The Fifth Generation System
Artificial Intelligence

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On the occasion of "National Science Day – February 28, 2007", The Institute of Engineers (India), Madhya Pradesh State Center, Bhopal invited me to deliver a lecture. Given the choice, I preferred to choose "The Fifth Generation System - Artificial Intelligence" as the topic of my talk.

The discipline of Artificial Intelligence (AI) is fairly young, was born in the summer of 1956 at Dartmouth College in Hanover, New Hampshire. John McCarthy was first to coin of the term "Artificial Intelligence" in his 1955 proposal for the 1956 Dartmouth Conference. Since then half a century has passed, and AI has come a long way. The AI community took many bold decision during July 9-16, 2006, celebration of "50th Anniversary Summit of Artificial Intelligence" at Centro Steno Franscini – Monte Verita Switzer Land.

I extended my talk over 50 slides, tried to give an over view of computer systems since 1940, the first generation to till today the fourth generation and then from 1956 the Fifth Generation System - Artificial Intelligence. The subject matter included definition and goals of AI, approaches, techniques that make systems to behave as "Intelligent" - Describe and match, Goal reduction, Constraint satisfaction, Tree Searching, Rule based systems, and the biology inspired "Artificially Intelligent" techniques - Neural Networks, Genetic Algorithms, Reinforcement learning. Also, included the applications of AI - Game playing, Speech Recognition, Understanding Natural Language, Computer Vision, Expert Systems were. Finally the talk was concluded taking a note from the "50th Anniversary Summit of Artificial Intelligence - 2006" that the natural intelligence is far from being understood and the artificial forms of intelligence is still very primitive. Simple tasks like object manipulation and recognition - which a 3-year-old can do - have not yet been realized artificially.

Assuming that the target audience would be scientists and engineer from different discipline, the presentation slides included many schematics and examples for easy understanding.

February 28, 2007 R.C. Chakraborty

Celebration of National Science Day

February 28, 2007

The Institution of Engineers (India),

Madhya Pradesh State Centre, Bhopal

Sir Chandrasekhara Venkata Raman
(N0v. 7, 1888 - Nov. 21, 1970)

Published his work on the "Molecular Diffraction of Light", the first of a series of investigations with his collaborators which ultimately led to his discovery, on the 28th of February, 1928, of the radiation effect which bears his name ("A new radiation", Indian J. Phys., 2 (1928) 387), and which gained him the 1930 Nobel Prize in Physics.

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Artificial Intelligence

By

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AT

The Institution of Engineers (India)

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The Fifth Generation System

Artificial Intelligence

- **Artificial intelligence (AI) has a unique place in science, sharing borders with mathematics, computer science, philosophy, psychology, biology, cognitive science and others.**

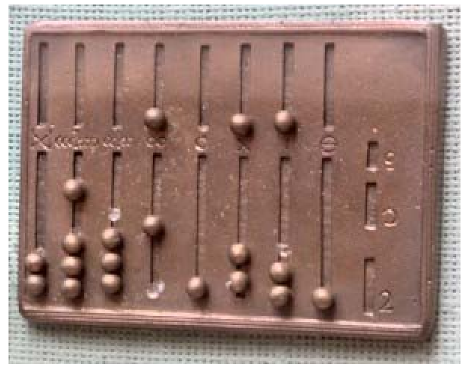
- **Although there is no clear definition of Artificial Intelligence or even Intelligence, it can be described as an attempt to build machines that like humans can *think* and *act*, able to *learn* and use *knowledge* to *solve problems* on their own.**

- **Researchers are creating systems which can mimic human thought, understand speech, beat the best human chess player, and countless other feats never before possible.**

▶ Roots of AI - 5,000 years ago

The Complexity in accounting for crops, land, populations, etc., grew. So machines with memory emerged to help calculation and to keep computation trail to track errors. The first computational device Abacus originated in the Far East roughly 5,000 years ago.

An abacus is a calculation tool is still used by merchants in China, Japan, Hong Kong, Africa and elsewhere. The Roman abacus shown, contains 8 long grooves containing up to 5 beads in each and 8 shorter grooves having either one or no beads in each.



Reconstructed Roman Abacu
(The original is bronze in Paris.)

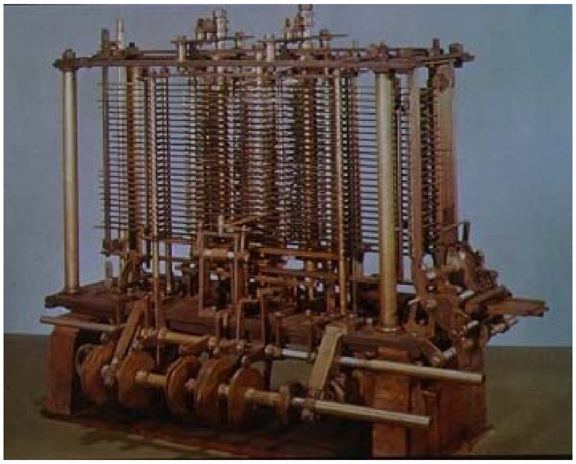
- **Calculating machines :**

  <u>Pascal (1623-62),</u> the French mathematician and philosopher designed calculating machines that mechanized arithmetic, but never claimed that the devices could think.

Pascaline, by Pascal in 1652

- **Analytical Engine:**

  Charles Babbage (1791-1871), the English mathematician in 1822, came up with programmable mechanical calculating machines as Difference Engine. It consists of columns, numbered from 1 to N, each to store one decimal number. The only operation the engine can do is add the value of column n + 1 to column n.



Difference engine by Babbage in 1849.

- **The Calculus of Logic - Boolean algebra**

George Boole (1815-1864), the English mathematician and logician published "An Investigation of the laws of Thought", in1854, on which Mathematical Theories of Logic and Probabilities are based upon. He used multiplication, addition and subtraction which respectively correspond to the symbolic operations of the logical AND, OR and NOT.

Example of Algebraic manipulation of logical statements :

Take two statements,

"A" is all new cars

"B" is all red cars

Then combine them, using x for AND, and + for OR.

A + B is all cars that are either new OR red,

A x B (ie A times B) is all cars that are both new AND red.

