (you have never been there before), search without falling over objects, and eventually find the screwdriver.

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“The design and study of computer programs that behave intelligently. These programs are constructed to perform as would a human or an animal whose behavior we consider intelligent” **Dean et al., 1995**

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-(Barr & Feigenbaum, 1981)

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  It is the science and engineering of making intelligent machines, especially intelligent computer programs. It is related to the similar task of using computers to understand human intelligence, but AI does not have to confine itself to methods that are biologically observable.

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What's involved in Intelligence?

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  - e.g., speech recognition and understanding and synthesis
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- Learning and Adaptation
  - we are continuously learning and adapting
  - our internal models are always being "updated"
    - e.g., a baby learning to categorize and recognize animals

What do you think “AI IS”?

Views of AI fall into four categories:

System that think like humans

Introspection-trying to catch our own thought

Psychological experiments- simulations through computer programs

-Russell Straut and Peter Norvig

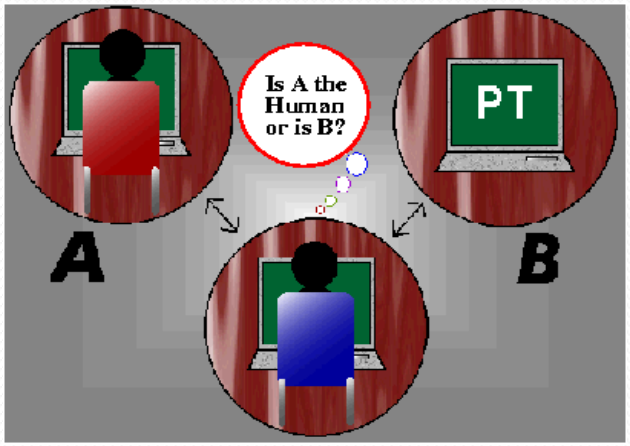
Thinking humanly: cognitive modeling

- 1960s "cognitive revolution": information-processing psychology
- Requires scientific theories of internal activities of the brain
- How to validate? Requires
  1) Predicting and testing behavior of human subjects (top-down) or
  2) Direct identification from neurological data (bottom-up)
- General Problem Solver(GPS)
  - Compares traces of reasoning
- Now broadly categorized as Cognitive Science

Acting Humanly

System that think like humans

- Operational Defition.
- Turing test: ultimate test for acting humanly
  - Computer and human both interrogated by judge
  - Computer passes test if judge can't tell the difference for 30% of the time



Characteristics to Pass Turing Test

- Natural Language Processing
  - Enable it to communicate successfully in English
- Knowledge Representation
  - Store what it knows or hear
- Automated Reasoning
  - Use the stored info to answer or to draw new conclusion
- Machine Learning
  - Adapt to new circumstances and to detect and extrapolate patterns

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Total Turing Test

- Computer Vision
- Robotics

Chinese Room Argument

Imagine you are sitting in a room with a library of rule books, a bunch of blank exercise books, and a lot of writing utensils. Your only contact with the external world is through two slots in the wall labeled ``input'' and ``output''. Occasionally, pieces of paper with Chinese characters come into your room through the ``input'' slot. Each time a piece of paper comes in through the input slot your task is to find the section in the rule books that matches the pattern of Chinese characters on the piece of paper. The rule book will tell you which pattern of characters to inscribe the appropriate pattern on a blank piece of paper. Once you have inscribed the appropriate pattern according to the rule book your task is simply to push it out the output slot.

By the way, you don't understand Chinese, nor are you aware that the symbols that you are manipulating are Chinese symbols.

In fact, the Chinese characters which you have been receiving as input have been questions about a story and the output you have been producing has been the appropriate, perhaps even "insightful," responses to the questions asked. Indeed, to the outside questioners your output has been so good that they are convinced that whoever (or whatever) has been producing the responses to their queries must be a native speaker of, or at least extremely fluent in, Chinese.

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System that think rationally

Aristotle: what are correct arguments/thought processes?

Several Greek schools developed various forms of *logic*: *notation* and *rules of derivation* for thoughts; may or may not have proceeded to the idea of mechanization

Direct line through mathematics and philosophy to modern AI

Problems:

Not all intelligent behavior is mediated by logical deliberation

What is the purpose of thinking? What thoughts should I have?

