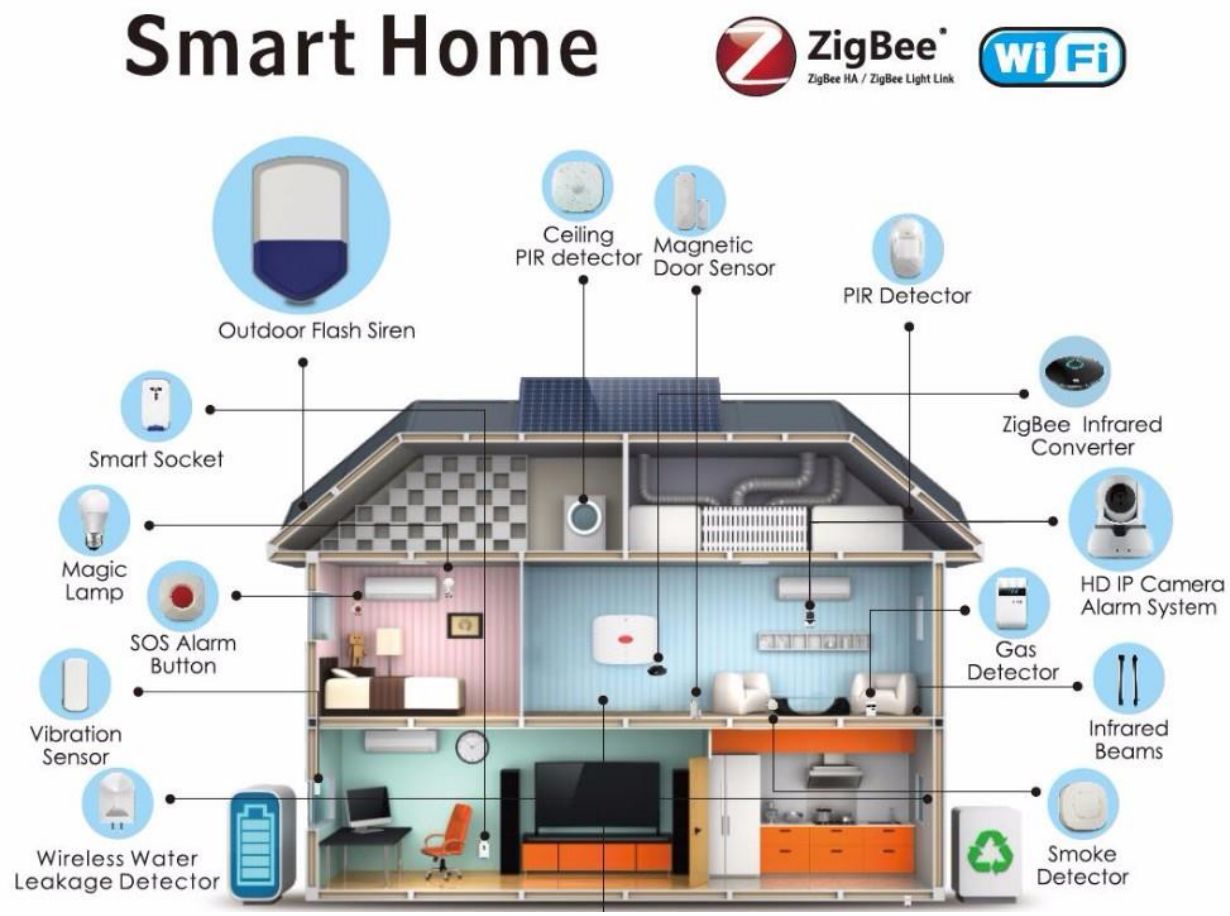
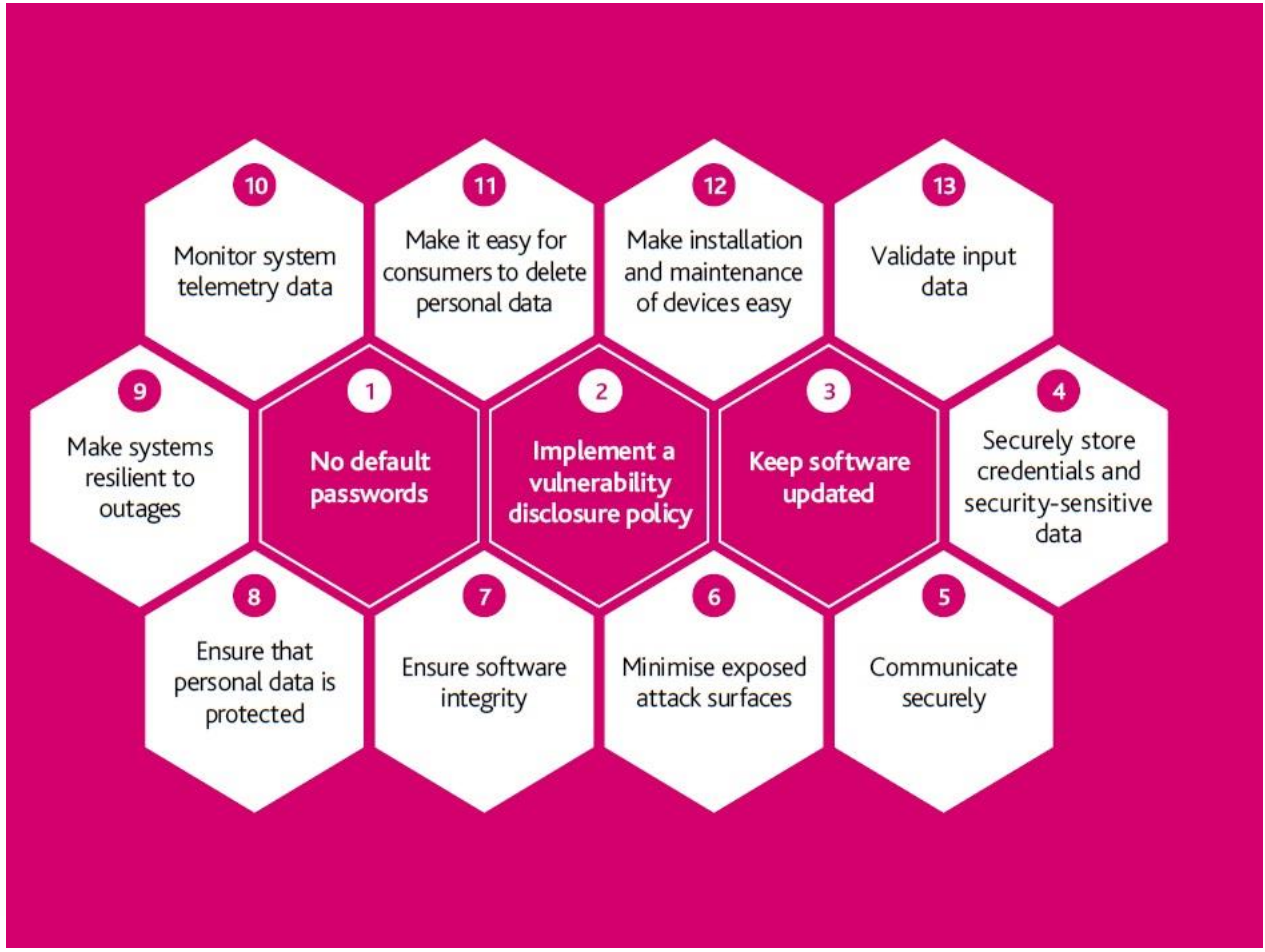
CASE STUDIES
Sensors & Actuators

Smart Home Sensors

Standards issued by UK govt
DDCMS 2018





Source: https://www.alibaba.com/product-detail/Smart-Home-2-4G-ZigBee-Indoor_60643366019.html

Smart city!!

