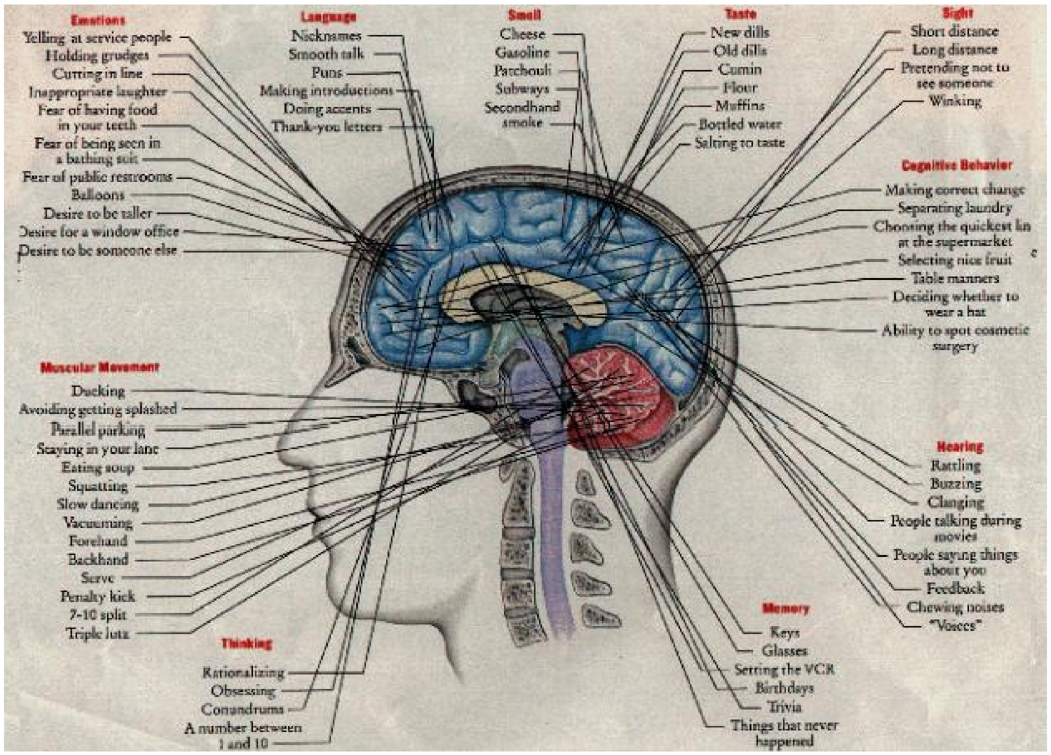
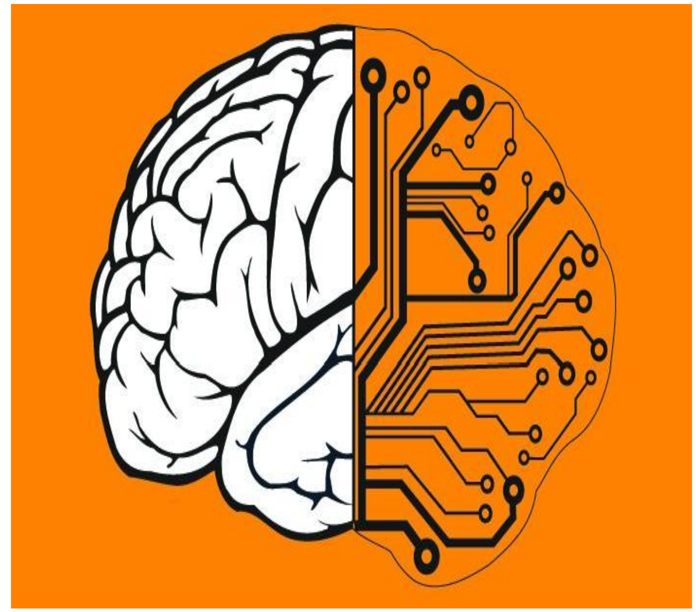
Artificial Intelligence
CSE3013, Fall Semester, 2021-22

Module: 1 (Part-I)

What is AI?

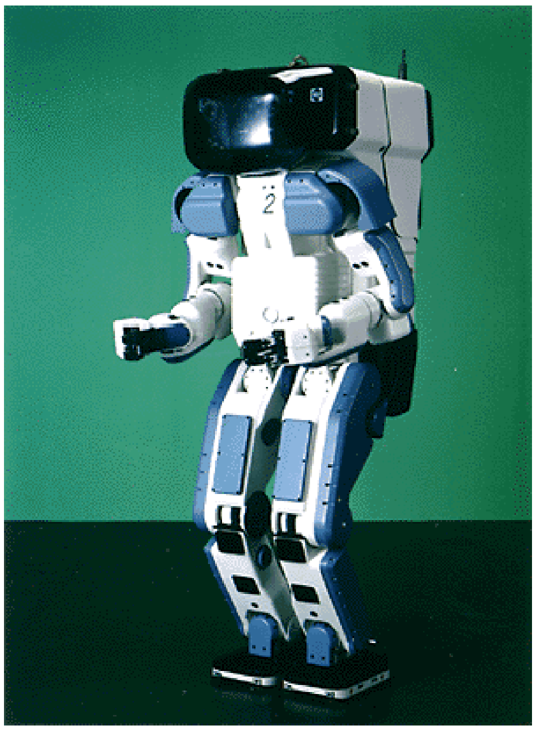


Human Brain

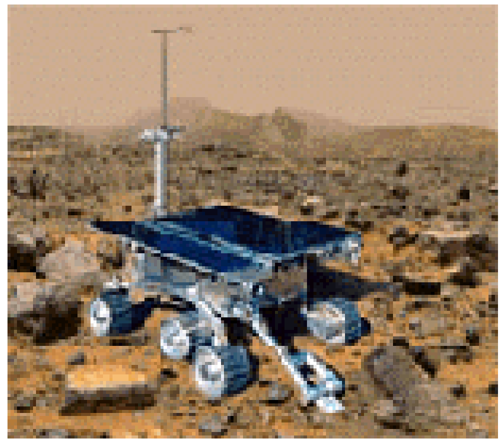


Mapping of Human brain into machine

Why study AI?



Labor



Science

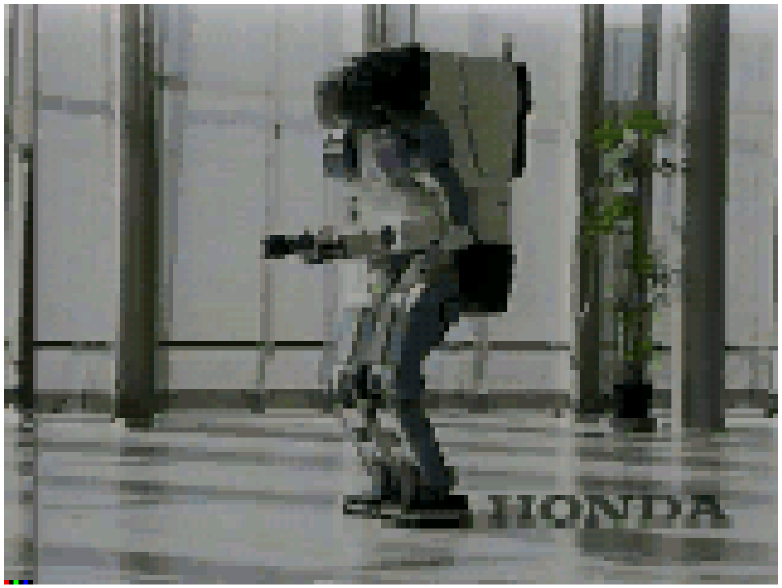
Search engines

Medicine/
Diagnosis

Appliances

What else?