-Russell Straut and Peter Norvig

What do you think “AI IS”?

Views of AI fall into four categories:

System that act rationally

- Rational behavior: doing the right thing
- The right thing: that which is expected to maximize goal achievement, given the available information
- Doesn't necessarily involve thinking – e.g., blinking reflex – but thinking should be in the service of rational action

This is approach adopted by Russell & Norvig

-Russell Straut and Peter Norvig

What do you think “AI IS”?

Views of AI fall into four categories:

Machine Thinking humanly	Machine Thinking rationally
Machine Acting humanly	Machine Acting rationally

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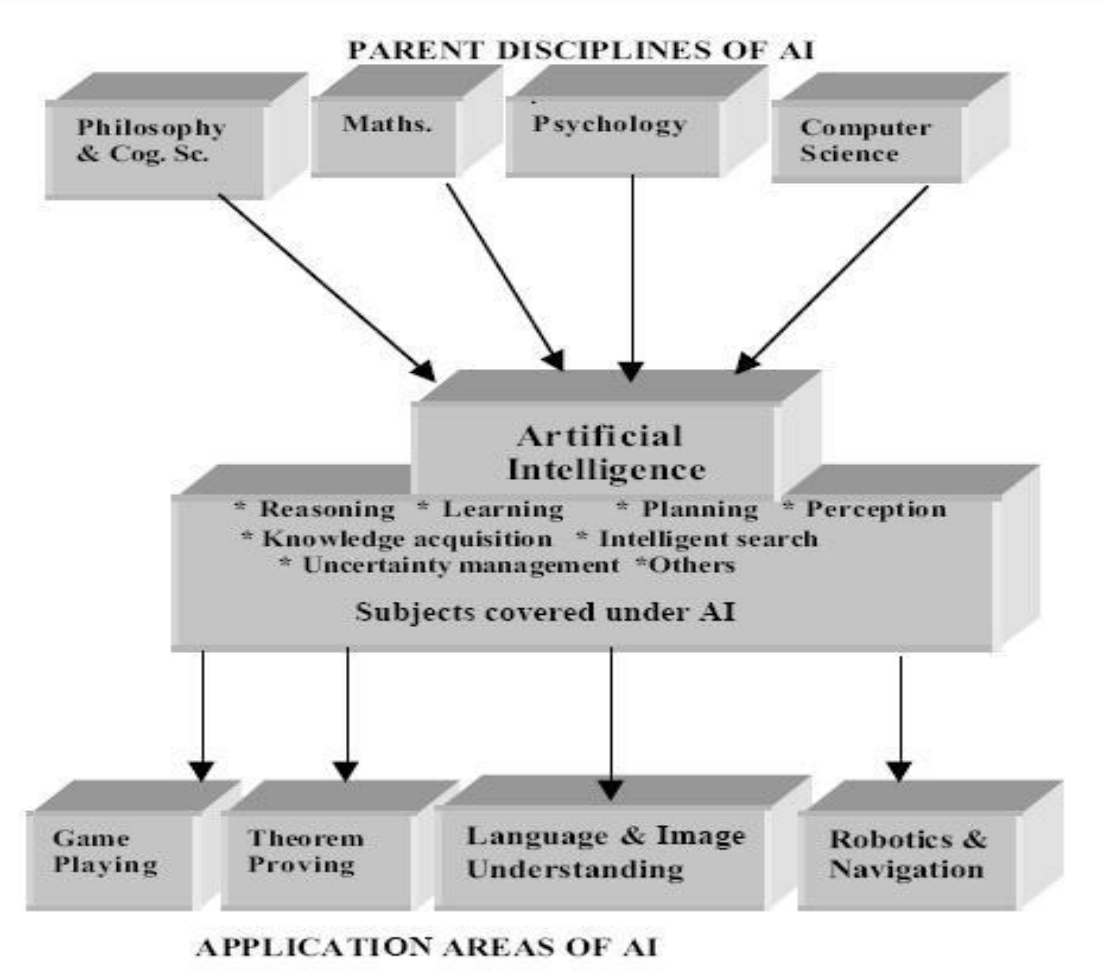
Roots


