

# TYPES OF SENSORS:

1. Temperature Sensors
2. Humidity Sensors
3. Proximity Sensors
4. Motion Sensors
5. Light Sensors (Photocells or LDRs)
6. Pressure Sensors
7. Gas Sensors
8. Sound Sensors (Microphones)
9. Image Sensors
10. IR (Infrared) Sensors
11. Vibration Sensors
12. Water Quality Sensors
13. Weight Sensors (Load Cells)
14. RFID (Radio-Frequency Identification) Sensors
15. Accelerometers and Gyroscopes
16. GPS (Global Positioning System)
17. Ultrasonic Sensors

For monitoring walking and related health parameters, particularly in the context of gait analysis, the following sensors would be relevant:

1. Motion Sensors (Accelerometers and Gyroscopes):
  - Essential for capturing movement and acceleration during walking. These sensors can provide data on step count, walking speed, and gait patterns.
2. Pressure Sensors:
  - Placed in insoles or shoes, pressure sensors can help analyse the distribution of pressure during each step, providing insights into gait patterns and potential foot abnormalities.
3. Weight Sensors (Load Cells):
  - Integrated into footwear or walkways, weight sensors can assist in analysing weight distribution and changes in body weight during walking.
4. Inertial Measurement Units (IMUs):
  - Combining accelerometers and gyroscopes, IMUs offer a comprehensive solution for capturing detailed information on body movement and posture during walking.
5. IR (Infrared) Sensors:
  - Useful for proximity sensing and detecting obstacles during walking. These sensors can contribute to fall detection and prevention.
6. Cameras (Image Sensors):
  - Deployed in the environment or on the person, cameras can capture visual information related to walking patterns, posture, and potential abnormalities.

## 7. Ultrasonic Sensors:

- Measure distance and can be used for obstacle detection during walking, contributing to a safer walking environment.

These sensors, when strategically integrated into a system, can provide comprehensive data for gait analysis and monitoring. The combination of motion sensors, pressure sensors, and IMUs allows for detailed insights into walking patterns, while additional sensors like cameras and ultrasonic sensors enhance the system's ability to detect obstacles and ensure a safe walking environment. The specific choice of sensors would depend on the level of detail required for gait analysis and the objectives of the health monitoring system.

## What is lidar?

Lidar (light detection and ranging) uses eye-safe laser beams to “see” the world in 3D, providing machines and computers an accurate representation of the surveyed environment.

## How Does Lidar Work?

- A typical lidar sensor emits pulsed light waves into the surrounding environment.
- These pulses bounce off surrounding objects and return to the sensor.
- The sensor uses the time it took for each pulse to return to the sensor to calculate the distance it travelled.

**Functionality:** Lidar sensors use laser beams to measure the time it takes for the laser light to bounce off objects, thereby calculating the distance to those objects. This allows Lidar to generate detailed, accurate 3D maps of the environment.

### **Applications:**

**Autonomous Vehicles:** Lidar is a key sensor for autonomous cars and drones, providing real-time mapping and obstacle detection capabilities.

**Robotics:** Lidar enables precise mapping and navigation for robots in various environments.

**Smart Cities:** Lidar can be used for city planning, traffic management, and infrastructure monitoring.

**Industrial Automation:** Lidar is employed in industrial settings for tasks such as object detection and material handling.

While Lidar sensors serve specific applications, they are not as widespread as some other sensors in everyday consumer IoT devices. Their usage is more prevalent in specialized fields where accurate distance measurements and detailed mapping are critical for safe and efficient operation.

# Types of lidar:

## 1. Airborne

As the name suggests, Airborne LiDAR's are mounted on top of a helicopter or drone. The light is first emitted towards the ground and then it moves towards the sensor. Airborne LiDAR is further classified into topographic and bathymetric.

### Topographic LiDAR

It is used mainly in monitoring and mapping topography of a region. So it has its applications in geomorphology, urban planning, landscape ecology, coastal engineering, survey assessment etc.

### Bathymetric LiDAR

Bathymetric LiDAR's are used in measuring the depth of water bodies. In a bathymetric LiDAR survey, the infrared light is reflected back to the aircraft from the land and water surface, while the additional green laser travels through the water column. Bathymetric information is crucial near coastlines, in harbours, and near shores and banks. Bathymetric information is also used to locate objects on the ocean floor.