Honda Humanoid Robot



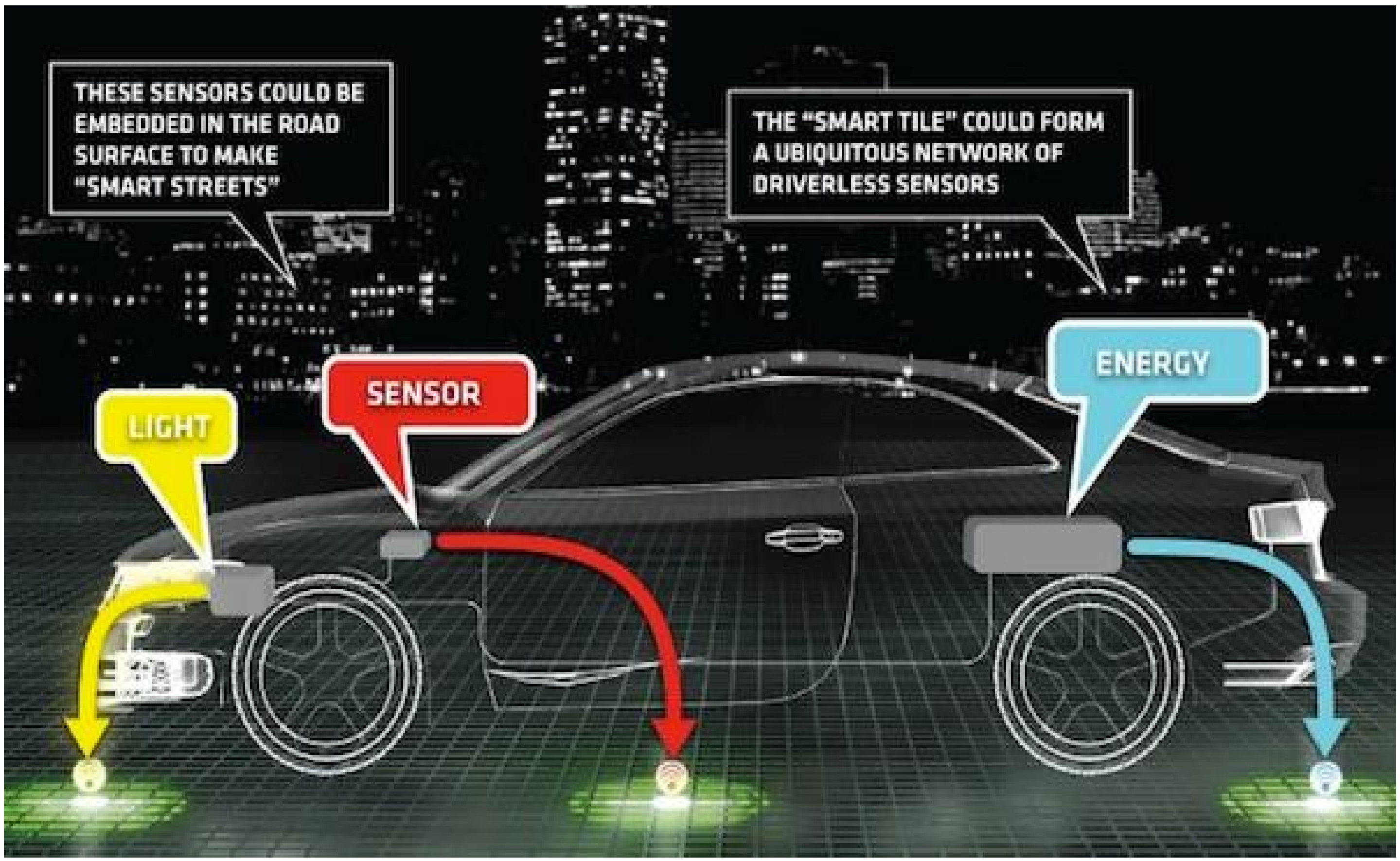
Walk

Turn

Stairs

Milestone in the field of Artificial Intelligence

Driver-less Car



Human vs Robot Table Tennis game

Purchase Prediction
Fraud Detection
Security Surveillance
Smart Home Devices
https://www.youtube.com/watch?v=ZFB6lu3WmEw
https://www.youtube.com/watch?v=O-h8fFkm3UA

- Introduction

- Foundations of artificial intelligence(AI)
- History of AI
- Basics of AI
- Artificial Intelligence Problems
- Artificial Intelligence Techniques

What is Artificial Intelligence?

- Not just studying intelligent systems, but building them…
- Psychological approach: an intelligent system is a model of human intelligence
- Engineering approach: an intelligent system solves a sufficiently difficult problem in a generalizable way

Definition(s)

Thinking Humanly “The exciting new effort to make computers think … *machines with minds*, in the full and literal sense.” (Haugeland, 1985) “[The automation of] activities that we associate with human thinking, activities such as decision-making, problem solving, learning …” (Bellman, 1978)	**Thinking Rationally** “The study of mental faculties through the use of computational models.” (Charniak and McDermott, 1985) “The study of the computations that make it possible to perceive, reason, and act.” (Winston, 1992)
Acting Humanly “The art of creating machines that perform functions that require intelligence when performed by people.” (Kurzweil, 1990) “The study of how to make computers do things at which, at the moment, people are better.” (Rich and Knight, 1991)	**Acting Rationally** “Computational Intelligence is the study of the design of intelligent agents.” (Poole *et al.*, 1998) “AI …is concerned with intelligent behavior in artifacts.” (Nilsson, 1998)

…contd.

- *Thought processes*
- R*easoning*,
- *Behavior*.

❖ Fidelity to *human* performance,

❖ Rationality measure against an *ideal* performance.

"A system is rational if it does the "right thing," given what it knows."

What is Intelligence?

- Is there a "holistic" definition for intelligence?
- Here are some definitions:
  - *the ability to comprehend; to understand and profit from experience*
  - *a general mental capability that involves the ability to reason, plan, solve problems, think abstractly, comprehend ideas and language, and learn*
  - *is effectively perceiving, interpreting and responding to the environment*
- None of these tells us what intelligence is, so instead, maybe we can enumerate a list of elements that an intelligence must be able to perform:
  - perceive, reason and infer, solve problems, learn and adapt, apply common sense, apply analogy, recall, apply intuition, reach emotional states, achieve self-awareness
- Which of these are necessary for intelligence? Which are sufficient?
- Artificial Intelligence – should we define this in terms of human intelligence?
  - does AI have to really be intelligent?
  - what is the difference between being intelligent and demonstrating intelligent behavior?

