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Internal Assessment Test 2 – Jan 2025

Sub:	Introduction to Internet of Things (IOT)				Sub Code:	BETCK105H	Branch:	Physics Cycle
Date:	20/01/2025	Duration:	90 Minutes	Max Marks: 50	Sec:	I		OBE

	Answer any FIVE FULL Questions	MARK S	CO	RBT
1.	What are the various decision making approaches chosen for offloading data in IoT?	[10]	CO3	L2
2.	What are the different components of an Agricultural IoT?	[10]	CO4	L2

Offload decision making

The choice of where to offload and how much to offload is one of the major deciding factors in the deployment of an offsite-processing topology-based IoT deployment architecture.

- Naive Approach: This approach is typically a hard approach, without too much decision making. It can be considered as a rule-based approach in which the data from IoT devices are offloaded to the nearest location based on the achievement of certain offload criteria. Although easy to implement, this approach is never recommended, especially for dense deployments, or deployments where the data generation rate is high or the data being offloaded in complex to handle (multimedia or hybrid data types). Generally, statistical
measures are consulted for generating the rules for offload decision making.
- Bargaining based approach: This approach, although a bit processing-intensive during the decision making stages, enables the alleviation of network traffic congestion, enhances service QoS (quality of service) parameters such as bandwidth, latencies, and others. At times, while trying to maximize multiple parameters for the whole IoT implementation, in order to provide the most optimal solution or QoS, not all parameters can be treated with equal importance. Bargaining based solutions try to maximize the QoS by trying to reach a point where the qualities of certain parameters are reduced, while the others are enhanced. This measure is undertaken so that the achieved QoS is collaboratively better for the full implementation rather than a select few devices enjoying very high QoS. Game theory is a common example of the bargaining based approach. This approach does not need to depend on historical data for decision making purposes.
- Learning based approach: Unlike the bargaining based approaches, the learning based approaches generally rely on past behavior and trends of data flow through the IoT architecture. The optimization of QoS parameters is pursued by learning from historical trends and trying to optimize previous solutions further and enhance the collective behavior of the IoT implementation. The memory requirements and processing requirements are high during the decision making stages. The most common example of a learning based approach is machine learning.

1.1 Components of an agricultural IoT*** Main components of agricultural IoT are

- *Cloud computing, Sensors, Cameras*
- *Satellites, Analytics, Wireless connectivity*
- *Handheld devices, Drones.*

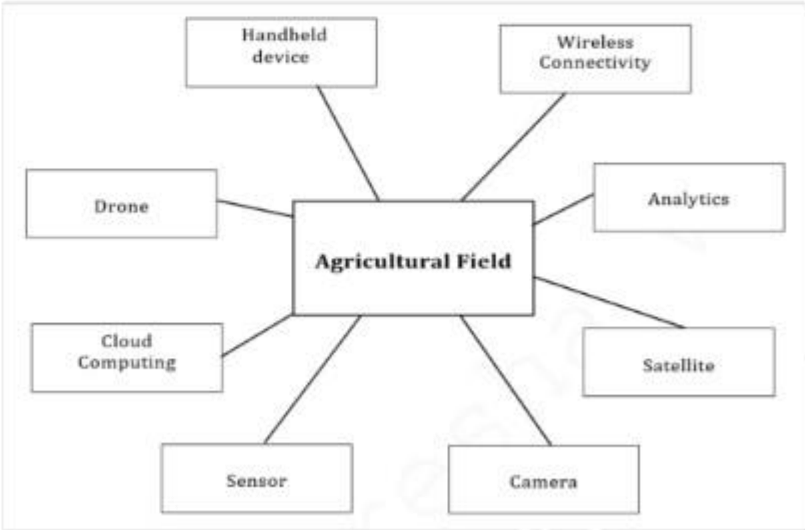

Figure 1.2 Components of agricultural IoT

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- The description of components is as follows

(i) Cloud computing:

- It processes and analyzes huge amounts of agricultural data like soil moisture, humidity, soil pH level, and plant images produced by sensors. Based on the data analysis, action needs to be taken, such as switching on the water pump for irrigation.
- It stores analyzed data on a long-term basis since it may be useful for serving future applications.

