CS0302 - Artificial Intelligence & Expert Systems

R.Rajkumar

AP / CSE

SRM University

CS0302 - Artificial Intelligence & Expert Systems

Required Text Books:

1.Elaine Rich, "*Artificial Intelligence*", 2nd Edition, McGraw Hill, 2005

2. Dan W.Patterson, "*Introduction to AI and ES*", Pearson Education, 2007

- **REFERENCE BOOKS**
- 1.Peter Jackson, "*Introduction to Expert Systems*", 3rd Edition, Pearson Education, 2007
- 2.Stuart Russel, Peter Norvig "*AI - A Modern Approach*", 2nd Edition, Pearson Education 2007

Objectives

- 1.To study the concepts of Artificial Intelligence
- 2.Methods of solving problems using Artificial Intelligence
- 3.Introduce the concepts of Expert Systems and machine learning

Prerequisite :

- Remember CS0202 – Principles of Programming Languages
- Common sense

Assessment Details

• Cycle Test – I	:	10Marks
• Surprise Test – I	:	5 Marks
• Cycle Test – II	:	10Marks
• Model Exam	:	20 Marks
• Attendance	:	5 Marks

Outcomes

- Who have successfully completed this course will have full understanding of the following concepts
- 1. Various Ideas in AI
- 2. Various Types of Expert systems

  & High Grade in Exam

Introduction to AI

Introduction to Intelligence

What is Intelligence?

- Intelligence:
  - "the capacity to learn and solve problems" (Websters dictionary)
  - in particular,
    - *the ability to solve novel problems*
    - *the ability to act rationally*
    - *the ability to act like humans*

- Artificial Intelligence
  - build and understand intelligent entities or agents
  - 2 main approaches: "engineering" versus "cognitive modeling"

What is Artificial Intelligence?

R.Rajkumar notes

- **What is artificial intelligence?**

  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.

- **Yes, but what is intelligence?**

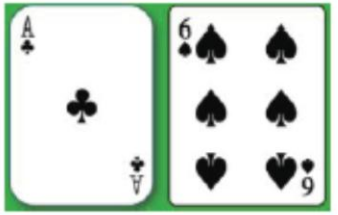
  Intelligence is the computational part of the ability to achieve goals in the world. Varying kinds and degrees of intelligence occur in people, many animals and some machines.

- **Isn't there a solid definition of intelligence that doesn't depend on relating it to human intelligence?**

  Not yet. The problem is that we cannot yet characterize in general what kinds of computational procedures we want to call intelligent. We understand some of the mechanisms of intelligence and not others.

Exercise

这是什么意思?



What's involved in Intelligence?

- Ability to interact with the real world
  - to perceive, understand, and act
  - e.g., speech recognition and understanding and synthesis
  - e.g., image understanding
  - e.g., ability to take actions, have an effect
- Reasoning and Planning
  - modeling the external world, given input
  - solving new problems, planning, and making decisions
  - ability to deal with unexpected problems, uncertainties
- 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

Academic Disciplines relevant 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/Statistics	modeling uncertainty, learning from data
• Economics	utility, decision theory, rational economic agents
• Neuroscience	neurons as information processing units.
• Psychology/ Cognitive Science	how do people behave, perceive, process cognitive information, represent knowledge.
• Computer engineering	building fast computers
• Control theory	design systems that maximize an objective function over time
• Linguistics	knowledge representation, grammars

History of AI

- 1943: early beginnings
  - McCulloch & Pitts: Boolean circuit model of brain
- 1950: Turing
  - Turing's "Computing Machinery and Intelligence“
- 1956: birth of AI
  - Dartmouth meeting: "Artificial Intelligence“ name adopted
- 1950s: initial promise
  - Early AI programs, including
  - Samuel's checkers program
  - Newell & Simon's Logic Theorist
- 1955-65: “great enthusiasm”
  - Newell and Simon: GPS, general problem solver
  - Gelertner: Geometry Theorem Prover
  - McCarthy: invention of LISP

