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foundation

Multiclass Driver Monitoring System

Problem Statement

Unsafe and distracted driving behaviors—particularly mobile phone usage while driving—are major contributors to road accidents globally. Manual monitoring is impractical and reactive, while existing automated systems often fail to distinguish between specific distraction types or require extensive computational resources. There is a critical need for an **accurate, automated, and scalable system** that can classify multiple driver behaviors in real-time using visual data, enabling timely interventions and enhanced road safety.

Scope of the project :

- To design an automated system to detect driver behavior
- To classify multiple driver activities using a comnination of YoLo Models
- To improve road safety by identifying unsafe driving patterns
- To build a robust and scalable deep learning solution

Project Overview

- Driver behavior monitoring is an important part of intelligent transportation systems aimed at improving road safety. Many road accidents occur due to driver distractions such as mobile phone usage and improper driving actions. With the advancement of deep learning, automated systems can now analyze driver images to recognize unsafe behaviors.

- This project presents a Multi-Class Driver Behavior Monitoring System designed to automatically recognize and classify different driver activities from images. The main goal is to enhance road safety by detecting unsafe driving behaviors using deep learning.

- The final implementation is based on YOLO object detection models, which are well-suited for real-world scenarios. Additionally, a CNN-based classification model was implemented and evaluated separately for comparative analysis.

- The system processes camera images of drivers and predicts behavior **Classes** such as:
  - Smoking
  - Seatbelt
  - Phone Usage (Texting, Calling)
  - Drinking
  - Eating
  - Drowsy

Solution Offered

The proposed solution is an **AI-driven Driver Monitoring System (DMS)** that automatically detects and classifies unsafe driver behaviors using **deep learning–based computer vision**. The system processes in-vehicle camera images to identify behaviors such as safe driving, mobile phone usage, and other distraction-related activities in near real time.

The solution employs a **dual-YOLO architecture**, where two object detection models operate in parallel, each specialized for a distinct detection task. A **confidence-based decision mechanism** selects the most reliable prediction, improving accuracy and reducing false detections compared to single-model approaches. This design ensures **high reliability under real-world** conditions such as varying lighting, driver posture, and camera angles.

The system is designed to be modular, scalable, and deployment-ready. It can be integrated into Advanced Driver Assistance Systems (ADAS), fleet management platforms, and smart transportation solutions. A lightweight web-based interface enables visualization of predictions and supports monitoring and reporting functions for stakeholders.

From a business perspective, the solution helps organizations **reduce accident risk, lower operational** and **insurance costs**, **and improve compliance with road safety** regulations. Its extensible architecture allows future upgrades, including real-time video analysis, sensor fusion, and edge deployment, making it a future-ready investment for intelligent mobility ecosystems.

Who Are The End Users?

1. **Automobile Manufacturers (Advanced Driver Assistance Systems – ADAS)**
   - Can integrate the system into ADAS to **enhance in-vehicle safety**
   - Helps in detecting driver distraction and fatigue in real time
2. **Traffic Safety Authorities**
   - Supports **automated detection** of unsafe driving behaviors
   - Reduces reliance on manual surveillance and enforcement
3. **Insurance Companies**
   - Enables **behavior-based risk assessment** of drivers
   - Helps in designing dynamic and fair insurance premium models
4. **Smart Vehicle and Transportation System Developers**
   - Can be used as a core module in **intelligent and connected vehicles**
   - Supports integration with smart mobility and transportation platforms

Technology Used To Solve The Problem

- **Programming Language:** Python
- **Deep Learning Models:** YOLO (Object Detection), CNN (Image Classification – experimental)
- **Frameworks & Libraries:** TensorFlow, Keras, OpenCV, NumPy, Ultralytics
- **Model Development Environment:** Google Colab
- **Dataset Source:** Kaggle (Multi-Class Driver Behavior Image Dataset), Roboflow
- **Visualization & Evaluation:** Matplotlib, Seaborn
- **User Interface (UI):** Web-based UI and Flask (for displaying final prediction)

Model Overview :

1.YOLO (You Only Look Once)

- YOLO is a **single-stage object detection algorithm** that detects multiple objects and their locations in real time.
- It processes the entire image in **one forward pass**, making it highly suitable for **real-time driver monitoring systems**.
- The use of **dual YOLO models** improves reliability through confidence-based prediction selection
- Mean average precision :
  map50: 0.9134820409250091 , map50-95: 0.6636814530384787

2. CNN (Convolutional Neural Network)

- CNN is a **deep learning model specialized for image classification** and feature extraction.
- In this project, a CNN-based model was implemented as an **experimental approach** to compare classification--based performance with YOLO detection results.