(ii) Sensors:

- Sensors are the major backbone of any IoT application and these sensors are indispensable components.
- A few of the common sensors used in agriculture are sensors for soil moisture, humidity, water level, and temperature.

(iii) Cameras:

- Imaging is one of the main components of agriculture used for crop security
- Multispectral, thermal, and RGB cameras are commonly used for scientific agricultural IoT.
- These cameras are used for estimating the nitrogen status, thermal stress, water stress, and crop damage due to infestation.
- Video cameras are used for crop security.

(iv) Satellites:

- Satellite images are used in agricultural applications to monitor different aspects of the crops such as crop health monitoring and dry zone assessment over a large area.

(v) Analytics:

- Analytics is the systematic computational analysis of data or statistics.
- It is used for the discovery, interpretation, effective decision-making, and communication of meaningful patterns in data.
- Analytics contribute to modern agriculture massively. Currently, with the help of analytics, farmers can take different agricultural decisions, such as estimating the required amount of fertilizer and water in an agricultural field.
- Estimating the type of crops that need to be cultivated during the upcoming season.
- Data analytics can also be used for estimating crop demand in the market.

(vi) Wireless connectivity:

- Wireless connectivity enables the transmission of agricultural sensor data from the field to the cloud/server.
- It also enables farmers to access various application services over handheld devices, which rely on wireless connectivity for communicating with the cloud/server.

3.	What is virtualization? How is it useful for end users? Explain the types of virtualizations.	[10]	CO4	L2

- The technique of sharing a single resource among multiple end users is known as *"Virtualization"*. It is the key concept of cloud computing.
- In the virtualization process, a physical resource is logically distributed among multiple users. However, a user realizes that the resource is unlimited and is dedicatedly provided to him/her.

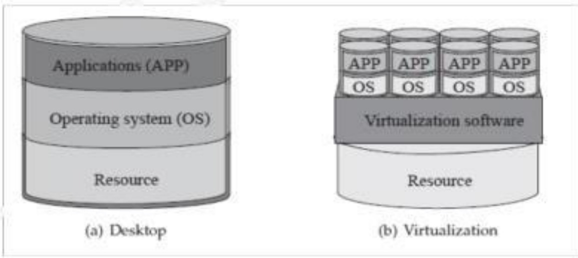


Figure 2.1 Traditional desktop versus virtualization

- Figure 2.2(a) represents a traditional desktop, where an application (App) is running on top of an OS, and resources are utilized only for that particular application.
- Figure 2.2(b) virtualization software separates the resources logically so that there is no conflict among the users during resource utilization.
- Typically, there are different software such as VMware, hypervisor, and virtual machines which enable the concept of virtualization.

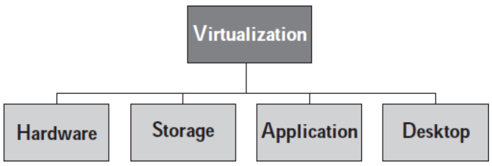
architecture: *(1) End users and (2) Cloud Service providers (CSPs).* Both are benefited in several aspects through the process of virtualization. The

(1). Advantages of virtualization for End Users: They are as follows

(a) Variety *(b) Availability*
(c) Portability *(d) Elasticity*

(a) Variety:

- It enables various types of applications based on the requirements.
- It enables end users to access applications, hardware, or software virtually from a variety of devices and networks, regardless of their operating system (OS).



Hardware Virtualization:

- This type of virtualization indicates the sharing of hardware resources among multiple users.
- For example, a single processor appears as many different processors in a cloud computing architecture.
- Different operating systems can be installed in these processors and each of them can work as stand-alone machines.

Storage Virtualization:

- In storage virtualization, the storage space from different entities are accumulated virtually, and seem like a single storage location.
- Through storage virtualization, a user's documents or files exist in different locations in a distributed fashion.
- However, the users are under the impression that they have a single dedicated storage space provided to them.

Application Virtualization:

- A single application is stored at the cloud end.
- However, as per requirement, a user can use the application in his/her local computer without ever actually installing the application.

Desktop Virtualization:

- This type of virtualization allows a user to access and utilize the services of a desktop that resides at the cloud.

