



DEPARTMENT OF MECHATRONICS ENGINEERING

TECHNICAL MAGAZINE

Issue 1[March, 2022]

Message from the Head of Department

The Department commenced its academic journey in the year of 2013 and built-up ambience and infrastructural facilities for effective academic and research activities over the period. Our students have excelled in curricular, co-curricular and extra-curricular activities. Mechatronics major combines the areas of Mechanical, Electronics, Computer Systems and Software Engineering to equip students with requisite skills in Robotics and Automation. The Mechatronics Engineering programme is wholly tailored towards moulding competent engineers who would oversee the design, manufacture and optimization of products that serve humanity, keeping firmly in mind the urgent sustainable technological need of a developing nation and the global community at large.



Dr.R.SIVAKUMAR

Professor and Head

Department of Mechatronics Engineering

VISION AND MISSION OF THE DEPARTMENT

VISION OF THE DEPARTMENT

Developing competent Mechatronics Engineers with a focus on employability, research capability, entrepreneurship and human values.

MISSION OF THE DEPARTMENT

DM 1: To adopt transforming teaching-learning strategies in the field of Mechatronics Engineering by providing innovative and value-based education with relevant industrial exposure in basic domain and interdisciplinary areas.

DM 2: To nurture entrepreneurial skills with social and ethical values and develop the students for life-long learning to achieve professional excellence.

DM 3: To provide the facilities for implementation of automation techniques in real-life environment to meet the needs of industry and society.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

PEO 1: The graduates will be able to apply Mechatronics systems and components to promote automation as per the needs of industry and society.

PEO 2: The graduates will be able to pursue higher studies with a specific interest towards research and innovation in Mechatronics and allied areas.

PEO 3: The graduates will be able to nurture ethical values and generate employment for the social and economic development.

PROGRAM SPECIFIC OUTCOMES (PSOs)

PSO 1: Professional skills: Students shall have skills and knowledge in mechatronics domains like robotics, electronics, computer science, telecommunication, systems, controls and product engineering for innovative products incubation.

PSO 2: Competency: Students shall qualify at the State, National and International level competitive examination for employment, higher studies and research.

PROGRAM OUTCOMES (POs)

PO 1: Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO 2: Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO 3: Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations

PO 4: Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO 5: Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO 6: The Engineer and Society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO 7: Environment and Sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO 8: Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO 9: Individual and Team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO 10: Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO 11: Project management and Finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO 12: Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

MESSAGE FROM EDITORIAL TEAM

We are pleased to present the second issue of our technical magazine, focusing on intermediate concepts in Robotics, Automation, and Mechatronics. We appreciate your support and enthusiasm for our first issue, and we are excited to continue this journey with you.

In this edition, we have curated a selection of articles that delve deeper into key topics and technologies within these fields. Our contributors have worked hard to provide you with valuable insights and practical knowledge that can enhance your understanding and skills.

As we explore these intermediate concepts, we encourage you to engage with the content, ask questions, and share your thoughts. Your feedback is vital in helping us improve future issues and ensuring that we meet your interests and needs.

Thank you for being a part of our community. We hope you find this issue informative and inspiring as we continue to explore the world of mechatronics together.

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FOUNDATIONS OF ROBOTICS, AUTOMATION, AND MECHATRONICS

INTRODUCTION

Robotics, automation, and mechatronics are interconnected fields that play a crucial role in modern technology. They involve the design, development, and application of systems that can perform tasks autonomously or semi-autonomously. Understanding the foundations of these fields is essential for anyone interested in engineering, manufacturing, or technology.

ROBOTICS

Robotics is the branch of technology that deals with the design, construction, operation, and application of robots. Robots are programmable machines capable of carrying out a series of actions autonomously or semi-autonomously.

KEY COMPONENTS OF ROBOTS:

- **Sensors:** These allow robots to perceive their environment. Common sensors include cameras, ultrasonic sensors, and infrared sensors.
- **Actuators:** These are the components that enable robots to move and interact with their environment. Examples include motors and hydraulic systems.
- **Control Systems:** These are the brains of the robot, processing input from sensors and sending commands to actuators.