PARENT DISCIPLINES OF AI
Philosophy & Cog. Sc.
Maths.
Psychology
Computer Science
Artificial Intelligence
* Reasoning * Learning * Planning * Perception
* Knowledge acquisition * Intelligent search
* Uncertainty management *Others
Subjects covered under AI
Game Playing
Theorem Proving
Language & Image Understanding
Robotics & Navigation
APPLICATION AREAS OF AI

Roots

Philosophy Contd…

- ~400 BC Socrates asks for an *algorithm to distinguish piety from non-piety.*
- ~350 BC Aristotle formulated different styles of *deductive reasoning, which could* mechanically generate conclusions from initial premises, e.g.
- Modus Ponens If *A* ➡ *B and A then B*

Roots

Philosophy

- **1596 – 1650** Rene Descartes idea of mind-body *dualism* – *part of the mind is exempt* from physical laws.
- Otherwise how do we have *free will?*
- **1646 – 1716** Wilhelm Leibnitz was one of the first to take the *materialist position*
- which holds that the mind operates by ordinary physical processes – this has the
- implication that mental processes can potentially be carried out by machines.

Roots

Logic/Mathematics

- **1777** Earl Stanhope's Logic Demonstrator was a machine that was able to solve syllogisms, numerical problems in a logical form, and elementary questions of probability.
- **1815 – 1864** George Boole introduced his formal language for making logical inference in 1847 – Boolean algebra.
- **1848 – 1925** Gottlob Frege produced a logic that is essentially the first-order logic that today forms the most basic knowledge representation system.

Roots

Logic/Mathematics

- **1906 – 1978** Kurt Gödel showed in 1931 that there are limits to what logic can do. His *Incompleteness Theorem showed that in any formal logic powerful enough to* describe the properties of natural numbers, there are true statements whose truth cannot be established by any algorithm.
- **1995** Roger Penrose tries to prove the human mind has non-computable capabilities.

Roots Contd…

Computation

- **1869** William Jevon's Logic Machine could handle Boolean Algebra and Venn Diagrams, and was able to solve logical problems faster than human beings.
- **1903 – 1957** John von Neumann proposed the *von Neuman architecture which allows* a description of computation that is independent of the particular realisation of the computer.
- **~1960s** Two important concepts emerged: *Intractability (when solution time grows at* least exponentially) and *Reduction (to 'easier' problems).*

Roots Contd…

Computation

- **1912 – 1954** Alan Turing tried to characterize exactly which functions are capable of being computed. Unfortunately it is difficult to give the notion of *computation a* formal definition. However, the Church-Turing thesis, which states that a *Turing machine is capable of computing any computable function, is generally accepted as* providing a sufficient definition. Turing also showed that there were some functions which no Turing machine can compute (e.g. Halting Problem).

Roots Contd…

Psychology / Cognitive Science

- Modern Psychology / Cognitive Psychology / Cognitive Science is the science which studies how the mind operates, how we behave, and how our brains process information.
- It is natural for us to try to use our understanding of how human (and other animal) brains lead to intelligent behavior in our quest to build artificial intelligent systems. Conversely, it makes sense to explore the properties of artificial systems (computer models/simulations) to test our hypotheses concerning human systems.

Biology / Neuroscience

- Our brains (which give rise to our intelligence) are made up of tens of billions of neurons, each connected to hundreds or thousands of other neurons. Each neuron is a simple processing device (e.g. just firing or not firing depending on the total amount of activity feeding into it). However, large networks of neurons are extremely powerful computational devices that can ***learn how best to operate.***
- The field of ***Connectionism or Neural Networks attempts to build artificial systems*** based on simplified networks of simplified artificial neurons. The aim is to build powerful AI systems, as well as models of various human abilities.

Sources of derivation

- Philosophy — Logic, methods of reasoning, mind as physical system foundations of learning, language, rationality
- Mathematics — Formal representation and proof algorithms, computation, (un)decidability, (in)tractability, probability
- Economics — utility, decision theory
- Neuroscience physical substrate for mental activity
- Psychology — phenomena of perception and motor control, experimental techniques
- Computer engineering — building fast computers
- Control theory — design systems that maximize an objective function over time
- Linguistics — knowledge representation, grammar

