# Artificial Intelligence
# CSE 573

Mausam

(Based on Slides by Stuart Russell, Henry Kautz, and UW-AI faculty)

# Logistics

- Instructor: Mausam, CSE 454, mausam@cs.washington.edu
- TA: Janara Christensen, janara@cs.washington.edu
- Course Website: www.cs.washington.edu/573
- Join class mailing list (instructions on website)
- Text: Artificial Intelligence: A Modern Approach (3rd edition), Russell and Norvig
- One project = two programming assignments
- Grading:
  - 50% programming assignments
  - 10% short written assignments
  - 30% final
  - 10% class/mailing list participation

# Goals of this course

- A brief intro to the philosophy of AI
- A brief intro to the breadth of ideas in AI

- General computer scientist
  - general tools to aid in attacking a new problem

- Serious AI enthusiast
  - A primer from which to launch advanced study

# Science of AI

Physics: Where did the ***physical universe*** come from?
And what laws guide its dynamics?

Biology: How did ***biological life*** evolve?
And how do living organisms function?

AI: What is the nature of ***intelligent thought?***

# AI as Engineering

- How can we make software systems more powerful and easier to use?
  - Speech & intelligent user interfaces
  - Autonomic computing
  - Mobile robots, softbots & immobots
  - Data mining
  - Medical expert systems
  - …

# What is intelligence?

- Dictionary.com: *capacity for learning, reasoning, understanding, and similar forms of mental activity*

- Ability to perceive and act in the world
- Reasoning: proving theorems, medical diagnosis
- Planning: take decisions
- Learning and Adaptation: recommend movies, learn traffic patterns
- Understanding: text, speech, visual scene

# Intelligence vs. humans

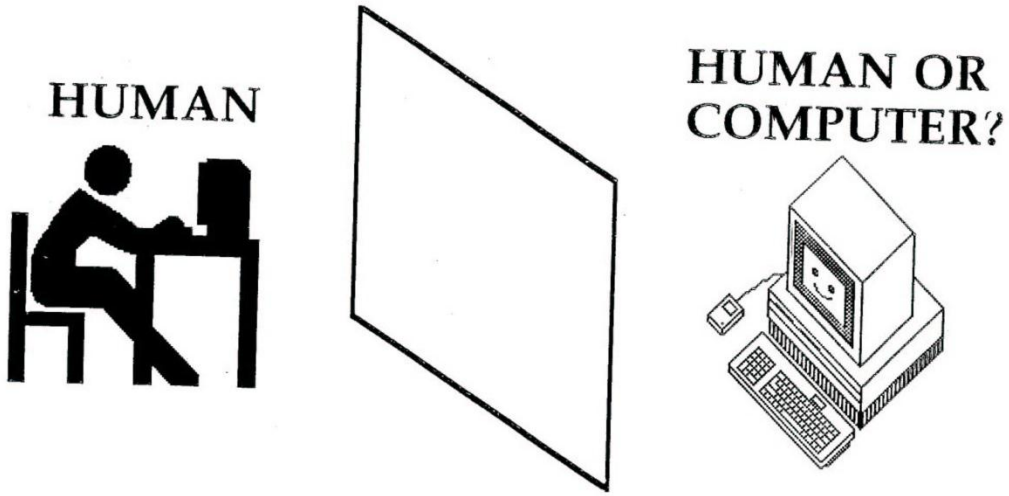
- Are humans intelligent?
- Are humans rational?
- Can non-human behavior be intelligent?

# What is *artificial* intelligence?

| thought *vs.* behavior \ human-like *vs.* rational | human-like *vs.* rational |
|---|---|
| thought | Systems that think like humans | Systems that think rationally |
| behavior | Systems that act like humans | Systems that act rationally |

# Turing's Test

- If the human cannot tell whether the responses from the other side of a wall are coming from a human or computer, then the computer is intelligent.