- 1966—73: Reality dawns
  - Realization that many AI problems are intractable
  - Limitations of existing neural network methods identified
    - Neural network research almost disappears
- 1969—85: Adding domain knowledge
  - Development of knowledge-based systems
  - Success of rule-based expert systems,
    - E.g., DENDRAL, MYCIN
    - But were brittle and did not scale well in practice
- 1986-- Rise of machine learning
  - Neural networks return to popularity
  - Major advances in machine learning algorithms and applications
- 1990-- Role of uncertainty
  - Bayesian networks as a knowledge representation framework
- 1995-- AI as Science
  - Integration of learning, reasoning, knowledge representation
  - AI methods used in vision, language, data mining, etc

Success Stories

- Deep Blue defeated the reigning world chess champion Garry Kasparov in 1997
- AI program proved a mathematical conjecture (Robbins conjecture) unsolved for decades
- 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
- Robot driving: DARPA grand challenge 2003-2007
- 2006: face recognition software available in consumer cameras
- 2013: Social network behavior

DARPA Grand Challenge

- Grand Challenge
  - Cash prizes ($1 to $2 million) offered to first robots to complete a long course completely unassisted
  - Stimulates research in vision, robotics, planning, machine learning, reasoning, etc

- 2004 Grand Challenge:
  - 150 mile route in Nevada desert
  - Furthest any robot went was about 7 miles
  - … but hardest terrain was at the beginning of the course

- 2005 Grand Challenge:
  - 132 mile race
  - Narrow tunnels, winding mountain passes, etc
  - Stanford 1st, CMU 2nd, both finished in about 6 hours

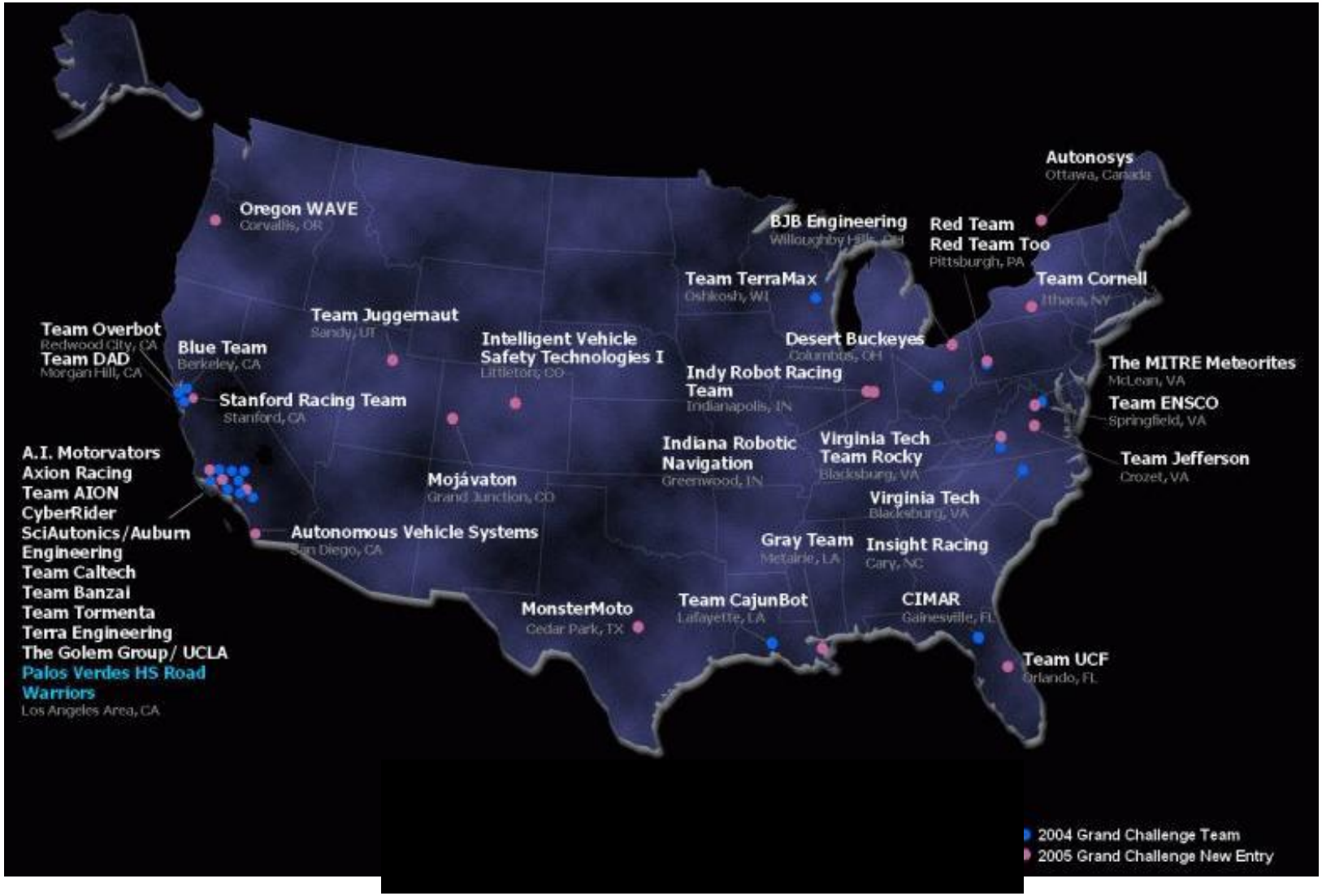
- 2007 Urban Grand Challenge
  - This November in Victorville, California

