Introduction to AI and Intelligent System

What is Intelligence?

- Intelligence is a property of mind that encompasses many related mental abilities, such as the capabilities to
  - reason
  - plan
  - solve problems
  - think abstractly
  - comprehend ideas and language and
  - Learn

Categories of AI System

- Systems that think like humans
- Systems that act like humans
- Systems that think rationally
- Systems that act rationally

Artificial intelligence (AI)

- Focuses on developing intelligent machines that can perform tasks that typically require human intelligence, such as visual perception, speech recognition, decision-making, and language translation.
- are designed to learn from experience, adapt to new situations, and improve performance over time without being explicitly programmed.
- The ultimate goal of AI is to create machines that can simulate human intelligence, including reasoning, problem-solving, and creativity.
- **AI is classified into 3 categories processes: Sensing, Reasoning, and Acting.**
- AI has become increasingly important in modern society for a variety of reasons:
  - Efficiency, Improved decision-making, Personalization
  - Accessibility and Innovation

Key concepts and terminology

Machine learning

- is a subset of artificial intelligence (AI) that involves training algorithms to make predictions or decisions based on input data.
- Unlike traditional programming, where rules and logic are explicitly defined, ML algorithms are trained using large datasets to learn patterns and make decisions.
- There are several types of machine learning algorithms, including
  - supervised learning: Supervised learning involves training an algorithm on labeled data
  - unsupervised learning: unsupervised learning involves training an algorithm on unlabeled data
  - and reinforcement learning: Reinforcement learning involves training an algorithm to make decisions based on rewards and punishments.

Some examples of machine learning in practice include:

- Image recognition
- Speech recognition
- Fraud detection
- Personalization
- Healthcare
- Natural language processing

Deep learning

- is a subset of machine learning that involves training neural networks with multiple layers to recognize patterns in data.
- Deep learning models are typically used for complex tasks that involve large amounts of data, like image and speech recognition, natural language processing, and autonomous driving.

- Deep learning models consist of layers of artificial neurons, each processing input data and passing it on to the next layer.
- These layers allow the model to learn increasingly complex representations of the input data, ultimately making predictions or decisions based on the known patterns.
- Some examples of deep learning in practice:
- Image recognition
- Speech recognition
- Natural language processing
- Autonomous driving
- Robotics

Natural Language Processing (NLP)

- is a subfield of artificial intelligence (AI) that involves training machines to understand, interpret, and generate human language.
- NLP allows machines to process and analyze large amounts of text and speech data, enabling applications such as language translation, sentiment analysis, and chatbots.
- Natural language processing in practice:
  - Language translation
  - Sentiment analysis
  - Chatbots
  - Text summarization
  - Named entity recognition

