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Chapter 6
Automated and Emerging Technologies

Automated Systems

What is an automated system?

An **automated system** is a computer system that collects information and can react and perform tasks based on the data without human intervention.

Automated systems are made using three components:

- **Sensors** - collects information and provides the microprocessor with it as an input
- **Microprocessors** - processes the information and makes decisions based on pre-programmed rules
- **Actuators** - makes physical changes based on instructions given by the microprocessor (outputs)

Advantages & Disadvantages of Automated Systems

Advantages of Automated Systems	Disadvantages of Automated Systems
• Reduced **labour costs** • Improved **efficiency** (e.g. energy, fuel) • Improved **accuracy** • **Consistent** results • Improved **safety** • Able to collect large amounts of data **quickly**	• High **initial investment** • High **maintenance costs** • Significant testing must be done before being used • can result in major job losses

There are also scenarios where specific advantages and disadvantages are important such as:		
Scenario	**Advantages**	**Disadvantages**
Industry	- Increased production - Improved quality control	- High investment costs - Job losses
Transport	- Less accidents & traffic congestion - Increased logistical efficiency	- Transportation drivers lose jobs - Technology reliability

Agriculture	- Less manual labour - Can operate 24/7	- High start-up costs for equipment and sensors - Job losses
Weather	- Accurate forecasting - Continuous monitoring	- High initial cost - May not 100% accurate all the time
Gaming	- Personalised experience - Able to create interactive games	- Lack of human creativity - May be affected by technical glitches
Lighting	- Increased energy efficiency - Scheduled lighting	- High initial cost - Requires internet connection
Science	- Faster & more precise - Reduced risk of human error	- High cost development and maintenance - May not be suitable for all types of experiments

Worked Example

A theme park has a game where a player tries to run from the start to the finish without getting wet.

The system for the game uses sensors and a microprocessor to spray water at a player as they run past each sensor.

Describe how the sensors and the microprocessor are used in this system **[8]**

Answer

A motion sensor collects data [1]

This data is converted to digital using ADC [1]

The sensor sends data to the microprocessor... [1]

... where the data is compared to stored data [1]

If the value is outside range, water will be sprayed [1]

A signal is sent to the actuator to spray water [1]

If the value is within range no action is taken [1]

This runs in a continuous loop [1]

Robotics

What is robotics?

Robotics is a branch of computer science that incorporates the **design**, **construction**, and **operation** of robots (to perform tasks).

Examples:

- **Factory equipment** (welding, painting, assembling)
- **Domestic robots** (household chores e.g. vacuuming)
- **Drones** (unmanned aerial vehicles e.g. photography, delivery, surveillance)

Characteristics

- **A mechanical structure or framework** – a physical body that can move and interact with the environment
- **Electrical components** e.g. sensors, microprocessors, actuators – allow robots to receive and respond to information
- **Programmable** – can follow a set of instructions, complete a variety of tasks, respond to changing situations

Robots are used in: industry (manufacturing and assembly lines), transport, agriculture, medicine (surgical procedures), domestic, entertainment	
Advantages of using Robots	**Disadvantages of using Robots**
• Increased **productivity** (can work continuously without breaks) • Performs tasks with high **accuracy** and **consistency** • Performs tasks that are **dangerous for humans** • Reduces **labour costs** in the long run	• High **initial cost** • High **maintenance cost** • Lack of **flexibility** (programmed for specific tasks and cannot adapt easily to new situations) • **Unemployment** (increased use of robots can lead to job loss) • May **deskill** the workforce • If they **malfunction** (do not work as expected), production stops

Worked Example

A company uses robots in its factory to manufacture restaurant tables and chairs.

(i) One characteristic of a robot is that they contain electrical components. **State** two other characteristics of a robot. **[2]**

(ii) Give **two advantages** to company **employees** of using robots to manufacture tables and chairs. **[2]**

(iii) Give **one disadvantage** to the company's owners of using robots to manufacture table and chairs **[1]**

Answer

(i)

- Mechanical structure
- Programmable

(ii)

- Employees don't need to lift heavy items
- Employees can be protected from dangerous tasks
- Employees can utilise their skills in other tasks
- Employees don't need to perform repetitive/mundane tasks

(iii)

- Expensive to install/purchase/setup
- High ongoing costs/maintenance costs
- May deskill the workforce
- If they malfunction, production may stop

Artificial Intelligence (AI)

What is artificial intelligence?

Artificial intelligence (**AI**) is a **branch of computer science** dealing with the **simulation of intelligent behaviours similar to that of a human**.

