Artificial Intelligence

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Unit – 1 INTRODUCTION

* Introduction to AI
* The Foundations of AI
* AI Technique
* Tic-Tac-Toe
* Problem characteristics
* Production system characteristics
* Production systems: 8-puzzle problem.
* **Searching:**
* Uninformed search strategies:
  * Breadth first search
  * Depth first search

Intelligence

Intelligence

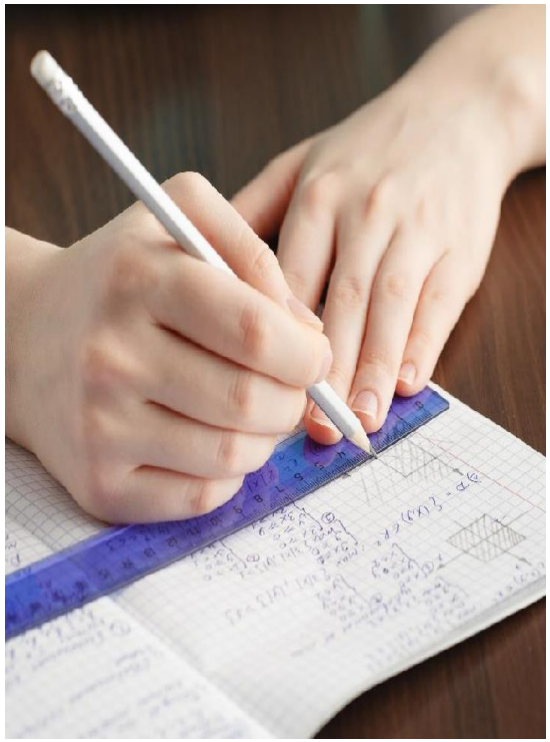
"The ability to acquire and apply knowledge."

"The ability to learn or understand."

"Goal-directed adaptive behavior."

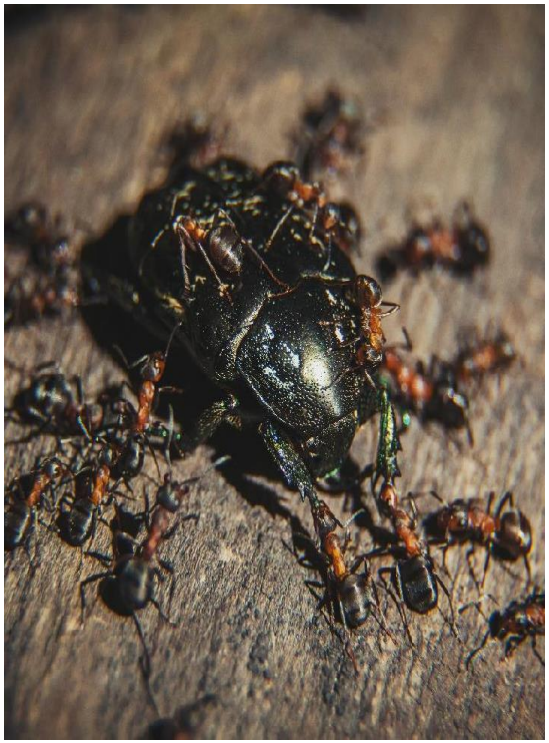
"The ability to deal with cognitive complexity."

Examples of Intelligence



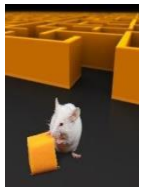
Human intelligence

Animal intelligence

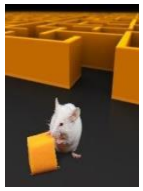


Collective intelligence

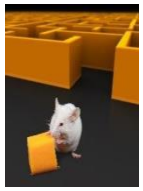
Examples of Intelligence

	Agent
	Human
	Mouse
	Ants

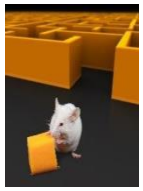
Examples of Intelligence

	Agent	Environment
	Human	Exam
	Mouse	Maze
	Ants	Colony

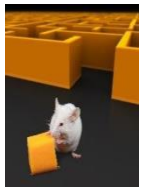
Examples of Intelligence

	Agent	Environment	Goal
	Human	Exam	Pass
	Mouse	Maze	Cheese
	Ants	Colony	Protect

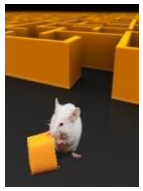
Examples of Intelligence

	Agent	Environment	Goal	Perception
	Human	Exam	Pass	Read
	Mouse	Maze	Cheese	See
	Ants	Colony	Protect	Smell

Examples of Intelligence

	Agent	Environment	Goal	Perception	Action
	Human	Exam	Pass	Read	Solve
	Mouse	Maze	Cheese	See	Navigate
	Ants	Colony	Protect	Smell	Attack

Examples of Intelligence

	Agent	Environment	Goal	Perception	Action
	Human	Exam	Pass	Read	Solve
	Mouse	Maze	Cheese	See	Navigate
	Ants	Colony	Protect	Smell	Attack

Intelligence

The ability of an agent
to perceive an environment
and to choose actions
that increase its chances
of achieving a goal

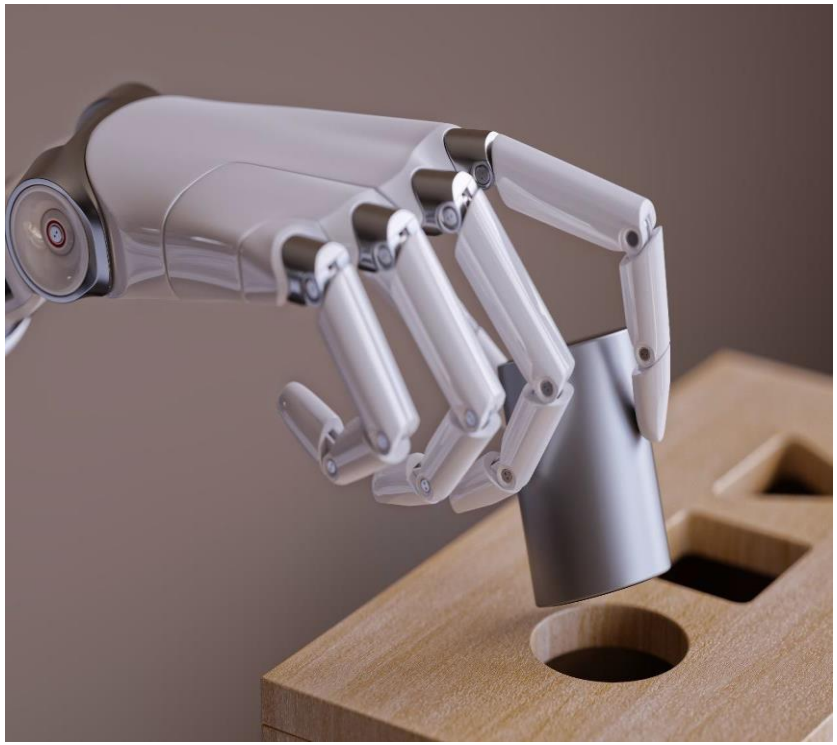
Intelligence

The ability of an agent
to perceive an environment
and to choose actions
that increase its chances
of achieving a goal
by learning, knowledge,
reasoning, planning, etc.

