SMART HIGHWAY SAFETY SYSTEM USING DEEP LEARNING FOR ANIMAL DETECTION

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ABSTRACT - Road accidents caused by unexpected animal crossings have become a significant concern, particularly during nighttime when visibility is severely limited. These incidents not only lead to property damage but also pose serious risks to human life and wildlife. The proposed system addresses this challenge by introducing an intelligent animal detection and alert framework designed to enhance road safety through continuous real-time monitoring. High-resolution night-vision cameras capture live footage of roadways, which is then processed using advanced deep learning techniques, including Convolutional Neural Networks (CNN) and YOLO-based detection models. These algorithms enable accurate identification of animals even under low-light, foggy, or adverse weather conditions. By automatically distinguishing animals from other objects such as vehicles or pedestrians, the system reduces the reliance on human intervention and ensures precise detection in dynamic environments.

KEYWORDS - Deep Learning,Wild life Monitoring, Computer Vision,Real-Time Monitoring,Covolutional Neural Network(CNN),You Only Look Once(YOLO).

1. INTRODUCTION

Road accidents involving unexpected animal crossings are a growing concern worldwide, particularly in regions where highways and rural roads intersect with wildlife habitats. Such accidents often occur at night, when low visibility significantly increases the risk of collisions. The static road signs and fences, are often insufficient to prevent these incidents due to the unpredictable behavior of animals and the dynamic nature of road environments. Consequently, there is an urgent need for intelligent systems capable of detecting animals in real time and alerting drivers to potential hazards, thereby enhancing both human safety and wildlife protection.

Techniques such as Convolutional Neural Networks (CNN) and YOLO (You Only Look Once) enable the recognition and classification of objects with high accuracy, even under challenging conditions like low light, fog, or rain. warning mechanisms such as

sirens, flash lights or in-vehicle notifications to alert approaching drivers and the integration of real-time processing automated detection, and adaptive alert generation ensures rapid response times suitable for fast-moving traffic.

1.1 SCOPE OF THIS PROJECT

This project aims to:

- The scope of this project encompasses the design and implementation of an intelligent animal detection and alert system aimed at enhancing road safety, particularly during nighttime or low-visibility conditions.
- The system is intended for deployment on highways, rural roads, and wildlife-prone areas where animal crossings are frequent and unpredictable.
- By utilizing high-resolution night-vision cameras combined with deep learning algorithms such as CNN and YOLO, the project ensures accurate real-time detection and classification of multiple animal species.
- The training of deep learning models on diverse datasets, including real-world road scenarios, ensures that the system can recognize various animals in different postures and distances.
- The system's automated alert mechanism, flashing lights, sirens, provides drivers with timely warnings.

detection models, it is possible to continuously monitor roadways and identify the presence of animals in real time.

2. PROPOSED WORK

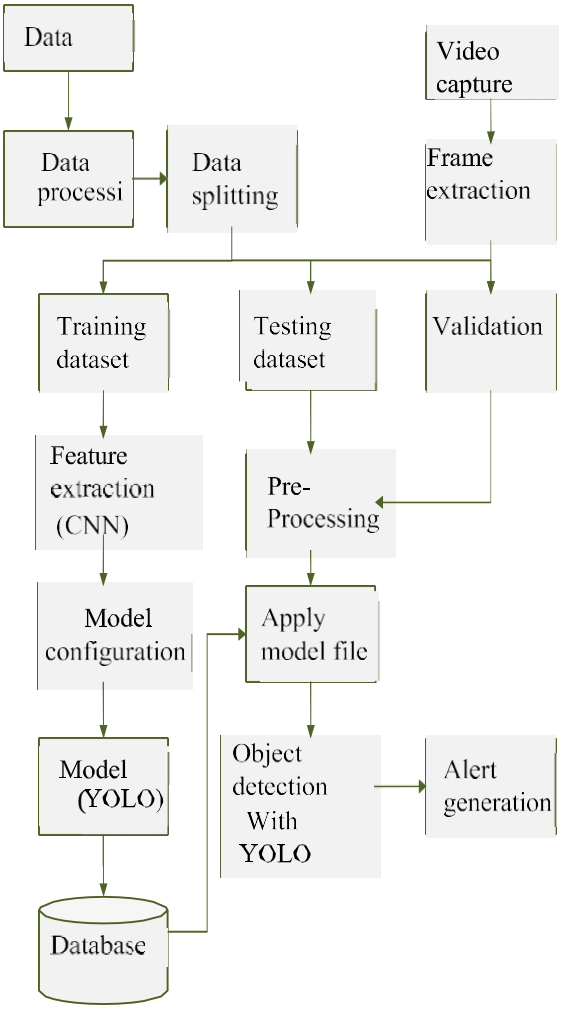
The proposed system introduces an intelligent and automated animal detection and alert framework designed to enhance road safety, particularly during night-time and low-visibility conditions.

