LECTURE NOTE

ON

ARTIFICIAL INTELLIGENCE

COURSE CODE: CSC4209

Prepared By

ADAM SALEH ADAM

Department of Computer Science,
Yobe State University,
Damaturu – Nigeria

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COURSE DESCRIPTION

Introduction to artificial intelligence, understanding natural languages, knowledge representation, expert systems, pattern recognition, the language LISP.

COURSE OUTLINE

CSC4209: Artificial Intelligence: (2 Units)

Module – I: Introduction to Artificial Intelligence

- Basic Concept of Artificial Intelligence (AI)
- History of Artificial Intelligence
- The Importance of AI Knowledge
- Understanding Intelligence
- The Components of AI
- Application of AI
- Cognitive Modelling: Simulating Human Thinking Procedure

Module – II: Understanding Natural Languages

- Natural Language Processing (NLP)
- Challenges in NLP
- Techniques and Approaches in NLP
- Applications of NLP in AI

Module – III: Knowledge Representation

- Importance of Knowledge Representation in AI
- Types of Knowledge Representation
- Semantic Networks
- Frames and Scripts
- Ontologies

Module – IV: Expert Systems

- Introduction to Expert Systems
- Components of Expert Systems
- Knowledge Acquisition
- Inference Engines
- Examples and Applications of Expert Systems

Module – V: Pattern Recognition

- Introduction to Pattern Recognition
- Supervised Learning vs. Unsupervised Learning
- Feature Extraction

- Classification and Clustering Algorithms
- Applications of Pattern Recognition in AI

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Module – I: Introduction to Artificial Intelligence

Since the invention of computers or machines, their capability to perform various tasks has experienced an exponential growth. Humans have developed the power of computer systems in terms of their diverse working domains, their increasing speed, and reducing size with respect to time.

Artificial Intelligence is a concentration of computer science that aims to develop machines or computers with human-level intelligence.

1.1 Basic Concept of Artificial Intelligence (AI)

According to the father of Artificial Intelligence, John McCarthy, it is “The science and engineering of making intelligent machines, especially intelligent computer programs”.

Artificial Intelligence is a way of making a computer, a computer-controlled robot, or a software think intelligently, in the similar manner the intelligent humans think. AI is accomplished by studying how human brain thinks and how humans learn, decide, and work while trying to solve a problem, and then using the outcomes of this study as a basis of developing intelligent software and systems.

While exploiting the power of the computer systems, the curiosity of human, lead him to wonder, “Can a machine think and behave like humans do?”

Thus, the development of AI started with the intention of creating similar intelligence in machines that we find and regard high in humans.

1.2 History of Artificial Intelligence

The history of artificial intelligence (AI) is a journey of innovation and discovery, marked by several key milestones:

1. **Foundations (1940s-1950s):** The groundwork for AI was laid down by pioneers like Alan Turing, who proposed the concept of a universal computing machine. Turing also introduced the idea of testing a machine's intelligence, known as the Turing Test.
2. **Early Developments (1950s-1960s):** The 1950s and 1960s saw the creation of early AI programs such as the Logic Theorist and the development of the first chess-playing program. John McCarthy coined the term "artificial intelligence" in 1956, and the Dartmouth Conference in the same year is considered the birth of AI as a field.
3. **Expert Systems (1970s-1980s):** Despite setbacks in the 1970s and 1980s known as the "AI winter," research continued, focusing on expert systems. These systems aimed to replicate the decision-making abilities of human experts in specific domains.
4. **Neural Networks Resurgence (Late 1980s-1990s):** Neural networks experienced a resurgence with the development of backpropagation algorithms and their applications in pattern recognition and machine learning tasks.

5. **Machine Learning and Big Data (2000s-2010s):** The 2000s and 2010s saw significant progress in machine learning fueled by large datasets, increased computational power, and advances in algorithms like deep learning. AI applications became widespread across various industries.
6. **Current Trends (2010s-Present):** AI has become ubiquitous, with applications in healthcare, finance, transportation, and more. Ethical considerations, bias mitigation, and interpretability have gained importance, while research focuses on addressing challenges like explainable AI and AI safety.

1.3 The Importance of AI Knowledge

As we know that AI pursues creating the machines as intelligent as human beings. There are numerous reasons for us to study AI. The reasons are as follows:

1.3.1 AI can get knowledge from data.

We deal with enormous amounts of data in our daily lives, and the human brain is not designed to handle such volume of data. For this reason, we must automate the processes. AI is important to research because it can learn from data, do repeated jobs accurately, and prevent fatigue when undertaking automation.

1.3.2 Artificial Intelligence is self-learning.

It is very necessary that a system should teach itself because the data itself keeps changing and the knowledge which is derived from such data must be updated constantly.

We can use AI to fulfill this purpose because an AI enabled system can teach itself.