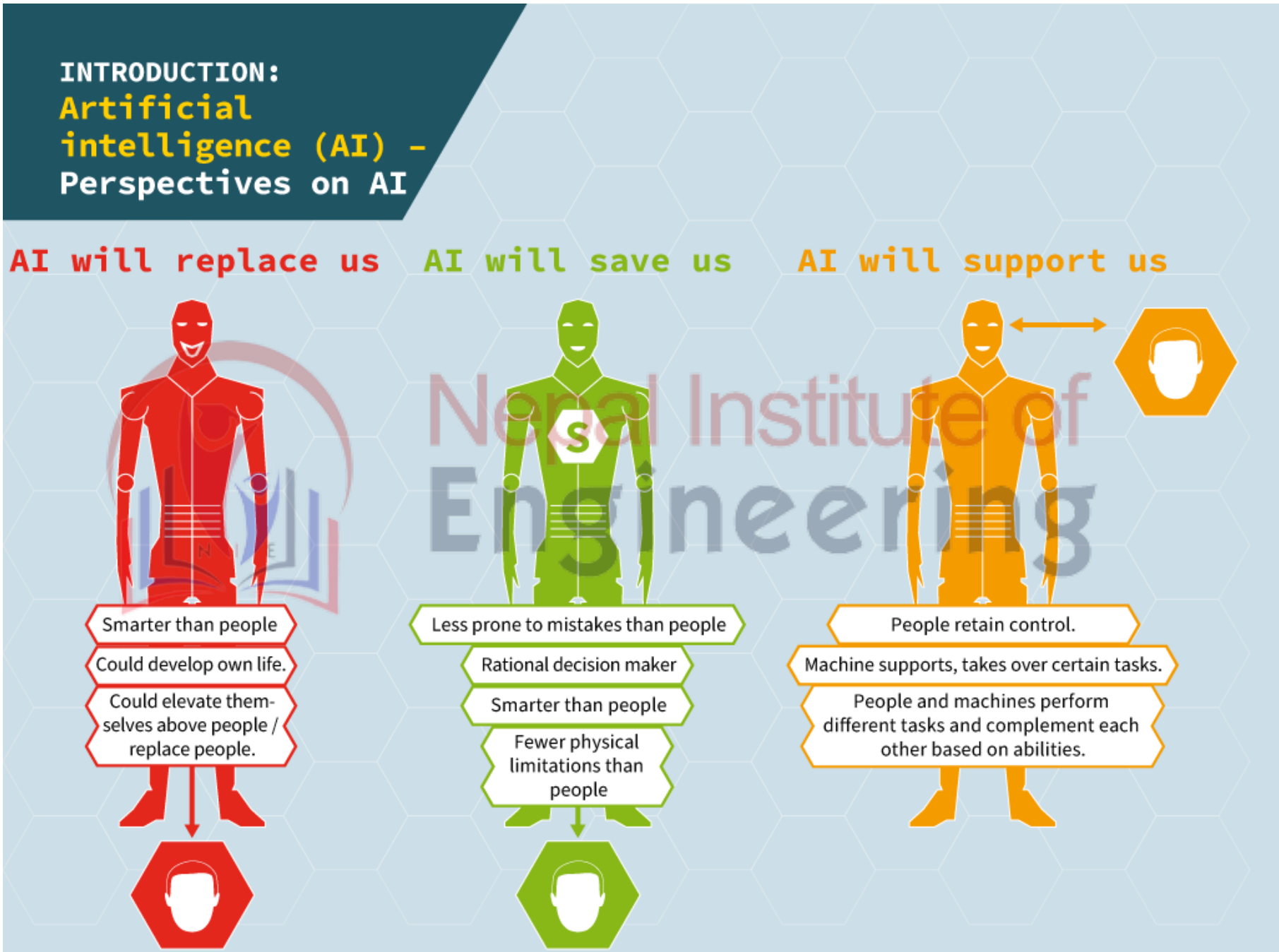
Robotics

- Robotics is a field of study and engineering that deals with robot design, construction, operation, and use.
- A robot is a machine or an autonomous agent capable of carrying out a complex series of actions automatically, typically by being programmed or controlled by a computer.
- Some examples of robotics in practice include:
  - Manufacturing
  - Healthcare
  - Exploration
  - Agriculture
  - Military

