# Acoustic-Based Drone Detection

## Identifying UAVs Through Sound Signatures

## Mentor Evaluation - 1


**Submitted by:**

**(102203449) Devansh Dhir**

**(102203061) Gautam Dhawan**

**(102203408) Iipsita Devgan**

**(102203012) Miet Pamecha**

**(102203413) Tamanna Bajaj**


**BE Third Year**

**CPG No. 179**

Under the Mentorship of

Dr. Sharad Saxena

Associate Professor





**Computer Science and Engineering Department**

**Thapar Institute of Engineering and Technology, Patiala**


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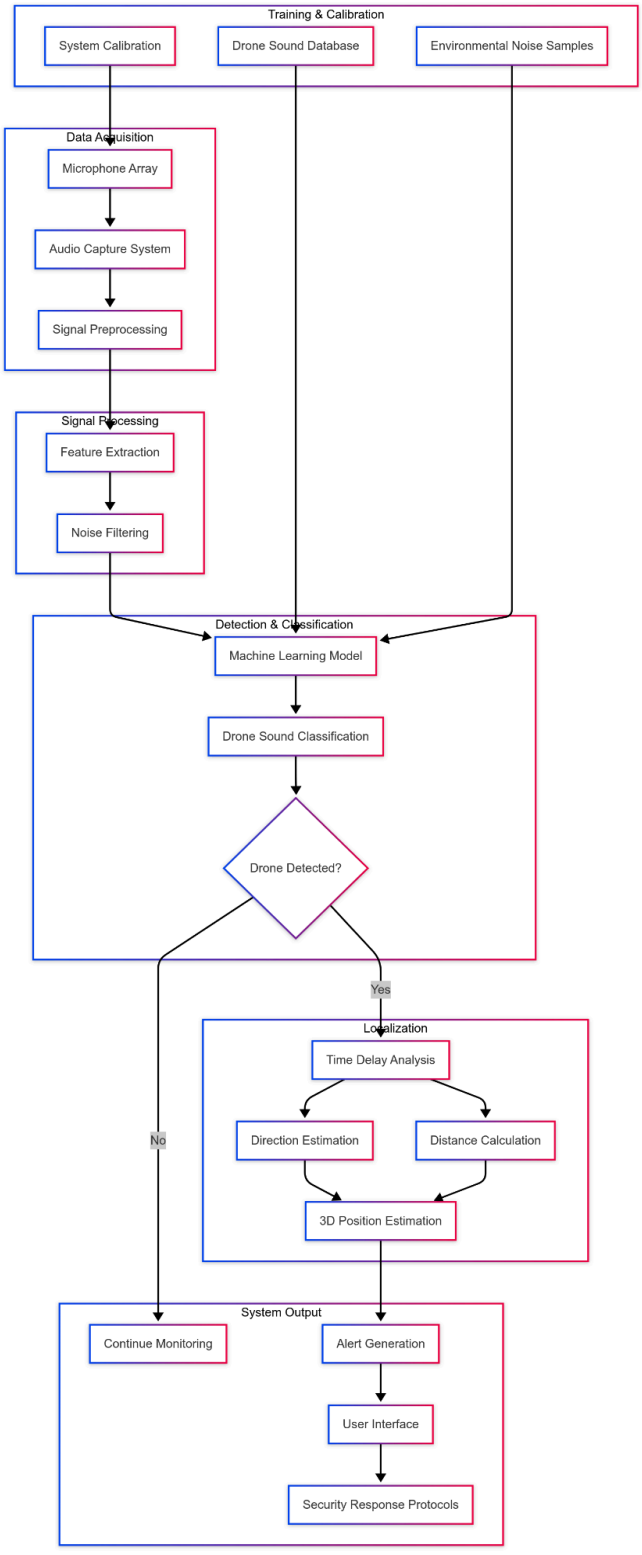
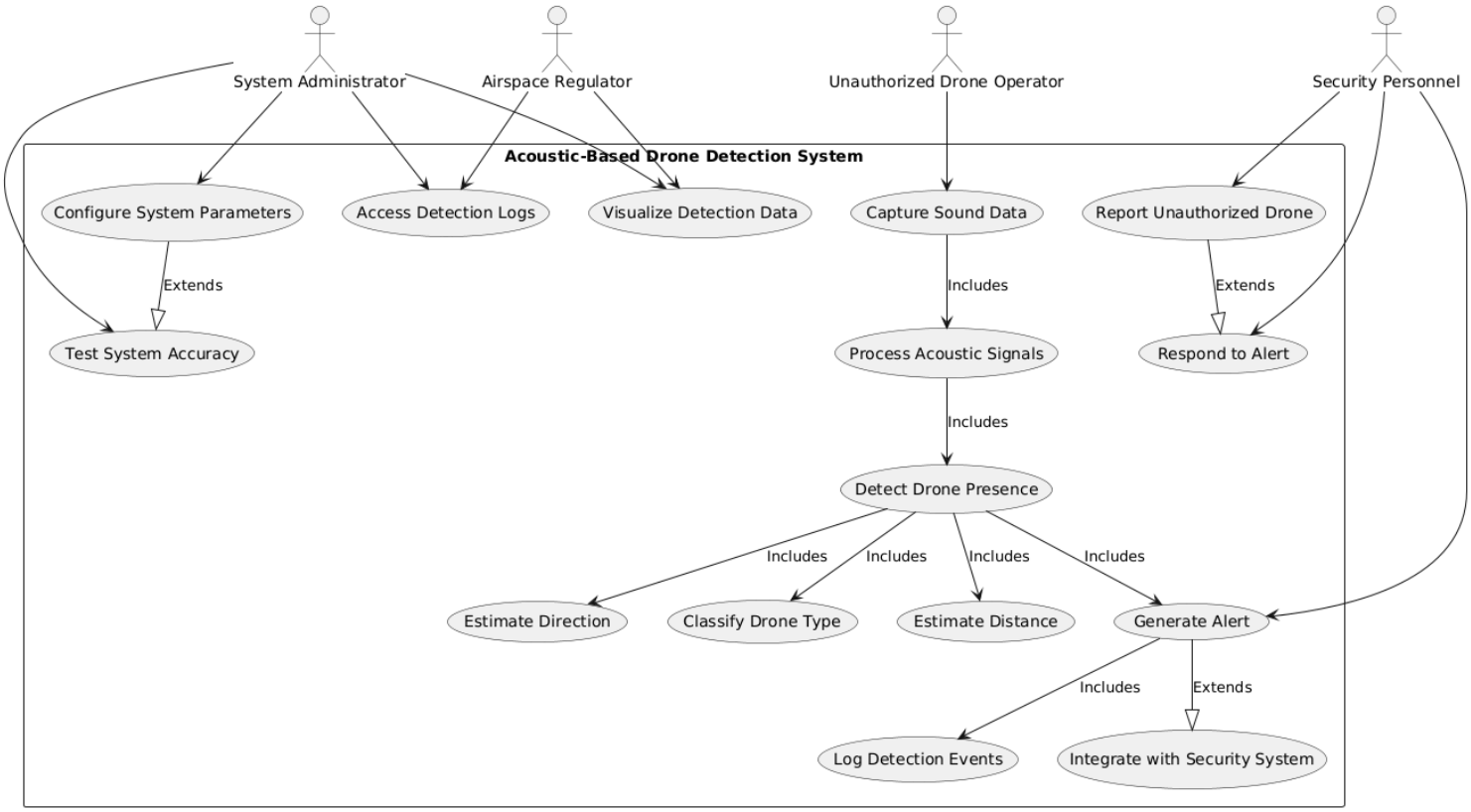
# Product Perspective

