Introduction to AI and Applications		Semester	I/II
Course Code	1BAIA103/203	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	3	Exam Hours	3
Examination type (SEE)	Theory		

Course outcome (Course Skill Set)

At the end of the course, the student will be able to:

- CO1: Explain the concepts and types of artificial intelligence.
- CO2: Illustrate basic machine learning methods for regression, classification and clustering.
- CO3: Identify real-world applications across different disciplines.
- CO4: Make use of prompt engineering techniques to interact with generative AI tools.
- CO5: Outline recent trends in artificial intelligence and machine learning.

Module-5

Robotics, Robotics-an Application of AI, Drones Using AI, No Code AI, Low Code AI. T1: Ch(8.3), Ch(1.7, 1.8, 1.10, 1.11)

Industrial Applications of AI: Application of AI in Healthcare, Application of AI in Finance, Application of AI in Retail, Application of AI in Agriculture, Application of AI in Education, Application of AI in Transportation, AI in Experimentation and Multi-disciplinary research. **T3: Ch3, Ch(5.1)** **Number of Hours: 08**

L1 Robotics, Robotics an Application of AI

8.3 Robotics

We have read that robot is a programmable machine that can complete a task. Correspondingly, the term robotics is the study focused on designing, developing and programming physical robots which are able to interact with the physical world and automate one or more tasks. Each robot has a different level of autonomy varying from human-controlled bots that carry out tasks to fully-autonomous bots that perform tasks without any external influences.

8.3.1 Artificially Intelligent Robot

Many people think that AI and robotics are synonymous.Table 8.1 highlights the difference between an AI program and a robot system.

TABLE 8.1 Difference between AI Program and Robot

AI Programs	Robots
They operate in computer-simulated worlds.	They operate in the real physical world.
Receives input in the form of symbols and rules.	Receives input as analogue signal or in the form of the speech waveform.
To operate an AI program, general-purpose or special-purpose computers are required.	To operate a robot, special hardware with sensors and effectors are needed.

Moreover, from the Venn diagram as shown in Fig. 8.8, it is clear that there is one small area where the two fields overlap and, in this area, we have artificially intelligent robots (AIRs). These AIRs are the bridge between robotics and AI.

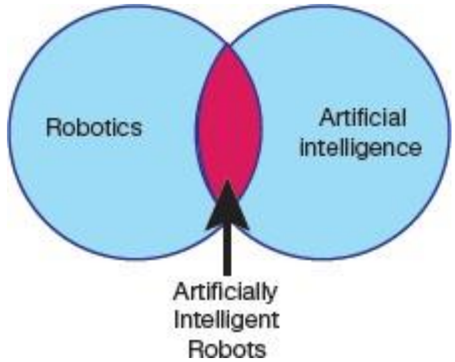

FIGURE 8.8 Venn diagram depiction relationship between AI and Robotics

Although many AIRs are controlled by AI programs, they are not artificially intelligent. For example, most industrial robots are programmed to carry out a repetitive series of movements which do not require artificial intelligence. However, such non-intelligent robots have limited functionality.

To perform complex tasks, an artificially intelligent robot must implement some AI algorithm(s). For example, consider the scenarios given below to understand how AI can guide the functionality of a robot.

Case 1: A warehousing robot may use a path-finding algorithm to navigate around the warehouse.

Case 2: A drone may use autonomous navigation to return to its owner when it is about to run out of batteries.

Case 3: A self-driving car uses AI techniques to detect and avoid potential hazards on the road.

8.3.2 Characteristics of Robots

A robot is a **mechanical device** which completes it tasks in the environment for which it is designed. For example, the Mars 2020 Rover's wheels are motorized and made of titanium tubing to firmly grip the harsh terrain of the red planet.

1. Robots need **electrical components** that control and power the machinery. Usually, they draw electric current using a battery.
2. Robots work on instructions written using **computer programming**. These instructions tell the robot what to do, when to do and how to do it.

8.3.3 Types of Robots

Mechanical bots come in a variety of designs, shapes and sizes to efficiently perform the task they are designed to perform. For example, RoboBee is a 0.2-millimeter-long robot while Vindskip is a

200-metre-long robotic shipping vessel. To classify them broadly into different categories, robots can be divided based on their capabilities to perform a particular task.

Pre-Programmed Robots

They operate in a controlled environment where they perform simple, monotonous tasks. For example, a mechanical arm on an automotive assembly line to weld a door on, to insert a certain part into the engine, etc. (as shown in Fig. 8.10) is an example of such a robot that performs its tasks faster and more efficiently than a human.

Credit: Pop Nukoonrat / 123RF

FIGURE 8.10 Pre-Programmed Robots

Humanoid Robots

They look like or mimic human behaviour and usually perform human-like activities (like walking, carrying objects). These days, humanoids look like us. For example, Hanson Robotics' Sophia and Boston Dynamics' Atlas.

Autonomous Robots

These machines operate independently of human operators
and are usually designed to perform tasks in open environments without any human supervision. Autonomous robots perceive the world around them using sensors and then use decision-making capabilities to take the optimal next step based on their data and mission. For example, Roomba vacuum cleaner uses sensors to roam freely throughout a home. Other examples of autonomous robots are lawn trimming bots, hospitality bots, autonomous drones and medical assistant bots.

Most industrial robots are non-intelligent.
We often call these robots, cobots. Cobot, or a simple collaborative robot, is a non-intelligent robot. For example, a cobot can be programmed to pick up an object and place it elsewhere. This is done by training a specialized computer vision program to identify different types of objects generally by using an AI algorithm called Template Matching. Broadly, this is an autonomous function as no human intervention is required once the cobot has been programmed to do its task efficiently. Moreover, the task does not require any intelligence as the cobot will always be picking the object in the same way until its instructions are not changed.

Teleoperated Robots

These are semi-autonomous bots that use a wireless network to enable human control from a safe distance (as shown in Fig. 8.11). They are usually deployed in extreme geographical conditions, weather and circumstances. For example, drones used to detect landmines on a battlefield, robots used to fix underwater pipe leaks during oil spill are examples of teleoperated robots.

Credit: MONOPOLY919 / Shutterstock

FIGURE 8.11 Teleoperated Robots

Augmenting Robots

Also known as VR robots, they are used to enhance or replace current human capabilities. With their help, science fiction could become a reality very soon by making humans faster and stronger. For example, robotic prosthetic limbs or exoskeletons are used to lift hefty weights.

8.3.4 Types of Robots Based on Degree of Human Control

Independent Robots

They perform their work autonomously and independent of human operator control. So, they need to be intensely programmed. Such robots are deployed to replace humans for performing dangerous, mundane or otherwise impossible tasks ranging from bomb diffusion and deep-sea travel to factory automation. Though independent robots eliminate certain jobs, the also present new possibilities for growth.

Dependent Robots

These robots are non-autonomous robots as they interact with humans to perform their actions. Humans guide robots to enhance and supplement their already existing actions. For example, these days, advanced prosthetics (the branch of surgery concerned with the making and fitting of artificial body parts. For example, a piece of flexible material applied to a person's face or body to change their appearance temporarily) are controlled by the human mind.

In 2018, Johns Hopkins APL created a popular example of a dependent robot was created by in 2018 for a patient (Johnny Matheny) whose arm was amputated above the elbow. A modular prosthetic limb was fitted in Matheny that was controlled by electromyography, or signals sent from his amputated limb that controls the prosthesis. Over time, he could accurately move his arm and even play the piano. At this time, the signals sent from his amputated limb became smaller and less variable.

Chatbots

Software robotics, also called bots, are computer programs that perform tasks autonomously. For example, a chatbot is a computer program that simulates conversation both online and over the phone and is often used in customer service scenarios. While simple chatbots answer questions with an automated response, more complex digital assistants learn from user information.

Robotics involves building robots physical whereas AI involves programming intelligence.

Types of Bots

Bots, or software robots only exist on the Internet and originate within a computer. Hence, they cannot be called robots. We have learnt in the characteristics of a robot that a robot has a physical form, such as a body or a chassis. Some popularly used bots are as follows:

1. **Chatbots** carry out simple conversations to provide 24 X 7 customer service.
2. **Spam bots** collect email addresses and send spam mail.
3. **Download bots** automatically download software and apps.
4. **Search engine crawler bots** scan websites and make them visible on search engines.
5. **Monitoring bots** collect statistics to report speed and status of the website.

8.3.5 Components of a Robot

Robots are created to perform a variety of tasks to present a solution for a wide range of problems. For this, they need a set of specialized components that are discussed below.

Control System

Control system is a CPU that directs a robot's task at high level. It performs all computations to tell a robot how to utilize its specific components, like how our brain sends signals to other parts of the body to complete a specific task. The tasks that a robot completes vary from an invasive surgery to assembly line packing.

Sensors

Sensors are devices that detect the events or changes in the environment and send data to the computer processor. For this, they are equipped with other electronic devices to provide electrical signals that allows the robot to interact with the world. Basically, the electrical signals act as a stimulus that are processed by the controller. Based on the stimulus received, the controller instructs the robot to interact with the outside world.

This helps the robot to efficiently respond to real-time data. Popularly used sensors within a robot include video cameras (as eyes), photoresistors (react to light) and microphones (as ears). All these sensors allow the robot to capture information about its surroundings and process it to deduce the most logical conclusion and give commands to other components.

Robots are programmable, autonomous or semi-autonomous machines.
It is through these sensors that the robots get the ability to see, hear, touch and move like humans. *Sensors are devices or machines which help to detect the events or changes in the environment and send data to the computer processor. These devices are usually equipped with other electronic devices*. Similar to human organs, the electrical sensor also plays a crucial role in artificial intelligence and robotics. AI algorithms control robots by sensing the environment, and provide realtime information to computer processors.

Actuators

Actuators are the motor parts that facilitate a robot's movement. We have read that a machine is a robot if it has a movable frame or body and actuators are the components that cause movement. Actuators are made up of motors that receive signals from the control system and move in tandem to carry out the movement necessary to complete the assigned task. They are made of metal or elastic.

Electric motors are the devices that convert electrical energy into mechanical energy and are required for the rotational motion of the machines.
Actuators help in moving and controlling a robot by using energy that can be electrical, hydraulic and air, etc. This means that actuators are usually operated using electricity (electrical), compressed air (pneumatic actuators) or oil (hydraulic actuators). Actuators can create linear as well as rotary motion.

Power Supply

Power supply is done to the robot by a battery. Just as we need food to do our work, robots require power to operate. The main use of power supply is to convert electrical current to power the load. Stationary robots used in a factory work on AC power while others operate via an internal battery. While a majority of robots work on lead-acid batteries as they are safe and have long shelf life, others use compact and expensive silver-cadmium batteries. These batteries are chosen depending on safety, weight, replaceability and lifecycle of the robot. AI algorithms are used in Google searches, Amazon's recommendation engine and GPS route finders. However, for future robotic development, pneumatic power from compressed gasses, solar power, hydraulic power, flywheel energy storage, organic garbage through anaerobic digestion and nuclear power are also being considered as potential sources of power.

Example of a pure AI is AlphaGo.

Pure AI is usually found in games. For example, in 1997, AI Deep

Blue could easily defeat world champion. A more recent example is AlphaGo which won Lee Sedol, the world champion Go player, in 2016.

End Effectors

End effectors are the physical, typically external components of a robot that facilitate it to complete a task. For example, in factories, robots usually have interchangeable tools like paint sprayers, gripping claws or even hands for undertaking tasks like deliveries, packing, bomb diffusion, etc. All these components are central to every robot's construction.

8.3.6 AI Technology Used in Robotics

In this section, we will list AI technologies that are used in robotics. We have already studied some of them. These technologies are discussed below.

1. **Computer Vision:** As studied earlier, Computer Vision is an important domain of artificial intelligence that extracts useful information from images, videos and visual inputs to perform appropriate action(s).
2. **Natural Language Processing (NLP):** NLP is used to give voice commands to AI robots to create a strong human-robot interaction. NLP helps the robot to understand and reproduce human language. Besides recognizing human language, robots can learn the accent, and predict how humans speak.
3. **Edge Computing:** Edge computing in robots helps in robot integration, testing, design and simulation to provide better data management, lower connectivity cost, better security practices, more reliable and uninterrupted connection.
4. **Complex Event Process:** An event is said to occur when there is a change of state and one or more events combine to define a complex event. Correspondingly, complex event processing (CEP) helps us to understand the processing of multiple events in real time.

   The term 'complex event process' is popularly used in various industries including healthcare, finance, security, marketing, detecting credit card fraud, stock marketing, etc. For example, the deployment of an airbag in a car is a complex event that is based on real-time data coming from multiple sensors.

5. **Transfer Learning and AI:** Transfer learning solves a problem with the help of an already solved problem. So, the knowledge gained from solving one problem is utilized to solve another problem that is related to the problem to be solved. For example, the model used to recognize a square shape can also be used to identify a circular shape.

   Since transfer learning reuses the pre-trained model for a related problem, the actual learning time for the new problem to be solved is relatively less and thus provides a cheaper solution. In robotics, transfer learning trains one machine using other machines.

6. **Reinforcement Learning:** Reinforcement learning focuses on learning based on feedback. In this technique, an AI agent to learns and explores the environment, performs actions and automatically learns from experience or feedback obtained for each action. Reinforcement learning makes the agent learn to behave optimally through hit-and-trail method while interacting with the environment. It is mainly used to deduce decisions to achieve goals in an uncertain and potentially complex environment.

   In the context of robotics, robots explore the environment to learn how to work optimally through hit and trial method. For every correct action, the robot gets a reward and a punishment for an incorrect action. In this way, reinforcement learning provides a framework to design and simulate sophisticated and hard-to-engineer robotic behaviours.

7. **Affective computing:** Affective computing focuses on developing systems that can identify, interpret, process and simulate human emotions. Therefore, this study aims to imbibe emotional intelligence in robots so that they are able to observe interpret and express themselves emotionally.

8. **Mixed Reality:** Mixed reality is an emerging field that focuses on programming by demonstration (PbD). PbD creates a prototype using a combination of physical and virtual objects.

8.3.7 Planning and Navigation

To know more about Mobile robots that are critical to robust mobility one needs to know more about the kinematics of locomotion, sensors for determining the robot's environmental context and techniques for localizing with respect to its map. Cognitive level of robots are discussed here. It is the capability of a system to make purposeful decision and execute them to achieve its highest order goals. In the context of a mobile robot, cognition refers to robust mobility. Robot navigation aims to make the robot reach its goal position efficiently and reliably based on its knowledge about its environment, the goal position and values of the sensor.

Although many different approaches have been proposed for navigating a robot, there are strong similarities between all of them. The underlying difference exists in the manner in which they decompose the problem into smaller sub-units. Given a map and a goal location, path planning identifies a trajectory that will help the robot to reach the final destination.

8.3.7.1 Competencies for Planning—Planning and Reacting

Path planning is a strategic problem-solving competency (capability), as the robot must make vital decisions to achieve its goals. The second competency is tactical extreme to avoid all obstacles and collisions by modulating the trajectory of the robot. Given readings of real-time sensor readings, several approaches are proposed to avoid obstacles. We will discover a few of them. While navigating, a robot plans and reacts. Without reacting, the planning effort(s) will be of no use as the robot never be able to reach its goal. Correspondingly, without planning, the robot will never reach its goal.

Suppose a robot R at time i in the initial belief state b_i has a map M_i to reach position p while

satisfying certain some temporal constraints $loc_g(R) = p$; $(g \leq n)$ (like before timestep n).

Although the robot's movements have to be physical, the robot can only sense its belief state, not its physical location. We will, therefore, map the goal of reaching location p to reaching a belief state b_g. We need a plan q that specifies one or more trajectories from b_i to b_g.

However, the problem arises when either the robot's position is not quite consistent with b_i or M_i is incorrect and/or incomplete. Furthermore, the real-world environment is dynamic. Even if M_i is correct at time i, M may change over time as the robot must incorporate new information gained during plan execution. Over a period of time, the environment changes and the robot's sensors gather new information. In this scenario, reacting becomes more important. Reacting modulates the robot's behaviour to update the planned upon trajectory so that the robot still reaches its goal position. Moreover, unanticipated new information also requires changes to the robot's strategic plans. Therefore, in the specified time limits, the plan should consider every new piece of information in real time to produce a new plan to react to the new information appropriately. This theoretical extreme, the point at which the concept of planning and reacting merge, is called integrated planning and execution.