# What is *artificial* intelligence (agent view)

- An agent is anything that can be viewed as perceiving its environment through sensors and acting upon that environment through actuators

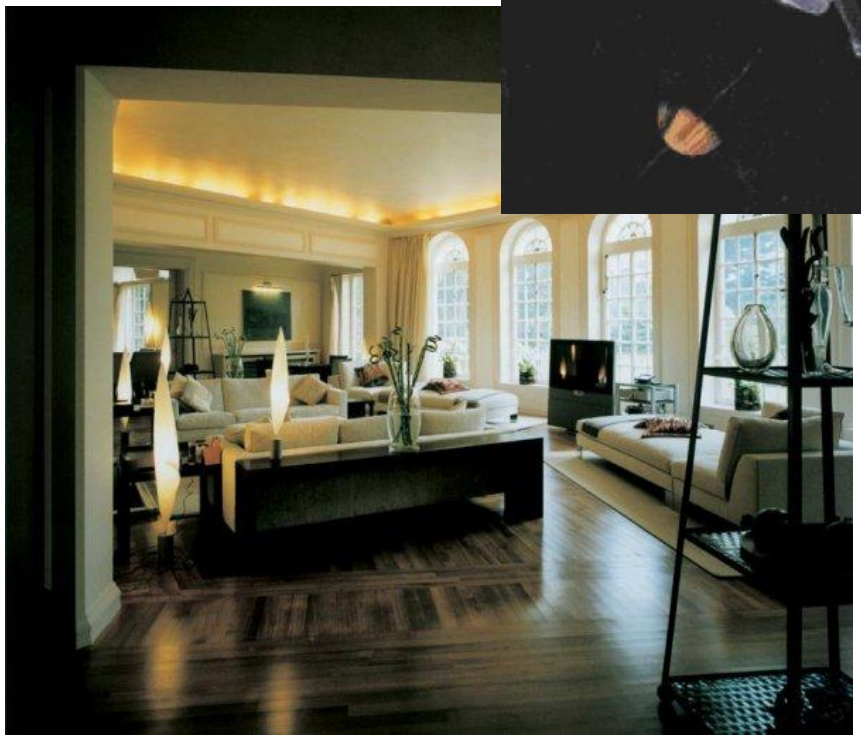
- Human agent:
  - eyes, ears, and other organs for sensors
  - hands, legs, mouth, and other body parts for actuators

- Robotic agent:
  - cameras and laser range finders for sensors
  - various motors for actuators

- We will revisit this view in detail later in the course

# Examples of Agents

- Robots
- Intelligent buildings
- Autonomous spacecraft
- Web agents



# What is *artificial* intelligence (algorithmic view)

- A large number of problems are NP hard

- AI develops a set of tools, heuristics, …
  - to solve such problems in practice
  - for naturally occurring instances

- Search
- Game Playing
- Planning
- …

# Examples: Mundane Tasks

- Perception
  - Vision
  - Speech
- Natural Language
  - Understanding
  - Generation
  - Translation
- Reasoning
- Robot Control

# Examples: Formal Tasks

- Games
  - Chess
  - Checkers
  - Othello
- Mathematics
  - Logic
  - Geometry
  - Calculus
  - Proving properties of programs

# Examples: Expert Tasks

- Engineering
  - Design
  - Fault Finding
  - Manufacturing planning
- Medical
  - Diagnosis
  - Medical Image Analysis
- Financial
  - Stock market predictions

# Recurrent Themes

- Logic *vs.* Probability
  - In 1950's, logic dominates (McCarthy, …
    - attempts to extend logic
  - 1988 – Bayesian networks (Pearl)
    - efficient computational framework
  - Today, no longer rivals
    - Hot topic: combining probability & FOL