The collected data is processed using advanced deep learning techniques, specifically Convolutional Neural Networks (CNN) for feature extraction and YOLO (You Only Look Once) for real-time object detection.

This combination allows the system to accurately identify the presence, type, and movement of multiple animal species, even under challenging environmental conditions such as fog, rain, or low light.

The framework also incorporates pre-processing techniques such as median filtering and background subtraction to enhance image clarity and remove visual noise, ensuring consistent performance under diverse conditions.

1.2 System Architecture



3.1 Data Processing and Preprocessing

Data preprocessing is the crucial initial step of cleaning and organizing raw data (such as images, video footage, or sensor readings) to ensure it is suitable for use by a machine learning model.

- **Data Collection**: Gathering diverse data, including images or videos of various animals, road conditions (day/night, different weather), and vehicle perspectives.
- **Data Cleaning**: Removing irrelevant or corrupted data points. This might involve deleting blurry images or footage where the camera view is entirely obstructed.
- **Data Labeling/Annotation:** The most critical step. Humans draw bounding boxes or outlines around animals in the images and label what they are (e.g., "deer," "dog," "kangaroo").
- **Data Normalization and Resizing**: Standardizing image sizes and pixel values to a uniform format that the computer system can process efficiently.
- **Data Augmentation**: Creating artificial variations of existing data (e.g., slightly rotated, flipped, or brightness-adjusted images).

3.2 Data Processing

Data processing refers to the stage where the prepared data is fed into algorithms to extract meaningful insights and enable real-time decision-making.

- **Model Training**: The annotated dataset is used to train a machine learning model (often a deep learning neural network) to automatically recognize animals.
- **Feature Extraction**: The model learns to automatically identify key visual features associated with animals, such as shapes, textures, and movement patterns.
- **Inference (Real-time Detection):** Once trained, the model is deployed in systems (e.g., cameras on vehicles or alongside roads). It analyzes live video streams in real time.
- **Decision and Action**: When an animal is detected, the system immediately triggers an alert.

3.3 Tools And Libraries

- **PyTorch:** Dynamic computation graph, easy debugging.
- **TensorFlow / Keras:**Strong production and deployment.
- **Object Detection Libraries:** These are specialized for detecting animals in images/videos.
- **YOLO (You Only Look Once):** Most widely used for animal detection.
- **Pretrained Detection Models:** You can fine-tune these for animals instead of training from scratch.
- **Wildlife-Specific & Animal-Focused Tools**

  MegaDetector - Pretrained model for camera-trap images,Detects animals, humans, vehiclesBuilt on deep learning (YOLO/Faster R-CNN)

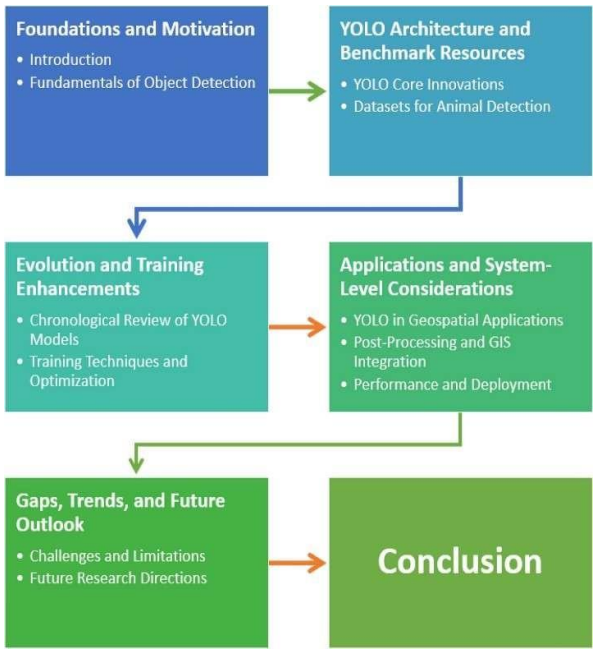
3.4 Model Training and Evaluation

YOLO Model Selection: Choose an appropriate YOLO variant (e.g., YOLOv8n, known for speed and efficiency).

