1. Artificial Intelligence (AI) and Robotics

1.1 Artificial Intelligence (AI)

Definition
AI is the branch of computer science that tries to create machines that can perform tasks which normally require human intelligence, such as learning, reasoning, problem solving, perception and language understanding.

Main features / capabilities

- Learning from data (machine learning)
- Reasoning and decision making
- Pattern recognition (image, speech)
- Natural language processing
- Problem solving and planning

Applications

- Expert systems (medical diagnosis, troubleshooting)
- Speech recognition (Siri, Google Assistant)
- Image and face recognition
- Self-driving cars
- Recommendation systems (YouTube, Netflix, e-commerce)

Advantages

- Works tirelessly, high speed and accuracy
- Handles large data better than humans
- Helpful in dangerous or repetitive tasks

Limitations / issues

- Lack of common sense and emotions
- Can cause job displacement
- Ethical issues (privacy, bias, misuse)

Expert System

1. Definition

An **expert system** is a computer program that uses artificial intelligence techniques to imitate the decision-making ability of a human expert in a specific field by using a stored knowledge base and an inference engine.

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2. Advantages

1. Provides expert-level advice in a narrow domain.
2. Works consistently without fatigue or emotions.
3. Available 24×7 once developed.
4. Useful for training and decision support for beginners.
   (Also: can work in dangerous or remote environments, can respond faster than humans.)

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3. Limitations

1. Works only within the knowledge stored; lacks common sense.
2. Knowledge collection from experts is difficult and time-consuming.
3. Cannot easily handle completely new or unexpected situations.
4. Needs regular updating when rules/conditions change.
   (Also: development cost can be high, cannot replace human creativity.)

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4. Types of Expert Systems

1. **Rule-based expert system** – uses IF–THEN rules as knowledge.
2. **Frame-based expert system** – uses frames (objects with attributes).
3. **Model-based expert system** – uses a model of a physical system to reason.
4. **Case-based expert system** – solves new problems using past similar cases.
   (Extra: Hybrid expert system, Distributed/web-based expert system.)
5. **Knowledge Based expert System**-A knowledge-based expert system is an AI system that stores expert knowledge about a specific domain in a **knowledge base** and uses an **inference engine** to solve problems or give advice like a human expert.
6. **Fuzzy Logic Based Expert System**-A fuzzy-logic-based expert system is an expert system that uses **fuzzy logic** to handle imprecise, vague or linguistic information (e.g. “high temperature”, “low speed”) instead of only exact true/false values.

1.2 Robotics

Definition
Robotics is the branch of technology that deals with the design, construction and operation of robots—programmable machines capable of carrying out tasks automatically.

Basic components of a robot

- Mechanical body (joints, arms, wheels)
- Sensors (light, temperature, distance, camera)
- Actuators (motors, hydraulic systems)
- Controller (microprocessor/microcontroller)
- Power supply and software

Applications

- Industrial automation (assembly, welding, painting)
- Space exploration (rovers)
- Medical surgery and rehabilitation
- Military and defense
- Service robots (cleaning, delivery, companion robots)

Advantages

- Works in hazardous environments
- High precision and speed
- Can do repetitive tasks consistently

Limitations

- Expensive to design and maintain
- Limited to programmed tasks
- Fear of unemployment and misuse (weapons)

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2. Cloud Computing

Definition
Cloud computing is a technology that provides computing resources (hardware, software, storage, network, etc.) as services over the internet on pay-as-you-use basis instead of owning local servers.

2.1 Characteristics

- On-demand self-service

- Broad network (large) access
- Resource pooling (shared servers and storage)
- Rapid elasticity (scale up/down quickly)
- Measured service (pay per use)
- Easy maintenance and automatic updates
- High availability and reliability

2.2 Service models

- **SaaS (Software as a Service)** – ready-made applications delivered via browser (Gmail, Google Docs). Users do not manage infrastructure.
- **PaaS (Platform as a Service)** – platform for developers to build and deploy apps (e.g. Google App Engine, Heroku).
- **IaaS (Infrastructure as a Service)** – virtual machines, storage, networks provided as infrastructure (e.g. AWS EC2).

2.3 Advantages

- Lower initial cost (no need to buy servers)
- Scalability and flexibility
- Backup and disaster recovery
- Access from anywhere with internet

2.4 Disadvantages / risks

- Dependency on internet connectivity
- Vendor lock-in (hard to move provider)
- Security and privacy concerns
- Less control over underlying infrastructure

2.5 Applications

- Online storage and backup (Google Drive, Dropbox)
- Web and app hosting
- Online collaboration tools
- Big-data analytics platforms
- Streaming services

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3. Big Data

Definition
Big Data refers to extremely large and complex data sets that cannot be effectively captured, stored and processed by traditional database systems.

3.1 Characteristics (3Vs / 5Vs)

- **Volume** – huge amount of data
- **Velocity** – high speed of data generation and processing
- **Variety** – different forms (text, image, video, sensor data)
  Sometimes also: **Veracity** (uncertainty) and **Value** (usefulness).