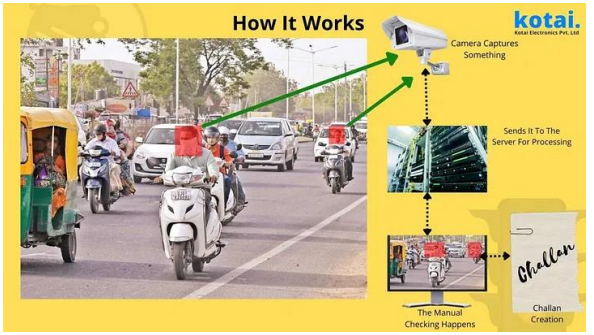
Management of disasters

Air pollution monitoring (control?)

Infrastructure management

<u>Reliability – require a good study of failures</u>

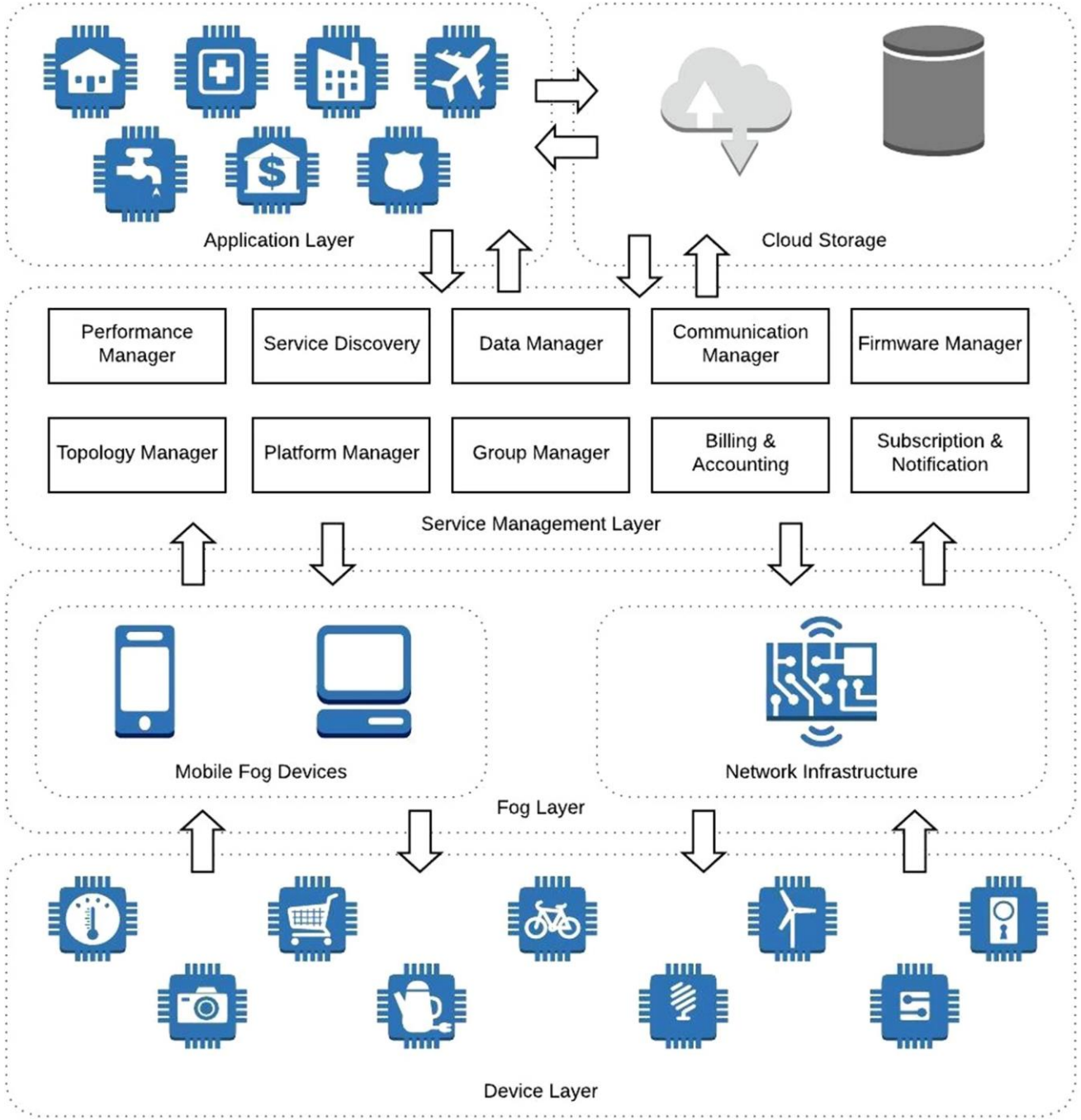
Mean Time to Failure (MTTF), closely related to Mean Time Between Failures (MTBF)
is the expected lifetime that the system will operate normally before a failure occurs.



Traffic management

Parking

Waste, water, and electricity management



https://link.springer.com/article/10.1007/s42486-020-00037-z

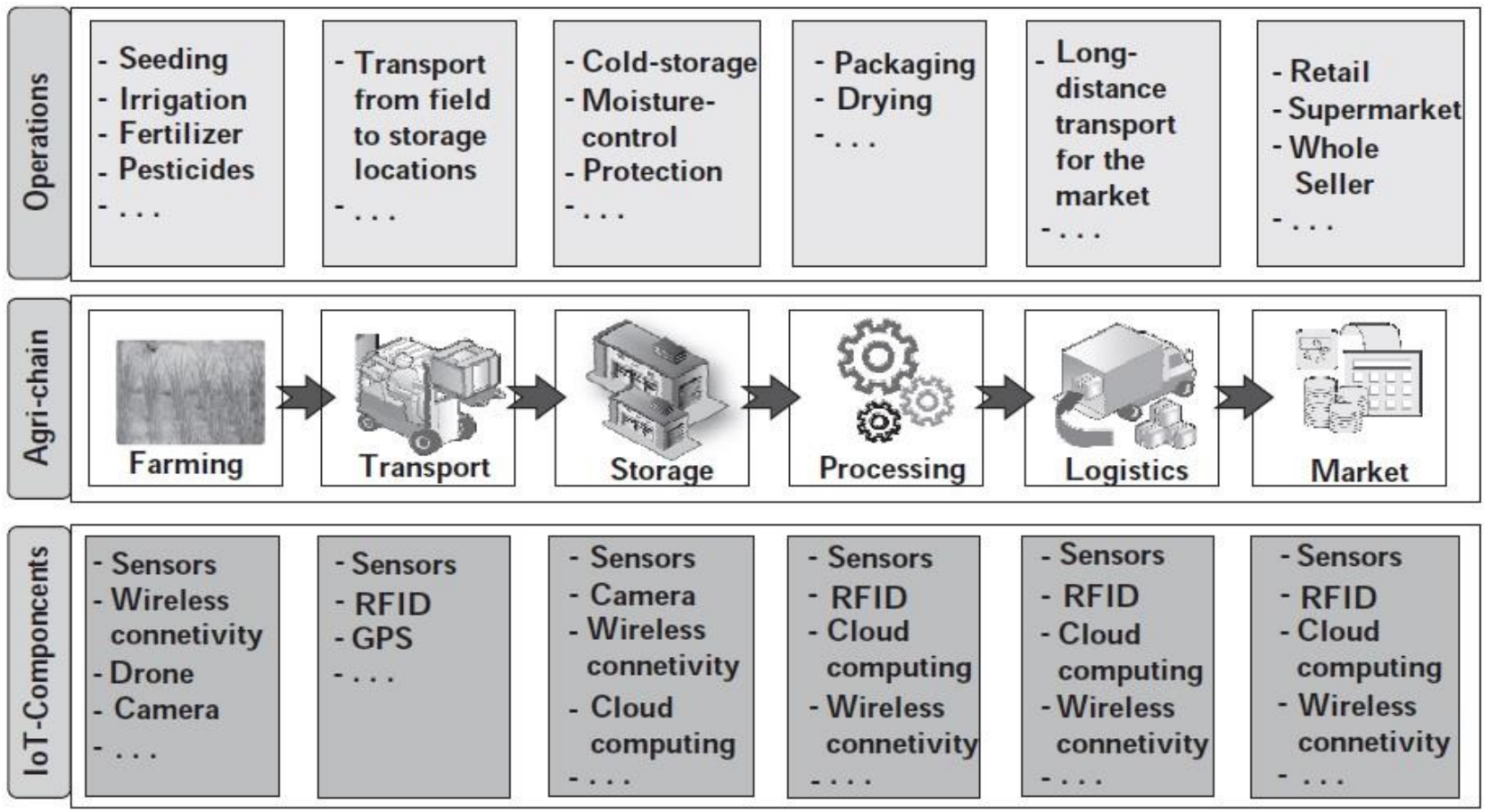
Case study – sensors in agriculture (IoT)