Artificial Intelligence

Types of Intelligence

Natural intelligence



Artificial intelligence

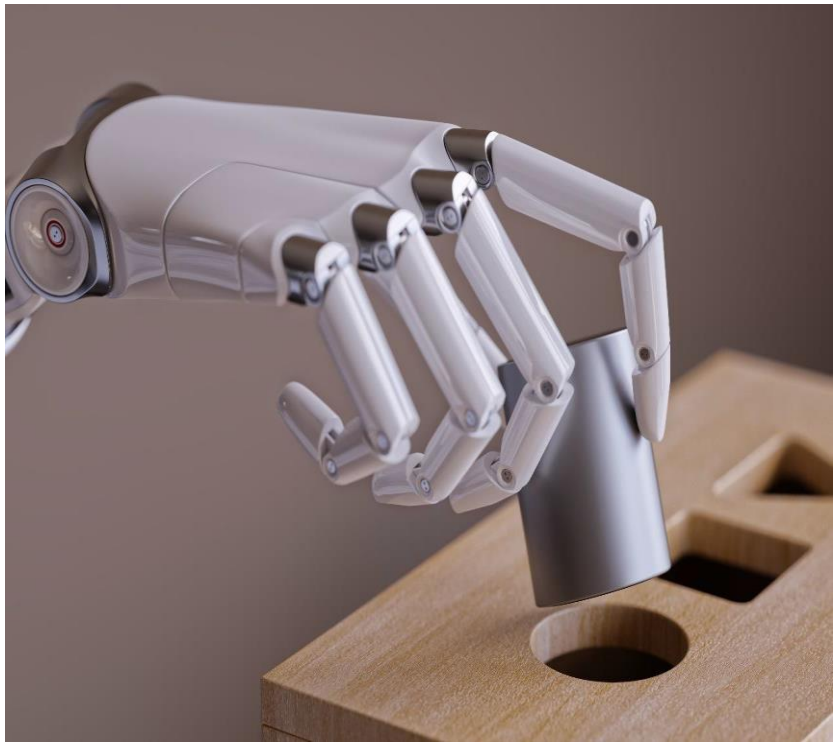
Types of Intelligence

Natural intelligence

Artificial intelligence

Types of Intelligence

Natural intelligence



Artificial intelligence

Artificial Intelligence

The ability of a machine
to replicate natural intelligence

Artificial Intelligence

The ability of a machine
to perceive an environment
and to choose actions
that maximize
the expected likelihood
of achieving a goal

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Artificial Intelligence

Anything a human can do
but a machine cannot yet do

Components of A.I.

Components of Artificial Intelligence

Perception

Learning

Knowledge

Reasoning

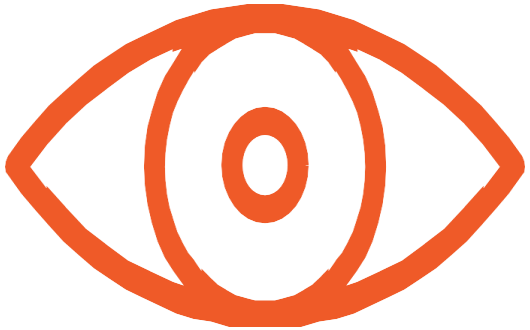
Planning

Perception

Deduce state from sensors

Recognize patterns

Detect features

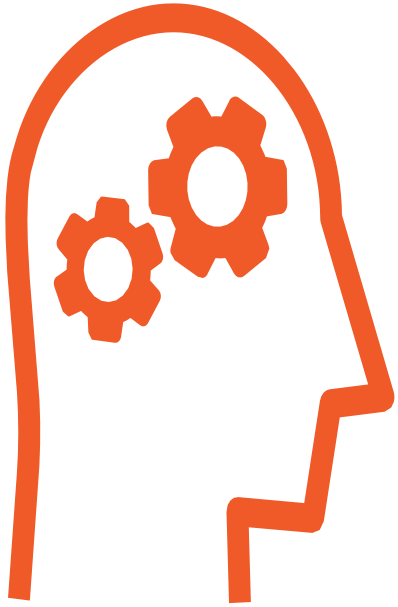


Learning

Extract knowledge

Data in, action out

Maps state to action



Knowledge

Represent learning

Collection of information

Various representations

Reasoning

Infer conclusions

Deduction

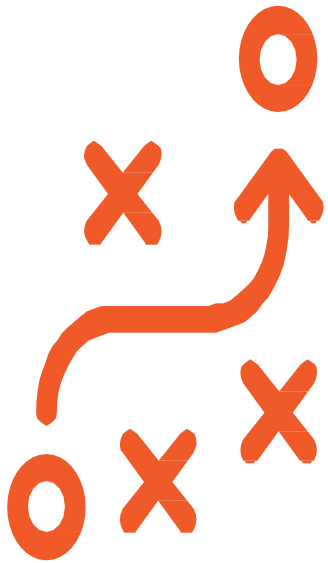
Induction

Planning

Set and achieve goals

Visualize future states

Predict actions



Components of Artificial Intelligence

Perception

Learning

Knowledge

Reasoning

Planning

Applications of A.I.

Examples of A.I.

Customer Service

FAQ generators

Chat bots

Voice assistants

Finance

Trading algorithms

Fraud detection

Portfolio management

Healthcare

Diagnostic tools

Treatment recommendation

Prescription verification

Manufacturing

Product design

Industrial robots

Defect detection

Marketing

Advertisement optimization

Sentiment analysis

Product recommendation

Transportation

Warehouse robots

Route optimization

Delivery drones

Types of A.I.

Introduction

1. Definition of AI
2. Example Systems
3. Approaches to AI
4. Brief History

What is AI?

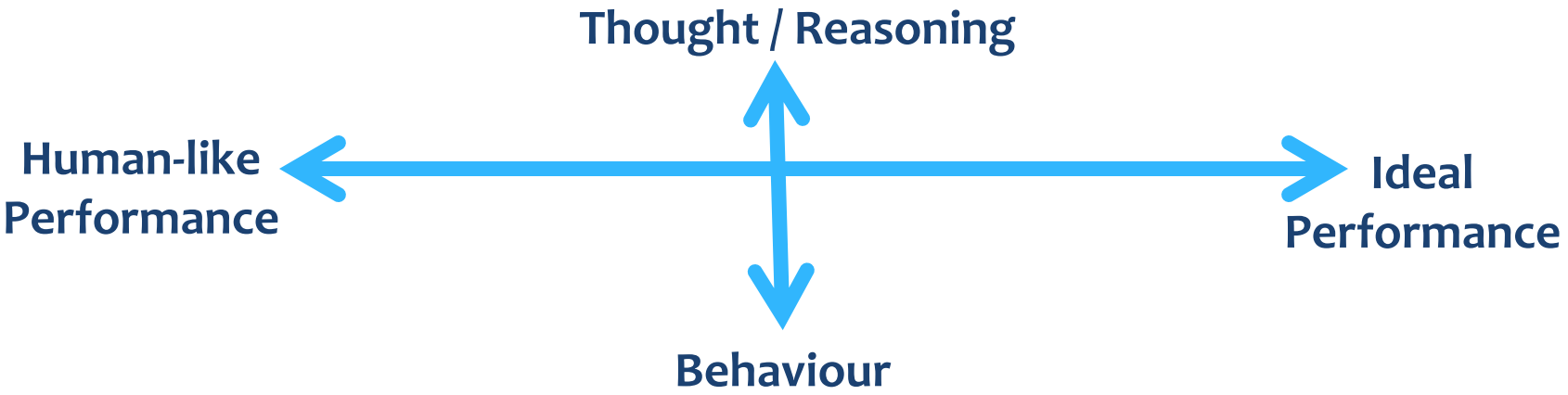
* Artificial Intelligence
  * Is concerned with the design of intelligence in an artificial device
  * Term coined by McCarthy in 1956

What is AI?