8.3.7.2 Key Terms in Trajectory Planning

Trajectory Planning

Trajectory planning refers to moving from point A to point B while avoiding collisions over time in a 2D or 3D space (refer Fig. 8.12). It is an important concept in designing autonomous vehicles. Trajectory planning also known as motion planning is mistakenly referred to as path planning.

However, it is different from path planning as it is parametrized by time. Besides path planning, trajectory planning also incorporates planning based on velocity, time, and kinematics.

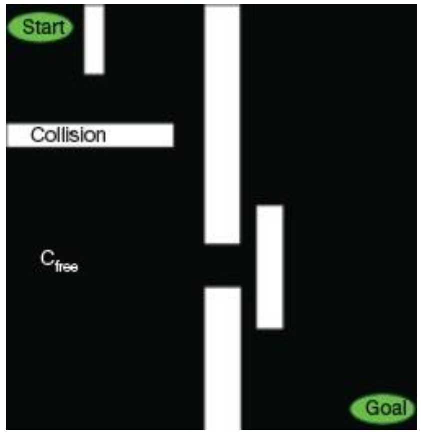

FIGURE 8.12 Trajectory planning

Configuration Space

A configuration is the pose of a robot describing its position. Correspondingly, Configuration Space C, is the set of all configurations. For example, in a 2D space, a robot's configuration is given by coordinates (x, y) and angle θ.

Similarly, in 3D space, a robot's configuration is given by coordinates (x, y, z) and angles (α, β, γ).

The goal of path planning is to find a path from the initial position to the goal position in the physical space that avoids all collisions with the obstacles. This problem becomes particularly more difficult as k grows large. If we define the configuration space obstacle O as the subspace of C, the free space in which the robot can move safely can be computed as, F = C - O.

Figure 8.13 shows a picture of the physical space and a 2D configuration space for a planar robot arm with two links. The robot's goal is to move its end effector from position c1 to c2.

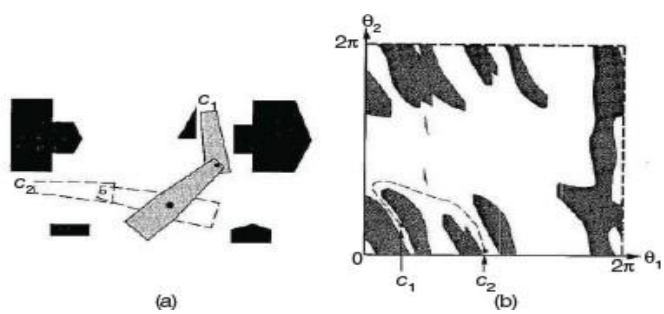

FIGURE 8.13 Physical space and a 2D configuration space

Free Space

Free space C_{free} is the set of all configurations that are collisionfree. The robot should be programmed to use kinematics and collision detection from sensors to ensure if a given configuration is a collision free or not.

Target Space

Target space is a linear subspace of free space and consists of space in which we want the robot to explore. In global motion planning, target space is observable by the robot's sensors. But in local motion planning, some states in target space are not observable by robot's sensors. To solve a problem, robots assume several observable virtual target spaces (around itself). The virtual target space is often referred to as sub-goal.

Degrees of Freedom

It specifies modes in which a mechanical device or system can move. This means that the number of degrees of freedom is equal to the total number of independent displacements or aspects of motion. For example, in a robotic arm, shoulder and wrist can move up or down, left or right but elbow can move up or down. Wrist and shoulder can also be rotated (or rolled).

Therefore, such a robot arm has five to seven degrees of freedom. And if the robot has two arms, then total number of degrees of freedom is doubled.

Multi-legged mobile robots can have more than 20 degrees of freedom. For example, Project Nao, which looks superficially like a large space-age doll, has 25 degrees of freedom.

8.3.7.3 Problem Constraints in Trajectory Planning

Trajectory planning suffers from two main problems which are discussed below.

Holonomicity

This gives the relationship between the controllable degrees of freedom and total degrees of freedom of the robot. A robot is said to be holonomic if the number of controllable degrees of freedom is greater than or equal to the total degrees of freedom. Holonomic robots are easy to work with as they facilitate many movements easier to make. Moreover, returning to a past pose is much easier.

For example, if a self-driving car is designed as a non-holonomic robot, then it will have no way to move laterally, thereby making its certain movements (like parallel parking) difficult. In contrast to this, a holonomic vehicle would be one with mecanum wheels, such as the new Segway RMP.

Dynamic Environments

In dynamic environments, like the real world, objects that may cause collision are not stationary. This makes trajectory planning more difficult as objects are moving with respect to time. Many-a-time, it may not be possible for a robot to move backward in time. Moreover, many choices are completely irreversible due to terrain, such as moving off of a cliff.

8.3.7.4 Planning Algorithms

In this section, we will discuss three types of planning algorithms.

1. **Artificial Potential Field:** The algorithm places values over the map with the goal having the lowest or highest value that either increases or decreases depending on the distance from the goal (refer Fig. 8.14).

FIGURE 8.14 Artificial Potential Field

Obstacles defined can have an incredibly high or low value. The robot is programmed to move to the lowest or (highest) potential value adjacent to it, which should lead it to the goal. However, this algorithm often gets trapped in local minima.

2. **Sampling-based Planning:** Roadmap method is an example of sampling-based planning method. The algorithm first selects a sample of N configurations in C as milestones. Then, a line PQ is formed between all milestones as long as the line PQ is completely in C_{free}. Following this, any graph search algorithms can be used to find a path from start to the goal. Though a large number of N increases computation time, it results in better solutions.

3. **Grid-based Planning:** This algorithm overlays a grid on the map (as shown in Fig. 8.15) and then ensures that every configuration corresponds with a grid pixel. The robot can move from one grid pixel to another adjacent grid pixel if that grid pixel is in C_{free}. T

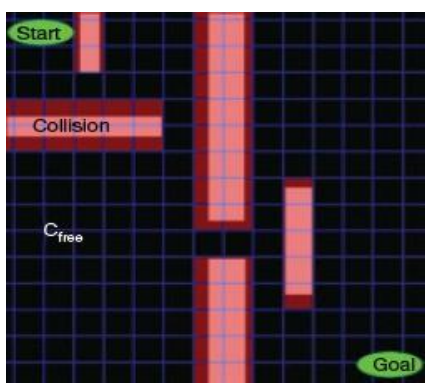

FIGURE 8.15 Grid-based Planning

Search algorithm like A is used to find a path to reach the goal position from the starting position. Although a lower resolution grid having bigger pixels will make the search procedure execute faster, it may however miss paths through narrow spaces of C_{free}. Moreover, as the resolution of the grid increases, memory usage also grows exponentially. In such a scenario and especially in large areas, another path planning algorithm may be necessary.

4. **Reward-based Planning:** Algorithms based on researchbased planning assume that robot in each state (position) may select any action (regarding motion). However, the result of each action is not definite. In such a case, outcomes or displacement, in this context, are partly random and partly under the robot's control. On reaching the goal, the robot gets a positive reward and a negative reward on colliding with an obstacle.

   Research-based planning algorithms, therefore, aim to find a path giving maximum future rewards. Markov decision processes (MDPs) is a popular technique used in many of reward-based algorithms. Though this technique generates optimal path, this path may not be smooth as it limits the robot to choose from a finite set of actions. To overcome this drawback, usually Fuzzy Markov decision processes (FDMPs), an extension of MDPs, is used to generate a smooth path with using a fuzzy inference system.

5. **Road-map Path Planning:** Road-map path planning algorithms capture the connectivity of the robot's free space in a network of one-dimensional curves or lines, called roadmaps. Once a road-map is constructed, it is then used to plan a robot's motion. The algorithm reduces the problem of path planning to connecting the initial and goal positions of the robot to the road network and then searching the roads from the initial position to the goal position of the robot. This means that, road-map uses the obstacle's geometry to decompose the robot's configuration space.

The challenge is to construct a set of roads that together helps the robot to move around anywhere in its free space, while minimizing the number of total roads. In this section, we will discuss two approaches for road mapping—visibility graph and Voronoi diagram. While visibility graph finds paths that have minimum lengths by bringing the roads closer to the obstacles, Voronoid diagram, on the other hand, keeps roads as far as possible from the obstacles.

8.3.7.5 Visibility Graph

The visibility graph for a polygonal configuration space C includes all edges (including initial and final positions) joining every pair of vertices that can see each other. The unobstructed roads depicted as straight lines in the graph are the shortest distances between two vertices. The job of the path planning algorithm is to find the shortest path from the initial position to the goal position along the roads drawn in the visibility graph (see Fig. 8.16).

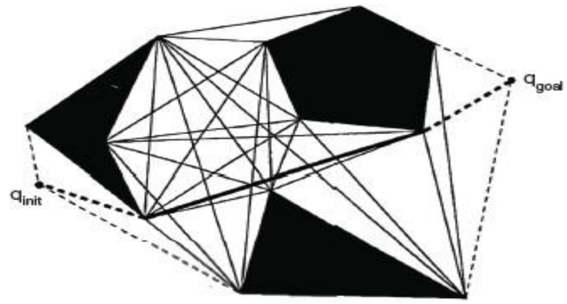

FIGURE 8.16 Visibility Graph

The visibility graph path planning algorithm is very simple and straight-forward. It can be readily used when objects in the environment are described as polygons either in continuous or in discrete space. However, there are two important limitations of this algorithm.

First, with increase in the number of obstacle polygons, the number of edges and vertices increases. Therefore, this algorithm works well in sparse environments, but is very slow and inefficient when used in densely populated environments.

Second, the solution paths found by visibility graph planning algorithm takes the robot as close as possible to obstacles on the way to the goal.

Though this algorithm is optimal in terms of the length of the solution path, it does not keep the robot away from obstacles. This compromises safety. A potential solution can be either to grow the obstacle's size significantly so that it becomes more than the robot's radius, or modify the solution path after path planning to distance the path from obstacles. However, such fixes compromise the optimal-length results of the algorithm.

8.3.7.6 Voronoi Diagram

A Voronoi diagram maximizes the distance between the robot and obstacles in the map. For each point in the free space, distance from that point to the nearest obstacle is calculated and plotted as a height coming out of the page (refer to Fig. 8.17). As the robot moves away from the obstacle, the height increases. Sharp ridges can be seen in the Voronoi diagram at points that are equidistant from two or more obstacles. Edges are formed by these sharp ridge points. When obstacles in the configuration space are polygons, the Voronoi diagram has straight and parabolic segments.

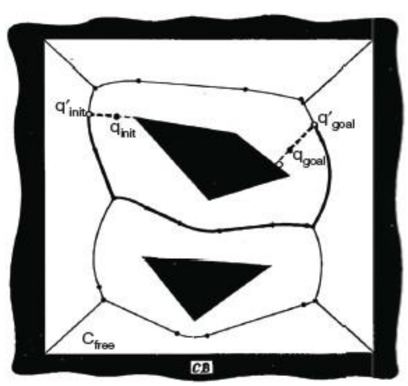

FIGURE 8.17 Voronoi Diagram

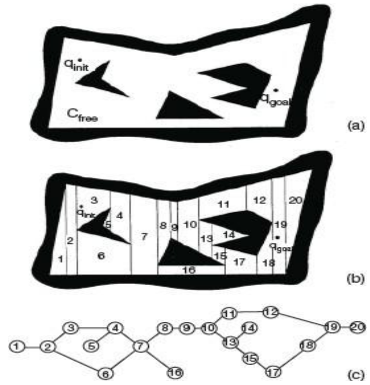

FIGURE 8.18 Forming Edges and making graph from the given Vornoi Diagram

The path in the Voronoi diagram may not be optimal in terms of total path length. Another limitation of this diagram is limited range localization sensors. Since the distance between the robot and obstacle is maximized, any short-range sensor on the robot may not be able to sense its surroundings. Hence, the chosen path may be quite poor from a localization point of view.

However, the main reason of popularity of the Voronoi diagram method is its executability. Given a planned path via Voronoi diagram planning, a robot with range sensors can follow a Voronoi edge in the physical world using simple control rules that match those used to create the Voronoi diagram. Voronoi Diagram can also be used to conduct automatic mapping of an environment by finding and moving on unknown Voronoi edges and creating a consistent Voronoi map of the environment.

8.3.7.7 Cell Decomposition Path Planning

The cell decomposition path planning aims to distinguish between geometric areas, or cells, that are free and areas that are occupied by objects. The following must be kept in mind.

1. The graph is divided into simple, connected regions called 'cells'.
2. A connectivity graph is constructed by identifying opens cells that are adjacent.
3. Identify the cells in which the initial and goal configurations lie. Select a path in the connectivity graph that joins the initial and the goal cell.
4. From the cells identified, compute a path within each cell following motions and movements along straight lines.

The most important concept in cell decomposition method is the placement of the boundaries between cells. There are two methods which perform the task.

1. *Exact cell decomposition:* In this technique, the boundaries are placed as a function of the structure of the environment in such a way that the decomposition is lossless.
2. *Approximate cell decomposition:* This approach performs decomposition as an approximation of the actual map.

8.3.7.8 Exact Cell Decomposition

In Fig. 8.19, exact cell decomposition has been used. Here, the boundary of cells is based on geometric criticality. So, the resulting cells are either completely free or completely occupied resulting in a complete path. In this method, the robot's ability
to traverse from each free cell to adjacent free cells is more important than the position of the robot within each cell of free space.

Advantage

In environments that are extremely sparse, the number of cells will be small.

Disadvantages

1. The number of cells and computational efficiency of the overall path planning algorithm depends upon the density and complexity of objects in the environment.
2. Due to complexities in implementation, the exact cell decomposition technique is less frequently used in mobile robot applications.

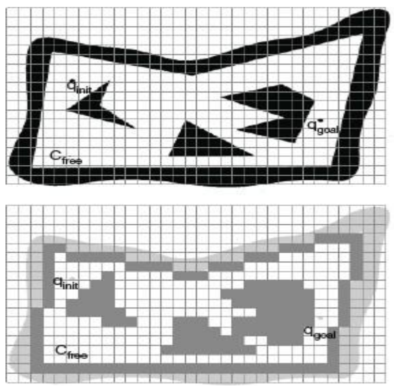

FIGURE 8.19 Exact Cell Decomposition

8.3.7.9 Approximate Cell Decomposition

Approximate cell decomposition is a popular technique for mobile robot path planning. It uses grid-based environmental representations that are themselves fixed gridsize decompositions. They are quite similar to an approximate cell decomposition of the environment.

We can see that in Fig. 8.20, the cell size is not dependent on the particular objects in an environment resulting in loss of narrow passageways due to the inexact nature of the tessellation. However, this is rarely a problem as the cell size used is very small, usually 5 cm on each side.

The main advantage of fixed-size cell decomposition is the low computational complexity of path planning. In Fig. 8.20, we see that the free space is externally bounded by a rectangle which is further decomposed into four identical rectangles. The rectangle is not decomposed further only in two conditions.

1. First, the interior of a rectangle lies completely in free space.
2. Second, the interior of a rectangle lies completely in the configuration space obstacle.

If the two conditions are not satisfied, then the rectangle is recursively decomposed into four rectangles until one of them is met. Note that the white cells lie outside the obstacles, the black inside and the grey are part of both the regions.

This technique is an efficient and simple strategy for finding routes in fixed-size cell arrays. The algorithm starts from the goal position marking for each cell its distance to the goal cell until the initial robot position is reached. At this point, distance to the goal position and a specific solution trajectory is known by linking together cells that are adjacent and closer to the goal.

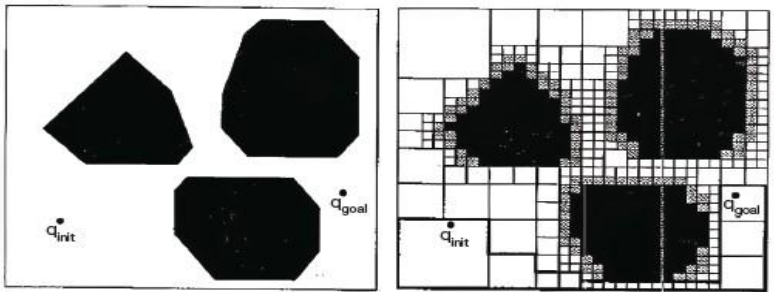

FIGURE 8.20 Approximate Cell Decomposition

If the entire array is in memory, then each cell is visited only once to deduce the shortest path from the initial position to the goal position. So, the search is linear. Therefore, the complexity of this algorithm neither depends on the sparseness and density of the environment, nor on the complexity of the objects' shapes in the environment.