AI is a system that can:

Learn - acquire new information

Decide - analyse and make choices

Act autonomously - take actions without human input

Characteristics of AI

- **Collection of data and rules**

  Large amounts of data are processed using **rules** to make **decisions/predictions**

- **Ability to reason**

  AI systems use **logical reasoning** to evaluate information and **make decisions**

- **Ability to learn and adapt**

  Can **learn from previous experiences** and change its **data and rules** accordingly

Advantages and disadvantages of AI

Advantages of AI	Disadvantages of AI
- Can work for 24/7 - Increased accuracy - The system can serve more users without delay - Reduce human error	- Job losses - Need to collect many data - High development cost - Lack of creativity and emotion

Operation & Components of AI Systems

➢ Expert Systems

An expert system mimics human knowledge and experience and uses a combination of the two to solve problems or answer questions.

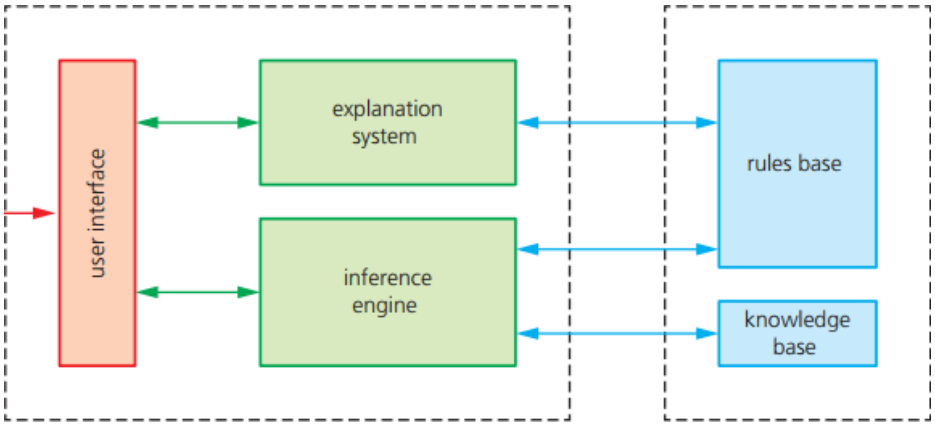
Characteristics of Expert System

- **Knowledge base** – a database of facts to generate rules that make decisions
- **Rule base** – a set of rules to apply the knowledge in the knowledge base to specific problems
- **Inference engine** – a program that applies the rules in the rule base to the facts in the knowledge base to solve problems
- **Interface** – a way for users to interact with the system and provide input

Advantages of Expert System	Disadvantages of Expert System
- Consistent results - Faster response - Can store large amount of data - Can available 24/7	- Only good as the data entered - Requires training to use correctly - Expensive to develop and maintain - Lack of emotional intelligence

How an Expert System Works:

1. The user provides input (e.g., symptoms or data) through the user interface.
2. The inference engine will decide which question to ask by using the previous answers given
3. The inference engine checks the rule base to find matching rules
4. It applies the rules in the rule base to the facts in the knowledge base to solve problems
5. The system displays a solution or recommendation to the user through user interface



➢ Machine Learning

Machine learning is a type of artificial intelligence (AI) that allows computer systems to automatically learn from data and improve their performance without specific instructions written in program.

For example:

- If you show a machine learning model thousands of pictures of cats and dogs, it can **learn to tell them apart**.
- Over time, as it sees more pictures, it gets **better at identifying** them even new ones it hasn't seen before.

Machine Learning capabilities

- It is a form of artificial intelligence which can edit its own algorithm
- It can be trained with or without human interaction
- The system identifies patterns and relationships within the data.
- It stores the successful and unsuccessful results to improve future decisions

How Machine Learning / AI works

1. **Collects data**

   – The system gathers information from its environment.

   Example: A robot collects data about where it has been, where obstacles are, and what actions it took.

2. **Stores outcomes**

   – It records which actions were **successful** and which were **unsuccessful**.

   Example: If the robot bumped into a wall, which is stored as an unsuccessful action.

3. **Analyzes data using Machine Learning algorithms**

   – The system uses ML algorithms to **analyze the data**, looking for **patterns and relationships**.

   Example: It may learn that turning left at a certain point always avoids an obstacle.

4. **Improves future decisions**

   – Based on what it has learned, the system makes **better decisions next time**.

   Example: The robot avoids obstacles more efficiently because it has learned from past mistakes.

Describe how machine learning / AI works – Exam style answer

• It could use machine learning algorithm
• A large amount of data is collected
• The data is used to adapt its own process
• It analyses the data to find patterns and relationships
• The system makes predictions or decisions based on these patterns and relationships
• It stores the successful and unsuccessful results to improve future decisions