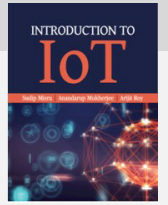
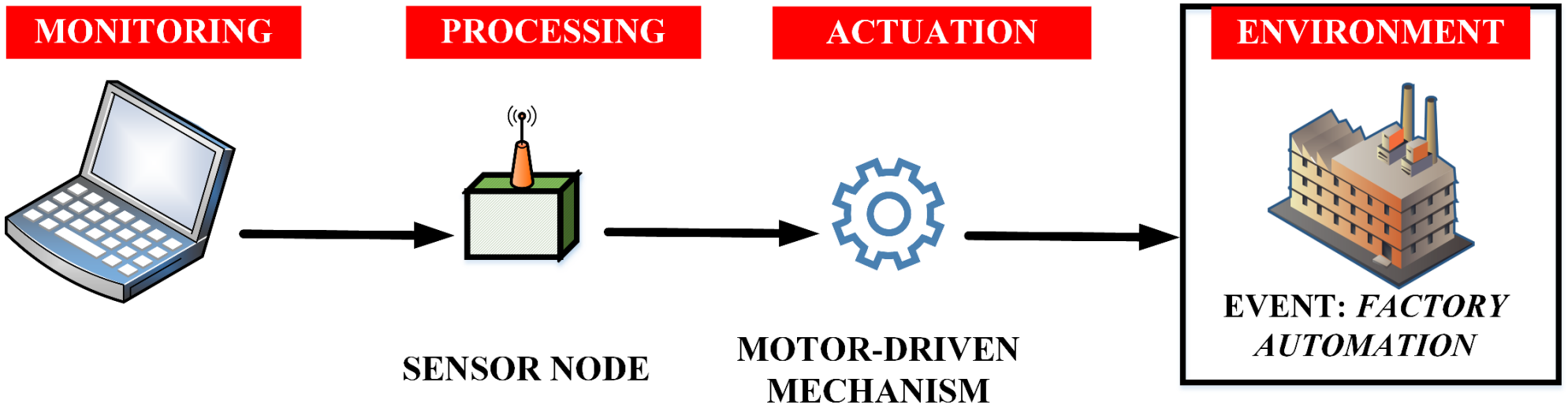
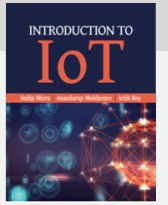


Actuators

- An actuator can be considered as a machine or system's component that can affect the movement or control the said mechanism or the system.
- Control systems affect changes to the environment or property they are controlling through actuators.
- The control system activates the actuator through a control signal, which may be digital or analog.
- The control system elicits a response from the actuator, which is in the form of some form of mechanical motion.
- The control system of an actuator can be a mechanical or electronic system, a software-based system (e.g., an autonomous car control system), a human, or any other input.

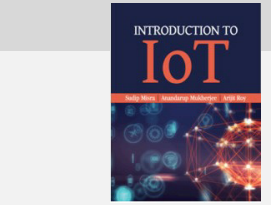




Actuator Types

Broadly, actuators can be divided into seven classes

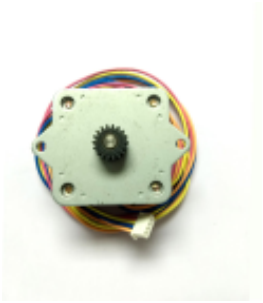
1. Hydraulic Pneumatic
2. Electrical
3. Thermal/ Magnetic
4. Mechanical
5. Soft
6. Shape Memory Polymers.
7.



Some Actuators

(o) Brushless DC motor

(p) Brushless DC motor



(q) Stepper motor

(r) Geared DC motor

(s) DC motor

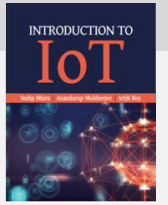
(t) Relay array

(u) Hydroelectric flow generator

(v) Hydroelectric flow generator

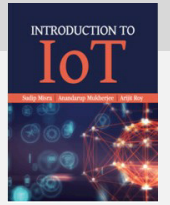
(w) Solenoid-based valve

(x) Solenoid-flow valve



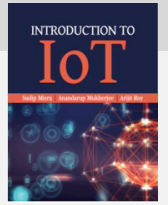
Electric Actuators

1. Typically, electric motors are used to power an electric actuator by generating mechanical torque.
2. This generated torque is translated into the motion of a motor's shaft or for switching (as in relays).
3. For example, actuating equipments such as solenoid valves, control the flow of water in pipes in response to electrical signals.
4. This class of actuators is considered one of the cheapest, cleanest and speedy actuator types available.



Thermal or Magnetic Actuators

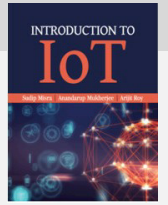
1. The thermal or magnetic energy is used for actuation tasks using this class of actuators.
2. These actuators have a very high power density and are typically compact, lightweight, and economical.
3. One classic example of thermal actuators is shape-memory materials (SMMs) such as shape memory alloys (SMAs).
4. These actuators do not require electricity for actuation.
5. These are not affected by vibration and can work with liquid or gases. Magnetic shape memory alloys (MSMAs) are a type of magnetic actuator.