## 2. Terrestrial LiDAR

Terrestrial LIDAR can be installed either on a tripod or on a moving vehicle. It collects data points that help in the highly-accurate identification of data. This has its application in surveying and creating 3D Modelling. Terrestrial LiDAR can be either Mobile or Static

**Mobile:** It is mostly used to analyse infrastructure and observe roads. Mobile LiDAR systems mostly include sensors, camera and GPS.

**Static:** Static LiDAR is more portable, handy to use. It collects cloud points from a fixed location and is used in mining and archaeology.

## 3. Mechanical Scanning Lidar:

Utilizes a rotating mirror or prism to direct laser beams in different directions. It captures a 3D point cloud over time.

Applications: Ideal for detailed mapping, such as creating accurate topographic models of landscapes.

## 4. Solid-State Lidar:

Employs fixed arrays of lasers and detectors without mechanical components. Offers faster and more reliable performance.

Applications: Used in real-time applications, including robotics, autonomous vehicles, and scenarios requiring rapid data acquisition.

## 5. Flash Lidar:

Illuminates the entire field of view with a laser flash and captures the reflected light to create an instant 3D map.

Applications: Suitable for applications requiring rapid data acquisition, such as autonomous vehicles and robotics.

## Which Lidar is better?

Terrestrial LiDAR emerges as a cornerstone technology for IoT health monitoring systems, offering unparalleled advantages in capturing precise data relevant to walking patterns and gait changes. With its highly accurate 3D modelling capabilities, Terrestrial LiDAR provides a meticulous representation of outdoor environments, crucial for closely monitoring and analysing subtle changes in individuals' walking patterns. The system's effectiveness in infrastructure analysis, especially through Mobile LiDAR, proves invaluable for optimizing walkways and pathways, ensuring safe and conducive conditions for health monitoring initiatives. Terrestrial LiDAR's portability and versatility enable seamless deployment across diverse outdoor landscapes, providing a flexible solution tailored to the evolving needs of health monitoring projects. Its detailed cloud points offer comprehensive insights into terrain and objects, essential for monitoring changes in walking patterns and environmental conditions. With robust surveying capabilities, both in Mobile and Static forms, Terrestrial LiDAR supports health monitoring projects requiring detailed assessments of outdoor spaces. While its applications extend to mining and archaeology, showcasing its adaptability, Terrestrial LiDAR remains a pivotal technology uniquely suited to meet the demands of IoT health monitoring systems.

- Terrestrial LiDAR prices between \$15,000 and \$120,000, depending on its range, accuracy and other data acquisition capabilities.

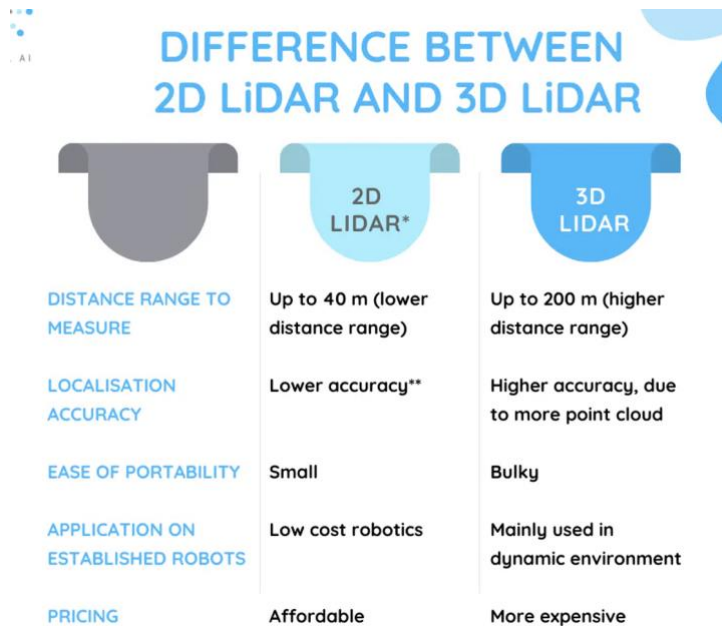
## 2D and 3D Lidar sensors:

LiDAR technology is often used in robotics, especially to navigate robots and enable it to work autonomously. By using 2D and 3D LiDAR technology, robots can see the environment as accurately as a human eye. Due to the artificial intelligence, robots will be able to move freely without worrying about colliding into nearby objects like walls, glasses, boxes, or other robots.