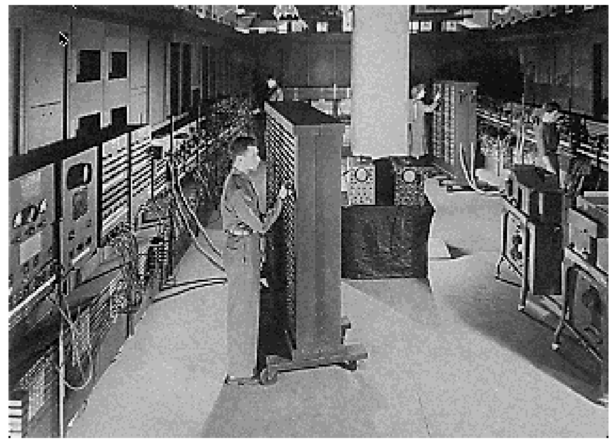
- **Turing Machine**

  Alan Turing(1912-1954), the English mathematician and logician, published "Computing Machinery and Intelligence"(1950). The Turing machine concept aimed to capture what the *human mind* can do when carrying out a procedure. Turing held that computers would, in time, be programmed to acquire abilities rivaling human intelligence. The Turing machine is 'theoretical,' in the sense that it is not intended actually to be engineered but such as could actually be implemented. Turing machine would read a series of 1's and 0's from a tape. These 1's and 0's described the steps to solve a particular problem or task in sequence. His work is regarded as the foundation of computer science and of the artificial intelligence program.

Digital Computers

<u>ENIAC (1943-1946)</u> : Project PX – the contract was signed on June 5, 1943 by the University of Pennsylvania's and completed on February 14, 1946. This unveiled the invention of "ENIAC" (Electronic Numerical Integrator and Calculator) in 1946, the first completely electronic "general-purpose" computer by Eckert and Mauchly.

Physically, ENIAC was massive compared to modern PC. It contained 17,468 vacuum tubes, 7,200 crystal diodes, 1,500 relays, 70,000 resistors, 10,000 capacitors and around 5 million hand-soldered joints. It weighed 30 tons, size 8x3 x100 feet took 1800 sq. feet, and consumed 150 kW power.



***General View of the ENIAC, 1946*.**

Von Neumann Architecture

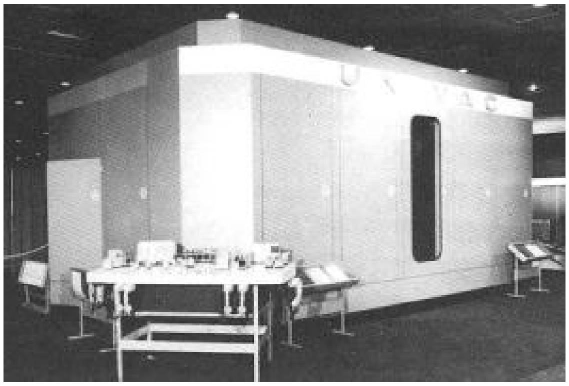
John von Neumann (1903-1957), a mathematician and a chemical engineer, born in Budapest and moved to Princeton in 1932. John von Neumann in 1945, conceived the architecture for the digital computer called "von Neumann architecture".

- In 1950 von Neumann was employed as a consultant to proposed and ongoing advanced technology projects.
- Since then, the electronic computer technology evolved fast: the magnetic memory (small magnetic cores), magnetic tape and the "drum" disks were realized in the early '50s.
- In 1951, the first commercial computer "UNIVAC-I" (UNIVersal Automatic Computer I) hit the market.

- **UNIVAC-I (UNIVersal Automatic Computer I)**

UNIVAC-I (1951) : The first American commercial computer UNIVAC I, designed for business use was delivered to US Census Bureau on March 31, 1951. A total of 46 systems were built and delivered.

UNIVAC-I used 5,200 vacuum tubes, consumed 125 kw, clock 2.25 mhz., memory 1000 words of 12 characters, operations 1,905 per second. The central complex (processor and memory unit) was 4.3 m × 2.4 m × 2.6 m. The complete system occupied more than 350 Sq. ft floor space and weight 13 tons.



UNIVAC I Central Complex, containing the central processor and main memory unit.
Cost $1,250,000 and $1,500,000

- **The notion of "generations"**

  The time line of computer development is often referred to the different generations of computing devices. Each generation of computer is characterized by a major technological development that fundamentally changed the way computers operate, resulting in increasingly smaller, cheaper, more powerful and more efficient and reliable devices.

First Generation	1940 - 1956	Vacuum Tubes
Second Generation	1956 - 1963	Transistors
Third Generation	1964 - 1971	Integrated Circuits
Fourth Generation	1971- Present	Microprocessors
Fifth Generation	Present & Beyond	Artificial Intelligence

- **First Generation - 1940-1956: Vacuum Tubes**

  Used vacuum tubes for circuitry, and magnetic drums for memory, machine language to perform operations, input on punched cards and paper tape, and output on printer, often enormous in power, heat, size, cost. Examples : UNIVAC and ENIAC.

- **Second Generation - 1956-1963: Transistors**

  Transistors invented in 1947 replaced vacuum tubes, allowing computers to become smaller, faster, cheaper, more energy-efficient and more reliable, moved from a magnetic drum to magnetic core technology, continued input on punched cards and paper tape, and output on printer, moved from machine language to assembly languages (specify instructions in words), stored their instructions in their memory. High-level programming languages COBOL and FORTRAN being developed, , which moved from a magnetic drum to magnetic core technology. The first computers of this generation were developed for the atomic energy industry.

- **Third Generation - 1964-1971: Integrated Circuits**

  The first integrated circuit (IC) developed in 1959 became the hallmark of the third generation of computers, the punched cards and print outs were replaced by users interacted through keyboards and monitors and interfaced with an operating system, which allowed the device to run many different applications at one time with a central program that monitored the memory. Computers for the first time became accessible to a mass audience because they were smaller and cheaper.

- **Fourth Generation - 1971-Present: Microprocessors**

  The microprocessor brought the fourth generation of computers, as thousands of integrated circuits were built onto a single silicon chip. The Intel 4004 chip, developed in 1971, located all the components of the computer - from the central processing unit and memory to input/output controls - on a single chip. The computers became small, more powerful, could be linked together to form networks, which eventually led to the development of the Internet. Fourth generation computers also saw the development of GUIs, the mouse and handheld devices.

- **Fifth Generation - Present and Beyond: Artificial Intelligence**

  Fifth generation computing system are based on artificial intelligence and are still in development.

  <u>Conventional computers</u> built during all four generations follow an operational design known as the Von Neumann process.

  ‡ **It can do only what it is instructed to do in a detailed program.**

  ‡ **It cannot assimilate new facts that were not included in the program.**

  <u>Artificial intelligent computers</u> operate in a fundamentally different fashion are primarily symbolic processors. Artificial Intelligence (AI) is the science that automates intelligent behaviors. It is a system that thinks and acts like humans, and rationally. It is the study of mental faculties through the use of computational methods, the use of computers to do symbolic reasoning, pattern recognition, learning, and some forms of inference.

  ‡ **The AI program sorts through its stored memory to determine its own sequence of steps.**

  ‡ **AI systems uses "heuristics," instead of merely preset algorithms.**

  ‡ **Heuristics enable machines to recognize promising approaches to solving problems**

Comparison of Conventional and AI systems

Artificial Intelligence	Conventional Computer
Primarily symbolic processes	Often primarily numeric
Heuristic search (solution steps implicit)	Algorithmic (solution steps explicit)
Control structure is separate from domain knowledge	Information and control integrated together
Easy to modify, update, and enlarge	Difficult to modify
Some incorrect answers often tolerable	Correct answers required
Satisfactory answers usually acceptable	Best possible solution usually sought

1. Artificial Intelligence (AI) - What we expect ?

Computers to do things which, at the moment, people do better".

