SYLLABUS UNIT-II: Artificial Intelligence

Overview of Artificial Intelligence: Introduction, Definitions of AI, History of AI, The Importance of AI, Processes Involved with AI, AI as an Interdisciplinary Tool, Types of AI, Advantages and Disadvantages of AI, Some Examples of AI, Applications of AI

Programming Languages Used in AI: Introduction, the Role of AI, Languages Used in AI

Artificial Intelligence in Image Processing: Introduction, Images, Real time usage of Image Processing, Artificial Intelligence in Image Processing, Sobel Edge detection, Threshold, Ant colony optimization.

UNIT II

1. Definitions of AI

The father of AI is John McCarthy. He defined Artificial intelligence as "the science and engineering of making intelligent machines, especially intelligent computer programs"

And other words, AI can be defined as "a branch of computer science by which we create intelligent machines which can think like human, act like human, and able to make decisions like human".

Various Definitions of Artificial Intelligence given by different authors are

Bellman (1978) "The automation of activities that we associate with human thinking, activities such as decision making, problem solving, learning."

Haugeland (1985) "The exciting new effort to make computers think machines with minds, in the full and literal sense."

Schalkoff (1990) "A field of study that seeks to explain and emulate intelligent behavior in terms of computational processes."

Kurzweil (1990) "The art of creating machines that perform functions that require intelligence when performed by people."

Rich and Knight (1991) "The study of how to make computers do things at which, at the moment, people are better."

Winston (1992) "The study of the computations that make it possible to perceive, reason, and act."

Luger and Stubblefield (1993) "The branch of computer science that is concerned with the automation of intelligent behaviour."

Dean et al. (1995) "The design and study of computer programs that behave intelligently. These programs are constructed to perform as would a human or an animal whose behavior we consider intelligent."

Nilsson (1998) "Many human mental activities, such as writing computer programs, doing mathematics, engaging in common sense reasoning, understanding language, and even driving an automobile, are said to demand intelligence. We might say that (these systems) exhibit artificial intelligence."

2. History of AI

The systematic development of AI tools and technology.

First computer-related developments

1836 Charles Babbage, mathematician at Cambridge University, and Augusta Ada Byron first developed a programmable machine.

1923 Karel Čapek's play Rossum's Universal Robots opened in London, where the word "robot" was used first time.

1940s John Von Neumann, mathematician at Princeton University, conceived the architecture for a computer that included a program and its processed data that can be stored in the computer's memory.

Maturation of Artificial Intelligence

1943 Warren McCulloch and Walter Pits carried out the first work that is now known as AI. They suggested a model of artificial neurons. The foundation for neural networks was laid out.

1945 Isaac Asimov, a Columbia University alumnus, coined a term "robotics."

1949 Donald Hebb developed a new rule, called Hebbian learning, for modifying the strength between neurons.

1950 Alan Turing, a British mathematician, World War II code-breaker, and a pioneer in machine learning, published Computing Machinery and Intelligence. He introduced the Turing Test for evaluation of intelligent behavior of the machines equivalent to human intelligence. Claude Shannon published Detailed Analysis of Chess Playing.

The birth of artificial intelligence

1955 Allen Newell and Herbert A. Simon developed the first artificial intelligence program, naming it the "Logic Theorist." This program was capable of proving 38 out of 52 mathematics theorems, as well as develop new proofs for several problems.

1956 American computer scientist John McCarthy at the Dartmouth College Conference first used the term "artificial intelligence." During that time, computer languages, such as FORTRAN, LISP, and COBOL, were invented. Demonstration of the first running AI program was done at Carnegie Mellon University. It attracted lot of government and industry support.

The golden years – early enthusiasm

1965 Robinson's complete algorithm for logical reasoning was introduced.

1966 Algorithms for solving mathematical problems were developed. Same year, Joseph Weizenbaum created the first chatbot, named ELIZA, which laid the foundation for the chatbots used today.

1969 Shakey, a robot having locomotion, perception, and problem-solving capabilities, was developed by Stanford Research Institute.

1972 The first intelligent humanoid robot, named WABOT- 1, was built in Japan.

1973 Edinburgh University's robot, called Freddy, could use vision technology to locate and assemble models.

The first AI winter

1974 The beginning of a period, which would last until the end of the decade, during which computer developers experienced a severe shortage of government fund for research work, leading to a decrease in interest in AI.

1979 Stanford Cart, the first computer-controlled autonomous vehicle, was built.

A boom of AI

1980 AI came back using new techniques of deep learning, including Edward Feigenbaum's Expert Systems that replicated the decision-making capability of human experts. That year, the American Association of Artificial Intelligence organized its first national conference at Stanford University.

1985 Aaron, the drawing program, was created by Harold Cohen.

1986 Popularity of neural networks.

The second AI winter

1987 Private investment and government funding for AI research dry out once again due to huge costs and not enough return on investment. However, the XCON Expert System proved very cost effective.

1990 Many advances in AI took place, such as machine learning, Web crawler, scheduling, data mining, multi-agent planning, natural language understanding and translation, case-based reasoning, games, vision, and virtual reality.

1991 AI logistics planning and scheduling program that involved up to 50,000 vehicles, cargo, and people was adopted by US forces during the First Gulf War.

3. The Importance of AI

- ✓ AI can automate repetitive learning through the datasets.
- ✓ AI is different from hardware-driven automation.
- ✓ AI can perform continuous, large-volume tasks reliably.
- ✓ AI uses progressive learning algorithms that allow the data to carry out the programming.
  - It can find structure and irregularities in the data to be used in classification and/or a prediction.
  - AI can analyze large data with neural networks.
  - The more data is fed to models, the more accurately they predict the results.
  - For example, Alexa, Google Search, and Google Photos image classification, and object recognition techniques.
- ✓ AI is not going to replace humans, but it supplements human abilities so they can be performed better.

Benefits Of Artificial Intelligence

a) No Human Error

AI reduces errors, increasing the chances of accuracy and level of precision. Intelligent machines make precise decisions based on the past information they accumulate over time, implementing specific algorithms.

b) 24*7 Availability

Machines don't need lunch or coffee breaks, unlike human beings. They can work 24*7 without being bored or getting fatigued. Example : AI-based helpline system for companies to address customer queries and resolve issues continually.

c) Unbiased Decisions

Machines have no emotions, unlike emotionally driven humans. AI thinks more practically and has a rational approach. A big advantage of AI is that it does not have biased views, thus ensuring an accurate decision-making process.

d) Quicker Decision-Making

Intelligent machines can make decisions faster compared to humans. You might question the machine's decisions! But as discussed earlier, it makes decisions without any emotions and biased views. This ensures result-oriented decision-making.

For example, IBM's Deep Blue supercomputer makes decisions based on all the possibilities from the opponent's side. However, a human brain cannot fathom so many possibilities like a machine.

e) No Risks

some tasks can be hazardous for humans; For example, allowing machines to handle a natural calamity can result in quicker recovery and lesser pressure on human teams. This concept arises from Google & Harvard's initiative of building an AI system to forecast the aftershock locations of an earthquake.

f) Healthcare Applications

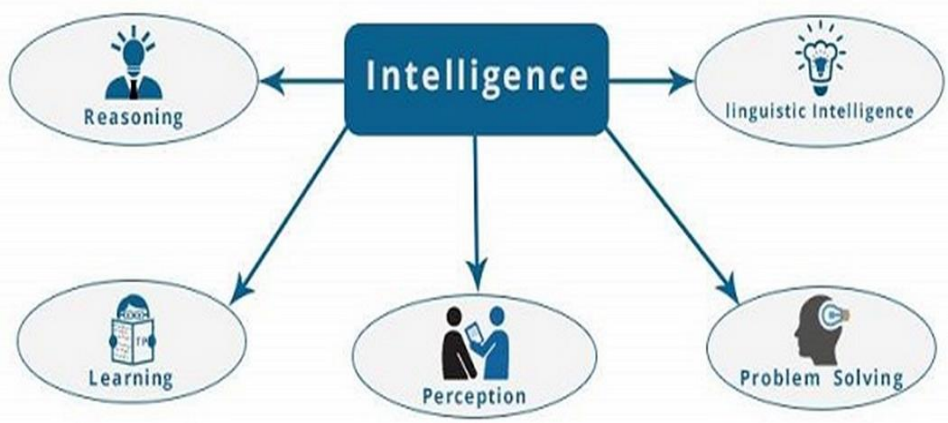
AI techniques are highly utilized in the medical field. For instance, AI machines in healthcare devices have helped doctors evaluate the patient's health-related data and risk factors as well. It helps patients know the side effects of various medicines. Moreover, robotics is also used in treating mentally sick patients, such as depression. At present, there is also software available to detect & monitor neurological disorders and stimulate the human brain's functionality.

g) Managing Recurring Tasks

Repetitive tasks are monotonous in nature. And such tasks can be easily managed with AI's help. Intelligent machines process much faster and can perform several tasks at once to generate the best outcomes. These intelligence machines save a lot of humans, and they can focus on more complex tasks.

