SPPU New Syllabus

A Book Of

Artificial Intelligence

For M.Sc. (Computer Applications) : Semester - III

[Course Code CA-601-MJ : Credits-04]

CBCS Pattern

As Per New Syllabus (Under NEP), Effective from 2023-2024

Mrs. Dipali Mali (Mahajan)
MCA (Science), CBSE-UGC NET, Pursuing Ph.D.
Asst. Professor
PDEA's Annasaheb Magar College, Hadapsar
Pune 4110028

Mrs. Monica Deshmane (Dhotre)
MCS, UGC NET, Pursuing Ph.D.
Asst. Professor
Haribhai V. Desai College of Commerce, Arts and Science
Pune 411002

Price ₹ 185.00

NIRALI PRAKASHAN
ADVANCEMENT OF KNOWLEDGE

N0342

ARTIFICIAL INTELLIGENCE **ISBN 978-93-6109-476-7**

First Edition : June 2024
© : Authors

The text of this publication, or any part thereof, should not be reproduced or transmitted in any form or stored in any computer storage system or device for distribution including photocopy, recording, taping or information retrieval system or reproduced on any disc, tape, perforated media or other information storage device etc., without the written permission of Authors with whom the rights are reserved. Breach of this condition is liable for legal action.

Every effort has been made to avoid errors or omissions in this publication. In spite of this, errors may have crept in. Any mistake, error or discrepancy so noted and shall be brought to our notice shall be taken care of in the next edition. It is notified that neither the publisher nor the authors or seller shall be responsible for any damage or loss of action to any one, of any kind, in any manner, therefrom. The reader must cross check all the facts and contents with original Government notification or publications.

Published By :
NIRALI PRAKASHAN
Abhyudaya Pragati, 1312, Shivaji Nagar,
Off J.M. Road, Pune – 411005
Tel - (020) 25512336/37/39
Email : niralipune@pragationline.com

Polyplate

Printed By :
YOGIRAJ PRINTERS AND BINDERS
Survey No. 10/1A, Ghule Industrial Estate
Nanded Gaon Road
Nanded, Pune - 411041

DISTRIBUTION CENTRES

PUNE

Nirali Prakashan
(For orders outside Pune)
S. No. 28/27, Dhayari Narhe Road, Near Asian College
Pune 411041, Maharashtra
Tel : (020) 24690204; Mobile : 9049672225
Email : bookorder@pragationline.com

Nirali Prakashan
(For orders within Pune)
119, Budhwar Peth, Jogeshwari Mandir Lane
Pune 411002, Maharashtra
Mobile : 96577031450, 9890997937
Email : niralilocal@pragationline.com

MUMBAI

Nirali Prakashan
Rasdhara Co-op. Hsg. Society Ltd., 'D' Wing Ground Floor, 385 S.V.P. Road
Girgaum, Mumbai 400004, Maharashtra
Mobile : 7045821020, Tel : (022) 2385 6339 / 2386 9976
Email : niralimumbai@pragationline.com

DISTRIBUTION BRANCHES

DELHI

Nirali Prakashan
Room No. 2 Ground Floor
4575/15 Omkar Tower, Agarwal Road Darya Ganj, New Delhi 110002
Mobile : 9555778814/9818561840
Email : delhi@niralibooks.com

BENGALURU

Nirali Prakashan
Maitri Ground Floor, Jaya Apartments, No. 99, 6th Cross, 6th Main, Malleswaram, Bengaluru 560003 Karnataka; Mob : 9686821074
Email : bengaluru@niralibooks.com

NAGPUR

Nirali Prakashan
Above Maratha Mandir, Shop No. 3, First Floor, Rani Jhanshi Square, Sitabuldi Nagpur 440012 (MAH)
Tel : (0712) 254 7129
Email : nagpur@niralibooks.com

KOLHAPUR

Nirali Prakashan
438/2, Bhosale Plaza, Ground Floor
Khasbag, Opp. Balgopal Talim
Kolhapur 416 012 Maharashtra
Mob : 9850046155
Email : kolhapur@niralibooks.com