- Increase crop productivity
- Surveillance
- Cropping planning

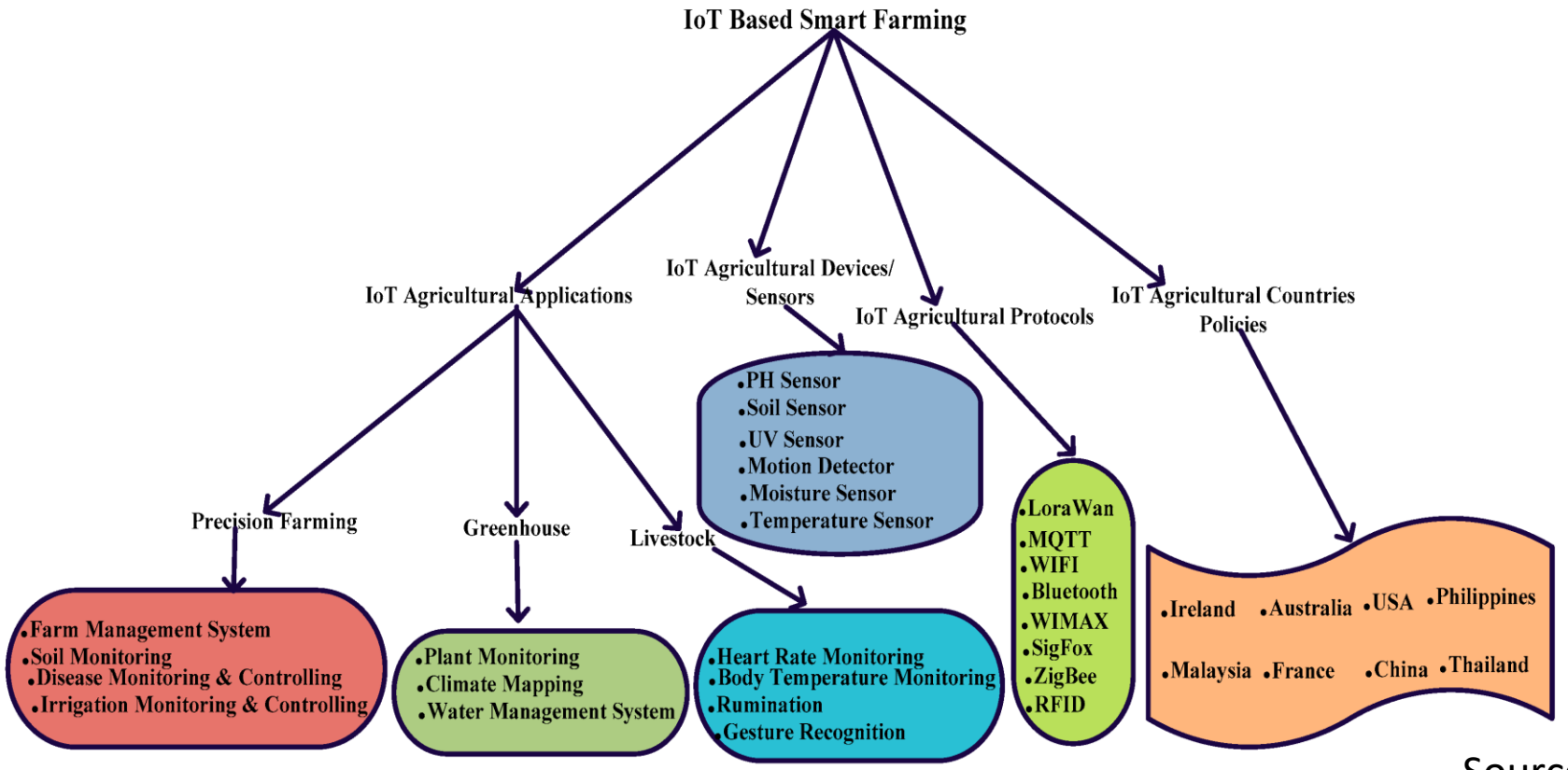
Agricultural sensors
Farming drones
Smart Greenhouses
Monitoring climate conditions
Crop management - Crop rotation
Water management
Cattle monitoring and management