Table-Lookup vs. Reasoning

- Consider two approaches to programming a Tic-Tac-Toe player
  - Solution 1: a pre-enumerated list of best moves given the board configuration
  - Solution 2: rules (or a heuristic function) that evaluate a board configuration, and using these to select the next best move
- Solution 1 is similar to how Eliza works
  - This is not practical for most types of problems
  - Consider solving the game of chess in this way, or trying to come up with all of the responses that a Turing Test program might face
- Solution 2 will reason out the best move
  - Given the board configuration, it will analyze each available move and determine which is the best
  - Such a player might even be able to “explain” why it chose the move it did
- We can (potentially) build a program that can pass the Turing Test using table-lookup even though it would be a large undertaking
- Could we build a program that can pass the Turing Test using reasoning?
  - Even if we can, does this necessarily mean that the system is intelligent?

Problems with Symbolic AI Approaches

- Scalability
  - It can take dozens or more man-years to create a useful systems
  - It is often the case that systems perform well up to a certain threshold of knowledge (approx. 10,000 rules), after which performance (accuracy and efficiency) degrade
- Brittleness
  - Most symbolic AI systems are programmed to solve a specific problem, move away from that domain area and the system's accuracy drops rapidly rather than achieving a graceful degradation
    - this is often attributed to lack of common sense, but in truth, it is a lack of any knowledge outside of the domain area
  - No or little capacity to learn, so performance (accuracy) is static
- Lack of real-time performance

Problems with Connectionist AI Approaches

- No “memory” or sense of temporality
  - The first problem can be solved to some extent
  - The second problem arises because of a fixed sized input but leads to poor performance in areas like speech recognition
- Learning is problematic
  - Learning times can greatly vary
  - Overtraining leads to a system that only performs well on the training set and undertraining leads to a system that has not generalized
- No explicit knowledge-base
  - So there is no way to tell what a system truly knows or how it knows something
- No capacity to explain its output
  - Explanation is often useful in an AI system so that the user can trust the system’s answer

So What Does AI Do?

- Most AI research has fallen into one of two categories
  - Select a specific problem to solve
    - study the problem (perhaps how humans solve it)
    - come up with the proper representation for any knowledge needed to solve the problem
    - acquire and codify that knowledge
    - build a problem solving system
  - Select a category of problem or cognitive activity (e.g., learning, natural language understanding)
    - theorize a way to solve the given problem
    - build systems based on the model behind your theory as experiments
    - modify as needed
- Both approaches require
  - one or more representational forms for the knowledge
  - some way to select proper knowledge, that is, search

A Bit of AI History

- Gestation/Development (1943-1955)
  - Early learning theory, first neural network, Turing test
  - McCulloch and Pitts artificial neuron, Hebbian learning
- Birth (1956)
  - Name coined by McCarthy
  - Organized a conference on machine intelligence
  - Solving problems require commonsense is AI
- Early enthusiasm, great expectations (1952-1969)
  - GPS, physical symbol system hypothesis
  - Geometry Theorem (Gelertner), Checkers (Samuels)
  - Lisp (McCarthy), Theorem Proving (McCarthy)
  - Fuzzy Logic, PROLOG

In 1956, Dartmouth conference, John McCarthy coined the term "Artificial Intelligence"

A Brief History of AI: 1950s

- Computers were thought of as an electronic brains
- Term “Artificial Intelligence” coined by John McCarthy
  - John McCarthy also created Lisp in the late 1950s
- Alan Turing defines intelligence as passing the Imitation Game (Turing Test)
- AI research largely revolves around toy domains
  - Computers of the era didn’t have enough power or memory to solve useful problems
  - Problems being researched include
    - games (e.g., checkers)
    - primitive machine translation
    - blocks world (planning and natural language understanding within the toy domain)
    - early neural networks researched: the perceptron
    - automated theorem proving and mathematics problem solving

The 1960s

- AI attempts to move beyond toy domains
- Syntactic knowledge alone does not work, domain knowledge required
  - Early machine translation could translate English to Russian (“the spirit is willing but the flesh is weak” becomes “the vodka is good but the meat is spoiled”)
- Earliest expert system created: Dendral
- Perceptron research comes to a grinding halt when it is proved that a perceptron cannot learn the XOR operator
- US sponsored research into AI targets specific areas – not including machine translation
- Weizenbaum creates Eliza to demonstrate the futility of AI

1970s

- AI researchers address real-world problems and solutions through expert (knowledge-based) systems
  - Medical diagnosis
  - Speech recognition
  - Planning
  - Design
- Uncertainty handling implemented
  - Fuzzy logic
  - Certainty factors
  - Bayesian probabilities
- AI begins to get noticed due to these successes
  - AI research increased
  - AI labs sprouting up everywhere
  - AI shells (tools) created
  - AI machines available for Lisp programming
- Criticism: AI systems are too brittle, AI systems take too much time and effort to create, AI systems do not learn

1980s: AI Winter

- Funding dries up leading to the AI Winter
  - Too many expectations were not met
  - Expert systems took too long to develop, too much money to invest, the results did not pay off
- Neural Networks to the rescue!
  - Expert systems took programming, and took dozens of man-years of efforts to develop, but if we could get the computer to learn how to solve the problem…
  - Multi-layered back-propagation networks got around the problems of perceptrons
  - Neural network research heavily funded because it promised to solve the problems that symbolic AI could not
- By 1990, funding for neural network research was slowly disappearing as well
  - Neural networks had their own problems and largely could not solve a majority of the AI problems being investigated
  - Panic! How can AI continue without funding?

1990s: ALife

- The dumbest smart thing you can do is staying alive
  - We start over – lets not create intelligence, lets just create “life” and slowly build towards intelligence
    - Alife is the lower bound of AI
  - Alife includes
    - evolutionary learning techniques (genetic algorithms)
    - artificial neural networks for additional forms of learning
    - perception and motor control
    - adaptive systems
    - modeling the environment
- Let’s disguise AI as something new, maybe we’ll get some funding that way!
  - Problems: genetic algorithms are useful in solving some optimization problems and some search-based problems, but not very useful for expert problems
  - perceptual problems are among the most difficult being solved, very slow progress

