INTELLIGENT SYSTEM
SEM- 6TH
SECTION-D (NOTES)

Learning

Learning is essential for unknown environments, i.e., when designer lacks omniscience
Learning is useful as a system construction method,i.e., expose the agent to reality rather than trying to write it down
Learning modifies the age decision mechanism to improve performance.
Machine learning is the subfield of computer science that gives computers the ability to learn without being explicitly programmed . Evolved from the study of pattern recognition and computational learning theory in artificial intelligence, machine learning explores the study and construction of algorithms that can learn from and make predictions on data – such algorithms overcome following strictly static program instructions by making data driven predictions or decisions, through building a model from sample inputs. Machine learning is employed in a range of computing tasks where designing and programming explicit algorithms is infeasible; example applications include spam filtering, detection of network intruders or malicious insiders working towards a data breach,optical character recognition (OCR), search engines and computer vision.

Machine learning is closely related to (and often overlaps with) computational statistics, which also focuses in prediction-making through the use of computers. It has strong ties to mathematical optimization, which delivers methods, theory and application domains to the field. Machine learning is sometimes conflated with data mining,where the latter subfield focuses more on exploratory data analysis and is known as unsupervised learning. Machine learning can also be unsupervised and be used to learn and establish baseline behavioral profiles for various entities and then used to find meaningful anomalies.

Types of problems and tasks

Machine learning tasks are typically classified into three broad categories, depending on the nature of the learning "signal" or "feedback" available to a learning system. These are:

- **Supervised learning:** The computer is presented with example inputs and their desired outputs, given by a "teacher", and the goal is to learn a general rule that maps inputs to outputs.
- **Unsupervised learning:** No labels are given to the learning algorithm, leaving it on its own to find structure in its input. Unsupervised learning can be a goal in itself (discovering hidden patterns in data) or a means towards an end (feature learning).
- **Reinforcement learning:** A computer program interacts with a dynamic environment in which it must perform a certain goal (such as driving a vehicle or playing a game against an opponent. The program is provided feedback in terms of rewards and punishments as it navigates its problem space.

Between supervised and unsupervised learning is semi-supervised learning, where the teacher gives an incomplete training signal: a training set with some (often many) of the target outputs missing. Transduction is a special case of this principle where the entire set of problem instances is known at learning time, except that part of the targets are missing.

Another categorization of machine learning tasks arises when one considers the desired *output* of a machine-learned system:

- In classification, inputs are divided into two or more classes, and the learner must produce a model that assigns unseen inputs to one or more (multi-label classification) of these classes. This is typically tackled in a supervised way. Spam filtering is an example of classification, where the inputs are email (or other) messages and the classes are "spam" and "not spam".
- In regression, also a supervised problem, the outputs are continuous rather than discrete.
- In clustering, a set of inputs is to be divided into groups. Unlike in classification, the groups are not known beforehand, making this typically an unsupervised task.
- Density estimation finds the distribution of inputs in some space.
- Dimensionality reduction simplifies inputs by mapping them into a lower-dimensional space. Topic modeling is a related problem, where a program is given a list of human language documents and is tasked to find out which documents cover similar topics.

DISCOVERY AS LEARNING:

Discovery is a restricted form of learning. The knowledge acquisition is done without getting any assistance from a teacher. Discovery Learning is an inquiry-based learning method.

In discovery learning, the learner uses his own experience and prior knowledge to discover the truths that are to be learned. The learner constructs his own knowledge by experimenting with a domain, and inferring rules from the results of these experiments. In addition to domain information the learner need some support in choosing and interpreting the information to build his knowledge base.

A *cluster* is a collection of objects which are similar in some way. Clustering groups data items into similarity classes. The properties of these classes can then be used to understand problem characteristics or to find similar groups of data items. Clustering can be defined as the process of reducing a large set of unlabeled data to manageable piles consisting of similar items. The similarity measures depend on the assumptions and desired usage one brings to the data.

Clustering begins by doing feature extraction on data items and measure the values of the chosen feature set. Then the clustering model selects and compares two sets of data items and outputs the similarity measure between them. Clustering algorithms that use particular similarity measures as subroutines are employed to produce clusters.

The clustering algorithms are generally classified as Exclusive Clustering, Overlapping Clustering, Hierarchical Clustering and Probabilistic Clustering. The selection of clustering algorithms depends on various criteria such as time and space complexity. The results are checked to see if they meet the standard otherwise some or all of the above steps have to be repeated.

Explanation-Based Learning:

An Explanation-based Learning (**EBL**) system accepts an example (i.e. a training example) and explains what it learns from the example. The **EBL** system takes only the relevant aspects of the training. This explanation is translated into particular form that a problem solving program can understand. The explanation is generalized so that it can be used to solve other problems.