Marut (https://www.marutdrones.com/

IoT components in the agricultural chain

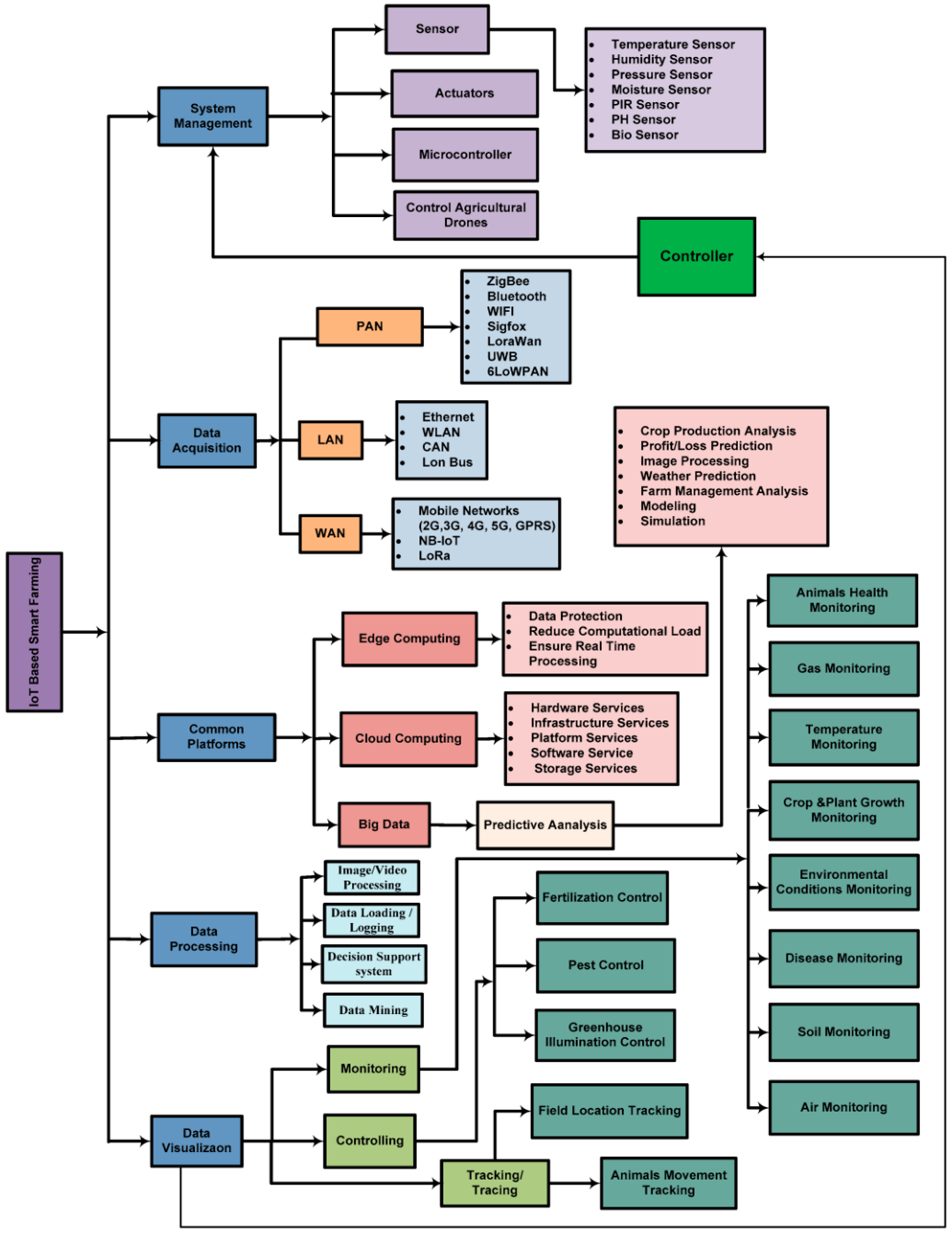


IoT in Agriculture



Source: Farooq et al.,2020

Role of IoT Technology in Agriculture: A Systematic Literature Review



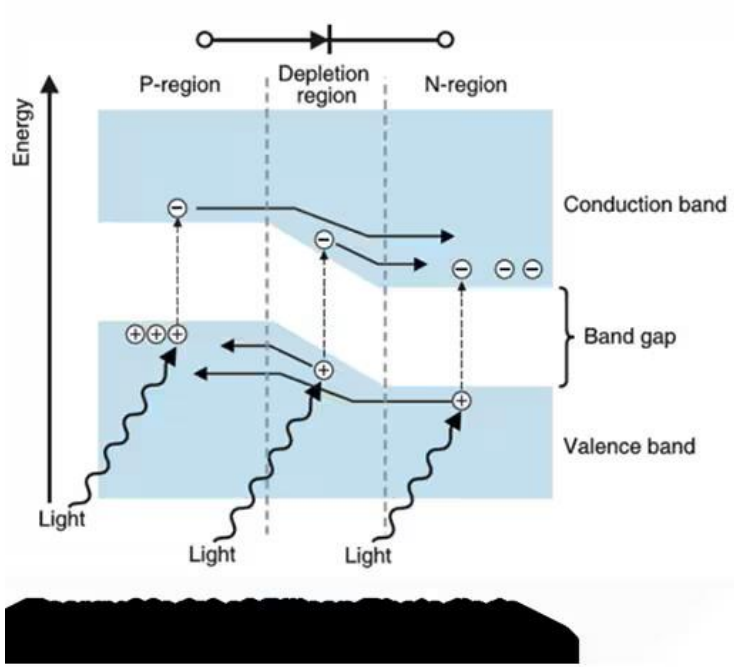
Source: Farooq et al.,2020

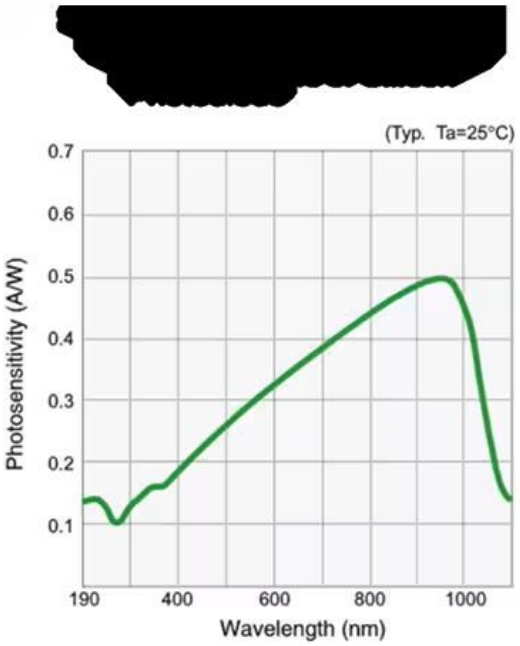
Role of IoT Technology in Agriculture: A Systematic Literature Review

In-situ assessment of leaf area index using IoT-based agricultural system

- The PAR (Photosynthetically Active Radiation) Sensor measures photosynthetic light levels in both air and water.

The PAR (Photosynthetically Active Radiation) Sensor reports the Photosynthetic Photon Flux Density (PPFD), which corresponds to micromoles of photons per meter squared per second (µmol m^{-2} s^{-1}).