3.2 Types of data

- Structured (tables, relational DB)
- Semi-structured (XML, JSON, logs)
- Unstructured (text, images, audio, video)

3.3 Applications

- Social media and web analytics
- Market analysis and targeted advertising
- Fraud detection in banking
- Healthcare (disease prediction, patient records)
- Smart cities and traffic management

3.4 Advantages

- Better decision making and predictions
- Discover hidden patterns and trends
- Improved services and customer satisfaction

3.5 Challenges

- Storage and processing requirement
- Data quality and consistency
- Privacy and security issues
- Need of skilled professionals (data scientists)

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4. Virtual Reality (VR)

Definition
Virtual Reality is a computer technology that creates a simulated three-dimensional environment in which the user can feel present and interact, usually using a head-mounted display and sensors.

4.1 Components

- VR headset (goggles with screens)
- Motion tracking sensors (head, hand, body)
- Input devices (controllers, gloves)
- VR software and 3D environment

4.2 Applications

- Gaming and entertainment
- Education and virtual labs
- Training and simulation (pilots, soldiers, surgeons)
- Virtual tours (tourism, real estate)
- Therapy and rehabilitation

4.3 Advantages

- Highly immersive and realistic experience
- Safe training in risky environments
- Increases engagement and motivation

4.4 Limitations

- Expensive devices
- Motion sickness, eye strain for some users
- Requires powerful computer and content

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5. e-Commerce, e-Medicine, e-Government

5.1 e-Commerce (Electronic Commerce)

Definition
Buying, selling, and exchanging goods and services using electronic networks, mainly the internet.

Types (basic)

- B2B – Business to Business
- B2C – Business to Consumer
- C2C – Consumer to Consumer (e.g. online marketplaces)

Advantages

- 24×7 online shop
- Wider market reach
- Lower operating cost
- Easy price comparison for customers

Disadvantages

- Security and privacy issues
- Lack of physical inspection of goods
- Delivery delays and logistics problems

5.2 e-Medicine (Telemedicine / e-Health)

Definition
Use of information and communication technologies (ICT) to provide medical services such as consultation, diagnosis, monitoring, and health information over distance.

Applications

- Online doctor consultation
- Remote monitoring of patients
- Electronic health records
- Health awareness portals and apps

Advantages

- Access to specialists in remote areas
- Saves travel time and cost
- Useful in emergencies and pandemics

Limitations

- Dependence on network and devices
- Legal and privacy issues with medical data

5.3 e-Government (e-Gov)

Definition
Use of ICT by government to deliver information and services to citizens, businesses and other government agencies in an efficient, transparent and convenient way.

Objectives

- Improve efficiency of government services
- Increase transparency and reduce corruption
- Enhance citizen participation
- Provide anytime, anywhere access to services

Examples

- Online tax payment and revenue portals
- Online form submission (citizenship, passport, license)
- Government websites and information portals
- Digital identity and online voting (in some countries)

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6. Mobile Computing

Definition
A technology that allows transmission of data, voice, and video through a computer or other wireless-enabled device without being connected to a fixed physical link, enabling users to compute anytime, anywhere.

6.1 Features

- Portability (smartphones, tablets, laptops)
- Wireless connectivity (Wi-Fi, mobile data, Bluetooth)
- Location awareness (GPS)
- Synchronization with cloud services
- Battery-powered operation

6.2 Advantages

- Access to information and services on the move
- Improved productivity and flexibility
- Supports mobile apps (banking, learning, shopping)

6.3 Limitations

- Small screen and limited battery life
- Security risks (lost devices, insecure Wi-Fi)
- Network coverage and speed issues

6.4 Applications

- Mobile banking and payment wallets
- Mobile learning (e-learning apps)
- Location-based services (maps, ride sharing)
- Mobile entertainment and social networking

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7. Internet of Things (IoT)

Definition
IoT is a network of physical objects (“things”) embedded with sensors, software and connectivity that enables them to collect and exchange data over the internet, often without human intervention.

7.1 Components

- Things (devices, sensors, actuators)
- Connectivity (Wi-Fi, Bluetooth, mobile network)
- Data processing platform (cloud/fog/edge)
- User interface (apps, dashboards)

7.2 Characteristics

- Interconnection of many devices
- Real-time sensing and monitoring
- Remote control and automation
- Scalability to millions of devices
- Data-driven decision making

7.3 Applications

- Smart home (smart lights, thermostats, security cameras)
- Smart city (traffic, waste management, street lights)
- Industrial IoT (monitoring machines in factories)
- Smart agriculture (soil moisture sensors, irrigation control)

- Healthcare (wearable health trackers)

7.4 Advantages

- Automation and reduced human effort
- Better resource utilization (energy, water, time)
- Improved safety, comfort and efficiency

7.5 Challenges

- Security and privacy of connected devices
- Standardization and interoperability
- Managing huge data from many sensors