4. Process involved in AI

The AI programs will have cognitive skills: reasoning, problem solving, learning, perception, and self-correction, as given below (McCarthy, 2019):



a) ***Reasoning process:*** The AI program here focuses on selecting the most appropriate algorithm to achieve the required results. It is the process that is used for making judgments, decisions, and predictions. Reasoning processes are mainly categorized as inductive reasoning and deductive reasoning.

b) ***Learning process:*** Its function is acquiring data and creating rules in order to devise actionable information from data. Learning improves understanding of the subjects under study. The rules, also called algorithms, help provide sequences of instructions to perform a task using computing devices. It involves acquiring knowledge by way of study, practice, and gaining experience. Humans, some animals, and AI-based systems have the ability to learn (Rouse, 2020).

c) ***Problem- solving process:*** It is used to get the required solution from the current situation by taking another approach. Problem solving may include decision-making, i.e., selecting the best out of several possible alternatives to get the objectives.

d) ***Perception process:*** It includes selecting, acquiring, interpreting, and ultimately analyzing the information. In case of humans, perception is supported by sensory organs. Perception mechanisms in AI place the sensors data together in a useful manner.

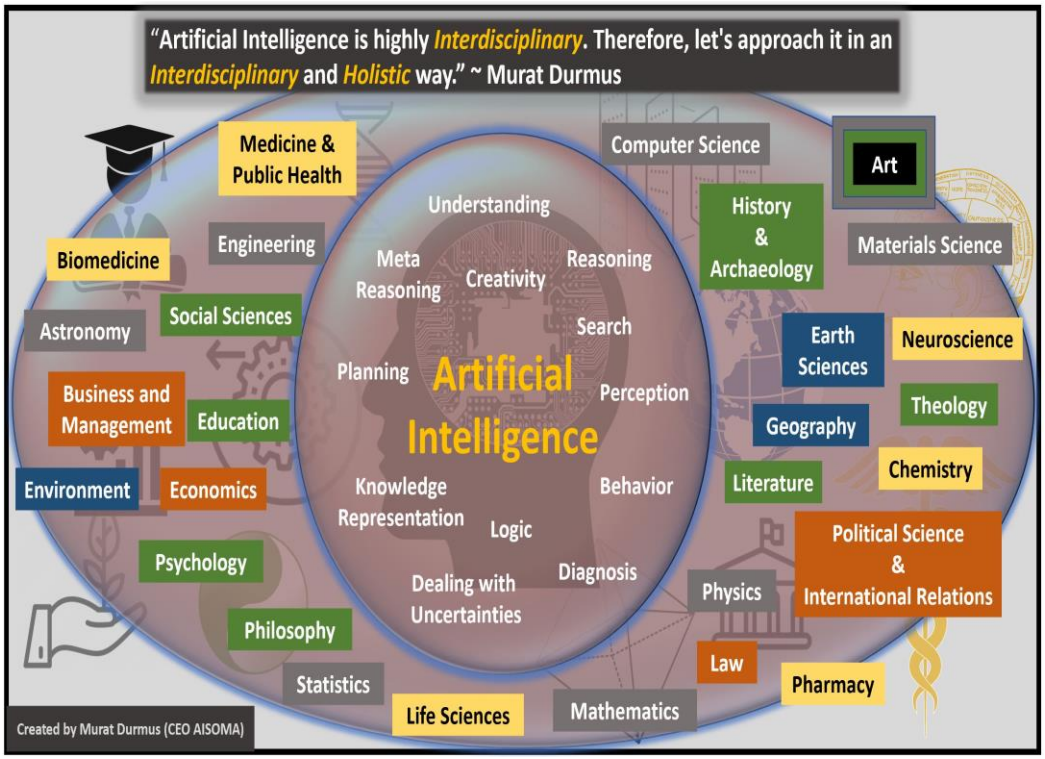
e) ***Self- correction process:*** It is designed to continually refine the algorithm so that it determines the most accurate results.

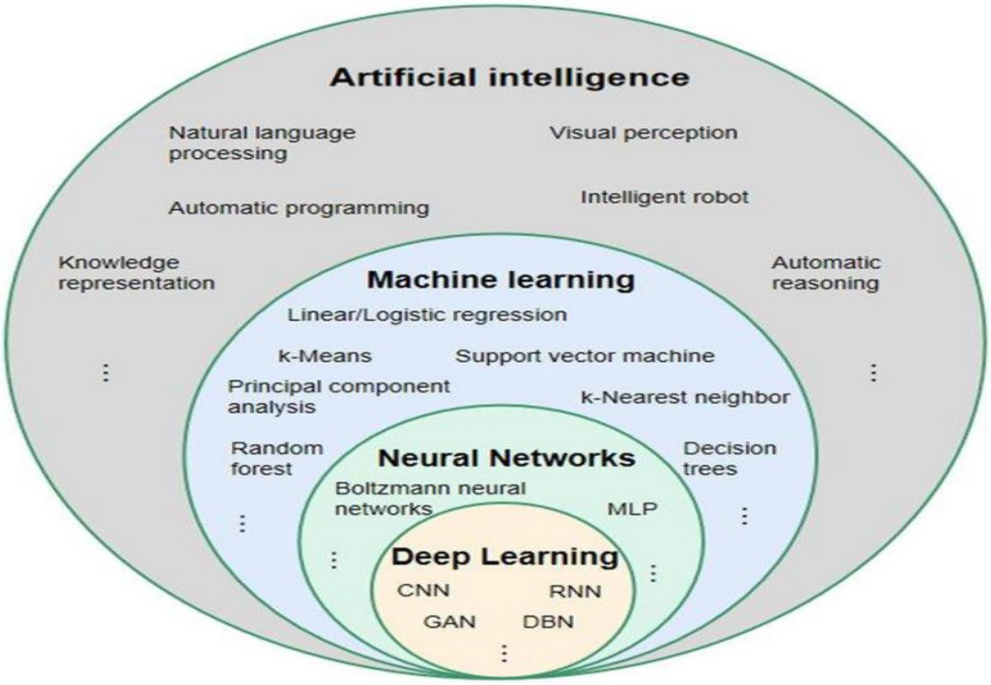
5. AI as an Interdisciplinary Tools (Domains & Fields)

AI is a technology that encompasses many areas including computer science, biology, psychology, sociology, philosophy, mathematics, and neuron science. One or more areas may be required to create an AI system. From an interdisciplinary perspective, the AI domains

include explicit knowledge, language aptitude, verbal and numerical reasoning, creative and critical thinking, as well as working memory, as shown in Figure

AI today is one of the growing technologies in computer science or data science, which has created a revolution globally by developing intelligent machines and tools (Shankar, 2020). AI is developed in a way similar to the operation of a human brain, specifically the way a human learns, decides, and works while attempting to solve a problem, and then using this outcome to develop intelligent machines and software. AI includes the use of expert systems, machine learning (ML), deep learning (DL), natural language processing (NLP), neural network, and fuzzy logic, as shown in Figure





Various interdisciplinary domains of AI.

6. AI as an Interdisciplinary Tools (Domains & Fields)

S. No.	Programming not using AI	Programming using AI
1	Without AI, any computer program may be able to answer only the **specific questions.**	With AI, any computer program may be able to answer the **generic questions**.
2	Modifications in the program would require **changes in its basic structure.**	AI programs can easily adapt new changes by having independent modules together, so any module can be modified **without changing its basic structure.**
3	**Changes** in the **program** are **time-consuming,** and may affect the program entirely.	**Modification** in the **program** is **quick and easy.**

7. AI vs ML vs ANN vs DL:

A correlation between AI, ML, ANN, and DL is shown in Figure 1.3. The broad differences are given below

AI

- It originated around the 1950s
- It is a subset of data science It is a subset of data science and AI
- It represents simulated intelligence in machines, and its aim is to build machines that can think like humans.

ML

- It originated around the 1960s
- It is a subset of data science, AI.
- Computer can work/act without programming. Its aim is to make machines learn through data so that they can solve problems.

- Google search engine is used for speech recognition, image search, translation, etc. For example, Amazon and Flipkart are providing personalized services to individuals based on their likes and dislikes.