Applications of Robotics:

- **Manufacturing:** Robots are widely used in assembly lines for tasks such as welding, painting, and assembling parts.
- **Healthcare:** Surgical robots assist doctors in performing precise operations.

- **Exploration:** Robots are used in space exploration and underwater research where human presence is challenging.

AUTOMATION

Automation refers to the use of technology to perform tasks with minimal human intervention. It aims to increase efficiency, accuracy, and productivity in various processes.

TYPES OF AUTOMATION:

- **Fixed Automation:** This involves the use of specialized equipment to perform a specific set of tasks. It is commonly used in mass production.
- **Programmable Automation:** This type allows for reprogramming to accommodate different tasks. It is suitable for batch production.
- **Flexible Automation:** This is the most advanced form, allowing for quick changes in production processes. It is used in environments where products change frequently.

BENEFITS OF AUTOMATION:

- **Increased Productivity:** Automation can operate continuously without breaks, leading to higher output.
- **Improved Quality:** Automated systems can perform tasks with high precision, reducing errors.
- **Cost Reduction:** Automation can lower labor costs and reduce waste.

MECHATRONICS

Mechatronics is an interdisciplinary field that combines mechanical engineering, electrical engineering, computer science, and control engineering. It focuses on the design and creation of intelligent systems and products.

CORE ELEMENTS OF MECHATRONICS:

- **Mechanical Systems:** These include the physical components and structures of a system.
- **Electronic Systems:** These involve the use of sensors, actuators, and control circuits.
- **Control Systems:** These manage the behavior of the system, often using software algorithms.
- **Computer Systems:** These provide the computational power needed for processing data and executing control algorithms.

APPLICATIONS OF MECHATRONICS:

- **Automotive Industry:** Mechatronics is used in the development of advanced driver-assistance systems (ADAS) and autonomous vehicles.
- **Consumer Electronics:** Products like smartphones and smart home devices rely on mechatronic principles.
- **Industrial Automation:** Mechatronics plays a key role in the development of automated machinery and robotics.

CONCLUSION

Robotics, automation, and mechatronics are foundational fields that drive innovation and efficiency in various industries. By understanding their core principles and applications, one can appreciate the technological advancements that shape our world. These fields offer exciting opportunities for those interested in engineering and technology, promising a future where intelligent systems and automation play an even greater role in our daily lives.

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CHAPTER 1 - INTRODUCTION TO ROBOTICS

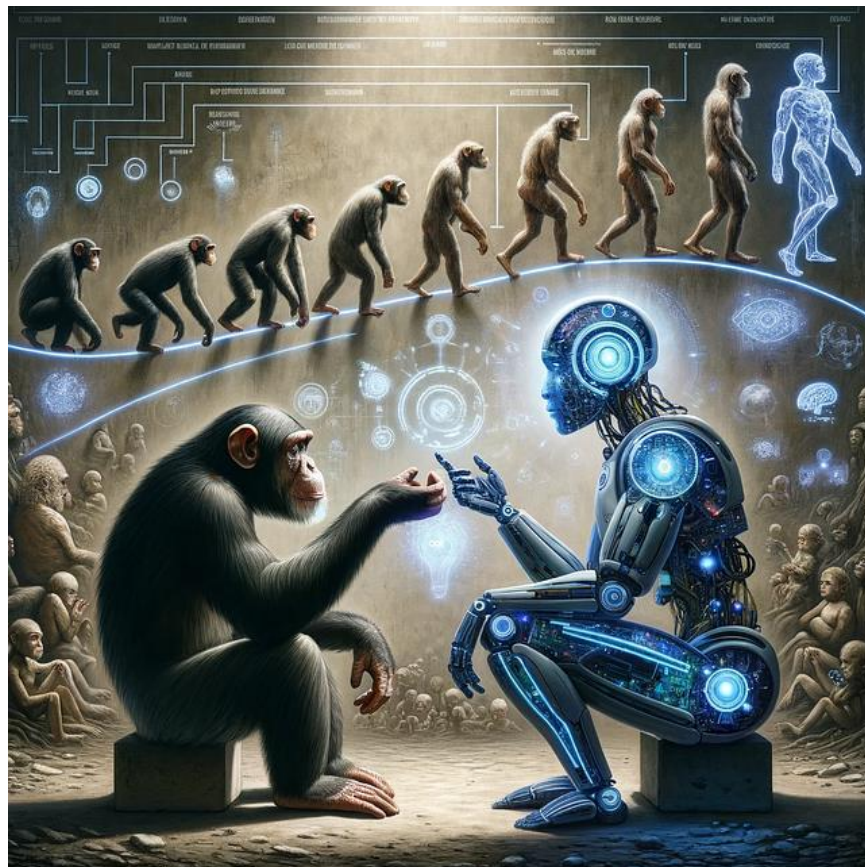
OVERVIEW OF ROBOTICS

INTRODUCTION

Robotics is an interdisciplinary field that combines elements of mechanical engineering, electrical engineering, computer science, and other disciplines to design, build, and operate robots. Robots are programmable machines capable of performing a variety of tasks autonomously or semi-autonomously. This overview will cover the history, key components, types, and applications of robotics.

HISTORY AND EVOLUTION

The concept of robots dates back to ancient civilizations, where myths and legends spoke of mechanical beings. However, modern robotics began in the 20th century. The term “robot” was first used by Czech writer Karel Čapek in his 1920 play “R.U.R.” (Rossum’s Universal Robots). The development of robotics accelerated with advancements in technology, particularly during the mid-20th century with the invention of programmable computers.



KEY COMPONENTS OF ROBOTS

Robots are composed of several essential components that enable them to perform tasks:

1. **Sensors:** These devices allow robots to perceive their environment. Common sensors include cameras, ultrasonic sensors, and infrared sensors. They provide data that the robot's control system uses to make decisions.
2. **Actuators:** Actuators are the components that enable robots to move and interact with their environment. Examples include electric motors, hydraulic systems, and pneumatic systems. They convert energy into motion.
3. **Control Systems:** The control system is the brain of the robot. It processes input from sensors and sends commands to actuators. Control systems can be simple, like a set of instructions, or complex, involving artificial intelligence and machine learning algorithms.
4. **Power Supply:** Robots require a power source to operate. This can be in the form of batteries, solar power, or a direct electrical connection.
5. **End Effectors:** These are the tools or devices at the end of a robotic arm, designed to interact with the environment. Examples include grippers, welding torches, and paint sprayers.



BASIC TYPES OF ROBOTS

Industrial Robots: These robots are used in manufacturing and production environments. They are designed for tasks such as welding, painting, assembly, and material handling. Industrial robots are typically stationary and operate in a fixed location.

1. **Mobile Robots:** Mobile robots can move around in their environment. Examples include autonomous vehicles, drones, and robotic vacuum cleaners. They are equipped with navigation systems to avoid obstacles and reach their destinations.
2. **Service Robots:** Service robots assist humans in various tasks, such as cleaning, cooking, and providing companionship. Examples include robotic vacuum cleaners, lawn mowers, and social robots like Pepper.
3. **Medical Robots:** These robots are used in healthcare for tasks such as surgery, rehabilitation, and patient care. Surgical robots, like the da Vinci Surgical System, allow for precise and minimally invasive procedures.
4. **Exploration Robots:** Exploration robots are designed for tasks in hazardous or inaccessible environments. Examples include space rovers like NASA's Curiosity rover on Mars and underwater robots used for ocean exploration.

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CHAPTER 2- BASICS OF AUTOMATION

INTRODUCTION TO AUTOMATION

Automation is a transformative technology that revolutionizes how tasks are performed by minimizing human intervention. By leveraging machines, robotics, and computerized systems, automation streamlines processes, enhances efficiency, and reduces errors. Let's delve into the world of automation, exploring its types, benefits, and importance.



WHAT IS AUTOMATION?

At its core, **automation** refers to using technology to execute tasks with minimal human involvement. Rather than relying solely on manual labor, automation employs robots, computers, or other devices to handle repetitive or complex activities. The goal is to achieve greater efficiency and accuracy while freeing humans from mundane tasks.

TYPES OF AUTOMATION

1. **Basic Automation:**

- **Definition:** Basic automation targets simple, routine tasks and digitizes them. Examples include distributing onboarding materials to new hires, forwarding documents for approvals, or automatically sending invoices to clients.
- **Benefits:**
 - Eliminates errors associated with manual work.
 - Accelerates transactional processes.

- Frees employees to focus on higher-value tasks.

2. Process Automation:

- **Definition:** Process automation tackles more complex, multi-step processes (often involving multiple systems). It brings uniformity and transparency to business and IT processes.
- **Examples:**
 - **Process Mining:** Analyzing process data to identify bottlenecks and inefficiencies.
 - **Workflow Automation:** Automating approval workflows or task sequences.
 - **Business Process Management (BPM):** Managing end-to-end processes.
 - **Robotic Process Automation (RPA):** Using software robots to perform rule-based tasks.

3. Intelligent Automation:

- **Definition:** This advanced form combines artificial intelligence (AI), business process management, and RPA. It scales decision-making across organizations.
- **Components:**
 - **Virtual Agents:** AI-powered chatbots or virtual assistants.
 - **Natural Language Processing (NLP):** Understanding and generating human language.
 - **Intelligent Search:** Enhancing search capabilities.
- **Benefits:**
 - Reduces costs.
 - Empowers employees and customers.
 - Enhances productivity and customer experience.

IMPORTANCE OF AUTOMATION

- **Productivity Boost:** Automation accelerates processes, allowing organizations to achieve more with fewer resources.

- **Error Reduction:** Automated systems minimize human errors, leading to better quality outcomes.
- **Cost Savings:** By optimizing workflows, automation reduces operational costs.
- **Scalability:** Businesses can scale efficiently by automating repetitive tasks.
- **Digital Transformation:** Automation is a key component of digital transformation initiatives.

THE IMPORTANCE OF AUTOMATION IN MODERN INDUSTRIES

Automation is a pivotal force shaping the landscape of modern industries. As technology advances, businesses are increasingly turning to automation to enhance efficiency, reduce costs, and improve overall productivity. Let's explore why automation matters and how it impacts various aspects of industry.

1. Boosting Productivity

- **Efficiency Gains:** Industrial automation significantly increases productivity by streamlining tasks, processes, and operations. What once required armies of workers can now be accomplished with a fraction of that labor force. For instance, consider car manufacturing or food processing plants from a few decades ago—today, automation handles much of the workload.
- **Digitalization and IIoT:** The digitalization of manufacturing, coupled with the Industrial Internet of Things (IIoT), enables increased throughput and minimized downtime. Sensors on machinery allow for real-time monitoring, predictive maintenance, and optimized utilization

2. Quality Enhancement

- **Consistency:** Automated processes ensure consistent quality by minimizing human error. Whether it's precision machining or assembly lines, automation maintains uniformity.
- **Reduced Variability:** Automation reduces product variability, leading to better quality control and customer satisfaction.

3. Cost Reduction and Profitability

- **Labor Costs:** While automation may replace some manual tasks, it also frees up workers to focus on more complex and creative aspects. Machinists, for example, can shift from routine operations to programming and inspection. This transition requires additional

education and training, but it ultimately enhances job satisfaction and attracts skilled workers.

- **Operational Efficiency:** Automation optimizes resource utilization, reduces waste, and minimizes production bottlenecks. It also allows companies to scale without proportionally increasing labor costs.
- **Maintenance Savings:** Predictive maintenance through automation ensures machinery operates at peak efficiency, reducing costly downtime.