The Cye robot is an example of a commercially available robot that plans path in a 2D space with 2 cm fixed-cell decomposition of the environment. Unlike exact cell decomposition method, approximate cell decomposition method does not guarantee completeness but it is mathematically less involving and easier to implement.

8.3.7.10 Potential Field Path Planning

Potential field path planning algorithm creates a field across the robot's map that directs the robot to the goal position. The potential field technique considers robot as a point under the influence of an artificial potential field $U(q)$.

Like a ball roll downhill under a gravitational field, the robot moves by following the potential field. The goal acts as an attractive force on the robot and the obstacles act as peaks, or repulsive forces. The superposition of all forces is applied to the robot. The artificial potential field thus created helps the robot to avoid known obstacles and smoothly move towards the goal. Thus, this concept goes beyond path planning.

Basically, the resulting field is a control law for the robot. A robot can always decide its next action, assuming that it can localize its position based on the map and potential field.

Knowing that the robot is attracted towards the goal and repulsed by the known obstacle, we need to update the potential field as soon as a new obstacle appear during robot motion. Considering robot as a point, the robot's orientation θ is neglected and the resulting potential field is only two dimensional (x,y).

Assuming a differentiable potential field function U(q), related artificial force F(q) acting at the position (x,y) is calculated as follows:

$$F(q) = -\Delta U(q),$$

where $\Delta U(q)$ is the gradient vector of U at position q.

$$\nabla U = \begin{bmatrix} \frac{\partial U}{\partial x} \\ \frac{\partial U}{\partial y} \end{bmatrix}$$

The potential field acting on the robot is then computed as the sum of the attractive field of the goal and the repulsive fields of the obstacles. Thus,

$$U(q) = U_{att}(q) + U_{rep}(q)$$

Correspondingly, the net force after considering attracting and repulsing forces is calculated as,

$$\begin{aligned} F(q) &= F_{att}(q) - F_{rep}(q) \\ &= -\nabla U_{att}(q) - \nabla U_{rep}(q) \end{aligned}$$

Robotics—an Application of AI

Robotics is a branch of engineering that involves the conception, design, manufacture and operation of robots. It is an inter-disciplinary field that includes the study of electronics, computer science, artificial intelligence, mechatronics, nanotechnology and bioengineering.

Science-fiction author Isaac Asimov, first used the term 'robotics' in the 1940s. According to him, robots must ensure the following:

Rule 1: Never harm humans.

Rule 2: Always follow instructions from humans without violating rule 1.

Rule 3: Protect themselves without violating the other rules. Some important aspects of robots include the following:

1. They have electrical components for providing power and control the machinery.
2. They have mechanical construction and their shape or design depends on the task they are intended to accomplish.
3. They are programmed. Instructions fed to them helps them to determine what, when and how it would do something.

These days, robots are being extensively designed as bots that explore the Earth's harshest conditions and assist in almost every facet of healthcare. Though the robotics industry is still evolving, we already have robots that work in the deepest depths of our oceans to the highest heights of outer space. They are being used to do everything that humans could not dream of doing.

1.7.1 Types of Robots

Pre-programmed robots operate in a controlled environment to perform simple, monotonous tasks. For example, a mechanical arm on an automotive assembly line that is used to weld a door, or insert a certain part into the engine. This type of robot can perform that task for longer hours, faster and more efficiently than a human.

Humanoid robots look like humans and/or mimic human behaviour. They can perform human-like activities (like running, jumping and carrying objects). Sophia and Atlas are two popular examples of humanoid robots.

Autonomous robots operate without human operators. They are designed to perform tasks in open environments that do not require human supervision. For example, the Roomba vacuum cleaner uses sensors to roam freely throughout a home to clean it.

Teleoperated robots are mechanical bots controlled by humans. They are used in extreme geographical conditions, weather, circumstances, etc. For example, human-controlled submarines used to fix underwater pipe leaks during the BP oil spill or drones used to detect landmines on a battlefield are examples of teleoperated robots. Robots are also used for tasks varying from diffusing bombs to performing surgeries. VR robots are also becoming popular these days.

Augmenting robots either enhance current human capabilities or replace the capabilities a human may have lost. Robotic prosthetic limbs or exoskeletons used to lift hefty weights are examples of such robots.

1.7.2 Uses of Robotics

Robots are used in the following areas.

1. Helping fight forest fires
2. Assisting humans in manufacturing plants (known as co-bots)
3. Provide companionship to the elderly
4. Work as surgical assistants
5. Deliver food orders or other packages
6. Perform household tasks like vacuuming and mowing the grass
7. Locate and transfer items throughout warehouses
8. Perform search-and-rescue missions after natural disasters

9. Landmine detectors in war zones

Industry-wise applications can be given as follows:

The manufacturing industry is amongst the first well-known users of robots. They use robots and co-bots (bots that work alongside humans) to efficiently test and assemble products, like cars and industrial machinery.

Logistics companies use robots in their warehouses to perform tasks like shipping, handling goods and ensuring quality control. Robots are supposed to take items off the shelves, transport them across the warehouse floor and package them. They are now also used for last-mile delivery of packages for faster and efficient delivery.

Self-driving cars are a result of integrating data science with robotics. Automakers like Tesla, Ford, Waymo, Volkswagen and BMW are all working to provide users an ultimate experience of travel that will let them sit back, relax and enjoy the ride. Companies like Uber and Lyft are also developing autonomous rideshare vehicles that will be operated without humans.

The healthcare industry uses robots to perform complicated surgeries, deliver everything from medicines to clean linens.

Space agencies like NASA use robots in different ways. Robotic arms on spacecraft can move large objects in space. Robotic spacecraft can visit other worlds like the Moon or Mars. For example, Mars rovers Spirit and Opportunity are robots. Cassini studies Saturn and its Moons and rings. Robots like The Voyager and Pioneer spacecraft are now travelling beyond our solar system. People on the Earth use computers to send messages to the spacecraft. The robots have antennas that pick up the message commands and work as per the instructions given to it.

Robotic airplanes can fly without a pilot aboard. NASA is also developing Robonaut to help people in space. The upper body of Robonaut looks like a person. It has a chest, head and arms. They can work outside a spacecraft and work like an astronaut on a spacewalk.

NASA is also working on robots that might help an astronaut in an emergency. For example, when the astronaut is seriously hurt, a doctor on Earth could use the robotic arm to perform surgery. This technology can help doctors on Earth, as well. Doctors can help people in faraway places where there are no surgeons to perform complicated surgeries.

Robots are also used as **scouts** to check out new areas to be explored. They take photographs, measure the terrain, look for dangers and find the best places to walk, drive or stop. This not only helps scientists and engineers make better plans for exploring but also helps astronauts to work more safely and quickly.

Note:

- ASIMO is a humanoid that has the ability to recognise moving objects, postures, gestures, understand its environment, and interact with humans.

- Pepper is the world's first robot capable of recognising human emotions. It is social, can converse with people, give them directions and even dancing with them
- Romeo helps with everyday tasks, assist when people have fallen over, make conversations and play games.
- Buddy is designed to entertain the family, help you with your everyday activities, offer reminders, provides recipes in the kitchen, make video calls, keep an eye on your home while not at home, connect all your smart home devices together and even help your children learn.
- Panasonic Egg uses NLP Robot to communicate with you. It's an intelligent assistant that can be controlled by your voice, play video footage via a built- in projector and even engage in interactive games. This robot is Wi-Fi connected and promises software updates in future to improve it further.
- REEM is a full-size humanoid service robot that can act as a receptionist, provide entertainment for guests, make presentations and give speeches in different languages and help with a variety of different chores. REEM is able to selfnavigate, interact with people it encounters and keep on running for up to eight hours.

Review Questions

What is robotics? (Define it in one sentence.)

How is an artificially intelligent robot (AIR) different from a normal robot?

Name any two types of robots and give one example for each.

What is the function of sensors in a robot?

What does trajectory planning help a robot to do?

What is a chatbot and why can it not be called a robot?

L2 Drones in AI

1.8 Drones Using AI

The term 'drone' generally means any unpiloted aircraft that operates using a combination of technologies including computer vision, artificial intelligence, object avoidance tech and others. Also known as 'unmanned aerial vehicles' (UAVs), these drones can be as large as an aircraft or as small as the palm of your hand. With drones becoming readily accessible, they are now increasingly being used for the most dangerous and high-paying jobs that are discussed below.

Credit: Slavoljub Pantelic / Shutterstock

FIGURE 1.11

Emergency Response

Drones outfitted with thermal imaging cameras are used by emergency response teams to identify victims who are difficult to spot with the naked eye.

Humanitarian Aid and Disaster Relief

During times of natural disaster, drones are used to assess damage, locate victims and deliver aid. In addition, they are also used to prevent disasters altogether (refer Fig. 1.14).

Surveillance

Drones outfitted with thermal imaging cameras can be used to monitor and combat forest fires. Thermal cameras can measure and detect abnormal forest temperatures. This information can then be used to identify areas that are more prone to forest fires or identify fires just minutes after they begin (refer Fig. 1.13).

Conservation

Poaching and activities resulting in climate change have adversely affected wildlife worldwide. In fact, according to the World Wildlife Fund, thousands of species are estimated to extinct each year. To help combat this trend, conservationists are extensively using drones for geospatial imagery to monitor and track animals to protect our biological ecosystem.

Disease Control

Many infectious diseases spread through animals. In such a scenario, drones can be used to capture and test mosquitoes for infectious disease. This initiative can not only protect local residents, but can also prevent epidemics before they begin.

Moreover, drones are also being used in remote areas to provide quick access to vital drugs, medicines and medical equipment. All these initiatives have a profound impact on preventing disease, increasing life expectancy and raising general standards of living.

Bomb Detection

Small sized drones fitted with effective cameras can easily penetrate into constricted spaces to detect live bombs and save lives of thousands of people.

Air Strikes

Drones are used for conducting air strikes. Former US President Barack Obama had been using drones regularly to attack militants in the tribal areas of Pakistan. While being controlled by the defense personnel, drones can be made to fly around suspected areas to fulfill military operations (as shown in Fig. 1.12). However, use of drones for military operations has also raised numerous moral and ethical concerns as they lack accountability and failure to fully grasp the consequences of actions.

Credit: Alex Yuzhakov / Shutterstock

FIGURE 1.12 Usig Drones for Air Strikes

Agriculture

Farmers in some advanced countries are extensively using drones to gather data, automate redundant processes and improve efficiency to reduce costs and expand yields. Drones also help farmers to predict their potential harvest.

Weather Forecasting

Scientists are using drones to collect data about temperature, humidity, wind speed and other climatic parameters that could help them to accurately predict future changes to global weather systems. Drones used as autonomous sailboats are used to collect oceanic and atmospheric data from the ocean surface.

Maritime

Drones are used to inspect ships above the surface as well as hulls from below. Countries like the Netherlands, Denmark, and Norway are already using drones to identify ships committing emissions infractions.

Waste Management

Drones are being used to clean oceans, collect waste in ports and harbours and maintain systems for wastewater management.

Energy

Drones are used by energy generating companies to set up new sites for the production of energy. For this, the drones are made to survey areas and gather topographic detail that can be used to help oil and gas companies identify new drill sites. Drones are also used to extract, refine and transport oil and gas while ensuring compliance with regulations and standards.

Drones fitted with specialized thermal sensors can detect leaks faster than a human inspector. Even companies generating solar energy can use drones to design configurations for new arrays.

Mining

Mining activities require constant measurement and assessment of stockpiles of ore or rock or minerals. Drones fitted with unique cameras can capture large amounts of data from the air, thereby reducing the risks associated with having surveyors on the ground.

Drones are being using by the Indian government to deliver COVID vaccines even in the remotest areas.

Construction Planning

Drones are used to improve construction planning, enhance project monitoring and site management. Cameras fitted in these drones monitor buildings and gauge topography and soil type throughout the construction lifecycle.

Urban Planning

With increasing urbanization, cities are overburdened to accommodate more people in already congested spaces. In such a scenario, urban planning is being done with drones to implement data-driven improvements. For example, drones are used to gather data in populated areas. This data when analysed using ML algorithms can suggest areas that may get benefited from green space or classify the different types of structures and regions on the map.

Credit: 102 / Shutterstock

FIGURE 1.13 Drones for Survelliance

Personal Transportation

China-based EHANG was started as an autonomous aerial vehicle (AAV) that operates with four rotors (quadcopter) for vertical takeoff. The vehicle is used to help passengers reach their destinations. Such a vehicle is especially very useful in an urban environment with plenty of obstacles. Personal transportation drones require minimal inputs from the passenger and aims to allow safe landings even in case of engine failure or a collision.

Big companies like Uber, Airbus, Boeing and Rolls-Royce are working on developing flying drones (robotaxis) for ferrying passengers around.

Space

Drones are being used to be moved in the space. For example, NASA is using a drone-like helicopter in its Mars 2020 mission to help look for signs of life on Mars. In this mission, the helicopter will act as a scout for the rover, gathering data about the planet's terrain and surveying areas the rover cannot reach. NASA is also using a nuclear-powered drone for exploring Titan, one of Saturn's moons. The drone will arrive on Titan by 2034, autonomously traverse the planet for about 2 years, taking photos and sending data back for analysis.

FIGURE 1.14 Drones for delivering medical help

Telecommunications

Telecommunication towers must be inspected frequently to ensure service reliability. However, this process is too dangerous and time-consuming to do manually. In such a scenario, drones are able to quickly assess damage to help guide repair teams in restoring service.

Internet

Drones are being used to provide Internet access in remote areas and over irregular landforms. For example, Facebook has designed a solar-powered drone called Aquila, to provide Internet access to rural parts of the world. However, in 2018, Facebook halted the use of Aquila and used only third-party drones instead.

Even SoftBank, in collaboration with the drone manufacturer AeroVironment, is planning to develop drones that will operate in the stratosphere to serve as 'floating cell towers' to provide internet service to customers.

Outdoors

Drones are used outdoors to perform aerial landscape photography and extreme sports footage and map the entire mountain face to help climbers and skiers to better understand the terrain.

Tourism and Hospitality

These days, flying drones providing luxury accommodations can be used to travel to new locations on demand or to remote and traditionally inaccessible locations for guests. They are also being used to deliver packages and room service quickly.

Live Entertainment

Drones are already being used by Disney for entertainment through synchronized lights shows, floating projection screens and as drone puppeteers.

Journalism and News Coverage

News companies are using drones to gather news, especially from areas that are difficult to visit due to safety issues, high costs or physical barriers. For example, drones are used to get aerial footage of the aftermath of hurricane, wildfires and assess flood-ridden areas in the midwest.

Food Services

Drones are being used by online food ordering and delivery services for faster, cheaper delivery. This helps restaurants downsize their physical locations and lower real estate expenses.

Review Questions

What is a drone and what technologies does it use to operate?

How are drones useful in emergency response and disaster relief?

Name any two industries where drones are used and explain one use in each.

How do drones help in environmental protection or conservation?

L3 No Code AI, Low Code AI

1.10 No Code AI

Right from the first generation of computers, exhaustive efforts have been made to make programming easier, faster, less technical so that it can become accessible to a much larger audience.

No-code tools allow people to build applications and systems without having to write long and complex program codes. Applications can now be designed using visual interfaces and guided user actions. No-code tools are pre-integrated with other tools to exchange information as needed. Given below are some applications that can be built entirely using such tools.