ANN

- It originated around the 1950s
- It is a subset of data science, AI, and ML
- These are the set of algorithms, modeled just like the human brain Their objective is to tackle complex problems

DL

- It originated around the 1970s
- It is a subset of data science, AI, and ML
- It is the process of automation of predictive analytics. It uses neural networks to automatically identify the patterns for feature extraction.
- Some deep learning examples include self-driven vehicles, face recognition on phone, computer vision, and tagging on facebook

8. Types of AI

AI can be classified into seven types depending on the performance of machines

a) reactive machines - unable to correct their present actions based on their past experiences
b) limited memory machines- machines can retain data for a short time
c) theory of mind,
d) self-aware,
e) ANI,
f) AGI,
g) ASI

a) ***Reactive machines:*** Reactive machines are conventional type that work without memory-based functionality, and so they are unable to correct their present actions based on their past experiences. Therefore, these machines are not capable of "learning."
Example: The Deep Blue can recognize pawn on the chessboard to make a move, but it cannot retain any memory as well as incorporate past experiences for making present decisions.

b) ***Limited memory:*** The AI systems have a small amount of memory, and thus very limited capacity to apply past experiences to new decisions. This group includes, among others, chatbots, virtual assistants, and self-driving vehicles. The machines can retain data for a short time, limited by the capacity of their memory.
Example : A self-driven vehicle constantly detect & store the speed and pattern of changing lanes, of vehicles around it, and can safely navigate on the basis of these data.

c) ***Theory of mind:*** This is a psychology term. The future AI systems that are presently planned to be developed to have the social intelligence to understand emotions.
For example, Bellhop Robot is being developed for hotels, with the ability to assess the demands of people wishing to come stay at the hotel.

d) ***Self- aware:*** AI will operate like a human and start predicting its own needs and demands. The self-aware AI is expected to enhance the output many times, but it can also lead to disaster.

e) ***Artificial Narrow Intelligence (ANI***): The ANI is also known as Weak AI, designed and trained to undertake only one particular type of work (Rouse, 2020). the ANI performs only a specific task autonomously due to its programming limitations,
Example: Speech recognition AI which identifies spoken words and converts them into a machine-readable format.

f) ***Artificial General Intelligence (AGI):*** The AGI is also known as Strong AI.
It is a self-teaching system that employ fuzzy logic to apply domain knowledge and find a solution automatically to an unknown task. Such systems are able to reduce substantially the time required for training.
Examples include the Pillo Robot that can answer questions related to health.
Washing machines now use fuzzy logic. They can sense how heavy a load is and determine the correct amount of water and detergent, speed of agitation, and length of the wash cycles. There is no single standard for the dirty laundry. Fuzzy logic enables the machine's computer to make "in between" decisions.

g) ***7.Artificial Super Intelligence (ASI):*** The ASI is future AI that will not only replicate the intelligence of human beings but also have much higher storage (i.e., memory), faster data analysis, and better decision-making powers. The AGI and ASI are expected to

create a big revolution in the future, but they also may threaten our way of life. An example Alpha 2, which is the first humanoid ASI Robot (Rouse, 2020).

9. Advantages and Disadvantages of AI:

Advantages

1. Better accuracy: The AI-based machines help analyze patterns and trends by accurately assessing the needs of the users. An AI-enabled machine is responsible for selecting the input data and values as per past experience or information, reducing human error and providing high accuracy. For instance, if a firm is more dependent on the data that is fed to a system manually, the chances of 100% correctness of data entered into the system are lower than if the input is automated. By contrast, a machine that can analyze its surroundings to capture the data automatically into the system is considered to be more accurate, eliminating the possibility of a manual error.

2. Higher speed: The AI systems are very fast and can make predictions with a higher degree of accuracy than is possible for humans.

3. Better decision- making: Human perception, understanding, and decision-making are often affected by personal bias and current emotional state. Since the machines are not affected by bias or emotions, AI- enabled systems could provide the most optimal decisions and solutions without any personal prejudices. One of the first examples of this is the loss of Garry Kasparov – a chess grand champion but still prone to human error – to IBM's Deep Blue back in the 1990s.

4. High reliability: AI- equipped machines are capable of performing repeating actions with an unchangingly high degree of accuracy.

5. Day- night working: The AI systems can work continuously for long periods of time, without the need for break for sleep, food, elimination, or recreation, all of which humans need.

6. Dealing with complexities: While many people tout their ability to "multitask" on their resumes,

it is actually impossible for humans to handle several tasks at the same time with the same degree of focus given to all of them. Machines, on the other hand, can process large amounts of data required for several tasks to be performed simultaneously, without any confusion and consequent errors.

7. Working in risky areas: AI-equipped machines are very useful in actions that are hazardous to humans, such as defusing a bomb, exploring the nuclear sites, cleaning up a toxic spill, and the like.

8. Optimization of resources: The AI systems have the capabilities to assess and interpret multiple data streams at the same time, from handling databases of products and customers to analyzing the patterns of purchase. Humans are not physically able to accomplish these multiple tasks simultaneously. Thus, these machines would help in the resource optimization.

9. Digital assistant: For example, the AI technology is used by various e-commerce companies to display the products per customer's need.

10. Working as a public utility: AI is helpful in public utilities, self-driving cars, regulation of traffic, facial recognition, natural language processing, etc.

Disadvantages

1. High cost: An AI system consisiting of hardware and software is very costly, and it also requires recurring expenses for maintenance and upgrades to meet day-to- day needs. In addition, it may be costly to process the voluminous information required by AI programming.
2. No original creativity: Humans are always creative and full of new ideas, but AI machines are not creative and imaginative to beat the human intelligence.
3. No out- of- box thinking: Even smarter AI-based machines cannot think or work out of context, but will perform the task they have been trained on.
4. No feelings and emotions: Even the best-performing AI machines do not have feelings, so they fail to make any kind of emotional attachment with humans. These machines, in fact, may be harmful to users if they are not used properly.
5. Dependency on machines: With the advancements in technology, humans are becoming dependent on gadgets/devices/machines/software, and thus may not use much of their mental capabilities.

10. Some Examples of AI:

Intelligent gadgets can make everyday tasks simple and fast. For example, Alexa is capable of keeping a record of our daily appointments, list of items to be purchased, play the desired music, read news, and play innovative games (Shankar, 2020). Some other examples include the following:
1. Echo: Echo, launched by Amazon, is a cloud-based voice assistant, Alexa. It is capable of hearing, comprehending, and responding to commands or questions of the users and offer possible solutions. For example, you can ask Alexa if you need an umbrella before going out, and it might suggest you take one, as it may to rain in the afternoon.
2. Flipkart: Flipkart, an e-commerce shopping platform, can be used to suggest items to its customers based on their past purchase or viewing history of items.
3. Pandora: The Pandora platform uses AI to determine the music the users require. It does not, however, provide any song choices.
4. Netflix: Netflix is the most popular Over The Top (OTT) platform today, and is also known as Other Than Television platform, among which are Amazon Prime, Hulu, and others. The OTT platforms provide services that deliver content to its customers over the internet by paying a subcription fee. They also recommend additional content based on the user's previous choices.
5. Siri: Developed by Apple, Siri is a voice-activated interactive assistant. It uses ML technology to understand the ways the users are navigating through their phones, sending messages, and making phone calls. To use this feature, begin by saying, "Hello Siri," followed by an action request.

11. Applications of AI:

AI has wide applications. The following are some areas having potential applications of AI:
1. AI as a Service (AIaaS)
2. Automobiles
3. Agriculture
4. Banking

5. Business
6. Data security
7. Gaming
8. Government
9. Health care
10. Natural language processing
11. Vision systems
12. Handwriting recognition

1. AI as a Service (AIaaS): The AIaaS allows to experiment with various AI platforms for businesses and applications before investing heavily in an AI platform. Popular AI- based cloud offerings include IBM Watson Assistant, Amazon AI, Google AI, Microsoft Cognitive Services, etc.
2. Automobiles: The AI is now being applied toward development of driverless cars. These cars, are able to apply brakes, change lanes, navigate, etc. Such cars will study the patterns of other surrounding cars moving on the road and implement the moves necessary for safe driving autonomously.
3. Agriculture: Agriculture robotics is being applied in agriculture for crop monitoring and predictive analysis to help farmers. The AI techniques for farming help increase productivity and yield.
4. Banking: Banks are using chatbots to provide services and offers to their customers, and to deal with the transactions without human involvement. Financial organizations make use of AI to improve decision-making for loans, keep track of approved loans, set credit limits, as well as highlight the investment opportunities to their customers (Tucci, 2020).
5. Business: Business can use AI-based solutions to assess the weaknesses and strengths in order to improve its financial and customer relationship management (CRM), among other things.
6. Data security: In digital worlds, cyberattacks are growing very fast, and the security of data has become crucial for all organizations. AI is being used to make this data safer and more secure. AI and ML in cybersecurity products are providing added value to identify malware attacks. they can also be used to determine software bugs that allow cyberattacks to happen (McCarthy, 2019).
7. Gaming: AI can be used for gaming purpose to generate alternative solutions in a game based on decisions taken by the users in the game, such as player movements, pathfinding, etc. AI-based programming is used by many video games today, such as Minecraft and Splinter Cell (Tutorials Point, 2021).
8. Government: Governments are using AI to draw suitable policies and services, analyze road accidents, and find solutions for many other problems. The AI-based applications are reducing costs, minimizing errors, taking heavy workloads, and helping bust the backlogs.
9. Health care: AI is assisting doctors in many ways and providing faster recovery to the patients (Iyer, 2018). AI can help doctors and patients with diagnoses and inform the latest conditions to the patients, and, if the condition is serious, ensuring medical help reach patients faster. It is known that robots are increasingly assisting the surgeons in an operating room.