Abridged history of AI

- 1943 — McCulloch & Pitts: Boolean circuit model of brain
- 1950 — Turing's "Computing Machinery and Intelligence"
- 1956 — Dartmouth meeting: "Artificial Intelligence" adopted
- 1952—69 — Look, Ma, no hands!
- 1950s — Early AI programs, including Samuel's checkers program, Newell & Simon's Logic Theorist, Gelernter's Geometry Engine
- 1965 — Robinson's complete algorithm for logical reasoning
- 1966—73 — AI discovers computational complexity
  Neural network research almost disappears
- 1969—79 — Early development of knowledge-based systems
- 1980-- — AI becomes an industry
- 1986-- — Neural networks return to popularity
- 1987-- — AI becomes a science
- 1995-- — The emergence of intelligent agents

State of the art

- What AI can do today?
- NASA spacecraft landed on another planet, as multiple cameras captured its Perseverance rover touching down on the surface of Mars
- The stunning new image of the shadow of Supermassive black hole in the center of Messier 87 (M87), an elliptical galaxy some 55 million light-years from Earth.
- **Sophia** is a social humanoid robot developed by Hong Kong -based company Hanson Robotics
- No hands across America (driving autonomously 98% of the time from Pittsburgh to San Diego)
- NASA's on-board autonomous planning program controlled the scheduling of operations for a spacecraft

Intelligent Systems in Your Everyday Life

- **game playing**

  Deep Blue defeated the reigning world chess champion Garry Kasparov in 1997

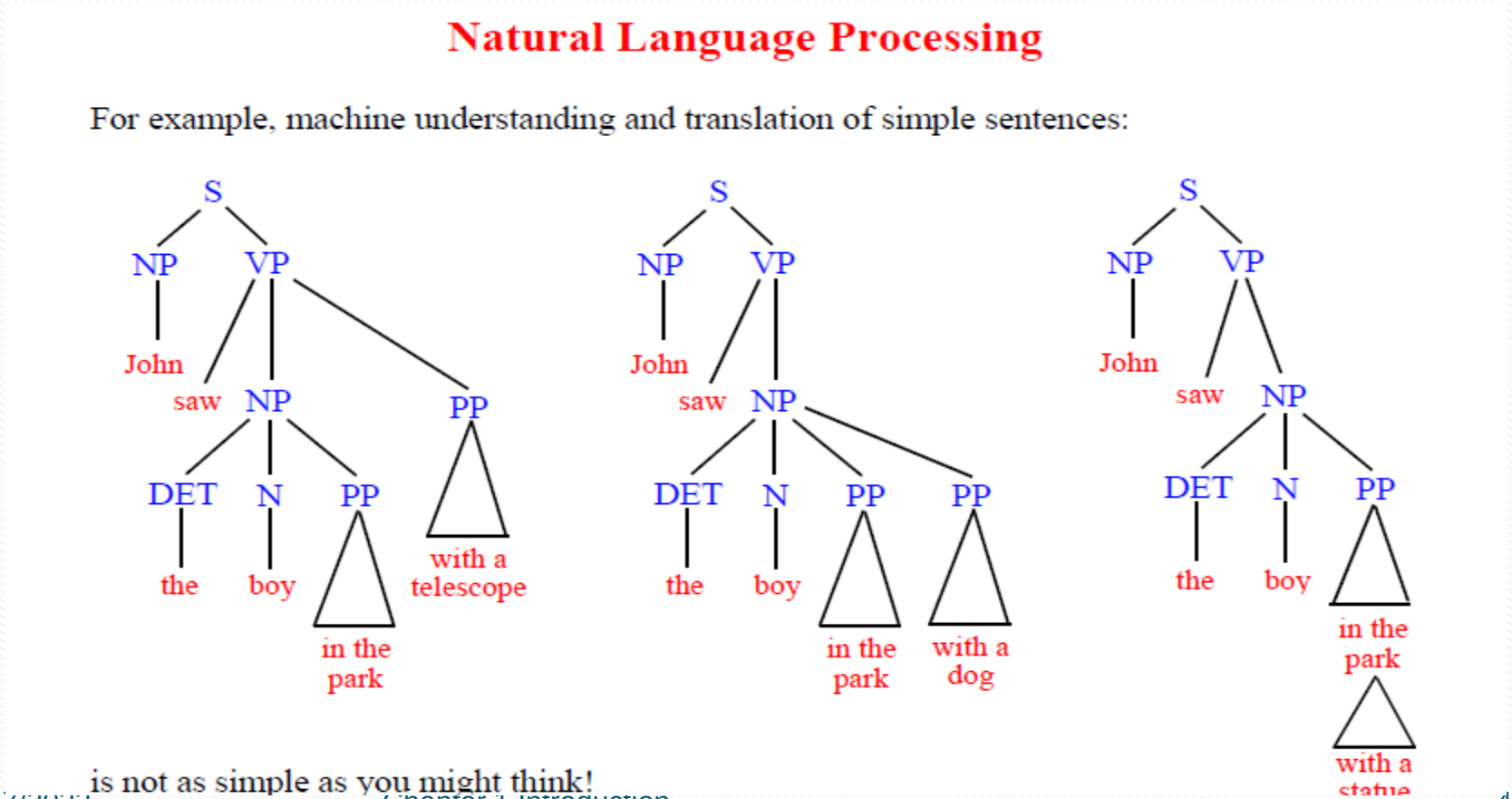
Intelligent Systems in Your Everyday Life