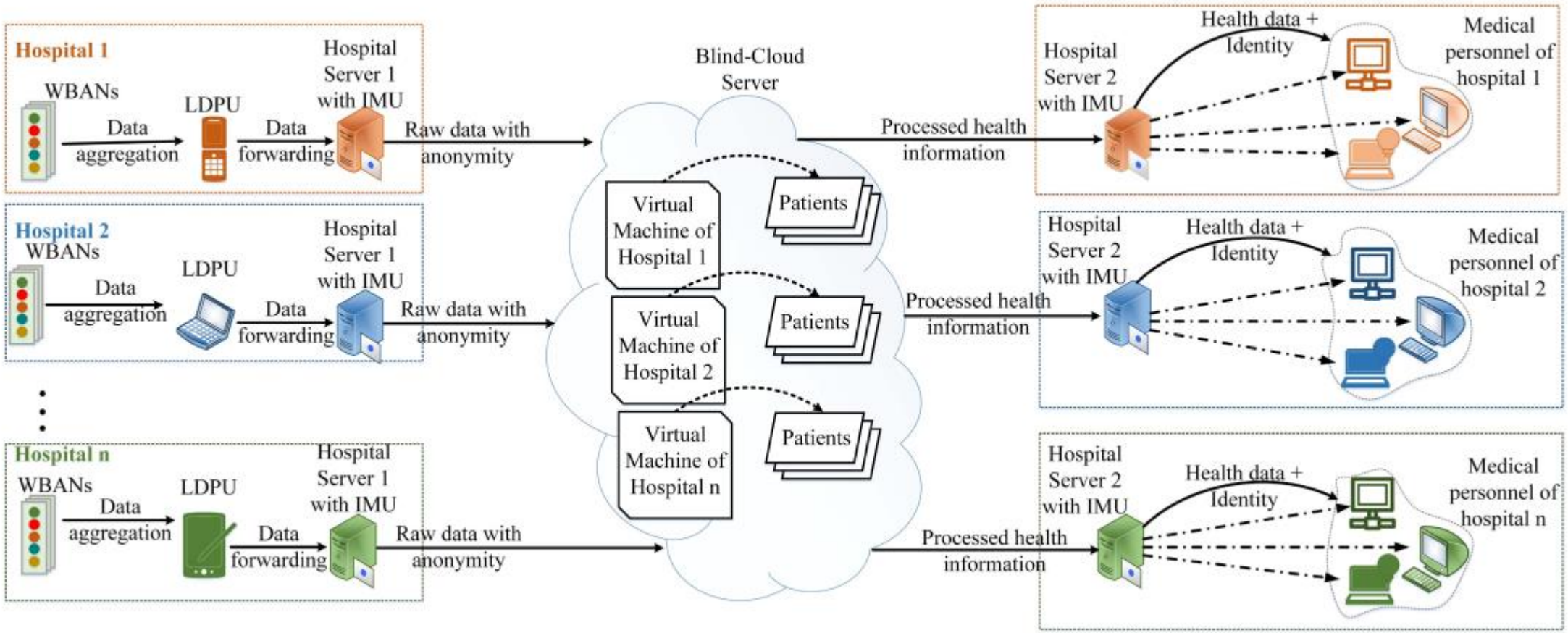


Source: Shimadzu

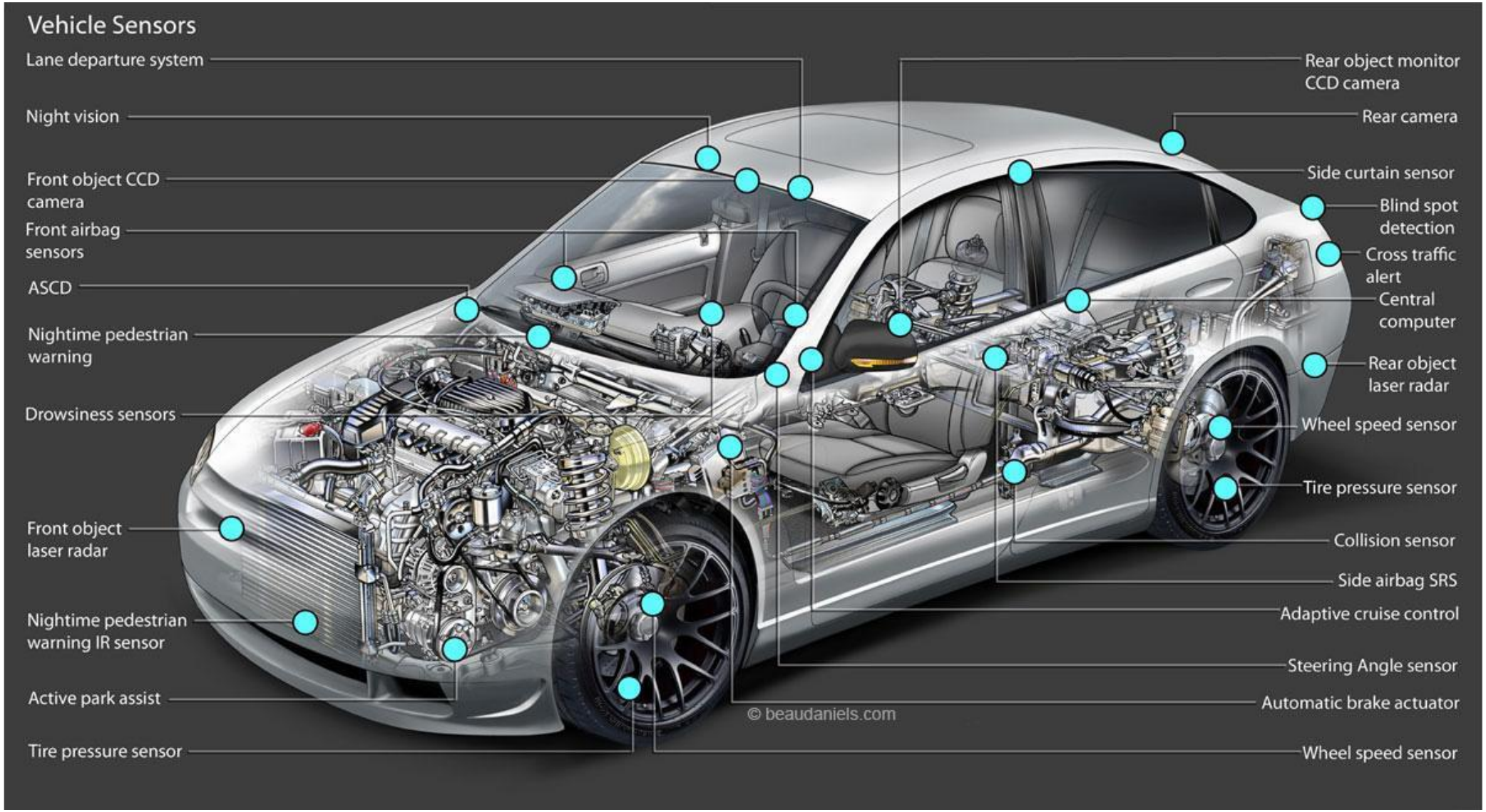
Healthcare IoT

- AmbuSens (IIT KGP students)

- connecting all patient vitals : hospital 1 ➔ ambulance ➔ hospital 2



Vehicular IoT



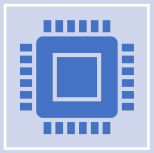
Challenges for IoT

- These barriers include:
  - trust,
  - security,
  - interoperability,
  - reliability,
  - scalability,
  - performance,
  - availability and mobility

- Unique to India – maintenance & engineering skills to design,develop, deploy and innovate in this area.

Actuators & Sensors

Actuators



Devices that take signal in electrical form and transform it to something that can influence the physical world

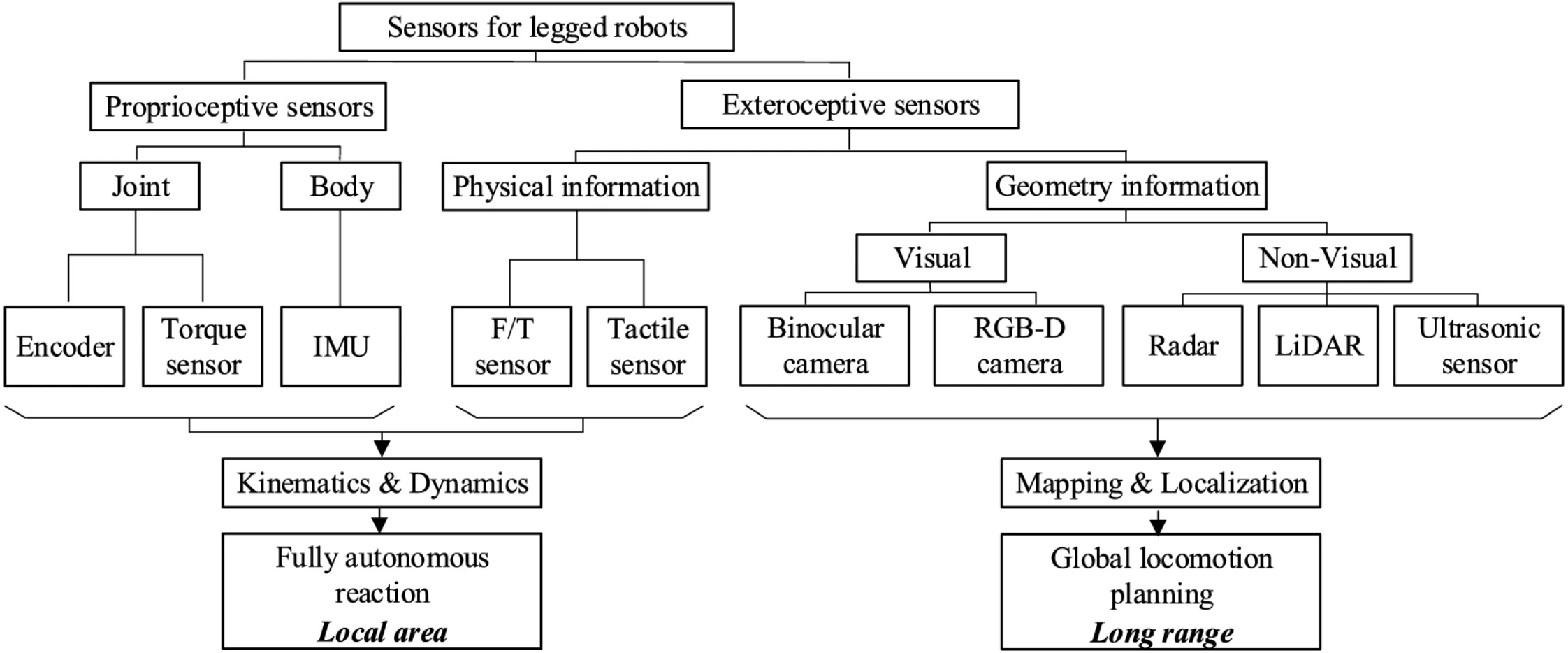
Can almost say that this is the end goal of all IoT devices, i.e., influencing or altering the physical world