PRODIGY is a system that integrates problem solving, planning, and learning methods in a single architecture. It was originally conceived by Jaime Carbonell and Steven Minton, as an AI system to test and develop ideas on the role that machine learning plays in planning and problem solving. **PRODIGY** uses the **EBL** to acquire control rules.

The **EBL** module uses the results from the problem-solving trace (ie. Steps in solving problems) that were generated by the central problem solver (a search engine that searches over a problem space). It constructs explanations using an axiomatized theory that describes both the domain and the architecture of the problem solver. The results are then translated as control rules and added to the knowledge base. The control knowledge that contains control rules is used to guide the search process effectively

EBL software takes four inputs:

- a hypothesis space (the set of all possible conclusions)
- a domain theory (axioms about a domain of interest)
- training examples (specific facts that rule out some possible hypotheses)
- operationality criteria (criteria for determining which features in the domain are efficiently recognizable, e.g. which features are directly detectable using sensors)

NEURAL NETS:

Neural networks or **connectionist systems** are a computational approach used in computer science and other research disciplines, which is based on a large collection of neural units (artificial neurons), loosely mimicking the way a biological brain solves problems with large clusters of biological neurons connected by axons. Each neural unit is connected with many others, and links can be enforcing or inhibitory in their effect on the activation state of connected neural units. Each individual neural unit may have a summation function which combines the values of all its inputs together. There may be a threshold function or limiting function on each connection and on the unit itself, such that the signal must surpass the limit before propagating to other neurons. These systems are self-learning and trained, rather than explicitly programmed, and excel in areas where the solution or feature detection is difficult to express in a traditional computer program.

Neural networks typically consist of multiple layers or a cube design, and the signal path traverses from front to back. Back propagation is the use of forward stimulation to reset weights on the "front" neural units and this is sometimes done in combination with training where the correct result is known. More modern networks are a bit more free flowing in terms of stimulation and inhibition with connections interacting in a much more chaotic and complex fashion. Dynamic neural networks are the most advanced, in that they dynamically can, based on rules, form new connections and even new neural units while disabling others.

The idea of ANNs is based on the belief that working of human brain by making the right connections, can be imitated using silicon and wires as living **neurons** and **dendrites**.

The human brain is composed of 100 billion nerve cells called **neurons.** They are connected to other thousand cells by **Axons.** Stimuli from external environment or inputs from sensory organs are accepted by dendrites. These inputs create electric impulses, which quickly travel through the neural network. A neuron can then send the message to other neuron to handle the issue or does not send it forward.

The goal of the neural network is to solve problems in the same way that the human brain would, although several neural networks are more abstract. Modern neural network projects typically work with a few thousand to a few million neural units and millions of connections, which is still several orders of magnitude less complex than the human brain and closer to the computing power of a worm.

GENETIC ALGORITHM:

In computer science and operations research, a **genetic algorithm** (**GA**) is a metaheuristic inspired by the process of natural selection that belongs to the larger class of evolutionary algorithms (EA). Genetic algorithms are commonly used to generate high-quality solutions to optimization and search problems by relying on bio-inspired operators such as mutation, crossover and selection.

Genetic algorithms are based on biological evolution. Genetic algorithms can be used to solve a wide variety of problems. Given a problem a genetic algorithm generates a set of possible solutions and evaluates each in order to decide which solutions are fit for reproduction. If a particular solution is more fit then it will have more chances to generate new solutions. Finally we can find a real solution.

Genetic algorithms are so powerful that they can exhibit more efficiency if programmed perfectly. Applications include learning Robot behavior, molecular structure optimization, automated design of mechatronic systems, and electronic circuit design.

A Genetic Approach Methodology for Knowledge Acquisition for Intelligent Diagnosis is a project done by CEEP (Center for Engineering Education and Practice), University of Michigan-Dearborn, to develop diagnosis knowledge for robot arm movements. In this project, a robot was selected for analysis. The wrong arm movements of robot were observed and collected as failure data. Then the project applied *genetic algorithm* to extract knowledge from the failure data. The acquisition of knowledge was automatic. The knowledge extracted is then stored in the knowledge base to make use of in the intelligent diagnosis system. The knowledge so stored is known as diagnosis knowledge as it s used to detect what went wrong and to decide the course of action in order to make the robot perfect.

A typical genetic algorithm requires:

1. a genetic representation of the solution domain,
2. a fitness function to evaluate the solution domain.