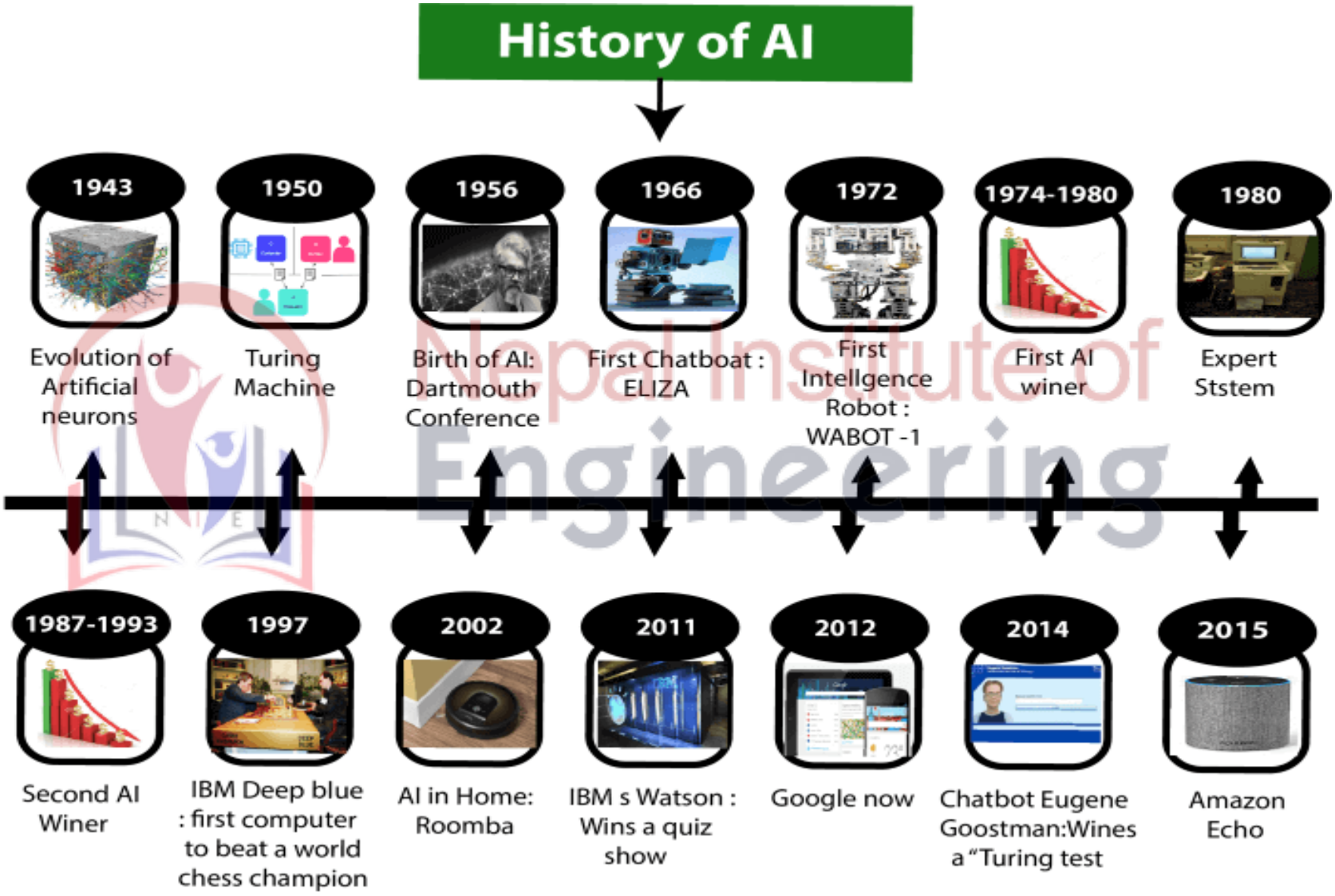
Computer vision

- Computer vision is a field of study and engineering that focuses on enabling machines to interpret and analyze visual data from the world around them.
- Computer vision involves the development of algorithms and techniques that allow devices to recognize, process, and understand images and videos.
- Computer vision in practice includes:
  - Object recognition
  - Image segmentation
  - Optical character recognition (OCR)
  - Augmented reality

INTRODUCTION:
Artificial intelligence (AI) - Perspectives on AI



History of AI



Maturation of Artificial Intelligence (1943-1952)

- Year 1943
  - The first work which is now recognized as AI was done by Warren McCulloch and Walter pits in 1943. They proposed a model of artificial neurons.
- Year 1949
  - Donald Hebb demonstrated an updating rule for modifying the connection strength between neurons. His rule is now called Hebbian learning.
- Year 1950
  - The Alan Turing who was an English mathematician and pioneered Machine learning in 1950. Alan Turing publishes "Computing Machinery and Intelligence" in which he proposed a test. The test can check the machine's ability to exhibit intelligent behavior equivalent to human intelligence, called a Turing test.

The birth of Artificial Intelligence (1952-1956)

- Year 1955
  - An Allen Newell and Herbert A. Simon created the "first artificial intelligence program"Which was named as "Logic Theorist". This program had proved 38 of 52 Mathematics theorems, and find new and more elegant proofs for some theorems.
- **Year 1956**
  - The word "Artificial Intelligence" first adopted by American Computer scientist John McCarthy at the Dartmouth Conference. For the first time, AI coined as an academic field.
- At that time high-level computer languages such as FORTRAN, LISP, or COBOL were invented. And the enthusiasm for AI was very high at that time.