Today: The New (Old) AI

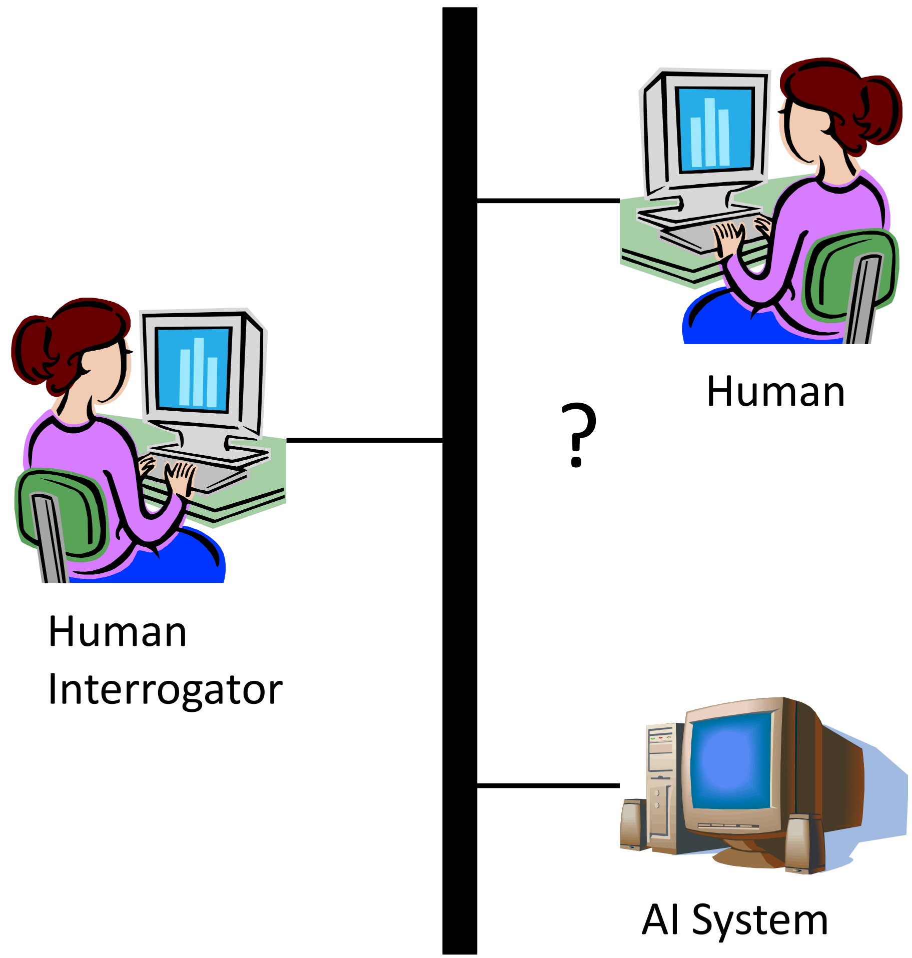
- Look around, who is doing AI research?
- By their own admission, AI researchers are not doing “AI”, they are doing
  - Intelligent agents, multi-agent systems/collaboration
  - Ontologies
  - Machine learning and data mining
  - Adaptive and perceptual systems
  - Robotics, path planning
  - Search engines, filtering, recommendation systems
- Areas of current research interest:
  - NLU/Information Retrieval, Speech Recognition
  - Planning/Design, Diagnosis/Interpretation
  - Sensor Interpretation, Perception, Visual Understanding
  - Robotics
- Approaches
  - Knowledge-based
  - Ontologies
  - Probabilistic (HMM, Bayesian Nets)
  - Neural Networks, Fuzzy Logic, Genetic Algorithms

What is Artificial Intelligence? (again)

- **Systems that think like humans**
  - Cognitive Modeling Approach
  - “The automation of activities that we associate with human thinking...”
  - Bellman 1978
- **Systems that act like humans**
  - Turing Test Approach
  - “The art of creating machines that perform functions that require intelligence when performed by people”
  - Kurzweil 1990
- **Systems that think rationally**
  - “Laws of Thought” approach
  - “The study of mental faculties through the use of computational models”
  - Charniak and McDermott
- **Systems that act rationally**
  - Rational Agent Approach
  - “The branch of CS that is concerned with the automation of intelligent behavior”
  - Lugar and Stubblefield

Acting Humanly

- The Turing Test (1950)
  - Can machines think?
  - Can machines behave intelligently?
- Operational test for intelligent behavior
  - The Imitation Game



Acting Humanly

- Turing Test (cont)
  - Predicted that by 2000, a machine might have a 30% chance of fooling a lay person for 5 minutes
  - Anticipated all major arguments against AI in following 50 years
  - Suggested major components of AI: knowledge, reasoning, language understanding, learning
- Problem!
  - The turning test is not reproducible, constructive, or amenable to mathematical analysis

Thinking Humanly

- 1960’s cognitive revolution
- Requires scientific theories of internal activities of the brain
  - What level of abstraction? “Knowledge” or “Circuits”
  - How to validate?
    - Predicting and testing behavior of human subjects (top-down)
    - Direct identification from neurological data (bottom-up)
- Cognitive Science and Cognitive Neuroscience
  - Now distinct from AI

Thinking Rationally

- Normative (or prescriptive) rather than descriptive
- Aristotle: What are correct arguments / thought processes?
- Logic notation and rules for derivation for thoughts
- Problems:
  - Not all intelligent behavior is mediated by logical deliberation
  - What is the purpose of thinking? What thoughts should I have?

Acting Rationally

- Rational behavior
  - Doing the right thing

- What is the “right thing”
  - That which is expected to maximize goal achievement, given available information

- We do many (“right”) things without thinking
  - Thinking should be in the service of rational action

Task Domains of AI

- Mundane Tasks *(“ Repetitive but necessary ”)*

1. Perception (Vision, Speech)

2. Natural Language (Understanding, Synthesis, Translate)

3. Reasoning

4. Robot Control

Task Domains of AI

- Formal Tasks

1. Games (Adversarial search, Chess, Checkers, PokemonGO)

2. Mathematics(Logic, Geometry, Calculus, Theorem proving)

Task Domains of AI

- Expert Tasks (Till now application specific)

1. Engineering (Design, Modeling, Fault detection)

2. Scientific Analysis

3. Medical Diagnosis

4. Business Analysis

AI Technique

- *“ Intelligence requires knowledge ”*
- The act, fact, or state of knowing
- Method of exploiting the knowledge such that:-

→ The knowledge captures generalization. If multiple number of individual statements are similar, then the common characteristics can be stored with out storing them all.

→ It can be understood by people who provide it.

→ Can be used in numerous situations even though it may not be complete or totally accurate.