1. Websites and landing pages with Webflow.
2. Web or mobile applications with Bubble, Adalo, Mendix or Thunkable Number and applications of No Code AI tools will grow steadily
3. Chatbots or virtual assistants through Octane AI, Kore.ai, Landbot or mindsay
4. Databases through Airtable
5. Connecting your tool stack with Zapier, tray.io, Integromat, Parabola or Paragon
6. E-commerce through Shopify or Weebly
7. Manage memberships with Memberstack
8. Newsletters with Mailchimp or Mailjet

1.10.1 Why No-Code AI?

Majority of businesses struggle to implement AI to its full in such a scenario, use of no code AI tools can be a great help due to the following reasons:

1. These tools allow automation through plug-and-play or dragand-drop UI.
2. Users with absolutely no coding skills too can leverage benefits of AI for business issues.

3. Businesses that cannot afford to invest additional time and resources to develop AI applications can build such systems from the ground up.
4. **Improves accessibility** to intensify use of data science or AI by even small and mid-sized companies.
5. **Enhances usability** as more and more non-technical users can create AI based solutions to a problem in low-cost and less-time.
6. No-code AI solutions are of fairly good quality and reduces human error(s) when setting up such systems. Refer Fig. 1.16 to know about some No Code AI Tools. Figure 1.17 list their applicabilities.

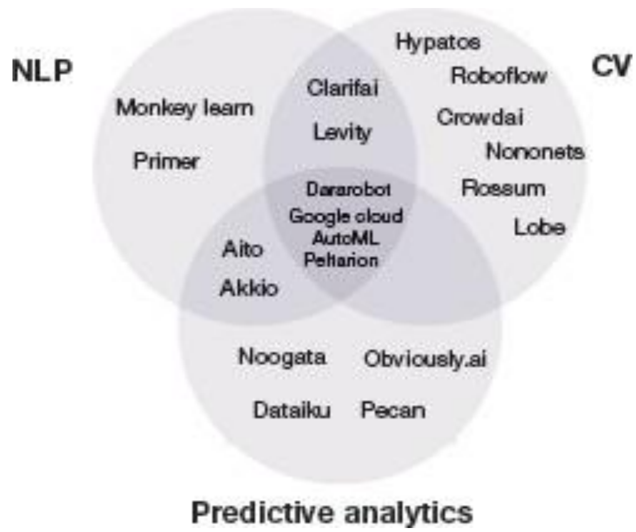

FIGURE 1.16 No-code AI landscape 2022: Technology

	Text	Image	Docs	Video	Audio	Tabular
No Code						
Levity	✓	✓	✓			
Aito	✓					✓
Akkio	✓					✓
Lobe		✓				
Monkey learn	✓					
Obviously.ai						✓
Pecan						✓
Low code						
Clarifai	✓	✓		✓	✓	
Crowdai		✓			✓	
Dataiku						✓
Dararobot	✓	✓		✓	✓	✓
Google cloud AutoML	✓	✓		✓		✓
Hypatos			✓			
Nononets			✓			
Noogata						✓
Peltarion	✓	✓			✓	✓
Primer	✓					
Roboflow		✓		✓		✓
Rossum			✓			

FIGURE 1.17 No-Code AI landscape 2022 : Data type

When running this exercise, it made sense to group the tools by the technology they use. Here's a quick round of definitions:

Computer Vision

It allows machines to obtain information from digital images, videos, pdfs and other visual data, and take actions based on their learnings.

NLP

This allows machines to understand and process language both spoken and written, for example, text messages.

Predictive Analytics

This refers to predictive modelling based on structured (i.e., tabular data), for example, predicting churn rate, forecasting and stock prices.

We also made a distinction between no-code tools and low-code tools. The no-code tools follow basic criteria: they are end-toend tools that are usable without coding knowledge. In that sense, low-code tools are better suited if you have someone on your team who *speaks data*. Figure 1.18 categorizes these tools based on their usage.

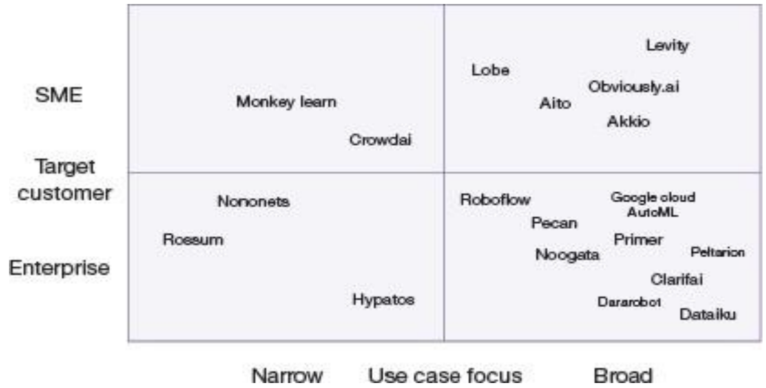

FIGURE 1.18 No-code AI landscape 2022: Customer vs use case

What is Monkey Learn No Code AI

User-friendly, no-code AI text analytics platform that empowers businesses to analyze unstructured text data (like reviews, surveys, emails) without coding, using machine learning for tasks like sentiment analysis, topic detection, and keyword extraction, to quickly gain insights, automate workflows, and improve customer understanding. It offers pre-built models and custom training, integrating with tools like Zapier and Google Sheets, making complex NLP accessible to marketing, support, and operations teams.

Key Features & Functions:

- **No-Code Interface:** Build text analysis models through a visual, intuitive interface, no data science skills needed.
- **Text Classification:** Automatically categorize text based on custom rules (e.g., routing support tickets).
- **Sentiment Analysis:** Understand customer feelings (positive, negative, neutral) in feedback.
- **Keyword/Topic Extraction:** Identify key themes and words from large text volumes.
- **Data Integration:** Connects with Google Sheets, Zapier, Zendesk, and others to automate data flow.
- **Customization:** Train models with your own data for specific business needs.

What it Does:	Who Uses It:	Brief what it does
Analyzes customer feedback, support tickets, social media, and reviews. Extracts actionable insights to improve products and services. Automates the processing of qualitative data, saving time.	Marketing, Support, Operations, and Analytics teams. Businesses from startups to enterprises	Performs text analysis Facilitates data visualization Supports unstructured text-based data Used to get topic, sentiment, intent, keywords, etc. Also used for automatically tagging business data visualizing actionable communication with business customers providing insights and trends. Provides simplified processes for text classification and extraction

TABLE 1.3 No-Code AI Tools and their Usage

Tool	Description	Tool	Description
Google AutoML	Trains high-quality models specific to business needs AutoML Image for image annotation & labelling AutoML Video for video annotation & labelling. AutoML Text for semantic analysis & text classification	**Monkey Learn**	Performs text analysis Facilitates data visualization Supports unstructured text-based data Used to get topic, sentiment, intent, keywords, etc. Also used for automatically tagging business data visualizing actionable communication with business customers providing insights & trends. Provides simplified processes for text classification as well as extraction
IBM Watson	Helps in model creation, training, & deployment, without any serious integration features	**Noogata**	Predictive analytics tool Helps to customize your model Used for making data-driven decisions
Clarifai	An NLP & Computer Vision tool Modelling unstructured data for the entire AI lifecycle Offers image, video & text recognition solutions	**Causaly**	Same as causal AI field, but is focused on finding causal relationships in biomedical science research Uses machine learning to analyze over 30 million papers, clinical trials & side effect databases
Levity	Focuses on image, text & document classification Enables users to train custom models on their use-case-specific data automatically learn from user interactions Easily integrates with all the tools	**PredictNow.ai**	A vertical specific no-code AI solution focused on financial machine learning Computes the probability of profit for your next investment
Lobe	Free, private desktop application by Microsoft Used for image classification, with object detection, & data classification coming soon	**Aito**	Performs predictive analytics & NLP automation Has a simple UI Furnished with APIs that integrate well with many automation platforms Focus on tabular datasets Offers automated re-training system

	Has pre-trained solutions (e.g., offers emotional reactions to enable the program to react to different expressions) Allows people to send emoji reactions using just their faces		Usually designed for sales, marketing & financial activities
Accern	Functions for credit risk, ESG investing, quantitative research, financial crimes analysis, etc. For all applications involving heavy-duty finance needs	**Runway ML**	Made for creators & creatives, with features for image, video & text data Allow users to create synthetic images & videos, cut objects out of videos & more
Nanonets	Used in the domain of Computer Vision Used to build an ID card verification model for any country, format or language	**MLJar**	Highly focused on modelling, automating feature engineering, algorithm selection, documentation & explanations
Evisort	Embeds AI into contract management software Helps businesses automate the contract management process, from data extraction to analysis & approvals Uses AI to underst& the contents of contracts, as well as to identify risks & opportunities	**Kinetix**	Uses no-code AI to create high-quality 3D animations Users provide any video, which gets converted into 3D animated avatars In the Web3 world, these avatars can then be used for a variety of purposes, such as in video games, social media or even as customer service agents
Obviously AI	Uses NLP processing to perform tasks on user-specific text data. Drags & drop CSV file or integrate with HubSpot, Salesforce, or MySQL for getting predictions Performs tasks like forecasting company revenue, optimizing supply chain, personalizing marketing campaigns, etc.	**Loris**	Provides conversational AI software to help human agents make customer support more human Help businesses automate customer support tasks with a high-touch, human experience Crafts real-time suggested responses based on the customer's tone & sentiment
Prevision	Increases the productivity of data science projects Focused on AI modelling Users can upload data, train the model, analyse performance & then get predictions	**Webio**	Allows businesses to quickly use conversational AI Integrates with SMS, WhatsApp & other channels, to allow
Primer	NLP model builder Powerful integrations with other tools Offers pre-trained models that are ready to be used Offers features to visualize your model performance in one go	**Neptune Software**	Uses AI-augmented workflow to support users in creating apps, either from scratch or from a library of customizable templates & components
Apteo	Helps to make more repeat sales Analyses customer database to find out which products certain customers are likely to buy next Using this information, crafts better messages for more accurate targeted upselling It integrates with ecommerce tools like Shopify, Stripe & Square	**Dataiku**	Supports visual AutoML functionality More focused on general data science tasks like data integration, building data pipelines, data visualizations & statistical analysis Provides users with a drag-&-drop interface for more advanced users, Dataiku also provides the ability to code in Python & R. within the platform Offers a wide range of tools for data preparation, machine learning & deployment For data preparation, Dataiku offers an interface for ETL tasks like data cleaning, transformation & enrichment
causa Lens	Finds cause-&-effect relationships in data Uses an innovative approach to AutoML	**Crowd AI**	Uses Computer Vision for both images & video Used for applications like vegetation management or disaster responses

1.10.2 Future of No Code AI

Businesses are steadily moving towards no-code platforms. Research shows that by 2024, nearly 65% of application development will be done through either through low-code or no-code platforms. And, no code AI will play a big role in this. Some advantages of these tools are as follows.

1. No-code AI is a code-free technology. Google AutoML is the no-code AI solution that provides a feature-rich suite of AI products that helps to train highquality ML models tailored to unique business needs.

2. It facilitates non-AI experts also to implement and test their ideas without any help of AI experts
3. AI experts can create ML solutions in less time using minimum efforts.
4. It supports collaboration between AI experts and domain experts.
5. It has drag-and-drop or wizard-based interface to build Applications
6. It helps to solve problems with improved productivity and efficiency.

All in all, no code AI ensures that **AI technology can be adopted by everyone and everywhere.**

1.10.3 Why No-Code AI Must be Used?

No code AI (refer Fig. 1.19) will become more important as it solves the following problems.

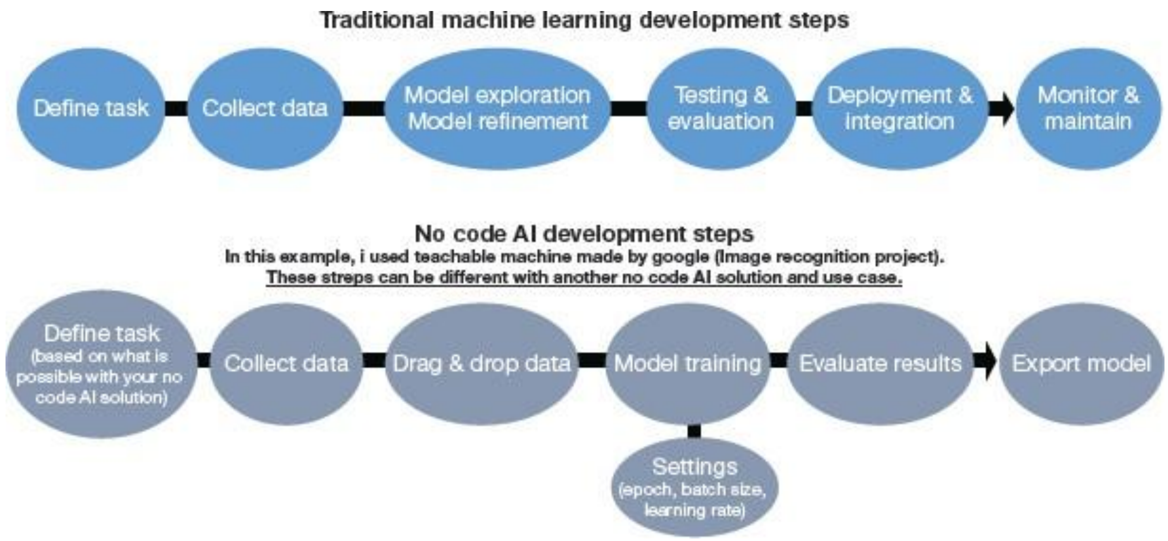

FIGURE 1.19 Steps in a Traditional ML Model Development and in a No-Code AI Model Development

Gap Between AI Experts and Domain Experts

Every year, more and more companies are adopting AI technology. There is a huge gap between AI experts and domain experts. They rarely understand terminology used by others. While AI experts talks using terms of machine learning (ML) models and optimization algorithms, domain experts, on the other hand, use only business-specific words to **solve their problems**. This gap is critical to the success of AI initiatives. Many projects fail due to lack of understanding. In such a scenario, no-code AI platforms allow domain experts to test their ideas and communicate their issues with AI experts in a better way. At the same time, these tools also help AI experts to add value for the domain experts in less time with less effort. We can categorize no-code AI platforms based on the type of interface: drag-and-drop or wizard-based.

Limited AI Experts and More Problems

We know that many problems can be solved fully or partially using AI technology. But to solve them, we need AI experts. These experts are still less in number and charge a heavy fee. So, here, domain experts can run their experiments and get AI solutions using No-code AI platforms.

Steve Jobs said, 'the line of code that's the fastest to write, that never breaks, that doesn't need maintenance, is the line you never had to write.'

It is interesting to note that only 0.25% population of the world can do coding but anyone can be taught to quickly and easily use no-code tools.

1.11 Low Code AI

The use of no-code as well as low-code platforms is constantly on the rise. Today, the growing demand for AI solutions in business applications has paved the way for low-code and nocode AI tools. These tools give companies the flexibility and agility to create new applications.00:00

Low-code is a software development technique that was introduced in 2011 to promote application development in less time with little to no coding required. For this, it supports visual development of applications using intuitive modeling with a graphical user interface (GUI).

Low-code development platforms are based on the concepts of model-driven design, automatic code generation and visual programming. These platforms provide integrated tools to eliminate the need to write code line-by-line. When working on these platforms, the user draws flowcharts in a visual editor, and the code is produced automatically. Users can even create software applications by dragging and dropping pre-defined components. Today, some of the most popular low-code software platforms that are used by both programmers and non-programmers are Mendix, Outsystems, Creatio, Appian and Creator.

According to Gartner, the demand for information systems will increase five times faster than IT departments' ability to provide them because the number of employees is not growing at a sufficient pace. Lower the difficulty level of application development processes, broader is the audience. Low-code solutions not only enables fast delivery of applications with minimum effort but also ensure least possible effort for the installation and configuration of environments, training and implementation. Apart from other reasons, low-code AI is also preferred as it provides built-in security and maintenance, saving costs and time. It also lowers development risks at a high return on investment. The key differences between traditional and low-code development are given in Table 1.4.