10. Natural language processing: The NLP utilizes the capabilities of machines to understand natural languages. Two of the most commonly in many smartphones and computer software, are spell check and autocorrect, recommending words.

11. Vision systems: Vision based algorithms are being developed to predict future actions of individuals Police can use them to recognize the faces of criminals based on drawings done by a forensic artist.

12. Handwriting recognition: The algorithm is able to read the text written on paper using a pen or on screen using a stylus. In addition, it can also recognize letter shapes and convert them into editable text .

12. Role of AI:

AI is the " **field of study where machine has a ability to perform tasks by intelligence or reasoning. "**

AI offers

- less chance of an error,
- better performance standards,
- more effective usage of resources.

Russel and Norvig define AI as "the study of agents that receive percept from the environment and perform actions." Accordingly, there are four different ways for defining AI, namely thinking humanly, thinking rationally, acting humanly, and acting rationally. The first two terms deal with reasoning and processing whereas the other two deal with behavioral aspects.

In today's society

AI is used in many different types of applications

- homes,
- industry,
- educational institution,
- transport,
- games, remote sensing,
- automatized control,
- medical diagnosis, etc.

AI is incorporated in

- playing games,
- helping marketers advertise
- playing music, painting,

The Role of AI:

AI capabilities are being utilized in different fields

AI in Agriculture
AI in Security
AI in Education
AI in Health Care
AI in Industry

AI in Agriculture

AI can be used in agriculture for monitoring of crops, predictive analysis of the weather, detection of diseases in crops, pest control, etc. AI helps in real-time analysis of various factors such as climate, water, and soil conditions, among others, to help farmers make decisions on farming technique, choice of feed and/or fertilizer, etc. This leads to enhanced harvesting. The use of AI to improve crop yield is called precision agriculture. Another role of AI is in the use of bots to perform such hazardous duties as weed elimination.

Monitoring the Crop

Predicting soil nutrients after 6 days

Detecting the disease on crop

Recommending the pest control

AI in Security

With the availability of Internet and devices using Internet, there has been a rise in cybercrime. AI has been successful in making data and resources safe and secure. Facial data can be captured for biometric recognition and analyses for authentication. AI is used in video surveillance to detect humans, cars, and other objects.

Smart devices & Internet

Increase in Cyber crimes

Detecting Malware & S/w Bugs

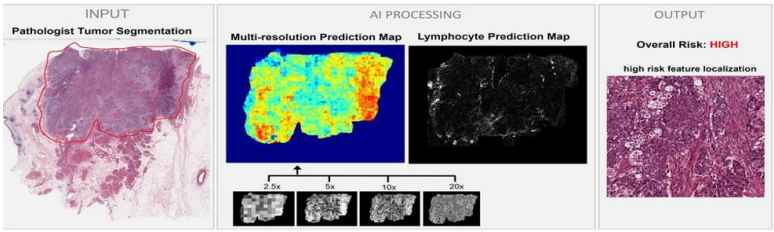
Video Surveillance

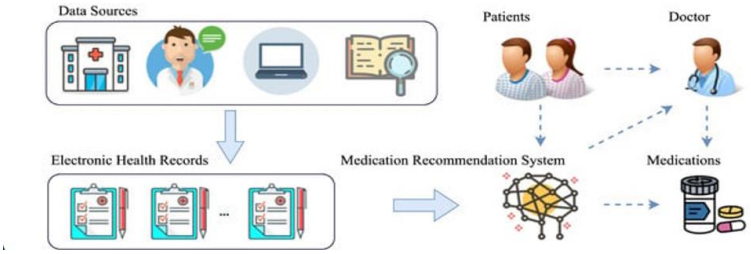
AI in Education

Educational institutions can use AI in many ways, such as automatic grading and doing routine admin job. This will allow teachers to spend more quality time on teaching and research. AI chatbots can also respond to various queries from students. AI can enable each student to work individually, at their own pace, and according to their own interest.

AI in Health Care

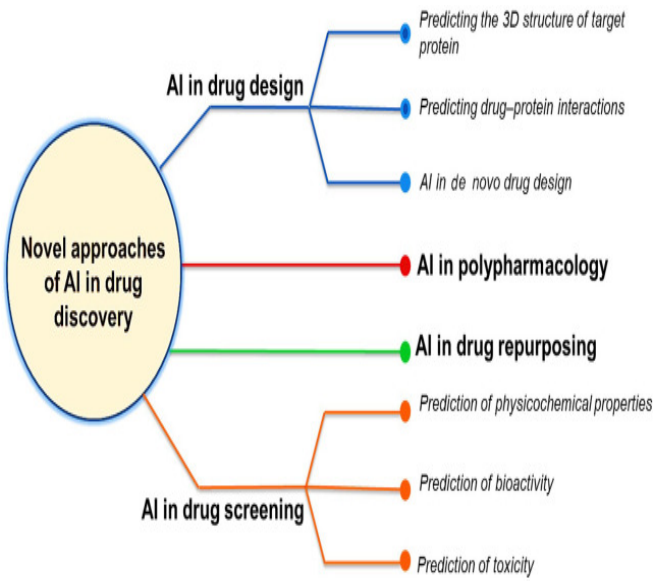
AI has a major impact on health care. It enables more efficient and quicker diagnosis of diseases. AI can be used to develop automatized medical image analysis [9]. It can analyze large volumes of patient data to identify patients at risk. Chatbots can be developed to provide primary care to patients in rural and far- away areas [19–21].

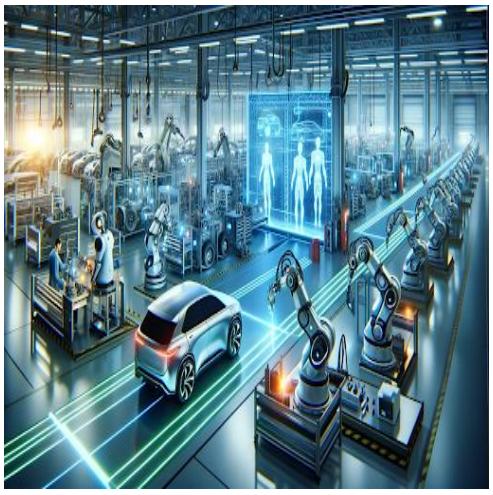




AI in Industry

In manufacturing, AI can be utilized to perform some repetitive tasks, saving human time and effort. It can be used to analyze customer preferences to predict trends in the retail sector. It can be used to develop chatbots to help customers have better and more personalized shopping experience. It can be used to predict risk and fraud in financial institutions and insurance companies. The role of AI has been introduced in various fields like health care, education, autonomous cars, business, security, entertainment, gaming, and simulation. It has ushered us into the world of smart cities. To unleash the potential and promises of AI in their true sense, implementations for the betterment of society and lifestyle applications should be developed. Developing AI-enabled applications requires appropriate programming languages. In the next section, languages used in AI are discussed to provide a reference that will help users understand and select which language is to be used in what kind of application.





13.Programming Languages Used in AI

To guide the growth of AI in these domains, strong, robust, and powerful programming languages are required

They are

- Python,
- Prolog,
- Lisp,
- Java,
- and C++

Java is a popular ***OOP language*** used for developing a games, websites, server-side programs, mobile computing, etc.

- Java provides ***features*** such as ***easy debugging, maintainability, portability, security, and robustness, among others.***
- ***Java is chosen for AI development*** becoz it supports machine learning, **genetic programming**, neural network.
- ***Java Virtual Machine,*** also supports an ***automatic memory manager*** that simplifies program development and deployment.
- Disadvantages : Java is ***slower in execution*** and ***requires more response time*** as compared to programming languages like C++.

C++ is widely preferred by AI developers because it provides the ***high response time***; ***fastest execution*** for building search engine, games, life-critical systems, etc.,

- C++ is efficient in ***statistical techniques*** implementation.
- C++ has object-oriented properties such as ***inheritance and data hiding***. These properties ensure ***time saving, reusability of code, and security.***
- ***Machine learning and neural network*** are also supported by C++.

The main disadvantages are

- ✓ lack of ability to multitask efficiently
- ✓ For complex algorithms it is not preferable
- ✓ bottom-up approach.
- ✓ does not support garbage collection

Python programming is preferred in AI development.

- It is preferred by the beginners, because **easy to learn huge library support, and good community support.**
- It provides ***extensive framework for DL & ML***
- Some of the ***popular*** **Python libraries** are:
  - Sklearn – used for machine learning algorithm
  - scipy – used for complex mathematical solution
  - keras; MXnet – used for deep learning applications
  - PyTorch – used for CV and NLP
- ***portable for platform*** for Mac, Windows, and Linux.