The users can use the desktop from their local desktop.

4.	Explain different cloud models.	[10]	CO5	L2

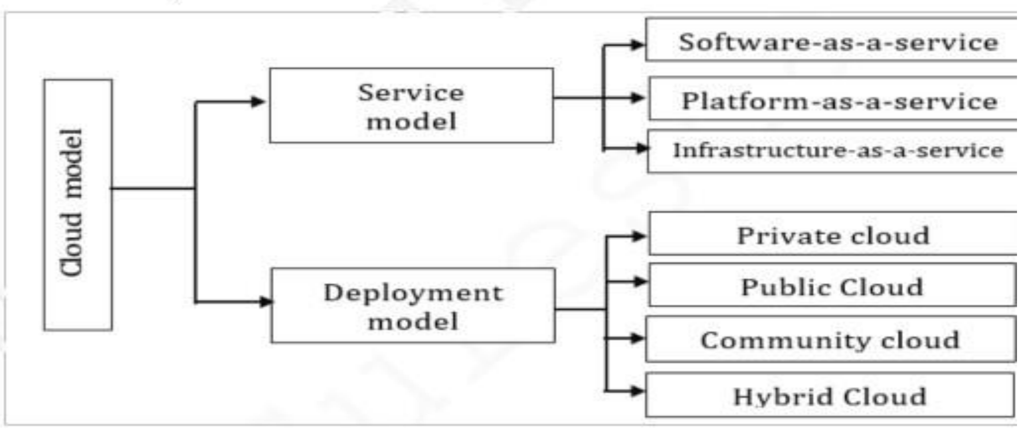


Figure 3.1 Cloud model

- **Infrastructure as a Service (IaaS)**:

- **What it is**: Provides virtualized computing resources over the internet.
- **Who uses it**: IT admins and developers who need to build applications and manage infrastructure.
- **Examples**: AWS EC2, Microsoft Azure, Google Compute Engine.
- **Key Benefits**: You can rent computing power, storage, and networking without managing physical hardware.

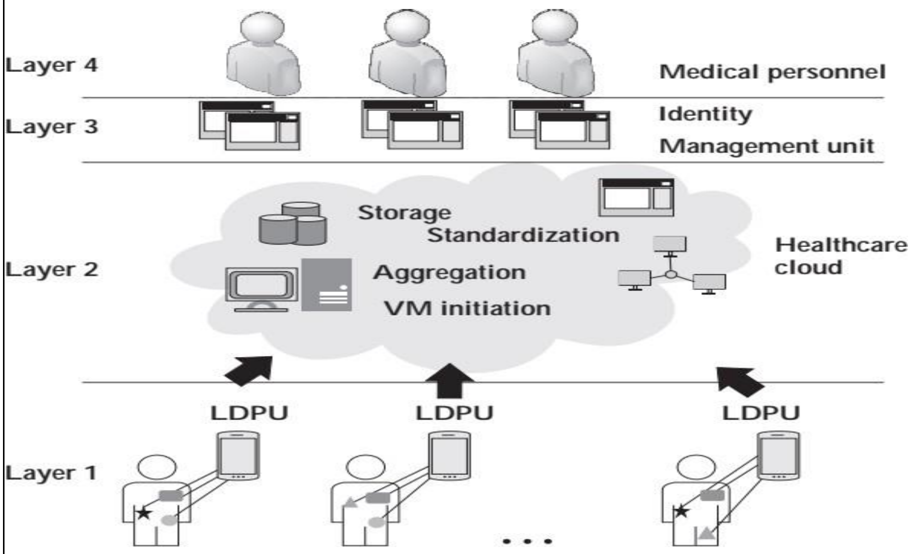
- **Platform as a Service (PaaS)**:
  - **What it is**: Offers hardware and software tools for application development, typically hosted in the cloud.
  - **Who uses it**: Developers who want to focus on creating apps without worrying about the underlying hardware or software layers.
  - **Examples**: Google App Engine, Microsoft Azure App Services, Heroku.
  - **Key Benefits**: Streamlines development, testing, and deployment processes with pre-configured tools and frameworks.
- **Software as a Service (SaaS)**:
  - **What it is**: Provides software applications over the internet on a subscription basis.
  - **Who uses it**: End-users who need access to ready-to-use applications.
  - **Examples**: Gmail, Dropbox, Microsoft 365, Salesforce.
  - **Key Benefits**: No need to install or maintain software on your own machines, and it's accessible from anywhere with an internet connection.