TABLE 1.4 Differences between traditional and low-code development

Feature	Traditional Tool	Low-Code
Time to market	Slow to launch, and is slow to change	Quick to launch
Uses	Manual coding	Drag and drop design, pre-built components
Scope	Planned and developed as large, complex projects	Small and independent solutions
Development	Difficult to align to business demands and has slow turnaround times	Allows up to 5x quicker building, efficient testing, and higher ROI.
Maintenance	Requires additional development and involves expensive support	Development enables easy and quick updating or extending of the solution. This makes it excellent for prototyping
Integration	Software integrations are time and investment-intensive, documentation is required, as well as extensive testing phases	Offers pre-built connectors live debugging and creating web services with no coding
Deployment	Slow and complex; it requires multiple steps and development resources	offers one-touch deployment, an application is sent to production in just a single click
Low-risk/ high ROI	High risk is involved	robust security measures, data integration and cross-platform support are already built-in and can be easily customized

1.11.1 Low-Code vs No-Code AI Development

Low code development requires very less or minimal programming effort from the user, whereas no-code software does not require any programming at all. Though both low-code and no-code use building blocks to create applications, low-code facilitates the integration of custom software in the form of such building blocks.

1.11.2 Who Uses Low-Code Development?

Low-code development is beneficial for different types of users to speed up their projects and simplify the deployment process. Low-code AI platforms enable rapid development, testing and scaling of apps. In this section, we will discuss who use these platforms and for what purpose.

Low-Code for AI Beginners

Low-code and no-code AI platforms make AI technologies more accessible to technical and non-technical users. Businesses no longer need to hire a full-time AI developer. These platforms have made it much easier for beginners to get started with AI technologies.

Low-Code for Developers

Low-code platforms help AI developers (like Computer Vision Engineer) to develop AI applications, add their own custom software or AI models as integrations to the platform. This helps programmers and researchers to spend less time on repetitive coding tasks, write less code and focus resources on enhancing and optimizing the functionality of the application.

Low-Code for Researchers

Researchers can use low-code platforms to quickly develop prototypes, speed up their experiments and test each change without the need to invest in expensive infrastructure. Moreover, they can easily compare different approaches and benchmark multiple versions.

1.11.3 Low-Code AI Platform for Computer Vision

A low-code AI platform for automating computer vision applications is a difficult task. Lot of research is done in this area to overcome the challenges and technological problems. The latest AI low-code platform, specifically designed for computer vision applications is, viso.ai.

viso.ai is used to create custom computer vision and deep learning applications that process video feeds of numerous cameras in real-time with deployed AI algorithms. Using finetuned, pre-trained AI algorithms and pre-built modules in a visual editor, viso.ai quickly creates a custom AI vision solution. The platform continuously optimizes AI applications to achieve progressively better results.

1.11.4 Components of Low-Code AI Platforms

A low-code AI platform includes the following elements:

Graphical User Interface (GUI)

An intuitive GUI with clear visual elements can be easily used non-technical users to construct AI vision applications. The purpose and usage of the element must be easily understandable by the users.

Pre-Built Integrations

The AI vision application may use visual input of cameras and some pre-trained AI models, so these functionalities are available as ready to use building-blocks to the user. Pre-built integrations of modules that ensures secure data storage and communication are available with these platforms.

Application Manager

Developing an application with a low-code AI platform is just one portion of the software development process. The application needs testing, deployment and maintenance on a regular basis. For this, the platform offers tools to update code, remove bugs and improve its functionality and performance.

1.11.5 Disadvantages of Low-Code/No-Code Platforms

Though no-code/low-code AI platforms sounds interesting to use, there are some concerns which should be addressed before taking the final call in selecting a platform.

Security

Some platforms may not be able to design access protocols. In such a case, security may be compromised and this is a serious concern for many companies where security is at the utmost priority. Therefore, it is crucial to read, research and clearly understand the terms and conditions to interpret where and how data will be used.

Lack of Customization

Low-code/no-code platforms offer limited functionality as they are specifically designed to solve a particular problem.

Requires Consultation or Training

All users, technical or non-technical, must be able to use the low-code/no-code platforms. But usually, it is used by an ML engineer who also need lot of training and consultations to guide other team members to solve problems using AI.

Lack of Trust

According to Google Trends, the interest in no code ML is increasing but people interested in traditional ML are far ahead. Support for libraries for ML and computer vision are much more than low-code/no-code AI platforms.

Lock-In Strategy

Considerable amount of switching cost is involved while moving from one vendor to another. Thus, most of the times, a user is entirely dependent on a particular software vendor. **Limitations on Personalization**

Some no-code and low-code solutions do not allow users to change certain parameters.

Data Management

Even while using no-code solutions, businesses may have to rely on the expertise of data scientists and data engineers for data processing tasks.

Scalability

As of now, creating scalable solutions for solving complex problems using a no-code machine learning platform is far from reality.

1.11.6 is Low-Code the Future of Software Development?

Low-code AI solutions are having a deep impact on the overall market right now, and its use is quickly expanding. For example, if you want to enhance your existing application, then either you can use a coding language such as Python or a lowcode/no-code (LCNC) framework that has pre-designed and tested code blocks that can be instantly incorporated to use its functionality.

The forecast about the use of low-code/no-code development platforms follow a strongly positive curve. By the end of 2024, it is expected that more than 65% of applications will be developed using the low-code/no-code development approach. Also, more than 75% of large enterprises will be using at least four low-code/no-code development tools.

The demand for low-code/no-coding development platforms has increased tremendously and the worldwide low-code development technologies market is estimated to be $65 billion market cap by 2026. Businesses will benefit from low-code/nocode AI platforms in more data-driven sectors, such as marketing, sales, and finance. AI can help in predicting churn rates, analyzing reports, adding smart suggestions, automating invoicing and for lot more applications.

By 2030, the low-code development platform is expected to generate a revenue of $187 billion. As compared to no-code tools, low-code platforms provide a better scope of customization as per business requirements.

Chatgpt (Chat Generating Pre-Training)

ChatGPT is a language-generation software that can easily converse with people. For this, it answers follow-up questions, rejects inappropriate queries and even admits its mistakes (Source: OpenAI summary of the language model). To perform its task, ChatGPT has been extensively trained on an enormous amount of text data.

Using NLP techniques, training data and crawling the web to study archived books and Wikipedia, ChatGPT can recognize patterns to create text that mimics various writing styles. Some features of this amazing tool are as follows.

1. Facilitates communication in conversational format.
2. Uses Reinforcement learning techniques to respond more accurately and dynamically.

ChatGPT is developed by OpenAI using GPT-3.5 language.

We know that reinforcement learning learns by rewards and punishments received. In case of ChatGPT, a question is asked from the software. Then, a number of answers are sampled which are later manually ranked by humans. In fact, these ranks serve as training data for the reward model. The output of the reward model is then improved by further training a finetuned language model using reinforcement learning to react to queries. Therefore, human feedback plays a crucial role in the success of deploying this software.

Once trained, ChatGPT can respond to follow-up inquiries, acknowledge its errors, refute false assumptions and refuse unsuitable proposals.

Besides conversing, ChatGPT can respond to all types of writing, including theoretical essays, mathematical solutions and stories.

The underlying technique of ChatGPT can also alter how people use search engines by delivering answers to complex problems.

ChatGPT is a good debugging tool and can also fix the bug when you are asking a question.

ChatGPT is still in the research review stage. But still users can sign up and test it out for free.

Did you know that as soon as Elon Musk learned that OpenAI was using Twitter's database to train ChatGPT, he immediately stopped it from doing so because OpenAI is no longer opensourced and non-profit, and it should eventually pay for this knowledge.

Chat GPT-3 be used to create more complex chatbots. Those chatbots can provide detailed information or perform difficult tasks like book flights, order food, automate simple tasks (like scheduling meetings, tracking appointments), notify about upcoming events, find local businesses, give personalized recommendations and advice based on preferences. Imagine a fitness freak person getting healthy recipes and exercise routines for a chatbot.

Big Concern: Human Replacement

Most significantly, ChatGPT has demonstrated the ability to build complex Python code and compose college-level essays. This has raised concerns that such technologies may eventually replace human workers like journalists or programmers.

Limitations

1. Chatbot is not a new thing. Several companies including Microsoft have developed them but did not get much success. We have read that in less than 24 hours, Twitter users taught Microsoft's Tay bot misogynistic and racist language. Meta released BlenderBot 3 which also disseminated racial, antisemitic and misleading information, including the assertion that Donald Trump won the 2020 presidential elections.
2. To prevent these kinds of incidents, OpenAI used a Moderation API (an AI-based moderation system) that notifies when language violates the company's content policy to stay away from communicating harmful or unlawful content. However, its moderation still has issues and is not perfect.

3. Like any other AI tool, ChatGPT is only as good as the data it is trained on. If the training data contains biases or inaccuracies, the model may reproduce these biases in its outputs.
4. ChatGPT sometimes write nonsensical answers and fixing this issue is challenging because there may be no source of truth and building more restrictions may result in declining questions that it can answer correctly.
5. ChatGPT gives different results when the questions are either slightly rephrased or asked multiple times.
6. Text generated by ChatGPT excessively uses certain phrases especially when trainers want longer answers that look more comprehensive.
7. Ideally, ChatGPT should ask clarifying questions when the user asks ambiguous queries but instead, it gives answers by guessing what the user intended.
8. Attempts were made to make ChatGPT refuse inappropriate requests, but it sometimes respond to harmful instructions or exhibit biased behaviour.
9. ChatGPT writes long paragraphs, poems, stories, etc. but it has not mastered the art of creative style, so its output has not yet topped bestseller lists. However, the program does write good bedtime stories for kids. But models like ChatGPT can never replace children's books that have been traditionally published.

Conclusion: Chat GPT is a powerful and versatile NLP tool that has the potential to revolutionize the way humans interact with machines.

Wishing you and everyone in your family a very healthy, wealthy, happy and prosperous 2023. Stay abundantly blessed always.

Review Questions

What is meant by No-Code AI?

Name any two applications that can be built using no-code tools.

Why is No-Code AI useful for businesses? Give one reason.

What is the difference between low-code and no-code development?

Who can benefit from low-code AI platforms?

Mention one disadvantage of using low-code/no-code platforms.

What is the purpose of a GUI in a low-code AI platform?

Name one popular no-code or low-code AI platform mentioned in the notes.

L4 Industrial Applications of AI: Application of AI in Healthcare,

Industrial Applications of AI

In the last two chapters, we have been introduced to the basic concepts of AI, the different constituents (or sub-areas) that it has and also how the concepts have evolved over the past few decades. We have also briefly touched upon the industrial applications of AI, highlighting a few quick points of enablement in these areas. However, to appreciate the fact that AI has a significant impact in solving complex problems in different industries, a deep dive into some of the industries is needed. Only then, looking at a few salient use cases, we can appreciate the fact that AI is absolutely essential to solve a few of these problems. In this chapter, we will delve into the applications of AI in industries and see how this technology is not just a futuristic concept but a present reality that is fundamentally changing the landscape of commerce, healthcare, finance, manufacturing and beyond. Across diverse industry sectors, some of which are shown in Fig. 3.1, AI applications are reshaping the way businesses operate, solve problems, and interact with their stakeholders. By combining computing capabilities with AI algorithms, we are witnessing a new era of efficiency, innovation, and adaptability.

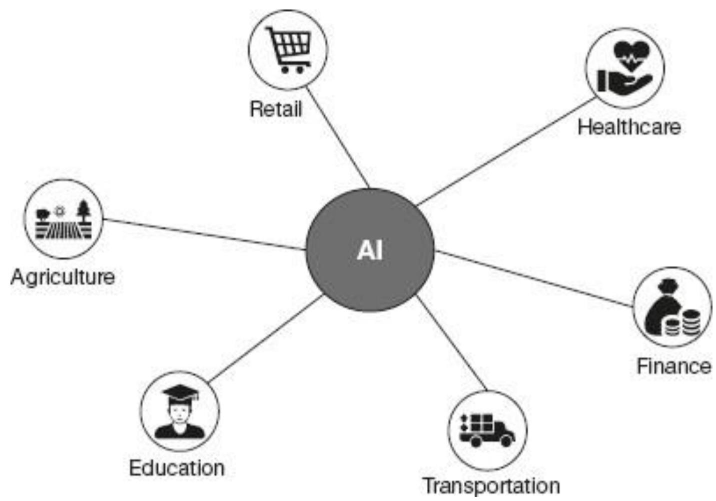

Figure 3.1 Applications of AI in Industry

In the realm of e-commerce specifically, AI has become a tool for enhancing customer experience by streamlining operations and predicting market trends. E-commerce platforms use AI algorithms to analyse consumer behaviour patterns and anticipate preferences to offer recommendations. Virtual assistants equipped with natural language processing capabilities provide customer interactions by handling queries and facilitating purchases. Moreover, AI-powered chatbots play a role in customer service by promptly addressing inquiries and ultimately improving overall satisfaction. The integration of AI into commerce not only optimizes business processes, it also creates an intuitive and responsive environment for consumers. The healthcare industry is at the forefront of incorporating AI technology, which has brought about changes in diagnostics, treatment plans and patient care. AI algorithms are now able to analyse large amounts of medical images enabling fast diagnoses for conditions ranging from cancer to neurological disorders. In this sector, AI has become a game changer by providing insights, risk assessments and operational efficiency. As we explore the applications of AI across industries, it becomes clear that its transformative power extends beyond specific sectors. The combination of data analytics, machine learning and intelligent automation is reshaping how businesses operate by challenging traditional models and emphasizing adaptability and innovation. In the following sections, we will delve deeper into examples and case studies that highlight the impact of AI in each industry while shedding light on what lies in this era of unprecedented technological advancement.

3.1 APPLICATION OF AI IN HEALTHCARE

In recent years, the healthcare sector has embraced Artificial Intelligence (AI) leading to an era characterized by innovation and improved efficiency. The integration of AI into healthcare practices is revolutionizing how medical professionals diagnose, treat and manage conditions with a focus on enhancing patient outcomes. The widespread adoption of AI in the healthcare sector is driven by several factors.

1. The healthcare industry generates an abundance of data including images, patient histories and prescriptions. This data intensive nature of healthcare industry makes it necessary to use automation to analyse and draw insights from this information.
2. Healthcare data has high variability complexity. It is also extremely intense a manual process to analyse and infer from medical data. So, automation is really needed to complement manual analysis.

This section delves into the multifaceted applications of AI in healthcare, highlighting its role in diagnostics, personalized medicine, administrative tasks and patient care.

3.1.1 Role of AI in Medical Diagnosis

One specific area where AI has made significant contributions is diagnosis. By employing machine learning algorithms, AI has transformed the way diagnoses are made in healthcare. These algorithms have proven their capabilities in analyzing datasets, interpreting images and identifying subtle patterns that aid traditional diagnostic methods. Following are some of the areas of applications of AI in medical diagnosis.

1. **Radiology & Imaging**
2. **Retinal Imaging & Disease Detection**
3. **Pathology & Histopathology**
4. **Dermatology & Skin Conditions**
5. **Cardiology & ECG Analysis**

Radiology and Imaging

AI has made advancements in the field of radiology and medical imaging. By training machine learning models on large collections of images, AI algorithms have exhibited exceptional abilities to detect anomalies and identify patterns associated with various diseases. Overall, AI's role, in healthcare extends beyond diagnostics to include medicine, administrative tasks and patient care. In the case of breast cancer, for example, AI-powered analysis of mammograms has shown high sensitivity and specificity helping radiologists detect it early and accurately. Moreover, AI algorithms are used in the examination of X-rays, MRIs and CT scans (as resembled in Fig. 3.3) to not only speed up the process, but also enhance overall precision.

Retinal Imaging and Disease Detection

Moving on to retinal imaging and disease detection, AI can play a role in early identification of diseases like diabetic retinopathy and age-related macular degeneration (AMD). By analysing scans, AI algorithms can detect changes that indicate these conditions with a higher level of accuracy than traditional diagnostic methods. Glaucoma diagnosis and management also benefit from AI technology as it is one of the leading causes of blindness. In cataract surgery planning, AI is streamlining processes and improving outcomes by analysing data such as thickness and axial length. AI algorithms also predict the most suitable intraocular lens power for individual patients. This personalized approach enhances the accuracy of cataract surgery outcomes by reducing errors while increasing overall patient satisfaction.

Pathology and Histopathology

In pathology and histopathology, AI is transforming the way that tissue samples and pathology slides are analysed. Automated image recognition algorithms coupled with pattern detection, help pathologists identify abnormalities efficiently while ensuring diagnoses. AI-driven systems in the field of pathology have shown promise in detecting cancer cells, leading to a reduction in incorrect diagnosis and improved efficiency in pathology laboratories.