1.3.3 AI can respond in real time

Artificial intelligence with the help of neural networks can analyze the data more deeply. Due to this capability, AI can think and respond to the situations which are based on the conditions in real time.

1.3.4 AI achieves accuracy

With the help of deep neural networks, AI can achieve tremendous accuracy. AI helps in the field of medicine to diagnose diseases such as cancer from the MRIs of patients.

1.3.5 AI can organize data to get most out of it

The data is an intellectual property for the systems which are using self-learning algorithms. We need AI to index and organize the data in a way that it always gives the best results.

1.4 Understanding Intelligence

Intelligent systems can be created with AI. To enable our brain to create another intelligence system that is similar to its own, we must comprehend the notion of intelligence.

1.4.1 What is Intelligence?

The capacity of a system to perform calculations, reason, recognize connections and analogies, learn from mistakes, store and recall data from memory, solve issues, understand complicated concepts, speak naturally, categorize, generalize, and adjust to novel circumstances.

1.4.2 Types of Intelligence

According to American developmental psychologist Howard Gardner, intelligence has several functions.

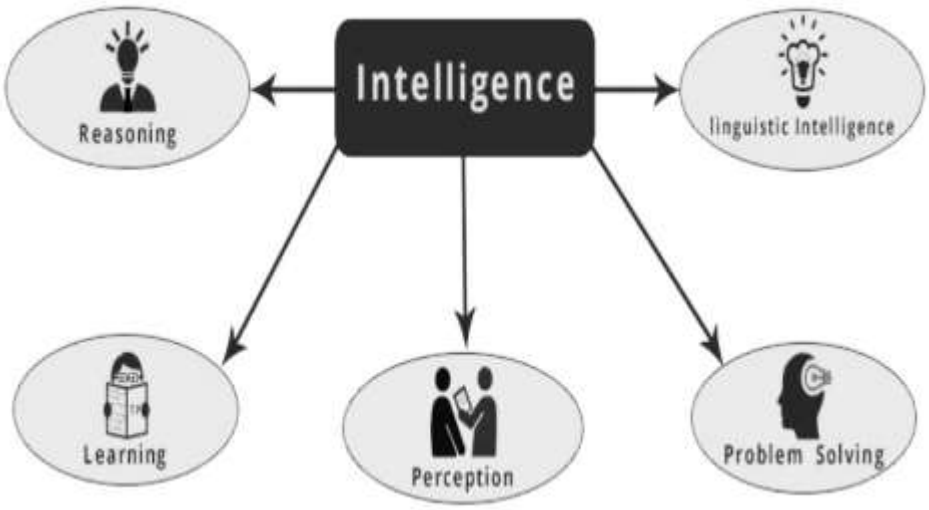
Intelligence	Description	Example
Linguistic intelligence	The ability to speak, recognize, and use mechanisms of phonology (Speech sounds), syntax (grammar), and semantics (meaning).	Narrators, Orators
Musical intelligence	The ability to create, communicate with, and understand meanings made of sound, understanding of pitch, rhythm.	Musicians, Singers, Composers
Logical-mathematical intelligence	The ability to use and understand relationships in the absence of action or objects. It is also the ability to understand complex and abstract ideas.	Mathematicians, Scientists
Spatial intelligence	The ability to perceive visual or spatial information, change it, and re-create visual images without reference to the objects, construct 3D images, and to move and rotate them.	Map readers, Astronauts, Physicists
Bodily-Kinesthetic intelligence	The ability to use complete or part of the body to solve problems or fashion products, control over fine and coarse motor skills, and manipulate the objects.	Players, Dancers
Intra-personal intelligence	The ability to distinguish among one's own feelings, intentions, and motivations.	Gautam Buddhha
Interpersonal intelligence	The ability to recognize and make distinctions among other people's feelings, beliefs, and intentions.	Mass Communicators, Interviewers

When a machine or system possesses all or at least one intelligence, you can refer to it as artificially intelligent.

1.4.3 What Constitutes Intelligence?

Intelligence is intangible. It is composed of:

- Reasoning
- Learning
- Problem Solving
- Perception
- Linguistic Intelligence



Let's quickly go over each component:

1. ***Reasoning***

It is the set of processes that enable us to provide basis for judgement, making decisions, and prediction. There are broadly two types:

Inductive Reasoning	**Deductive Reasoning**
It conducts specific observations to makes broad general statements.	It starts with a general statement and examines the possibilities to reach a specific, logical conclusion.
Even if all of the premises are true in a statement, inductive reasoning allows for the conclusion to be false.	If something is true of a class of things in general, it is also true for all members of that class.
Example – "Nita is a teacher. Nita is studious. Therefore, all teachers are studious."	Example – "All women of age above 60 years are grandmothers. Shalini is 65 years. Therefore, Shalini is a grandmother."