- Speech Interaction
  - speech synthesis
  - speech recognition
  - speech understanding

- Image Pattern Recognition

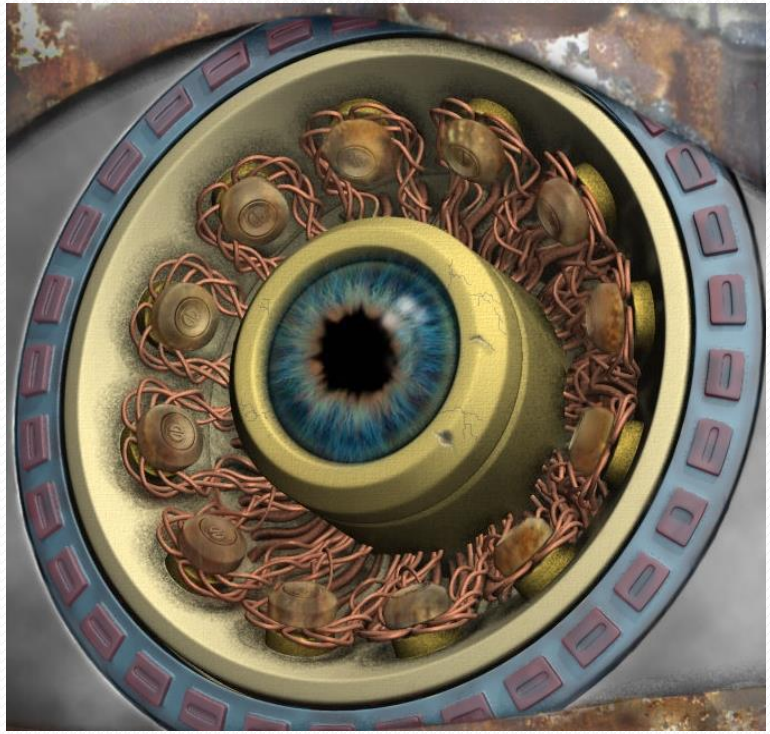
Intelligent Systems in Your Everyday Life

