

Sensor Limitations

Introduction:

Sensors are basically devices which detect and respond to input from a physical environment. These inputs can be changes like temperature or motion or moisture or chemical composition. Sensors convert these inputs into signals which can be analyzed by computers or humans. One of the most common examples of a sensor is a smoke detector or Carbon monoxide detector found in every residential and commercial building.

Classification:

Sensors are used in various applications to monitor various systems. Some of the most common examples are:

Smartphones: touch sensor, motion sensor etc

Automobiles: Engine management, airbag sensors, LiDAR sensors

Medical devices: diagnostic sensors, Blood Pressure monitor

Agriculture: Moisture sensors, weather sensors, LiDAR sensors

Sensors can be classified based on

Detection principle: Optical sensors, Thermal sensors, Chemical sensors and Mechanical Sensors [1]

Output Type: Analog and Digital

Energy based: Active and Passive Sensors

Sensors are extremely adaptable and have a wide range of applications. Sensors are now indispensable and a vital part of evolving global technology.

Industry Trends and Needs:

Most of the modern software applications, from self-driving Tesla to smart gadgets, depend on sensors. Some of the most important apps or products where sensors are prioritized are as follows:

- **Google maps:**
A navigation app which provides real-time navigation and selects best and accurate transit routes for user by analyzing the exact location and movement of the user. It minimizes traffic congestion and determines the best routes for the user's destinations.
- **Fitbit App:**
Provides health metrics like number of steps, heart rate, blood oxygen levels and sleep patterns [2]. Based on this data, it provides the user with useful predictions on their health and guides for better habits for a healthier lifestyle. A user can monitor his/her fitness and health using this app.
- **Home Security App (Ring):**
Enables and provides home security through real-time surveillance. It alerts the homeowners about unauthorized breaches. The homeowner is able to check on their property remotely and also take care of their pets and children through smart surveillance apps like Ring Indoor Cam.
- **Tesla Autopilot:**
Provides advanced driver-assistance features and real time driving assistance. It helps the driver in lane-keeping, adaptive cruise control, real-time obstacle detection and safe navigation.
- **Augmented Reality app (IKEA Place):**
Helps IKEA customers to visualize the selected furniture in their living room or space. This option is very helpful for customers in choosing the aptly sized furniture without actually facing the hassles of moving big furniture.
- **Agriculture App (FieldView):**
Provides farmers with precision agriculture. This app helps to optimize the crop yield through optimal resource usage [3]. It can monitor field health by showing early pest infestations. It helps in water conservation through soil moisture data. It provides early weather forecasts and alerts.

Current Solutions:

Sensors are used widely in various fields to solve problems and achieve better output through accurate data analysis derived from these devices.

1) Automotive Industry:

- Self-driving cars with LiDAR, radar, cameras and ultrasonic sensors help in autonomous vehicle abilities.
- IoT sensors which monitor vehicle metrics and tire pressure, and engine performance helps drivers with alerts and vital insights and hence prevent vehicle crashes and breakdowns.

2) Agriculture:

- Moisture sensors, weather sensors and Temperature sensors enable farmers to monitor conditions like water usage, climate and soil conditions. This in turn helps the farmers to study the data and implement changes to optimize resource usage and plan for a better crop or yield.
- Drones with LiDAR sensors and multispectral sensors help in aerial imaging which helps in determining early pest infestations or early nutrient deficiencies. These sensors help the farmer to take critical decisions regarding crop health.

3) Healthcare:

- Smart watches have sensors like accelerometers and heart rate monitors which help in collecting health metrics. These sensors help in monitoring activity levels, sleep quality and vital signs
- Remote Patient Monitoring or RPM devices help in tracking and monitoring vital signs or patients remotely. Examples include implantable cardiac monitors and implantable glucose monitors which are commonly used for optimizing treatment plans [4].

4) Smart Home Security:

- Motion sensors for detecting open doors and windows help in alerting users for possible breaches in their home.
- Smart Doorbell cameras and indoor cameras integrated with AI features help in detecting type of movement and differentiate between a pet or an intruder.
- Smart locks have sensors to facilitate remote locking and unlocking enhancing homeowners control and hence provide safety and convenience.