2. Learning

The ability of learning is possessed by humans, particular species of animals, and AI enabled systems. Learning is categorized as follows:

a) Auditory Learning
It is learning by listening and hearing. For example, students listening to recorded audio lectures.

b) Episodic Learning
To learn by remembering sequences of events that one has witnessed or experienced. This is linear and orderly.

c) Motor Learning
It is learning by precise movement of muscles. For example, picking objects, writing, etc.

d) Observational Learning
To learn by watching and imitating others. For example, child tries to learn by mimicking her parent.

e) Perceptual Learning
It is learning to recognize stimuli that one has seen before. For example, identifying and classifying objects and situations.

f) Relational Learning
It involves learning to differentiate among various stimuli on the basis of relational properties, rather than absolute properties. For Example, adding 'little less' salt at the time of cooking potatoes that came up salty last time, when cooked with adding say a tablespoon of salt.

- **Spatial Learning** − It is learning through visual stimuli such as images, colors, maps, etc. For example, A person can create roadmap in mind before actually following the road.
- **Stimulus-Response Learning** − It is learning to perform a particular behaviour when a certain stimulus is present. For example, a dog raises its ear on hearing doorbell.

3. Perception

It is the process of acquiring, interpreting, selecting, and organizing sensory information.

Perception presumes **sensing**. In humans, perception is aided by sensory organs. In the domain of AI, perception mechanism puts the data acquired by the sensors together in a meaningful manner.

4. Problem Solving

It's the process of seeing a situation as it is and trying to find a way around obstacles, either known or unknown, in order to reach a desired outcome.

Making decisions, which is the process of choosing the most appropriate option from a range of options to accomplish a goal, is another aspect of problem solving.

5. Linguistic Intelligence

It is one's ability to use, comprehend, speak, and write the verbal and written language. It is important in interpersonal communication.

1.5 The Components of AI

Artificial intelligence is a vast area of study. This field of study helps in finding solutions to real world problems.

Let us now see the different fields of study within AI:

1.5.1 Machine Learning

It is among the most well-known areas in AI. The fundamental principle underlying this discipline is to teach machines from data in the same way that humans gain knowledge through experience. It comprises learning models that enable the generation of predictions on data that is not yet known.

1.5.2 Logic

It is another important field of study in which mathematical logic is used to execute the computer programs. It contains rules and facts to perform pattern matching, semantic analysis, etc.

1.5.3 Searching

This field of study is basically used in games like chess, tic-tac-toe. Search algorithms give the optimal solution after searching the whole search space.

1.5.4 Artificial Neural Networks (ANN)

This is a network of efficient computing systems the central theme of which is borrowed from the analogy of biological neural networks. ANN can be used in robotics, speech recognition, speech processing, etc.

1.5.5 Genetic Algorithm

Genetic algorithms help in solving problems with the assistance of more than one program. The result would be based on selecting the fittest.

1.5.6 Knowledge Representation

It is the field of study with the help of which we can represent the facts in a way the machine that is understandable to the machine. The more efficiently knowledge is represented; the more system would be intelligent.

1.6 Application of AI

In this part, we shall examine the various domains that AI supports:

1.6.1 Gaming

AI plays crucial role in strategic games such as chess, poker, tic-tac-toe, etc., where machine can think of large number of possible positions based on heuristic knowledge.

1.6.2 Natural Language Processing

It is possible to interact with the computer that understands natural language spoken by humans.

1.6.3 Expert Systems

There are some applications which integrate machine, software, and special information to impart reasoning and advising. They provide explanation and advice to the users.

1.6.4 Vision Systems

These systems understand, interpret, and comprehend visual input on the computer. For example:

- A spying aeroplane takes photographs, which are used to figure out spatial information or map of the areas.
- Doctors use clinical expert system to diagnose the patient.
- Police use computer software that can recognize the face of criminal with the stored portrait made by forensic artist.

1.6.5 Speech Recognition

Some intelligent systems are capable of hearing and comprehending the language in terms of sentences and their meanings while a human talks to it. It can handle different accents, slang words, noise in the background, change in human's noise due to cold, etc.

1.6.6 Handwriting Recognition

The handwriting recognition software reads the text written on paper by a pen or on screen by a stylus. It can recognize the shapes of the letters and convert it into editable text.

1.6.7 Intelligent Robots

Robots are able to perform the tasks given by a human. They have sensors to detect physical data from the real world such as light, heat, temperature, movement, sound, bump, and pressure. They have efficient processors, multiple sensors and huge memory, to exhibit intelligence. In addition, they are capable of learning from their mistakes and they can adapt to the new environment.

1.7 Cognitive Modelling: Simulating Human Thinking Procedure

Cognitive modelling is basically the field of study within computer science that deals with the study and simulating the thinking process of human beings. The main task of AI is to make machine think like human. The most important feature of human thinking process is problem solving. That is why more or less cognitive modelling tries to understand how humans can solve the problems. After that this model

can be used for various AI applications such as machine learning, robotics, natural language processing, etc.

The graphic below illustrates the several stages of thought in the human brain: