IGCSE Computer Science CIE

YOUR NOTES

6. Automated and emerging technologies

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6.1 Automated Systems

Automated Systems

Automated Systems

- Automated systems use sensors, a microprocessor and actuators
  - **Sensors** detect changes in the environment and **convert them into electrical signals** that can be processed by a microprocessor
  - **Microprocessors** analyse the signals from the sensors and **make decisions** based on pre-programmed logic
  - **Actuators** receive **signals** from the microprocessor and **perform actions** such as opening a valve or turning on a motor
- By combining sensors, microprocessors, and actuators, automated systems can be created that respond to changes in the environment without human intervention

Here are some scenarios where automated systems are used

Scenario	Advantages	Disadvantages
Industry	• **Reduced labour costs** • Improved efficiency and accuracy • Increased production rate	• **High initial investment** • Limited flexibility to changes in production processes • **Maintenance costs can be high**
Transport	• Improved safety and reliability • **Reduced labour costs** • Improved fuel efficiency	• **High initial investment** • **May not be suitable for all types** of transportation • **Maintenance costs can be high**
Agriculture	• Increased efficiency in planting and harvesting crops • Improved crop yield and quality • **Reduced labour costs**	• **High initial investment** • **May not be suitable for all types** of crops or terrain • **Maintenance costs can be high**

Weather	• Improved accuracy in weather prediction • Ability to issue warnings in a timely manner • Ability to collect large amounts of data quickly	• May be affected by external factors like interference or equipment failure • May not be 100% accurate all the time • May require continuous monitoring and calibration
Gaming	• Improved speed and efficiency in game development • Ability to create complex and interactive games • **Reduced labour costs**	• **May not be suitable for all types** of games or game development • May require significant programming expertise • May be affected by technical glitches or bugs
Lighting	• Improved energy efficiency • Ability to program lighting to suit different needs • **Reduced labour costs**	• **High initial investment** • **May not be suitable for all types** of lighting needs • **Maintenance costs can be high**
Science	• Improved speed and accuracy in data collection and analysis • Ability to carry out complex experiments • **Reduced labour costs**	• **High initial investment** • **May not be suitable for all types** of experiments • May require significant technical expertise

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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]

- A motion sensor collects analogue 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]

Exam Tip

- The way marks are awarded on these questions is very similar. Make sure you relate your answer specifically to the scenario in the question

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6.2 Robotics

Robotics

Robotics

Robotics is an area of computer science that deals with the creation, design, and operation of robots.

- Design and Construction:
  - Robotics involves the **design and construction** of robots for various applications
  - Robots are designed using a combination of **mechanical, electrical, and computer engineering**
  - Robotic design can be **customised** to meet specific needs, such as factory automation or household tasks
- Operation:
  - Once a robot is built, it needs to be **programmed** to carry out specific tasks
  - Programming involves **creating a set of instructions** that tell the robot what actions to perform in a specific sequence
  - The robot's **sensors** are used to **detect and respond to changes** in its environment
  - Robots can also be **operated remotely** using a controller
- Examples:
  - **Factory equipment:** Robots perform tasks such as welding, painting, and assembling products
  - **Domestic** robots: These are robots designed to perform household chores such as vacuuming or mowing the lawn
  - **Drones**: Drones are unmanned aerial vehicles that can be used for tasks such as aerial photography, delivery, and surveillance

Characteristics

- A robot is a **machine** that can be **programmed** to carry out a range of tasks autonomously or semi-autonomously
- Robots have a mechanical structure or framework, which gives them a physical body that can move and interact with the environment
- **Electrical components**, such as sensors, microprocessors and actuators, allow robots to receive information from their surroundings and respond to it
- Robots are **programmable**, which means they can be designed to follow a set of instructions or algorithms, allowing them to complete a variety of tasks and respond to changing situations

Roles

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Robots can perform various tasks in different areas, such as:

- Industry
  - Robots can be used in **manufacturing** and assembly lines to increase productivity and accuracy
- Transport
  - Robots can be used in warehouses and logistics to move and **transport** goods
- Agriculture
  - Robots can be used for tasks such as planting, **harvesting**, and spraying crops
- Medicine
  - Robots can be used in **surgical procedures** to increase **precision** and reduce risk of errors
- Domestic
  - Robots can be used for tasks such as **vacuuming**, lawn mowing, and cleaning
- Entertainment
  - Robots can be used as **toys** or in amusement parks to provide entertainment

Advantages	Disadvantages
Increased productivity: robots can work continuously without breaks or fatigue	**High initial investment**: purchasing and setting up robots can be expensive
Consistency and accuracy: robots can perform tasks with a high level of precision and accuracy	**Maintenance costs**: robots require regular maintenance and repairs, which can add to the overall cost.
Safety: robots can perform tasks that are dangerous or hazardous for humans	**Lack of flexibility**: robots are programmed for specific tasks and cannot adapt easily to new situations or tasks.
Cost-effective: robots can help reduce labour costs in the long run	**Unemployment**: increased use of robots can lead to job loss in certain industries.

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6.3 Artificial Intelligence

AI

AI

- Artificial Intelligence is a branch of computer science that involves creating computer systems that can **perform tasks that would normally require human intelligence**
- The goal of AI is to **simulate intelligent behaviour** in machines, including:
  - problem-solving, decision-making, natural language processing
- AI is often used in areas such as:
  - **Robotics**
  - **Natural language processing**
  - **Expert systems**
  - **Machine learning**
- Machine learning is a **subset of AI** that focuses on giving computers the ability to **learn and improve from data**, without being explicitly programmed
- There are different types of AI, including weak AI, strong AI, and superintelligence
  - **Weak AI**, also known as narrow AI, is designed to perform a specific task or set of tasks
  - **Strong AI**, also known as artificial general intelligence (AGI), is designed to perform any intellectual task that a human can do
  - Superintelligence is a hypothetical AI that would surpass human intelligence in all areas
- AI has advantages such as increased efficiency, accuracy, and scalability
- However, AI also has disadvantages such as the potential for job loss, biassed decision-making, and ethical concerns around its use

Characteristics

- Collection of data and rules
  - AI systems require **large amounts of data** to perform tasks
  - The data is processed using **rules or algorithms** that enable the system to make decisions and predictions
- Ability to reason
  - AI systems can use logical reasoning to evaluate information and **make decisions** based on that information
- Ability to learn and adapt
  - This will mean it can change its own rules and data

AI systems can be designed to **learn from past experiences** and adjust their behaviour accordingly

Components

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There are two main types of AI systems:

Expert Systems:

- Have a **knowledge base**
  - A database of **facts to generate rules** that are used to solve problems and **make decisions**
- Have a **rule base**
  - A set of rules or logic that is used to **apply the knowledge** in the knowledge base **to specific problems**
- Have an **inference engine**
  - A program that **applies the rules** in the rule base **to the facts** in the knowledge base **to solve problems**
- Have an **interface**
  - A way for **users to interact with the system** and provide input

Machine Learning:

- The program has the ability to **automatically adapt its own processes** and/or data
- **Uses algorithms** to analyse data and **identify patterns** or relationships
- The system can learn from the data and **improve its performance** over time
- Can be **supervised or unsupervised**:
  - Supervised machine learning uses labelled data to train the system
  - Unsupervised machine learning uses unlabelled data