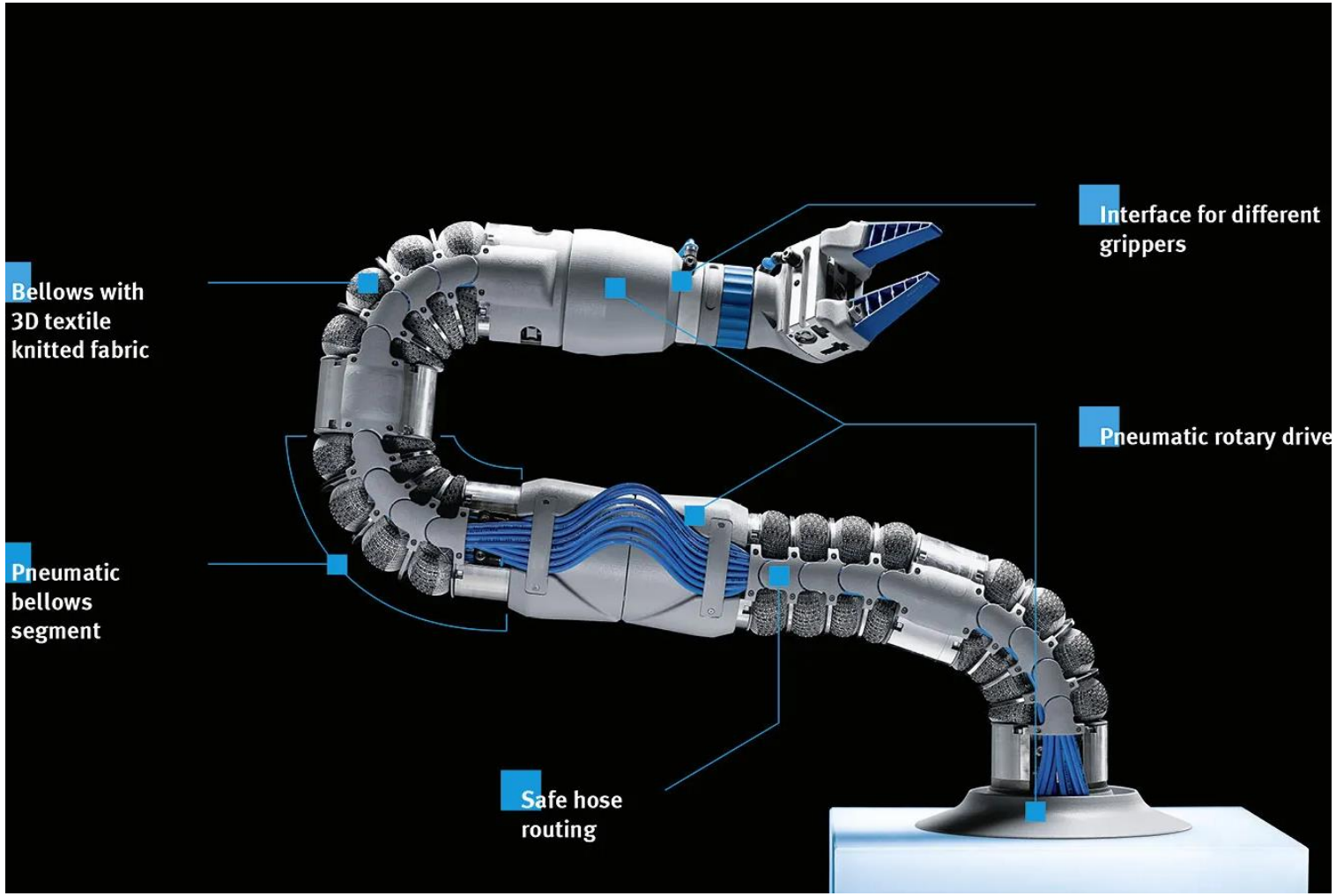
Can obtain actuation in many forms – movement, temperature (heating/cooling), light, sound, etc.

Legged robots – the sensor & actuators

- https://www.youtube.com/watch?v=rVlhMGQgDkY
- https://www.youtube.com/watch?v=bKDhmENcKto
- https://www.youtube.com/watch?v=7atZfX85nd4

Case Study – sensors in legged robots





Actuators in Robots

BionicSoftArm: Modular pneumatic lightweight robot

https://robocademy.com/2020/04/13/how-to-choose-an-actuator-for-your-robot/

Types of actuators

To enact movement, the actuator requires energy. The main types of energy sources are the following:
electric
hydraulic
pneumatic
thermal/magnetic

Electric actuators

- **Advantages of electric actuators**

1. These actuators offer the highest precision among other actuators.
2. It can be easily network and can easily program. They offer immediate feedback for diagnostic and maintenance.
3. They provide complete control on motion profiles and can include an encoder to control the velocity, position, and torque.
4. Less noise compared to hydraulic and pneumatic actuators
5. No fluid leak, so fewer environmental hazards.

- **Disadvantages of electric actuators**

1. The initial cost of the electrical actuator is higher
2. Unlike pneumatic and hydraulic actuators, these actuators are not suitable for all environments.
3. There are overheating, wear and tear issues are there compared to pneumatic and hydraulic actuators.
4. The actuator’s parameters are fixed, so to change torque, speed, etc to a different level, actuators should be replaced.

Making things move

- First kind of actuation is electromagnetic drives
- Most common actuation technique used to get mechanical motion from electrical energy
- Motion can then be converted to displacement, force, pressure
- Workhorse of the industrial society

https://www.youtube.com/watch?v=XHSYEH133HA

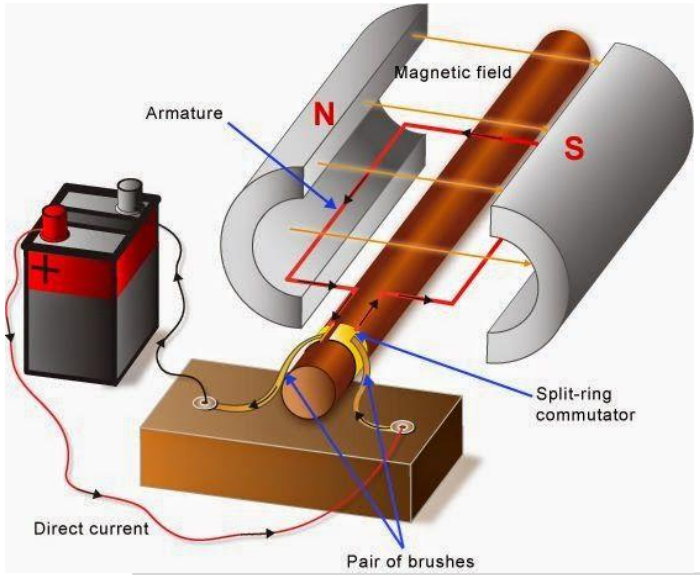
https://www.youtube.com/watch?v=3EHAEo0bm10&t=12s

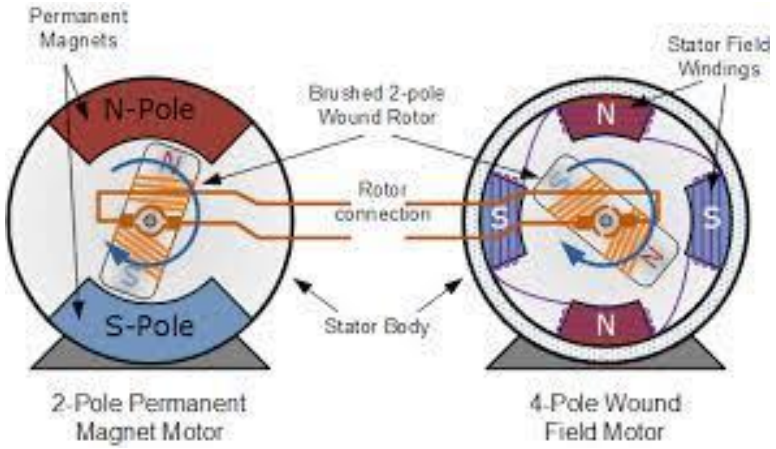
Making things move

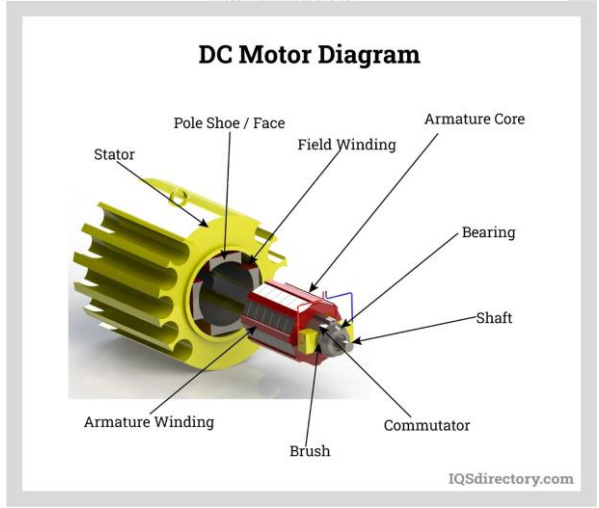
- Basic principle is very simple – uses two fundamental laws of physics:
  - When a current flows through a conductor, a magnetic field is produced
  - The conductor experience a force that tries to align their magnetic field
- Magnetic fields are typically produced by a stator (fixed) and rotor (movable)
- The fields can be produced using a permanent magnet or electromagnets

