AeroHacks

Bird Deterrent System

Key Features

- **Multi-sensor bird detection** using ultrasonic sensors
- **Dual-mode deterrent system** (audio and visual)
- **Weather-resistant operation** with environmental monitoring
- **Intelligent power management** with battery monitoring
- **Real-time telemetry and monitoring** via ground station
- **Adaptive response patterns** to prevent habituation
- **Emergency shutdown capabilities**

System Specifications

- **Detection Range**: Up to 400cm with 3-sensor array
- **Coverage Area**: 360-degree monitoring capability
- **Operating Voltage**: 12V DC primary, 5V and 3.3V rails
- **Communication**: Serial (115200 baud) with ground station
- **Environmental Rating**: Weather-protected with seal monitoring
- **Audio Output**: Variable frequency (80Hz - 24kHz)
- **Visual Output**: High-intensity LED strobes with thermal protection

Hardware Architecture

Core Processing Unit

- **Microcontroller**: Arduino-compatible platform
- **Processing Power**: Sufficient for real-time sensor processing and deterrent control
- **Memory**: Program storage and data logging capabilities
- **I/O Pins**: Multiple digital and analog pins for sensor and actuator control

Power Management System

Voltage Rails

- **Primary Rail (12V)**: Main system power and high-power components
- **Secondary Rail (5V)**: Logic circuits and moderate power devices
- **Logic Rail (3.3V)**: Low-power sensors and communication modules

Power Monitoring

- **Battery Voltage Range**: 10.5V - 16.8V operating range
- **Current Monitoring**: Real-time current draw measurement per rail
- **Thermal Protection**: Automatic shutdown at 75°C
- **Low Power Mode**: Activates at 11.0V threshold
- **Efficiency Monitoring**: Target >95% system efficiency

Sensor Array

Bird Detection Sensors

- **Type**: Ultrasonic distance sensors (HC-SR04 compatible)
- **Quantity**: 3 sensors for triangulation
- **Range**: 2cm - 400cm detection range
- **Accuracy**: ±3mm resolution
- **Update Rate**: Staggered readings every 50ms + sensor offset
- **Noise Filtering**: Median filter with 5-sample history

Environmental Sensors

- **Temperature**: Internal and external temperature monitoring
- **Humidity**: Relative humidity measurement
- **Pressure**: Barometric pressure for weather monitoring
- **Wind Speed**: Anemometer integration
- **Precipitation**: Rain/snow detection
- **Light Level**: Ambient light sensing for adaptive responses

Deterrent Hardware

Audio System

- **PWM Audio Generation**: Software-generated waveforms
- **Amplifier**: Enable/disable control with thermal monitoring
- **Frequency Range**: 80Hz - 24kHz (including ultrasonic)
- **Volume Control**: Software-controlled amplitude adjustment
- **Thermal Protection**: Automatic reduction at high temperatures
- **Environmental Noise Compensation**: Adaptive volume adjustment

Visual System

- **LED Channels**: 2 high-intensity LED channels
- **PWM Control**: 255-level brightness control
- **Thermal Monitoring**: Individual channel temperature tracking
- **Thermal Shutdown**: Protection at 70°C
- **Adaptive Brightness**: Ambient light compensation

Protection Systems

- **Enclosure Sealing**: Integrity monitoring
- **Ventilation Control**: Active air circulation
- **Heating System**: Internal temperature regulation
- **Desiccant Management**: Humidity control
- **Pressure Monitoring**: Differential pressure sensing

Software Architecture

Real-Time Operating System

The system operates on a cooperative multitasking architecture with priority-based task scheduling:

Tracking Algorithm

- **Sensor Fusion**: Combines data from 3 ultrasonic sensors

- **Kalman Filtering**: Noise reduction and trajectory prediction
- **Confidence Scoring**: Graduated confidence levels (0-100)
- **Stale Detection Removal**: Automatic cleanup of old detections

Deterrent Patterns

Audio Patterns

The system includes multiple pre-programmed audio patterns:

1. **Crow Distress**: 800-1200Hz range, moderate intensity
2. **Eagle Distress**: 1200-2200Hz range, high intensity
3. **Hawk Screech**: 1800-2500Hz range, piercing tones
4. **General Alarm**: Multi-frequency sweep pattern
5. **Ultrasonic Sweep**: 17-24kHz for ultrasonic deterrence
6. **Predator Growl**: Low frequency 80-200Hz intimidation
7. **Emergency Siren**: Continuous high-intensity pattern

Pattern Rotation

- **Anti-Habituation**: Automatic pattern cycling every 30 seconds
- **Effectiveness Monitoring**: Pattern performance tracking
- **Environmental Adaptation**: Weather-based pattern selection
- **Noise Compensation**: Volume and frequency adjustment

Learning Algorithms

- **Success Rate Tracking**: Monitors deterrent effectiveness
- **Pattern Optimization**: Adjusts parameters based on results
- **Seasonal Adaptation**: Long-term behavior pattern learning

Communication Protocols

Ground Station Interface

The system communicates with a Python-based ground station application via serial connection.