* Artificial Intelligence is concerned with the design of intelligence in an artificial device
* What is Intelligence?
* Humans?
  * Behave as intelligently as a human
  * Behave in the best possible manner
  * Thinking?
  * Acting?

Definitions of AI

* Thought processes / reasoning Vs behavior
* Human-like performance Vs Ideal performance



Introduction

Views of AI fall into four categories:

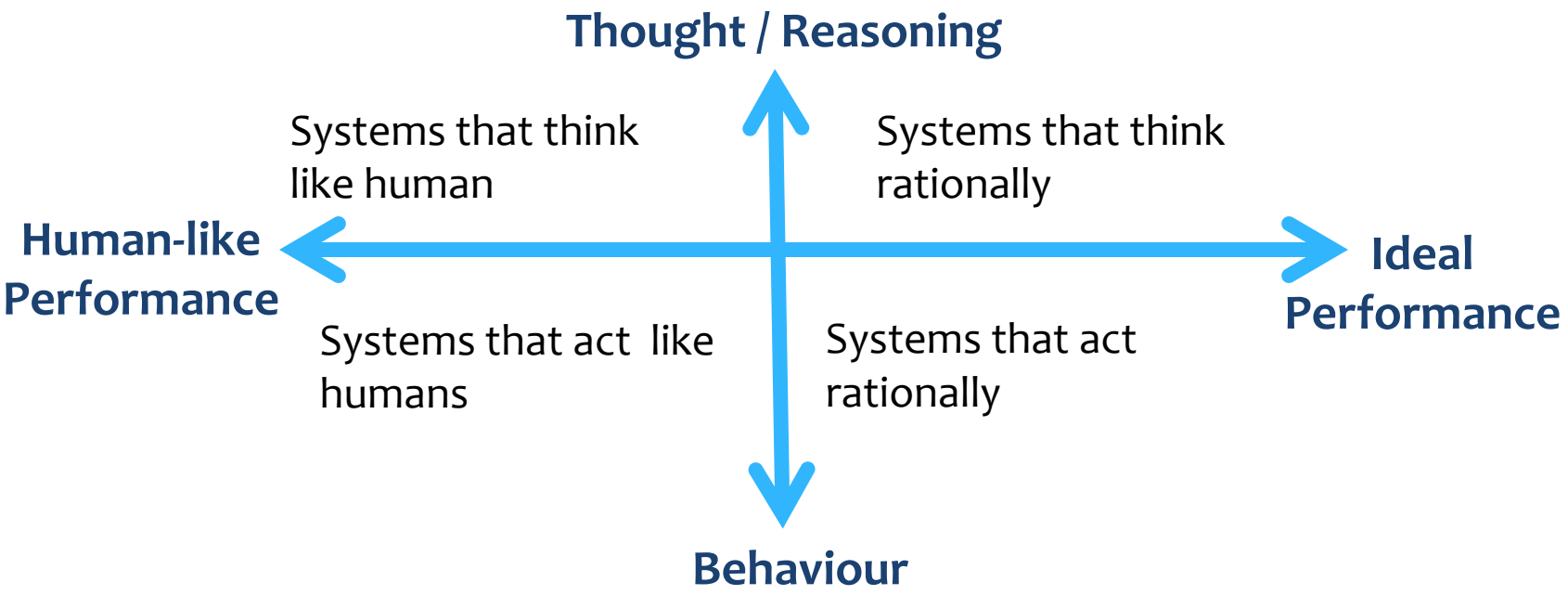
Thinking humanly

Thinking rationally

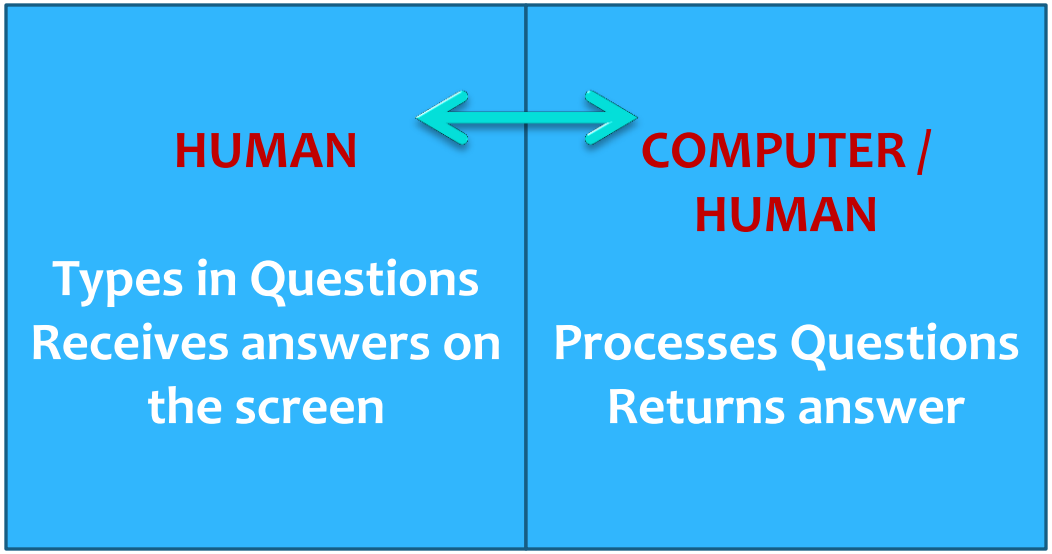
Acting humanly

Acting rationally

Approaches to AI



The Turing Test



Both claim to be human

The Turing Test: Result

If the interrogator cannot reliably distinguish human from the computer, then

the computer possess intelligence

Typical AI Problems

* Intelligent entities or agent need to be able to do both mundane and expert tasks
* Mundane Tasks
  * Planning route, activity
  * Recognizing people or objects
  * Communicating through natural language
  * Navigating around obstacles on the street
* Expert Tasks
  * Medical diagnosis
  * Mathematical problem solving

What is easy and What is hard?

* It has been very hard to mechanize tasks that animals can do
  * Walking around without walking into things
  * Catching prey and avoiding predators
  * Interpreting complex sensory information
  * Modeling the internal states of other animals from their behavior

Intelligent Behavior

* Perception
* Reasoning
* Learning
* Understanding language
* Solving problems

Examples Systems

* Applications of AI
  * Computer Vision
  * Image recognition including face recognition
  * Robotics
  * NLP, NLU, Speech Processing etc.