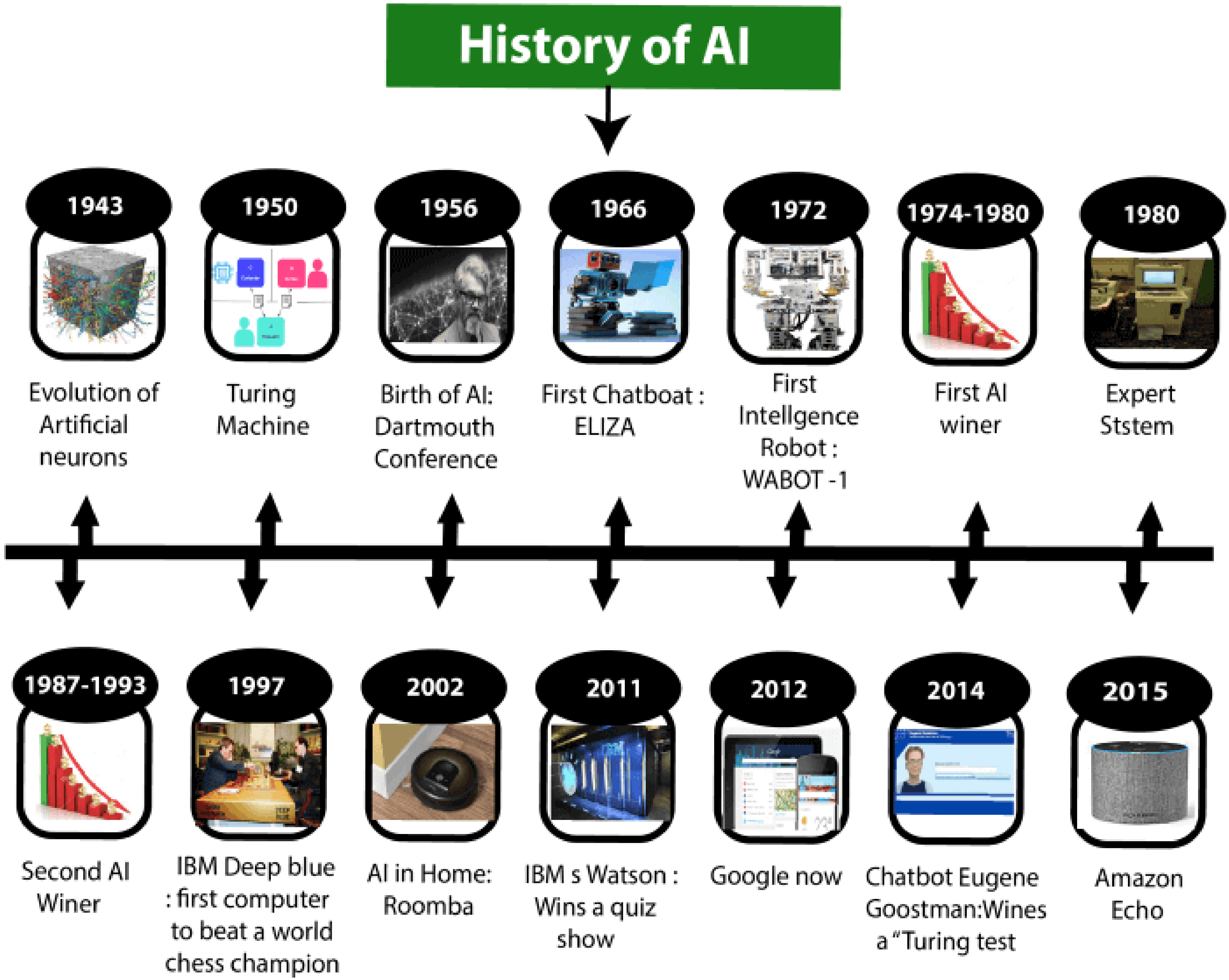
→ Can be used to reduce it’s own bulk store.

Applied Areas of AI

- Heuristic Search
- Computer Vision
- Adversarial Search (Games)
- Fuzzy Logic
- Natural Language Processing
- Knowledge Representation
- Planning
- Learning

Examples

- Playing chess
- Driving on the highway
- Mowing the lawn
- Answering questions
- Recognizing speech
- Diagnosing diseases
- Translating languages
- Data mining



History of AI
1943
Evolution of Artificial neurons
1950
Turing Machine
1956
Birth of AI: Dartmouth Conference
1966
First Chatboat : ELIZA
1972
First Intellgence Robot : WABOT -1
1974-1980
First AI winer
1980
Expert Ststem
1987-1993
Second AI Winer
1997
IBM Deep blue : first computer to beat a world chess champion
2002
AI in Home: Roomba
2011
IBM s Watson : Wins a quiz show
2012
Google now
2014
Chatbot Eugene Goostman:Wines a "Turing test
2015
Amazon Echo

Applied Areas of AI

- Heuristic Search
- Computer Vision
- Adversarial Search (Games)
- Fuzzy Logic
- Natural Language Processing
- Knowledge Representation
- Planning
- Learning

Advent of the Expert systems (1970)
Uses logical rules that are derived from the knowledge experts to solve problems

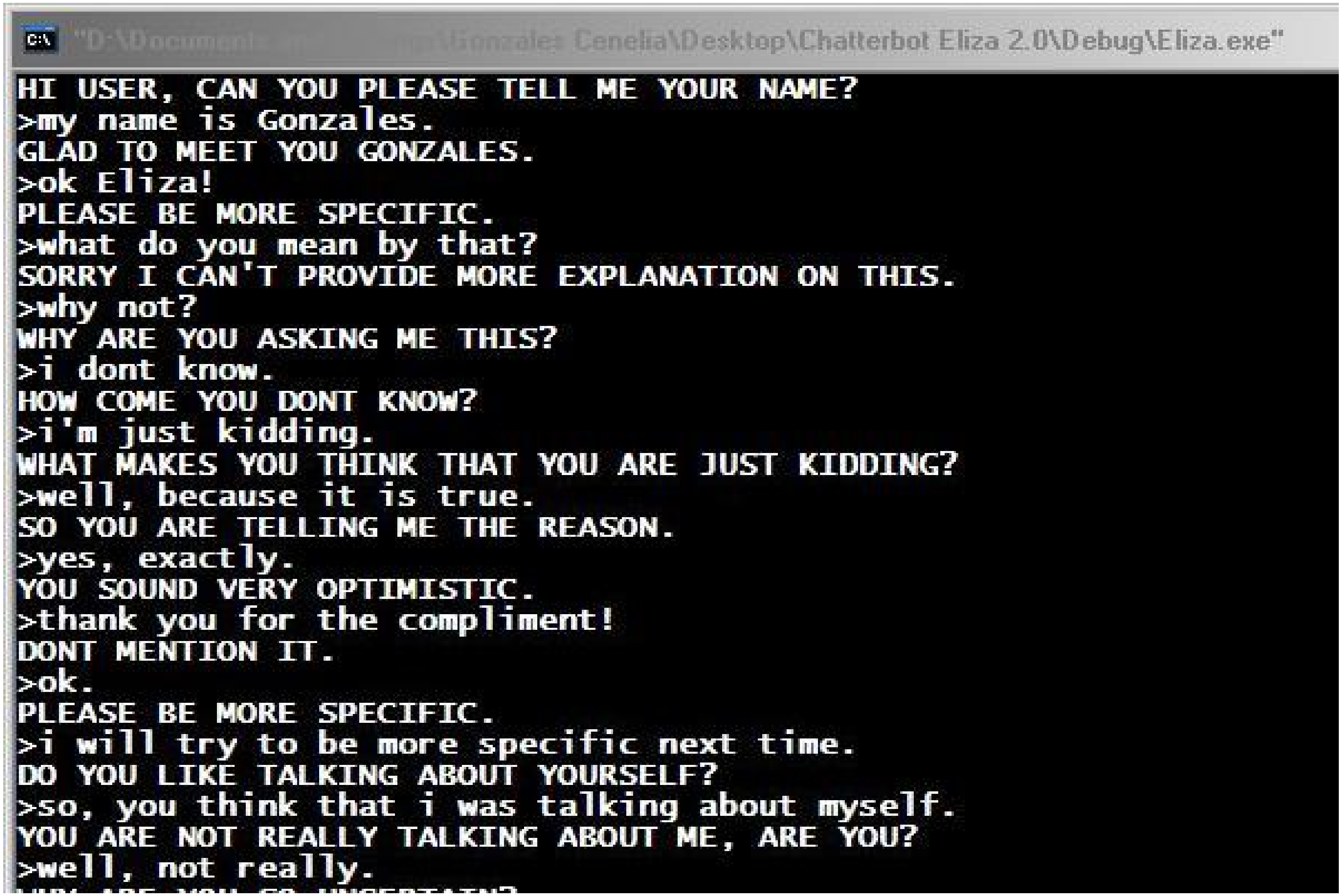
- Playing chess
- Driving on the highway
- Trimming/Mowing the lawn
- Answering questions
- Recognizing speech
- Diagnosing diseases
- Translating languages
- Data mining
- Stock market forecasting

