Welcome to CompSci 171 spring 2007
Introduction to AI.

http://www.ics.uci.edu/~welling/teaching/ICS171spring07/ICS171spring07.html

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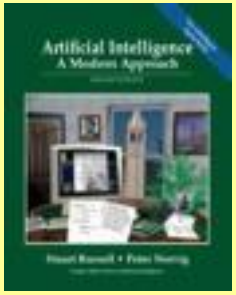
Book: **Artificial Intelligence, A Modern Approach**

Russell & Norvig

Prentice Hall



- ***Grading:***
  -Homework (0%, required)
  -Quizzes (each other week) (20%)
  -One project (20%)
  -A midterm (20%)
  -A Final Exam (40%)

Graded Quizzes/Exams
  -Will be distributed and discussed in class

Grading Disputes:
Turn in your work for regrading at the discussion section to the TA within 1 week.
Note: we will regrade the entire paper: so your new grade could be higher **or** lower.

Course related issues can be addressed in the first 10 minutes of every class.

Academic (Dis)Honesty

- **It is each student's responsibility to be familiar with UCI's current policies on academic honesty**
- **Violations can result in getting an F in the class (or worse)**
- **Please take the time to read the UCI academic honesty policy**
  - in the Fall Quarter schedule of classes
  - or at: *http://www.reg.uci.edu/REGISTRAR/SOC/adh.html*
- **Academic dishonesty is defined as:**
  - Cheating
  - Dishonest conduct
  - Plagiarism
  - Collusion

Syllabus:

Lecture 1. *Introduction:* Goals, history (Ch.1)
Lecture 2. *Agents* (Ch.2)
Lecture 3-4. *Uninformed Search* (Ch.3)
Lecture 5-6 *Informed Search* (Ch.4)
Lecture 7-8. *Constraint satisfaction* (Ch.5). □ Project
Lecture 9-10 *Games* (Ch.6)
Lecture 11. Midterm
Lecture 12-13. *Propositional Logic* (Ch.7)
Lecture 14-15. *First Order Logic* (Ch.8)
Lecture 16-17. *Inference in logic* (Ch.9)
Lecture 18 *Uncertainty* (Ch.13)
Lecture 19. *Philosophical Foundations (*Ch.26).
Lecture 20. *AI Present and Future* (Ch.27).
Final

This is a very rough syllabus. It is almost certainly the case that we will deviate from this. Some chapters will be treated only partially.

Meet HAL

- ***2001: A Space Odyssey***
  - classic science fiction movie from 1969

http://www.youtube.com/watch?v=LE1F7d6f1Qk

- **HAL**
  - part of the story centers around an intelligent computer called HAL
  - HAL is the “brains” of an intelligent spaceship
  - in the movie, HAL can
    - speak easily with the crew
    - see and understand the emotions of the crew
    - navigate the ship automatically
    - diagnose on-board problems
    - make life-and-death decisions
    - display emotions

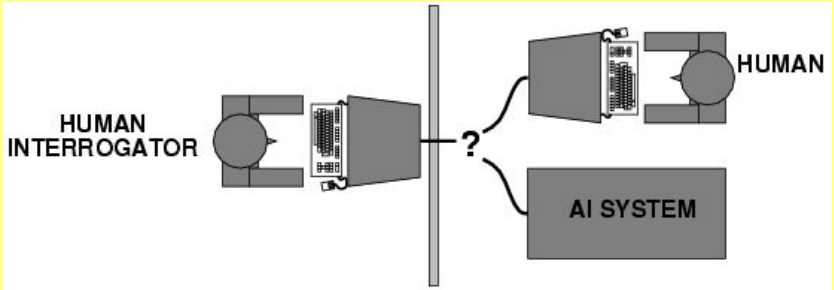
- **In 1969 this was science fiction: is it still science fiction?**

Different Types of Artificial Intelligence

- **Modeling exactly how humans actually think**
  - cognitive models of human reasoning
- **Modeling exactly how humans actually act**
  - models of human behavior (what they do, not how they think)
- **Modeling how ideal agents "should think"**
  - models of "rational" thought (formal logic)
  - note: humans are often not rational!
- **Modeling how ideal agents "should act"**
  - rational actions but not necessarily formal rational reasoning
  - i.e., more of a black-box/engineering approach
- **Modern AI focuses on the last definition**
  - we will also focus on this "engineering" approach
  - success is judged by how well the agent performs
  - -- modern methods are also inspired by cognitive & neuroscience (how people think).

Acting humanly: Turing Test

- Turing (1950) "Computing machinery and intelligence":
- "Can machines think?" □ "Can machines behave intelligently?"
- Operational test for intelligent behavior: the Imitation Game



- Suggested major components of AI:
  - knowledge representation
  - reasoning,
  - language/image understanding,
  - learning

Can you think of a theoretical system that could beat the Turing test yet you wouldn't find it very intelligent?

Acting rationally: rational agent

- **Rational behavior: Doing that was is expected to maximize one's "utility function" in this world.**

- **An agent is an entity that perceives and acts.**
- **A rational agent acts rationally.**

- **This course is about designing rational agents**

- **Abstractly, an agent is a function from percept histories to actions:**

$$[f: \mathcal{P}^* \rightarrow \mathcal{A}]$$

- **For any given class of environments and tasks, we seek the agent (or class of agents) with the best performance**

- **Caveat: computational limitations make perfect rationality unachievable**
  - design best program for given machine resources

Academic Disciplines important to AI.

- **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, rational economic agents
- **Neuroscience** neurons as information processing units.
- **Psychology/ Cognitive Science** how do people behave, perceive, process information, represent knowledge.
- **Computer engineering** building fast computers
- **Control theory** design systems that maximize an objective function over time
- **Linguistics** knowledge representation, grammar

History of AI

- 1943 McCulloch & Pitts: Boolean circuit model of brain
- 1950 Turing's "Computing Machinery and Intelligence"
- 1956 Dartmouth meeting: "Artificial Intelligence" adopted
- 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

- Deep Blue defeated the reigning world chess champion Garry Kasparov in 1997
- Proved a mathematical conjecture (Robbins conjecture) unsolved for decades
- No hands across America (driving autonomously 98% of the time from Pittsburgh to San Diego)
- 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
- NASA's on-board autonomous planning program controlled the scheduling of operations for a spacecraft
- `Proverb` solves crossword puzzles better than most humans
- Stanford vehicle in Darpa challenge completed autonomously a 132 mile desert track in 6 hours 32 minutes.

Consider what might be involved in building a "intelligent" computer….

- **What are the "components" that might be useful?**
  - Fast hardware?
  - Foolproof software?
  - Chess-playing at grandmaster level?
  - Speech interaction?
    - speech synthesis
    - speech recognition
    - speech understanding
  - Image recognition and understanding ?
  - Learning?
  - Planning and decision-making?

Can we build hardware as complex as the brain?

- **How complicated is our brain?**
  - a neuron, or nerve cell, is the basic information processing unit
  - estimated to be on the order of 10^{11} neurons in a human brain
  - many more synapses (10^{14}) connecting these neurons
  - cycle time: 10^{-3} seconds (1 millisecond)

- **How complex can we make computers?**
  - 10^6 or more transistors per CPU
  - supercomputer: hundreds of CPUs, 10^9 bits of RAM
  - cycle times: order of 10^{-8} seconds

- **Conclusion**
  - **YES**: in the near future we can have computers with as many basic processing elements as our brain, but with
    - far fewer interconnections (wires or synapses) than the brain
    - much faster updates than the brain
  - **but** building hardware is very different from making a computer behave like a brain!

Must an Intelligent System be Foolproof?

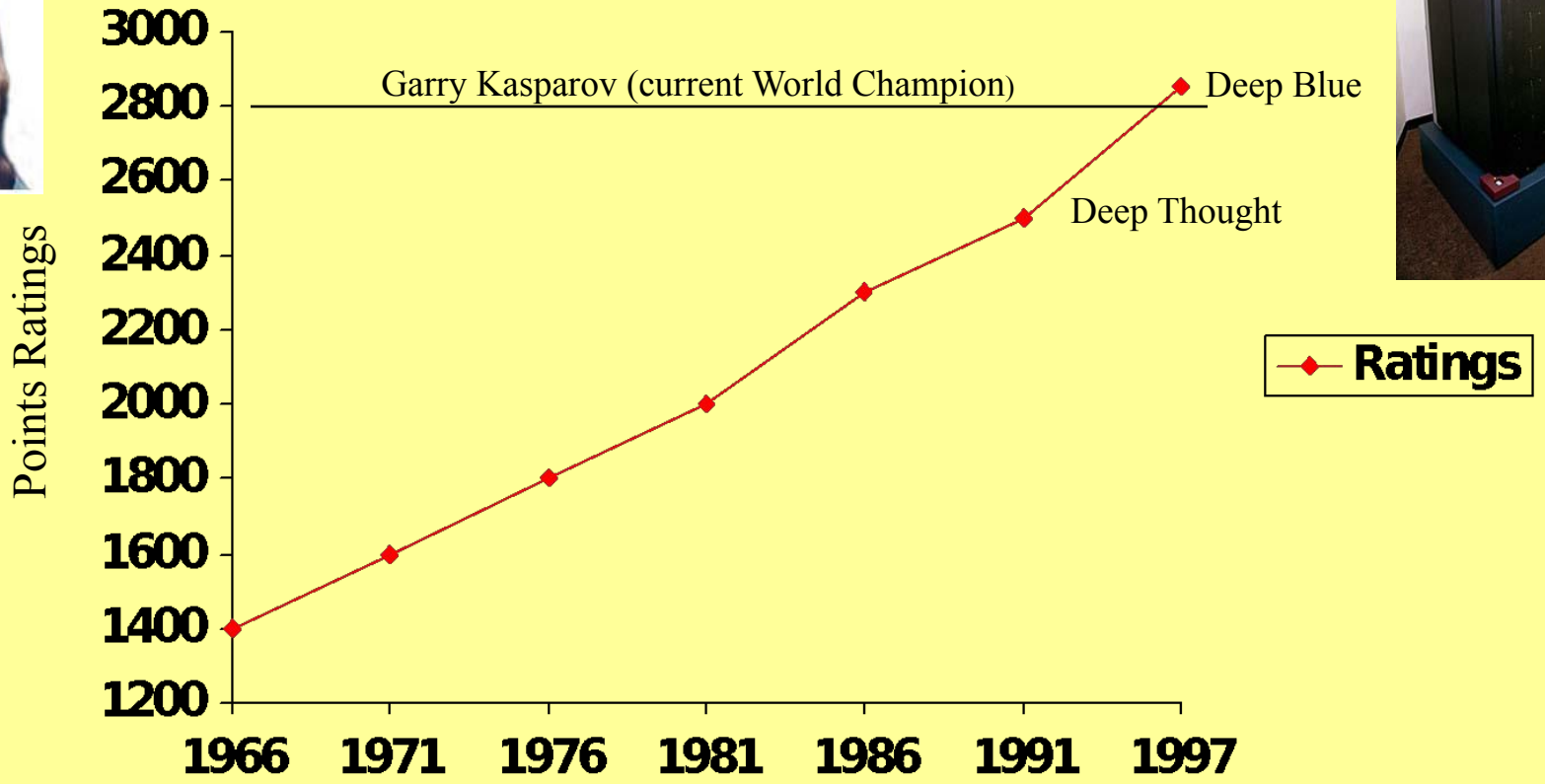
- **A "foolproof" system is one that never makes an error:**
  - Types of possible computer errors
    - hardware errors, e.g., memory errors
    - software errors, e.g., coding bugs
    - "human-like" errors
  - Clearly, hardware and software errors are possible in practice
  - what about "human-like" errors?

- **An intelligent system can make errors and still be intelligent**
  - humans are not right all of the time
  - we learn and adapt from making mistakes
    - e.g., consider learning to surf or ski
      - we improve by taking risks and falling
      - an intelligent system can learn in the same way

- **Conclusion:**
  - **NO**: intelligent systems will not (and need not) be foolproof

Can Computers play Humans at Chess?

- **Chess Playing is a classic AI problem**
  - well-defined problem
  - very complex: difficult for humans to play well



- **Conclusion: YES:** today's computers can beat even the best human

Can Computers Talk?

- **This is known as "speech synthesis"**
  - translate text to phonetic form
    - e.g., "fictitious" -> fik-tish-es
  - use pronunciation rules to map phonemes to actual sound
    - e.g., "tish" -> sequence of basic audio sounds

- **Difficulties**
  - sounds made by this "lookup" approach sound unnatural
  - sounds are not independent
    - e.g., "act" and "action"
    - modern systems (e.g., at AT&T) can handle this pretty well
  - a harder problem is emphasis, emotion, etc
    - humans understand what they are saying
    - machines don't: so they sound unnatural

- **Conclusion: NO,** for complete sentences, but YES for individual words

Can Computers Recognize Speech?

- **Speech Recognition:**
  - mapping sounds from a microphone into a list of words.
  - Hard problem: noise, more than one person talking, occlusion, speech variability,..
  - Even if we recognize each word, we may not understand its meaning.

- **Recognizing single words from a small vocabulary**
  - systems can do this with high accuracy (order of 99%)
  - e.g., directory inquiries
    - limited vocabulary (area codes, city names)
    - computer tries to recognize you first, if unsuccessful hands you over to a human operator
    - saves millions of dollars a year for the phone companies

Recognizing human speech (ctd.)

- **Recognizing normal speech is much more difficult**
  - speech is continuous: where are the boundaries between words?
    - e.g., “John’s car has a flat tire”
  - large vocabularies
    - can be many tens of thousands of possible words
    - we can use **context** to help figure out what someone said
      - try telling a waiter in a restaurant:
        “I would like some dream and sugar in my coffee”
  - background noise, other speakers, accents, colds, etc
  - on normal speech, modern systems are only about 60% accurate

- **Conclusion: NO,** normal speech is too complex to accurately recognize, but **YES** for restricted problems
  - (e.g., recent software for PC use by IBM, Dragon systems, etc)

Can Computers Understand speech?

- **Understanding is different to recognition:**
  - "Time flies like an arrow"
    - assume the computer can recognize all the words
    - but how could it understand it?
      - 1. time passes quickly like an arrow?
      - 2. command: time the flies the way an arrow times the flies
      - 3. command: only time those flies which are like an arrow
      - 4. "time-flies" are fond of arrows
    - only 1. makes any sense, but how could a computer figure this out?
      - clearly humans use a lot of implicit commonsense knowledge in communication

- **Conclusion: NO,** much of what we say is beyond the capabilities of a computer to understand at present

Can Computers Learn and Adapt ?

- **Learning and Adaptation**
  - consider a computer learning to drive on the freeway
  - we could code lots of rules about what to do
  - and/or we could have it learn from experience

Darpa's Grand Challenge. Stanford's "Stanley" drove 150 without supervision in the Majove dessert

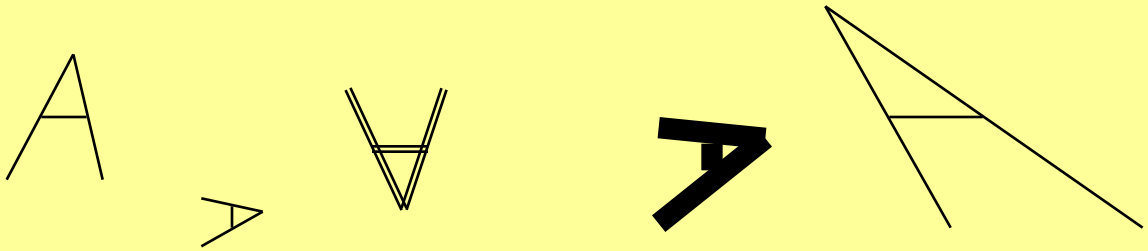
  - **machine learning** allows computers to learn to do things without explicit programming

- **Conclusion: YES,** computers can learn and adapt, when presented with information in the appropriate way

Can Computers "see"?

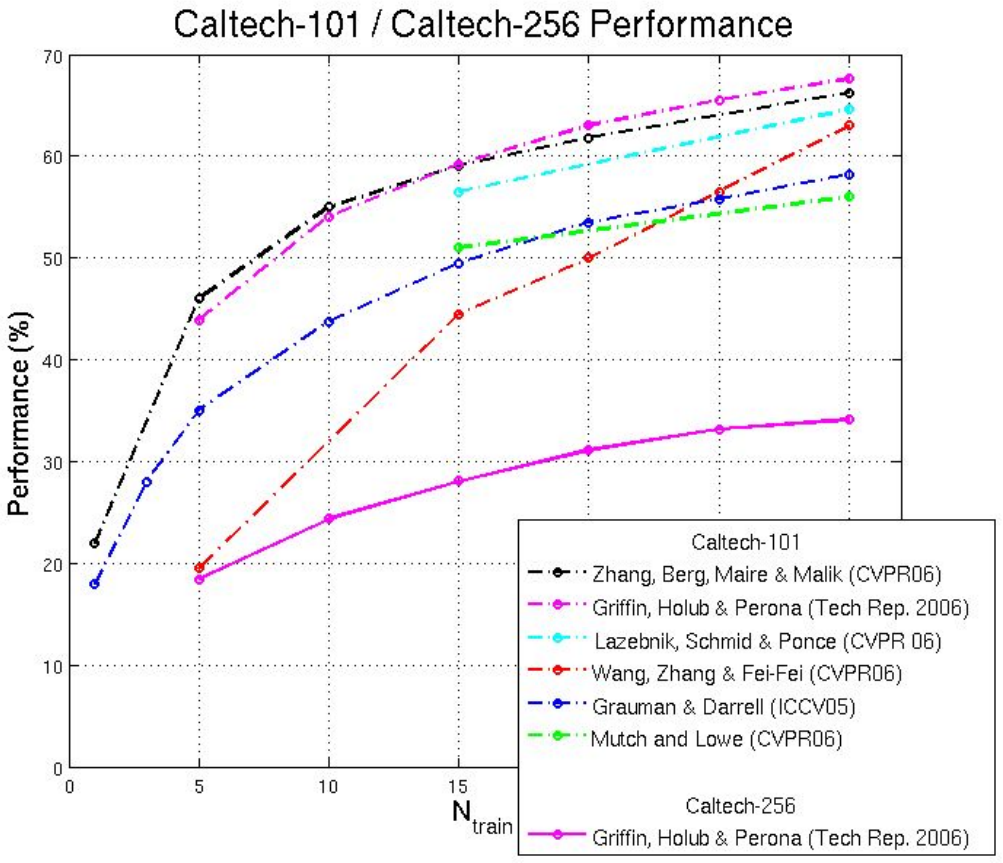
- **Recognition v. Understanding (like Speech)**
  - Recognition and Understanding of Objects in a scene
    - look around this room
    - you can effortlessly recognize objects
    - human brain can map 2d visual image to 3d "map"

- **Why is visual recognition a hard problem?**



- **Conclusion: mostly NO:** computers can only "see" certain types of objects under limited circumstances: but **YES** for certain constrained problems (e.g., face recognition)

In the computer vision community research compete to improve recognition performance on standard datasets



Can Computers plan and make decisions?

- **Intelligence**
  - involves solving problems and making decisions and plans
  - e.g., you want to visit your cousin in Boston
    - you need to decide on dates, flights
    - you need to get to the airport, etc
    - involves a sequence of decisions, plans, and actions

- **What makes planning hard?**
  - the world is not predictable:
    - your flight is canceled or there's a backup on the 405
  - there is a potentially huge number of details
    - do you consider all flights? all dates?
      - no: commonsense constrains your solutions
  - AI systems are only successful in constrained planning problems

- **Conclusion: NO,** real-world planning and decision-making is still beyond the capabilities of modern computers
  - exception: very well-defined, constrained problems: mission planning for satelites.

Intelligent Systems in Your Everyday Life

- **Post Office**
  - automatic address recognition and sorting of mail
- **Banks**
  - automatic check readers, signature verification systems
  - automated loan application classification
- **Telephone Companies**
  - automatic voice recognition for directory inquiries
- **Credit Card Companies**
  - automated fraud detection
- **Computer Companies**
  - automated diagnosis for help-desk applications
- **Netflix:**
  - movie recommendation
- **Google:**
  - Search Technology

AI Applications: Consumer Marketing

- Have you ever used any kind of credit/ATM/store card while shopping?
  - if so, you have very likely been "input" to an AI algorithm
- All of this information is recorded digitally
- Companies like Nielsen gather this information weekly and search for patterns
  - general changes in consumer behavior
  - tracking responses to new products
  - identifying customer segments: targeted marketing, e.g., they find out that consumers with sports cars who buy textbooks respond well to offers of new credit cards.
  - Currently a very hot area in marketing

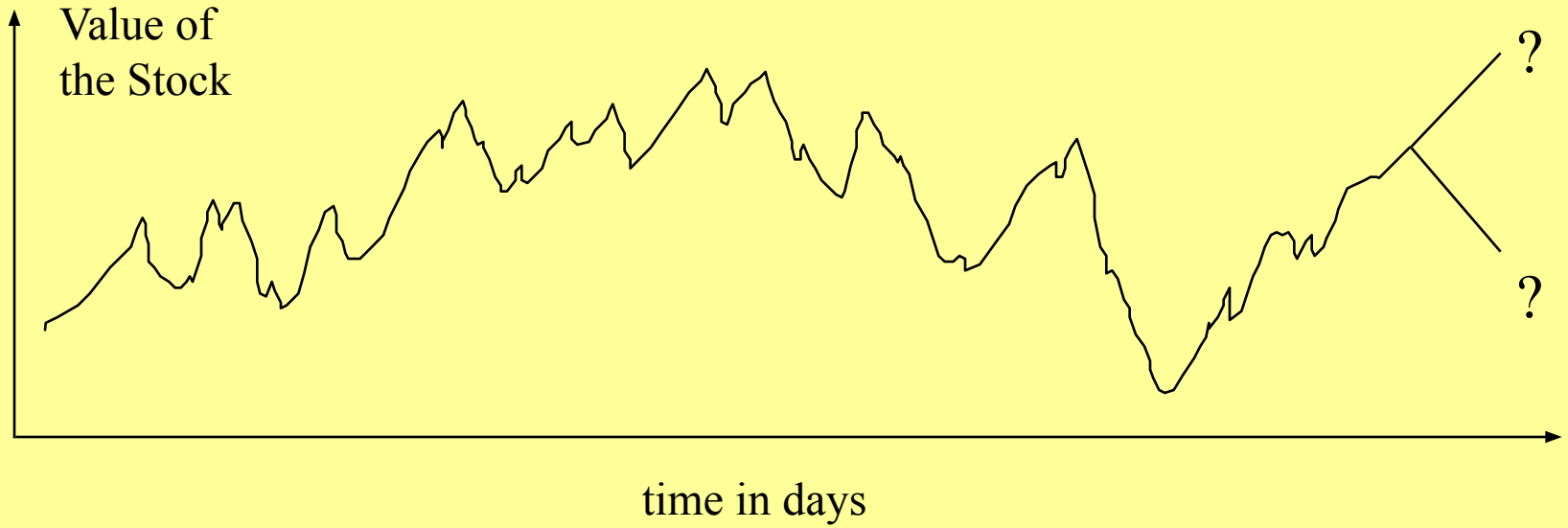
- **How do they do this?**
  - Algorithms ("data mining") search data for patterns
  - based on mathematical theories of learning
  - completely impractical to do manually

AI Applications: Identification Technologies

- **ID cards**
  - e.g., ATM cards
  - can be a nuisance and security risk:
    - cards can be lost, stolen, passwords forgotten, etc

- **Biometric Identification**
  - walk up to a locked door
    - camera
    - fingerprint device
    - microphone
    - iris scan
  - computer uses your biometric signature for identification
    - face, eyes, fingerprints, voice pattern, iris pattern

AI Applications: Predicting the Stock Market



- **The Prediction Problem**
  - given the past, predict the future
  - very difficult problem!
  - we can use learning algorithms to learn a predictive model from historical data
    - `prob(increase at day t+1 | values at day t, t-1,t-2....,t-k)`
  - such models are routinely used by banks and financial traders to manage portfolios worth millions of dollars

AI-Applications: Machine Translation

- **Language problems in international business**
  - e.g., at a meeting of Japanese, Korean, Vietnamese and Swedish investors, no common language
  - or: you are shipping your software manuals to 127 countries
  - solution; hire translators to translate
  - would be much cheaper if a machine could do this!

- **How hard is automated translation**
  - very difficult!
  - e.g., English to Russian
    - "The spirit is willing but the flesh is weak" (English)
    - "the vodka is good but the meat is rotten" (Russian)
  - not only must the words be translated, but their meaning also!

- **Nonetheless....**
  - commercial systems can do alot of the work very well (e.g.,restricted vocabularies in software documentation)
  - algorithms which combine dictionaries, grammar models, etc.
  - see for example babelfish.altavista.com

Summary of Today's Lecture

- **Artificial Intelligence involves the study of:**
  - automated recognition and understanding of speech, images, etc
  - learning and adaptation
  - reasoning, planning, and decision-making

- **AI has made substantial progress in**
  - recognition and learning
  - some planning and reasoning problems

- **AI Applications**
  - improvements in hardware and algorithms => AI applications in industry, finance, medicine, and science.

- **AI Research**
  - many problems still unsolved: AI is a fun research area!

- **Assigned Reading**
  - Chapter 1 in the text