AI AIU

Definitions

Lecture one

AI: “AI is the ability of digital computers or computer-controlled robots to solve problems that are
normally associated with the higher intellectual processing capabilities of humans...”

Introspection: trying to catch our own thoughts as they go by

Agent: An agent is just something that acts (agent comes from the Latin agere, to

A rational agent: is one that acts so as to achieve the best outcome or, when there is
uncertainty, the best expected outcome.

Lecture three- Logic & Reasoning in Artificial Intelligence

knowledge base: The central component of a knowledge-based agent. knowledge base is a set of sentences.

knowledge representation language: The language sentences are expressed in.

axiom: sentences that are taken as given without being derived from other sentences.

MAKE-PERCEPT-SENTENCE: constructs a sentence asserting that the agent perceived the
given percept at the given time.

MAKE-ACTION-QUERY constructs a sentence that asks what action should be done at the
current time. Finally,

MAKE-ACTION-SENTENCE: constructs a sentence asserting that the chosen action was
executed. The details of the inference mechanisms are hidden inside TELL and ASK.

Logical representation: is a language with some concrete rules which deals with propositions and has no ambiguity in representation.

Logical representation means drawing a conclusion based on various conditions. This representation lays down some important communication rules. It consists of
precisely defined syntax and semantics which supports the sound inference.

Syntaxes: are the rules which decide how we can construct legal sentences in the logic.

Semantics: are the rules by which we can interpret the sentence in the logic.

Logic is concerned with reasoning and the validity of arguments.

tautology: the value of the expression $A \vee \neg A$ is true regardless of the value of A. An expression like this that is always true.

First-Order Logic: is a logic which is sufficiently expressive to represent a good deal of our
commonsense knowledge. adopts the foundation of propositional logic with all its advantages to build a more expressive logic on that foundation, borrowing representational ideas from natural language while avoiding its drawbacks.

Semantic networks are alternative of predicate logic for knowledge representation. In Semantic
networks, we can represent our knowledge in the form of graphical networks. This network
consists of nodes representing objects and arcs which describe the relationship between those
objects.

A frame is a record like structure which consists of a collection of attributes and its values to
describe an entity in the world. Frames are the AI data structure which divides knowledge into
substructures by representing stereotypes situations. It consists of a collection of slots and slot
values.

Facets: The various aspects of a slot is known as Facets. Facets are features of frames which
enable us to put constraints on the frames.

Production rules system consist of (condition, action) pairs which mean, "If condition then
action".

Reasoning can be defined as the logical process of drawing conclusions, making predictions or
constructing approaches towards a particular thought with the help of existing knowledge.

Deductive Reasoning is a process in which general premises are used to obtain a specific
inference. Reasoning moves from a general principle to a specific conclusion.

Abduction is a form of deductive logic which provides only a 'plausible inference'.

Abduction is heuristic in the sense that it provides a plausible conclusion consistent with available
information, but one which may in fact be wrong.

Inductive reasoning: A principle of reasoning to a conclusion about all members of a class from examination of only a few members of the class; broadly, reasoning from the particular to the general.

Analogical Reasoning: Analogical reasoning assumes that when a question is asked, the answer
can be derived by analogy.

Formal Reasoning: Formal reasoning involves syntactic manipulation of data structures to deduce
new facts. A typical example is the mathematical logic used in proving theorems in geometry.

Procedural Numeric Reasoning: Procedural numeric reasoning uses mathematical models or
simulation to solve problems. Model-based reasoning is an example of this approach.

Generalization and Abstraction: Generalization and abstraction can be successfully used with both
logical and semantic representation of knowledge.

Meta level Reasoning: Meta level reasoning involves "knowledge about what you know". Which
approach to use, how successful the inference will be, depends to a great extent on which

knowledge representation method is used. For example; reasoning by analogy can be more successful with semantic networks than with frames.

model-based reasoning refers to an inference method used in expert systems based on a model of the physical world.
With this approach, the main focus of application development is developing the model.

In a model-based reasoning system knowledge can be represented using **causal rules.**

Rule based reasoning: A particular type of reasoning which uses "if-then-else" rule statements.