- It easily ***integrates with other programing languages*** such as C, C++, Cobra, Java, SQL, HTML etc.
- One of the issues it is ***slower in compilation*** and execution compared to C++ and Java. This happens due to the fact that an interpreter is used in Python.
- Python is not suitable for ***mobile computing.***

LISP (LISt Processing)

- John McCarthy developed the ***oldest programming language*** for AI.
- It is ***strong and dynamic programming*** language.
- provides a ***macro framework*** that involves ***inductive logic and ML***
- It is ***fast in execution and coding***, as it uses compilers.
- It provides ***automatic garbage collection for memory management***.
- ***Rapid prototype creation & developing dynamic objects*** used in AI.
- Popular programing languages like ***R, Julia*** are motivated by LISP.
- The main drawback with LISP is ,
  - ✓ it ***lacks a well-established library*** ,
  - ✓ Its ***syntax is also not easy*** to the programmers.
  - ✓ requires ***rigorous configuration for usage in latest OS & devices.***

Prolog *stands for Programming Logic (1972).*

- *First chatbot, "Eliza," used Prolog ,for pattern matching & automatic back tracking.*
- *It is suitable for creating Database ,fast prototype and representation tree–based data structure.(parse trees)*
- *Two approaches used for implementing AI with prolog are*
  1. *Symbolic - rule-based expert system,*
     constraint-based approach,
  2. *Statistical approach - Data mining, ML, and NN*
- *It is different and more difficult to learn than conventional programming languages such as C++.*
- *No fully standardized features and characteristics .*

R (1995) - Ross and Robert Gentleman

- It is facilitated with statistics and data analysis.
- R is preferred for AI programming,
  - ✓ very efficient in dealing with large numerical values
  - ✓ supports vector computation
  - ✓ object-oriented programming.
  - ✓ large variety of packages and functionalities
  - ✓ collaborate with other languages such as C, C++, and Fortan.
  - ✓ capability of producing good- quality graphs.
- Popular package in R are:
  - Gmodel – for facilitating model fitting
  - Tm – for text mining
  - ROBDC – database connectivity interface for R
  - One R – for implementing machine learning application.
- R has a very active and strong community support.
- Disadvantages: it uses more memory ,lacks basic security, rendering ,it not suitable for

Web-based applications. It is not suitable for graphics and its much slower in execution.

Artificial Intelligence (AI) has led to many innovations and technological break through in various areas of automation.

The AI aims to automatize the systems for optimum performance and more efficient results.

It is being used in many diverse areas like diagnosis , diseases in plants or animals, virtual chatbots, livestock managements, autonomous cars, medical image analysis, warehouse supply chain, analysis of sport, security or surveillance activities, etc.,

The capacity of computers, robots, or any machine to do work intelligently is called Artificial Intelligence.

14. Image processing

Image processing is the ***collection of methods*** used to perform some techniques on image

- to derive ***useful information*** from the image edges etc
- to ***enhance the visual cues*** in the image in terms of color, contrasts.

Image-processing techniques are broadly classified into two forms, i.e., the **analog image processing** and the **digital image processing.**

In ***analog image processing***, hard copy of the images like photographs, printouts, etc. is used as the processing medium. The output of analog image processing is always an image.

Digital image processing refers to *manipulating the images with the help of a computer*. The output in this case may be images or attributes of images in form of masks, feature list, etc.,

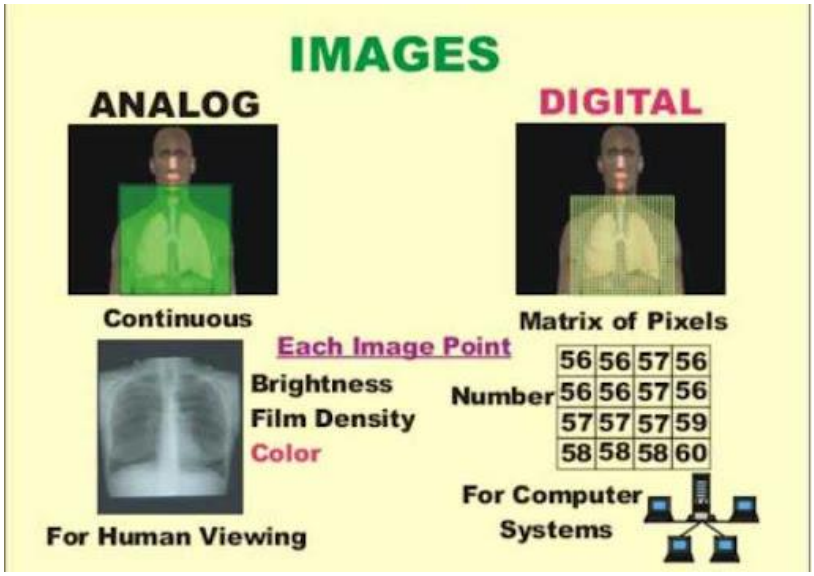


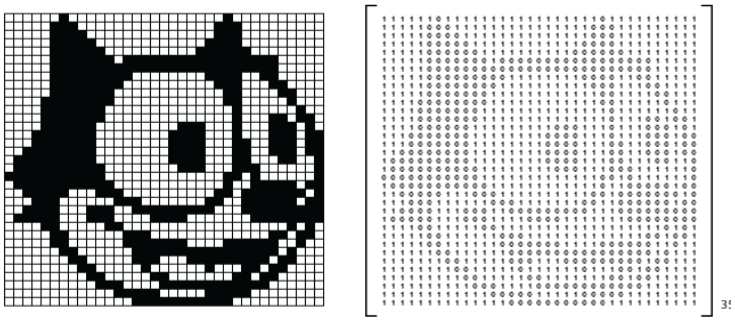
Image is two- dimensional, arranged in rows and columns.

Mathematically,

image can be defined as function f(x, y)

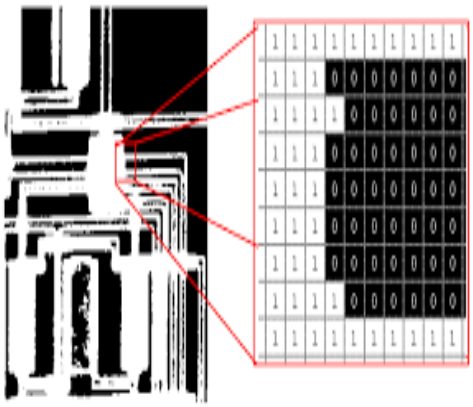
where x is the horizontal and y is the vertical coordinate.

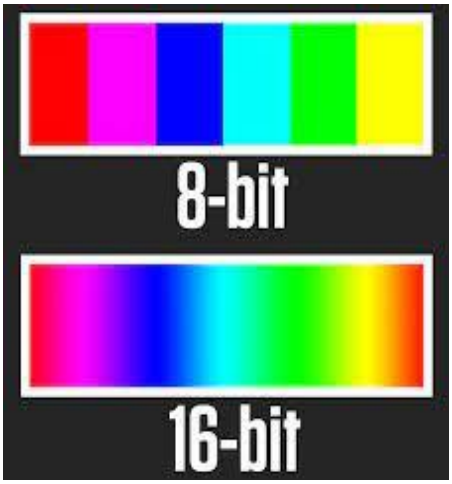
The amplitude of f at any point (x, y) is the intensity of the point providing representation in the image.



A digital image can be of different types such as

- binary image,
- black-and- white image,
- 8-bit color format,
- 16-bit color format,
- 24-bit color format, etc.





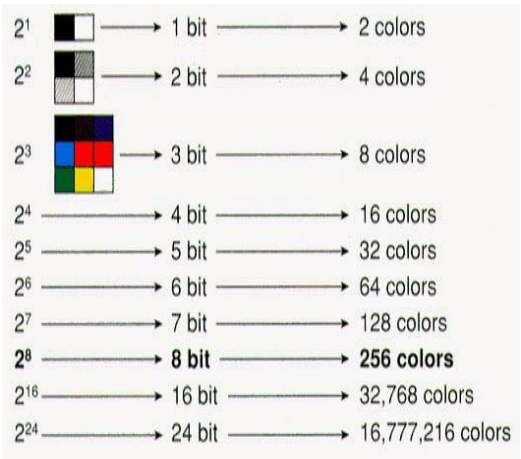


Image processing consists of three steps:

- Input image
- Analysis and manipulation of image
- Output in the form of image or report that is based on the analysis of image

the important purpose of image processing are:

1. Visualization refers to the methods used to represent data in a form that can be ***understandable***.

2. Restoring and sharpening process that improves the ***quality of the image***.
3. Image retrieval helps ***image-based search in DB***.
4. Measurement involves ***measuring objects*** in background or foreground.
5. ***Pattern recognition*** distinguishes and classifies objects in an image.

The phases **of digital image processing** are

- **Image acquisition** means capturing of image by a camera or other sensor and transforming it into a digital form.
- Extracting the hidden details in the image and improvement of image appearance are done by **image enhancement, image restoration**, etc.
- The color of the image is used to extract the **ROI.**

- the ***important steps*** that can be applied as per the requirement of the application are
- ✓ ***Wavelet and multi-resolution*** processing,
- ✓ image compression,
- ✓ morphological transformation,
- ✓ segmentation process,

and object recognition

Typical components of an image processing system are:

I. ***Image sensors*** that are used to acquire digital images.

II. ***Special hardware*** for image processing consisting of digitizer and an *arithmetic and logic unit(ALU). Digitizers* convert the output from sensors to digital formats. ALU carries arithmetic and logic application in the entire image.