Deployment models

- **Public Cloud**:
  - **What it is**: Cloud resources (like servers and storage) are owned and operated by third-party cloud service providers and made available to the general public.
  - **Who uses it**: Organizations or individuals who don’t require full control over the infrastructure and are okay with shared resources.
  - **Examples**: AWS, Microsoft Azure, Google Cloud.
  - **Key Benefits**: Low upfront costs, scalability, and the provider manages the infrastructure, making it ideal for businesses that don’t need complete control over their cloud environment.
- **Private Cloud**:
  - **What it is**: Cloud infrastructure is used exclusively by a single organization. It can be hosted on-premises or by a third-party provider.
  - **Who uses it**: Large businesses or those with sensitive data or regulatory requirements that need more control over their cloud resources.
  - **Examples**: Private cloud solutions by VMware, OpenStack.
  - **Key Benefits**: Higher levels of security, customization, and control over data and infrastructure.
- **Hybrid Cloud**:
  - **What it is**: Combines private and public cloud environments, allowing data and applications to be shared between them. It provides greater flexibility in how data is managed.
  - **Who uses it**: Organizations that want to keep some workloads on a private cloud while leveraging public cloud resources for scalability.
  - **Examples**: A mix of on-premises servers for sensitive data and public cloud services like AWS for less-sensitive workloads.
  - **Key Benefits**: Flexibility to move workloads between private and public clouds as needs change, cost optimization, and better disaster recovery options.
- **Community Cloud**:
  - **What it is**: A shared cloud infrastructure that is used by a specific group of organizations with similar goals or compliance needs.
  - **Who uses it**: Groups of organizations in the same industry or with similar regulatory concerns (e.g., healthcare or finance).
  - **Examples**: Government or healthcare organizations sharing a cloud service to meet specific compliance standards.
  - **Key Benefits**: Shared costs, enhanced security for a particular group, and tailored to meet industry-specific needs.

5.	Explain the hardware components of front end design features of AmbuSense	[10]	CO5	L2

To overcome these shortcomings, the Smart Wireless Applications and Networking (SWAN) laboratory at the Indian Institute of Technology Kharagpur developed a system: ***AmbuSens***. The primary objectives of the AmbuSens system are summarized as follows:



Hardware:

In the AmbuSens system, a variety of hardware components are used such as sensors, communication units, and other computing devices.

1. **Sensors:** The sensors used in the AmbuSens system are non-invasive.
   - ***Optical Pulse Sensing Probe***: It senses the *photoplethysmogram* (PPG) signal and transmits it to a GSR expansion module. Further, the GSR expansion module transfers the sensed data to a device in real-time.
   - ***Electrocardiogram (ECG) unit and sensor:*** The ECG sensor measures the pathway of electrical impulses through the heart to sense the heart's responses to physical exertion and other factors affecting cardiac health.
   - ***Electromyogram (EMG) sensor:*** This sensor is used to analyze and measure the biomechanics of the human body. Particularly, the EMG sensor is used to measure different electrical activity related to muscle contractions; it also assesses nerve conduction, and muscle response in injured tissue.
   - ***Temperature sensor:*** The body temperature of patients changes with the condition of the body.
   - ***Galvanic Skin Response (GSR) sensor:*** The GSR sensor is used for measuring the change in electrical characteristics of the skin.
2. **Local Data Processing Unit (LDPU):**
   In AmbuSens, all the sensors attached to the human body sense and transmit the sensed data to a centralized device, which is called an LDPU.
   - An LDPU is a small processing board with limited computation capabilities.
   - The connectivity between the sensors and the LDPU follows a single- hop star topology.
   - The LDPU is programmed in such a way that it can receive the physiological data from multiple sensor nodes, simultaneously.
   - Further, it transmits the data to the cloud for long-term storage and heavy processing.
3. **Communication Module:**
   - Each sensor node consists of a Bluetooth (IEEE 802.15.1 standard) module.
   - The communication between the sensor nodes and the LDPU takes place with the help of Bluetooth, which supports a maximum communication range of 10 meters in line-of-sight.
   - The LDPU delivers the data to the cloud with 3G/4G communication.

