INT404 ARTIFICIAL INTELLIGENCE

Lecture 1

Artificial Intelligence – an Overview

What is intelligence?

- Intelligence is hard to describe.
- More a performance view rather than a structural one.
- Intelligence is observed in NEW areas.
  - New areas → where the knowledge is still incomplete.

Intelligence - ability to work efficiently with *Incomplete*, *Complex* patterns

Artificial Intelligence – an Overview

Artificial Intelligence - Enabling computers to work efficiently with *Incomplete, Complex* Patterns.

What is the problem?

Incomplete, complex patterns → a large, unbounded search space.

Searching this is time consuming – Non Polynomial time complexity.

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More details on patterns:

- Pattern – a set of repeating, significant attributes.
- Complexity of a pattern – measured by the number of attributes and the relationships between these attributes.
  - The more attributes – The more complex
  - The more relationships (inter dependencies) – The more complex.

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A view of the world:

Three segments –

Segment 1 – Totally known segment.

- All knowledge in this segment is known→ Methods exist for all problems →
- Solutions are method oriented. Underlying patterns can be ignored.
- Example - Find the square root of a number.

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A view of the world:

Segment 3 - Totally Unknown

- Hardly anything of topics in this area is known. → Human beings are themselves unable to do much here.
- Example - Life on other planets

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A view of the world:

Segment 2 – Partially Known.

- Quite a lot is known about topics in this segment, but not everything. => Incomplete, Ambiguous patterns.
- Example – Diagnosing diseases.

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Intelligence is required to handle problems in Segment 2.

- Algorithmic approaches cannot work here as an algorithm, by definition is finite, definite, and effective. (Definite is the **opposite** of ambiguous.)
- As more knowledge is acquired, topics in Segment 3 move to Segment 2 and topics in Segment 2 move to Segment 1.

Artificial Intelligence – an Overview

- Problem that artificial intelligence attempts to handle is "Providing efficient solutions to problems in an ambiguous, incomplete pattern area".
- Artificial intelligence itself lies in Segment 2 of the view of the world.

  Solution - Non-algorithmic approaches.

Artificial Intelligence – an Overview

Artificial intelligence techniques can be divided into **two** types:

1) Symbolic computation
2) Non- symbolic computation

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Symbolic Computation:

- Symbol: represents a concept, rather than a value. e.g. ax+y=0
- A symbol represents a relationship among two or more classes. ('class' as in Object Oriented Programming Systems.) e.g. father
- Symbolic computation represents an extreme in a continuum(undistinguishable): Variable (representing numbers), Data Structure (variables of a particular type), Class (representing a collection of related variables and their functions), Symbol (representing collection of Objects and the relationships between them)

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Symbolic Computation has two branches

1. Heuristic search – Adjoining, Segment 1 of the World view.

   Heuristic – A guide, an approximation, a thumb rule. Basically helps in pruning(Weed out **unwanted** or unnecessary things) the search tree.

2. Knowledge-based systems – In the world view, **between** heuristic search and sub-symbolic computation (neural networks).

   Knowledge – "Data is an understood, recognized format",
   "Information is Useful data" and
   "Knowledge is Generalized Information." => Concepts, Patterns.

Artificial Intelligence – an Overview

Heuristic Search – Two types

1. Proceeds from Start state to Goal state – A* - Data driven.
2. Proceeds from Goal state to Start state – AO* - Goal driven.

A* - generates a solution path. Uses heuristics to prune the possible set of operators.

AO* - generates a solution tree. Creates sub-goals for a particular goal, until the sub-goal is directly achievable.

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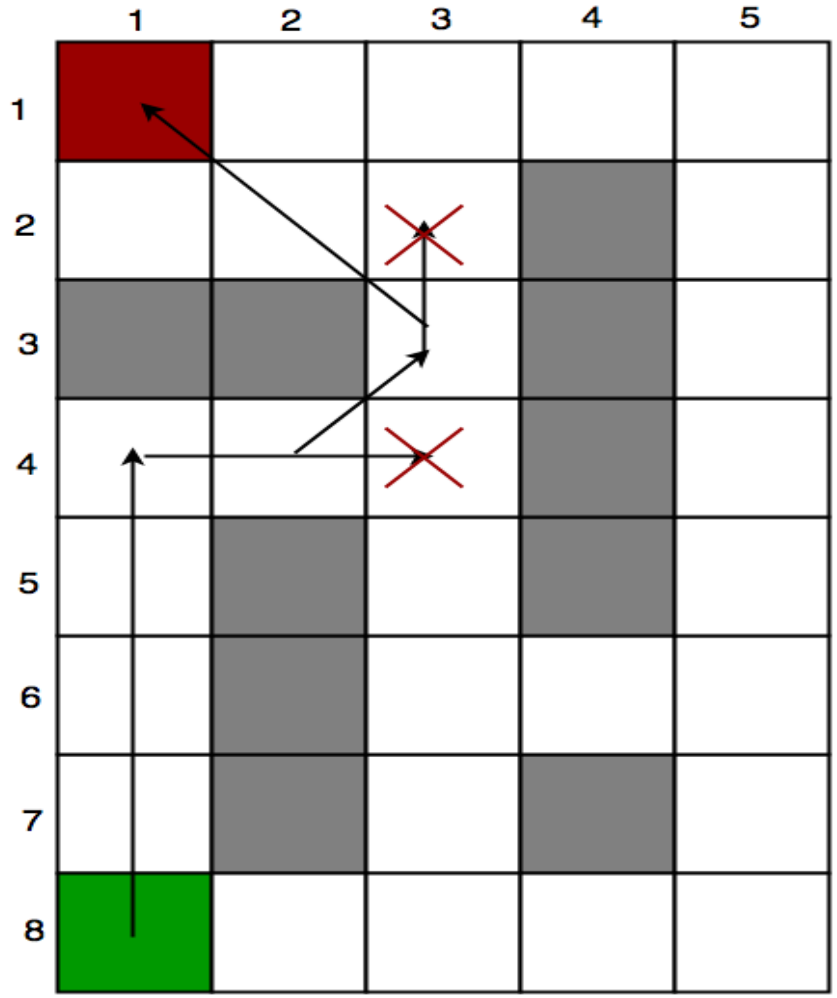
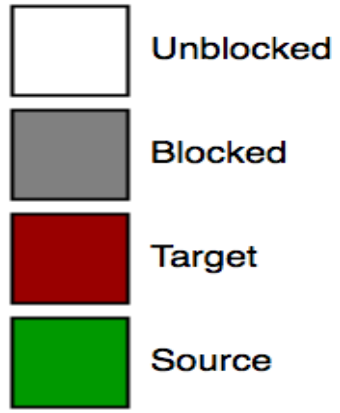
Heuristic Search(A*)

- A* Search algorithm is one of the best and popular technique used in path-finding and graph traversals.
- unlike other traversal techniques, it has “brains”. What it means is that it is really a smart algorithm which separates it from the other conventional algorithms.

Heuristic Search(A*)





A* Search Algorithm makes the most intelligent choice at each step. Hence you can see that algorithm goes from (4,2) to (3,3) and not (4,3) (shown by cross).

Similarly the algorithm goes from (3,3) to (2,2) and not (2,3) (shown by cross).

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Heuristic Search

Core areas of Heuristic search:

a) Problem representation - by a State space. Each node in the State space represents a complete state of the problem.

b) Operators – Change one state to another.

c) Heuristic Evaluation function – Evaluates the goodness of each of the possible next states. (Not a definite evaluation, only an approximation.)

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Heuristic Search

The Heuristic evaluation function is basically a form of hill climbing: Take the steepest gradient – which will be the shortest path to the peak (goal).

Problems in Heuristic Search:

Local Maxima – A particular point in the search space may be better than all neighboring points, but still, may not be the ultimate goal. This is called a Local Maxima. Solved by making Random Jumps.

Artificial Intelligence – an Overview

Knowledge Based Systems:

Core Areas of Knowledge Based systems

1. Knowledge Base Representation
2. Inference Engine
3. User interface
4. Knowledge acquisition module

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Knowledge Based Systems:

Representation techniques are primarily:

1. production rules – sets of if-then rules, similar to production rules used to specify a grammar.

   Example: If the car does not start check the battery, by pressing the horn.

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Knowledge Based Systems:

Representation techniques are primarily:

2. Semantic Networks – Set of Nodes and Links between them. The links represent Relationships between the nodes

   Example: Nodes – Man, Hands, Legs, Walk

   Relationships – Has (between Man and hands and between Man and Legs) and Can (between Man and Walk).

   A type of Semantic networks is Frames (Slot-filler notation). These encode default (commonly occurring) values (filler) for the attributes in a relation (slot).

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Knowledge Based Systems:

Inference Engine - Search on the knowledge base leads to Inferences.

Knowledge Acquisition module - The knowledge being incomplete will be dynamic. Provision to acquire knowledge is provided by using machine learning strategies.