Natural language processing

Natural language processing (**NLP**) is a field of computer science, artificial intelligence, and computational linguistics concerned with the interactions between computers and human (natural) languages and, in particular, concerned with programming computers to fruitfully process large natural language corpora. Challenges in Natural Language Processing frequently involve natural language understanding, natural language generation (frequently from formal, machine-readable logical forms), connecting language and machine perception, managing human-computer dialog systems, or some combination thereof.

Natural Language Processing (NLP) refers to AI method of communicating with an intelligent systems using a natural language such as English.

Processing of Natural Language is required when you want an intelligent system like robot to perform as per your instructions, when you want to hear decision from a dialogue based clinical expert system, etc.

The field of NLP involves making computers to perform useful tasks with the natural languages humans use. The input and output of an NLP system can be −

- Speech
- Written Text

Components of NLP

There are two components of NLP as given −

Natural Language Understanding (NLU)

Understanding involves the following tasks −

- Mapping the given input in natural language into useful representations.
- Analyzing different aspects of the language.

Natural Language Generation (NLG)

It is the process of producing meaningful phrases and sentences in the form of natural language from some internal representation.

It involves −

- **Text planning** − It includes retrieving the relevant content from knowledge base.
- **Sentence planning** − It includes choosing required words, forming meaningful phrases, setting tone of the sentence.
- **Text Realization** − It is mapping sentence plan into sentence structure.

Steps in NLP

There are general five steps −

- **Lexical Analysis** − It involves identifying and analyzing the structure of words. Lexicon of a language means the collection of words and phrases in a language. Lexical analysis is dividing the whole chunk of txt into paragraphs, sentences, and words.
- **Syntactic Analysis (Parsing)** − It involves analysis of words in the sentence for grammar and arranging words in a manner that shows the relationship among the words. The sentence such as "The school goes to boy" is rejected by English syntactic analyzer.
- **Semantic Analysis** − It draws the exact meaning or the dictionary meaning from the text. The text is checked for meaningfulness. It is done by mapping syntactic structures and objects in the task domain. The semantic analyzer disregards sentence such as "hot ice-cream".
- **Discourse Integration** − The meaning of any sentence depends upon the meaning of the sentence just before it. In addition, it also brings about the meaning of immediately succeeding sentence.
- **Pragmatic Analysis** − During this, what was said is re-interpreted on what it actually meant. It involves deriving those aspects of language which require real world knowledge.

Rule-based system

In computer science, **rule-based systems** are used as a way to store and manipulate knowledge to interpret information in a useful way. They are often used in artificial intelligence applications and research.

A typical rule-based system has four basic components:

- A list of rules or **rule base**, which is a specific type of knowledge base.
- An inference engine or semantic reasoner, which infers information or takes action based on the interaction of input and the rule base. The interpreter executes a production system program by performing the following match-resolve-act cycle:
    - Match: In this first phase, the left-hand sides of all productions are matched against the contents of working memory. As a result a conflict set is obtained, which consists of instantiations of all satisfied productions. An instantiation of a production is an ordered

list of working memory elements that satisfies the left-hand side of the production.
- Conflict-Resolution: In this second phase, one of the production instantiations in the conflict set is chosen for execution. If no productions are satisfied, the interpreter halts.
- Act: In this third phase, the actions of the production selected in the conflict-resolution phase are executed. These actions may change the contents of working memory. At the end of this phase, execution returns to the first phase.

- Temporary working memory.
- A user interface or other connection to the outside world through which input and output signals are received and sent.

Advantages of Rule based Expert Systems

Modular nature: This allows encapsulating knowledge and expansion of the expert system done in a a easy way.

Explanation facilities: Rules make it easy to build explanation facilities. By keeping track of the rules that are fired, an explanation facility can present a chain of reasoning that led to a certain conclusion.

Similarity to the human cognitive process: Newel and Simon have showed that rules are the natural way of modeling how humans solve problems. Rules make it easy to explain the structure of knowledge to the experts.

Applications

A classic example of a rule-based system is the domain-specific expert system that uses rules to make deductions or choices. For example, an expert system might help a doctor choose the correct diagnosis based on a cluster of symptoms, or select tactical moves to play a game.

Rule-based systems can be used to perform lexical analysis to compile or interpret computer programs, or in natural language processing.

Rule-based programming attempts to derive execution instructions from a starting set of data and rules. This is a more indirect method than that employed by an imperative programming language, which lists execution steps sequentially.

Expert system

In artificial intelligence, an **expert system** is a computer system that emulates the decision-making ability of a human expert. Expert systems are designed to solve complex problems by reasoning about knowledge, represented mainly as if–then rules rather than through conventional procedural code. The first expert systems were created in the 1970s and then proliferated in the 1980s. Expert systems were among the first truly successful forms of artificial intelligence (AI) software.

An expert system is divided into two subsystems: the inference engine and the knowledge base. The knowledge base represents facts and rules. The inference engine applies the rules to the known facts to deduce new facts. Inference engines can also include explanation and debugging abilities.

The expert systems are the computer applications developed to solve complex problems in a particular domain, at the level of extra-ordinary human intelligence and expertise.

Characteristics of Expert Systems

- High performance
- Understandable
- Reliable
- Highly responsive

Capabilities of Expert Systems

The expert systems are capable of −

- Advising
- Instructing and assisting human in decision making
- Demonstrating
- Deriving a solution
- Diagnosing
- Explaining
- Interpreting input
- Predicting results
- Justifying the conclusion
- Suggesting alternative options to a problem

They are incapable of −

- Substituting human decision makers
- Possessing human capabilities
- Producing accurate output for inadequate knowledge base
- Refining their own knowledge

Components of Expert Systems

The components of ES include −

- Knowledge Base
- Inference Engine
- User Interface

Knowledge Base

It contains domain-specific and high-quality knowledge. Knowledge is required to exhibit intelligence. The success of any ES majorly depends upon the collection of highly accurate and precise knowledge.

The data is collection of facts. The information is organized as data and facts about the task domain.

Data, information, and **past experience** combined together are termed as knowledge.

Components of Knowledge Base

The knowledge base of an ES is a store of both, factual and heuristic knowledge.

- **Factual Knowledge** − It is the information widely accepted by the Knowledge Engineers and scholars in the task domain.
- **Heuristic Knowledge** − It is about practice, accurate judgement, one's ability of evaluation, and guessing.

Knowledge representation

It is the method used to organize and formalize the knowledge in the knowledge base. It is in the form of IF-THEN-ELSE rules.

Knowledge Acquisition

The success of any expert system majorly depends on the quality, completeness, and accuracy of the information stored in the knowledge base.

The knowledge base is formed by readings from various experts, scholars, and the **Knowledge Engineers**. The knowledge engineer is a person with the qualities of empathy, quick learning, and case analyzing skills.

He acquires information from subject expert by recording, interviewing, and observing him at work, etc. He then categorizes and organizes the information in a meaningful way, in the form of IF-THEN-ELSE rules, to be used by interference machine. The knowledge engineer also monitors the development of the ES.

Knowledge acquisition is the process used to define the rules and ontologies required for a knowledge-based system. The phrase was first used in conjunction with expert systems to describe the initial tasks associated with developing an expert system, namely finding and interviewing domain experts and capturing their knowledge via rules, objects, and frame-based ontologies.

Expert systems were one of the first successful applications of artificial intelligence technology to real world business problems. Researchers at Stanford and other AI laboratories worked with doctors and other highly skilled experts to develop systems that could automate complex tasks such as medical diagnosis. Until this point computers had mostly been used to automate highly data intensive tasks but not for complex reasoning. Technologies such as inference engines allowed developers for the first time to tackle more complex problems.

As expert systems scaled up from demonstration prototypes to industrial strength applications it was soon realized that the acquisition of domain expert knowledge was one of if not the most critical task in the knowledge engineering process. This knowledge acquisition process became an intense area of research on its own.

One approach to knowledge acquisition investigated was to use natural language parsing and generation to facilitate knowledge acquisition. Natural language parsing could be performed on manuals and other expert documents and an initial first pass at the rules and objects could be developed automatically. Text generation was also extremely useful in generating explanations for system behavior. This greatly facilitated the development and maintenance of expert systems. Knowledge acquisition is the process of adding new knowledge to a knowledge base and refining or otherwise improving knowledge that was previously acquired. Acquisition is usually associated with some purpose such as expanding the capabilities of a system or improving its performance at some specified task. It is goal oriented creation and refinement of knowledge . It may consist of facts, rules , concepts, procedures, heuristics, formulas, relationships, statistics or other useful information.

APPLICATION OF ROBOTICS:

Robotics is a branch of AI, which is composed of Electrical Engineering, Mechanical Engineering, and Computer Science for designing, construction, and application of robots.

Aspects of Robotics

- The robots have **mechanical construction**, form, or shape designed to accomplish a particular task.
- They have **electrical components** which power and control the machinery.
- They contain some level of **computer program** that determines what, when and how a robot does something.

1. Education

2. Finance

3. Hospitals and medicine

4. Heavy industry

5. Online and telephone customer service

6. Transportation

7. Telecommunications maintenance

8. Toys and games

9. Music

In the future, AI combined with advances in robot hearing and vision has the potential to result in an ‘explosion’ of intelligent robots which will work closely with humans. Of course trends can change, depending on what is enabling them, and also on factors that might get in their way