III. The ***computer system***, which can be a personal computer or a supercomputer.

IV. **Image-processing software** consisting of specific methods to perform tasks specific to images.

Major programming languages, like MatLab, C++, Python, etc., contain modules related to image processing.

V. ***Storage area*** is very important in case of image, as the requirement of memory in this case is large.Short- term storage is used during processing, online storage for fast processing, and mass storage for permanent storage and infrequent access.

VI. ***Image displays*** are done by devices by color monitors and facilitated by graphical display unit, etc.

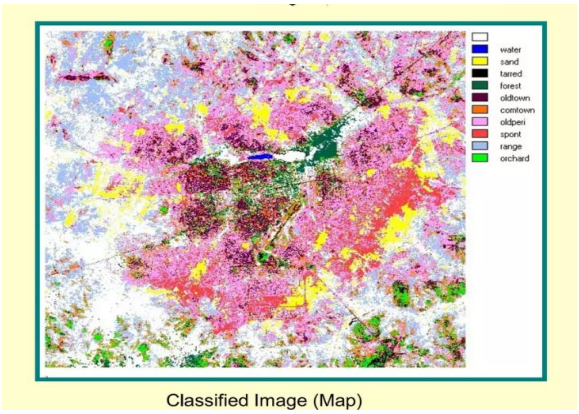
VII. ***Hardcopy devices*** include printers, plotters, etc. to obtain a hard copy of the image.

VIII. ***Network devices*** are essential due to the usage of computer communication; network devices are an inevitable part of an image processing system.

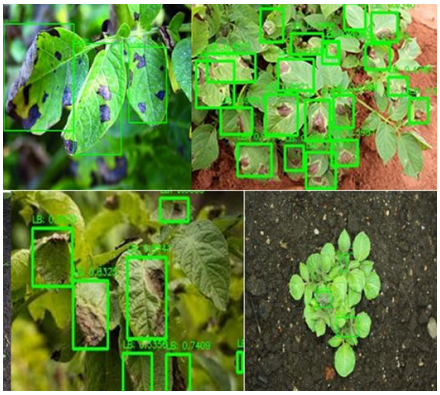
One of the requirements of an image-processing application is high bandwidth for transmission.

15. Real-Time Usage of Image Processing

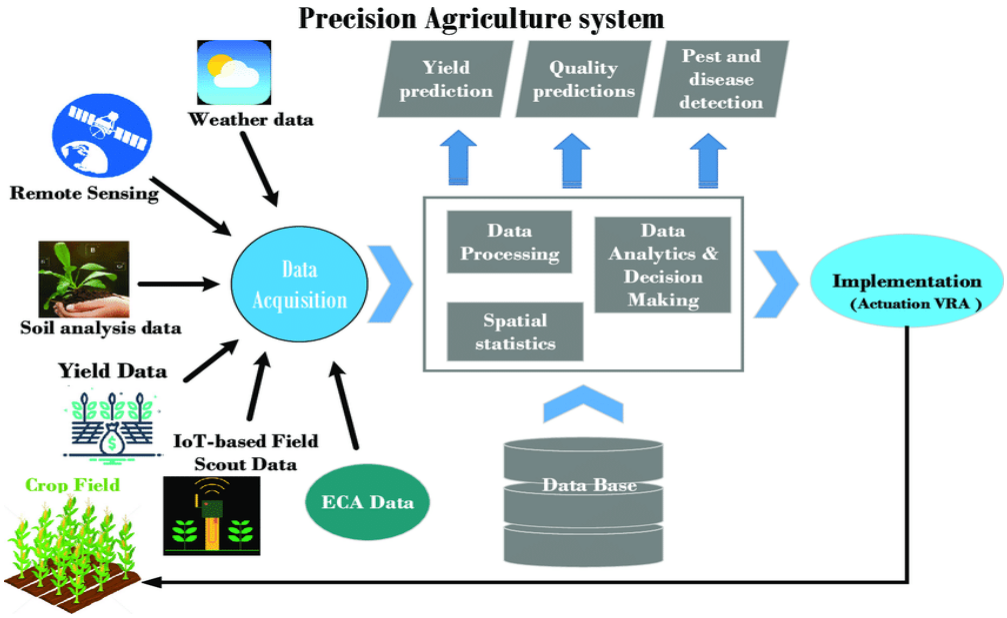
Image processing has introduced some major innovations in various fields such as agriculture, security, remote sensing, computer visions, diagnosis of diseases, etc.



Classified Image (Map)

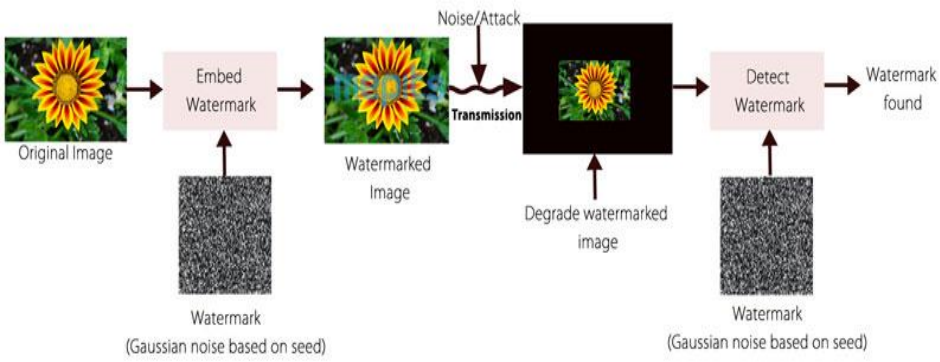


Precision agriculture is a farming technique that utilizes information technology to ensure maximum productivity of crops and optimum usage of resources [14, 18].



A computerized imaging system to determine the quantity of weeds present in crop cultivation has been developed [19].

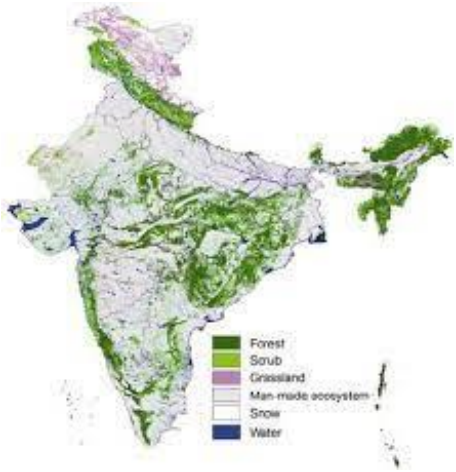
Image processing plays an important role in security by providing and enhancing use of techniques such as digital watermarking, digital signature, biometric security, etc. [20].



Real-Time Usage of Image Processing in **Remote sensing** refers to the area where ***information is collected with physical proximity***. It acquires, detects, and processes the data to monitor information about a particular subject ***without physical contact***.

Some of the major uses of remote sensing are

- ✓ detection of road condition,
- ✓ forest area coverage,
- ✓ collection of Earth images to monitor atmospheric conditions, in agriculture, etc.



Some other applications of image processing are automatized photography, space imaging, medical imaging, automatic product optical sensing, robotic vision, unlock technology of devices, etc.

AI has also provided to be an **inherent technology** in the field of **image processing**.
For example, AI algorithm can be used for **border detection of objects, to interpret images, recognize objects,** etc.

In 2006, Stoitsis et al. have introduced the usage of AI in developing **computer-aided diagnostics (CAD)** for ***CT images*** *by focusing on* ***liver tissues to classify into different categories.*** AI **helps improve quality** and **interpretation** of medical images and early diagnosis [26].

AI integrated with **optical coherence tomography** (OCT) was used to **detect glaucoma**. Glaucoma is a disease of eyes and can lead to vision loss if not treated correctly and timely. AI-based systems will focus on time and better chance of correct diagnosis [27].

AI-based **classification techniques** for ***diagnosis of skin disease*** also represent an area of research [28].

In **finance and commerce applications**, AI is also popular and integrated with image-processing techniques such as sophisticated **chatbots, robots, prediction tools,** etc.
In 2011, Zhong et al. have developed an **AI image classification system** for **remote images** [29].

AI integrated with computer vision, image processing, sensor technology, etc. has been used in efficient **fruit and vegetable drying facility**. The model and technique of drying are to be automatically controlled to solve issues, such as uneven drying, nutrient loss, damage of crops, etc. [30].

Mubarak et al. created a **detection system for forest fire** by ***applying temporal variations*** with **rule-based image processing** [31].

AI integrated with image processing is a promising area to develop various applications for ***enhancing the quality of life*** and sustainable development.