Stanley Robot

Stanford Racing Team

Next few slides courtesy of Prof. Sebastian Thrun, Stanford University

Semi-Finalists: 43 Teams



The Grand Challenge Race

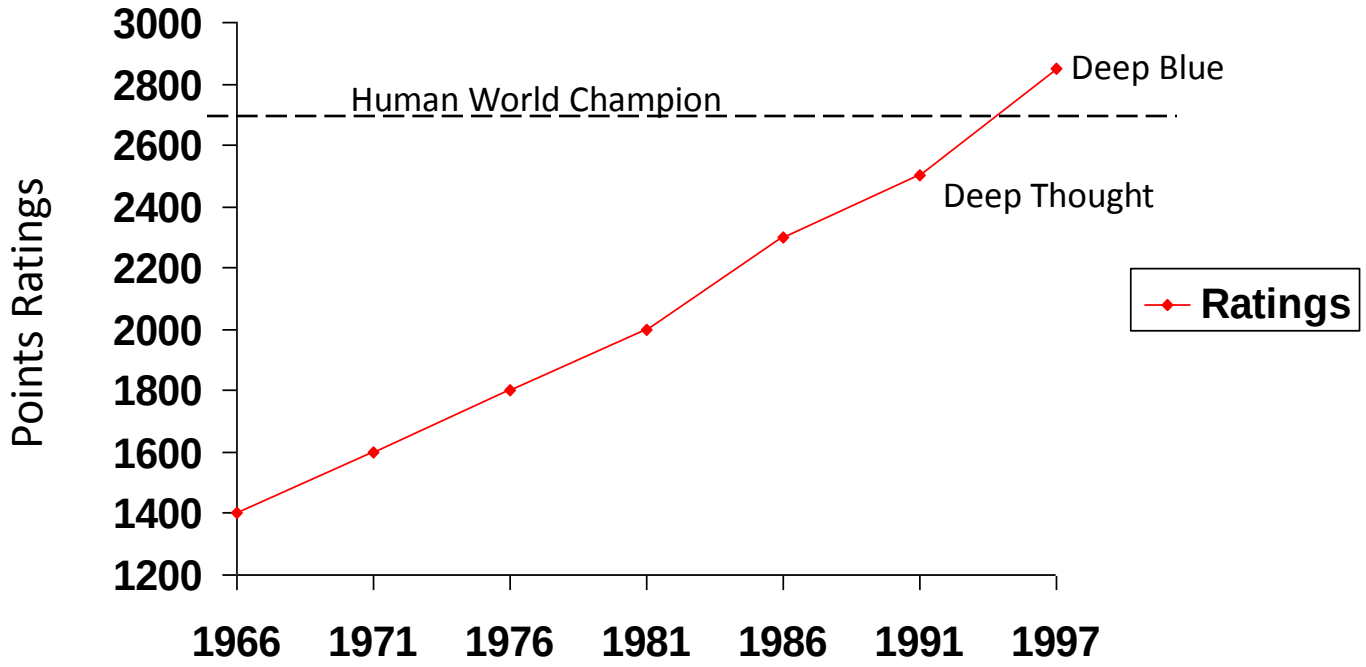
What is next?