Practical Impact of AI

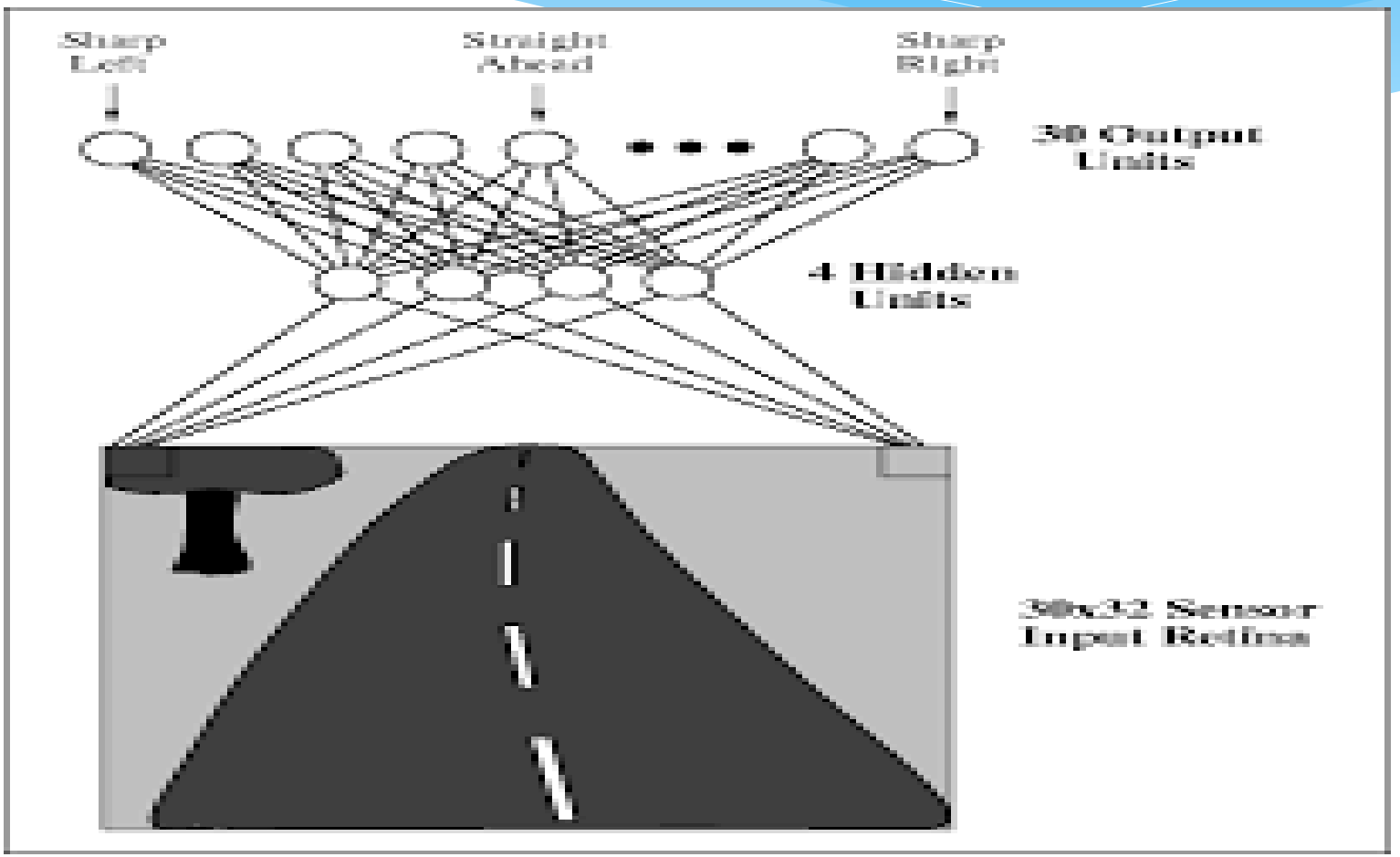
* AI components are embedded in numerous devices. Eg. copy machines
* AI Systems are in everyday use
  * Detecting credit card fraud
  * Configuring products
  * Aiding Complex Planning tasks
  * Advising physicians
* Intelligent tutoring systems provide students with personalized attention

Autonomous Land Vehicle In a Neural Network (ALVINN)

- ALVINN is an automatic steering system for a car based on input from a camera mounted on the vehicle.
  - Successfully demonstrated in a cross-country trip.

Dean Pomerleau
CMU

Autonomous Land Vehicle in a Neural Network



Deep Blue

* 1997: The Deep blue chess program beats the world chess champion, Gary Kasparov, in a widely followed match

IBM's Deep Blue

- By 1997 IBM's Deep Blue chess machine beat then World Champion, Garry Kasparov by two wins against one win and three draws.
- This marked the first time in human history that a machine had ever defeated a World Champion.

Machine Translation

* US military was giving a simpler one way translation device which were used in Iraq.

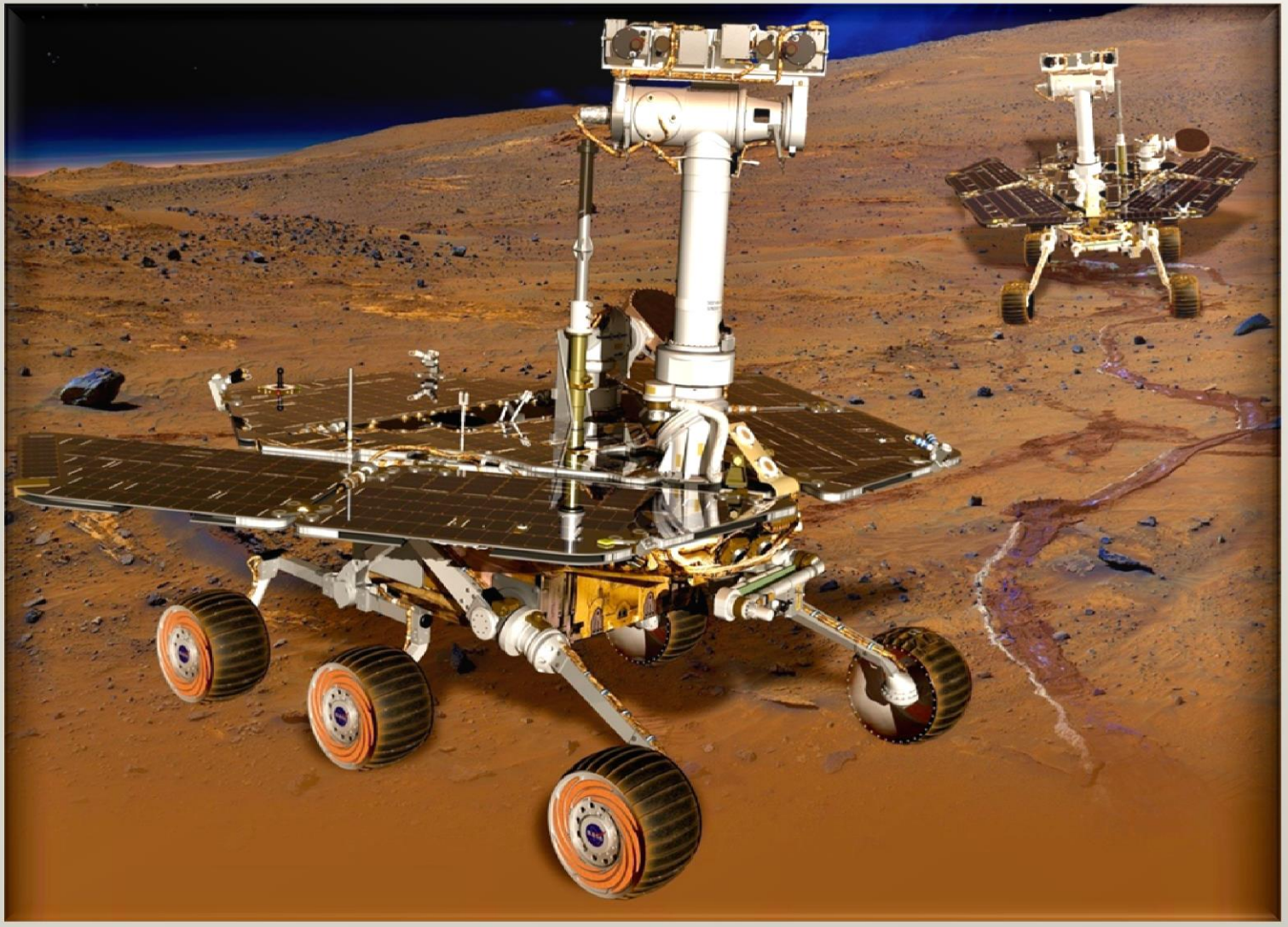
* US forces are using the Phraselator to communicate with injured Iraqi prisoners of war travelers at checkpoints and for other peace keeping duties.

