Boom Barrier System for Wildlife Sanctuary Protection

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1. Introduction

Wildlife sanctuaries are crucial for preserving biodiversity and protecting endangered species. However, roadways intersecting these sanctuaries pose significant threats to wildlife due to vehicular accidents. The rapid expansion of human infrastructure has made it essential to develop systems that balance development with conservation. To address this issue, we propose a **Boom Barrier System** aimed at mitigating vehicle-wildlife collisions by controlling vehicular access during animal crossings. This system leverages modern technology to ensure the safety of wildlife while maintaining smooth human transportation.

2. Objective

The primary objective is to design and implement an automated boom barrier system that prevents vehicles from entering designated crossing zones when wildlife is detected. The system will serve to:

- Enhance the safety of wildlife by reducing collisions.
- Provide an efficient solution for managing vehicle traffic in sanctuaries.
- Raise awareness about the importance of wildlife conservation.

3. Key Features

1. **Animal Detection System**:
    - Utilizes infrared sensors, motion detectors, and AI-based cameras to identify wildlife near roads.
    - Capable of differentiating between various species to prioritize endangered ones.
    - Sends real-time alerts to the control system upon detection.
2. **Boom Barrier Mechanism**:

- Automated barriers installed at critical crossing zones with rapid deployment capability.
- Designed to handle different vehicle speeds and stop vehicles safely.

3. **Alert System**:
   - Visual indicators (flashing lights) and auditory alarms to notify drivers.
   - Dynamic digital signage displaying warnings, wait times, and conservation messages.
4. **Remote Monitoring and Control**:
   - Centralized system for monitoring wildlife activity and barrier operations.
   - Mobile app integration for real-time updates to drivers, sanctuary authorities, and nearby residents.
5. **Data Logging**:
   - Records the frequency and type of wildlife crossings.
   - Provides valuable data for sanctuary management and research.

4. System Design

4.1. Hardware Components

- **Sensors**:
  - Passive Infrared (PIR) sensors for motion detection.
  - Thermal imaging cameras for night-time visibility.
  - AI-enabled cameras for species identification.
- **Boom Barrier**:

    - Motorized barriers with both automatic and manual operation modes.

- **Warning System**:
    - LED lights, sirens, and electronic signboards integrated for driver awareness.

4.2. Software Components

- **AI Algorithm**:
    - Trained model to distinguish wildlife from other objects like vehicles or humans.
    - Predictive analysis for animal movement patterns based on historical data.
- **Control Software**:
    - Integrates sensors, barriers, and alerts.
    - Web-based dashboard for live monitoring, data visualization, and system management.

5. Implementation

5.1. Site Selection

- Conduct an environmental impact assessment to identify high-risk animal crossing zones within the sanctuary.
- Prioritize locations based on historical data, traffic density, and species vulnerability.

5.2. Installation

- Deploy sensors and cameras along identified zones.
- Install boom barriers and connect them to the central control system.

- Position warning systems at sufficient distances to allow vehicles to stop safely.

5.3. Testing and Calibration

- Conduct controlled tests to evaluate system responsiveness and accuracy.
- Simulate animal crossings and vehicular scenarios under various conditions.
- Refine AI models for improved detection accuracy and reduced false positives.