Dermatology and Skin Conditions

Moving on to dermatology, AI applications offer solutions for diagnosing skin conditions. By using datasets of skin images, AI algorithms can accurately classify various dermatological conditions, including skin cancers. Teledermatology, enabled by AI, allows patients to remotely submit images of their skin lesions for analysis, enabling assessments and interventions. This not only improves accessibility to expertise, but also contributes to early detection and management of skin diseases.

Cardiology and ECG Analysis

In the area of cardiology, AI is making progress in analysing electrocardiograms (ECGs) for the detection of cardiovascular diseases. With the ability to identify patterns and deviations in ECG readings that may indicate conditions like arrhythmias or heart abnormalities, AI algorithms greatly aid accuracy. Additionally, integrating AI into cardiology enables patient monitoring, offering an approach to managing cardiovascular health.

The incorporation of AI into diagnosis opens up opportunities for more accurate, efficient and timely disease detection. The collaboration between AI systems and healthcare professionals is crucial in using the potential of this technology. It can lead to patient outcomes accurate diagnoses and a reimagined approach to medical practices. As artificial intelligence (AI) continues to advance, it is expected to have a role in shaping the future of healthcare. One area where AI can make a difference is in the field of diagnosis enabling precision medicine and personalized patient care.

3.1.2 Role of AI in Early Detection and Disease Prevention

Use of ML algorithms and advanced data analytics empowers healthcare professionals to proactively anticipate, identify and mitigate health risks.

Early Disease Detection & Intervention

Personalized Risk Assessment & Prevention Strategies

Disease Surveillance & Outbreak Prediction

Early Disease Detection and Intervention

One of the primary applications of AI in predictive analytics is the early detection of diseases

By analysing datasets that include health records, genetic information and lifestyle data, AI algorithms can identify patterns that indicate the onset of diseases.

For instance, AI driven predictive analytics can assess a persons risk based on factors like age, genetic pre-disposition and lifestyle choices. Early detection allows healthcare providers to intervene before symptoms appear and disease progression occurs ultimately improving outcomes.

Personalized Risk Assessment and Prevention Strategies

AI's advanced analytics capabilities enable the personalized assessment of risk for individuals. Considering markers such as history and lifestyle choices, AI algorithms can generate customized risk profiles. This valuable information empowers healthcare professionals to develop prevention strategies tailored to the needs of each individual. These strategies may include targeted interventions, lifestyle adjustments and screening protocols.

Moreover, by analysing data related to symptoms, medication adherence and lifestyle behaviours, AI can predict disease aggravations or complications. This foresight allows health-care providers to take measures such as adjusting medications or providing lifestyle recommendations to effectively manage conditions. The result is a patient-centred approach to healthcare that prioritizes prevention than reactive treatment.

Disease Surveillance and Outbreak Prediction

Machine learning models can monitor data sources like travel patterns, climate conditions and social media activity to identify outbreaks of diseases. For example, during the COVID-19 pandemic, AI models were used to track the virus spread and predict areas at risk of outbreaks. This information helped allocate resources and mitigate the impact of diseases on populations through timely responses from public health authorities.

3.1.3 Role of AI in Drug Discovery and Development

By harnessing the power of AI-driven analytics, time consuming processes, various applications of AI in drug discovery etc target identification, compound screening and overall effectiveness throughout the drug development lifecycle have improved. Some of the areas are as below.

Clinical Trial Optimization

Virtual Drug Design

Safety Assessment

Clinical Trial Optimization

AI-driven analytics plays a role in optimizing clinical trials by enhancing patient recruitment, trial design and endpoint prediction. By analysing electronic health records and historical trial information, AI algorithms can identify participants and predict how patients will respond to treatments. This data-driven approach improves the efficiency of trials while reducing costs and timelines. Additionally, AI aids in identifying biomarkers that can serve as indicators for treatment efficacy enabling decision-making during the clinical development process.

Virtual Drug Design

The introduction of AI-driven analytics has brought about groundbreaking advancements in drug design. Virtual screening entails using models to analyse chemical databases and forecast the binding affinity between molecules and specific targets. By employing AI algorithms, potential drug candidates with desired properties can be identified, leading to time and resource savings compared to experimental screening. This approach facilitates the discovery of compounds and repurposing of existing drugs for therapeutic indications thereby maximizing the efficiency of drug development.

Safety Assessment

AI contributes to predictive analytics for drug safety assessment by analysing large datasets to predict potential adverse effects and toxicity of drug candidates. By considering factors such as chemical structure, pharmacokinetics, and biological interactions, AI models can forecast potential safety issues early in the drug development process. This proactive approach enables researchers to prioritize safer compounds, reducing the likelihood of late-stage failures and ensuring that only the most promising candidates progress through the pipeline.

3.1.4 AI-powered Virtual Medical Assistant (VMA)

AI-powered virtual assistants are designed to enhance patient care, streamline processes, and provide valuable health-related information. VMAs have the ability to understand natural language, interpret medical data, and deliver personalized insights.

Patient Engagement and Communication
Medication Management and Adherence
Appointment Scheduling and Administrative Tasks

Patient Engagement and Communication

Virtual Medical Assistants powered by AI, excel in engaging patients through their natural language processing capabilities. Patients can have interactions with these VMAs to seek information about symptoms, medications or treatment plans. The AI algorithms are designed to understand the context enabling context-aware conversations. This not only enhances engagement but also creates a more accessible and user-friendly healthcare experience.

Medication Management and Adherence

AI-equipped VMAs play a role in managing medications by providing medication reminders information on drug interactions and personalized support for adherence. By analysing data, the AI algorithms predict adherence patterns and identify potential obstacles to medication compliance. Through timely interventions, VMAs minimize the risk of adverse events.

Appointment Scheduling and Administrative Tasks

The integration of AI into VMAs extends to streamlining tasks such as appointment scheduling and workflows. Patients can interact with VMAs to conveniently schedule appointments, receive reminders and access information seamlessly. This not only improves the efficiency of healthcare operations, but also enhances the overall patient experience by reducing administrative burdens.

3.1.5 AI-powered Robotics in Healthcare

The convergence of AI and robotics has ushered in an era in healthcare. The collaboration between AI and robotics has had an impact on the medical field. It has brought about advancements in practices leading to more precise surgeries, efficient diagnostics and personalized patient care. Below are some examples of how AI and robotics are being applied in healthcare.

Robotic Surgery and Precision Procedures

Rehabilitation Robotics and Physical Therapy

Robotic-Assisted Personalized Care

Robotic Surgery and Precision Procedures

The integration of AI-driven robotics has revolutionized the field of surgery by offering levels of precision and capabilities. Surgical robots guided by AI algorithms assist surgeons in performing procedures with enhanced accuracy. One notable example is the da Vinci Surgical System, which uses AI to translate surgeon movements into actions resulting in minimally invasive surgeries that lead to quicker recovery times. The use of AI algorithms also enhances real-time decisionmaking during surgeries in procedures like tumour removal and organ transplants.

Rehabilitation Robotics and Physical Therapy

In the realm of rehabilitation, AI-powered robotics play a role in assisting and optimizing therapy for patients recovering from injuries or surgeries. Robotic exoskeletons and rehabilitation devices equipped with AI algorithms adapt to the needs of each individual, providing personalized rehabilitation programs. These robotic systems analyse patient movements, adjust resistance levels accordingly and offer real-time feedback to optimize the recovery process effectively. The application of AI-driven rehabilitation robotics has shown results for patients, especially with neurological disorders or mobility impairments.

Robotic-Assisted Personalized Care

Robotics, combined with AI technology, plays a role in providing patient care. By analysing health data, AI-powered robots can customize treatment plans to suit each patient's needs. These robots can administer medications, monitor vital signs and offer companionship in an adaptive manner. This tailored approach enhances patient comfort, adherence to treatment plans and overall well-being in long-term care situations.

3.1.6 Challenges of AI in Healthcare

The following are areas of concern that must be resolved for the implementation of AI in healthcare.

Data Privacy & Security
Ethical Considerations:
Regulatory Compliance:
Interoperability:

Data Privacy and Security: One major concern revolves around the privacy and security of patient data within AI-driven healthcare systems. Potential risk of breaches or unauthorized access to information is considered a primary threat.

Ethical Considerations: Ensuring the use of AI in decision-making processes is particularly crucial when it comes to areas, like diagnosis and treatment planning. One significant area of focus involves addressing biases in AI algorithms that could lead to disparities in the delivery of healthcare services.

Regulatory Compliance: It is crucial to navigate through frameworks to ensure that AI applications comply with healthcare standards. Adhering to data protection regulations, such as GDPR in Europe, adds layers of complexity.

Interoperability: A major challenge lies in the lack of protocols for data exchange and collaboration between different healthcare systems and AI applications. This hampers the ability to integrate AI-driven tools effectively.

In summary, the integration of Artificial Intelligence, in the healthcare industry is reshaping the ecosystem. AI plays a role in enhancing accuracy and streamlining administrative tasks, ultimately leading to patient-centred care. With advancing technology, the collaboration between AI and healthcare presents the potential for solutions that can improve health benefits and pave the way for care and precision medicine. It is crucial for healthcare professionals, policymakers and the wider community to embrace and fully leverage AI's power to unlock its potential for promoting healthcare.

Review Qns

How does AI help in medical diagnosis?

What is one way AI supports early detection and disease prevention?

Name one challenge of using AI in healthcare.

L5 Application of AI in Finance, Retail

3.2 APPLICATION OF AI IN FINANCE

Finance sector has benefitted from the introduction of algorithms and advanced analytics, enhance decision-making capabilities and improve customer experiences. One notable area where AI excels is algorithmic trading. Through models that leverage data and market trends, high speed trades can be executed efficiently leading to an increase in analysis driven strategies like high frequency trading. Furthermore, risk management has greatly benefited from AI implementations. Credit scoring and fraud detection have witnessed improvements with the assistance of AI models analysing datasets that include transaction history as well as social media activity have enabled real-time evaluation of creditworthiness while identifying any anomalies that may pose risks—providing institutions with robust defences against such risks. AI has greatly improved customer service. Virtual assistants and chatbots have completely transformed support systems by offering help and automated tasks. This ultimately enhances the experience, for customers. AI-powered robo-advisors have made personalized banking and financial planning more accessible providing customized investment advice and portfolio management based on preferences and financial goals. The analysis of datasets using algorithms, ensures adherence to regulations benefiting processes like antimoney laundering (AML) and know-your-customer (KYC). The integration of AI in the finance sector also addresses concerns regarding data security. Advanced algorithms are leveraged for real-time detection and prevention of cyber threats. However, it is crucial to consider regulatory and privacy aspects.

1 AI in Algorithmic Trading	***2 AI in Financial Risk Management***	***3 AI-based Customer Service***
Historical Data Analysis	Credit Scoring and Underwriting	Chatbots
High-Frequency Trading (HFT)	Fraud Detection	Robo-advisors
Risk Management	Compliance and Regulatory Risk	Personalized Financial Planning
Adaptive Trading Strategies		

3.2.1 AI in Algorithmic Trading

Algorithmic trading, also known as algo trading or automated trading, trading involves using computer algorithms to execute trading strategies with speed and efficiency. AI plays a role in this domain by providing analytical capabilities and automation features. Here are some key aspects related to AI-enabled trading.

Historical Data Analysis

AI algorithms analyse large amounts of market data such as price movements, trading volumes and other relevant indicators. This analysis helps to identify patterns and trends that human traders might not easily notice. Machine learning techniques are used by AI models to predict market movements based on data. By understanding these patterns AI can provide insights for decision making in trading. Additionally, AI-powered algorithms can analyse news articles, social media and other sources to gauge market sentiment. This allows for adjustments in trading strategies to capitalize on market sentiment.

High-Frequency Trading (HFT)

AI enables algorithms to execute trades, such as buying and selling quantities of stocks and shares at high speeds sometimes within microseconds or milliseconds. This is particularly vital in high frequency trading since swift order execution is crucial for taking advantage of price differences. AI algorithms optimize trade routing to reduce latency ensuring that trades are executed as swiftly as possible.

Risk Management

AI algorithms continuously assess risk factors and adjust trading parameters to minimize potential losses. This includes monitoring market volatility, liquidity levels and other indicators of risk. With the help of AI-powered algorithms, stop loss orders can be automatically triggered when predefined risk thresholds are reached—thus reducing the impact of market movements.

Adaptive Trading Strategies

AI algorithms have the ability to adapt and evolve based on changing market dynamics. By continuously learning from new data, algorithms remain relevant and effective in various market conditions. AI also enables the simulation of trading strategies using data to evaluate their performance. This assists in refining strategies before implementing them in real market situations. It can learn from both successful and unsuccessful attempts, improving strategies over time to enhance performance.

In summary, AI enhances trading by using data analysis, machine learning and automation. Its ability to process bulk amounts of data to adapt with changing market conditions and execute trades quickly, makes AI a powerful tool.

3.2.2 AI in Financial Risk Management

AI significantly enhances risk management by providing tools and capabilities for analysing, predicting and mitigating various types of risks. The application of AI in financial risk management is broad and covers different areas. Some key areas are described below.

Credit Scoring and Underwriting

AI models analyse datasets that include credit information as well as alternative sources like social media and transaction history to assess the creditworthiness of individuals and businesses. Based on these algorithms the credit underwriting process is automated, enabling real time decisions on loan approvals based on an evaluation of risk factors.

Fraud Detection

AI uses machine learning algorithms to identify patterns and anomalies in transactions aiding in the detection of potentially fraudulent activities. By analysing data and user behaviour, AI can establish patterns enabling the identification of deviations that may indicate fraudulent activities. AI-based fraud detection systems can operate continuously, monitoring transactions and user activities as they occur.

Compliance and Regulatory Risk

AI automates processes such as Anti Money Laundering (AML) and Know Your Customer (KYC) by analysing vast amounts of data ensuring adherence to regulatory requirements. Additionally, AI helps financial institutions stay aligned on changes by analysing and adapting policies to ensure compliance. The benefits of adopting AI-powered risk management solutions are as follows:

- Faster detection and response to fraudulent transactions
- Enhanced accuracy and reduced False Positives
- Increased flexibility and agility through the ability to adapt to new and evolving risks
- Cost Savings due to minimized human intervention required

3.2.3 AI-based Customer Service

Chatbots

AI-powered chatbots and virtual assistants offer personalized customer support by addressing inquiries and handling tasks, thereby enhancing customer experience. AI has revolutionized customer interactions by using natural language processing (NLP) to automate communication. This makes it easier for customers to access information and carry out transactions.

Robo-advisors

Robo-advisors powered by AI offer personalized investment advice, portfolio management and financial planning services. These advisors analyze customer data and preferences to tailor their recommendations. By understanding customer behavior and data they can predict financial needs and provide tailored products and services.

Personalized Financial Planning

AI considers individual goals, such as retirement planning, education funding, or saving for a home, to tailor investment strategies to specific objectives. Recommendations are adjusted based on life events like job changes, marriages, or the birth of a child to align with changing financial priorities. When it comes to personalized financial planning, AI considers goals like retirement planning, education funding or saving for a home. Investment strategies are customized based on objectives. Additionally, recommendations are adjusted as life events such as job changes, marriages or the birth of a child occur, aligning with changing priorities.

3.2.4 Challenges in Application of AI in Finance

Some of the challenges associated with the integration of AI in finance are presented below.

1. **Handling Sensitive Information & Adversarial Attacks:**
2. **Regulatory Compliance:**

3. **Overreliance on Historical Data:**
4. **Ethical Concerns:**
5. **Complexity of Models &Interpretability:**
6. **Operational Risks:**
7. **Market Manipulation**

Handling Sensitive Information and Adversarial Attacks: One major challenge is handling information, especially protecting them against adversarial attacks, since the finance industry deals with highly confidential personal and financial data. It is crucial for AI systems to have security measures in place to prevent data breaches or unauthorized access. AI models can be susceptible to attacks where malicious individuals manipulate input data to deceive the system and produce predictions or decisions.

Regulatory Compliance: In the finance industry, there are regulations in place. However, keeping up with evolving frameworks and complying with existing regulations can be a challenge for AI applications. This is especially true as regulations may not have kept pace with advancements.