Machine Translation

* Carnegie Mellon University was working on a system called the speechlator for use in doctor patient interview.

Mars Exploration Rover Mission

* In space exploration robotic space probes autonomously monitor their surroundings, make decisions and act to achieve their goals.



Internet Agents

* The explosive growth of the Internet has also led to growing interest in Internet Agents to
  * Monitor user's tasks
  * Seek needed information
  * Learn which information is more useful

Approaches to AI

Strong AI

* aims to build machines that can truly reason and solve problems.
* Strong AI are machines are self aware and whose overall intellectual ability is indistinguishable from that of a human being.
  * Human like
  * Non-human like

Contd…

Weak AI

* Deals with the creation of some Artificial Intelligence that cannot truly reason and solve problems but act as if it were intelligent.
* weak AI claim that machines which have been suitably programmed can simulate human cognition
* strong AI deals with machines that really have mental states that think, reason, understand their behavior

Contd…

Applied AI

* Aims to produce commercially viable smart systems.
* For example, a security system that is able to recognize the faces of people who are permitted to enter a particular building.

Contd…

Cognitive AI

Computers are used to test theories about how the human mind works.

For example, theories about how we recognize faces and other objects or about how we solve abstract problems

AI Topics

* **Core Areas**
  * Knowledge Representation
  * Reasoning
  * Machine Learning
* **Perception**
  * Vision
  * Natural Language
  * Robotics
* **Uncertainty**
  * Probabilistic Approaches

Contd…

* **General Algorithms**
  * Search
  * Planning
  * Constraint Satisfaction
* **Applications**
  * Game Playing
  * AI and Education
  * Distributed Agents
* **Decision Theory**
* **Reasoning with symbolic data**

AI Technique

* Intelligence requires Knowledge
* Knowledge possesses less desirable properties such as:
  * Voluminous
  * Hard to characterize accurately
  * Constantly changing
  * Differs from data that can be used

Contd…

* AI technique is a method that exploits knowledge that should be represented in such a way that:
  * Knowledge captures generalization
  * It can be understood by people who must provide it
  * It can be easily modified to correct errors.
  * It can be used in variety of situations

Introductory Problem: Tic-Tac-Toe

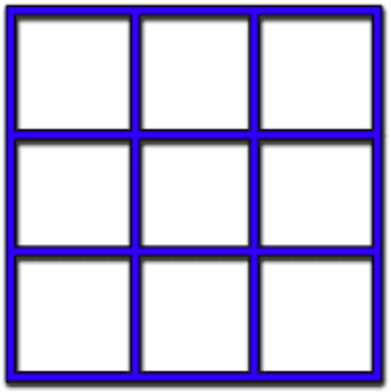
* Also known as **Noughts** and **Crosses**
* **X**s and **O**s

The player needs to take turns marking the spaces in a 3x3 grid with their own marks,

if 3 consecutive marks (**Horizontal**, **Vertical**, **Diagonal**) are formed then the player who owns these moves get won.

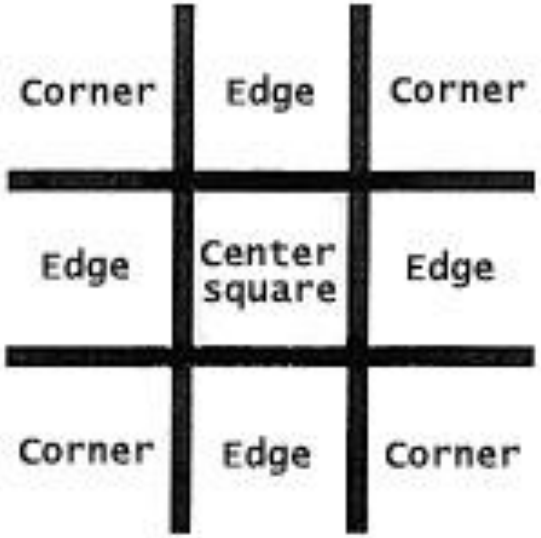
Contd…

Board Structure



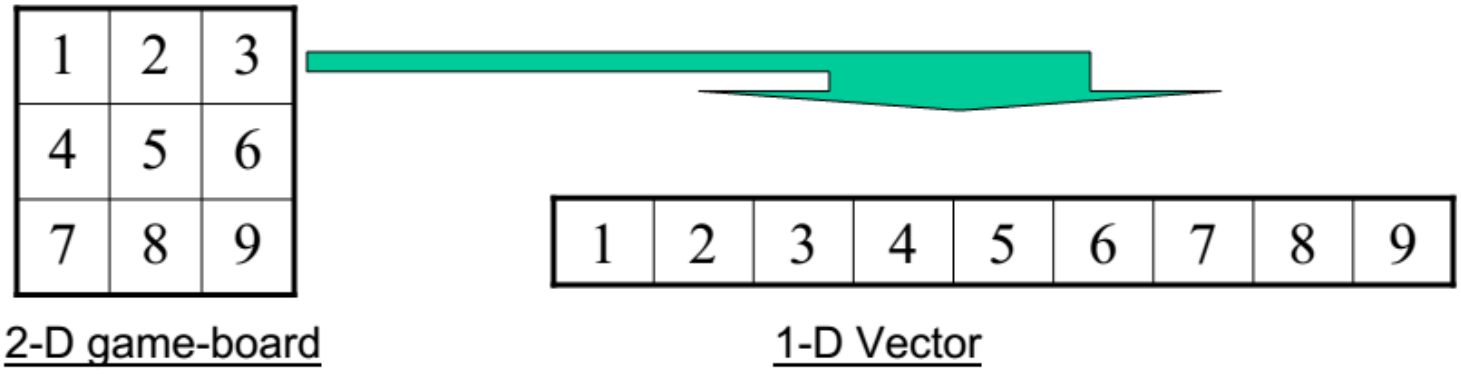
Contd…

Cells can be represented as



Contd…

Number each square from 1 to 9



Contd…

* **Consider a Board having nine elements vector. Each element will contain**
  * 0 for blank
  * 1 indicating X player move
  * 2 indicating O player move
  * Computer may play as X or O player. First player is always X.

Contd..

* **Move Table**
  It is a vector of 3^9 elements, each element of which is a nine element vector representing board position.
  Total of 3^9(19683) elements in move table
  Move Table

*

Index	Current Board position	New Board position
0	000000000	000010000
1	000000001	020000001
2	000000002	000100002
3	000000010	002000010
.		

Tic Tac Toe Algorithm

To make a move, do the following:

* View the vector (board) as a ternary number and convert it to its corresponding decimal number.
* Use the computed number as an index into the move table and access the vector stored there.
* The vector selected in step 2 represents the way the board will look after the move that should be made. So set board equal to that vector.

Contd…

Step 1: Now our board looks like **000 000 000** (ternary number) convert it into decimal no. The decimal no is **0**

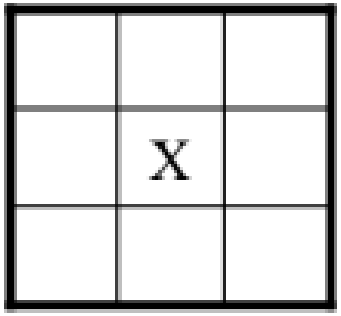
Step 2: Use the computed number ie **0** as an index into the move table and access the vector stored in New Board Position. The new board position is **000 010 000**

Step 3: The vector selected in step 2 (**000 010 000**) represents the way the board will look after the move that should be made. So set board equal to that vector.

Contd…

After completing the 3rd step your board looks like

000 010 000



X		X
	O	

Limits of AI

* **Successful AI Systems**
  * Operates in well defined domains
  * Employ narrow specialized knowledge

* **Commonsense Knowledge**
  * Needed in complex, open-ended worlds
  * Understand unconstrained natural language

What can AI Systems Do?

* **Computer Vision:** Face Recognition
* **Robotics:** autonomous
* **Natural Language Processing:** Simple machine translation
* **Expert Systems:** Medical diagnosis in a narrow domain
* **Spoken Language:** 1000 word continuous speech
* **Planning and scheduling:** Hubble Telescope experiments

Contd…

* **Learning:** Text categorization into ~1000 topics
* **Games:** Grand master level in chess (World Champions, Checkers, etc)

What AI Systems Can't do yet!!

* Understand natural language robustly

  Eg: Read and understand articles in a newspaper
* Surf the web
* Interpret an arbitrary visual scene
* Learn a natural language
* Construct plans in dynamic real time domains

Tic-Tac-Toe

* Three programs are presented :
  * Series increase
  * Their complexity
  * Use of generalization
  * Clarity of their knowledge
  * Extensibility of their approach

Tic-Tac-Toe

Program 1: Data Structures

Board:

9 element vector representing the board, with 1-9 for each square.

An element contains the value 0 if it is blank, 1 if it is filled by X, or 2 if it is filled with a O

Movetable:

A large vector of 19,683 elements (3^9), each element is 9-element vector.

Contd…

Algorithm:

1. View the vector as a ternary number. Convert it to a decimal number.
2. Use the computed number as an index into Move-Table and access the vector stored there.
3. Set the new board to that vector.

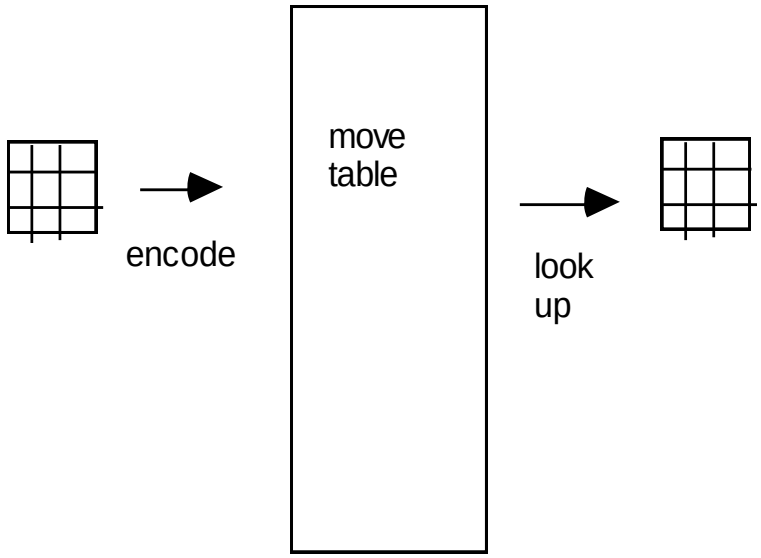
Contd…

Comments:
This program is very efficient in time.

1. A lot of space to store the Move-Table.
2. A lot of work to specify all the entries in the Move-Table.
3. Difficult to extend.

Tic Tac Toe #1

- Precompiled move table.
- For each input board, a specific move (output board)
- Perfect play, but is it AI?



Contd…

1	2	3
4	5	6
7	8	9

Program - 2

Program 2: Data Structure:

A nine element vector representing the board. But instead of using 0,1 and 2 in each element, we store 2 for blank, 3 for X and 5 for O

Contd…

Functions:

Make2 : returns 5 if the center sqaure is blank. Else any other balnk sq – No Corner square

Posswin(p): Returns 0 if the player p cannot win on his next move; otherwise it returns the number of the square that constitutes a winning move.

If the product is 18 (3x3x2), then X can win.

If the product is 50 (5x5x2) then O can win.

Go(n): Makes a move in the square n; 3 if turn is odd, 5 if turn is even

Contd…

Strategy:

Turn = 1	Go(1)
Turn = 2	If Board[5] is blank, Go(5), else Go(1)
Turn = 3	If Board[9] is blank, Go(9), else Go(3)
Turn = 4	If Posswin(X) ≠ 0, then Go(Posswin(X))

…….

Contd…

Comments:

1. Not efficient in time, as it has to check several conditions before making each move.
2. Easier to understand the program's strategy.
3. Hard to generalize.

Contd…

Change in the representation of the board

MAGIC SQUARE

8	3	4
1	5	9
6	7	2

15 – (8 + 5)

Contd…

* List for each player is maintained.
* Each pair of squares owned by the player; compute the difference between 15 and the sum of two squares
* If the difference is not positive or greater than 9 then the original two squares can be ignored.
* Square representing the difference is blank; a move will produce a win

Contd…

Comments:

1. Checking for a possible win is quicker.
2. Human finds the row-scan approach easier, while computer finds the number-counting approach more efficient.

Tic Tac Toe #2

* Represent board as a magic square, one integer per square
* If 3 of my pieces sum to 15, I win
* Predefined strategy:
  * 1. Win
  * 2. Block
  * 3. Take center
  * 4. Take corner
  * 5. Take any open square

Program 3

Data Structure

Contains a list of board positions that could result from the next move and a number representing how likely the board position is

Program 3

1. If it is a win, give it the highest rating.
2. Otherwise, consider all the moves the opponent could make next. Assume the opponent will make the move that is worst for us. Assign the rating of that move to the current node.
3. The best node is then the one with the highest rating.

Contd..

Comments:

1. Require much more time to consider all possible moves.

2. Could be extended to handle more complicated games.

Tic Tac Toe #3

* 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!

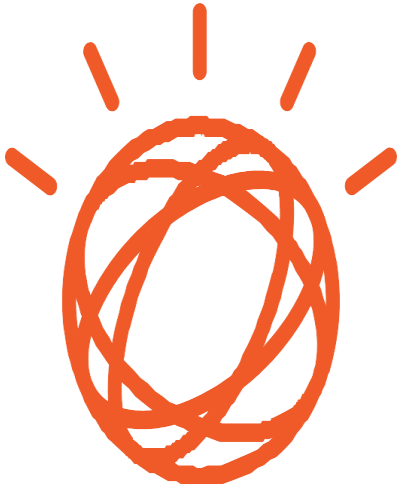
Types of A.I.

Artificial narrow intelligence

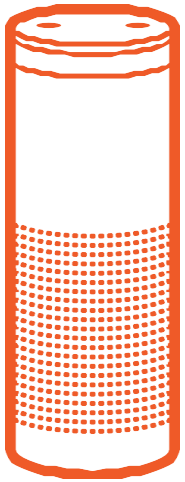
Artificial general intelligence

Artificial super intelligence

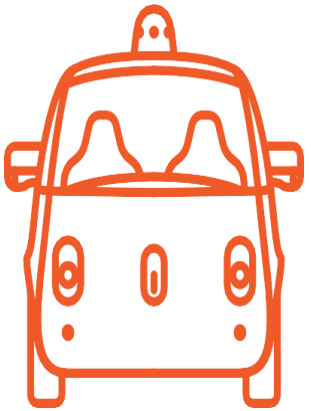
Artificial Narrow Intelligence



IBM
Watson

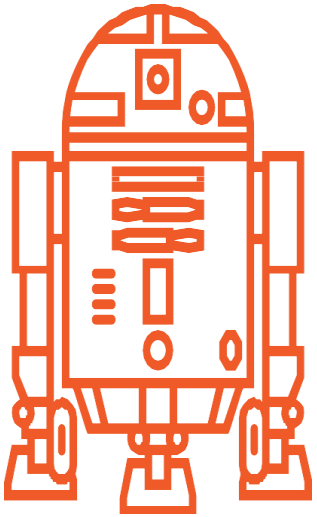


Amazon
Alexa

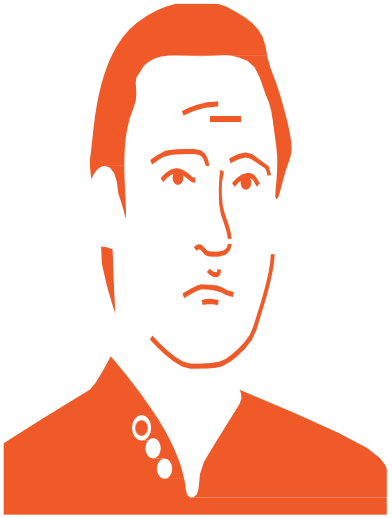


Google
Waymo

Artificial General Intelligence



R2D2



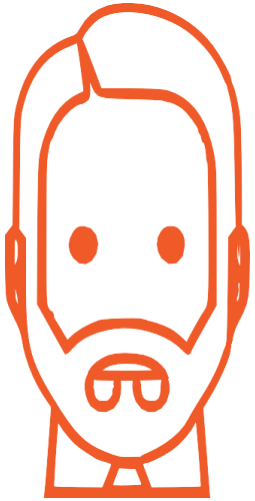
Data

HAL 9000

Artificial Super Intelligence

Skynet

Ultron



The Architect

AI History

* The dream of making computers imitate us started centuries ago

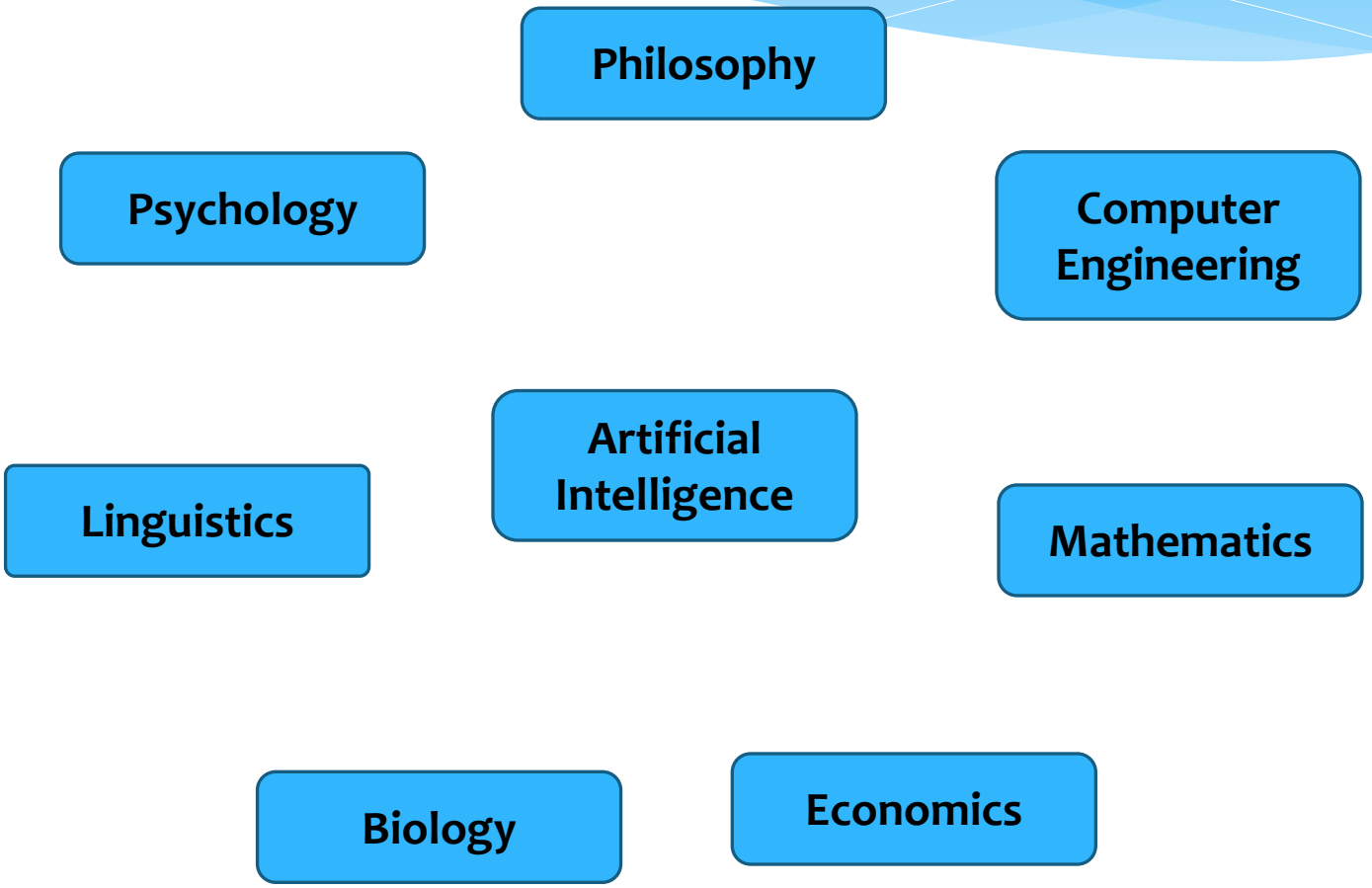
* Intellectual roots of AI stretch back thousands of years into the earliest studies of nature of knowledge and the nature of reasoning

* The concept of intelligent machines is found in Greek mythology.

Contd…

* In 8th century - Pygmalion
* Hephaestus created a huge robot Talos to guard Crete.

Foundations of AI



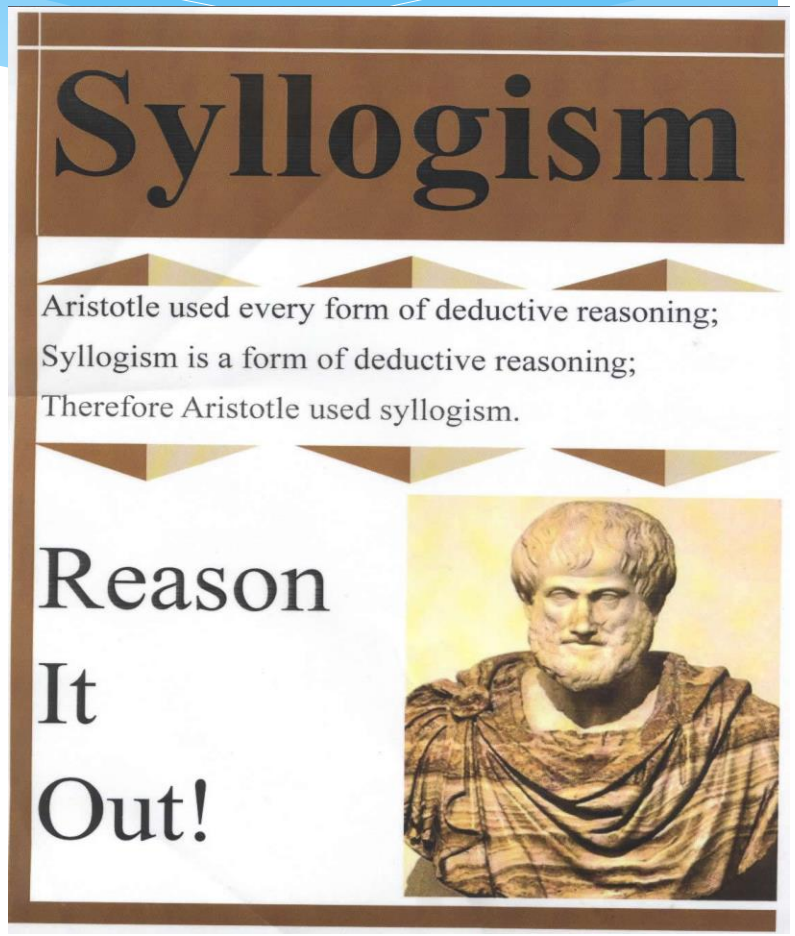
AI History

* **Philosophers** have analyzed the **nature of knowledge** and have explored formal frameworks for **developing conclusions.**
* There have been mathematical **formalizations in logic**, in **computation and probability.**
* Economists have developed **decision theory**

How does the brain process information?

* Psychologists have studied human cognition
  -- knowledge about the nature of human intelligence
* How do we build an efficient computer?

* **Aristotle** (384-322BC) developed an informal system of syllogistic logic , the first formal deductive reasoning system

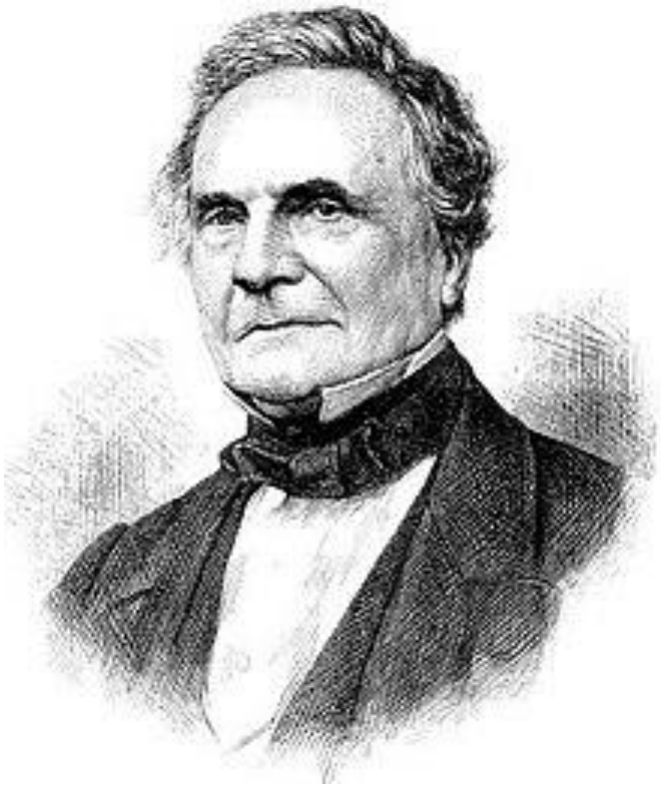


* In the 13th century, **Ramon Lull** a Spanish theologian invented the idea of a machine that would produce all knowledge by putting together words at random.

* In the 17th century **Descartes** proposed that bodies of animals are nothing more than complex machines.

Blaise Pascal in 1642 built the first mechanical digital calculating machine.

* **Leibniz** in 1673 improved Pascal's machine.



* In 19th century **George Boole** developed a binary algebra representation which laid the foundation of Boolean algebra. **Charles Babbage** and **Lady Ada Byron** worked on programmable mechanical calculating machines.

Contd…

* In the late 19th century and the early 20th century mathematical philosophers like
  * Gottlob Frege,
  * Bertram Russell,
  * Alfred Whitehead and
  * Kurt Gödel

  built on Boole's initial logic concepts to develop mathematical representations of logic problems.

Advent of Computer

* The advent of electronic computers really provided a revolutionary advance in our ability to study intelligence.

History Contd…

* In 1943 McCulloch and Pitts built a Boolean circuit model of the brain.
* A Logical Calculus of Ideas existing in Nervous Activity was published
* It explained for the first time how it is possible for neural networks to compute.

SNARC

* Marvin Minsky and Dean Edmonds built the SNARC in 1951 which is a neural network computer.
  * A neural network computer
  * Used 3000 vacuum tubes
  * Network with 40 neurons

* In **1950 Turing** published his computing machinery and intelligence and this article articulated a complete vision of AI

* Solving problems, how AI systems can solve problems by searching through a space of possible solutions guided by heuristics.

* Illustrated his ideas on machine intelligence by reference to chess. He propounded the possibility of letting the machine alter its own instructions so that machines can learn from experience.

* In 1952 - 56 Samuel designed a checkers playing program.
* In 1956 Allen Newell and Albert Simon designed the logic theorist.
* Then the general problem solver was built by the same people.
* In 1959 Gelernter developed the geometry engine for solving plane geometry problems.

* In 1961 James Slagle wrote the first symbolic integration program.
* This program saint could solve calculus problems at the college freshman level.
* In 1963 Thomas Evan's program analogy was designed, it could solve IQ test problems.
* In 1963 Feigenbaum and Feldman wrote a collection of important articles about AI.

* In 1964, Danny Bobrow worked with algebra word problems

* In 1965 Allen Robinson developed a resolution method.

* In 1966 to 74 there was a lot of work on computational complexity by not really AI researchers but by computer theorists which had a tremendous impact on the field of AI.

* In 1967 Feigenbaum and others developed a general program which was demonstrated and used to demonstrate and interpret mass spectrum on organic chemical compounds.

* In 1968 there was a very significant paper by Minsky and Papert which demonstrated the limits of simple neural net.

* In 1969 SRI robot, Shakey in Stanford demonstrated locomotion perception and problem solving.
* In 1969 to 79 knowledge based systems were developed.
* In 1976 Doug Lenat handled the program called AM and Heurisko demonstrated the discovery model.
* In 1978 Herbert Simon from CMU won the Nobel Prize in Economics for his theory of bounded rationality.

* In 1980 lisp machines were developed and marketed.
* In 1985 to 95 neural networks returned to popularity.
* In 1988 there was a resurgence of probabilistic and decision theoretic methods.
* Earlier AI systems used very general systems of little knowledge
* Recent AI systems use specialized knowledge to perform specific tasks.

* In 1990s there have been major advances in all areas of AI including
  * machine learning,
  * intelligent tutoring,
  * multi agent planning,
  * uncertain reasoning,
  * natural language understanding,
  * translation,
  * vision and other topics.

  Rodney Brooks worked on the cog project at MIT which made significant progress in building a humanoid robot.

* Interactive robot pets which have become commercially available realizing the vision of the 18th century toy makers.

* In 2000 the nomad robot explored remote regions of Antarctica and AI is a popular topic which is constantly in the news.

AI & Search

* "The two most fundamental concerns of AI researchers are *knowledge representation* and *search*"
* *"knowledge representation* … addresses the problem of capturing in a language…suitable for computer manipulation"
* "*Search* is a problem-solving technique that systematically explores a space of problem states".

Test Yourself!!!

* Define Intelligence.
* What are the different approaches of AI?
* If you are designing a machine to pass a Turing Test, what are the capabilities a machine must have?
* Design atleast 10 questions to check man / machine that takes a Turing Test.

Test Yourself!!!

* List at least FIVE tasks that you like computers to do in next 5 years.
* List FIVE tasks that you think computers will not be able to do in next 10 years.

TEXT BOOKS

Artificial Intelligence, 2nd Edition

- ✓ E. Rich and K. Knight
- ✓ TMH

Artificial Intelligence A Modern Approach

- ✓ S. Russell and P. Norvig
- ✓ Pearson Education