4. Safety and Risk Mitigation

- **Workplace Safety:** Automation minimizes exposure to hazardous conditions. Robots and machines handle repetitive, physically demanding, or dangerous tasks, reducing the risk of workplace injuries.
- **Compliance:** Automated systems adhere consistently to safety and regulatory standards, avoiding costly penalties.

5. Addressing Labor Shortages

- **Skills Gap:** As experienced workers retire, industries face a skills gap. Automation helps bridge this gap by allowing existing employees to take on higher-level responsibilities.
- **Attracting Talent:** Positions that involve programming, maintenance, and process optimization become more appealing to skilled workers seeking fulfilling work.

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CHAPTER 3 - INTRODUCTION TO MECHATRONICS

INTRODUCTION

Mechatronics, often referred to as the synergy of mechanics, electronics, and computing, is a dynamic and interdisciplinary field of engineering. It seamlessly integrates various domains to create smarter, more efficient systems. Let's delve into the world of mechatronics, exploring its components, applications, and significance.

INTEGRATION OF MECHANICAL, ELECTRONIC, AND CONTROL SYSTEMS

At its core, **mechatronics** represents the fusion of several engineering disciplines, including:

1. Mechanical Engineering:

- Involves designing and analyzing mechanical systems, such as sensors, actuators, and mechanical structures.
- Examples include robotic arms, automated machinery, and consumer products like cameras with auto-focus mechanisms.

2. Electronics:

- Utilizes electronic components and circuits to control and monitor mechanical aspects.
- Sensors collect data from the environment, while microcontrollers or microprocessors process this data to make decisions and control actuators.
- Circuit design, PCBs (Printed Circuit Boards), and electronic components play a crucial role.

3. Control Systems:

- Mechatronic systems often rely on control theory to regulate the behavior of mechanical components.
- Control systems ensure precise movement, stability, and responsiveness.

APPLICATIONS OF MECHATRONICS IN VARIOUS FIELDS

Mechatronics finds applications across various fields:

1. Manufacturing and Robotics:

- Industrial robots benefit significantly from mechatronics.

- Smaller robots handle pick-and-place operations, while larger ones perform tasks like welding, assembly, and material handling.
 - Control systems optimize production lines, ensuring efficiency and quality.
2. Automotive Industry:
- Mechatronics play a pivotal role in modern vehicles.
 - Anti-lock braking systems (ABS), electronic stability control (ESC), and adaptive cruise control rely on mechatronic principles.
 - Sensors, actuators, and control algorithms enhance safety and performance.
3. Consumer Electronics:
- Cameras, smartphones, and home appliances incorporate mechatronic features.
 - Auto-focus mechanisms, image stabilization, and automatic door openers exemplify mechatronics in everyday devices.
4. Aerospace and Aviation:
- Aircraft control surfaces, landing gear, and avionics systems benefit from mechatronics.
 - Precision and reliability are critical in aviation, making mechatronics indispensable.

KEY CONCEPTS: SENSORS, ACTUATORS, AND MICROCONTROLLERS

Introduction

In the fascinating world of mechatronics, three fundamental components play crucial roles: sensors, actuators, and microcontrollers. Let's explore each of these key concepts and understand their significance in creating intelligent systems.

1. Sensors

- What Are Sensors?
 - Sensors are devices that convert physical events or environmental changes into electrical signals.
 - They act as the sensory organs of mechatronic systems, providing information about the external world.
 - Examples include temperature sensors, pressure sensors, light sensors, and proximity sensors.

- How Sensors Work:
 - Each type of sensor operates based on specific principles (e.g., resistive, capacitive, or optical).
 - When exposed to a stimulus (such as heat, pressure, or light), sensors generate an electrical output.
 - This output can be analog (continuous voltage) or digital (discrete values).

2. Actuators

- What Are Actuators?
 - Actuators are devices that convert electrical signals into physical actions or movements.
 - They bring mechatronic systems to life by manipulating the environment.
 - Examples include motors, solenoids, pneumatic cylinders, and servos.
- Types of Actuators:
 - Rotary Actuators: These produce rotational motion (e.g., electric motors).
 - Linear Actuators: They create linear motion (e.g., hydraulic cylinders or solenoids).
 - Combination Actuators: Some actuators combine both rotational and linear motion.

3. Microcontrollers

- What Are Microcontrollers?
 - Microcontrollers (MCUs) are compact integrated circuits that combine a processor (CPU), memory, and peripherals.
 - Unlike general-purpose computers, MCUs are designed for specific tasks and operate in real-time.
 - They serve as the brains of mechatronic systems, executing control algorithms.
- Features of Microcontrollers:
 - Low Power Consumption: MCUs are energy-efficient, making them ideal for battery-powered devices.
 - Peripheral Interfaces: MCUs have built-in interfaces (GPIO pins, ADCs, UART, etc.) to connect with sensors and actuators.
 - Real-Time Capabilities: MCUs respond quickly to external events, critical for control applications.

INTEGRATION OF SENSORS, ACTUATORS, AND MICROCONTROLLERS

- The Workflow:
 1. Sensors: Sensing data (e.g., temperature, proximity) is collected by sensors.
 2. Microcontrollers: The data is sent to microcontrollers for processing.
 3. Control Algorithms: Microcontrollers analyze the data and generate control signals.
 4. Actuators: Actuators receive these signals and perform physical actions (e.g., motor rotation, valve opening).

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CHAPTER 4 - BASIC CONTROL SYSTEMS

FUNDAMENTALS OF CONTROL SYSTEMS

Control systems play a crucial role in regulating and directing the behavior of various devices or systems. Whether it's an electronic circuit, an industrial robot, or even our own body, control systems are everywhere. Let's dive into the fundamentals of control systems, understanding their types and applications. One of the primary features of ICMS is its robust user authentication and authorization system. The application implements a secure login mechanism

OPEN-LOOP VS. CLOSED-LOOP CONTROL

Open-Loop Control System:

- In an open-loop system, the control action is independent of whether the desired output is achieved.
- There is no feedback involved; the output doesn't influence the control input.
- Example: A microwave oven with a fixed cooking time—no adjustments based on actual cooking progress.

Closed-Loop Control System (Feedback Control):

- Most control systems fall into this category.
- Here, the output affects the control action, creating a feedback loop.
- A sensor measures the system's actual performance, and the controller adjusts the input accordingly.
- Example: A smart microwave oven with a sensor that detects when the food is fully cooked and adjusts the cooking time accordingly.

INTRODUCTION TO FEEDBACK SYSTEMS

Feedback is a fundamental concept that permeates various aspects of our lives. From biological processes to engineering systems, understanding feedback mechanisms is essential for achieving

desired outcomes. In this overview, we'll explore the basics of feedback systems, their historical context, and their relevance in modern engineering and control.

WHAT IS FEEDBACK?

At its core, **feedback** refers to the process of information returning to modify a system's behavior. Imagine a thermostat in your home: it senses the room temperature, compares it to the desired setting, and adjusts the heating or cooling accordingly. This closed-loop process ensures that the room maintains the desired temperature.

BASIC EXAMPLES AND APPLICATIONS

1. Industrial Automation:
 - Robots, assembly lines, and manufacturing processes rely on feedback for precision and efficiency.
2. Biomedical Devices:
 - Pacemakers, insulin pumps, and drug delivery systems use feedback to regulate physiological processes.
3. Aerospace and Automotive Systems:
 - Flight control systems, cruise control, and stability control benefit from feedback.
4. Climate Control:
 - Thermostats, air conditioning, and heating systems maintain desired temperatures.
5. Communication Networks:
 - Feedback ensures reliable data transmission and error correction.

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