6. Codes

```
#include <SPI.h>

#include <MFRC522.h>

#include <Servo.h>


#define SS_PIN  D8 // The ESP8266 pin D8

#define RST_PIN D2 // The ESP8266 pin D2

#define SERVO_PIN D1  // The ESP8266 pin connects to servo motor


MFRC522 rfid(SS_PIN, RST_PIN);

Servo servo;


byte authorizedUID[4] = {0x4E, 0x88, 0x5E, 0x73};

int angle = 0; // The current angle of servo motor


void setup() {

  Serial.begin(9600);
```

```
  SPI.begin(); // init SPI bus
  rfid.PCD_Init(); // init MFRC522
  servo.attach(SERVO_PIN);
  servo.write(angle); // rotate servo motor to 0°

  Serial.println("Tap RFID/NFC Tag on reader");
}

void loop() {
  if (rfid.PICC_IsNewCardPresent()) { // new tag is available
    if (rfid.PICC_ReadCardSerial()) { // NUID has been readed
      MFRC522::PICC_Type piccType = rfid.PICC_GetType(rfid.uid.sak);

      if (rfid.uid.uidByte[0] == authorizedUID[0] &&
          rfid.uid.uidByte[1] == authorizedUID[1] &&
          rfid.uid.uidByte[2] == authorizedUID[2] &&
          rfid.uid.uidByte[3] == authorizedUID[3] ) {
        Serial.println("Authorized Tag");

        // change angle of servo motor
        if (angle == 0)
          angle = 180;
        else //if(angle == 90)
          angle = 0;

        // rotate the servo motor to the angle position
        servo.write(angle);
        Serial.print("Rotate Servo Motor to ");
```

```
      Serial.print(angle);
      Serial.println("°");
     } else {
      Serial.print("Unauthorized Tag with UID:");
      for (int i = 0; i < rfid.uid.size; i++) {
       Serial.print(rfid.uid.uidByte[i] < 0x10 ? " 0" : " ");
       Serial.print(rfid.uid.uidByte[i], HEX);
      }
      Serial.println();
     }

     rfid.PICC_HaltA(); // halt PICC
     rfid.PCD_StopCrypto1(); // stop encryption on PCD
    }
  }
}
```

7. Benefits

1. **Wildlife Protection**:
    - Drastically reduces roadkill incidents.
    - Ensures the safety of endangered species and promotes biodiversity.
2. **Driver Safety**:
    - Prevents accidents caused by sudden animal crossings.
    - Enhances the overall driving experience by providing timely alerts.

3. **Conservation Awareness**:
    - Promotes a sense of responsibility among visitors.
    - Educates the public about the importance of coexisting with wildlife.
4. **Data-Driven Insights**:
    - Helps in studying animal behavior and improving sanctuary management.

8. Challenges and Solutions

1. **False Positives**:
    - **Challenge**: Non-animal objects or small animals triggering the system unnecessarily.
    - **Solution**: Enhance AI model training with diverse datasets and incorporate multi-sensor verification.
2. **System Downtime**:
    - **Challenge**: Power outages or hardware failures.
    - **Solution**: Deploy solar-powered systems with battery backups to ensure uninterrupted operation.
3. **Driver Non-compliance**:
    - **Challenge**: Drivers bypassing or ignoring the barrier.
    - **Solution**: Install surveillance cameras and implement penalties for violations. Raise awareness through education campaigns.

9. Future Scope

1. **Machine Learning Integration**:
    - Develop advanced machine learning models capable of detecting herd movements.

- Enable automatic barrier closures when a group of animals is detected crossing the road.
- Train models using diverse datasets to account for varying animal sizes and behaviors.

2. **IoT Integration**:
   - Connect the system to the Internet of Things (IoT) for enhanced real-time monitoring.
   - Enable data sharing between sanctuaries to create a networked conservation system.
3. **Scalability**:
   - Expand the system to cover larger sanctuaries and multiple crossing zones.
   - Customize solutions for different terrains and animal species.
4. **Collaboration with Conservation Organizations**:
   - Partner with wildlife experts and NGOs to refine the system.
   - Use gathered data for ecological studies and habitat improvement.

10. Conclusion

The boom barrier system is a practical and scalable solution to protect wildlife in sanctuaries from vehicular accidents. By integrating advanced technologies such as AI, sensors, and automated barriers, this project ensures a harmonious coexistence between wildlife and human activities. The addition of future developments, such as machine learning integration and IoT-enabled monitoring, promises even greater efficiency and reliability in wildlife protection efforts. This project not only addresses immediate safety concerns but also contributes to long-term conservation goals.

11. Appendix

1. **Data Sources**:
    - Historical records of wildlife accidents.
    - Movement patterns of animals.
    - Research papers on AI and conservation technologies.
2. **References**:
    - Wildlife conservation studies.
    - Technological solutions for road safety.