► **Intelligence**

- It relates to tasks involving higher mental processes.
- It is the computational part of the ability to achieve goals.

Intelligent behavior

- ***Perceive*** **one's environment**
- ***Act*** **in complex environments**
- ***Learn*** **and** ***understand*** **from experience**
- ***Reasoning*** **to solve problems and discover hidden knowledge**
- ***Knowledge*** **applying successfully in new situations,**
- ***Thinking*** **abstractly, using analogies,**
- ***Communicating*** **with others, and more like**
- ***Creativity*, *Ingenuity*, *Expressiveness*, *Curiosity*.**

Understanding AI – Do we have an answer ?

- How knowledge is acquired, represented, and stored ?
- How intelligent behavior is generated and learned ?
- How motives, emotions, and priorities are developed and used?
- How sensory signals are transformed into symbols ?
- How symbols are manipulated to perform logic, to reason about past, and plan for future ?
- How mechanisms of intelligence produce the phenomena of illusion, belief, hope, fear, dreams, kindness and love" ?

2. Goals of AI

- **The definitions of AI gives four possible goals to pursue :**

  1. Systems that think like humans. **2. Systems that think rationally.**

  3. Systems that act like humans **4. Systems that act rationally**

- **Traditionally, all four goals have been followed and the approaches were:**

	Human-like:	Rationally:
Think:	(1) Cognitive science Approach	(2) Laws of thought Approach
Act:	(3) Turing Test Approach	(4) Rational agent Approach

- **Most of AI work falls into category (2) and (4).**

3. AI Approaches

The approaches followed are defined by choosing the goals of the computational model, and basis for evaluating system performance.

3.1 Cognitive science : Think human-like

- **Efforts to make computers think; machines with minds, in the full and literal sense.**
- **Computational model to "how" results were obtained.**
- **Goal is to produce humanlike behavior and produce steps of the reasoning process, as human do.**

3.2 Laws of thought : Think Rationally

- **The study of mental faculties through the use of computational models;**
- **Systems of representation to allow inferences like "Socrates is a man. All men are mortal. Therefore Socrates is mortal."**
- **Goal is to formalize the reasoning process as a system of logical rules and procedures for inference.**

3.3 Turing Test : Act human-like

- **Creating machines that perform functions requiring intelligence when performed by people;**

- **Example : Turing Test**
  - **The machine tries to fool the interrogator to believe that it is the human, and the person also tries to convince the interrogator that it is the human.**
  - **If the machine succeeds in fooling the interrogator, then conclude that the machine is intelligent.**

- **Goal is to develop systems that are human-like.**

3.4 Rational agent : Act Rationally

- **Emulate intelligent behavior in terms of computational processes; it is concerned with the automation of intelligence.**

- **Goal is to develop systems that are rational and sufficient.**

4. AI Techniques

- **Various techniques have evolved. The techniques are concerned with how we represent, manipulate and reason with knowledge in order to solve problems.**

- **Example :**
  - ◇ **Techniques, not all "intelligent" but used to behave are**
    - **Describe and match**
    - **Goal reduction**
    - **Constraint satisfaction**
    - **Tree Searching**
    - **Generate and test**
    - **Rule based systems**
  - ◇ **Biology-inspired "artificially intelligent" techniques**
    - **Neural Networks**
    - **Genetic Algorithms**
    - **Reinforcement learning**

4.1 Techniques that make system to behave as "Intelligent"

- **Describe and Match**

  - **A model is a description of a system's behavior.**

  - **A finite state model consists of a set of states, a set of input events and the relations between them.**

  - **A computation model is a finite state machine. It includes of a set of *states*, a set of *start states*, an input *alphabet*, and a *transition function* which maps input symbols and current states to a *next state*.**

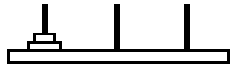
  - **A Representation of computational system include "start" "end", "transition rules". Problem is then to find the appropriate transition rules.**

  - **Example: "Towers of Hanoi puzzle".**

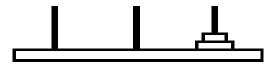
- **Puzzle "Towers of Hanoi" with only 2 disks**

Solve the puzzle :

Initial state



Goal state

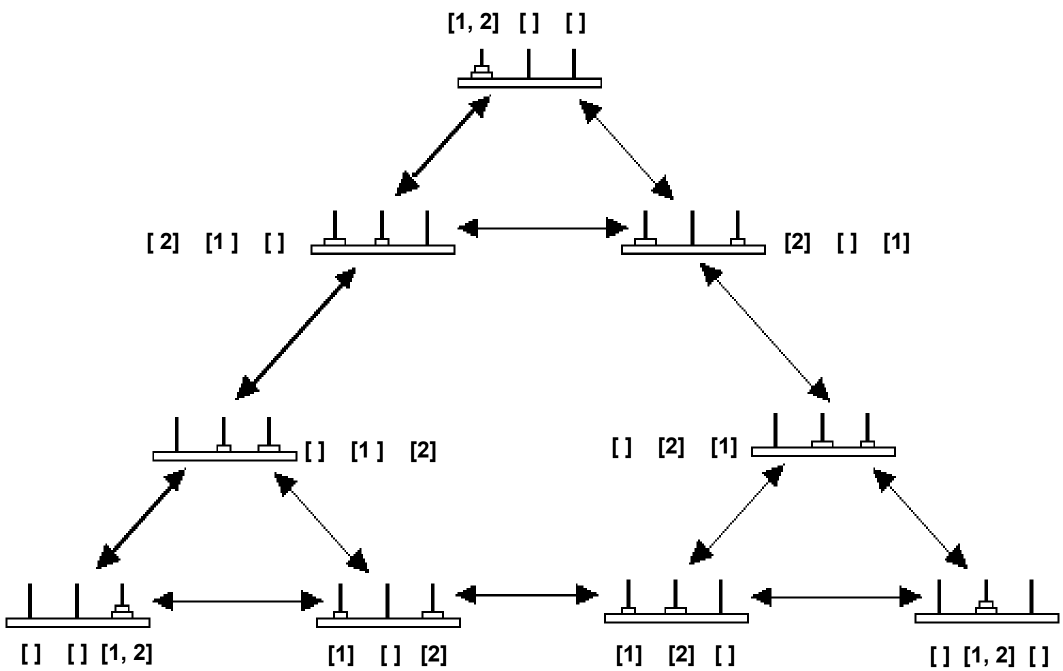


Move the disks on the leftmost post to the rightmost post while

- **never putting a larger disk on top of a smaller one;**
- **move one disk at a time, from one peg to another;**
- **middle post can be used for intermediate storage.**

Play the game in the smallest number of moves possible.