Front End:

- In the AmbuSens system, three actors—doctor, paramedic/nurse, and patient—are able to participate and use the services.
- The web interface is designed as per the requirements of the actors of the system.
- For example, the detailed health data of a patient is accessible only to the assigned doctor.
- The system provides the flexibility to a patient to log in to his/her account and download the details of his/her previous medical/treatment details.
- In AmbuSens, the database is designed in an efficient way such that it can deliver the customized data to the respective actor.

- In this system, the registration process is also designed in a customized fashion, that is, the details of a user to be entered into the registration form is different for different actors.

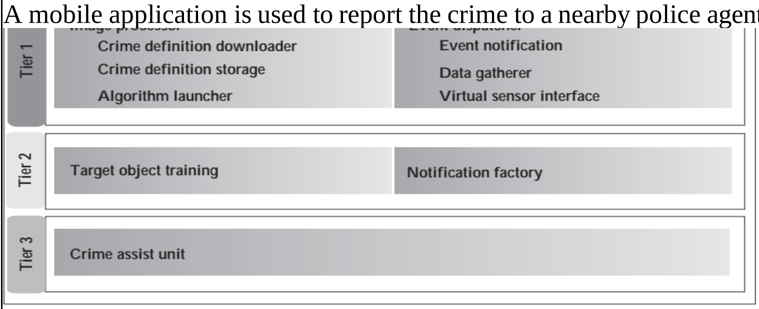
For example, a doctor must enter his/her registration number in the registration form.

6.	Explain fog framework for intelligent public safety in vehicular environment FISVER with block diagram.	[10]	CO5	L2

The system highlights a fog framework for intelligent public safety in vehicular environments (fog-FISVER). The primary aim of this system is to ensure smart transportation safety (STS) in public bus services. The system works through the following three steps:

- The vehicle is equipped with a smart surveillance system, which is capable of executing video processing and detecting criminal activity in real time.
- A fog computing architecture works as the mediator between a vehicle and a police vehicle.

A mobile application is used to report the crime to a nearby police agent



Architecture

The architecture of the fog-FISVER consists of different IoT components. The developers utilized the advantages of the low-latency fog computing architecture for designing their system. Fog-FISVER is based on a three-tiered architecture, as shown in Figure 9a.

1. Tier 1--- In-vehicle FISVER STS Fog :

- A fog node is placed for detecting criminal activities. This tier accumulates the real sensed data from within the vehicle and processes it to detect possible criminal activities inside the vehicle.
- This tier is responsible for creating crime-level metadata and transferring the required information to the next tier.
- Tier 1 consists of two subsystems: ***Image processor*** and ***event dispatcher***

Image Processor:

- The image processor inside Tier 1 is a potent component, which has a capability similar to the human eye for detecting criminal activities.
- Developers of the system used a deep-learning-based approach for enabling image processing techniques in the processor.
- To implement the fog computing architecture in the vehicle, a Raspberry- Pi-3 processor board is used, which is equipped with a high-quality camera.
- This architecture uses template matching and correlation to detect the presence of dangerous articles (such as a pistol or a knife) in the sub-image of a video frame.

The image processor is divided into the following three parts:

- **Crime definition downloader:** This component periodically checks for the presence of new crime object template definitions in fog-FISVER STS fog infrastructure. If a new crime object template is available, it is stored locally.
- **Crime definition storage:** In order to use template matching, the crime object template definition is required to be stored in the system. The crime definition storage is used to store all the possible crime object template definitions.
- **Algorithm launcher:** This component initiates the instances of the registered algorithm in order to match the template with the video captured by the camera attached in the vehicles. If a crime object is matched with the video, criminal activity is confirmed.