Intelligent Systems

- AI programs must have capability and characteristics of intelligence
  - Learning
  - Reasoning: the action of thinking about something in a logical, sensible way
  - Inferencing: a conclusion reached on the basis of evidence and reasoning
  - Perceiving: interpret or regard (someone or something) in a particular way.
  - Comprehending: to understand something completely

ELIZA

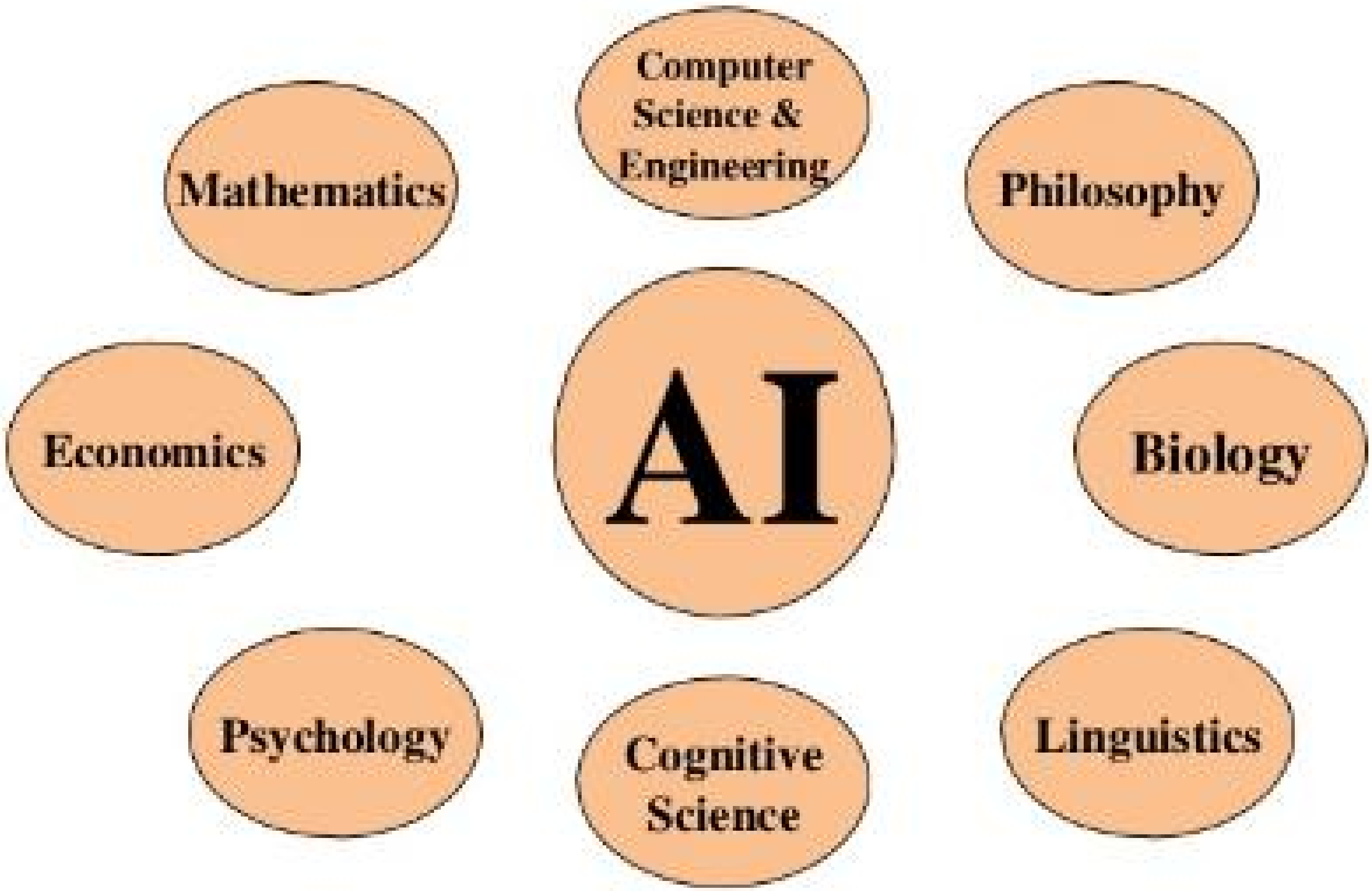
- **ELIZA** is an early natural language processing computer program created from 1964 to 1966
- Created to demonstrate the superficiality of communication between humans and machines
- Eliza simulated conversation by using a 'pattern matching' and substitution methodology


Cenelia\Desktop\Chatterbot Eliza 2.0\Debug\Eliza.exe"
HI USER, CAN YOU PLEASE TELL ME YOUR NAME?
>my name is Gonzales.
GLAD TO MEET YOU GONZALES.
>ok Eliza!
PLEASE BE MORE SPECIFIC.
>what do you mean by that?
SORRY I CAN'T PROVIDE MORE EXPLANATION ON THIS.
>why not?
WHY ARE YOU ASKING ME THIS?
>i dont know.
HOW COME YOU DONT KNOW?
>i'm just kidding.
WHAT MAKES YOU THINK THAT YOU ARE JUST KIDDING?
>well, because it is true.
SO YOU ARE TELLING ME THE REASON.
>yes, exactly.
YOU SOUND VERY OPTIMISTIC.
>thank you for the compliment!
DONT MENTION IT.
>ok.
PLEASE BE MORE SPECIFIC.
>i will try to be more specific next time.
DO YOU LIKE TALKING ABOUT YOURSELF?
>so, you think that i was talking about myself.
YOU ARE NOT REALLY TALKING ABOUT ME, ARE YOU?
>well, not really.