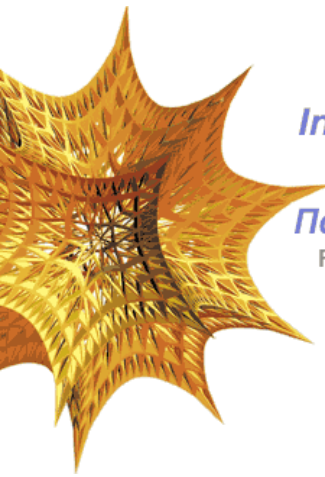
# Recurrent Themes

- Weak *vs.* Strong Methods
  - Weak – general search methods (e.g., A* search)
    - primarily for problem solving
    - not motivated by achieving human-level performance
  - Strong -- knowledge intensive (e.g., expert systems)
    - more knowledge $\Rightarrow$ less computation
    - achieve better performance in specific tasks
  - How to combine weak & strong methods seamlessly?

# Recurrent Themes

- Knowledge Representation
  - "In knowledge lies the power"
  - Feature engineering in Machine Learning
  - Reformulation
- Combinatorial Explosion
- Micro-world successes are hard to scale up.
- How to organize and accumulate large amounts of knowledge?

# Mathematical Calculation




$$\partial_r^2 u = -\left[E' - \frac{l(l+1)}{r^2} - r^2\right] u(r)$$

$$e^{-2s}\left(\partial_s^2 - \partial_s\right) u(s) = -\left[E' - l(l+1)e^{-2s} - e^{2s}\right] u(s)$$

$$e^{-2s}\left[e^{\frac{1}{2}s}\left(e^{-\frac{1}{2}s}u(s)\right)'' - \frac{1}{4}u\right] = -\left[E' - l(l+1)e^{-2s} - e^{2s}\right] u(s)$$

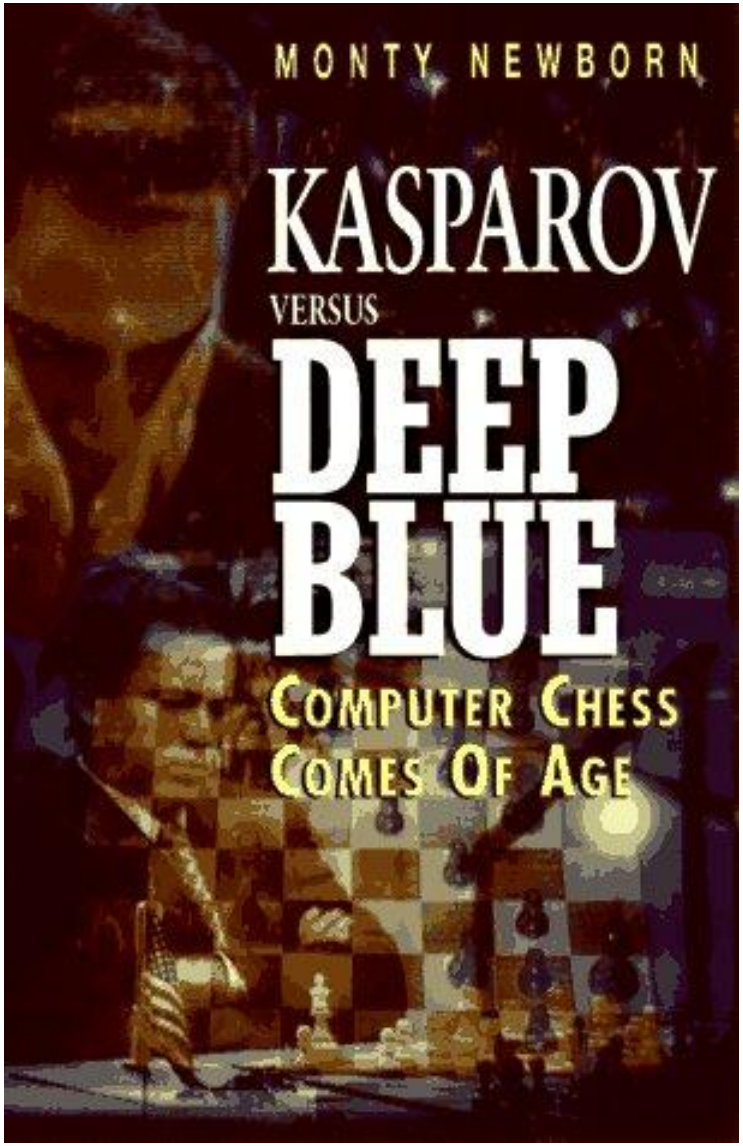
$$e^{-2s}\left[e^{\frac{1}{2}s}\left(e^{-\frac{1}{2}s}u(s)\right)''\right] = -\left[E' - \left(l+\frac{1}{2}\right)^2 e^{-2s} - e^{2s}\right] u(s)$$