- **understanding natural language**



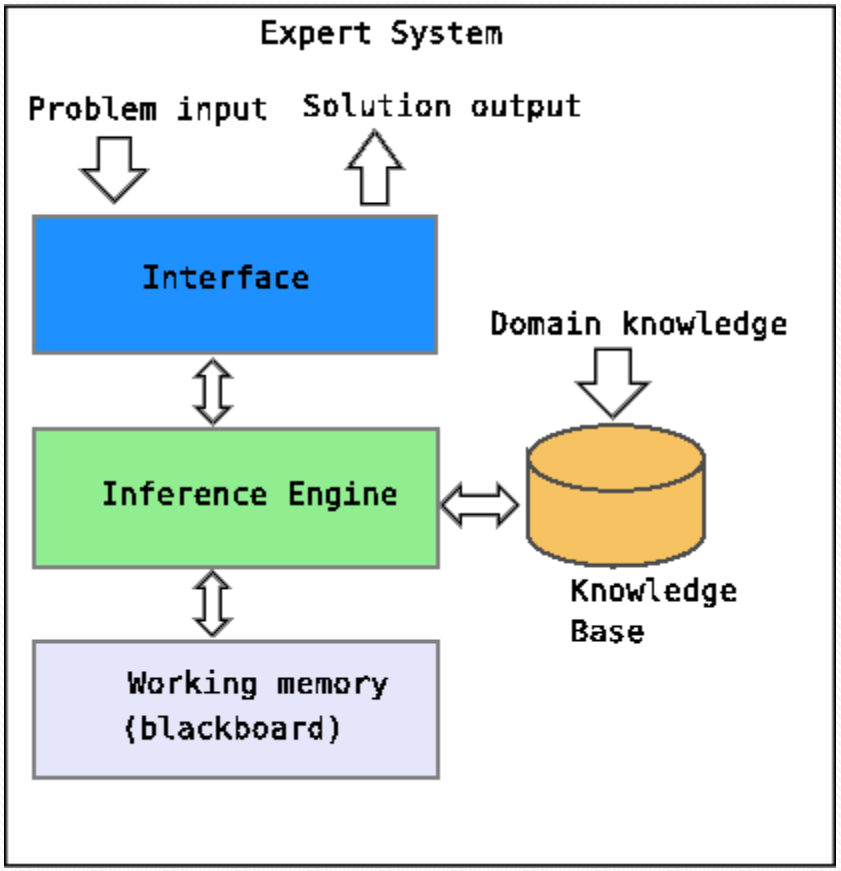
Intelligent Systems in Your Everyday Life

- **computer vision**
- **Camera Face detection**
- **Facebook auto tagging**
- **Mobile Retina locking**



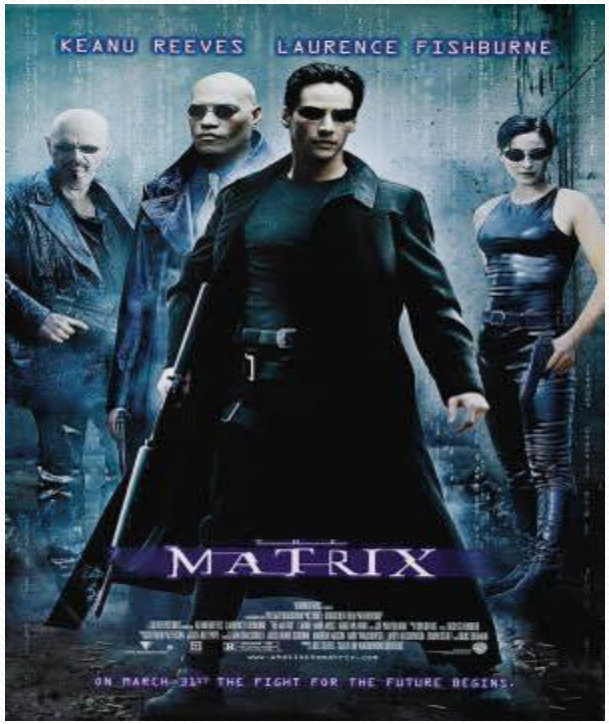
Intelligent Systems in Your Everyday Life

- **expert systems**
  - PXDES
  - Mycin
  - ELIZA
  - Chatbot MGONZ
  - ALICE
  - AGREX



Intelligent Systems in Your Everyday Life

- **Robotics**
- **Entertainment**
- **Movie**



Applications Contd..

- **War**
  - During the 1991 Gulf War, US forces deployed an AI logistics planning and scheduling program that involved up to 50,000 vehicles, cargo, and people

- **Experiments**

- Education
  - ETS has been using GMAT graders program
- Post Office
  - automatic address recognition and sorting of mail
- Banks
  - automatic check readers, signature verification systems
  - automated loan application classification
- Customer Service
  - automatic voice recognition
- The Web
  - Identifying your age, gender, location, from your Web surfing
  - Automated fraud detection
- Digital Cameras
  - Automated face detection and focusing
- Computer Games
  - Intelligent characters/agents

AI Questions

- Can we make something that is as intelligent as a human?
- Can we make something that is as intelligent as a bee?
- Can we make something that is evolutionary, self improving, autonomous, and flexible?
- Can we save this plant $20M/year by pattern recognition?
- Can we save this bank $50M/year by automatic fraud detection?
- Can we start a new industry of handwriting recognition agents?