The Acoustic Drone Detection System provides real-time identification and tracking of UAVs through advanced sound signature analysis. By leveraging microphone arrays and machine learning algorithms, the system enables non-intrusive monitoring of drones in diverse environments, offering a practical solution for enhancing airspace security and management in urban areas, event venues, and sensitive locations.



# Use Case Diagrams



# Use Case Templates

| | |
|---|---|
| **1.Use Case Title** | **Capture Sound Data** |
| **2. Abbreviated Title** | **CSD** |
| **3. Use Case Id** | **UC1** |
| **4. Actors** | **Drone Detection System , Unauthorized Drone Operator** |

**5. Description**

The system captures ambient sound data using acoustic sensors to detect potential drone activity.

**5.1. Pre Conditions:** System must be powered on and sensors must be functional.

**5.2. Task Sequence**

1. System initializes acoustic sensors.
2. Continuous or periodic recording of environmental sounds.
3. Store captured sound data for further processing.

**5.3. Post Conditions:**

1. Sound data is stored and ready for signal processing.

**6. Modification History:** 01-04-2025

**7. Author:** CPG 179

| | |
|---|---|
| **1.Use Case Title** | **Process Acoustic Signals** |
| **2. Abbreviated Title** | **PAS** |
| **3. Use Case Id** | **UC2** |
| **4. Actors** | **Acoustic-Based Drone Detection System** |

**5. Description**

The system processes recorded sound data to filter noise and extract relevant drone-related signals.

**5.1. Pre Conditions:** Sound data must be available from the sensors.

**5.2. Task Sequence**

1. Apply noise filtering techniques.
2. Extract features specific to drone sounds.
3. Prepare processed data for detection.

**5.3. Post Conditions:**

- Processed acoustic signals are available for drone detection.

**6. Modification History:** 01-04-2025

**7. Author:** CPG 179

| | |
|---|---|
| **1.Use Case Title** | **Estimate Distance** |
| **2. Abbreviated Title** | **ED** |
| **3. Use Case Id** | **UC4** |
| **4. Actors** | **Acoustic-Based Drone Detection System** |

**5. Description**
The system estimates the distance of a detected drone based on sound intensity analysis.

**5.1. Pre Conditions:** Drone presence must be detected.

**5.2. Task Sequence**

1. Measure sound intensity levels.
2. Use predefined models to approximate drone distance.

**5.3. Post Conditions:**

- Estimated distance value is available.

**6. Modification History:** 01-04-2025

**7. Author:** CPG 179

| | |
|---|---|
| **1.Use Case Title** | **Generate Alert** |
| **2. Abbreviated Title** | **GA** |
| **3. Use Case Id** | **UC5** |
| **4. Actors** | **Security Personnel, Acoustic-Based Drone Detection System** |

**5. Description**
The system generates an alert if unauthorized drone activity is detected.

**5.1. Pre Conditions:** Drone presence must be detected.

**5.2. Task Sequence**

1. Send alert notification to security personnel.
2. Log detection event.
3. Optionally, trigger integration with security systems.

**5.3. Post Conditions:**

- Security personnel is notified.

**6. Modification History:** 01-04-2025

**7. Author:** CPG 179

| 1.Use Case Title | Estimate Direction |
|---|---|
| 2. Abbreviated Title | EDIR |
| 3. Use Case Id | UC6 |
| 4. Actors | Acoustic-Based Drone Detection System |

**5. Description**
The system estimates the direction from which a detected drone is approaching.

**5.1. Pre Conditions:** A drone must be detected.

**5.2. Task Sequence**

1. Administrator logs into the system.
2. Admin views, adds, or modifies QR code placements.

**5.3. Post Conditions:**

- Directional data is available.

**6. Modification History:** 01-04-2025

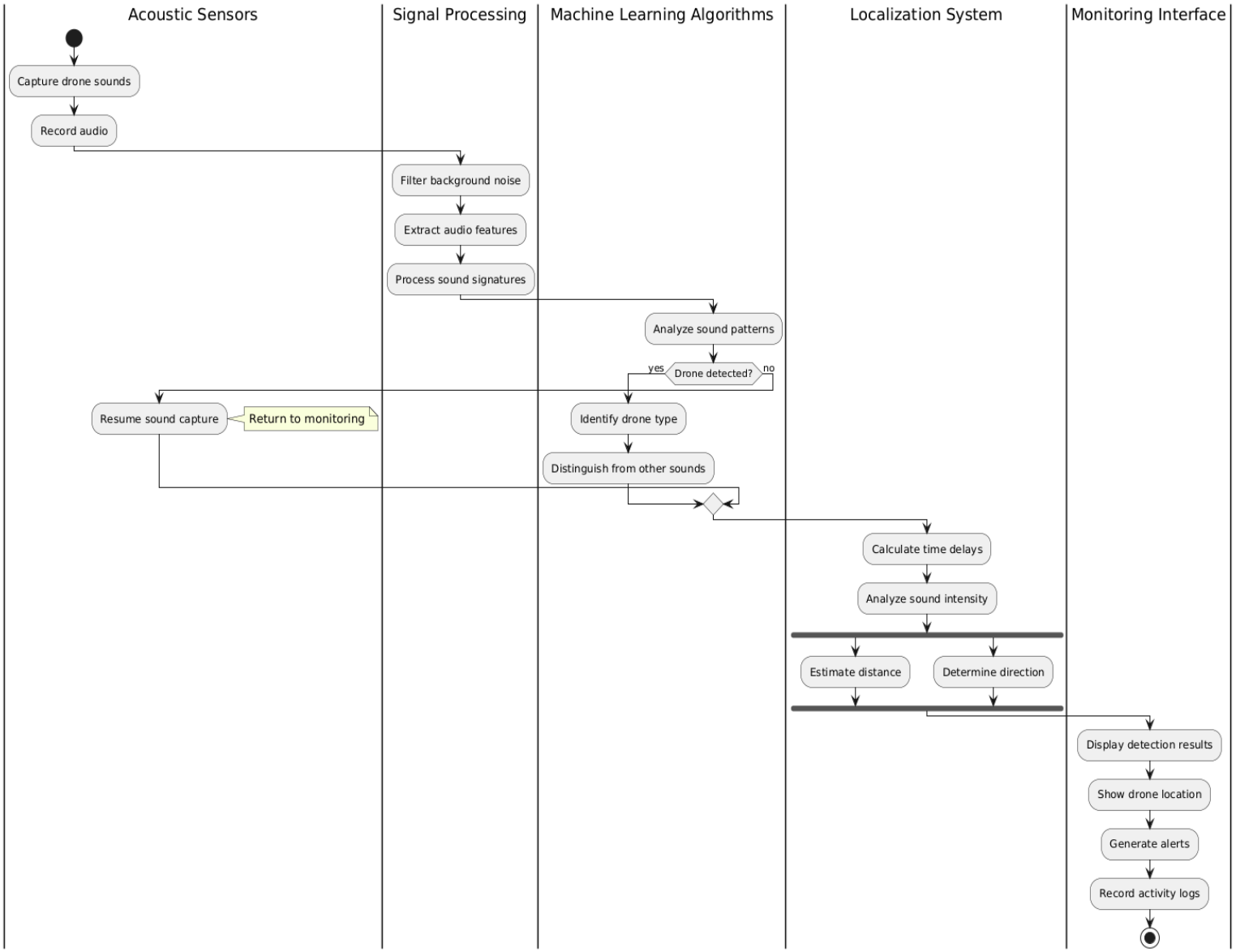
**7. Author:** CPG 179

# Tasks and Subtasks

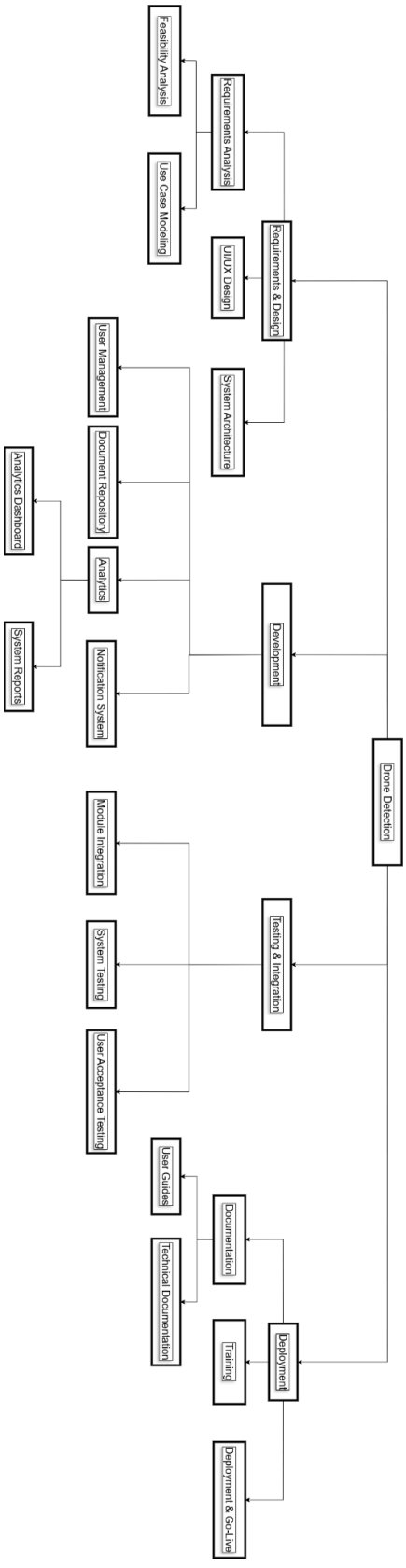
| Task | Subtask |
|---|---|
| • Researching Hardware / Planning | Identify required hardware components.<br>Define project scope and goals. |
| • Testing Hardware / Data Collection | Capture sounds from various drone models.<br>Record at different distances and angles.<br>Document flight modes.<br>Record background noise in target environments. |
| • Data Preprocessing & Feature Extraction | Filter background noise.<br>Normalize audio samples.<br>Segment recordings into usable frames.<br>Implement MFCC extraction.<br>Process STFT.<br>Extract time-domain features. |
| • Machine Learning Model Development | Evaluate classifiers (CNN, SVM, etc.).<br>Train models on dataset.<br>Optimize hyperparameters.<br>Test accuracy with validation data.<br>Measure false positive/negative rates. |
| • Implementation of Distance & Direction Estimation | Implement time-delay localization algorithms.<br>Develop beamforming techniques.<br>Calibrate for accurate directional data.<br>Create sound intensity analysis for distance estimation.<br>Develop triangulation methods. |
| • Model Evaluation / Testing | Evaluate in lab conditions.<br>Measure detection accuracy & range.<br>Test with multiple drones. |
| • System Integration / UI Development | Create real-time processing pipeline.<br>Implement detection algorithms.<br>Design user dashboard.<br>Create visualization components. |