Consider what might be involved in building a computer like Human….

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

Can Computers beat 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 Understand speech?

- Understanding is different to recognition:
  - "Time flies like an arrow"
    - assume the computer can recognize all the words
    - how many different interpretations are there?

Can Computers Understand speech?

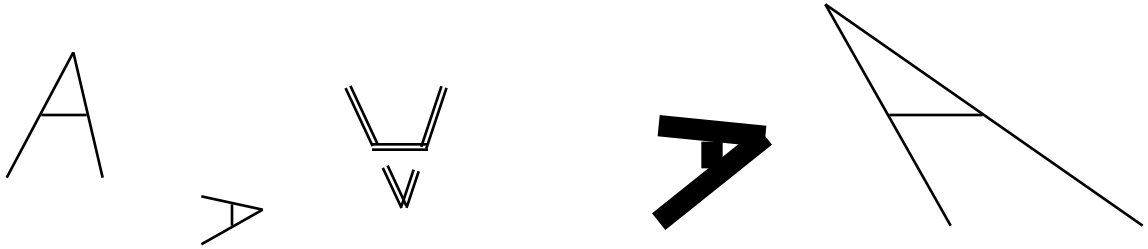
- Understanding is different to recognition:
  - "Time flies like an arrow"
    - assume the computer can recognize all the words
    - how many different interpretations are there?
      - 1. time passes quickly like an arrow?
      - 2. command: time the flies the way an arrow times the flies
      - 3. command: only time those flies which are like an arrow
      - 4. "time-flies" are fond of arrows

Can Computers Understand speech?

- Understanding is different to recognition:
  - "Time flies like an arrow"
    - assume the computer can recognize all the words
    - how many different interpretations are there?
      - 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 “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
  - YES for certain constrained problems (e.g., face recognition)

Can computers plan and make optimal decisions?

- Intelligence
  - involves solving problems and making decisions and plans
  - e.g., you want to take a holiday in Brazil
    - 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 are 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