Difference between 2D LiDAR and 3D LiDAR

2D LiDAR emits a single beam to the targeted object on the horizontal axis. The sensor will then spin to collect X and Y coordinates. On the other hand, 3D LiDAR emits several beams on the vertical axis, to collect X, Y, and Z coordinates.

In summary, both 2D and 3D LiDAR work in the same way, they emit beams to let robots see. However, they have some significant differences.



Lidar sensors come in different types based on their capabilities, with distinctions between 2D Lidar and 3D Lidar.

2D Lidar:

1. Single-Plane Lidar:

- Emits a laser beam in a single plane, either horizontally or vertically.
- Provides a one-dimensional scan of the environment, suitable for basic obstacle detection.

2. Multi-Plane Lidar:

- Utilizes multiple laser beams in different planes to capture a more comprehensive view.
- Can offer a two-dimensional representation by scanning in both horizontal and vertical directions.
- Applications:
  - Commonly used in applications where a simple, cost-effective solution for basic distance measurements and obstacle detection is sufficient.
  - Examples include simple robotics, industrial automation, and certain drone application

3D Lidar:

1. Mechanical Scanning Lidar

2. Solid-State Lidar

3. Flash Lidar

4. Airborne Lidar (Topographic and Bathymetric)

5. Terrestrial Lidar (Mobile and Static)

- Applications:
  - Autonomous Vehicles: 3D Lidar is a crucial sensor for creating detailed maps, detecting obstacles, and enabling safe navigation.
  - Robotics: Used for mapping and navigation in complex environments.
  - Surveying and Mapping: Valuable in geospatial applications for terrain mapping.

While these distinctions exist, it's essential to note that some Lidar sensors, especially those labelled as 2D, may still provide a limited form of depth information or operate in a specific plane. The choice between 2D and 3D Lidar depends on the specific needs of the application and the level of detail required for mapping or detection.

Hybrid Lidar:

- Some Lidar sensors combine both 2D and 3D capabilities, offering versatility in different applications.
- Hybrid Lidar systems may integrate mechanical scanning for a wide field of view with solid-state or flash Lidar for high-speed, detailed scanning.

## Why do we use LIDAR sensors:

The use of LiDAR (Light Detection and Ranging) sensors in the system for gait monitoring and data collection offers several advantages, enhancing the capabilities of the smart sensory path while addressing key considerations:

### 1. Detailed 3D Data:

- LiDAR sensors capture high-resolution 2D and 3D data, providing precise measurements of the user's movements, including step height, stride length, and posture. This additional dimension of data enables a more comprehensive understanding of gait patterns.

### 2. Enhanced Accuracy:

- LiDAR technology is renowned for its accuracy in measuring distances. By integrating a LiDAR sensor into the path, the system can obtain precise information about the user's position and movements, contributing to more accurate gait analysis.

### 3.Reduced Environmental Interference:

- LiDAR is less susceptible to environmental interference, such as varying lighting conditions, which can affect other sensor types. This makes it particularly suitable for outdoor applications where lighting may vary throughout the day.

#### 4. Real-time Monitoring:

- LiDAR sensors provide real-time data, enabling healthcare professionals to monitor users' gait patterns as they walk along the path. This capability allows for the prompt identification of any deviations from normal gait without compromising user privacy.

#### 5. Data Fusion:

- Combining data from the LiDAR sensor with existing multi-modal sensors enhances overall data quality. Data fusion techniques can be applied to extract valuable insights and detect anomalies more effectively, providing a holistic view of the user's gait while respecting user privacy.

The integration of a LiDAR sensor aligns with the latest advancements in gait analysis and outdoor public health monitoring. Its ability to capture detailed 3D data, provide accurate real-time monitoring, and reduce environmental interference makes it a valuable asset in this research. Importantly, the integrated approach leverages the strengths of various sensor technologies to improve the quality and depth of data collected, ultimately benefiting both users and healthcare professionals without compromising their privacy. This responsible choice for outdoor gait monitoring showcases the commitment to utilizing advanced technology for healthcare applications while respecting privacy concerns.