$$v'' = -e^{2s}\left[E' - \left(l+\frac{1}{2}\right)^2 e^{-2s} - e^{2s}\right] v$$

# Success Story: Chess

"I could feel – I could smell – a new kind of intelligence across the table"

-Gary Kasparov




Saying Deep Blue doesn't really think about chess is like saying an airplane doesn't really fly because it doesn't flap its wings.

– Drew McDermott

# Speech Recognition

# Autonomous Systems

- In the 1990's there was a growing concern that work in classical AI ignored crucial scientific questions:
  - How do we integrate the components of intelligence (*e.g.* learning & planning)?
  - How does perception interact with reasoning?
  - How does the demand for real-time performance in a complex, changing environment affect the architecture of intelligence?


- Provide a standard problem where a wide range of technologies can be integrated and examined
- By 2050, develop a team of fully autonomous humanoid robots that can win against the human world champion team in soccer.


http://www.youtube.com/watch?v=Cv7333wHFMM

# DARPA Urban Challenge: 11/2007

# Success Story: Stanley


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

# Software Robots (softbots)

- Softbots: 'intelligent' program that uses software tools on a person's behalf.

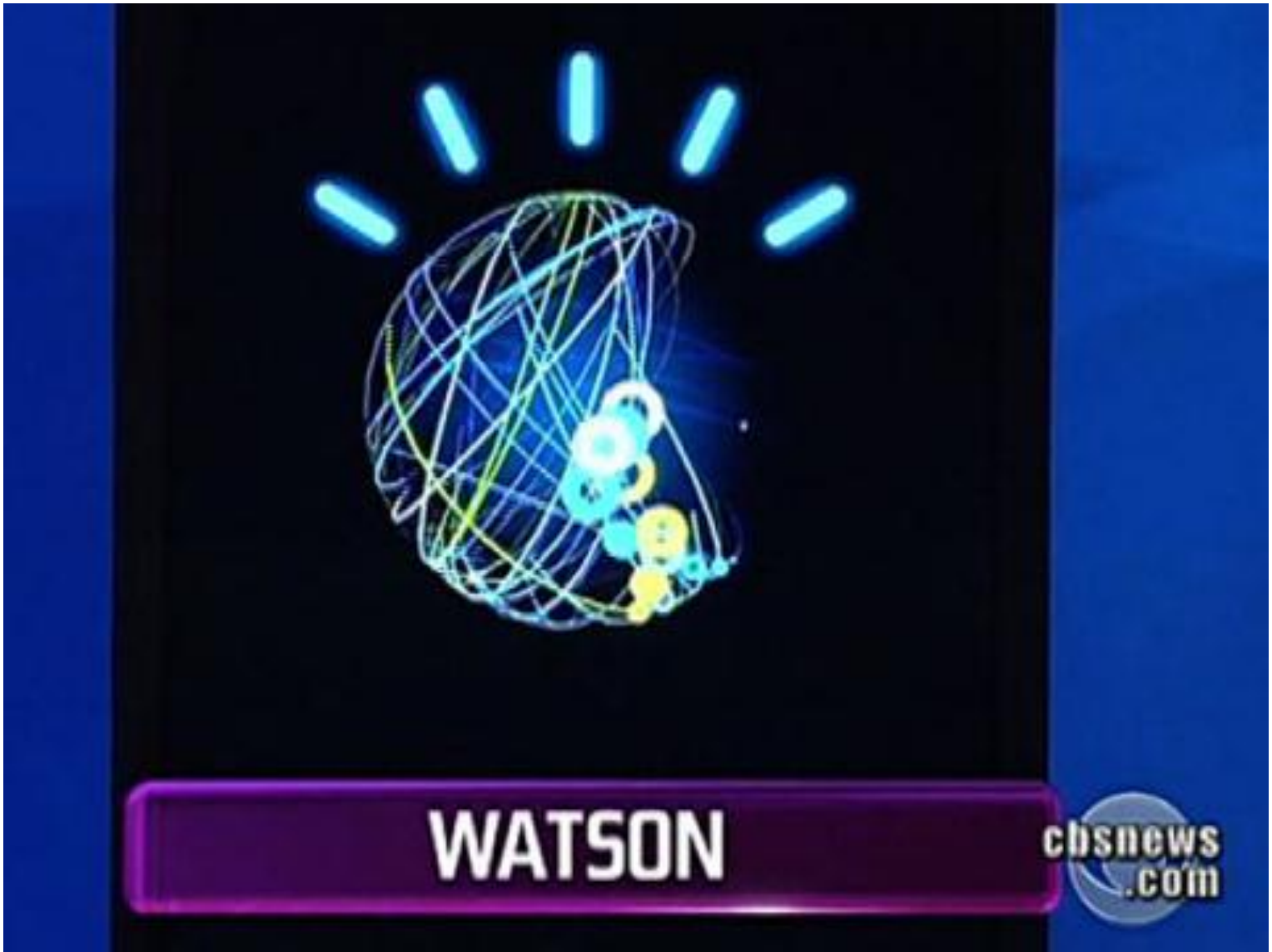
- Sensors = LS, Google, etc.
- Effectors = ftp, Amazon.com