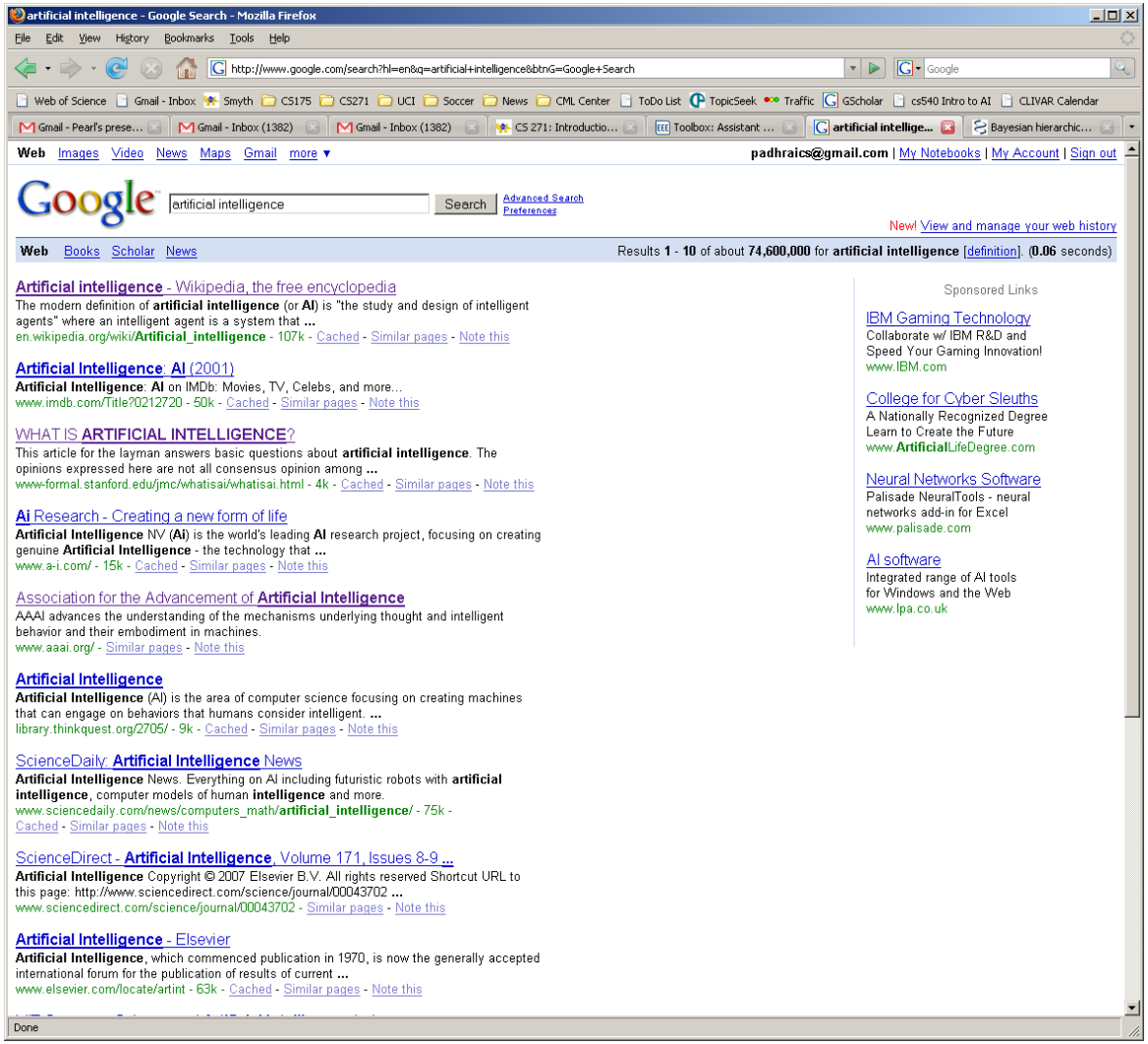
Summary of State of AI Systems in Practic

- Speech synthesis, recognition and understanding
  - very useful for limited vocabulary applications
  - unconstrained speech understanding is still too hard
- Computer vision
  - works for constrained problems (hand-written zip-codes)
  - understanding real-world, natural scenes is still too hard
- Learning
  - adaptive systems are used in many applications: have their limits
- Planning and Reasoning
  - only works for constrained problems: e.g., chess
  - real-world is too complex for general systems
- Overall:
  - many components of intelligent systems are “doable”
  - there are many interesting research problems remaining

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
- 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 and Web Search



What's involved in Intelligence? (again)

- Perceiving, recognizing, understanding the real world
- Reasoning and planning about the external world
- Learning and adaptation

- So what general principles should we use to achieve these goals?

Different Types of Artificial Intelligence

1. Modeling exactly how humans actually think

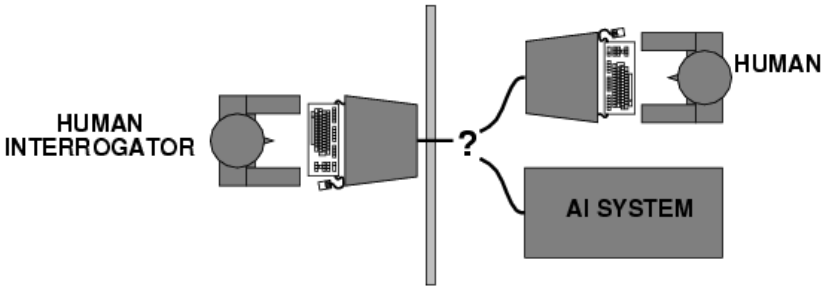
2. Modeling exactly how humans actually act

