- Common Techniques
  - ✓ Even apparently radically different AI systems (such as rule based expert systems and neural networks) have many common techniques.
  - ✓ Four important ones are:
    - o Knowledge Representation: Knowledge needs to be represented somehow – perhaps as a series of if-then rules, as a frame based system, as a semantic network, or in the connection weights of an artificial neural network.
    - o Learning: Automatically building up knowledge from the environment – such as acquiring the rules for a rule based expert system, or determining the appropriate connection weights in an artificial neural network.
    - o Rule Systems: These could be explicitly built into an expert system by a knowledge engineer, or implicit in the connection weights learnt by a neural network.
    - o Search: This can take many forms – perhaps searching for a sequence of states that leads quickly to a problem solution, or searching for a good set of connection weights for a neural network by minimizing a fitness function.

AI and related fields

- Logical AI

  What a program knows about the world in general the facts of the specific situation in which it must act, and its goals are all represented by sentences of some mathematical logical language. The program decides what to do by inferring that certain actions are appropriate for achieving its goals.

- Search

  AI programs often examine large numbers of possibilities, e.g. moves in a chess game or inferences by a theorem proving program. Discoveries are continually made about how to do this more efficiently in various domains.

- Pattern Recognition

  When a program makes observations of some kind, it is often programmed to compare what it sees with a pattern. For example, a vision program may try to match a pattern of eyes and a nose in a scene in order to find a face. More complex patterns, e.g. in a natural language text, in a chess position, or in the history of some event are also studied.

- Representation

Facts about the world have to be represented in some way. Usually languages of mathematical logic are used.

- Inference

From some facts, others can be inferred. Mathematical logical deduction is adequate for some purposes, but new methods of *non-monotonic* inference have been added to logic since the 1970s. The simplest kind of non-monotonic reasoning is default reasoning in which a conclusion is to be inferred by default, but the conclusion can be withdrawn if there is evidence to the contrary. For example, when we hear of a bird, we man infer that it can fly, but this conclusion can be reversed when we hear that it is a penguin. It is the possibility that a conclusion may have to be withdrawn that constitutes the non-monotonic character of the reasoning. Ordinary logical reasoning is monotonic in that the set of conclusions that can the drawn from a set of premises is a monotonic increasing function of the premises.

- Common sense knowledge and reasoning

This is the area in which AI is farthest from human-level, in spite of the fact that it has been an active research area since the 1950s. While there has been considerable progress, e.g. in developing systems of *non-monotonic reasoning* and theories of action, yet more new ideas are needed.

- Learning from experience

Programs do that. The approaches to AI based on *connectionism* and *neural nets* specialize in that. There is also learning of laws expressed in logic. Programs can only learn what facts or behaviors their formalisms can represent, and unfortunately learning systems are almost all based on very limited abilities to represent information.

- Planning

Planning programs start with general facts about the world (especially facts about the effects of actions), facts about the particular situation and a statement of a goal. From these, they generate a strategy for achieving the goal. In the most common cases, the strategy is just a sequence of actions.

- Epistemology

This is a study of the kinds of knowledge that are required for solving problems in the world.

- Ontology

Ontology is the study of the kinds of things that exist. In AI, the programs and sentences deal with various kinds of objects, and we study what these kinds are and what their basic properties are. Emphasis on ontology begins in the 1990s.

- Heuristics

A heuristic is a way of trying to discover something or an idea imbedded in a program. The term is used variously in AI. *Heuristic functions* are used in some approaches to search to measure how far a node in a search tree seems to be from a goal. *Heuristic predicates* that compare two nodes in a search tree to see if one is better than the other, i.e. constitutes an advance toward the goal, may be more useful.

- Genetic Programming

Genetic programming is a technique for getting programs to solve a task by mating random Lisp programs and selecting fittest in millions of generations.

- Soft Computing:

Soft computing, according to Prof. Zadeh, is "an emerging approach to computing, which parallels the remarkable ability of the human mind to reason and learn in an environment of uncertainty and imprecision". It, in general, is a collection of computing tools and techniques, shared by closely related disciplines that include fuzzy logig, artificial neural nets, genetic algorithms, belief calculus, and some aspects of machine learning like inductive logic programming. These tools are used independently as well as jointly depending on the type of the domain of applications. The scope of the first three tools in the broad spectrum of AI is outlined below.