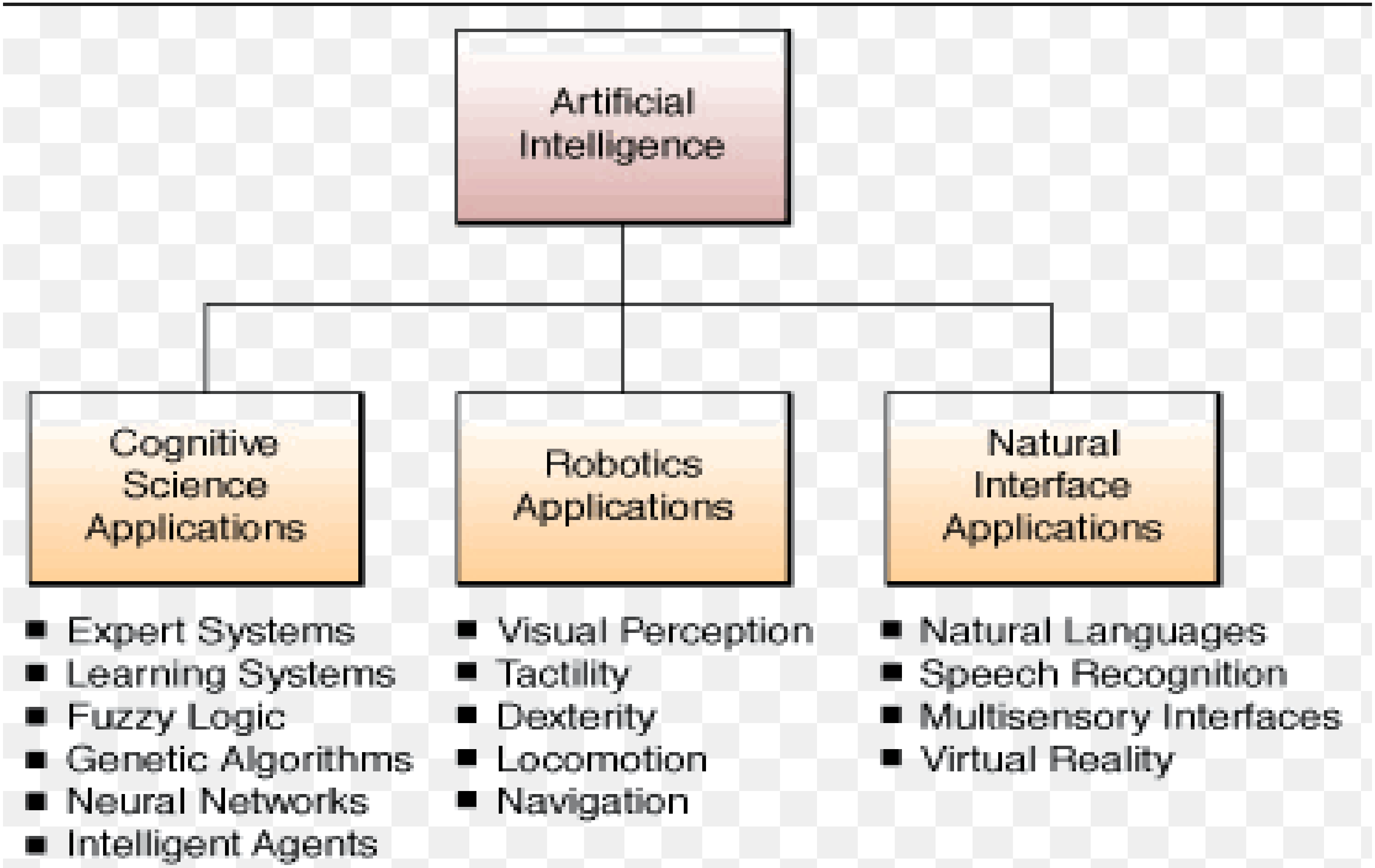
Categorization of Intelligent Systems

- System that thinks like humans
- System that acts like human
- System that thinks like rationally (logically /realistically)
- System that acts like rationally
- Intelligence can be defined as property of mind which encompasses many related mental abilities. They are
  - Reason and draw meaningful conclusions
  - Plan sequence of actions
  - Solve problems
  - Think abstractly
  - Comprehend ideas and help computers to communicate in NL
  - Store knowledge
  - Offer advice
  - Learn new concepts

Foundations of AI



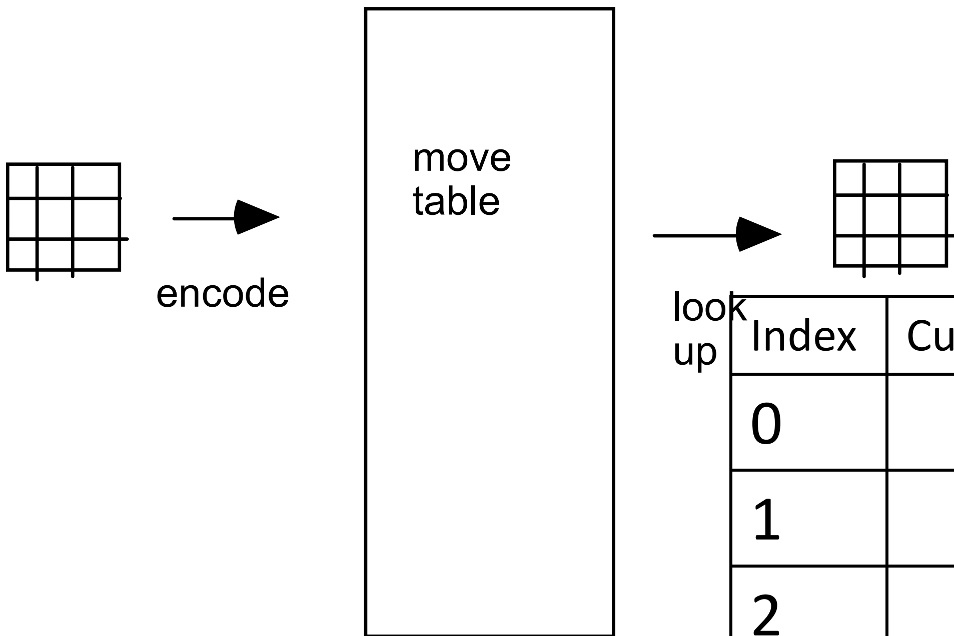
Application areas of AI



Applications

- Business
- Engineering
- Manufacturing
- Medicine
- Education
- Fraud Detection
- Object identification
- Space Shuttle Scheduling
- Information Retrieval

Example: Tic-Tac-Toe game playing #1



Move Table

Index	Current Board position	New board position
0	000000000	000010000
1	000000001	020000001
2	000000002	000100002
….		

- Precompiled move table.
- For each input board, a specific move (output board)
- Perfect play, but is it AI?
- 3^9 i.e. 19683 entries

- View the board as ternary number (0,1,2)
- Get an index by converting this vector to its corresponding decimal number.
- Get the vector from new board position stored at the index. Set board position equal to that vector.