In classification, feature extraction, edge detection, preprocessing, and other areas, AI has proven to be a very prominent optimizer of results. This led to development of various open-source libraries for processing of images and computer vision. Some of them are OpenCV (Open Source Computer Vision library), which can be integrated with major programming such as C++, Java, Python, MatLab, image-processing library, etc.

Also uses free image databases, like ImageNet and Pascal VOC, are available for researchers to carry out research in the field of image processing.

Sobel Detection Algorithm:

- The Sobel algorithm was developed by Irwin Sobel and Gary Feldman at the ***Stanford Artificial Intelligence Laboratory*** (SAIL) in 1968.
- Sobel algorithm is an important method of **image edge detection.**
- The Sobel algorithm works by ***measuring the varying pixel intensity in an image***.
- Naturally, this is easiest to accomplish when the image is a standardized grayscale image.
- In the simplest terms, their algorithm works by running a 3x3 matrix (known as the kernel) over all the pixels in the image.

Sobel algorithm is an important method of image edge detection. the advantage is it has fast detection speed, meanwhile, it has an effect on smoothing and suppressing noise. This is a kind of edge detection done in horizontal and vertical direction, it neglects edge points in other directions. It cannot achieve a true detection for the points on image edge.

The Sobel operator performs a 2-D spatial gradient measurement on an image.
It emphasizes regions of high spatial frequency that correspond to edges.
it is used to find the approximate absolute gradient magnitude at each point in an input grayscale image.
It Works with the operator consists of a pair of 3×3 convolution kernels as shown in Figure 1. One kernel is simply the other rotated by 90°. This is very similar to the Roberts Cross operator.

-1	0	+1
-2	0	+2
-1	0	+1

Gx

+1	+2	+1
0	0	0
-1	-2	-1

Gy

Figure 1 Sobel convolution kernels

These kernels are designed to respond maximally to edges running vertically and horizontally relative to the pixel grid,one kernel for each of the two perpendicular orientations.

The kernels can be applied separately to the input image, to produce separate measurements of the gradient component in each orientation (call these *Gx* and *Gy*).
These can then be combined together to find the absolute magnitude of the gradient at each point and the orientation of that gradient.

The gradient magnitude is given by:

$$|G| = \sqrt{Gx^2 + Gy^2}$$

Typically, an approximate magnitude is computed using:

$$|G| = |Gx| + |Gy|$$

which is much faster to compute.

The angle of orientation of the edge (relative to the pixel grid) giving rise to the spatial gradient is given by:

$$\theta = \arctan(Gy/Gx)$$

In this case, orientation 0 is taken to mean that the direction of maximum contrast from black to white runs from left to right on the image, and other angles are measured anti-clockwise from this.

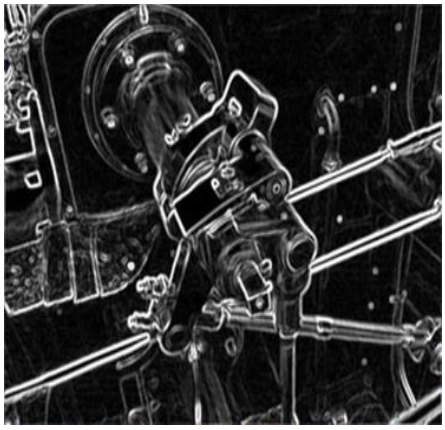
Example:

100	100	200	200
100	100	200	200
100	100	200	200
100	100	200	200

-1	0	1
-2	0	2
-1	0	1

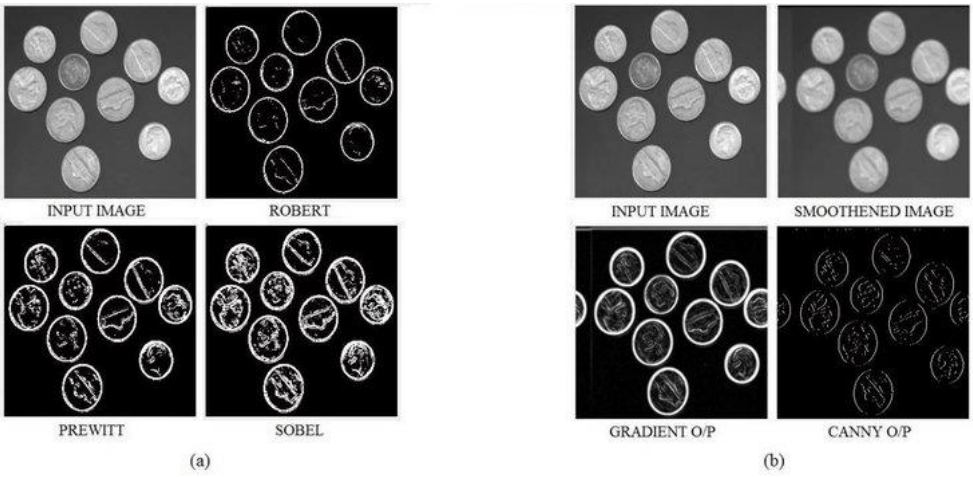
-100
-200
-100
200
400
+200
=400

The Sobel operator is slower to compute than the Roberts Cross operator, but its larger convolution kernel smooths the input image to a greater extent and so makes the operator less sensitive to noise.



The operator also generally produces considerably higher output values for similar edges, compared with the Roberts Cross.

Natural edges in images often lead to lines in the output image that are several pixels wide due to the smoothing effect of the Sobel operator. Some thinning may be desirable to counter this. Failing that, some sort of hysteresis ridge tracking could be used as in the Canny operator.



Edge Detection Techniques	Advantage	Disadvantage
Roberts (Based on First Order Derivatives)	Produces more accurate position of edges	Not reliable to extract the edge in presence of noise
Sobel (Based on First Order Derivatives)	Good noise suppression characteristics	Produce moderate result
Prewitt (Based on First Order Derivatives)	Masks have longer support, Prewitt is less vulnerable to noise	Produce sometimes noisier result
LOG (Based on Second Order Derivatives)	Having fixed characteristics in all the directions, detects good edges and its orientations	Sensitive to noise, generate closed and non-realistic contour
Canny (Based on Second Order Derivatives)	Better detection specially in noise condition	Complex, time consuming, false zero crossing

Image thresholding is a simple, yet effective, way of partitioning an image into a foreground and background.

- is one of the ***segmentation techniques***
- it generates a **binary image** (whose pixels have only two values 0 and 1)

- requires only **one bit** to store ***pixel intensity***
- from a given grayscale image by separating it into ***two regions based*** on a threshold value.

This image analysis technique is a type of image segmentation that isolates objects by converting grayscale images into binary images.

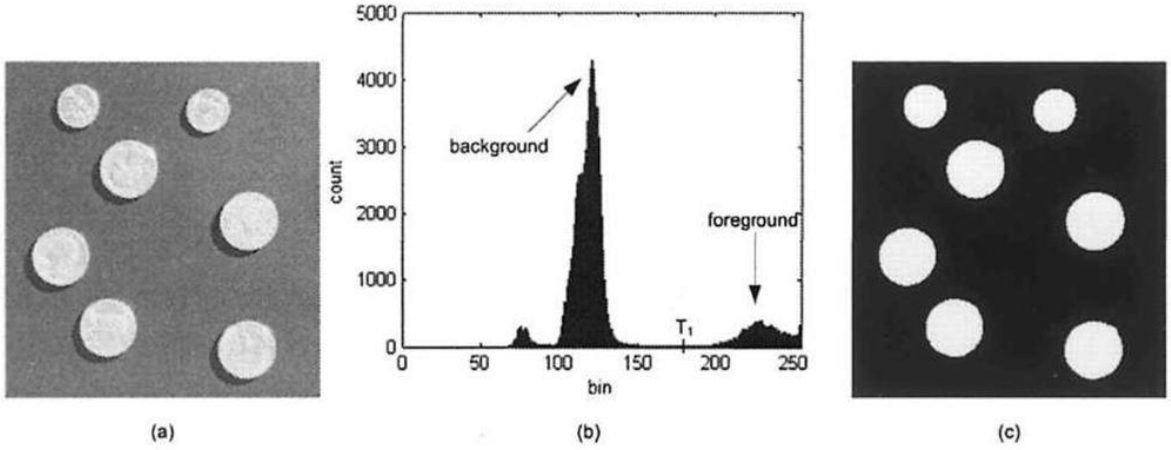
the threshold is set such that a desired percentage of pixels are labelled as edge points.