3. Modeling how ideal agents “should think”

4. Modeling how ideal agents “should act”

Acting humanly: Turing test

- Turing (1950) "Computing machinery and intelligence“
- "Can machines think?" → "Can machines behave intelligently?“
- Operational test



- Suggests major components required for AI:
  - knowledge representation
  - reasoning,
  - language/image understanding,
  - learning

* Question: is it important that an intelligent system act like a human?

Thinking humanly

- Cognitive Science approach
  - Try to get “inside” our minds
  - E.g., conduct experiments with people to try to “reverse-engineer” how we reason, learning, remember, predict
- Problems
  - Humans don’t behave rationally
    - e.g., insurance
  - The reverse engineering is very hard to do
  - The brain’s hardware is very different to a computer program

Thinking rationally

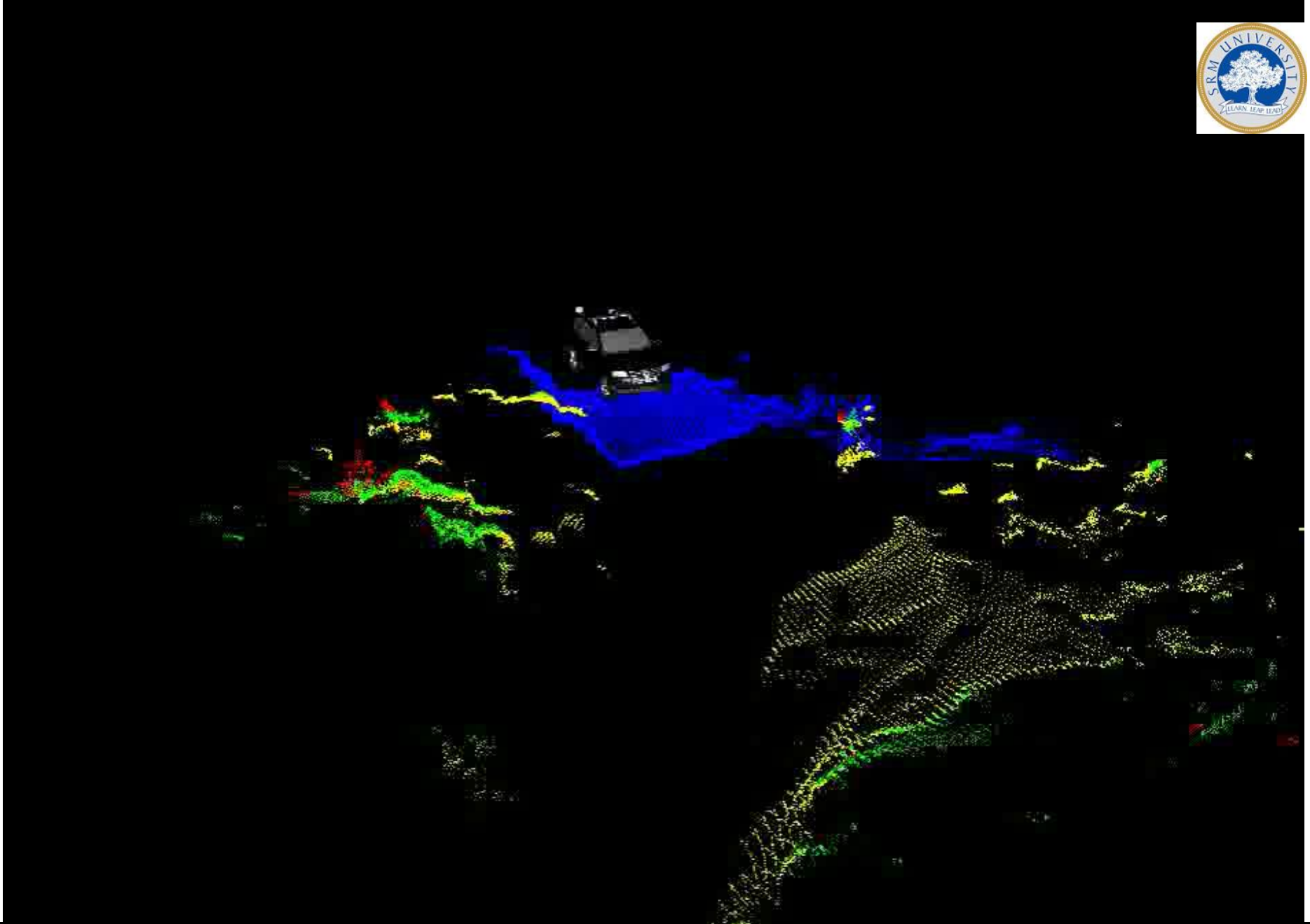
- Represent facts about the world via logic
- Use logical inference as a basis for reasoning about these facts
- Can be a very useful approach to AI
  - E.g., theorem-provers
- Limitations
  - Does not account for an agent's uncertainty about the world
    - E.g., difficult to couple to vision or speech systems
  - Has no way to represent goals, costs, etc (important aspects of real-world environments)