JALGAON

Nirali Prakashan
34, V. V. Golani Market, Navi Peth, Jalgaon 425001, Maharashtra
Tel : (0257) 222 0395
Mob : 94234 91860
Email : jalgaon@niralibooks.com

SOLAPUR

Nirali Prakashan
R-158/2, Avanti Nagar, Near Golden Gate, Pune Naka Chowk
Solapur 413001, Maharashtra
Mobile 9890918687
Email : solapur@niralibooks.com

marketing@pragationline.com | www.niralibooks.com
Also find us on www.facebook.com/niralibooks

Preface ...

"Artificial Intelligence" is a fundamental subject of Computer Science which is designed to understand Artificial Intelligence concepts using various tasks. Due to this student can easily solve problems using searching strategies in AI. It is our pleasure to present book on this subject for **MSc. (Computer Applications): Semester-III as per updated syllabus at 2023 pattern (Under NEP).**

To make the subject very interesting, lot of examples and code samples for various algorithms are mentioned in the book. Each chapter contains simple language for explanation and short code or examples are given with suitable diagrams. This book covers various search strategies for AI Problem Solving, also covers Multi-agent Environment, Knowledge Representation and Reasoning Mechanisms as well as Fundamentals of Game Theory such as Logical Inference, Future Scope and Recent Trends in AI. At the end of each chapter, Multiple Choice Questions, Short answer questions and Long answer questions are provided for practice.

I, Dipali Mali dedicate my work to my parents, all my B.C.S. and M.C.A. teachers, Husband and My daughter Swara.

I, Dipali Mali thankful to my parents Dipti and Deepak Mali, my husband Shailesh Mahajan and my teachers and guide Dr. S.N. Shinde, Dr. Vilas Wani and Dr. Prashant Mulay, for their support and inspiration.

I Monica Dhotre thankful to my mother Mrs. Meera Deshmane, My Husband Sagar Dhotre, my son Smaran, my whole family members, my friends, colleagues who are constant source of inspiration.

I express my sincere thanks to our former principal Dr. Ganesh Raut sir, Dr. Gulab Gugale sir (Chemistry dept H.V.Desai College Pune) for their support in writing book.

Our sincere thanks to Shri. Dineshbhai Furia, Mr. Jignesh Furia for trusting and giving this opportunity to work with them.

We also thank to Mrs. Anita Panajkar, Ms. Madhuri Gabale, Mr. Malik Shaikh, and Ms. Chaitali Takale for their excellent co-operation.

We also thank to Nirali Prakashan for bringing out the book in market within a short period of time.

Any suggestions and improvements in contents of book will be appreciated and accordingly modifications can be done in later editions.

Asst. Prof. Dipali Deepak Mali (Mahajan)
Annasaheb Magar College, Pune 28

Asst. Prof. Monica Deshmane (Dhotre)
Haribhai V. Desai College, Pune 2

***

Syllabus ...

1. **Introduction to Artificial Intelligence** **[12 Hrs.]**

   Introduction to Artificial Intelligence, Foundations of Artificial Intelligence, History of Artificial Intelligence, State of the Art, Intelligent Agents, Agents and Environments, Good Behavior: Concept of Rationality, Nature of Environments, Structure of Agents, Benefits and limitation of AI, Ethics in AI, AI Components, AI Architectures.

2. **Searching** **[12 Hrs.]**

   Uninformed Search Algorithms/Blind Search Techniques - Breadth-first Search, Depth-first Search.

   Informed (Heuristic) search Techniques: Generate-and-test, Simple Hill Climbing, Best First Search, Constraint Satisfaction, Means End Analysis, A* and AO*.

3. **Gaming** **[12 Hrs.]**

   Game Theory, Optimal Decisions in Games, Heuristic Alpha–Beta Tree Search, Monte Carlo Tree Search, Stochastic Games, Partially Observable Games, Limitations of Game Search Algorithms.