Event dispatcher:

The event dispatcher is responsible for accumulating the data sensed from vehicles and the image processor. After the successful detection of criminal activity, the information is sent to the fog-FISVER STS fog infrastructure. The components of the event dispatcher are as follows:

- **Event notifier:** It transfers the data to the fog-FISVER STS fog infrastructure, after receiving it from the attached sensor nodes in the vehicle.
- **Data gatherer:** This is an intermediate component between the event notifier and the physical sensor; it helps to gather sensed data.
- **Virtual sensor interface:** Multiple sensors that sense data from different locations of the vehicle are present in the system. The virtual sensor interface helps to maintain a particular procedure to gather data. This component also cooperates to register the sensors in the system.

2. <u>Tier 2--- FISVER STS Fog Infrastructure :</u>
Tier 2 works on top of the fog architecture. Primarily, this tier has three responsibilities—keep updating the new object template definitions, classifying events, and finding the most suitable police vehicle to notify the event. FISVER STS fog infrastructure is divided into two sub-components:

- **(i) Target Object Training:** This subcomponent of Tier 2 is responsible for creating, updating, and storing the crime object definition.
- The algorithm launcher uses these definitions in Tier 1 for the template matching process.
- The template definition includes different features of the crime object such as color gradient and shape format. A new object definition is stored in the ***definition database***.
- The database requires to be updated based on the availability of new template definitions.

(i) <u>Notification Factory:</u>

- This sub-component receives notification about the events in a different vehicle with the installed system.
- Further, this component receives and validates the events. In order to handle multiple events, it maintains a queue.

Tier 3 consists of mobile applications that are executed on the users' devices. The application helps a user, who witnesses a crime, to notify the police.

7.	Explain the four categories of Machine Learnings.	[10]	CO5	L2

Typically, ML algorithms consist of four categories: (i) Supervised (ii) Unsupervised (iii) Semi-supervised (iv) Reinforcement Learning (Figure 1). In this section, we briefly explore different categories of ML. Before discussing further, we determine the meaning of labeled- and unlabeled-data. As the name suggests, labeled data contain certain meaningful tags, known as labels. Typically, the labels correspond to the characteristics or properties of the objects. For example, in a dataset containing the images of two birds, a particular sample is tagged as a crow or a pigeon. On the other hand, the unlabeled dataset does not have any tags associated with them. For example, a dataset containing the images of a bird without mentioning its name.