Overreliance on Historical Data: One issue that arises when using AI models trained on data is their reliance on it. These models may struggleto adapt to shifts in market conditions or unforeseen events like crises or global pandemics. Financial markets are dynamic and ever-changing which can pose difficulties for models that were primarily trained on historical data.

Ethical Concerns: Ethical concerns also come into play when using AI algorithms. These algorithms have the potential to inherit biases from the training data leading to discriminatory outcomes. It is crucial to make efforts to address bias within algorithms to ensure fair treatment across demographics. Additionally, lack of transparency in how AI models make decisions can undermine trust from users and hinder regulatory compliance. Therefore, it is important to understand and explain how these models arrive at decisions.

Complexity of Models and Interpretability: Interpreting AI models, such as deep neural networks, can be complex and challenging due to their intricate nature. Lack of explainability can hinder comprehension, making it challenging to clarify model decisions to stakeholders including regulators and customers. Institutions are responsible for the outcomes of AI-based applications.

Operational Risks: Mistakes in algorithms or unforeseen behaviour can result in financial losses. To minimize the risk of failures, it is essential to implement safe measures and conduct thorough testing procedures. Additionally, relying heavily on AI systems introduces risks like system outages or technical malfunctions that can disrupt services and operations.

Market Manipulation: AI algorithms may be vulnerable to manipulation or exploitation by traders who aim to exploit the system for financial gain. This could potentially lead to market manipulation.

Addressing these challenges necessitates an approach that encompasses ethical considerations, ongoing monitoring, adaptation of regulatory collaboration, as well as a commitment to transparency and fairness in applying AI within the finance industry.

3.3 APPLICATION OF AI IN RETAIL

Retailers use AI for demand forecasting and inventory management, leveraging analytics to optimize stock levels and dynamically adjust inventory. Personalization is a focus as AI-driven recommendation engines tailor product suggestions based on customer behaviour and preferences. AI has greatly enhanced search (Fig. 3.11) and try-on experiences. This means that customers can now search for products using images and even virtually try them on. Furthermore, AI can optimize supply chains and through maintenance and route optimization businesses further costs and time can be cut.

Figure 3.11 AI in Retail Industry

AI-driven chatbots and virtual assistants offer instant support for order tracking and personalized assistance increasing customer engagement.. Retailers can use AI-powered dynamic pricing algorithms to adjust prices based on market conditions and demand. Analytics tools driven by AI analyse customer behaviour and provide insights for making informed decisions.

1 Inventory and Store Layout Management	2 Personalized Shopping Experience	3 Customer Support
Dynamic Inventory Optimization	Personalized Recommendation	Chatbots and Virtual Assistants
Supply Chain Optimization	Visual Search and Virtual Try-On	Voice-Activated Shopping
Smart Store Layouts and Shelf Management	Customer Insights and Analytics	Fraud Protection

3.3.1 Inventory and Store Layout Management

Dynamic Inventory Optimization

AI assists in dynamically adjusting inventory levels based on real-time data to prevent overstocking or stockouts (representative image in Fig. 3.12). Retailers rely on AI-powered algorithms that analyse data, seasonal trends and external factors to accurately predict demand.

Supply Chain Optimization

AI improves logistics and distribution processes by optimizing delivery routes for cost-effective and timely shipments. Furthermore, AI plays a role in enhancing the efficiency of supply chain operations by providing realtime insights and analytics for well-informed decision-making. These advancements not only streamline processes, they also contribute to building a resilient and agile supply chain enabling retailers to quickly adapt to market fluctuations and effectively meet customer expectations.

Figure 3.12 AI in Inventory and Store Management

Smart Store Layouts and Shelf Management

In terms of store management, AI-powered sensors and cameras analyse customer movement within the store to gain insights into areas. This helps to optimize store layouts for customer flow. Additionally, AI assists in managing inventory on shelves by ensuring that products are stocked according to demand and popularity.

3.3.2 Personalized Shopping Experience

Personalized Recommendation

To offer a shopping experience, AI-driven recommendation engines analyze customer behaviour purchase history and preferences. This analysis allows for product suggestions leading to increased customer engagement and sales. Furthermore, retailers can leverage AI to create targeted marketing campaigns by segmenting customers based on their preferences and behaviours.

Figure 3.13 AI Enabling Interactive Retail

Visual Search and Virtual Try-On

AI also brings value through search capabilities that enable customers to search for products using images. This enhances user experience and simplifies the product discovery process. Additionally, AI-powered augmented reality applications allow customers to virtually try on clothing items, accessories (refer to Fig. 3.13) or even makeup when shopping online. This feature enhances the online shopping experience while reducing return rates.

Customer Insights and Analytics

In the industry, AI tools play a role, in analysing customer behaviour both online and in-store. They provide insights into customer preferences buying patterns and emerging trends empowering retailers to make business decisions. By examining media, fashion blogs and other sources AI can even predict trends and help retailers stay ahead in the competitive market.

3.3.3 Customer Support

Chatbots and Virtual Assistants

When it comes to customer support AI AI-powered chatbots are highly effective. They offer efficient assistance by answering queries helping with product searches and handling routine tasks. This significantly improves customer satisfaction. Additionally, virtual assistants equipped with AI capabilities can provide real-time updates on order status, shipping details and delivery schedules.

Voice-Activated Shopping

Another innovative application of AI in retail is voice-activated shopping. By leveraging AI-driven voice assistants, customers can enjoy a shopping experience. They can effortlessly make purchases. Inquire about product details using language.

Fraud Protection

Fraud protection is another area where AI proves to be invaluable for retailers. Advanced algorithms analyse transaction patterns to detect any anomalies that may indicate activities. This does not safeguard the interests of customers. Also protects retailers from financial losses.

3.3.4 Challenges in Application of AI in Retail

While the application of AI, in the industry offers benefits mentioned above it does come with its own set of challenges that need to be addressed. To effectively tackle these challenges, a well-thought-out and strategic approach is necessary. It involves a combination of technology implementation, adherence to requirements, ethical considerations and organizational preparedness. As the retail industry continues to embrace AI, it becomes crucial to overcome these obstacles in order to fully harness the benefits of AI applications. Here are some of the challenges that need attention:

- **Privacy Concerns:** The use of AI in retail, particularly in customercentric applications, raises privacy concerns. Customers may be hesitant to share personal information, and retailers need to navigate the delicate balance between personalization and respecting privacy.
- **Customer Acceptance:** Customers may have reservations about AIdriven technologies, especially when it comes to tasks traditionally handled by humans, such as customer service. Building trust and ensuring a positive user experience are essential for widespread customer acceptance.
- **Regulatory Compliance:** The evolving landscape of data protection and privacy regulations poses challenges for retailers using AI. Staying compliant with regulations such as GDPR and ensuring responsible AI practices are crucial but can be complex.

The integration of AI in retail is a dynamic process, with continuous advancements contributing to improved efficiency, enhanced customer experiences, and increased competitiveness in the industry. As technology evolves, retailers are likely to explore even more innovative ways to leverage AI for sustainable growth and operational excellence.

Review Questions

How does AI help in algorithmic trading?

What is one way AI is used in financial risk management?

Name one challenge faced when applying AI in finance.

L6 Application of AI in Agriculture , Education,

3.4 APPLICATION OF AI IN AGRICULTURE

The application of AI in agriculture is transforming traditional farming practices and addressing long-standing challenges. Through the integration of advanced technologies such as machine learning, computer vision, and the Internet of Things (IoT), AI has facilitated the emergence of precision agriculture, enabling farmers to make data-driven decisions for optimal crop management. One of the primary applications lies in precision farming, where AI algorithms process real-time data from sensors, satellites, and drones, offering insights into soil conditions, crop health, and weather patterns. This empowers farmers to implement targeted strategies for irrigation, fertilization, and pest control, ultimately enhancing resource efficiency and crop yields.

1 Precision Farming	**2 Crop Monitoring and Management**	**.3 Smart Irrigation Systems**
Sensor Technologies	Automated Weeding and Harvesting	Sensor-based Monitoring

Data Analysis Crop Disease Prediction and Management Automated Irrigation
Climate Prediction
Risk Management

Figure 3.14 AI in Agriculture

AI also helps in crop monitoring and management by using image recognition technologies automating tasks like weeding and harvesting. By providing weather forecasts and assessment models for potential risk and Smart irrigation systems powered by AI optimize water usage by analysing soil moisture levels along with other factor -**It also impacts and influences supply chain optimization, livestock monitoring, market intelligence gathering well, as labour optimization— revolutionizing the entire agricultural ecosystem.**

3.4.1 Precision Farming

Sensor Technologies

Artificial intelligence integrates with sensor technologies such as drones, satellites and IoT devices to gather real-time data pertaining to soil conditions, crop health and weather patterns.

Data Analysis

Sophisticated AI algorithms process datasets to offer farmers insights that enable them to make precise decisions regarding irrigation, fertilization and pest control.

Figure 3.15 AI in Precision Agriculture

3.4.2 Crop Monitoring and Management

AI-powered image recognition tools diligently analyse satellite and drone imagery (refer to Fig. 3.16) to monitor crop growth accurately, identify diseases promptly and evaluate plant health.

Figure 3.16 AI-enabled Crop Management

Automated Weeding and Harvesting

Robotic systems driven by intelligence are equipped with computer vision capabilities that allow them to differentiate between crops and weeds seamlessly. This automation expedites the weeding process significantly. Additionally, harvesting robots use AI technology to identify crops for optimal harvesting.

Crop Disease Prediction and Management

AI models analyse historical and real-time data to predict the probability of disease outbreaks based on conditions and crop health status. Furthermore, drones equipped with AI powered cameras can swiftly detect signs of diseases or pests during their nascent stages - enabling farmers to take preventive measures.

Climate Prediction

AI examines weather data, satellite imagery and atmospheric conditions to provide weather forecasts, both short-term and long-term. This helps farmers plan their activities effectively based on the expected weather conditions.

Risk Management

By employing AI models, farmers can assess risks like weather events in advance. This allows them to take measures to protect their crops and livestock from any harm.

3.4.3 Smart Irrigation Systems

Sensor-based Monitoring

Modern practices leverage AI-enabled sensors installed in the fields to gather data on soil moisture levels, prevailing weather conditions and crop requirements.

Automated Irrigation

Using AI algorithms, gathered data is processed efficiently to optimize irrigation schedules accordingly (refer to Fig. 3.17). This ensures that crops receive an amount of water while minimizing water waste and improving irrigation efficiency.

Figure 3.17 AI-enabled Smart Irrigation System

3.4.4 Challenges in the Application of AI in Agriculture

While the integration of intelligence (AI) in agriculture offers benefits, it also poses several challenges that require careful consideration during implementation. Some key challenges include:

- **Limited Connectivity in Rural Areas:** Many agricultural regions lack robust internet connectivity, which hampers the seamless transmission of data necessary for the effective usation of AI applications. The limited access to high-speed internet can affect real-time functionality of AI systems.
- **Limited Energy Infrastructure:** Many agricultural areas face challenges with consistent access to electricity, internet connectivity and other resources. The successful implementation of AI technologies may face obstacles due to the requirement for a steady power supply, or internet connectivity and other essentials.
- **Trust and Acceptance:** When it comes to trust and acceptance, farmers may have reservations about relying on AI recommendations. This hesitation can stem from concerns regarding transparency or a perceived disconnect between farming knowledge and insights generated by AI. Building trust is crucial for adoption as some farming communities might resist embracing AI due to preferences or a deep-rooted reliance on traditional farming methods.
- **Weather Dependency:** Weather dependency is another factor to consider. Agriculture heavily relies on accurate and timely weather data, which in turn affects the reliability of predictions and recommendations made by AI systems. Variability in weather patterns or sudden changes can impact the effectiveness of these predictions.
- **Dependency on Tech Companies:** As agriculture becomes increasingly reliant on AI, there is a risk of farmers becoming overly dependent on technology providers. This dependency could lead to issues if there are interruptions in service, changes in pricing models or discontinuation of support. The integration of AI into agriculture holds potential for transforming farming practices, boosting productivity and contributing to sustainable agriculture. With advancements, we anticipate

that the role of AI in agriculture will continue to evolve offering even more sophisticated solutions for addressing industry challenges.

3.5 APPLICATION OF AI IN EDUCATION

By introducing learning experiences, improving administrative efficiency and enhancing student support AI istransforming education. Adaptive learning platforms use AI to tailor educational content based on individual student needs, creating a personalized and flexible learning environment. Intelligent tutoring systems provide virtual assistance by customizing teaching methods to suit the progress of students. Automated grading and feedback mechanisms save teachers time while providing insights into student's performance. Additionally, predictive analytics help identify learning challenges at a stage. Virtual classrooms and simulations powered by technologies like Virtual Reality (VR) and Augmented Reality (AR) create learning experiences. Language processing tools such as translation apps and language learning apps contribute to breaking down linguistic barriers.

1 Personalized Learning
Early Intervention Systems
Adaptive Learning Platforms
Intelligent Tutoring Systems

2 Administrative Tasks
Enrolment Management
Attendance Tracking
Automated Grading & Feedback

3 AI-based Language Processing Tools

3.5.1 Personalized Learning

Early Intervention Systems

AI-based analysis of student data helps identify learning difficulties or risks of dropout. This enables the implementation of intervention strategies aimed at providing support to struggling students.

Adaptive Learning Platforms

Adaptive learning platforms powered by AI analyse students' performance and customize content based on their needs. These platforms can suggest personalized learning materials, such as videos, articles and exercises, that align with each student's learning style. This approach enables students to learn at their own pace while receiving support in areas where they require assistance.

Intelligent Tutoring Systems

Tutoring systems driven by AI offer personalized guidance to students by addressing their questions, explaining concepts and providing feedback . These systems adapt their teaching methods based on the progress of each student.

3.5.2 Administrative Tasks

Enrolment Management

AI streamlines tasks like enrolment, scheduling and resource allocation to optimize the efficiency of educational institutions. By analysing large sets of educational data, AI can identify trends, assess institutional performance and contribute to decision-making processes.

Attendance Tracking

Facial recognition systems powered by AI automate attendance tracking, eliminating the need for manual recording. Additionally, AI can enhance campus security by monitoring surveillance footage for any unusual activity or potential threat.

Automated Grading and Feedback

AI algorithms can automate the grading process for assignments, quizzes and examinations—saving teacher's time while providing feedback to students. AI systems can provide personalized feedback by analysing students' work, aiding them in understanding their errors and enhancing their progress.

3.5.3 AI-based Language Processing Tools

AI-powered translation tools have the potential to bridge language barriers and facilitate communication and collaboration among students and educators, from different linguistic backgrounds. AI applications can support language learning by providing feedback on pronunciation, suggesting vocabulary and generating language exercises.

3.5.4 Challenges in Application of AI in Education

The implementation of AI in education comes with challenges that require consideration for responsible and effective use. Some of the key challenges are highlighted below.

- **Ethical Concerns** One significant challenge is ensuring ethical practices. AI systems in education often involve collecting and analysing student data making it crucial to protect privacy through security measures and compliance with data protection regulations. Additionally, there is a concern that AI algorithms may unintentionally reinforce existing biases in systems. It is important to address these issues to ensure fairness in grading and decision-making processes.
- **Teacher Training and Acceptance:** Another challenge lies in gaining acceptance from teachers and educational staff who may be resistant to adopting AI technologies. Convincing stakeholders about the benefits of AI while addressing concerns about job displacement or reduced autonomy can be obstacles to implementation and are key to successful implementation. Furthermore, providing training for teachers to effectively integrate AI tools into their teaching practices is essential.

- **Equity and Access:** We need to be mindful that AI-enhanced tools and technologies should be accessible to all students. The digital divide, which refers to disparities in access to technology and the internet, can widen the educational gap between students from socioeconomic backgrounds.
- **Pedagogical Effectiveness:** While we explore how AI can enhance learning outcomes, it is important that we conduct further research to understand how AI can best support pedagogical goals without replacing essential human elements in education.
- **Standardization of Regulatory and Policy Frameworks:** To ensure a smooth adoption of AI technologies in education, it is necessary to establish standardized regulations and policies that govern their implementation. Inconsistencies in implementation could hinder the use of AI in education.

Review Questions

How does AI help farmers in precision farming?

What is one way AI is used to support personalized learning in education?

Name one challenge of using AI in agriculture or education.