DC Motor

- One of the simplest designs for electromagnetic drives
- Stator is a permanent magnet and rotor is a coil connected to the power supply
- When the current flows through the rotor coils, they become electromagnets and try to align with the stator field, causing rotation







Stepper Motor

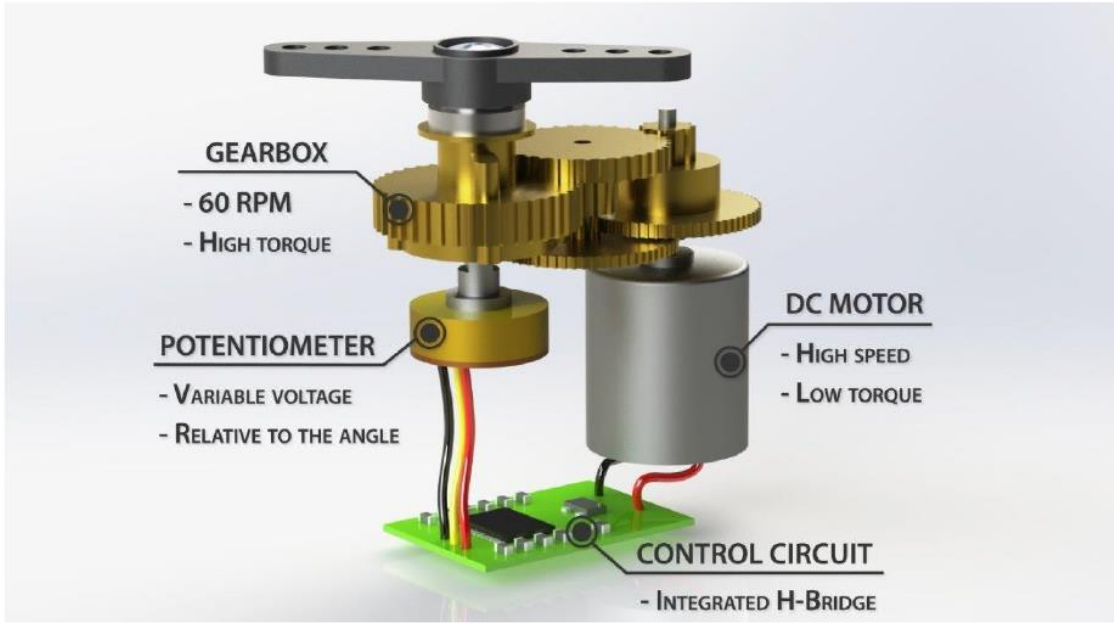
- Class of motors used to produce rotational motion in exact increments
- Typically has a permanent magnet rotor that aligns to the magnetic field of the stator coils
- When the next stator coil is energized, the rotor moves one step and locks in place
- This mechanism yields precise movement

https://www.youtube.com/watch?v=XHSYEH133HA

https://www.youtube.com/watch?v=3EHAEo0bm10&t=12s

Servo Motor

- Commonly used in robotics and industrial applications where a knowledge of the shaft position is required
- Uses a position sensor to control the motor (closed loop system)
- Control circuit provides feedback on the current position of the motor shaft → allows to rotate with great precision
- A gear assembly is used to obtain high torque



' ttps://www.youtube.com/watch?v=LXURLvga8bQ&t=27s

MG996R Servo Motor – good for most projects

Classification on type of displacement

1. **Linear Actuators**: The shaft of the linear actuators will only move in a linear fashion.
2. **Rotary actuators**: The shaft of the rotary actuator will only rotate in an axis.

Hydraulic actuators

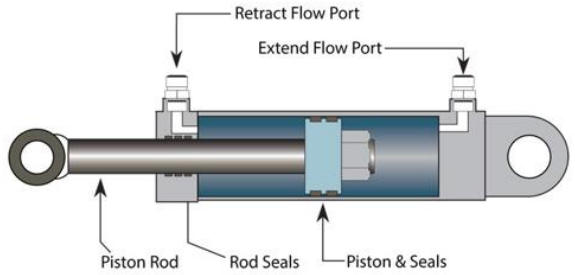
Advantages of Hydraulic actuator

1.Easy to control and accurate
2.Simpler and easier to maintain
3.Constant torque or force regardless of speed changes
4.Easy to spot leakages of system
5.Less noise

Disadvantages of Hydraulic actuator

1.Proper maintenance is required
2.Expensive
3.Leakage of the fluid creates environmental problems
4.Wrong hydraulic fluid for a system can damage the components