Acting rationally

- Decision theory/Economics
  - Set of future states of the world
  - Set of possible actions an agent can take
  - Utility = gain to an agent for each action/state pair

  - An agent acts rationally if it selects the action that maximizes its "utility"
    - Or expected utility if there is uncertainty

- Emphasis is on autonomous agents that behave rationally (make the best predictions, take the best actions)
  - on average over time
  - within computational limitations ("bounded rationality")



For a machine?

- Computation (time/memory)
- Information (data)

- How do we ~~solve~~ tackle these challenging problems?

Real-world task 

Modeling

Formal task (model) 

Algorithms

Program 

Machine learning

- Low level intelligence to High level Intelligence

Home work

- What was the most surprising thing you learn at today?

Summary of Today's Lecture

- Artificial Intelligence involves the study of:
  - automated recognition and understanding of signals
  - reasoning, planning, and decision-making
  - learning and adaptation

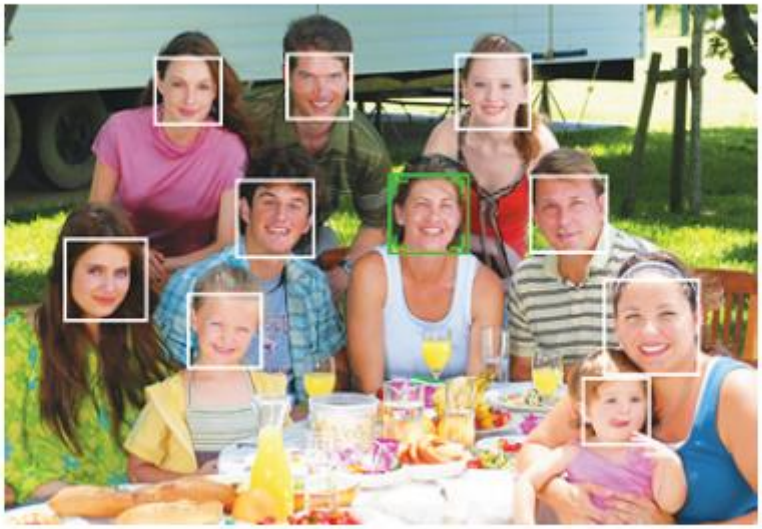
- AI has made substantial progress in
  - recognition and learning
  - some planning and reasoning problems
  - …but many open research problems