The golden years-Early enthusiasm (1956-1974)

- **Year 1966**
  - The researchers emphasized developing algorithms which can solve mathematical problems. Joseph Weizenbaum created the first chatbot in 1966, which was named as ELIZA.
- **Year 1972**
  - The first intelligent humanoid robot was built in Japan which was named as WABOT-1.

The first AI winter (1974-1980)

- The duration between years 1974 to 1980 was the first AI winter duration. AI winter refers to the time period where computer scientist dealt with a severe shortage of funding from government for AI researches.
- During AI winters, an interest of publicity on artificial intelligence was decreased.

A boom of AI (1980-1987)

- **Year 1980**
  - After AI winter duration, AI came back with "Expert System". Expert systems were programmed that emulate the decision-making ability of a human expert.
- In the Year 1980, the first national conference of the American Association of Artificial Intelligence **was held at Stanford University**.

The second AI winter (1987-1993)

- The duration between the years 1987 to 1993 was the second AI Winter duration.
- Again Investors and government stopped in funding for AI research as due to high cost but not efficient result. The expert system such as XCON was very cost effective.

The emergence of intelligent agents (1993-2011)

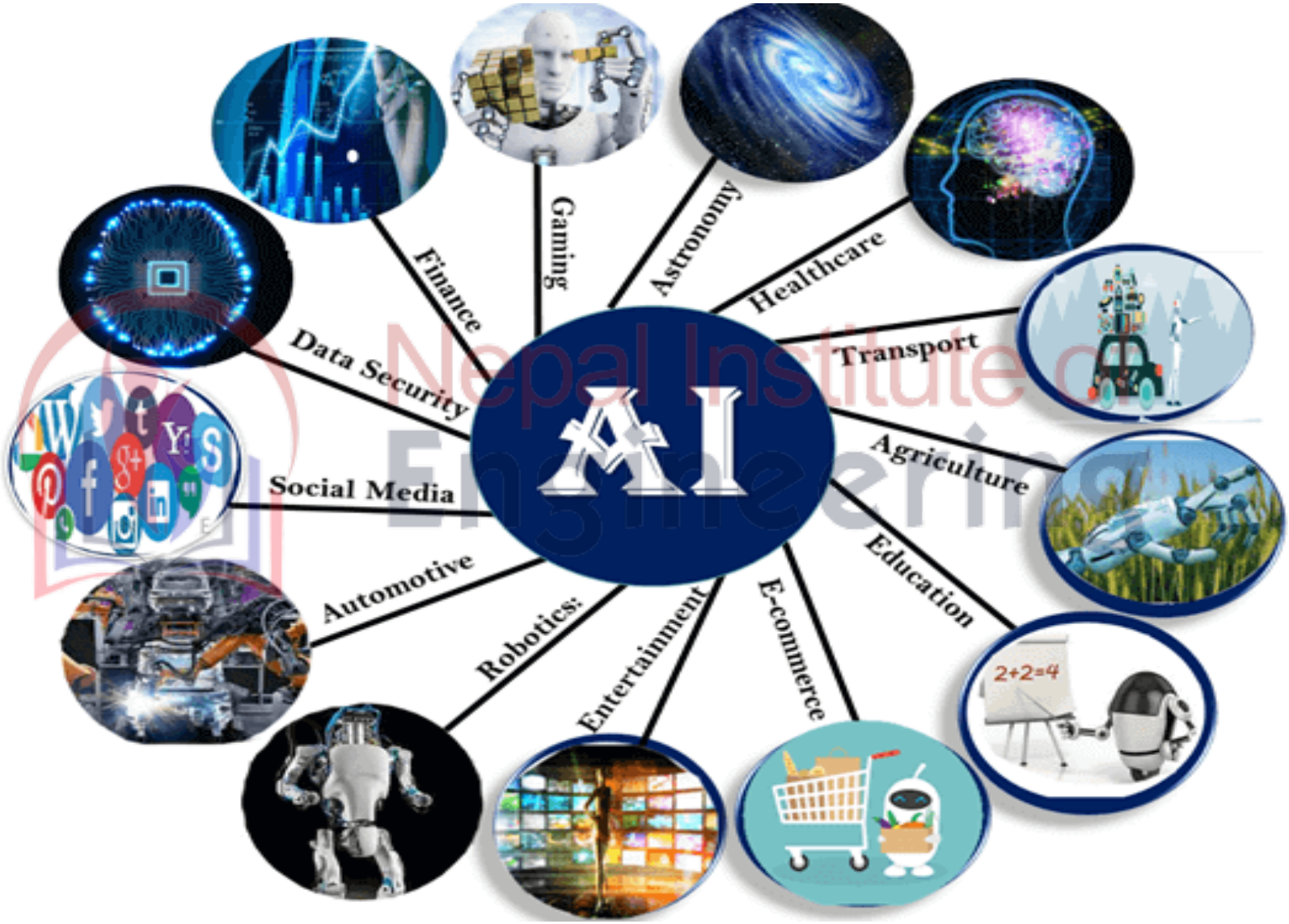
- **Year 1997**
  - In the year 1997, IBM Deep Blue beats world chess champion, Gary Kasparov, and became the first computer to beat a world chess champion.
- **Year 2002**
  - for the first time, AI entered the home in the form of Roomba, a vacuum cleaner.
- **Year 2006**
  - AI came in the Business world till the year 2006. Companies like Facebook, Twitter, and Netflix also started using AI.