Hydraulic Actuator

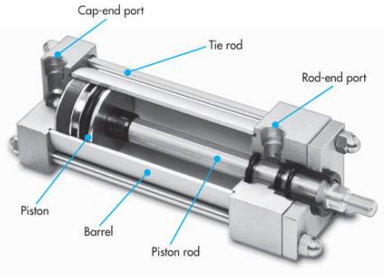


Section of Hydraulic Actuator

Pneumatic actuators

Similar to Hydraulic, use air instead of fluid

Pneumatic actuator



Section of pneumatic actuator

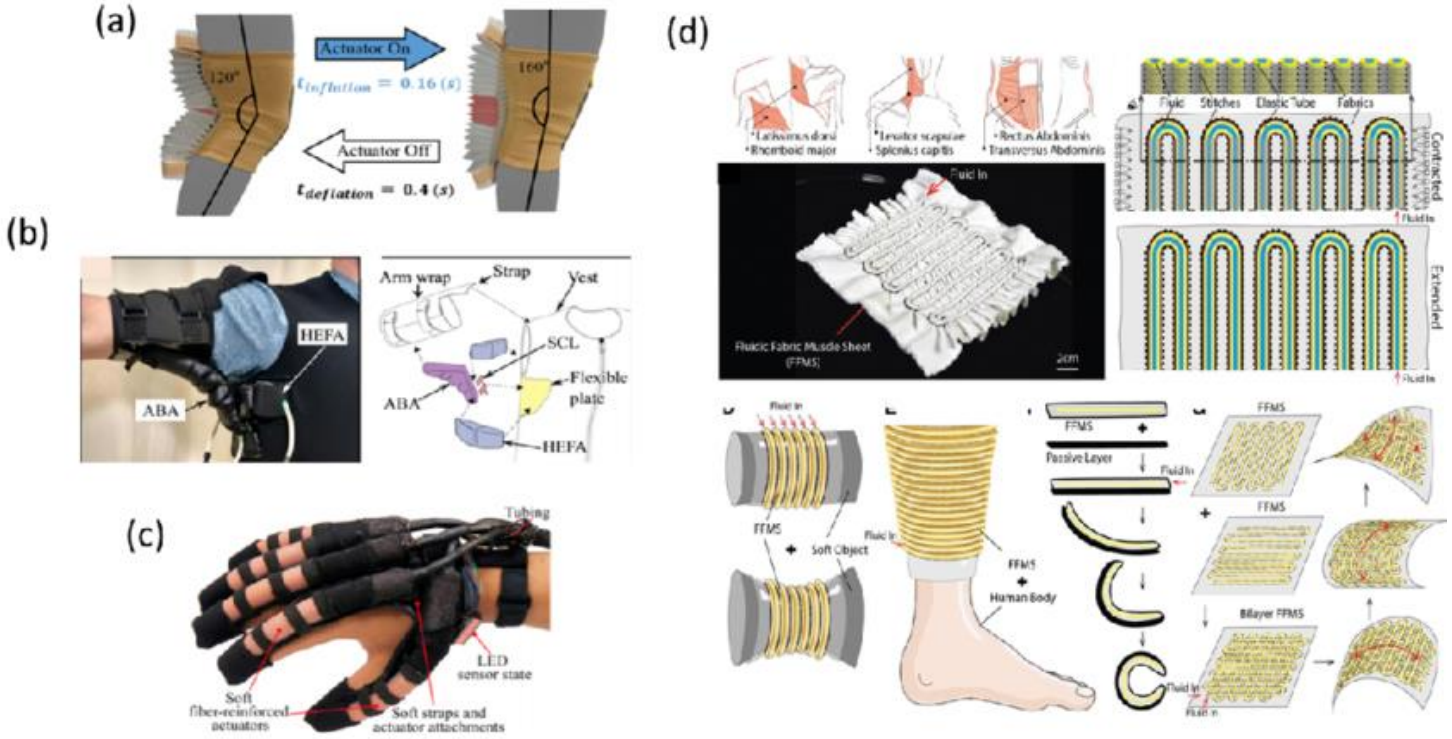
Advantages of Pneumatic actuators

1.Clean, less pollution to the environment
2.Inexpensive
3.Safe and easy to operate

Disadvantages of Pneumatic actuators

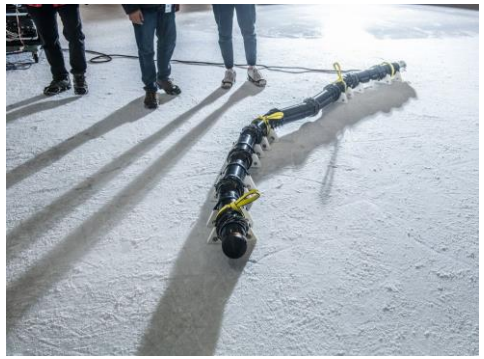
1.Loud and noisy
2.Lack of precision controls
3.Sensitive to vibrations

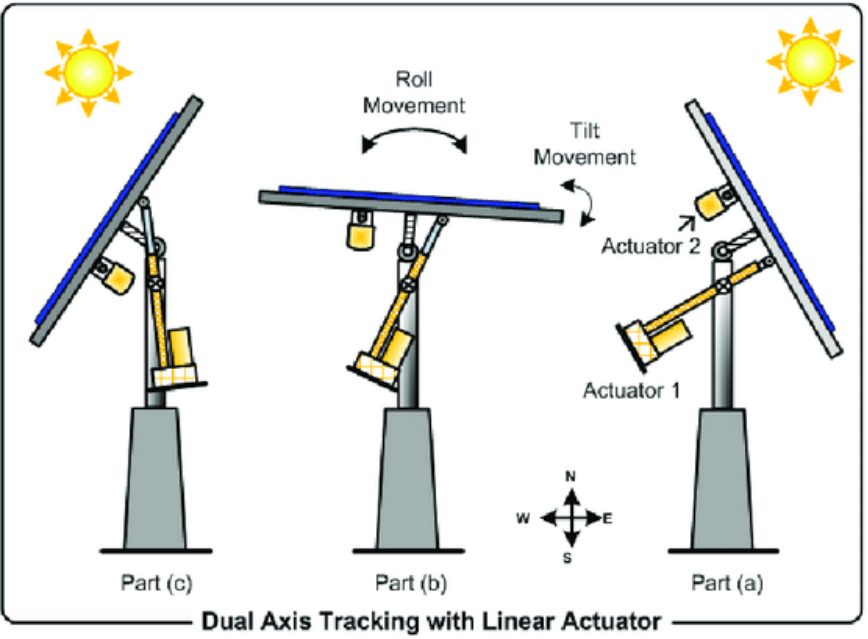
Actuators - applications



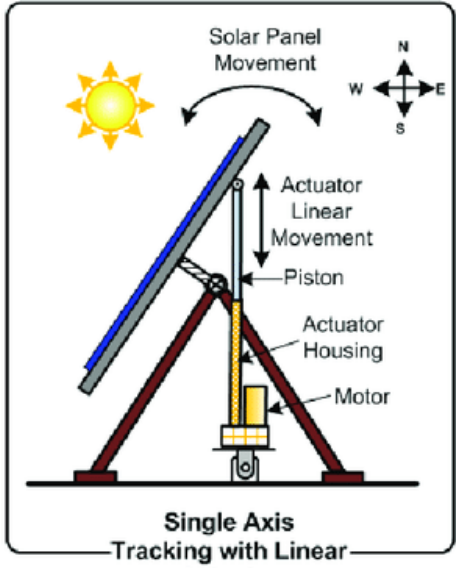
Wearable Actuators: An Overview
August 2021
1(2):283-321
DOI: 10.3390/textiles1020015

Exoskeletons
https://www.youtube.com/watch?v=-vTk-TRN0C8
https://www.youtube.com/watch?v=_6neruNxa_g

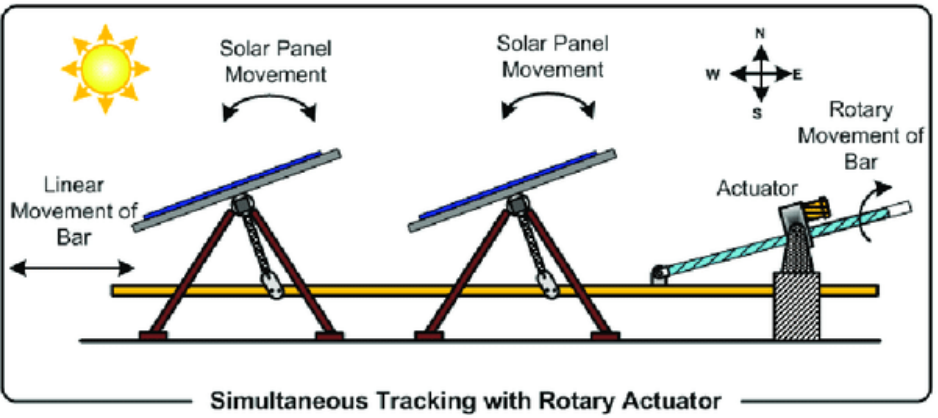




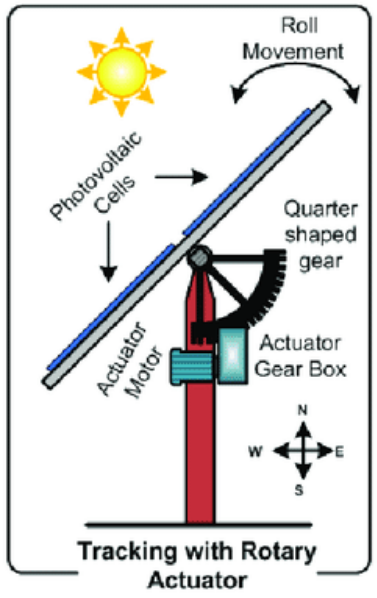
Dual Axis Tracking with Linear Actuator



Single Axis
Tracking with Linear
Actuator



Simultaneous Tracking with Rotary Actuator



Tracking with Rotary
Actuator

Functionality Analysis of Electric Actuators in Renewable Energy Systems—A Review

http://dx.doi.org/10.3390/s22114273

Other examples

- Solenoid valves
- Electrical relays