5) Retail (Amazon Go)

- Computer Vision Cameras help in tracking the customer movement through the store and detecting the items picked up or returned.
- Shelves with weight sensors help in determining if an item has been removed from a shelf or placed back.

Critical Analysis of Sensors:

Pros:

- **Improved Efficiency and Automation:** Autonomous vehicles with LiDAR sensors and smart home cameras and humidity sensors help in automating processes and hence improve the overall operational efficiency and also prevent human error.
- **Real-Time Data and Monitoring:** Smart watches and smart home security devices enable real-time data thus helping in making timely and informed decisions.
- **Enhanced Safety:** Smart home security devices and other sensors in autonomous vehicles help in detecting obstacles and alert users to accidents and health hazards thus helping in enhanced safety.
- **Resource Optimization:** In agriculture, sensors track soil moisture and weather conditions to enhance water and resource usage, boosting crop yields and minimizing waste.
- **Convenience:** Smart devices, such as home security systems with locks and cameras or Amazon Go's checkout free shopping, simplify routine tasks and offer greater convenience.

Cons:

- **High Cost:** Advanced sensors, like those in autonomous vehicles (LiDAR), healthcare wearables, and retail systems like Amazon Go, are expensive, limiting accessibility for some users or businesses.
- **Privacy and Security Risks:** Sensors that gather personal data, such as those in smart home security systems or healthcare devices, pose concerns about data security, privacy breaches, and potential misuse.
- **Data Complexity:** The vast amount of data produced by sensors in agriculture, automotive, and healthcare sectors requires substantial processing power and expertise, which can be challenging for those without the necessary resources.
- **Environmental Sensitivity:** Many sensors, including those in vehicles and agricultural drones, can be affected by environmental factors like weather, dust, or obstructions, impacting their performance and reliability.
- **Maintenance Requirements:** Sensors in smart devices, security cameras, or wearables often need regular maintenance (e.g., battery replacement) to function properly, leading to additional costs and effort.

Propose a new solution or an improvement to an existing solution that minimizes or removes a limitation of existing solutions

Problem:

LiDAR sensors are used in agriculture for topography mapping, crop health monitoring and yield estimation. A vineyard can use a drone equipped with LiDAR sensors to collect data on plant height, density and canopy structure. But these sensors face various problems like changing environmental conditions like intense sunlight, fog, dust and rain. This introduces noise into the data which limits the accuracy of the crop health data and terrain mapping. LiDAR sensors are energy intensive and hence not suited for use in remote areas with limited power sources.

Solution:

One solution for reducing the noise generated in this LiDAR sensor data would be to integrate AI-based noise filtering algorithms which can adapt to various environmental conditions like dust, light or weather changes. It would help improve the accuracy of crop health assessments and terrain mapping. Additionally, leveraging low-power, high-efficiency LiDAR chips can reduce energy usage, making sensors more practical for remote farming operations.

References:

- [1] D. Sehrawat and N. S. Gill, "Smart Sensors: Analysis of Different Types of IoT Sensors," *2019 3rd International Conference on Trends in Electronics and Informatics (ICOEI)*, Tirunelveli, India, 2019, pp. 523-528, doi: 10.1109/ICOEI.2019.8862778.
- [2] Ara Jo, Bryan D. Coronel, Courtney E. Coakes, Arch G. Mainous, "Is There a Benefit to Patients Using Wearable Devices Such as Fitbit or Health Apps on Mobiles? A Systematic Review," *The American Journal of Medicine*, Volume 132, Issue 12, 2019, Pages 1394-1400.e1, ISSN 0002-9343, <https://doi.org/10.1016/j.amjmed.2019.06.018>.
- [3] DeLay, Nathan, Nathanael Thompson, and James Mintert. "Farm data usage in commercial agriculture." *Purdue University. Center For Commercial Agriculture* (2020)
- [4] [20+ Remote Patient Monitoring Devices in Healthcare](#)