- **Possible state transitions**



- **The shortest solution is the sequence of transitions from the top state downward to the lower left.**

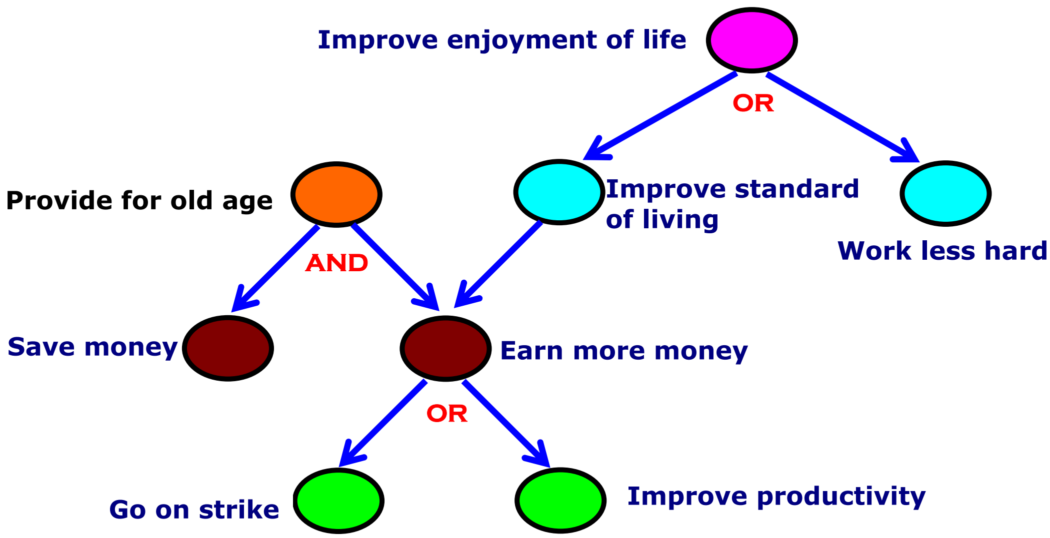
- **Goal Reduction**

  - **The process involves the hierarchical sub-division of goals into sub-goals, until the sub-goals which have an immediate solution are reached.**

  - **Goal-reduction process is illustrated in the form of "AND/OR" tree drawn upside-down.**

  - **An AND-OR tree/graph structure can represent relations between goals and sub-goals, and alternative sub-goals.**

- **Example : AND-OR tree/graph structure to represent facts such as "enjoyment", "earning/save money", "old age" etc.**



◇ **Hierarchical <u>relationships</u> between goals and subgoals:**

e.g.: "going on strike" is a sub-goal of "earning more money", is a sub-goal of "improving standard of living ", is a sub-goal of "improving enjoyment of life".

◇ **<u>Alternative ways</u> of trying to solve a goal:**

e.g.: "going on strike" and "increasing productivity" are alternative ways of trying to "earn more money" (increase pay).

e.g.: "improving standard of living" and "working less hard" are alternative ways of trying to "improve enjoyment of life".

- **Constraint Satisfaction Techniques**

  - **<u>Constraint</u> is a logical relation among variables. e.g. "*circle is inside the square*".**
  - **<u>Constraint satisfaction</u> is a process of finding a solution to a set of constraints.**
  - **<u>Constraint Satisfaction Problem</u> (CSP) and its solution**
    - **Problem (CSP) consists of :**
      - **Variables, a finite set $X = \{x_1, \ldots, x_n\}$,**
      - **Domain, a finite set Di of possible values which each variable xi can take,**
      - **Constraints, a set of values that the variables can simultaneously satisfying of the constraint (e.g. D1 != D2)**
    - **A solution to a CSP is to assign of a value from its <u>domain</u> to every <u>variable</u> satisfying every <u>constraint</u>;:**
      - **one solution, with no preference as to which one,**
      - **all solutions,**
      - **an optimal, or a good solution - Constraint Optimization Problem (COP).**

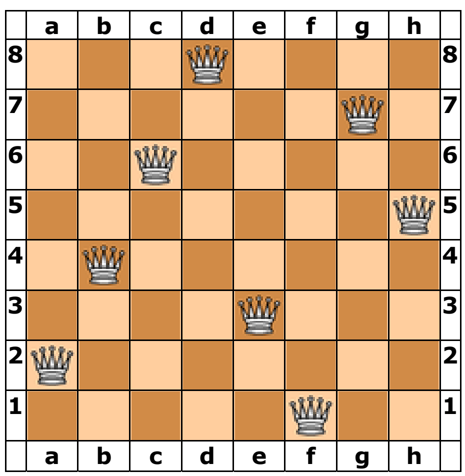
- **Constraint satisfaction has application in Artificial Intelligence, Programming Languages, Symbolic Computing, Computational Logic.**
- **Examples**

  N-Queens puzzle :

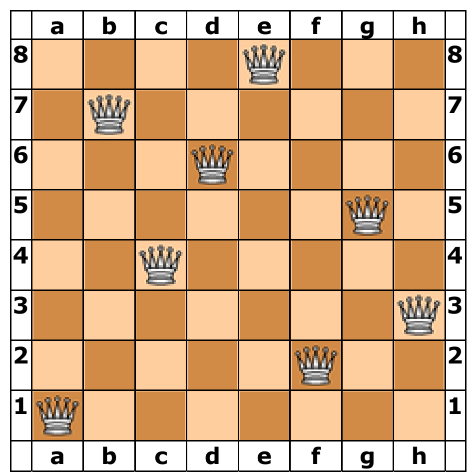
  Problem : Given any integer N, place N queens on N*N chessboard satisfying constraint that no two queens threaten each other (a queen threatens other queens on same row, column and diagonal).

  Solution : To model this problem :

  - Assume that each queen is in different column;
  - Assign a variable Ri (i = 1 to N) to the queen in the i-th column indicating the position of the queen in the row.
  - Apply "no-threatening" constraints between each couple Ri and Rj of queens and evolve the algorithm.
  - **Example : 8 - Queens puzzle**