Fuzzy Logic: Fuzzy logic deals with fuzzy sets and logical connectives for modeling the human-like reasoning problems of the real world. A fuzzy set, unlike conventional sets, includes all elements of the universal set of the domain but with varying membership values in the interval [0,1]. It may be noted that a conventional set contains its members with a value of membership equal to one and disregards other elements of the universal set, for they have zero membership. The most common operators applied to fuzzy sets are AND (minimum), OR (maximum) and negation (complementation), where AND and OR have binary arguments, while negation has unary argument. The logic of fuzzy sets was proposed by Zadeh, who introduced the concept in systems theory, and later extended it for approximate reasoning in expert systems.

Artificial Neural Nets: Artificial neural nets (ANN) are electrical analogues of the biological neural nets. Biological nerve cells, called neurons, receive signals from neighboring neurons or receptors through dendrites, process the received electrical pulses at the cell body and transmit signals through a large and thick nerve fiber, called an axon. The electrical model of a typical biological neuron consists of a linear activator, followed by a non-linear inhibiting function. The linear activation function yields the sum of the weighted input excitation, while the non-linear inhibiting function

attempts to arrest the signal levels of the sum. The resulting signal, produced by an electrical neuron, is thus bounded (amplitude limited). An artificial neural net is a collection of such electrical neurons connected in different topology. The most common application of an artificial neural net is in machine learning. In a learning problem, the weights and/or non-linearities in an artificial neural net undergo an adaptation cycle. The adaptation cycle is required for updating these parameters of the network, until a state of equilibrium is reached, following which the parameters no longer change further. The ANN support both supervised and unsupervised types of machine learning. The supervised learning algorithms realized with ANN have been successfully applied in control, automation, robotics and computer vision. The unsupervised learning algorithms built with ANN, on the other hand, have been applied in scheduling, knowledge acquisition, planning and analog to digital conversion of data.

Genetic Algorithms: A genetic algorithm (GA) is a stochastic algorithm that mimics the natural process of biological evolution. It follows the principle of Darwinism, which rests on the fundamental belief of the "survival of the fittest" in the process of natural selection of species. GAs find extensive applications in intelligent search, machine learning and optimization problems. The problem states in a GA are denoted by chromosomes, which are usually represented by binary strings. The most common operators used in GA are crossover and mutation. The processes of execution of crossover and mutation are illustrated in fig.(1.4) and fig.(1.5) respectively.

The evolutionary cycle in a GA consists of the following three sequential steps.

(a) Generation of population (problem states represented by chromosomes).

(b) Genetic evolution through crossover followed by mutation.

(c) Selection of better candidate states from the generated population.

In step (a) of the above cycle, a few initial problem states are first identified. The step (b) evolves new chromosomes through the process of crossover and mutation. In step (c) a fixed number of better candidate states are selected from the generated population. The above steps are repeated a finite number of times for obtaining a solution for the given problem.

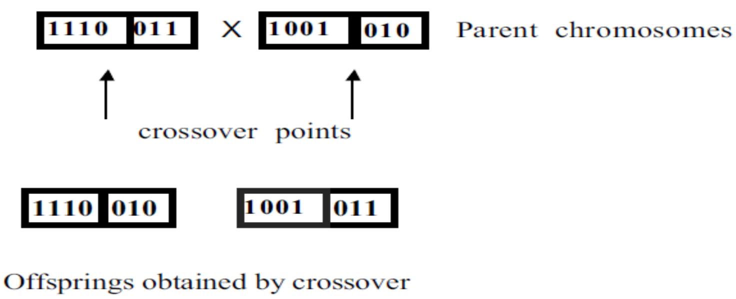
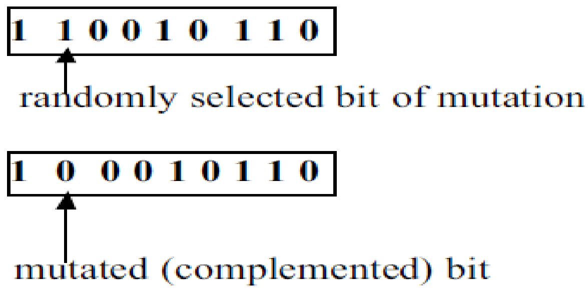


Fig.(1.4): Exchange of genetic information by crossover operation.



The mutation operation: randomly selected bits are complemented.