| | |
|---|---|
| • Performance Testing in Real-Time Environment | Deploy in real-world environments.<br>Test in varying weather conditions.<br>Document system limitations. |
| • Final Deliverables | Technical Documentation.<br>Develop user manual and guides.<br>Prepare demonstration materials. |

# Swimlane Diagram



# Work Breakdown Structure



# Gantt Chart

| Sr. No. | Activity | Month | February | | March | | | | April | | | | May | | | | June | | | | July | | | | August | | | | September | | | | October | | | | November | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Week No. | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| 1 | Researching Hardware / Planning | Plan | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | Actual | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2 | Testing Hardware / Data Collection | Plan | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | Actual | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3 | Data Preprocessing & Feature Extraction | Plan | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | Actual | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4 | Machine Learning Model Development | Plan | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | Actual | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5 | Implementation of distance & direction estimation techniques | Plan | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | Actual | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 6 | Model Evaluation / Testing | Plan | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | Actual | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 7 | System Integration / UI Development | Plan | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | Actual | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 8 | Performance Testing in Real Time Enviornment | Plan | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | Actual | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

# Functional and Non-Functional Requirements

## Functional Requirements

- **Sound Capture:** Capture drone sounds using microphones.
- **Audio Processing:** Continuously record and process audio.
- **Noise Reduction:** Apply noise reduction and filtering.
- **Sound Identification:** Identify and differentiate drone sounds.
- **Machine Learning Classification:** Use machine learning for classification**.**
- **Distance Estimation:** Estimate drone distance using sound intensity.
- **Direction Detection:** Determine drone direction using time-delay localization.
- **Monitoring Dashboard:** Offer a dashboard for real-time monitoring.

## Non-Functional Requirements

- **Real-Time Processing:** Process audio data in real-time.
- **Scalability:** Support multiple microphones for accuracy.
- **Large-Area Monitoring:** Scale for large-area coverage.
- **Detection Accuracy:** Achieve at least 90% detection accuracy.
- **Environmental Adaptability:** Perform reliably in different environments.
- **Error Reduction:** Minimize false positives and negatives.
- **Data Security:** Ensure secure data transmission and storage.
- **Regulatory Compliance:** Comply with data protection regulations.
- **Access Control:** Prevent unauthorized access.
- **User-Friendly Interface:** Provide an intuitive user interface.
- **Remote Access:** Support remote access via web or mobile.
- **Customizable Alerts:** Allow alert and notification customization.
- **Modular Design:** Ensure modular design for future upgrades.
- **System Updates:** Support updates without downtime.
- **Diagnostics & Troubleshooting:** Provide logs and diagnostics.
- **Operational Flexibility:** Operate in indoor and outdoor environments.
- **Weather Resistance:** Function under varying weather conditions.
- **Power Efficiency:** Be power-efficient with battery/solar support.