L7 Application of AI in Transportation

3.6 APPLICATION OF AI IN TRANSPORTATION

In the transportation sector, AI helps in improving efficiency, safety and sustainability.

1 Traffic Management and Optimization	2 Ride-Sharing and Mobility Services	3 Safety and Security
Traffic Prediction	Dynamic Pricing	Driver Monitoring
Smart Infrastructure	Surge Pricing	Security Surveillance
Route Optimization	Personalized Recommendations	

Figure 3.20 Application of AI in Transportation

However, integrating AI successfully in transportation comes with its set of challenges. These include regulatory considerations, ethical concerns and the need for upgrading infrastructure. To responsibly deploy AI technologies in the transportation sector it is crucial to ensure the security and privacy of data while establishing regulations. Now let us explore a few use cases that demonstrate how AI can be applied in transportation.

3.6.1 Traffic Management and Optimization

Traffic Prediction

AI algorithms analyse historical and real-time data to forecast traffic patterns accurately. This valuable information can then be used to optimize traffic signal timings, reroute vehicles and alleviate congestion (refer to Fig.3.21).

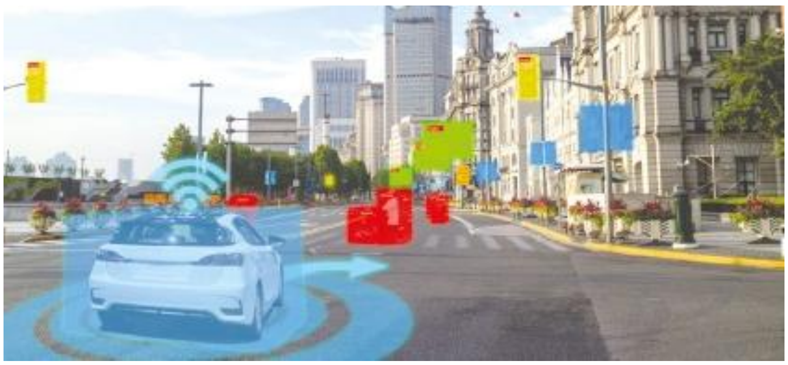

Figure 3.21 Application of AI in Traffic Management and Optimization

Smart Infrastructure

AI can be seamlessly integrated into infrastructure components like roads, bridges and tunnels to enhance safety and efficiency. For instance, smart road signs, adaptive speed limits and automated toll collection are some features made possible through AI technology. Moreover, AI-powered traffic lights dynamically adjust signal timings based on real-time traffic conditions—reducing waiting times for drivers while improving traffic flow.

Route Optimization

Artificial intelligence algorithms analyse factors including passenger demand and traffic conditions to enhance transportation routes. This optimization process aims to improve efficiency and minimize travel times for commuters.

3.6.2 Ride-Sharing and Mobility Services

Dynamic Pricing

Dynamic pricing systems rely on real-time information to assess the demand for services compared to the availability of vehicles or seats. By monitoring these factors, the pricing algorithm can adapt fares accordingly striking a balance between supply and demand. During peak hours of demand, dynamic pricing may result in higher fares as a means of encouraging a more even distribution of demand among users. Conversely, off-peak hours might see lower prices to attract ridership and optimize service capacity. Adverse weather conditions or heavy traffic can lead to increased prices due to increased travel times or greater demand for alternative transportation options. Additionally, events, holidays or festivals can significantly impact transportation demands. Dynamic pricing effectively adjusts fares during occasions to accommodate increased user needs while ensuring that those willing to pay a premium can secure transportation services.

Surge Pricing

In ride-sharing services, surge pricing is a common strategy to adjust prices dynamically. When demand surpasses available drivers, prices can surge to encourage more drivers to join the platform and meet the increased demand.

Personalized Recommendations

One interesting application of AI systems is personalized recommendations for transportation options. These recommendations are based on user preferences, historical data and contextual information. For example, the AI system might suggest a route for a weekend drive or recommend public transportation options for a specific event. Over time the AI algorithm learns from the user's preferences and adjusts its recommendations accordingly.

3.6.3 Safety and Security

Driver Monitoring

When it comes to safety and security in transportation, driver monitoring systems play a role. These systems utilize AI and sensors like cameras and accelerometers to monitor aspects of a driver's behaviour. This includes detecting signs of fatigue, distraction, aggressive driving or impaired driving caused by substances such as alcohol or drugs. By capturing expressions and tracking eye movements through cameras, these systems can detect signs of drowsiness or distraction in drivers. Eye tracking technology proves valuable in assessing a driver's attentiveness to the road and identifying instances of drowsy driving. It can even prompt alerts or interventions when Advanced driver assistance systems (ADAS), can monitor how a driver steers and stays in their lane. Driver monitoring systems can give drivers real-time alerts if they engage in unsafe behaviour. In the realm of transportation, driver monitoring often goes hand-in-hand with fleet management systems. This allows transportation companies to keep an eye on their driver's overall performance, pinpoint areas that need improvement and implement tailored training programs.

Security Surveillance

AI-powered video analytics bolster security at transportation hubs by identifying activities and potential security threats. The main objectives of security surveillance in transportation are to deter criminal activities, ensure passenger safety and respond swiftly to emergencies. Video cameras are strategically placed across locations including transportation hubs, stations, terminals and vehicles to provide monitoring. License plate recognition systems are employed to track and record the license plates of vehicles entering or leaving transportation hubs, parking lots or other critical areas.

3.6.4 Challenges in the Application of AI in Transportation

- **Reliability and Robustness:** Ensuring the reliability and robustness of AI algorithms is a challenge - especially when dealing with unpredictable transportation environments. These algorithms must be adaptable to scenarios while effectively handling real-world complexities.
- **Human-Machine Interaction:** One of the challenges we face is how AI systems interact with humans who are driving, walking or riding as passengers. It is important to design interfaces and communication methods that are intuitive and promote collaboration. This is crucial for ensuring safety and gaining user acceptance.
- **Public Acceptance and Trust:** Gaining public acceptance and trust in AI-driven transportation can be difficult. We need to communicate to individuals that AI-powered traffic management systems are safe, reliable and beneficial. Transparent testing and validation processes are also essential in building trust.
- **Regulatory Frameworks:** Developing comprehensive and standardized regulations for AI in transportation poses a challenge. There is a need for clear guidelines addressing safety, privacy, liability, and ethical considerations to ensure responsible deployment.

Review Questions

How does AI improve traffic management in transportation?

What is one way AI enhances safety and security in transportation?

Name one challenge faced in applying AI to transportation.

L8 AI in Research, Generative AI and Other Important Issues

AI in Research, Generative AI and Other Important Issues

In the constantly evolving realm of scientific investigation, the integration of Artificial Intelligence (AI) stands out as a transformative influence, fundamentally altering the approach researchers take toward specific challenges. This chapter explores the convergence of AI and scientific research, delving into the dynamic contributions of intelligent algorithms as they contribute to the pursuit of knowledge. Additionally, the emergence of Generative AI has brought forth numerous possibilities and applications for AI. Within this chapter, there will be a broad introduction to Generative AI, accompanied by an overview of its most prominent product, namely ChatGPT. Notably, Prompt Engineering is highlighted as a crucial skill, poised to become the next significant expertise, as it plays a pivotal role in unlocking the true capabilities of ChatGPT. The narrative extends to include a discussion on other noteworthy advancements in the field of AI.

5.1 AI IN EXPERIMENTATION AND MULTI-DISCIPLINARY RESEARCH

There are many activities in experimentation and research where AI can be of help. Some indicative steps are the Generation of Hypothesis, Virtual Prototyping or Simulation, Collection of the data and then doing analysis or finding patterns. In the following section, we will explore the use of AI in various disciplines and sub-disciplines.

1 Particle Physics (Identifying Particles in Collider Data)

2 Astro Physics and Space

3 Experimental Chemistry

4 Biology

5 Environmental Science

5.1.1 Application in Particle Physics (Identifying Particles in Collider Data)

At the Large Hadron Collider (LHC), AI algorithms are used to shift through massive amounts of data and accurately identify different particles, such as Higgs bosons, among billions of collisions. Located in Geneva, Switzerland this is definitely one of the wonders of Science and Engineering. Designed to collide protons and ions at close to the speed of light, recreating conditions similar to the Big Bang. This task would be extremely time-consuming for humans to do manually. Thousands of scientists from over 100 countries work on the LHC . CERN runs highly complex scientific instruments that require advanced control systems and produce enormous amounts of research data. Managing these complex systems and analysing massive datasets pose major challenges.

Figure 5.1 LHC Tunnel of CERN

To address these challenges, CERN is leveraging artificial intelligence techniques in various ways. AI is helping CERN improve particle beam handling through smarter control algorithms. It enables more efficient analysis of the petabyte-scale data generated by CERN's experiments. And AI techniques are being applied to optimize maintenance and upkeep of CERN's large-scale facilities. By harnessing artificial intelligence, CERN aims to enhance many aspects of operating its sophisticated scientific infrastructure for particle physics research.

5.1.2 Application in Astro Physics and Space

AI is used to analyse images of galaxies, stars, and other celestial objects to detect patterns, classify objects, and identify anomalies that might lead to new discoveries. Machine learning models can simulate the evolution of galaxies, predict the behaviours of stars, or simulate the effects of gravitational interactions. AI is used to simulate complex astrophysical phenomena, such as galaxy formation, star formation, and the dynamics of celestial bodies. This helps researchers understand the underlying processes and test theoretical models.

Scientists studying space have had a problem when creating simulations— they had to choose between making detailed simulations or covering a lot of the universe. Now, with the help of a technology called generative adversarial networks, they can do both.

Researchers from Carnegie Mellon University and the University of California came up with a smart computer program. This program can take basic simulations and turn them into highly detailed ones quickly. So now, scientists can make complex simulated universes in just one day. AI is also being used for mapping of dark matters (Fig. 5.2)

Figure 5.2 Mapping of Dark Matters using AI

5.1.3 AI in Experimental Chemistry

AI can assist in various aspects of experimental chemistry, offering benefits such as improved efficiency, data analysis and the discovery of novel compounds. The AI algorithms can analyse data from previous experiments to suggest optimal conditions for reactions, helping researchers design experiments with higher success rates. AI can predict reaction pathways and propose optimal sequences of reactions, facilitating the planning of complex syntheses. The AI algorithms can analyse spectroscopic data (e.g., NMR, IR, UV-Vis) to identify compounds, determine reaction progress, and characterize reaction products. It can help, process and analyse large datasets of chemical information, facilitating the extraction of meaningful patterns and insights. AI assists in the virtual screening of potential drug candidates, predicting their binding affinities to specific biological targets and prioritizing compounds for synthesis and testing.

Revolutionizing the art of molecule-making, AI retrosynthesis tools are rewriting the rules of chemical synthesis. These digital wizards take a target molecule as their canvas, then paint in reverse, meticulously charting the ideal pathway back to its simplest building blocks. One promising approach, 3N-MCTS, blends a timeless search algorithm with the power of three neural networks, unveiling the most efficient route from concept to creation. Despite the buzz these tools generate, the majority of chemists are yet to fully embrace their transformative potential.

5.1.4 AI in Biology

AI algorithms are deciphering the vast libraries of genetic information, identifying patterns and connections that would elude even the most dedicated human researchers. This is leading to breakthroughs in understanding diseases, personalized medicine, and even the evolution of life itself. Some of the use cases of AI in biology are as follows:

- Predicting protein structures from amino acid sequences using deep learning.
- Identifying disease risk factors and biomarkers from genetic data through machine learning.
- Automating the analysis of microscope images to detect cells, tissues, etc., via computer vision.
- Discovering new drugs and materials by screening virtual libraries with AI algorithms.
- Modelling complex biological systems like gene networks and cell interactions using Bayesian networks and machine learning.
- Synthesizing novel proteins with desired functions using generative AI models.
- Classifying bacteria species rapidly using image recognition and spectral data with neural networks.
- Tracking neural activity in the brain in real-time using AI signal processing and analytics.
- Mining scientific literature to extract biological knowledge and relationships using natural language processing.

One of the leading Research Organizations shows (Fig. 5.3) how Global AI Genomics is poised to grow.

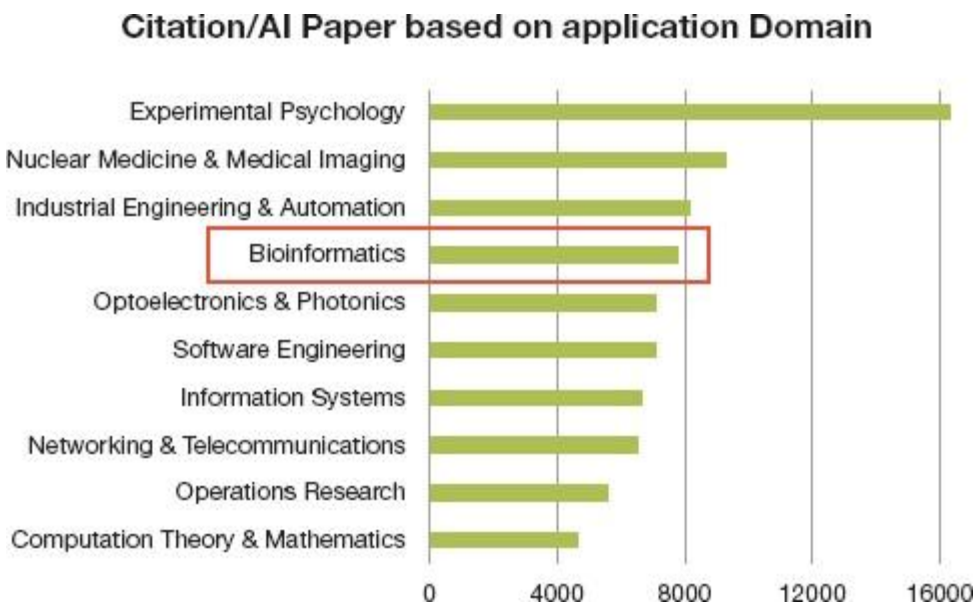

Figure 5.3 Growth Projection of Genomics Market in the US

5.1.5 AI in Environmental Science

Artificial Intelligence (AI) can be applied in various ways in environmental science to address challenges, improve efficiency and enhance decisionmaking.

Climate Modelling and Prediction: AI can analyse vast amounts of climate data to improve climate models and enhance predictions. Machine learning algorithms can identify patterns, trends, and correlations in climate data, leading to more accurate and timely climate forecasts.

Air and Water Quality Monitoring: AI technologies can be used to analyse sensor data and satellite imagery to monitor air and water quality. Machine learning algorithms can identify patterns and anomalies, providing insights into pollution sources, potential health risks, and environmental impacts.

Waste Management: AI technologies, including robotics and machine learning, can be applied to improve waste sorting, recycling processes and waste management overall. Automated systems can identify recyclable materials and help reduce the environmental impact of waste disposal.

Resource Management and Conservation: AI algorithms can optimize resource management strategies, such as precision agriculture. By analysing data on soil conditions, weather patterns and crop health, AI can help farmers make more informed decisions, reduce resource use, and minimize environmental impact.

POINTS TO PONDER AI for Penguins

In 2017, there was a very interesting competition launched by DrivenData. Antarctic penguins are hugely popular and appealing animals known for their distinctive behaviour. Their quirky nature has been documented extensively by wildlife photographers and researchers. To better manage and conserve penguin species over the long term, accurately modelling and predicting their population numbers is essential. It also provides insights into the dynamics of the broader Antarctic ecosystem. This data science competition aimed to leverage the skills of the data science community to develop models that can effectively forecast penguin population changes. By tapping into innovative modelling approaches, the goal was to produce more accurate and robust predictions of penguin populations and their shifts. Reliable models for anticipating population trends are vital tools for enacting evidence-based conservation policies for Antarctic penguin species. One of the prominent species is Emperor Penguin

Figure 5.4 Herd of Emperor Penguin

Review Questions

How does AI enhance experimentation and multi-disciplinary research?

and what are some key applications in scientific fields?

What role does AI play in particle physics, particularly at the Large Hadron Collider

How does it improve data analysis and facility management?

Describe the use of AI in astrophysics, chemistry, biology, and environmental science,

Give specific examples of how AI accelerates discoveries and improves efficiency in each field.