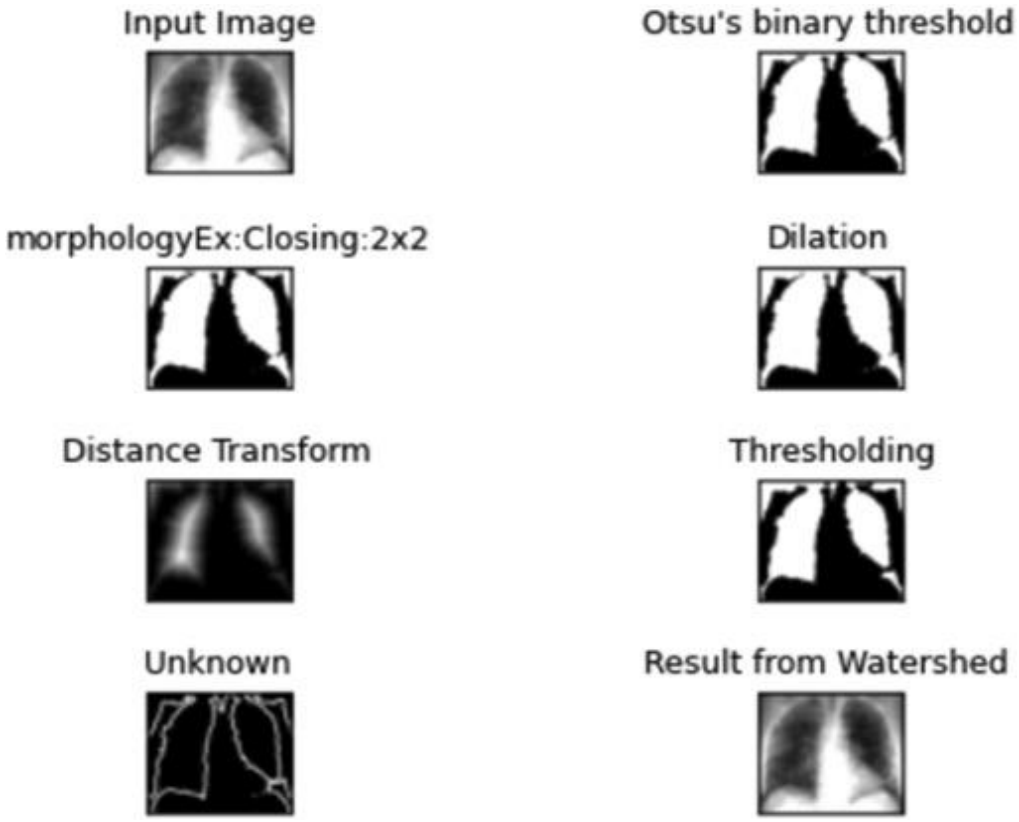
The figure below shows the gradient magnitudes on top, and the edge maps on the bottom, for several different threshold settings (2%, 5%, 10%, 15%)

for each of the two test images (25dB noise and 35dB).

The lower the threshold, the more edges will be detected, and the result will be increasingly susceptible to noise and detecting edges of irrelevant features in the image. Conversely a high threshold may miss subtle edges, or result in fragmented edges.

Thresholding is one of the segmentation techniques that generates a binary image (a binary image is one whose pixels have only two values – 0 and 1 and thus requires only one bit to store pixel intensity) from a given grayscale image by separating it into two regions based on a threshold value.


5000
4000
3000
2000
1000
0
count
background
foreground
T_1
0
50
100
150
200
250
bin
(a)
(b)
(c)


Input Image
Otsu's binary threshold
morphologyEx:Closing:2x2
Dilation
Distance Transform
Thresholding
Unknown
Result from Watershed

Algorithms are processes or optimized solutions are used to solve any complex problems.

There will a principle behind any algorithm design .Is it **natural laws or events?**

This algorithm uses natural events and behavior to get the low-cost and best possible solution to a complex problem.Lot of algorithms are based on natural behavior, and they are called **metaheuristics.**

Metaheuristics are made of two words:

Meta - which means **one level** above *; heuristics* - which means **to find**.

Particle Swarm Optimization and *Ant Colony Optimization* are examples of these **swarm intelligence algorithms.** The objective of the **swarm intelligence algorithms** is to get the **optimal solution** from the ***behavior** of **insects*, ants, bees, etc**.

To get the food, ants use the shortest path available from the food source to the colony.

Now ants going for the food secret the pheromone and other ants follow this pheromone to follow the shortest route.

Since more ants use the shortest route so the concentration of the pheromone increase and the rate of evaporation of pheromone to other paths will be decreased, so these are the two major factors to determine the shortest path from the food source to the colony.

Principle of Ant Colony Optimization:

This technique is derived from the behavior of ant colonies. Ants are social insects that

live in groups or colonies instead of living individually. For communication, they use **pheromones**.

Pheromones are the chemicals secreted by the ants on the soil, and ants from the same colony can smell them and follow the instructions.

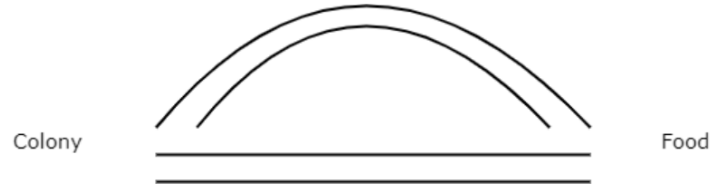
To get the food, ants use the shortest path available from the food source to the colony.

Now ants going for the food secret the pheromone and other ants follow this pheromone to follow the shortest route.

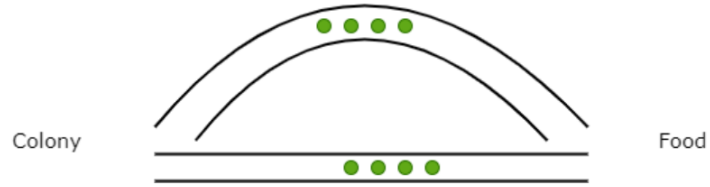
Since more ants use the shortest route so the concentration of the pheromone increase and the rate of evaporation of pheromone to other paths will be decreased, so these are the two major factors to determine the shortest path from the food source to the colony.

Ant Colony Optimization:

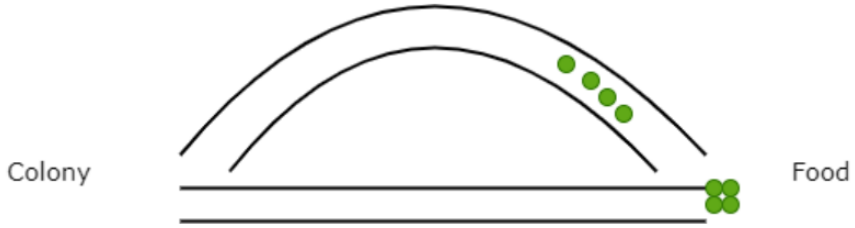
Stage 1: In this stage, there is no pheromone in the path, and there are empty paths from food to the ant colony



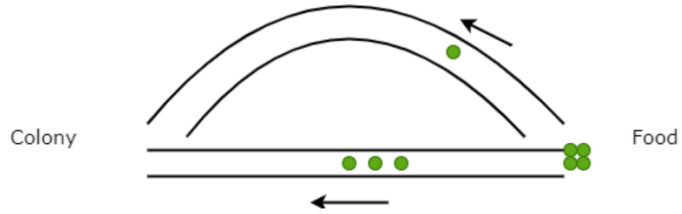
Stage 2 In this stage, ants are divided into two groups following two different paths with a probability of 0.5. So we have four ants on the longer path and four on the shorter path.



Stage3 Now, the ants which follow the shorter path will react to the food first, and then the **pheromone concentration will be higher on this path** as more ants from the colony will follow the shorter path.



Stage 4 more **ants will return from the shortest path**, and the concentration of pheromones will be higher. Also, the **rate of evaporation** from the longer path will be higher as fewer ants are using that path. Now more ants from the colony will use the shortest path.



The behavior of the ants can be used to design the algorithm to find the shortest path.
We can consider the ant colony and food source as the node or vertex of the graph and the path as the edges to these vertices.
Now the pheromone concentration can be assumed as the weight associated with each path.

Ant Colony Optimization Algorithm : Let's suppose There are only two paths which are P1 and P2. C1 and C2 are the weight or the pheromone concentration along the path, respectively. To represent it as graph G(V, E) where V represents the Vertex and E represents the Edge of the graph.

Initially, **for the ith path**, the probability of choosing is:

$$Pi = \frac{Ci}{C1+C2};\ where\ i = 1,2$$

If **C1 > C2**, then the probability of choosing path 1 is more than path 2.

If **C1 < C2**, then Path 2 will be more favorable.

For the **return path**,

a) the ***length of the path*** and the **rate of evaporation** of the pheromone are the two factors

Concentration of pheromone according to the length of the path:

$$Ci = Ci + \frac{K}{Li}$$

Where
Li is the length of the path and
K is the constant depending upon the length of the path.
If the path is shorter, concentration will be added more to the existing pheromone concentration.

b) Change in concentration according to the **rate of evaporation:**

$$Ci = (1 - v) * Ci$$

Here parameter v varies from 0 to 1.

If v is higher, then the concentration will be less.

Pseudo Code:

Procedure ACO:
Initialize the parameters and pheromone concentration;
while not termination do:
Generate initial ant population;
Calculate the fitness values for each ant of the colony;
Find optimal solution using selection methods;
Update pheromone concentration;
end while
end procedure

Ant Colony optimization is used in various problems like the Travelling Salesman Problem etc.