A blackboard system reasoning: is an artificial intelligence application based on the blackboard architectural model, where a common knowledge base, the "blackboard", is iteratively updated by a diverse group of specialist knowledge sources, starting with a problem specification and ending with a solution.

A Truth Maintenance System tries to adjust the Knowledge Base or Fact Base upon changes to
keep it consistent and correct.

A TMS uses dependencies among facts to keep track of conclusions and allow revision /
retraction of facts and conclusions.

Lecture four- Agent in artificial intelligence

Agent: An agent is an entity that is able to carry out some task, usually to help a human user.

Agent: An agent can be anything that perceive its environment through sensors and act upon that
environment through actuators.

A versatile agent is one that is able to carry out many different tasks.

benevolent which are liable to help others, if necessary, but some can be **competitive** or **nonhelpful**.

agents may be **altruistic** which can cooperate in achieving goals or **antagonistic**.

veracity: property that makes agent always truthful.

degrade gracefully: when the agent encounters a new problem that it is unable to solve, does it fail completely, or is it able to make some progress?).

mobility: by its ability to move about on the Internet or another network.

AI system: as the study of the rational agent and its environment.

Sensor: Is a device which detects the change in the environment and sends the information to
other electronic devices. An agent observes its environment through sensors.

Actuators: Are the component of machines that converts energy into motion. The actuators are
only responsible for moving and controlling a system. An actuator can be an electric motor,
gears, etc.

Effectors: Are the devices which affect the environment. Effectors can be legs, wheels, arms,
fingers, wings, fins, and display screen.

A rational agent is one that does the right thing.

Performance: The output which we get from the agent. All the necessary results that an agent
gives after processing comes under its performance.

Environment: All the surrounding things and conditions of an agent fall in this section. It basically
consists of all the things under which the agents work.

Actuators: The devices, hardware or software through which the agent performs any actions or
processes any information to produce a result are the actuators of the agent.

Sensors: The devices through which the agent observes and perceives its environment are the
sensors of the agent.

Simple Reflex Agent: This agent selects actions based on the agent's current perception or the world and not based on past perceptions.

Model-based Reflex Agent: The Model-based agent can work in a partially observable environment and track the situation. These agents have the model, "which is knowledge of the world" and based on the model they perform actions.

Goal-based Agents: The knowledge of the current state environment is not always sufficient to decide for an agent to what to do. Goal-based agents expand the capabilities of the model-based agent by having the "goal" information. They choose an action, so that they can achieve the goal.

Utility-based Agents: Utility Based Agents help to choose the best alternatives, when there are multiple alternatives available.

These agents maintain a high utility function that agent tries to maximize based on the external
performance measure.

Learning Agents: A learning agent in AI is the type of agent which can learn from its past experiences, or it has learning capabilities. It starts to act with basic knowledge and then able to act and adapt automatically through learning.

Lecture five - Problem solving using search

Search: Searching is a step-by-step procedure to solve a search-problem in a given search
space.

A search problem can have three main factors:

Search Space: Search space represents a set of possible solutions, which a system may have.

Start State: It is a state from where agent begins the search.

Goal test: It is a function which observe the current state and returns whether the goal
state is achieved or not.

Search Algorithm Terminologies:

Search tree: A tree representation of search problem is called Search tree. The root of the
search tree is the root node which is corresponding to the initial state.

Actions: It gives the description of all the available actions to the agent.

Transition model: A description of what each action do, can be represented as a transition
model.

Path Cost: It is a function which assigns a numeric cost to each path.

Solution: It is an action sequence which leads from the start node to the goal node.

Optimal Solution: If a solution has the lowest cost among all solutions.

Example Problems

A toy problem is intended to illustrate or exercise various problem-solving methods. It can be
given a concise, exact description and hence is usable by different researchers to compare the
performance of algorithms.

A real-world problem is one whose solutions people actually care about. Such problems tend
not to have a single agreed-upon description, but we can give the general flavor of their
formulations.

Properties of Search Methods- Complexity

The time complexity of a method is related to the length of time that the method would take
to find a goal state.

The space complexity is related to the amount of memory that the method needs to use.

Properties of Search Methods -Completeness

A search method is described as being **complete** if it is guaranteed to find a goal state if one
exists.

Properties of Search Methods- Optimality

A search method is **optimal** if it is guaranteed to find the best solution that exists. In other
words, it will find the path to a goal state that involves taking the least number of steps.