- Software: not physical but not simulated.

# 2004 & 2009

# Europa Mission ~ 2018

# Recentmost Success 2011



# Limits of AI Today

- Most of today's successful AI systems
  - operate in well-defined domains
  - employ narrow, specialized knowledge

- *Exceptions:*
  - *Watson???*
  - *Self-driving cars???*

- *Commonsense Knowledge*
  - needed in complex, open-ended worlds
    - Your kitchen vs. GM factory floor
  - understand unconstrained natural language

# Role of Knowledge in Natural Language Understanding

- WWW Information Extraction
- Speech Recognition
  - "word spotting" feasible today
  - continuous speech – rapid progress
- Translation / Understanding
  - limited progress

  ***The spirit is willing but the flesh is weak.*** ***(English)***

  ***The vodka is good but the meat is rotten.*** ***(Russian)***

# How the heck do *we* understand?

- John gave Pete a book.
- John gave Pete a hard time.
- John gave Pete a black eye.
- John gave in.
- John gave up.
- John's legs gave out beneath him.
- It is 300 miles, give or take 10.

# How to Get Commonsense?

- CYC Project (Doug Lenat, Cycorp)
  - Encoding 1,000,000 commonsense facts about the world by hand
  - Coverage still too spotty for use!

- Machine Learning
- Open Mind
- Mining from Wikipedia & the Web

# Topics of this Course

- Breadth
  - Search
  - Planning
  - Constraint Satisfaction
  - Logic
  - Uncertainty
  - Machine Learning
- Depth
  - UCT algorithm for decision making under uncertainty
  - Submodular functions for combinatorial optimization
  - Constraint Optimization for Scheduling
  - Text Analysis for Clustering

# 2 Mini-Projects = 1 Project

- Goal: to assist all conference organizers
  - Lot of papers are accepted
  - There are many parallel tracks
  - There are many scheduling constraints
  - Some schedules are better for the conference
    - More coherent sessions
    - Less conflicts in parallel sessions
    - Match all individual constraints

- http://www.aaai.org/Conferences/AAAI/2011/aaai11program.pdf

# Project (contd).