Unique solution 1



Unique solution 2

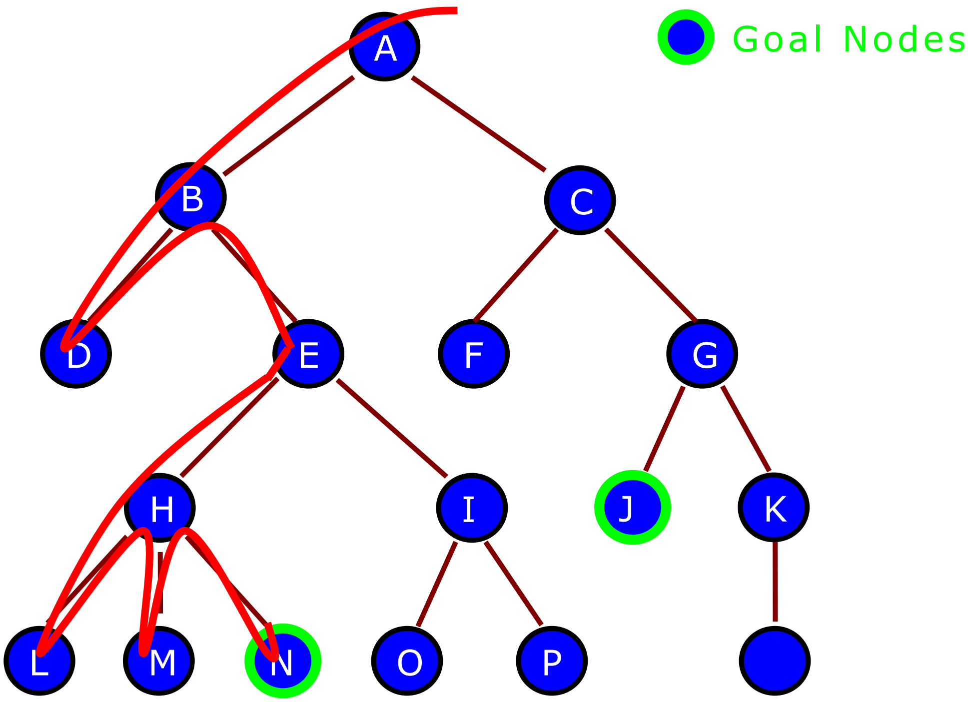
  - The eight queens puzzle has 92 distinct solutions. If solutions that differ only by symmetry operations (rotations and reflections) of the board are counted as one, the puzzle has 12 unique solutions, the two them are presented above.

- **Tree Searching**

  - **Problems** can be described in the form of a search tree. **Solution** to the problem is **finding a path** through this tree.
  - **Tree search strategies:**
    - **Depth-first search**
    - **Hill climbing**
    - **Breadth-first search**
    - **Beam search**
    - **Best-first search**

Depth-first search (DFS)

- **DFS explores a path**
- **Example: Depth-first search tree**



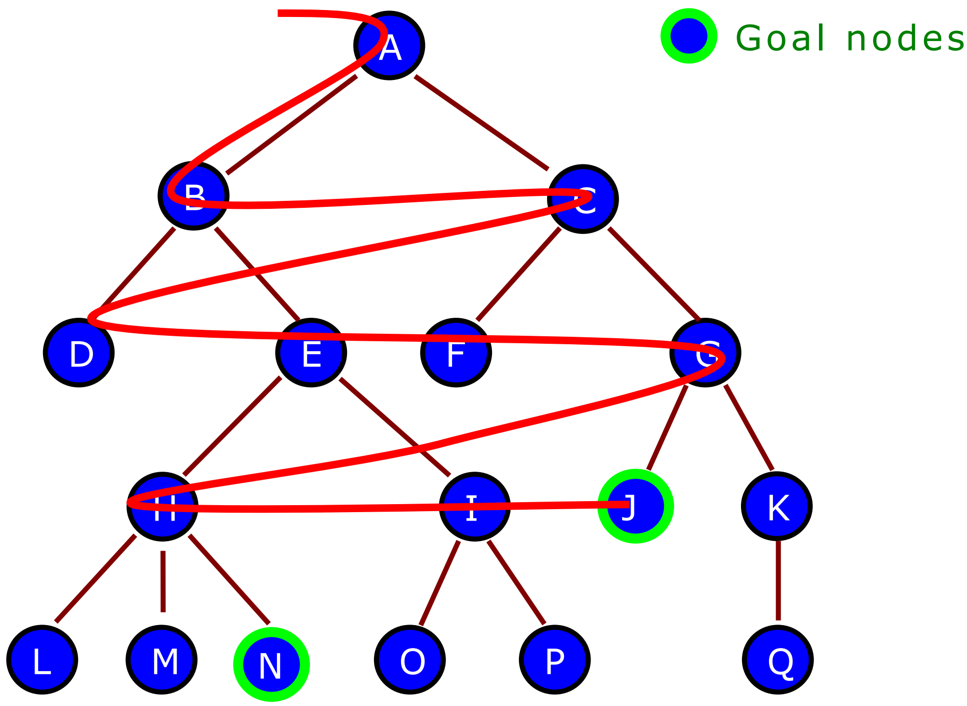
- **Node are explored in the order :**

  A B D E H L M N I O P C F G J K Q

- **After searching node A, then B, then D, the search backtracks and tries another path from node B .**
- **The goal node N will be found before the goal node J.**

Breadth-first search (BFS)

- **BFS explores nodes nearest to the root before exploring nodes further away.**
- **Example: Breadth-first search tree**



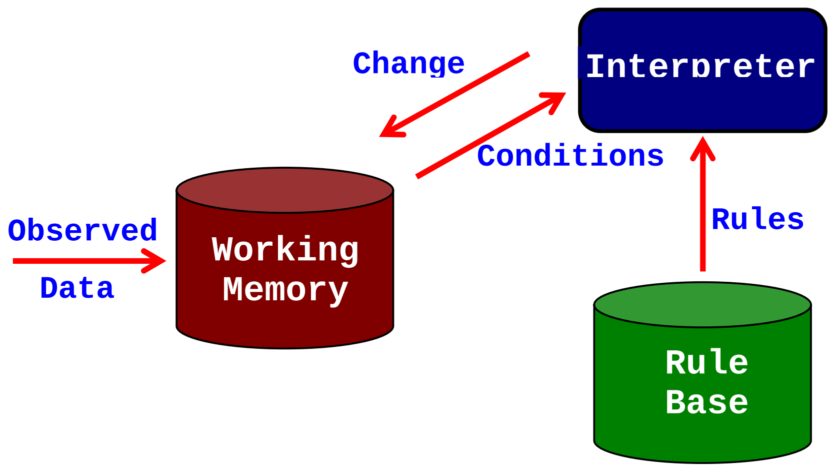
- **Node are explored in the order :**

  A B C D E F G H I J K L M N O P Q

  After searching A, then B, then C, the search proceeds with D, E, F, G, ……
- **The goal node N will be found before the goal node J.**

- **Rule-Based Systems (RBSs)**

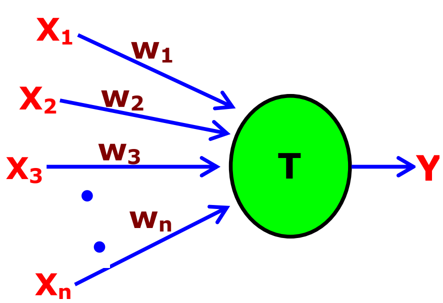
  - **Rule-based systems are simple and successful AI technique.**
    - **Rules are of the form: IF <condition> THEN <action>.**
    - **Rules are often arranged in hierarchies ("and/or" trees).**
    - **When all conditions of a rule are satisfied the rule is triggered.**
  - **Components of RBS : Working Memory, Rule Base, Interpreter.**



4.2 Biology-inspired AI techniques

- **Neural Networks (NN)**
  - **Neural Networks model a brain learning by example.**
  - **Neural networks are structures "trained" to recognize input patterns.**
  - **Neural networks typically take a vector of input values and produce a vector of output values; inside, they train weights of "neurons".**

  A Perceptron is a model of a single `trainable' neuron.