Training Environment Setup: Set up a development environment using Python and necessary packages like PyTorch and Ultralytics. You can leverage resources like Google Colab for access to GPUs.

Training: Train the YOLO model using your combined (real and synthetic) dataset. You can start with a pre-trained model on a general dataset (like MS-COCO) for faster convergence.

Evaluation: Evaluate the model's performance using metrics like mean Average Precision (mAP), precision, and recall. Test the model using separate real-world test images to ensure it generalizes well.

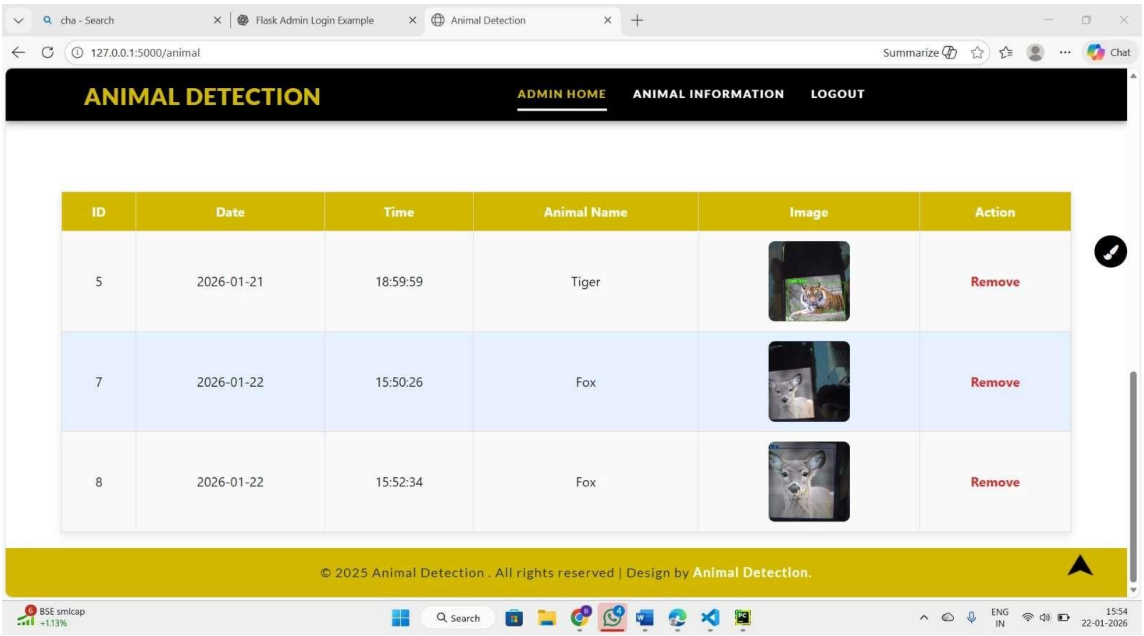


Model Training and Evaluation

4. PROGRAM

```
from flask import Flask, render_template, request, redirect,
session
import mysql.connector

app = Flask(__name__)
app.secret_key = "secret123"

def get_db():
    return mysql.connector.connect(
        host="localhost",
        user="root",
        password="",
        database="animaldbda"
    )

@app.route("/", methods=["GET", "POST"])
def login():
    if request.method == "POST":
        user = request.form["username"]
        pwd = request.form["password"]

        db = get_db()
        cur = db.cursor()
        cur.execute("SELECT * FROM regtb WHERE UserName=%s AND
Password=%s", (user, pwd))
        data = cur.fetchone()

        if data:
            session["user"] = user
            return "Login Successful"
        else:
            return "Invalid Login"

    return '''
        <form method="post">
            <input name="username">
            <input name="password" type="password">
            <button>Login</button>
        </form>
    '''

if __name__ == "__main__":
    app.run(debug=True)
```

5. RESULTS AND OUTPUT



6. CONCLUSION

The proposed animal detection and alert system demonstrates a significant advancement in enhancing road safety, particularly during nighttime and low-visibility conditions. By integrating high-resolution night-vision cameras with advanced deep learning techniques such as Convolutional Neural Networks (CNN) and YOLO, the system is capable of accurately detecting and classifying multiple animal species in real time.

Experimental results demonstrate that deep learning–based approaches outperform traditional detection methods in terms of accuracy, adaptability, and response time.

Overall, the Smart Highway Safety System represents a promising step toward intelligent transportation infrastructure. With future enhancements such as edge computing, multi-sensor fusion, and integration with smart traffic management systems, this approach can be widely adopted to create safer, smarter, and more sustainable highways.

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