An algorithm is then defined as a**dmissible** if it is guaranteed to find the best solution.

Types of search

Uninformed (Blind search) Search: The uninformed search does not contain any domain knowledge such as closeness, the location of the goal.

It operates in a brute-force way as it only includes information about how to traverse the tree
and how to identify leaf and goal nodes. It examines each node of the tree until it achieves the goal node.

1. **Breadth First Search (BFS)** Breadth-first search is the most common search strategy for traversing a tree or graph. This algorithm searches breadthwise in a tree or graph

   Breadth first search +

2. **Depth First Search (DFS)**: Depth-first search is a recursive algorithm for traversing a tree or graph data structure.

   Depth first search +

3. **Depth-Limited Search Algorithm:** A depth-limited search algorithm is similar to depth-first search with a predetermined limit.

Depth limited search

1. **Uniform Cost Search (UCS):** Uniform-cost search is a searching algorithm used for traversing a weighted tree or graph.

Uniform cost search

1. **Iterative Deeping Depth First Search (IDDFS):** The iterative deepening algorithm is a combination of DFS and BFS algorithms. This search algorithm finds out the best depth limit and does it by gradually increasing the limit until a goal is found.

Iterative deeping depth first search

1. **Bidirectional Search (BS):** Bidirectional search algorithm runs two simultaneous searches, one form initial state called as forward-search and other from goal node called as backward-search, to find the goal node.

Bidirectional search

Informed Search:

Informed search algorithms use domain knowledge. In an informed search, problem information
is available which can guide the search.
Informed search strategies can find a solution more efficiently than an uninformed search
strategy. Informed search is also called a Heuristic search.

1. **Best First Search (Greedy Search):** Greedy best-first search algorithm always selects the path which appears best at that moment. It is the combination of depth-first search and breadth-first search algorithms. It uses the heuristic function and search. Best-first search allows us to take the advantages of both algorithms.

best first search +

1. **A* Search:**

A* search is the most commonly known form of best-first search. It uses heuristic function
h(n), and cost to reach the node n from the start state g(n). It has combined features of UCS
and greedy best-first search, by which it solve the problem efficiently.

Lecture six- Fundamental of Machine Learning

Machine learning:

Machine Learning is the science (and art) of programming computers so they can learn from
data.

Machine Learning is a subset of artificial intelligence. It focuses mainly on the designing of
systems, thereby allowing them to learn and make predictions based on some experience which
is data in case of machines.

“Machine Learning is the] field of study that gives computers the ability to learn without being
explicitly programmed”. —Arthur Samuel, 1959.

Artificial Intelligence (AI): A technique which enables machines to mimic human behavior.

Machine Learning (ML): Subset of AI technique which use statistical methods to enable machines to improve with experience.

Deep Learning (DL): Subset of ML which make the computation of multi- layer neural network feasible.

Supervised Learning: Supervised learning algorithms or methods are the most commonly used ML algorithms. This method or learning algorithm take the data sample i.e., the training data and its associated output i.e., labels or responses with each data samples during the training process.

> **Regression:** The key objective of regression-based tasks is to predict output labels or responses which are continues numeric values, for the given input data.
>
> **Classification:** Classification algorithms are used when the output variable is categorical, which means there are two classes such as Yes-No, Male-Female, True-false, etc.

Unsupervised Learning: Unsupervised learning is best suited when the problem requires a massive amount of data that is unlabeled. For example, social media applications, such as Twitter, Instagram, Snapchat, and so on all have large amounts of unlabeled data.

> **Clustering:** Clustering is a method of grouping the objects into clusters such that objects with most similarities remains into a group and has less or no similarities with the objects of another group.
>
> **Association:** An association rule is an unsupervised learning method which is used for finding the relationships between variables in the large database.

Reinforcement Learning: Reinforcement Learning is a very different beast. The learning system, called an agent in this context, can observe the environment, select and perform actions, and get rewards in return (or penalties in the form of negative rewards).

Machine learning pipeline:

- **Data retrieval:** This is mainly data collection, extraction, and acquisition from various data
  sources and data stores.