Communication Parameters

- **Baud Rate**: 115200
- **Data Bits**: 8
- **Stop Bits**: 1
- **Parity**: None
- **Update Interval**: 1000ms
- **Timeout**: 30 seconds

Ground Station Features

- **Real-time Monitoring**: Live telemetry display
- **Historical Data Logging**: SQLite database storage
- **Alert Management**: Threshold-based alerting
- **Remote Control**: Command transmission capability
- **Data Visualization**: Matplotlib-based charts
- **Mission Planning**: Autonomous operation scheduling

Safety and Protection Systems

Thermal Protection

- **Component Monitoring**: Individual component temperature tracking
- **Graduated Response**: Automatic power reduction before shutdown
- **Thermal Shutdown**: Complete system protection
- **Cool-down Periods**: Automatic recovery timing

Emergency Systems

- **Multiple Trigger Sources**: Power, thermal, weather, manual
- **Graceful Shutdown**: Ordered system power-down
- **Emergency Signals**: High-intensity audio/visual alerts
- **Remote Emergency Stop**: Ground station emergency control

Environmental Safety

- **Weather Monitoring**: Continuous environmental assessment
- **Seal Integrity**: Enclosure breach detection
- **Pressure Management**: Internal pressure regulation
- **Moisture Control**: Desiccant and ventilation systems

Installation and Setup

Hardware Installation

1. **Mounting**: Secure mounting on elevated platform
2. **Sensor Positioning**: 120° spacing for optimal coverage
3. **Power Connection**: 12V DC supply with battery backup
4. **Weatherproofing**: Seal all connections and enclosures
5. **Ground Station**: USB/Serial connection to monitoring computer

Software Configuration

1. **Sensor Calibration**: Individual sensor baseline establishment
2. **Audio Testing**: Pattern verification and volume adjustment
3. **Visual Testing**: LED functionality and thermal limits
4. **Communication Setup**: Ground station connection verification
5. **Environmental Baseline**: Weather condition calibration

Operation Modes

Normal Operation Mode

- **Continuous Detection**: 24/7 bird monitoring
- **Adaptive Response**: Graduated deterrent activation
- **Power Management**: Optimized for extended operation
- **Data Logging**: Continuous telemetry transmission

Low Power Mode

- **Reduced Sensitivity**: Lower detection frequency

- **Limited Deterrents**: Audio-only responses
- **Extended Runtime**: Battery conservation priority
- **Critical Functions Only**: Essential systems maintained

Emergency Mode

- **Maximum Deterrence**: All systems at full intensity
- **Override Protections**: Thermal limits temporarily increased
- **Continuous Operation**: No power-saving delays
- **Alert Broadcasting**: Maximum visibility/audibility

Maintenance Mode

- **System Testing**: Built-in diagnostic routines
- **Calibration**: Sensor and deterrent adjustment
- **Data Download**: Historical data retrieval
- **Configuration Updates**: Parameter modification

Maintenance and Troubleshooting

Preventive Maintenance Schedule

Daily Checks

- Battery voltage monitoring
- Communication link verification
- Basic functionality test

Weekly Maintenance

- Sensor cleaning and calibration
- Deterrent system testing
- Weather seal inspection
- Data backup verification

Monthly Service

- Full system diagnostic
- Component temperature logging
- Effectiveness analysis
- Software updates

Each subsystem provides detailed status reports for troubleshooting:

- Component operational status
- Performance metrics
- Error conditions
- Calibration status
- Temperature and power readings

Common Issues and Solutions

Detection Problems

- **False Positives**: Adjust sensitivity thresholds
- **Missed Detections**: Sensor cleaning and recalibration
- **Range Issues**: Verify mounting height and angles

Deterrent Effectiveness

- **Bird Habituation**: Increase pattern rotation frequency
- **Volume Issues**: Environmental noise compensation
- **Visual Problems**: LED cleaning and thermal check

Power Management

- **Battery Drain**: Check for high-current components
- **Voltage Fluctuations**: Verify charging system operation
- **Thermal Issues**: Improve ventilation and component spacing

Communication Problems

- **Data Loss**: Check serial connections and baud rate
- **Timeout Issues**: Verify ground station configuration

- **Telemetry Gaps**: Review data logging settings