Deep learning, big data and artificial general intelligence (2011-present)

- **Year 2011**
  - In the year 2011, IBM's Watson won jeopardy, a quiz show, where it had to solve the complex questions as well as riddles. Watson had proved that it could understand natural language and can solve tricky questions quickly.

- **Year 2012**
  - Google has launched an Android app feature "Google now", which was able to provide information to the user as a prediction.
- **Year 2014**
  - In the year 2014, Chatbot "Eugene Goostman" won a competition in the infamous "Turing test."
- **Year 2018**
  - The "Project Debater" from IBM debated on complex topics with two master debaters and also performed extremely well.
- Google has demonstrated an AI program "Duplex" which was a virtual assistant and which had taken hairdresser appointment on call, and lady on other side didn't notice that she was talking with the machine.

Applications of AI



Foundations of AI

- Mathematics
  - What are the formal rules to draw valid conclusions?
  - What can be computed?
  - How do we reason with uncertain information?
  - **The main three fundamental areas are logic, computation and probability.**
  - Algorithm, incompleteness theorem, computable, tractability, NP completeness, Non deterministic polynomial and probability.
- Neuroscience
  - How do brains process information?
  - Early studies (1824) relied on injured and abnormal people to understand what parts of brain work

- More recent studies use accurate sensors to correlate brain activity to human thought
  - By monitoring individual neurons, monkeys can now control a computer mouse using thought alone
- Moore's law states that computers will have as many gates as humans have neurons in 2020
- How close are we to have a mechanical brain?
  - Parallel computation, remapping, interconnections,….

- Control Theory
  - **Machines can modify their behavior in response to the environment (sense/action loop)**
    - Water-flow regulator, steam engine governor, thermostat
  - The theory of stable feedback systems (1894)
    - Build systems that transition from initial state to goal state with minimum energy
    - In 1950, control theory could only describe linear systems and AI largely rose as a response to this shortcoming

Linguistics

- Speech demonstrates so much of human intelligence
- Analysis of human language reveals thought taking place in ways not understood in other settings
  - Children can create sentences they have never heard before
  - Language and thought are believed to be tightly inter twined

Introduction to Agents

- **An agent can be anything that perceive its environment through sensors and act upon that environment through actuators.**
- An Agent runs in the cycle of **perceiving**, **thinking**, and **acting**. An agent can be:
- **Human-Agent:** A human agent has eyes, ears, and other organs which work for sensors and hand, legs, vocal tract work for actuators.
- **Robotic Agent:** A robotic agent can have cameras, infrared range finder, NLP for sensors and various motors for actuators.
- **Software Agent:** Software agent can have keystrokes, file contents as sensory input and act on those inputs and display output on the screen.

Intelligent Agents

- **An intelligent agent is an autonomous entity which act upon an environment using sensors and actuators for achieving goals.**
- **An intelligent agent may learn from the environment to achieve their goals.** A thermostat is an example of an intelligent agent.
- Following are the main four rules for an AI agent:
  - **Rule 1:** An AI agent must have the ability to perceive the environment.
  - **Rule 2:** The observation must be used to make decisions.
  - **Rule 3:** Decision should result in an action.
  - **Rule 4:** The action taken by an AI agent must be a rational action.