- **Data preparation:** In this step, we pre-process the data, clean it, wrangle it, and manipulate it
  as needed.
- **Modeling:** In the process of modeling, we usually feed the data features to a Machine Learning
  method or algorithm and train the model and learn from the data.
- **Model evaluation and tuning:** Built models are evaluated and tested on validation datasets and
  based on metrics like accuracy, F1 score, and others, the model performance is evaluated.
- **Deployment and monitoring:** Selected models are deployed in production and are constantly
  monitored based on their predictions and results.

Lecture seven- Fundamental of Machine Learning

Regression analysis: is a statistical method to model the relationship between a dependent
(target) and independent (predictor) variables with one or more independent variables.

Linear Regression: Linear regression is a statistical regression method which is used for predictive analysis.

Logistic Regression: Logistic regression is another supervised learning algorithm which is used to solve the classification problems. In classification problems, we have dependent variables in a binary or discrete format such as 0 or 1.

Polynomial Regression: Polynomial Regression is a type of regression which models
the non-linear dataset using a linear model.

Support Vector Regression: Support Vector Machine is a supervised learning algorithm which can be used for regression as well as classification problems.

Decision Tree Regression: Decision Tree is a supervised learning algorithm which can be used for solving both classification and regression problems.

It can solve problems for both categorical and numerical data

Random Forest: Random forest is one of the most powerful supervised learning algorithms which is capable of performing regression as well as classification tasks.

Ridge Regression: Ridge regression is one of the most robust versions of linear regression in which a small amount of bias is introduced so that we can get better long term predictions.

Lasso Regression: Lasso regression is another regularization technique to reduce the complexity of the model.

Evaluating a Regression model

Mean Absolute Error (MAE): The Mean Absolute Error (or MAE) is the sum of the absolute differences between predictions and actual values.

Mean Squared Error (MSE): The Mean Squared Error (or MSE) is much like the mean absolute error in that it provides a gross idea of the magnitude of error.

R2: The R2 (or R Squared) metric provides an indication of the goodness of fit of a set of
predictions to the actual values.

R-squared is a statistical method that determines the goodness of fit.

Classification

Classification Algorithm: The Classification algorithm is a Supervised Learning technique that is used to identify the category of new observations on the basis of training data.
In Classification, a program learns from the given dataset or observations and then classifies new
observation into a number of classes or groups. Such as, Yes or No, 0 or 1, Spam or Not Spam,
cat or dog, etc.

Evaluating a Classification model:

Log Loss or Cross-Entropy Loss: It is used for evaluating the performance of a classifier, whose output is a probability value between the 0 and 1.

Confusion Matrix: A confusion matrix, also called a contingency table or error matrix, is used to visualize the performance of a classifier.

AUC-ROC curve: ROC curve stands for Receiver Operating Characteristics Curve and AUC stands for Area Under the Curve.
It is a graph that shows the performance of the classification model at different thresholds.

Lecture Eight- Fundamental of Machine Learning

Clustering: Clustering or cluster analysis is a machine learning technique, which groups the unlabeled dataset.
It can be defined as "A way of grouping the data points into different clusters, consisting of
similar data points. The objects with the possible similarities remain in a group that has less or
no similarities with another group.“

main clustering methods used in Machine learning:

Partitioning Clustering: Partitioning clustering divides the data into non-hierarchical groups. It is also known as the centroid-based method. The most common example of partitioning clustering is the K-Means Clustering algorithm.

Density-Based Clustering: The density-based clustering method connects the highly-
dense areas into clusters, and the arbitrarily shaped distributions are formed as long as the dense region can be connected.

Distribution Model-Based Clustering: In the distribution model-based clustering method, the data is divided based on the probability of how a dataset belongs to a particular distribution. The grouping is done by assuming some distributions commonly Gaussian Distribution.

Hierarchical Clustering: Hierarchical clustering can be used as an alternative for the partitioned clustering as there is no requirement of pre- specifying the number of clusters to be created.

In this technique, the dataset is divided into clusters to create a tree-like structure, which is also called a dendrogram.

Fuzzy Clustering: Fuzzy clustering is a type of soft method in which a data object may belong to more than one group or cluster.

Each dataset has a set of membership coefficients, which depend on the degree of membership to be in a cluster.