4. **Knowledge Representation** **[10 Hrs.]**

   Definition of Knowledge, Types of knowledge (Procedural and Declarative knowledge), Approaches to Knowledge Representation.

   Knowledge representation using Propositional and Predicate logic - Conversion to clause form, Resolution in Propositional logic, Resolution in Predicate logic.

5. **Reasoning** **[10 Hrs.]**

   Inference in First-Order Logic, Propositional vs. First-Order Inference, Unification and First-Order Inference, Forward Chaining, Backward Chaining, Resolution, Knowledge Representation, Ontological Engineering, Categories and Objects, Events, Mental Objects and Modal Logic, Reasoning Systems for Categories, Reasoning with Default Information

***

Contents ...

1.	Introduction to Artificial Intelligence	1.1 – 1.28
2.	Searching	2.1 – 2.25
3.	Gaming	3.1 – 3.31
4.	Knowledge Representation	4.1 – 4.21
5.	Reasoning	5.1 - 5.45

***

UNIT 1

Introduction to Artificial Intelligence

Contents

1.1 Introduction
1.2 Introduction to Artificial Intelligence
  1.2.1 Approaches of AI
  1.2.2 Application of Artificial Intelligence
  1.2.3 Types of AI
1.3 Foundations of Artificial Intelligence
  1.3.1 Philosophy
  1.3.2 Mathematics
  1.3.3 Economics
  1.3.4 Neuroscience
  1.3.5 Psychology
  1.3.6 Computer Engineering
  1.3.7 Control Theory and Cybernetics
  1.3.8 Linguistics
1.4 History of Artificial Intelligence
1.5 State of the Art
1.6 Intelligence Agents
  1.6.1 What is an Agent and its types?
  1.6.2 Characteristics of Intelligence Agents
  1.6.3 Uses of Agents
1.7 Agents and Environments
1.8 Good Behaviour: Concept of Rationality
1.9 Nature of Environments
1.10 Structure of Agents
1.11 Benefits and Limitations of AI
1.12 Ethics in AI
1.13 AI Components
1.14 AI Architectures

Objectives...

After reading this chapter, you will be able:

- To learn how to use intelligence artificially.
- To understand foundations of Artificial Intelligence.
- To do comparison between risks and benefits of AI.
- To learn the structure of Agents and its types.

1.1 INTRODUCTION

- For centuries, we have been trying to figure out how the thinking process works.
- The field of Artificial Intelligence, or AI used to understand, predict, manipulate and also to build intelligent entities.
- There are some differences in working of Computer & Human being:
  - Computers can perform Numerical Computation very fast; it has Large Information Storage Area. It can perform Repetitive Operations, Numeric Processing very fast and efficiently.
  - Whereas Human being can perform Numerical Computation very slow, they have less or limited Information Storage Area, even can perform Repetitive Operations, Numeric Processing very slowly. But Human being is intelligent not computers.

1.2 INTRODUCTION TO ARTIFICIAL INTELLIGENCE

What is AI?

- There are so many definitions of AI. We will see some of them:
  - "The automation of activities that we associate with human thinking, activities such as decision-making, problem solving, learning ..." (by Bellman, in 1978).
  - "The study of how to make computers do things at which, at the moment, people are better". (By Rich and Knight, in 1991).
  - A system is said to be rational if it does the "right thing", given whatever it knows.

1.2.1 Approaches of AI

- **A Human-centered Approach** involves observations and hypotheses about human behavior.
- **A Rationalist Approach** involves a combination of both engineering and mathematics.
- AI has historically followed four different approaches, each developed by different people using different techniques.
- Following are the four approaches of AI according to Thinking Humanly, Acting Humanly, Thinking Rationally and Acting Rationally:

1) Thinking Humanly: This is also called as the **Cognitive Modeling Approach**.

- After determining how humans think then only we can say that a given program thinks like a human.

- We need to think as per the actual workings of human minds. For doing this there are three ways**:**
  1. **Using Introspection:** In this method, human minds try to capture our own thoughts.
  2. **Using Psychological Experiments:** In this method, human minds observing action of a person.
  3. **Using Brain Imaging:** In this method, human minds observing the action of brain.
- If the program's input and output behavior is matches as per human behavior, it means that some of the program's mechanisms could also be operating in humans.

2) Acting Humanly: This is also called as the **Turing Test Approach**.

- TURING TEST is proposed by Alan Turing at year 1950, which was designed to provide an operational definition of intelligence.
- A computer is deemed to have passed a test when, after posing a series of written questions, a human investigator is unable to differentiate between the written answers provided by a person or a computer.
- Here, the computer should contain following capabilities**:**
  - NLP (Natural Language Processing) for successful communication in English.
  - Knowledge Representation for storing information that is known or heard.
  - Automated Reasoning for using the stored information for giving answers to questions and for drawing new conclusions.
  - Machine learning for adapting new circumstances and detecting patterns.

3) Thinking Rationally: This is also called as the **"laws of thought" Approach**.

- Aristotle, the Greek philosopher, was one of the first to attempt to codify "right thinking".
- These rules, known as *syllogisms*, formed the basis for argument structures that always gave correct results when applied correctly.
- Consider the example, "Socrates is a man; all men are mortal; therefore, Socrates is mortal". These laws of thought were LOGIC which is supposed to govern the operation of the mind. And their study initiated the field called **Logic.**

4) Acting Rationally: This is also called as the **Rational Agent Approach**.

- The term *agent* comes from the Latin *agere*; this means just something that acts.
- As we know that all the computer programs do something, but the computer agent is expected to do something more such as operating autonomously, perceiving their environment, persisting over a long time period, adapting as per RATIONAL AGENT changes, and also pursuing goals.
- A rational agent used to achieve the best outcome or, it gives the best expected outcome when there are uncertainties.
- The rational agent approach is more advantageous for two reasons comparing to the other approaches.
  - First, it is more general than the "laws of thought" approach as the correct inference is one of the several possible mechanisms to achieve rationality.
  - Second, it is more following to scientific development than human behavior or human thought approaches.

1.2.2 Application of Artificial Intelligence

- There are some Application of Artificial Intelligence which shown as below:
  1. **Games:** Game playing considered to be displaying intelligence that leads success or failure. For example, Chess.
  2. **Natural Language Processing:** NLP allows people and computer to communicate in a natural (means compatible to human) language, rather than in a computer language.
  3. **Theorem Proving:** It is one of the methods for displaying intelligence through logically.
  4. **Robotics:** This is an electro-mechanical device which is programmed to perform human tasks.
  5. **Vision and Speech Processing:** This is used to convert visible data or speech (audible data) to text without writing.
  6. **Real Life Applications:** In Automobiles, applications like self-driving cars, in Banking implementing Chatbot for helping the customers, detecting fraud transactions, security purpose using CCTV camera, in Social Media, Entertainment, and Education.

1.2.3 Types of AI

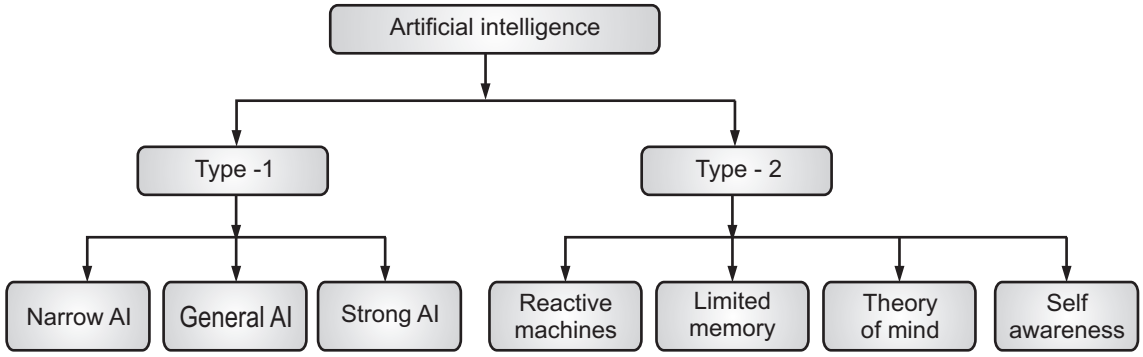


Fig. 1.1: Types of AI

Types of AI based on Capabilities:

1. **Weak AI/Artificial Narrow Intelligence (ANI):** AI which can perform a dedicated task using intelligence. For example, Siri, Alexa.
2. **Artificial General Intelligence (AGI):** AI which performs any intellectual task with efficiency like a human. For example, Self-driving cars.
3. **Artificial Super Intelligence (ASI):** This is a level of Intelligence in machines that can perform any task better than human with cognitive properties. For example, Hypothetical AI which is not achieved yet.

Types of AI based on functionality:

1. **Reactive Machines:** They focus on current scenarios and react on it as per possible best actions which do not store memories or past experiences for future actions.
2. **Limited Memory:** They may store past experiences or some data for some short period of time. It can use stored data for a limited time only.
   Example: Self-driving cars, monitoring traffic lights.

3. **Theory of Mind:** They focus on the human emotions, people, beliefs, and be able to interact socially like humans.
4. **Self-Awareness AI:** They contain advanced features of AI so this is the future of Artificial Intelligence. Machines will be super intelligent, and will have their own sentiments, emotions, consciousness, and self-awareness.

1.3 FOUNDATIONS OF ARTIFICIAL INTELLIGENCE

- In this section, we learn a brief history of the disciplines by which ideas, viewpoints, and techniques work with AI.

1.3.1 Philosophy

- Aristotle (384–322 B.C.) has formulated first a precise set of laws governing the rational part of the mind. He has developed proper reasoning informal system of syllogisms to generate conclusions mechanically.
- Ramon Llull (d. 1315) had the idea that mechanical artifact was the useful for reasoning.
- Thomas Hobbes (1588–1679) proposed that reasoning is that "we add and subtract in our silent thoughts" means numerical computation.
- Rene Descartes (1596–1650) has given the first clear distinction between mind and matter with the problems that arise which includes following some important terms:
  - **Rationalism:** The power of reasoning to understand the world philosophy.
  - **Dualism:** There is a soul or spirit called part of the human mind outside of nature, exempt from physical laws except in animals.
  - **Materialism:** The brain's operation as per the laws of physics constitutes the mind.

1.3.2 Mathematics

- Philosophers established some fundamental ideas of AI, but the base is mathematical formalization in three fundamental areas: Logic, Computation, and Probability.
- The mathematical development really began with the details of propositional, or Boolean, logic, work of George Boole (1815–1864), then extended Boole's logic with objects and relations, creating the first order logic used now days. After that a theory of reference introduced to relate the objects in logic to objects in the real world.
- The first nontrivial algorithm called Euclid's Algorithm introduced in computing greatest common divisors.
- Then some terms introduced that includes, intractable problem (if the time required to solve instances of the problem grows exponentially (even moderately large instances cannot be solved in any reasonable time) depending on the size of the instances), polynomial and exponential growth in complexity. Then some problems are converted into tractable sub problems rather than intractable ones. And the concept of NP-COMPLETENESS also comes in picture after some period of time.
- The third important contribution of mathematics to AI is nothing but theory of PROBABILITY which is framed by The Italian Gerolamo Cardano (1501–1576). The term was used for the possible outcomes of gambling events.

1.3.3 Economics

- The science of economics started in 1776, by Scottish philosopher Adam Smith. He has published "An Inquiry into the Nature and Causes of the Wealth of Nations".
- When we think about economics the idea comes in mind about money, but exactly if we ask economists, he will say that it is used to study how people make choices that lead to preferred outcomes.
- The term **Decision Theory** that combines probability theory with utility theory, which provides a complete framework for economic decisions made under uncertainty.
- Von Neumann and Morgenstern's development of game for some games, a rational agent should adopt policies that are randomized using Game Theory. Unlike Decision Theory, Game Theory does not offer an unambiguous prescription for selecting actions.

1.3.4 Neuroscience

- Neuroscience is nothing but the study of the nervous system. For example, the brain. Although we can't predict what the exact thoughts come in the brain, the fact that it does enable thought as the evidence that signals reaches to the head can lead to mental incapacitation.
- The term **Neuron** is nothing but nerve cells, or neurons which consists the brain. In 1873, Camillo Golgi has developed a staining technique that allows the observation of individual neurons in the brain.

1.3.5 Psychology

- The German physicist Hermann von Helmholtz and one of his students Wilhelm Wundt introduced origins of scientific psychology. His Handbook of Physiological Optics is well known as "the single most important treatise on the physics and physiology of human vision".
- Biologists studying animal behavior were described by H. S. Jennings (1906) in his work. Behavior of the Lower Organisms and when the concept applied to humans, the behaviorism movement comes in picture, by John Watson.
- By viewing the brain as an information-processing device the term called **Cognitive Psychology** comes in picture by William James.

1.3.6 Computer Engineering

- This area focuses on how we can build an efficient computer.
- For success Artificial Intelligence, we require two things: Intelligence and An artifact.
- The modern digital electronic computer was invented independently by scientists in three countries who battled in World War II.
- By the time in each generation of computer, hardware speed and capacity increased and the price decreased.

1.3.7 Control Theory and Cybernetics

- This is all about exploring the idea of how artifacts can work independently of each other.

- The first self-controlling machine called a *water clock with a regulator* which maintained a constant flow rate was built by Ctesibius of Alexandria.
- First time, only living things were able to modify their behavior according to changes in the environment. But in next examples of self-regulating feedback control systems that includes the Steam Engine Governor, which was created by James Watt, and the Thermostat and the Submarine, was invented by Cornelis Drebbel.

1.3.8 Linguistics

- Linguistics focuses on how the language relating to the thought in our mind.
- Verbal Behavior was published by B. F. Skinner In 1957.
- Earlier work in knowledge representation was tied to language and also informed by linguistics research.

1.4 HISTORY OF ARTIFICIAL INTELLIGENCE

1. The Gestation of Artificial Intelligence (1943–1955)

- The very first conceptual work of AI was done by Warren McCulloch and Walter Pitts in 1943.
- According to them there are three sources**:**
  (a) Knowledge of the basic physiology and function of neurons in the brain.
  (b) A formal analysis of propositional logic.
  (c) Turing's theory of computation.
- They conceptually presented the model of artificial neurons in which each neuron is passing response to sufficient number of neighboring neurons like "on" or "off", in a switch.

2. The Birth of Artificial Intelligence (1956):

- McCarthy after receiving PhD degree in 1951 and working for two years as an instructor, he moved to Stanford and then to Dartmouth College. He convinced other inventors to help him in Automata Theory, Neural Nets, and the Study of Intelligence.
- After some time, he found how to make machines that use language, form abstractions and concepts, solve problems now reserved for humans.

3. Early enthusiasm, great expectations (1952–1969):

- The primitive computers and programming tools at that time could do only arithmetic so the term preferred to believe that "a machine can never do X", where X's gathered by Turing.
- GPS was the first program that based on "thinking humanly" approach in 1976 to formulate the physical symbol system hypothesis.
- McCarthy at that time defined the high-level LISP language, which was to become the dominant AI programming language for the next 30 years.

4. A Dose of Reality (1966–1973):

- According to the statement "visible future" by Herbert Simon in 1957, within 10 years a computer would be chess champion, significant mathematical theorem would be proved by machine.
- In terms of problem-solving programs, early experiments in machine evolution done with the help of genetic algorithms, that were based on the undoubtedly correct belief to make a series of small mutations to a machine-code program, with good performance. Later on, it also tried for random mutations with a selection process to preserve mutations that appeared useful.

5. **Knowledge-Based Systems (1969–1979):**
- Problem solving at first decade of AI research was of a general-purpose search mechanism that tries to find complete solutions to problems. These approaches called Weak Methods because they do not scale up to large or difficult problem instances.
- Later on the method developed to solve the problem of inferring molecular structure from the information provided by a Mass Spectrometer.

