Artificial Intelligence

By Asif Rajput

Administrivia

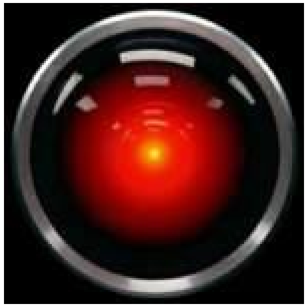
- **Email: asifali@iba-suk.edu.pk**
- **Contact Hours:**
  - Monday 3-4PM
  - Tuesday 2-4PM
  - (or by prior email, otherwise **wait for next week!**)
  - **NO contact via phone or whatsapp** (except for CR) (this includes facebook as well)
- 2x Assignments (will be checked for plagiarism and no extension of deadline etc will be allowed)
- 4x Quizzes (No reschedules will be allowed)

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



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

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

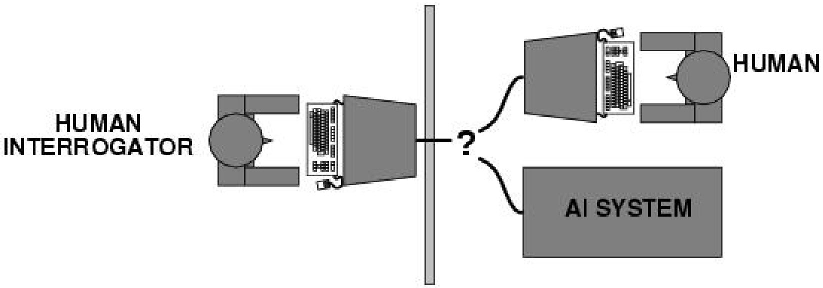
- **Modeling how ideal agents "should think"**
  - models of "rational" thought (formal logic)
  - note: humans are often not rational!

- **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*: P* → 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?

- 106 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?

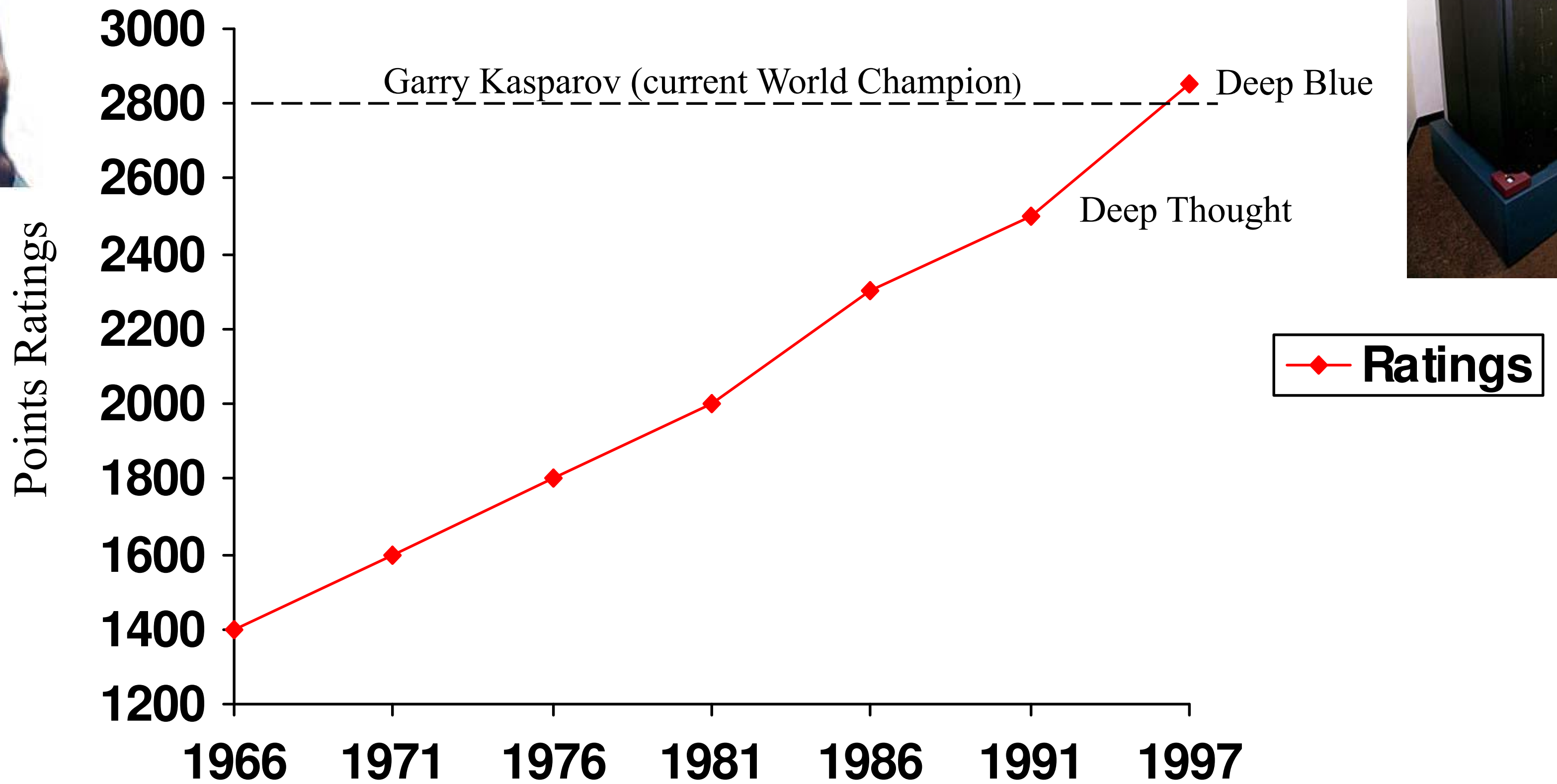
- **An intelligent system can make errors and still be intelligent**
  - humans are not right all of the time
  - we learn and adapt from making mistakes
    - e.g., consider learning to surf or ski
      - we improve by taking risks and falling
      - an intelligent system can learn in the same way