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

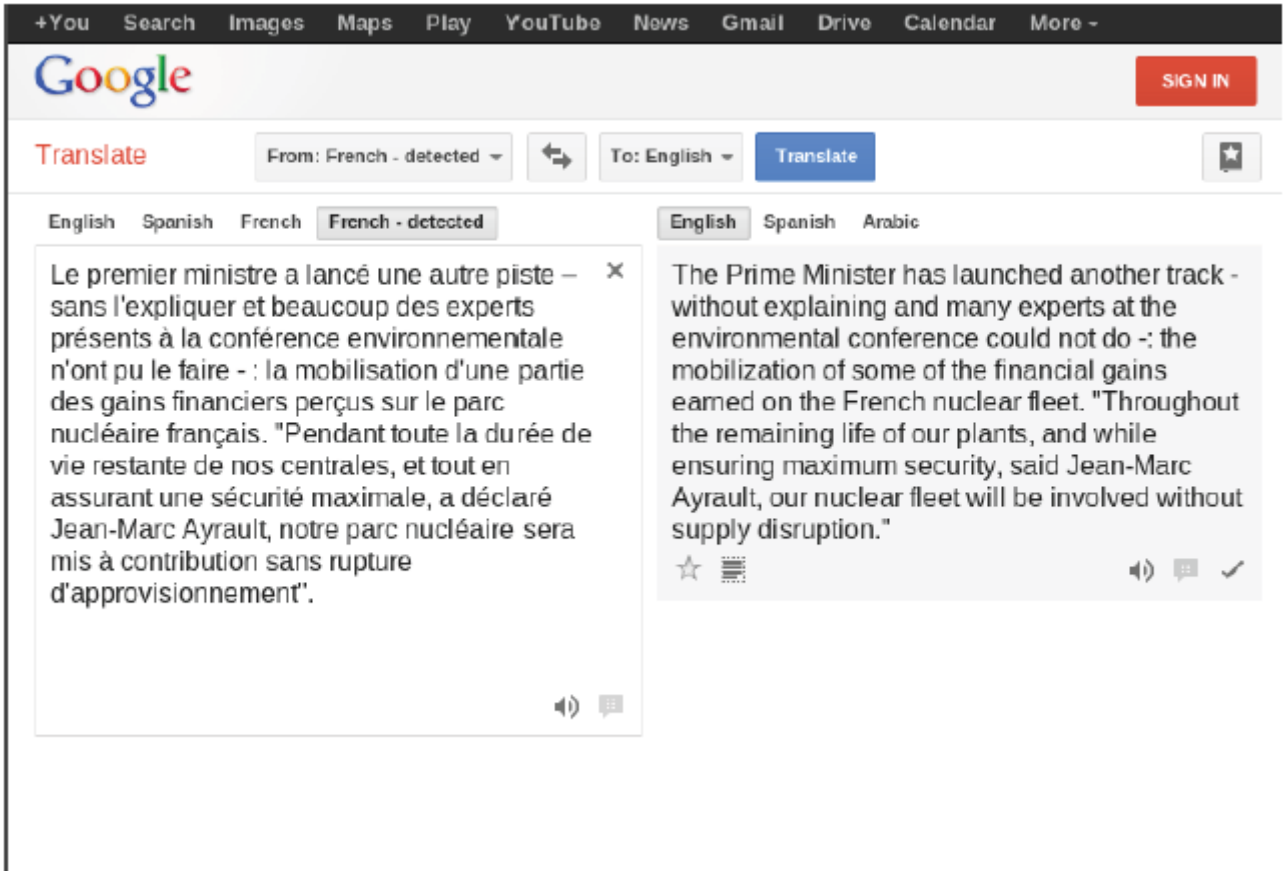
- Computer engineer Vs Computer Scientist

Handwriting recognition

Face detection



Translation



Route planning

Self driven

Physical Assistants

Virtual Assistants

- Web search
- Speech recognition
- Handwriting recognition
- Machine translation
- Information extraction
- Document summarization
- Question answering
- Spelling correction

- Image recognition
- 3D scene reconstruction
- Human activity recognition
- Autonomous driving
- Music information retrieval
- Automatic composition
- Social network analysis
- Product recommendation
- Advertisement placement
- Smart-grid energy optimization

- Household robotics
- Robotic surgery
- Robot exploration
- Fraud detection
- Fault diagnostics
- AI for video games
- Character animation
- Financial trading
- Protein folding
- Medical diagnosis
- Medical imaging