Disadvantages

- Very efficient in terms of time but
- Requires lot of memory (move table)
- Requires lot of effort (entries into move table)
- Difficult to extend to 3D tic-tac-toe game playing

Example: Tic-Tac-Toe game playing #2

- Given a board, consider all possible moves (future boards) and pick the best one

- Look ahead (opponent's best move, your best move…) until end of game

- Functions needed:
  - Next move generator
  - Board evaluation function

- Change these 2 functions (only) to play a different game!

Table 1.2 Rules for Nine Mo...

(C plays X, H plays O)	(H plays X, C plays O)
1 move : Go(5)/Go(1)	**2 move :** If B[5] is blank, then Go(5) else Go(1)
3 move : If B[9] is blank, then Go(9) else ***{make 2}*** Go(3)	**4 move:** *{By now human (playing X) has played 2 moves}*: If PossWin(X) then ***{block X}*** Go(PossWin(X)) else ***{make 2}*** Go(Make_2)
5 move : *{By now both have played 2 moves}*: If PossWin(X) then ***{X wins}*** Go(PossWin(X)) else if PossWin(O) ***{block O}*** then Go(PossWin(O)) else if B[7] is blank then Go(7) else Go(3)	**6 move :** {By now computer has played 2 moves}: If PossWin(O) then ***{O wins}*** Go(PossWin(O)) else if PossWin(X) ***{block X}*** then Go(PossWin(X)) else Go(Make_2)
7 & 9 moves : *{By now human (playing O) has played 3 chances}*: If PossWin(X) then ***{X wins}*** Go(PossWin(X)) else ***{block O}*** if PossWin(O) then Go(PossWin(O)) else Go(Anywhere)	**8 move :** *{By now computer has played 3 chances}*: If PossWin(O) then ***{O wins}*** Go(PossWin(O)) else ***{block O}*** if PossWin(X) then Go(PossWin(X)) else Go(Anywhere)

This version of the program is memory efficient and easier to und...

Example: Tic-Tac-Toe game playing #3

- Magic square i.e. sum each row, column, and diagonal is 15

- Evaluation(Utility) Function
  - A measure of winning possibility of the player

8	1	6
3	5	7
4	9	2

- **Turn 1:** Suppose H plays in the eighth block.
- **Turn 2:** C plays in fifth block (fixed move, see from Table 1.2).
- **Turn 3:** H plays in first block.
- **Turn 4:** C checks if H can win or not.
  - Compute sum of blocks played by H
    - $S = 8 + 1 = 9$
    - Compute $D = 15 - 9 = 6$
  - The sixth block is a winning block for H and not there on either list. So, C blocks it and plays in sixth block. The sixth block is recorded in the list of computer.
- **Turn 5:** H plays in fourth block.
- **Turn 6:** C checks if C can win as follows:
  - Compute sum of blocks played by C
    - $S = 5 + 6 = 11$
    - Compute $D = 15 - 11 = 4$; Discard this block as it already exists in X list
  - Now C checks whether H can win.
    - Compute sum of pair of square from list of H which have not been used earlier
      - $S = 8 + 4 = 12$
      - *Compute* $D = 15 - 12 = 3$
    - Block 3 is free, so C plays in this block. The third block is recorded in the list of computer.
- **Turn 7:** If H plays in second or ninth block, then computer wins. Let us assume that H plays in second block.
- **Turn 8:** C checks if it can win as follows:
  - Compute sum of blocks played by C which has not been used earlier
    - $S = 5 + 3 = 8;$

Development of AI languages

- AI has brought another level of smart technology to different industries and the prospects of its potential still grows with the expectation that it would reach the human intelligence.
- This is because developers are willing to explore, experiment and implement its capabilities to satisfy more of the human and organization necessities.
- are
- Java, Python, Lisp, PROLOG, and C++ are major the languages for artificial intelligence projects to satisfy different needs in the development and designing of different software.

Development of AI languages Cont.

- Python is a Multi-paradigm programming supporting object-oriented, procedural and functional styles of programming.
- Python supports neural networks and development of NLP solutions for its simple library function library.
- Python is very encouraging for machine learning for developers as it is less complex as compared to C++ and Java.
- A very portable language as it is used on platforms including Linux, Windows, Mac OS, and UNIX.

Current trends in AI

- Conventional Computing (Hard Computing)
  - Is the concept of precise modeling and analyzing to yield accurate results
  - Works well for simple problems
- NP-complete set of problems such as biology, medicine, management sciences, are intractable to conventional mathematical and analytical methods.
- Since such problems to solve would take lifetime even at super computing speeds.
- AI community has started looking towards soft computing methodologies which are complementary rather than competitive.
- Role model for soft computing is the human mind.
- Components of soft computing
  - Neural Networks
  - Fuzzy Systems
  - Evolutionary Algorithms

- Neural Networks
  - Developed based on functioning of the brain
  - Developed to facilitate predicting features in advance based on the previous details available
- Evolutionary Algorithms
  - Meta-heuristic optimization algorithms
  - Genetic Algorithms, Evolutionary programming
- Swarm Intelligence
  - Particle Swam Optimization, Ant Colony Optimization
- Fuzzy Systems
  - It is a method of reasoning that resembles human reasoning.
  - The approach using fuzzy logic imitates the way of decision making in humans that involves all intermediate possibilities between digital values YES and NO.

Types of AI Environments

1-Complete vs. Incomplete
Complete AI environments are those on which, at any give time, we have enough information to complete a branch of the problem. Chess is a classic example of a complete AI environment. Poker, on the other hand, is an incomplete environments as AI strategies can't anticipate many moves in advance and, instead, they focus on finding a good 'equilibrium" at any given time.

2-Fully Observable vs. Partially Observable
A fully observable AI environment has access to all required information to complete target task. Image recognition operates in fully observable domains. Partially observable environments such as the ones encountered in self-driving vehicle scenarios deal with partial information in order to solve AI problems.

Types of AI Environments

3-Competitive vs. Collaborative
Competitive AI environments face AI agents against each other in order to optimize a specific outcome. Games such as GO or Chess are examples of competitive AI environments. Collaborative AI environments rely on the cooperation between multiple AI agents. Self-driving vehicles or cooperating to avoid collisions or smart home sensors interactions are examples of collaborative AI environments.

4-Static vs. Dynamic
static AI environments rely on data-knowledge sources that don’t change frequently over time. Speech analysis is a problem that operates on static AI environments. Contrasting with that model, dynamic AI environments such as the vision AI systems in drones deal with data sources that change quite frequently.

Types of AI Environments

5-Discrete vs. Continuous

Discrete AI environments are those on which a finite [although arbitrarily large] set of possibilities can drive the final outcome of the task. Chess is also classified as a discrete AI problem. Continuous AI environments rely on unknown and rapidly changing data sources. Vision systems in drones or self-driving cars operate on continuous AI environments.

6-Deterministic vs. Stochastic

Deterministic AI environments are those on which the outcome can be determined base on a specific state. In other words, deterministic environments ignore uncertainty. Most real world AI environments are not deterministic. Instead, they can be classified as stochastic. Self-driving vehicles are a classic example of stochastic AI processes.