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

https://www.youtube.com/watch?time_continue=1&v=RASBcc4yOOo&feature=emb_title

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

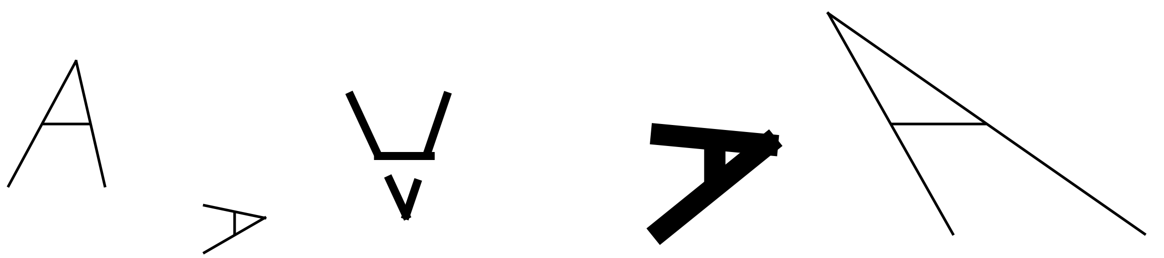
  - **machine learning** allows computers to learn to do things without explicit programming

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

Can Computers "see"?

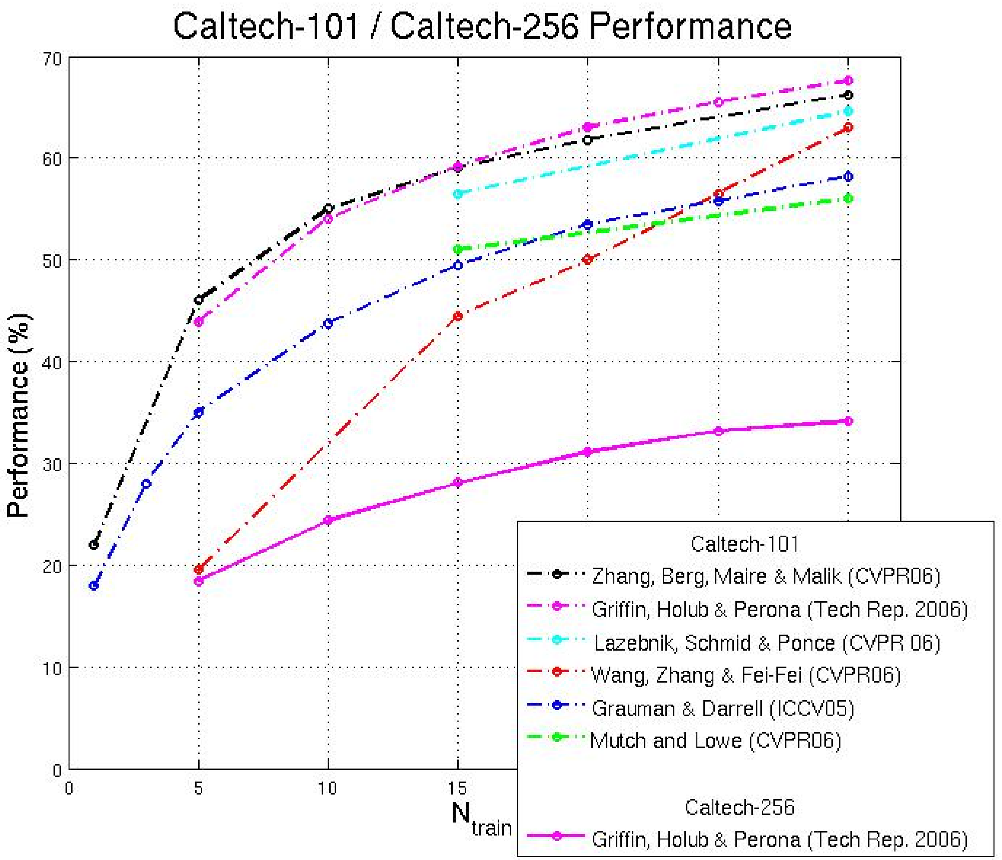
- **Recognition v. Understanding (like Speech)**
  - Recognition and Understanding of Objects in a scene
- look around this room
- you can effortlessly recognize objects
- human brain can map 2d visual image to 3d "map"