Mechanical Actuators

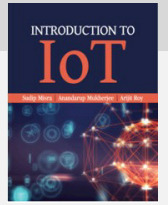
1. In mechanical actuation, the rotary motion of the actuator is converted into linear motion to execute some movement.
2. The use of gears, rails, pulleys, chains, and other devices are necessary for these actuators to operate.
3. These actuators can be easily used in conjunction with pneumatic(device that converts energy typically in the form of compressed air into mechanical motion) hydraulic, or electrical actuators.
4. They can work in a standalone mode also. The best example of a mechanical actuator is a rack and pinion mechanism.

For example, a hydroelectric generator convert the water-flow induced rotary motion of a turbine into electrical energy.



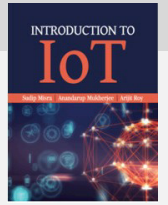
Soft Actuators

1. Soft actuators (e.g., polymer-based) consists of elastomeric polymers, which are used as embedded fixtures in flexible materials such as cloth, paper, fiber, particles, and others.
2. The conversion of molecular level microscopic changes into tangible macroscopic deformations is the primary working principle of this class of actuators.
3. These actuators have a high stake in modern-day robotics. They are designed to handle fragile objects such as agricultural fruit harvesting, or performing precise operations like manipulating the internal organs during robot-assisted surgeries.



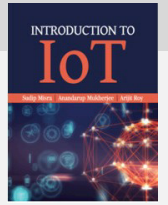
Shape Memory Polymers

1. Shape memory polymers (SMP) are considered as smart materials, which respond to some external stimulus by changing their shape, and then revert to their original shape once the affecting stimulus is removed.
2. Features such as high strain recovery, biocompatibility, low density, and biodegradability characterize these materials.
3. SMP-based actuators function similar to our muscles.
4. Modern-day SMPs have been designed, which respond to a wide range of stimuli such as pH changes, heat differentials, light intensity, and frequency changes, magnetic changes, and others.



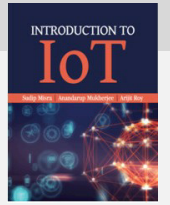
Light Activated Polymers

1. Photopolymer/light-activated polymers (LAP) are a particular type of SMP, which require light as a stimulus to operate.
2. LAP-based actuators are characterized by their rapid response times. Using only the variation of light frequency or its intensity, LAPs can be controlled remotely without any physical contact.
3. The development of LAPs have been reported, whose shape can be changed by the application of a specific frequency of light.
4. The polymer retains its shape after removal of the activating light. In order to change the polymer back to its original shape, a light stimulus of a different frequency has to be applied to them.



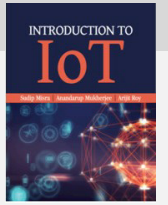
Actuator Characteristics

- The choice or selection of actuators is crucial in an IoT deployment, where a control mechanism is required after sensing and processing of the information obtained from the sensed environment.
- Actuators perform the physically heavier tasks in an IoT deployment, which require moving or changing the orientation of physical objects, changing the state of objects, and other such activities.
- The correct choice of actuators is necessary for the long-term sustenance and continuity of operations, as well as for increasing the lifetime of the actuators themselves.



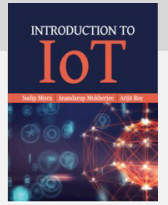
Actuator Characteristics: Weight

- The physical weight of actuators limits its application scope.
- For example, the use of heavier actuators is generally preferred for industrial applications and applications requiring no mobility of the IoT deployment.
- In contrast, lightweight actuators typically find common usage in portable systems used in vehicles, drones, and home IoT applications.
- It is to be noted that this is not always true. Heavier actuators also have selective usage in mobile systems, e.g., landing gears and engine motors in aircraft.



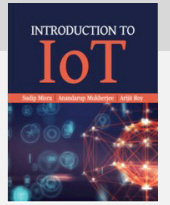
Actuator Characteristics: Power Rating

- This helps in deciding the nature of the application with which an actuator can be associated.
- The power rating defines the minimum and maximum operating power an actuator can safely withstand without damage to itself. Generally, it is indicated as the power-to-weight ratio for actuators. For example, smaller servo motors used in hobby projects typically have a maximum rating of 5VDC, 500mA, which is suitable for operations-driven using a battery-based power source.
- Exceeding this limit might be detrimental to the performance of the actuator and may cause burnout of the motor.
- In contrast to this, servo motors in larger applications have a rating of 460VAC, 2 5A, which requires standalone power supply systems for operations.
- It is to be noted that actuators with still higher ratings are available and vary according to application requirements.



Actuator Characteristics: Torque to Weight Ratio

- The ratio of torque to the weight of the moving part of an instrument/device is referred to as its torque/weight ratio.
- This indicates the sensitivity of the actuator. Higher is the weight of the moving part; lower will be its torque to weight ratio for a given power.



Actuator Characteristics: Stiffness and Compliance

- The resistance of a material against deformation is known as its stiffness, whereas compliance of a material is the opposite of stiffness.
- Stiffness can be directly related to the modulus of elasticity of that material.
- Stiff systems are considered more accurate than compliant systems as they have a faster response to the change in load applied to it.

For example, hydraulic systems are considered as stiff and non-compliant, whereas pneumatic systems are considered as compliant.