Association Rule Learning

Association rule learning is a type of unsupervised learning technique that checks for the
dependency of one data item on another data item and maps accordingly so that it can be
more profitable.
It tries to find some interesting relations or associations among the variables of dataset. It is
based on different rules to discover the interesting relations between variables in the database.

Types of Association Rule Learning:

Apriori Algorithm: This algorithm uses frequent datasets to generate association rules. It is designed to work on
the databases that contain transactions.
This algorithm uses a breadth-first search and Hash Tree to calculate the itemset efficiently.

Eclat algorithm: Eclat algorithm stands for Equivalence Class Transformation. This algorithm uses a depth-first search technique to find frequent itemsets in a transaction
database. It performs faster execution than Apriori Algorithm.

F-P growth Algorithm: The F-P growth algorithm stands for Frequent Pattern, and it is the improved version of the Apriori Algorithm.
It represents the database in the form of a tree structure that is known as a frequent pattern
or tree. The purpose of this frequent tree is to extract the most frequent patterns

Lecture nine- Knowledge engineering

knowledge engineering: is a branch of the science that develops rules to apply to data in order to simulate the thinking process of a human expert. It examines the

structure of a job or a choice in order to determine how a result is arrived at.

Knowledge engineering is the process of imitating how a human expert in a specific domain
would act and make decisions. It looks at the structures and processes in how a decision is
made or conclusion reached and at metadata, the information about a data object that
describes characteristics such as content, quality, and format.

Knowledge engineering attempts to take on challenges and solve problems that would usually
require a high level of human expertise to solve. The knowledge engineering pipeline starts with
representing information in a standard format, extracting the metadata, then parsing relationships using algorithms.

Knowledge engineering is the process of creating rules that apply to data in order to imitate
the way a human thinks and approaches problems. A task and its solution are broken down to
their structure, and based on that information, AI determines how the solution was reached.
Often, a library of problem-solving methods and knowledge to solve a particular set of problems
is fed into a system as raw data.

Knowledge: Knowledge is ‘The explicit functional associations between items of information and/or data’
(Debenham, 1988).

Data: Data (the plural of datum) are just raw facts

information: By information we mean data that have been shaped into a form that is meaningful and useful to human beings.

Knowledge: the result of the understanding of information.

Knowledge-based systems are computer programs that are designed to emulate the work of experts in specific areas of knowledge.

Lecture ten- Reinforcement learning

Reinforcement learning (RL) is an area of machine learning concerned with how intelligent
agents ought to take actions in an environment in order to maximize the notion of cumulative
reward.

It is employed by various software and machines to find the best possible behavior or path it
should take in a specific situation.

The agent transitions between different scenarios of the environment, referred to as **states**, by
performing **actions**. Actions, in return, yield rewards, which could be positive, negative or zero.

The agent's sole purpose is to maximize the notion of cumulative reward over an **episode**,
which is everything that happens between an initial state and a terminal state, where we decide
the rewards which align with the tasks that we want to accomplish.

Hence, we reinforce the agent to perform certain actions by providing it with positive rewards,
and to stray away from others by providing negative rewards. This is how an agent learns to
develop a **strategy or policy**.

lecture eleven- Agent and Multiagent Systems

Agent: An **entity** which is placed in an environment and senses different **parameters** that are
used to make a decision based on the goal of the entity. The entity performs the necessary
action on the **environment** based on this decision.

Entity: Entity refers to the type of the agent. An agent can be a software, e.g. daemon
security agents, a hardware component, e.g. thermostat, or a combination of both, e.g. a
robot.

Environment: This refers to the place where the agent is located. The environment can be a network in the case of traffic monitoring agents, a software when the agent is monitoring the actions of software components, etc. An agent uses the information sensed from the environment for decision making.

Parameters: The different types of data that an agent can sense from the environment are referred to as parameters. For instance, the parameters for a soccer robot agent are the position and speed of the team members and opponents, and the position of the ball.

Action: Each agent can perform an action that results in some changes in the environment.
For example, when a soccer robot kicks a ball the position of the ball changes. An agent can perform a set of discrete or continues actions. In a continues set of actions, the agent can perform unlimited actions, e.g. a soccer game. A discrete set of actions in contrast has a finite set of actions, e.g. an agent controlling a thermostat in a room.