6. **AI becomes an Industry (1980–present):**
- The program helped in configuring orders for new computer systems at 1986, this system was saving the company an estimated $40 million a year.
- AI industry in 1980 from a few million dollars boomed to billions of dollars in 1988, that includes hundreds of companies that build expert systems, vision systems, robots, and software and hardware specialized for these purposes.

7. **The Return of Neural Networks (1986–present):**
- In mid of 1980's, the different group of people have reinvented the back-propagation learning algorithm that was first found in 1969.

8. **AI Adopts the Scientific Method (1987–present):**
- AI has come under the scientific method. That was accepted, hypotheses tested using empirical experiments, and the results were analyzed statistically.
- Recently the approaches that are based on Hidden Markov Models (HMMs) come with following two aspects.
  (a) Based on a rigorous mathematical theory. Because of this speech researchers can develop mathematical results in other fields.
  (b) Training on a large corpus of real speech data. So the performance is robust.

1.5 STATE OF THE ART

- There are wide area applications of Artificial Intelligence. It can be very useful to solve complex problems in simple way.

1.5.1 Games

- The most widely used search problem Game playing which is base on Initial state, Successor function, Goal test and Path cost function.
- It results either in success or failure on the basis of number of steps and efforts.
- There are two main components of game playing,
  1. Using a plausible move generator which is used to expand only some selected moves.
  2. A static evaluation function which is totally based on heuristics and it generates the static evaluation function value for every move.
- Following are characteristics of game playing :
  1. "Unpredictable" opponent in which solution is a strategy specifying a move for each opponent reply.
  2. Time limits to find goal should be approximate.

Example: Chess
- It is AI-based game playing that uses intelligence with entertainment.
- World-champion chess playing programs may have more than twenty plus moves in advance for each move. Additionally, due to its capacity to acquire knowledge, the programs can progressively enhance their performance over time.

- In computerized games, the next move comes from exhaustive searches into all moves, and the next moves based on prior learning.

1.5.2 Natural Language Processing

- To make the effective use of a computer, we can use of a programming language to communicate with it.
- The main goal of natural language processing is to allow people to communicate with computer in a "natural " or human like real language such as a English rather than in a computer programming language.
- Natural language processing field is divided into the two main sub-fields **:**
  1. **Natural language understanding**: To allow computers to understand instruction given in ordinary English to understand people more easily.
  2. **Natural language generation**: To allow computers to generate ordinary English language sentences so that people can understand computers more easily.

1.5.3 Theorem Proving

- One of the characteristics of theorem proving is that those who are more proficient at intelligence.
- An early effort to prove mathematical theorems was **Logic Theorist**. Because of which many theorems on Foundations of Mathematics succeeded.
- The prover of Gelernters' theorem investigated an additional geometry in Mathematics.
- There are three main categories of issues exist in AI**:**
  1. **Ignorable problems**, where specific actions are ignored.
  2. **Irrecoverable problems**, in which specific actions cannot be undone.
  3. **Recoverable problems**, where solution actions can be undone.

1.5.4 Vision and Speech Processing

- The main focus of Natural Language Processing is to allow computers to communicate with people in English natural words and sentences that are typed on paper or displayed on a screen.
- So the primary method of communication used by humans is speech rather than reading and writing.
- NLP allows computers to understand human speech as they are able to hear our voices and also able to recognize speech. In Speech recognition, a camera is attached to computer to capture images. Using AI computers are able to interpret those images and can understand exactly what is visible. In same manner that we use vision to visualize things.
- Using AI computers become smarter with powerful facility for understanding their surroundings like able to hear, feel, smell or taste just like human.

1.5.5 Expert System

- An expert system also known as a knowledge-based system. This is a computer program which is designed to act as an expert in a particular domain.
- It is consisting knowledge of facts about the domain and rules for applying those facts.
- One of the very first expert systems was MYCIN which was came in picture in 1974, that diagnosed bacterial infections of the blood and suggested some Treatments