- $x_1, x_2, \ldots, x_n$ are input.
- $w_1, w_2, \ldots, w_n$ are weights
- T is the threshold.
- y is the output and is boolean.

If the net input which is $w_1\ x_1 + w_2\ x_2 + \ldots + w_n\ x_n$ is greater than the threshold "T" then output "y" is 1 else 0.

- **Genetic Algorithms (GA)**
  - **GAs are part of evolutionary computing.**
  - **Genetic algorithms are implemented as a computer simulation, where techniques are inspired by evolutionary biology.**
  - **Mechanics of biological evolution:**
    - Every organism has a set of rules, describing how that organism is built, and encoded in the genes of an organism.
    - The genes are connected together into long strings called chromosomes.
    - Each gene represents a specific trait (feature) of the organism and has several different settings, e.g. setting for a hair color gene may be black or brown.
    - The genes and their settings are referred as an organism's genotype.
    - When two organisms mate they share their genes. The resultant offspring may end up having half the genes from one parent and half from the other. This process is called cross over.
    - A gene may be mutated and expressed in the organism as a completely new trait.

- **Reinforcement Learning (RL)**

  - **RL is learning from interaction with an environment;**
  - **The basic RL model consists of: a set of "environment states - S "; a set of "actions - A"; and a set of scalar "rewards - R".**
  - **The decision-making agent interacting with its environment so as to maximize the cumulative reward it receives over time. The steps are:**
    - **At each time t, the agent perceives its "environment state s_t and the set of possible "actions $A(s_t)$",**
    - **It chooses an action a ∈ A(st) and receives from the environment the new state s_t+1 and a "reward r_t+1.**
    - **Based on these interactions, the agent develops a policy π:S⟶A which maximizes the quantity $R = r_0+r_1+\ldots+r_n$ for MDPs.**
  - **RL methods focus on the kind of learning and decision making problems that people face in their normal, everyday lives.**

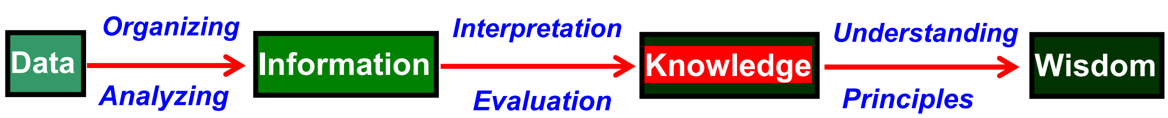
- **Knowledge Representation**

  - **How do we represent what we know?**

    Knowledge is a collection of "facts".

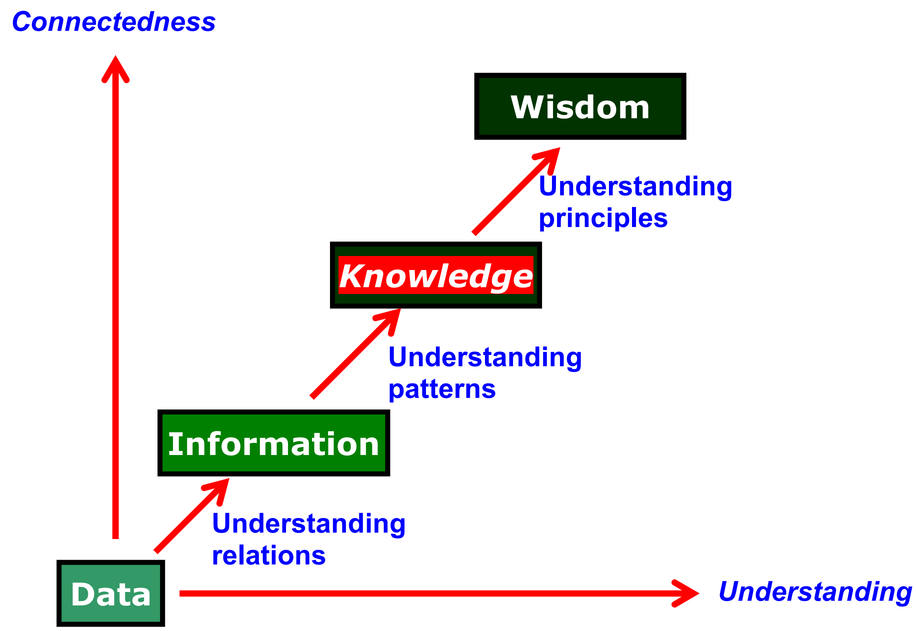
  - **Knowledge is a general term. Knowledge is defined as a progression that starts with data which is of limited utility. By organizing or analyzing the data, we understand what the data means, and this becomes information. The interpretation or evaluation of the data (information) yield knowledge. An understanding of fundamental principles embodied within the knowledge is wisdom**

    Knowledge Progression



Knowledge Model **(Bellinger 1980)**

The model says that, as the degree of "connectedness" and "understanding" increase, we progress from data through information and knowledge to wisdom.



- **Data** is viewed as disconnected collection of facts. : *e.g: It is raining.*
- **Information** emerges when relationships between the facts are established and understood; provides answers to "who", "what", "where", and "when". : *e.g: The temperature dropped 15 degrees and then it started raining.*
- **Knowledge** emerges when the patterns of relationships are identified and understood; provides answers as "how" . : *e.g: If the humidity is very high and the temperature drops substantially then atmospheres is unlikely to hold the moisture so it rains.*
- **Wisdom** is the pinnacle of understanding, uncovers the principles that describe the patterns of relationships. : *e.g: Encompasses an understanding of all the interactions that happen between raining, evaporation, air currents, temperature gradients, changes, and raining.*