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Knowledge Based Systems:

Machine Learning Strategies:

1. Rote learning – The system is told the actual knowledge. The system's work is to map the knowledge into its internal representation.
2. Learning by being told – The system is given paragraphs that convey the knowledge. The system has to glean the knowledge and then store it.
3. Learning by being told and asking questions – In addition to strategy 2, the system analyses the knowledge, finds discrepancies and asks questions to sort out the conflicts.
4. Learning by induction from positive examples - The system is given examples of the concept. It generalizes the examples to arrive at the knowledge

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Knowledge Based Systems:

Machine Learning Strategies:

5. Learning by Induction from Positive examples and Negative examples – To avoid over generalization, negative examples are given, which are used to specialize the knowledge.
6. Learning by Induction through experimentation - The system generates examples itself by designing experiments on the environment.
7. Learning by Analogy – The system maps the knowledge it has to the new problem, using analogy.
8. Learning by Abduction – The system creates new hypotheses and designs experiments to ratify them.

Knowledge Based Systems:

Genetic Programming:

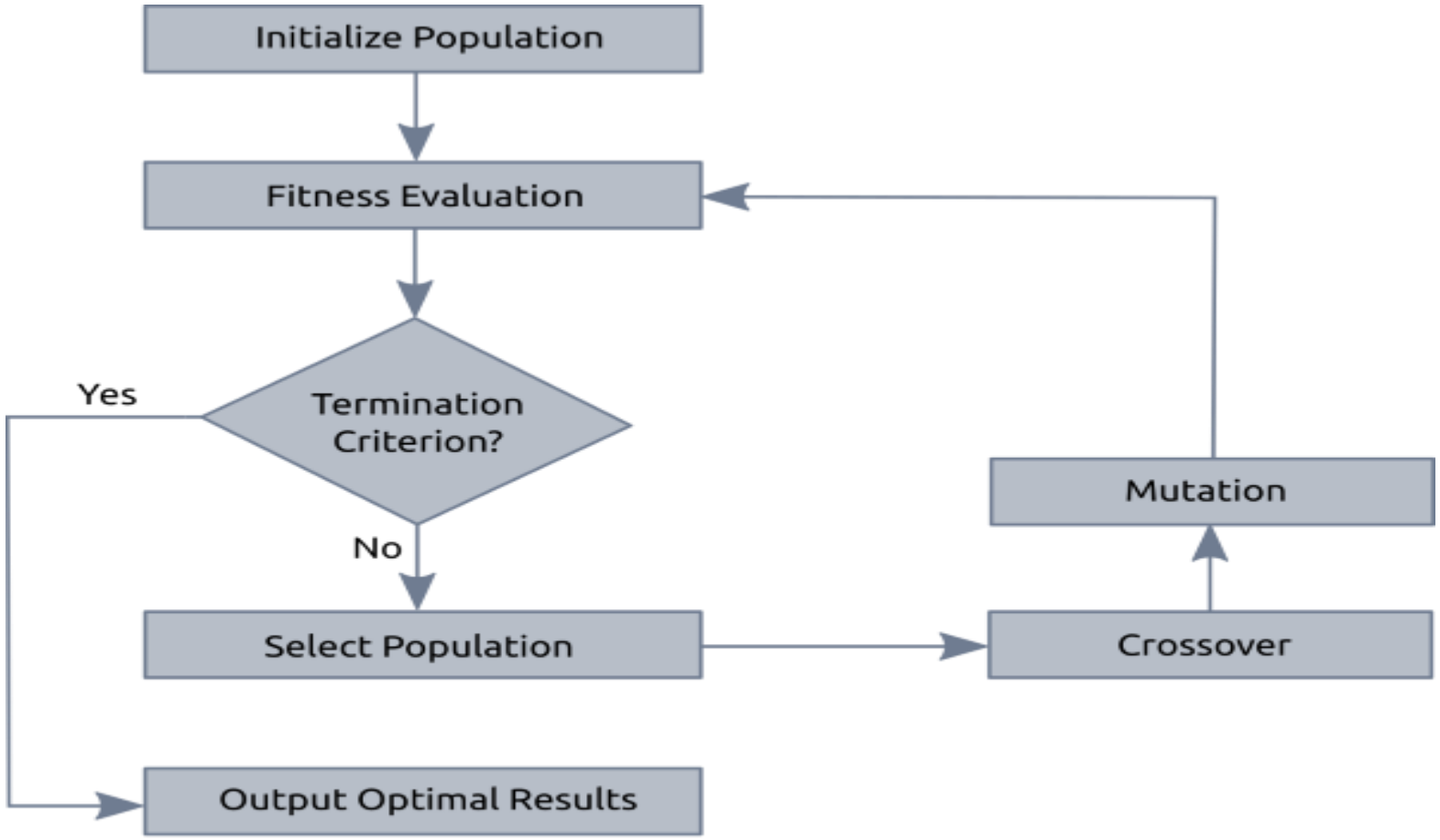

Figure 2: Basic structure of Genetic Algorithm

Knowledge Based Systems:

Genetic Programming:

This field lies at the extreme of Knowledge Based Systems (adjoining sub-symbolic computation in the World view)– They model Human evolution methods.

Approach:

1. Create an initial population of entities
2. Each entity's characteristics are represented
3. A fitness function evaluates the entities.
4. The best two of the population are chosen
5. These two are used to generate 'offspring's' –> new population. Process repeats.

Knowledge Based Systems:

Genetic Programming:

Offspring generation operators:

1. Reproduction – All characteristics of both parents are reproduced in the offspring.
2. Crossover - A subset of characteristics of one parent are linked with the subset of characteristics of the other parent.
3. Mutation – The characteristics of one parent are changed randomly to create the offspring. – Handles the Local Maxima problem

Sub Symbolic Computation (Neurocomputing):

- Adjoins Segment 3 of the world view.
- Deals with signal level computation required because a number of problems do not have explicit knowledge associated with them. Example – recognizing people or recognizing handwriting.
- This area deals with patterns that are more complex than the ones dealt with by symbolic computation.

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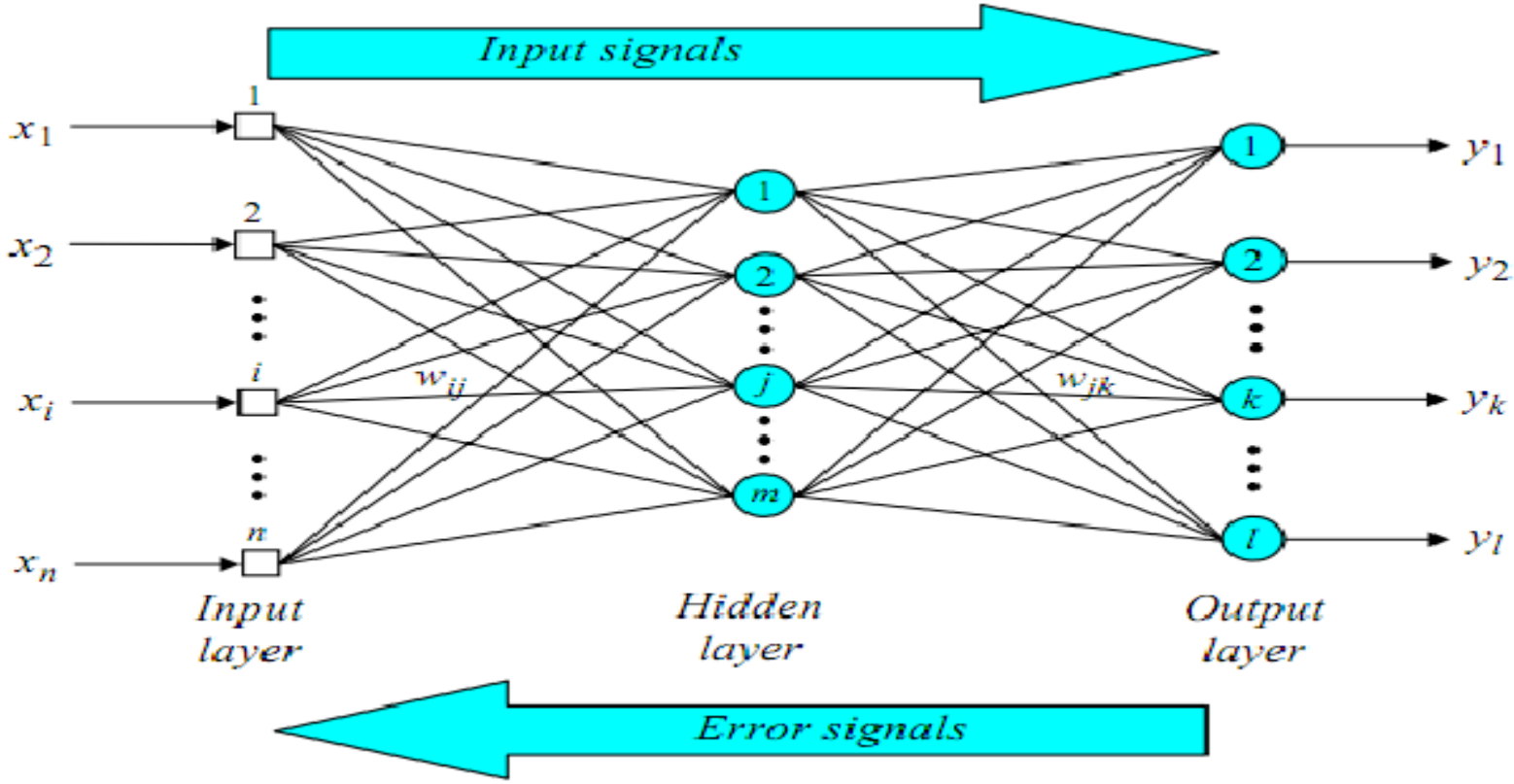


Sub Symbolic Computation (Neurocomputing):

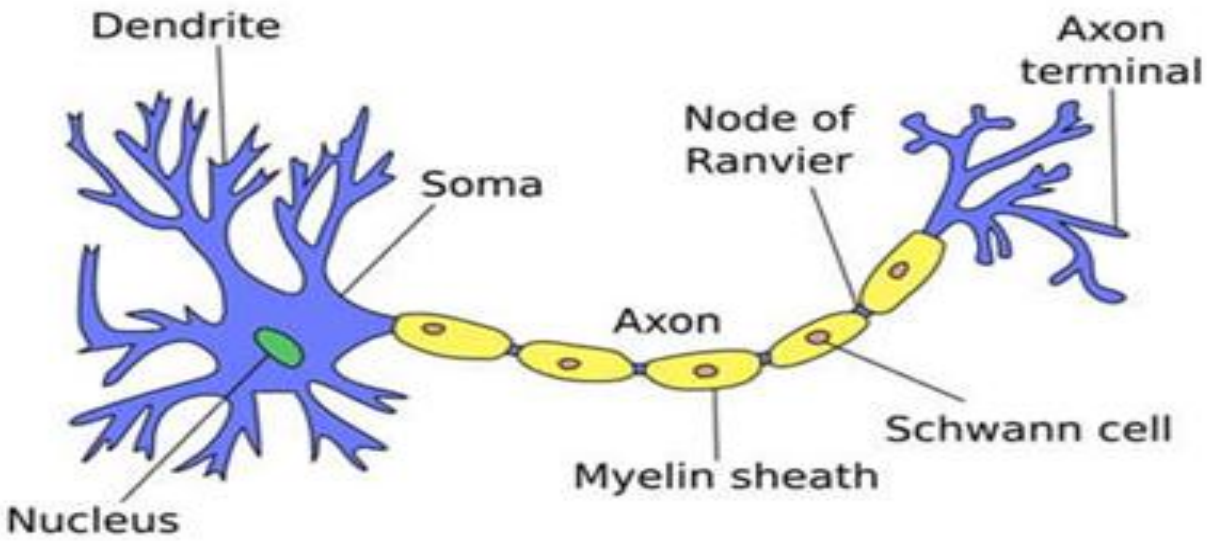
Core areas of Sub-symbolic computation are:

1. Architecture
2. Learning mechanism

In sub-symbolic computation all the knowledge is learnt by the system.

Neuro-computing attempts to mimic the structure of the human intelligence system, with its neurons and synapses.

Neuron – receives input from many other neurons. Each input is magnified by a multiplication factor. (This multiplication factor represents the degree of interest, effect that the particular input has on the neuron.)


Dendrite
Axon terminal
Node of Ranvier
Soma
Axon
Schwann cell
Myelin sheath
Nucleus

Sub Symbolic Computation (Neurocomputing):

- All the multiplied values are summed up and compared to a ‘threshold value’. If the threshold value is less then the neuron fires an output.
- Knowledge is acquired by learning the correct multiplication values.

Learning is done in one of two ways:

1. Supervised learning - Here the desired output for a given input is known. A simple method is Back Propagation network. Here the output is compared with the desired output. Differences are propagated backwards, to make changes to the multiplication factors.

Sub Symbolic Computation (Neurocomputing):

2. Unsupervised learning – Here the desired output is not given to the system. The system uses Clustering to club similar input together. Example – Kohonen
3. A third learning technique is Self-Supervised Learning - Here the results of a previous iteration are used to bias the clustering results in the current iteration.

   Example – Adaptive Resonance Technique.