- Management of Imprecision and Uncertainty:

Data and knowledge bases in many typical AI problems, such as reasoning and planning, are often contaminated with various forms of incompleteness. The incompleteness of data, hereafter called imprecision, generally appears in the database for: i) Lack of appropriate data. ii) Poor authenticity level of the sources.

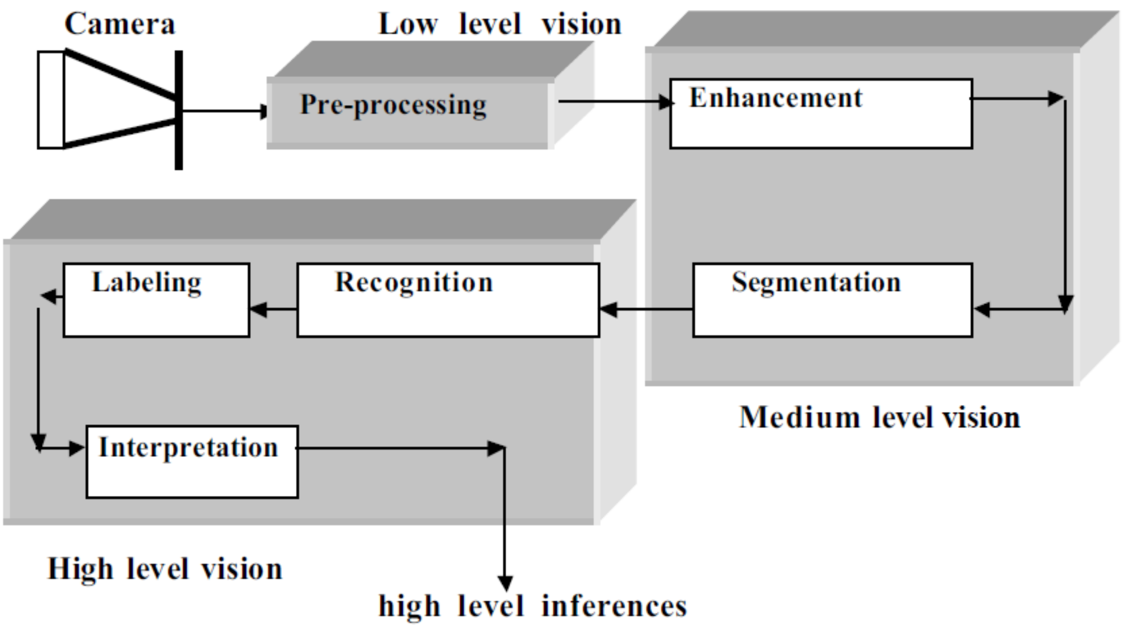
The incompleteness of knowledge, often referred to as uncertainty, originates in the knowledge base due to lack of certainty of the pieces of knowledge. Reasoning in the presence of imprecision of data and uncertainty of knowledge is a complex problem. Various tools and techniques have been devised for reasoning under incomplete data and knowledge. Some of these techniques employ: i) stochastic ii) fuzzy and iii) belief network models.

In a stochastic reasoning model, the system can have transition from one given state to a number of states, such that the sum of the probability of transition to the next states from the given state is strictly unity. In a fuzzy reasoning system, the sum of the membership value of transition from the given state to the next state may be greater than or equal to one. The belief network model updates

the stochastic/fuzzy belief assigned to the facts embedded in the network until a condition of equilibrium is reached, following which there would be no more change in beliefs. Recently, fuzzy tools and techniques have been applied in a specialized belief network, called a fuzzy Petri net, for handling both imprecision of data and uncertainty of knowledge by a unified approach.

- Image Understanding:

A digital image can be regarded as a two-dimensional array of pixels containing gray levels corresponding to the intensity of the reflected illumination received by a video camera. For interpretation of a scene, its image should be passed through three basic processes: low, medium and high level vision fig.(1.7). The importance of low level vision is to pre-process the image by filtering from noise. The medium level vision system deals with enhancement of details and segmentation (i.e., partitioning the image into objects of interest). The high level vision system includes three steps: recognition of the objects from the segmented image, labeling of the image and interpretation of the scene. Most of the AI tools and techniques are required in high level vision systems. Recognition of objects from its image can be carried out through a process of pattern classification, which at present is realized by supervised learning algorithms. The interpretation process, on the other hand, requires knowledge-based computation.



Basic steps in scene interpretation