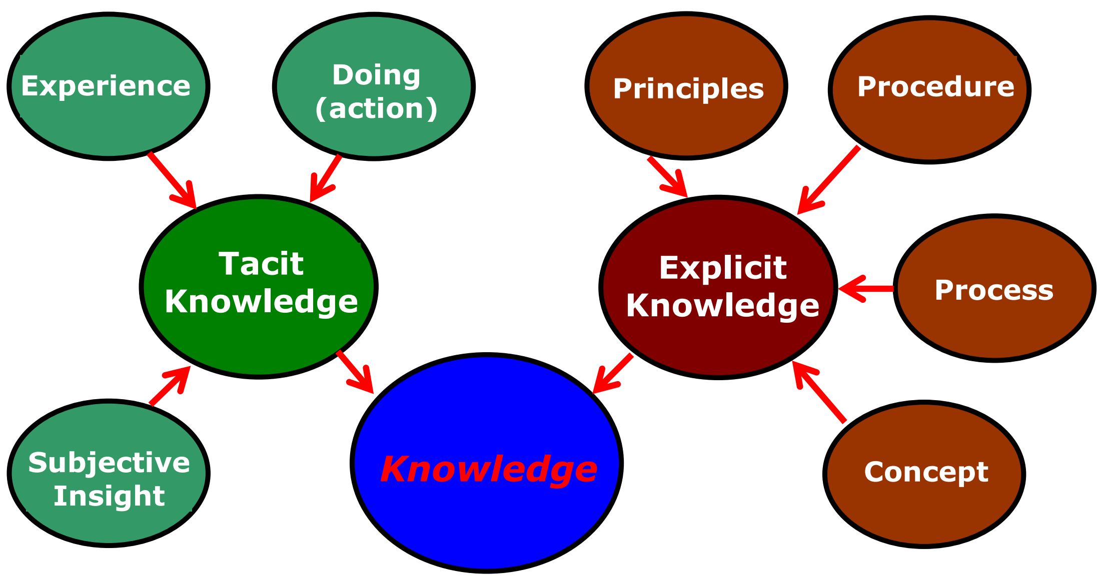
- **Knowledge Type**

Knowledge is categorized into two major types: Tacit and Explicit.

"Tacit" corresponds to implicit or <u>informal</u>.

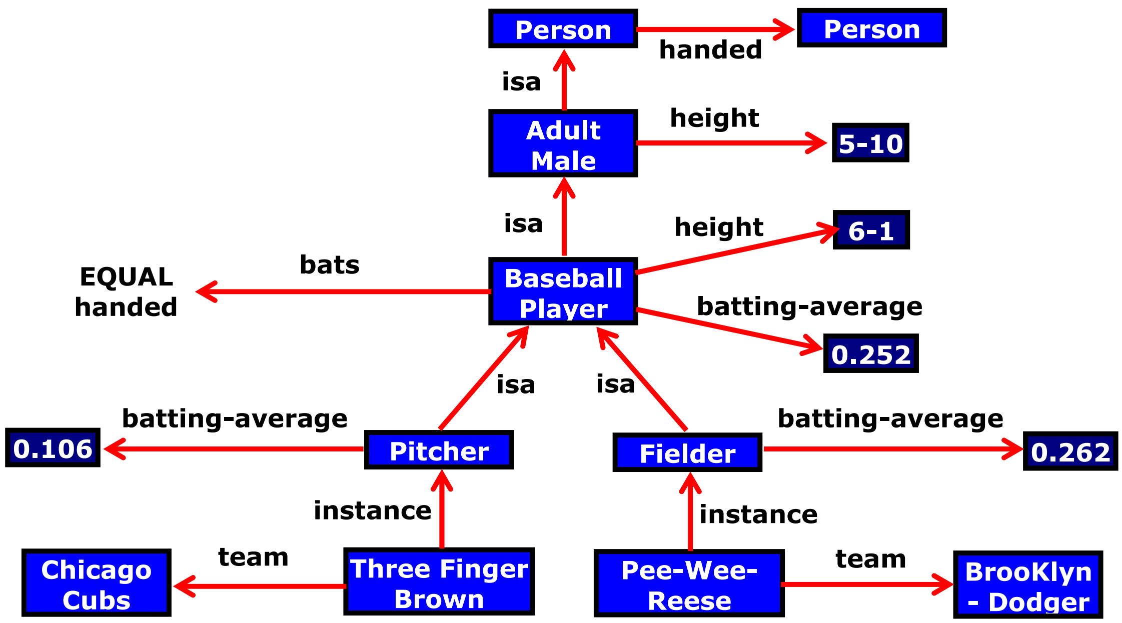
"Explicit" corresponds to <u>formal</u> knowledge.

Tacit knowledge	Explicit knowledge
◇ Exists within a human being;	◇ Exists outside a human being;
◇ Drawn from experience, action, subjective insight.	◇ An artifact of some type as principle, procedure, process, concepts.
◇ Difficult to articulate formally.	◇ Can be articulated formally.
◇ Difficult to share and communicate.	◇ Can be shared, copied, processed and stored.
◇ Hard to steal or copy.	◇ Easy to steal or copy



Example : Knowledge represented in hierarchical structure.

- **Property inheritance**
  - ‡ Objects/elements inherit values being members of a class.
  - ‡ Classes are organized in a generalized hierarchy.
- **Insertion of additional knowledge in the representation.**



- **Different types of knowledge require different types of representation. <u>Some KR techniques are</u>:**

◇ **Predicate logic**	**Predicate is a function may be "TRUE" for some arguments, and "FALSE" for others.**
◇ **Semantic networks**	**A semantic net is just a graph. where the nodes represent concepts, and the arcs represent binary relationships between concepts.**
◇ **Frames and scripts**	**A frame is a data structure that typically consists of: Frame name, Slot-filler (relations target), Pointers (links) to other Frames,**
◇ **Productions rules**	**Consists of a set of rules about behavior; productions consist of two parts: a precondition (or "IF") and an action (or "THEN");**

• Inference

- **Inference is the process of deriving a conclusion based solely on what one already knows; deduction of new facts from old ones. Logic capture inference.**
- **Deductive Inference :**
  - **Never false; inference is true if premise is true.**
  - **Traditional logics are based on deduction, a method of exact inference - no possibility of mistake if rules are followed exactly.**
  - **Requires complete, precise, and consistent information.**
- **Inductive Inference :**
  - **May be correct or incorrect inference, because in real world the information is incomplete, inexact, inconsistent;**
  - **Inductive logic, is the process of reasoning in which the premises of an argument are believed to support the conclusion but do not ensure it.**
  - **The reasoners need to draw conclusions tentatively reserving the right to retract them in the light of further information.**
  - **Example:**

    when we hear of a bird, we man infer that bird can fly, but this conclusion can be reversed when we hear that it is a penguin; bird penguin cannot fly

- **Common sense knowledge and reasoning**

  - **Common sense is the mental skills that most people have. Common Sense is ability to analyze a situation based on its context.**

    - **People can think because the brain contain vast libraries of common sense knowledge**
    - **Computer can not think; computers programs do many things, can play chess at the level of best players but cannot match capabilities of a 3 year old child at recognizing objects. Currently, computers lack common sense.**

  - **Teaching computers common sense**

    - **Project "OpenMind" at MIT- the goal is to teach a computer things that human take for granted;**
    - **Project "Cyc" - an attempt to manually build a database of human common sense knowledge; 1.5 million collection of common sense facts, still far away from several hundred million needed.**