Structure of an AI Agent

- The task of AI is to design an agent program which implements the agent function. The structure of an intelligent agent is a combination of architecture and agent program. It can be viewed as:
  - **Agent = Architecture + Agent program**
- **Architecture:** Architecture is machinery that an AI agent executes on.
- **Agent Function:** Agent function is used to map a percept to an action.
  - $f: P^* \rightarrow A$
- **Agent program:** Agent program is an implementation of agent function. An agent program executes on the physical architecture to produce function f.

Properties of agents

Rationality, autonomy, reactivity.

- Rationality
  - Rational agent
    - A rational agent is one which chooses the action which will make it most successful. In order to complete that definition we need to have a way of measuring how successful a course of action is. **The criteria for measuring the degree of successfulness is performance measure and it varies from agent to agent.**
    - Rationality of an agent is restricted by its percepts since it can only respond to the percept sequence, that is the history of things it has sensed from the environment. It is also limited by its effectors (motors in the case of robots)
    - .

- Autonomy
  - "A system is autonomous to the extent that its behaviour is determined by its own experience" If actions depend entirely on built in knowledge without considering percepts the agent lacks autonomy.
  - Autonomy is achieved by giving to the agent built in knowledge together with the ability to learn, just as in nature animals have instincts but also learn from the environment
  - **A truly autonomous intelligent agent should be able to operate successfully in a wide variety of environments given sufficient time to adapt.**
- Reactivity
  - In order to define reactivity we shall first define the notion of logical agent and consider what are Knowledge Based Agents.

PEAS Representation

- PEAS is a type of model on which an AI agent works upon. When we define an AI agent or rational agent, then we can group its properties under PEAS representation model. It is made up of four words:
- **P:** Performance measure
- **E:** Environment
- **A:** Actuators
- **S:** Sensors

Let's suppose a self-driving car then PEAS representation will be:

- **Performance:** Safety, time, legal drive, comfort
- **Environment:** Roads, other vehicles, road signs, pedestrian
- **Actuators:** Steering, accelerator, brake, signal, horn
- **Sensors:** Camera, GPS, speedometer, odometer, accelerometer, sonar.

Types of Agents

- Agents can be grouped into four classes based on their degree of perceived intelligence and capability :
- Simple Reflex Agents
- Model-Based Reflex Agents
- Goal-Based Agents
- Utility-Based Agents

Simple reflex agents

- **Operate based solely on the current percept, ignoring the entire history of past percepts.**
- They rely on condition-action rules, **where if a certain condition is met based on the current percept, an action is taken**.
- These agents are **effective only in fully observable environments**.
- **In partially observable environments, they may get stuck in infinite loops.**

- Introducing randomness in actions can potentially help these agents escape from such infinite loops.

Problems with Simple reflex agents are :

- Very limited intelligence.
- No knowledge of non-perceptual parts of the state.
- Usually too big to generate and store.
- **If there occurs any change in the environment, then the collection of rules needs to be updated.**

Model-based agent

- **utilizes a model of the world to handle partially observable environments.**
- It maintains an internal state that is updated with each percept, relying on percept history to track changes.
- This internal state represents the part of the world that is not directly observable.

- By maintaining this model and internal state, the agent can make more informed decisions about its actions in partially observable environments.

Goal-based agents

- **make decisions based on their current distance from a predefined goal or desirable situation.**
- They prioritize actions that minimize this distance, aiming to reach a goal state.
- **These agents rely on explicit knowledge representation, which can be modified to enhance flexibility.**
- Typically, they employ search and planning algorithms to navigate towards their goals.
- Their behavior is easily adaptable and can be adjusted to accommodate changes in objectives or environments.

Utility-based agents

- **are designed with their end goals as building blocks, focusing on achieving the best outcome among multiple alternatives.**
- These agents make decisions based on preferences, or utilities, assigned to each possible state.
- In scenarios where simply achieving a goal isn't sufficient, factors like speed, safety, cost, and agent happiness are considered.
- Utility reflects the level of "happiness" or satisfaction for the agent, with a utility function mapping states to real numbers representing happiness levels.
- Due to uncertainty in the environment, utility-based agents select actions that maximize the expected utility, aiming to optimize overall satisfaction or happiness.

Environments in AI

- An environment in artificial intelligence **is the surrounding of the agent.**
- The agent takes input from the environment through sensors and delivers the output to the environment through actuators.

Deterministic vs Stochastic

- When a uniqueness in the agent's current state completely determines the next state of the agent, the environment is said to be deterministic.
- The stochastic environment is random in nature which is not unique and cannot be completely determined by the agent.
- **Examples:**
  - **Chess –** there would be only a few possible moves for a coin at the current state and these moves can be determined.
  - **Self-Driving Cars-** the actions of a self-driving car are not unique, it varies time to time.

Dynamic vs Static

- An environment that keeps constantly changing itself when the agent is up with some action is said to be dynamic.
- A roller coaster ride is dynamic as it is set in motion and the environment keeps changing every instant.
- An idle environment with no change in its state is called a static environment.
- An empty house is static as there's no change in the surroundings when an agent enters.

Fully Observable vs Partially Observable

- When an agent sensor is capable to sense or access the complete state of an agent at each point in time, it is said to be a fully observable environment else it is partially observable.
- Maintaining a fully observable environment is easy as there is no need to keep track of the history of the surrounding.
- An environment is called **unobservable** when the agent has no sensors in all environments.
- **Examples:**
  - **Chess** – the board is fully observable, and so are the opponent's moves.
  - **Driving** – the environment is partially observable because what's around the corner is not known.

Single-agent vs Multi-agent

- An environment consisting of only one agent is said to be a single-agent environment.
- A person left alone in a maze is an example of the single-agent system.
- An environment involving more than one agent is a multi-agent environment.
- The game of football is multi-agent as it involves 11 players in each team.

Artificial Intelligence is about_____.

- Playing a game on Computer
- Making a machine Intelligent
- Programming on Machine with your Own Intelligence
- Putting your intelligence in Machine

Who is known as the -Father of AI"?

- Fisher Ada
- Alan Turing
- John McCarthy
- Allen Newell

If a robot is able to change its own trajectory as per the external conditions, then the robot is considered as the__

- Mobile
- Non-Servo
- Open Loop
- Intelligent

A technique that was developed to determine whether a machine could or could not demonstrate the artificial intelligence known as the___

- Boolean Algebra
- Turing Test
- Logarithm
- Algorithm

The component of an Expert system is_____.

- Knowledge Base
- Inference Engine
- User Interface
- All of the above

An AI agent perceives and acts upon the environment using___.

- Sensors
- Perceiver
- Actuators
- Both a and c

Which rule is applied for the Simple reflex agent?

- Simple-action rule
- Simple &Condition-action rule
- Condition-action rule
- None of the above

Which agent deals with the happy and unhappy state?

- Utility-based agent
- Model-based agent
- Goal-based Agent
- Learning Agent

Which AI technique enables the computers to understand the associations and relationships between objects and events?

- Heuristic Processing
- Cognitive Science
- Relative Symbolism
- Pattern Matching

The main function of problem-solving agent is to_____.

- Solve the given problem and reach the goal
- Find out which sequence of action will get it to the goal state.
- Both a & b
- None of the above

In artificial Intelligence, knowledge can be represented as_____.

- i. Predicate Logic
- ii. Propositional Logic
- iii. Compound Logic
- iv. Machine Logic
- **Both I and II**
- Only II
- Both II and III
- Only IV

- In how many categories process of Artificial Intelligence is categorized?
  a) categorized into 5 categories
  b) processes are categorized based on the input provided
  c) categorized into 3 categories
  d) process is not categorized
- What is the function of an Artificial Intelligence “Agent”?
  a) Mapping of goal sequence to an action
  b) Work without the direct interference of the people
  c) Mapping of precept sequence to an action
  d) Mapping of environment sequence to an action
- Which of the following is not a type of Artificial Intelligence agent?
  a) Learning AI agent
  b) Goal-based AI agent
  c) Simple reflex AI agent
  d) Unity-based AI agent
- Which of the following environment is strategic?
  a) Rational
  b) Deterministic
  c) Partial
  d) Stochastic