- **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

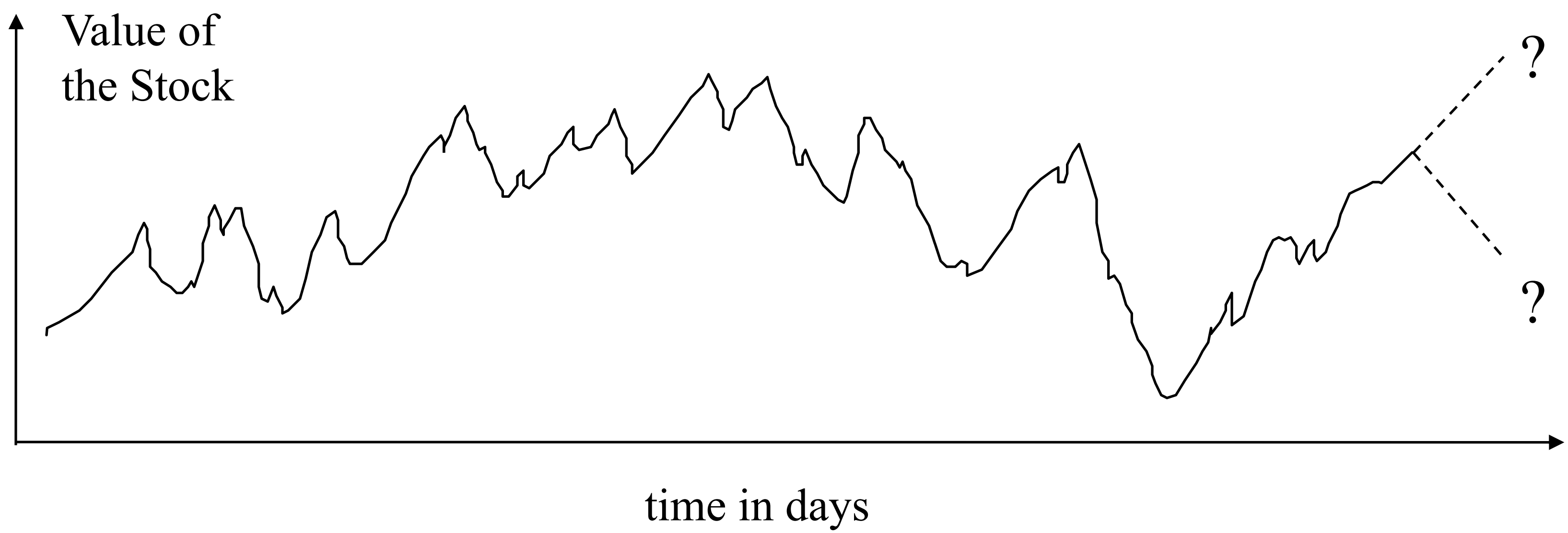
- **How do they do this?**
  - Algorithms (“data mining”) search data for patterns
  - based on mathematical theories of learning
  - completely impractical to do manually

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