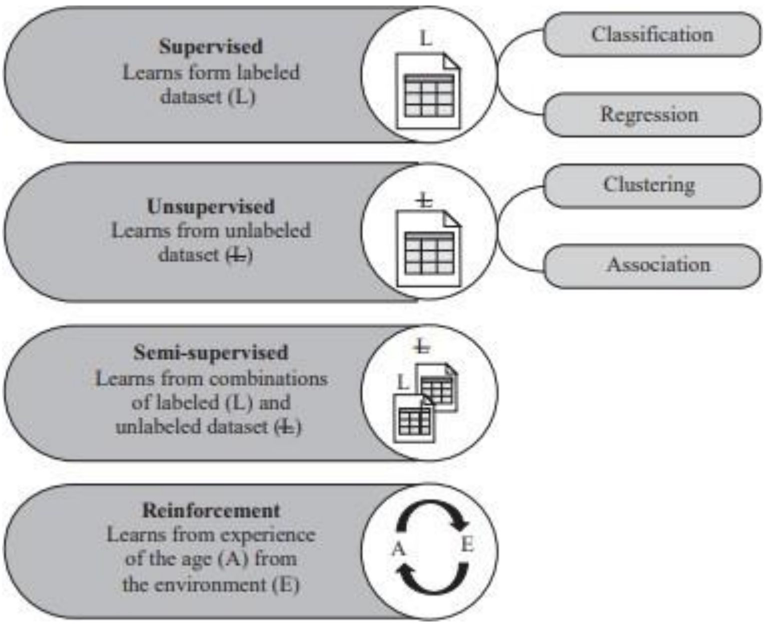


Figure 1: Types of Machine learning

(i) Supervised Learning: This type of learning supervises or directs a machine to learn certain activities using labeled datasets. The labeled data are used as a supervisor to make the machine understand the relation of the labels with the properties of the corresponding input data. Consider an example of a student who tries to learn to solve equations using a set of labeled formulas. The labels indicate the formulae necessary for solving an equation. The student learns to solve the equation using suitable formulae from the set. In the case of a new equation, the student tries to identify the set of formulae necessary for solving it. Similarly, ML algorithms train themselves for selecting efficient formulae for solving equations. The selection of these formulae depends primarily on the nature of the equations to be solved. Supervised ML algorithms are popular in solving classification and regression problems. Typically, the classification deals with predictive models that are capable of approximating a mapping function from input data to categorical output. On the other hand, regression provides the mapping function from input data to numerical output. There are different classification algorithms in ML. However, in this chapter, we discuss three popular classification algorithms: (i) k-nearest neighbor (KNN), (ii) decision tree (DT), and(iii) random forest (RF). We use regression to estimate the relationship among a set of dependent variables with independent variables, as shown in Figure 17.3. The dependent variables are the primary factors that we want to predict. However, these dependent variables are affected by the independent variables. Let x and y be the independent and dependent variables, respectively.

Mathematically, a simple regression model is represented as

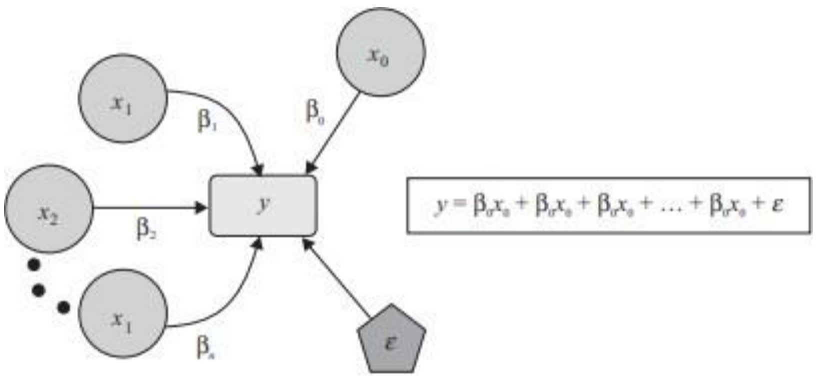


Figure 17.3 Regression model

$y = \beta_0 x_0 + \beta x + \varepsilon$ (17.1)

where β represents the amount of impact of variable x on y and ε denotes an error. In the given equation, x_0 creates β_0 impact on y, which indicates that the value of y can never be 0. Similarly, for multiple variables, say n, the regression model is represented as: $y = \sum_{i=0}^{n} \beta_i x_i + \varepsilon$ (17.2)

(ii) Unsupervised Learning: Unsupervised learning algorithms use unlabeled datasets to find scientific trends. Let us consider an example of the student similar to that described in the case of supervised learning, and illustrate how it differs in case of unsupervised learning. As already mentioned, unsupervised learning does not use any labels in its operations. Instead, the ML algorithms in this category try to identify the nature and properties of the input equation and the nature of the formulae responsible for solving it. Unsupervised learning algorithms try to create different clusters based on the features of the formulae and relate it with the input equations. Unsupervised learning is usually applied to solve two types of problems: clustering and association. Clustering divides the data into multiple groups. In contrast, association discovers the relationship or association among the data in a dataset.

(iii) Semi-Supervised Learning: Semi-supervised learning belongs to a category between supervised and unsupervised learning. Algorithms under this category use a combination of both labeled and unlabeled datasets for training. Labeled data are typically expensive and are relatively difficult to label correctly.

	Unlabeled data is less expensive than labeled data. Therefore, semi-supervised learning includes both labeled and unlabeled dataset to design the learning model. Traditionally, semi-supervised learning uses mostly unlabeled data, which makes it efficient to use, and capable of overcoming samples with missing labels. (iv) Reinforcement Learning: Reinforcement learning establishes a pattern with the help of its experiences by interacting with the environment. Consequently, the agent performs a crucial role in reinforcement learning models. It aims to achieve a particular goal in an uncertain environment. Typically, the model starts with an initial state of a problem, for which different solutions are available. Based on the output, the model receives either a reward or a penalty from the environment. The output and reward act as inputs for proceeding to the next state. Thus, reinforcement learning models continue learning iteratively from their experiences while inducing correctness to the output.			

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