- **Learning**

  - **Programs learn from what facts or behaviors can represent.**
  - **Definitions of some learning problem :**
    - **Marvin Minsky 1986** – **"Learning is making useful changes in the working of our mind."**
    - **Mitchell 1997** – **"A computer program is said to learn from experience E with respect to some class of tasks T and performance measure P, if its performance at tasks in T, as measured by P, improves with experience E."**
  - **Major Paradigms of Machine Learning**
    - **Rote** — **Learning by memorization**
    - **Induction** — **Learning by example**
    - **Analogy** — **Recognizing similarities in information already stored;**
    - **Genetic Algorithms** — **A way of solving problems by mimicking processes nature uses ie Selection, Crosses over, Mutation and Accepting to evolve a solution to a problem.**
    - **Reinforcement** — **Assign rewards, positive or negative, at end of a it learns which actions are good or bad.**

- **Planning**

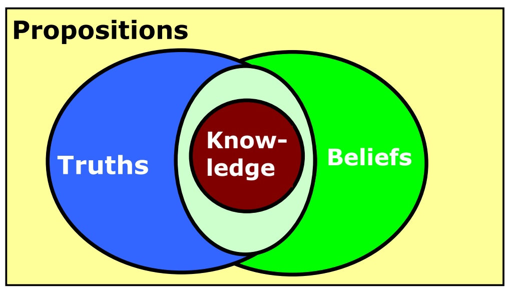
  - **A plan is a representation of a course of action. Planning is a problem solving technique. Planning is a reasonable series of actions to accomplish a goal.**

  - **Planning programs start with facts about the world, especially :**
    - **facts about the effects of actions,**
    - **facts about the particular situation, and**
    - **statement of a goal.**
  - **From these facts, the program generate a strategy for achieving the goal.**
  - **A Strategy is just a sequence of actions.**

- **Epistemology**

  - **Epistemology is the theory of knowledge;**
  - **There are various kinds of knowledge:**
    - knowing how to do something (e.g, how to ride a bicycle),
    - knowing someone in person, and
    - knowing a place or a city.
  - **Epistemology is the study of knowledge and justified belief.**
    - Consider a knowledge of proposition - a schema 'S knows that p' ;
    - Question asked - what are the necessary and sufficient conditions?

      S knows that P if and only if:
      - P is true;
      - S believes that P is true; and
      - S is justified in believing that P is true.



  - **Epistemology is the study of the kinds of knowledge that are required for solving problems in the world.**

- **Heuristics**
  - **Heuristics are simple, efficient rules; "rule of thumb"**
  - **In computer science, a heuristic is an algorithm.**
  - **Heuristics are intended to gain computational performance or conceptual simplicity, potentially at the cost of accuracy or precision.**
  - **People use heuristics to make decisions, come to judgments, and solve problems. These rules work well under most circumstances.**
  - **In AI programs, the heuristic functions are :**
    - **used to measure how far a node is from goal state.**
    - **used to compare two nodes, find if which is better**

5. Applications of AI

- **Game playing**
  - **Interactive computer games in which the goals of human-level AI are pursued.**
  - **Games are made by creating human level artificially intelligent entities, e.g. enemies, partners, and support characters that act just like humans.**
  - **Game playing is characterized by:**
    - **"Unpredictable" opponent**
    - **Time limits**
  - **Games**

Computers perform at champion level	:	Checkers, Chess, Othello, Backgammon,
Computers perform well	:	Bridge
Computers still do badly	:	Go, Hex

  - **The "Deep Blue" Chess program won over world champion Gary Kasparov.**

- **Speech Recognition**
  - **A process of converting a speech signal to a sequence of words;**
  - **In the 1990s, computer speech recognition reached a practical level for limited purposes.**
  - **The typical usages are voice dialing (Call home), call routing (collect call), simple data entry (credit card number). The Voice verification or Speaker recognition are a related process.**
  - **The spoken language interface PEGASUS in the American Airlines' allows users to obtain flight information and make reservations over the telephone.**

- **Understanding Natural Language**
  - **Natural language processing (NLP) does automated generation and understanding of natural human languages.**
  - ***Natural language generation* systems convert information from computer databases into normal-sounding human language**
  - ***Natural language understanding* systems convert samples of human language into more formal representations that are easier for computer programs to manipulate.**
  - **Some major tasks in NLP :**
    - **Text-to-Speech (TTS) system - converts normal language text into speech.**
    - **Speech recognition - process of converting a speech signal to a sequence of words;**
    - **Machine translation (MT) - translate text or speech from one natural language to another.**
    - **Information retrieval (IR)- searching for information from databases such as Internet or World Wide Web or Intranets.**

- **Computer Vision**
  - **It is a combination of concepts, techniques and ideas from Digital Image Processing, Pattern Recognition, Artificial Intelligence and Computer Graphics.**
  - **Examples:**
    - **Face recognition – the programs in use by banks**
    - **Autonomous driving - The ALVINN system, autonomously drove a van from Washington, D.C. to San Diego, averaging 63 mph day and night, and in all weather conditions.**
    - **The other usages are - handwriting recognition, baggage inspection, manufacturing inspection, photo interpretation, etc.**

- **Expert Systems**
  - **Systems in which human expertise is held in the form of rules which enable the system to diagnose situations without the human expert being present.**
  - **A Man-machine system with specialized problem-solving expertise. The "expertise" consists of knowledge about a particular domain, understanding of problems within that domain, and "skill" at solving some of these problems.**
  - **A "knowledge engineer'' interviews experts in a certain domain and tries to embody their knowledge in a computer program for carrying out some task.**
  - **One of the first expert systems was MYCIN in 1974, which diagnosed bacterial infections of the blood and suggested treatments.**
  - **Expert systems rely on knowledge of human experts, e.g.**
    - **Diagnosis and Troubleshooting - deduce faults and suggest corrective actions for a malfunctioning device or process**
    - **Planning and Scheduling – analyzing a set of goals to determine and ordering a set of actions taking into account the constraints; e.g. airline scheduling of flights**
    - **Financial Decision Making - advisory programs assists bankers to make loans, Insurance companies to assess the risk presented by the customer, etc.**
    - **Process Monitoring and Control - analyze real-time data, noticing anomalies, predicting trends, and controlling optimality and do failure correction.**

6. Conclusion

Despite the advances in the last 50 years, the original goals set by the first generation of AI visionaries have not been reached. Not only the natural intelligence is far from being understood, the artificial forms of intelligence is still very primitive. Simple tasks like object manipulation and recognition - which a 3-year-old can do - have not yet been realized artificially. ***(Ref : 50th Anniversary Summit of Artificial Intelligence, Centro Steno Franscini – Monte Verita Switzer Land, July 9-14, 2006).***

7. References :

Open sources – mainly internet and text books.

(Note : This talk has been prepared, using information available from open sources, mainly internet sources, for bring general awareness about Fifth Generation System - Artificial Intelligence among the scientist and engineers of different discipline. There is no commercial interest, what so ever, is involved.)