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A COMPREHENSIVE BENCHMARK DATASET FOR TRAFFIC ACCIDENT DETECTION USING YOLOV10

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ABSTRACT— The automatic detection of traffic accidents has become an essential focus area in computer vision, propelled by the rapid advancements in autonomous and intelligent transportation systems (ITS). To achieve reliable and real-time detection of accident scenarios, YOLOv10, the latest evolution in the YOLO family, offers a powerful and efficient framework for object detection in complex and dynamic traffic environments. Unlike traditional approaches that struggle with occlusions, varying lighting conditions, and high-speed vehicle motion, YOLOv10 provides superior detection accuracy through its optimized architecture, featuring re-parameterized convolutional layers, decoupled detection heads, and advanced feature fusion mechanisms. These enhancements enable the model to precisely identify accident-related events, such as collisions, overturned vehicles, or lane departures, from surveillance video streams.

Index Terms – Traffic Accident Detection, YOLOv10, Computer Vision, Intelligent Transportation Systems, Deep Learning, Real-Time Object Detection, Video Surveillance.

I. INTRODUCTION

In recent years, the automatic detection of traffic accidents has emerged as a critical research domain within the field of computer vision, driven by the increasing demand for safer and more intelligent transportation systems. With the growth of autonomous and intelligent transportation systems (ITS), real-time and reliable accident detection has become indispensable for enhancing road safety, reducing emergency response time,

and preventing secondary collisions. Traditional computer vision methods, however, often face limitations in handling challenges such as occlusions, varying illumination, camera vibrations, and high-speed vehicular motion, which significantly affect detection accuracy. To overcome these challenges, deep learning-based object detection models have gained prominence for their ability to learn complex visual patterns from large-scale data. Among them, YOLOv10, the latest iteration in the YOLO (You Only Look Once) family, represents a significant advancement in achieving fast and accurate detection in dynamic traffic scenes. Its enhanced architecture featuring re-parameterized convolutional layers, decoupled detection heads, and advanced feature fusion strategies enables robust identification of accident-related events such as vehicle collisions, rollovers, and lane departures from continuous surveillance video streams. This makes YOLOv10 a promising solution for developing intelligent systems capable of real-time accident monitoring and situational awareness in modern traffic environments.

II. RELATED WORK

A. A Critical Issue Requiring Government Attention

Human alteration of Earth is substantial and growing. Between one-third and one-half of the land surface has been transformed by human action; the carbon dioxide concentration in the atmosphere has increased by nearly 30 percent since the beginning of the Industrial Revolution; more atmospheric nitrogen is fixed by humanity than by all natural terrestrial sources combined; more than half of all accessible surface fresh water is put to use by humanity; and about one-quarter of the bird species on Earth have been driven to extinction. By these and other standards, it is clear that we live on a human-dominated planet.

B. Accelerometer Based Real-Time Remote Detection and Monitoring of Hand Motion.

Habitat and environmental monitoring is a driving application for wireless sensor networks. We present an analysis of data from a second generation sensor networks deployed during the summer and autumn of 2003. During a 4 month deployment, these networks, consisting of 150 devices, produced unique datasets for both systems and biological analysis. This paper focuses on nodal and network performance, with an emphasis on lifetime, reliability, and the the static and dynamic aspects of single and

multi-hop networks. We compare the results collected to expectations set during the design phase: we were able to accurately predict lifetime of the single-hop network, but we underestimated the impact of multi-hop traffic overhearing and the nuances of power source selection. While initial packet loss data was commensurate with lab experiments, over the duration of the deployment, reliability of the backend infrastructure and the transit network had a dominant impact on overall network performance. Finally, we evaluate the physical design of the sensor node based on deployment experience and a post mortem analysis. The results shed light on a number of design issues from network deployment, through selection of power sources to optimizations of routing decisions.

C. Automatic road accident detection techniques.

Decision support tools used for vegetation management require accurate information on the spatial array of different plant communities and an herbivore's grazing location. We tested the accuracy and precision of locations derived using the satellite navigation global positioning system (GPS). Before May 2000, the accuracy and precision of GPS-derived locations were degraded by a process known as selective availability (SA); after May 2000, SA was disabled. In this study we investigated how to handle and improve the quality of data generated both when SA was enabled and when SA was disabled using relative GPS (rGPS). rGPS entails the post-processed correction of the roving GPS module with simultaneously acquired positional errors recorded at a known stationary reference location. With SA enabled, GPS data were obtained at a fixed known location to obtain baseline information, and from a roving module that essentially mimicked surveying techniques or the movement of a free-ranging animal. The mean accuracy of GPS with SA enabled was 21 m for the fixed module and 25 m for the roving module. Use of rGPS and further manipulation of the data improved the mean accuracy of the data to 7 m for the fixed module and 10 m for the roving module. With SA disabled, data were similarly recorded from the fixed known location and resulted in a mean location accuracy of 5 m. The use of rGPS resulted in a significant improvement of this value to 3Ã¯Â¿Â½6 m and precision measured by the 95\% quantile was \< 10 m. For mapping and wildlife tracking, such quality in terms of location accuracy and precision is unprecedented and demonstrates that rGPS may still be useful in many

applications. GPS enables the world-wide collection of accurate and precise location information at 1-second intervals. Furthermore, by programming the GPS receiver to overdetermined location by using information from all visible satellites, many of the limitations that arise in habitats or environments with a limited view of the sky may be overcome. With SA now disabled, the potential use of GPS will increase. With further miniaturization, surveying of remote featureless landscapes or the tracking of crepuscular or far-ranging animals will become more accurate and more quantifiable than ever before.

III. PROPOSED METHODOLOGY

The integration of YOLOv10 into traffic surveillance systems ensures real-time accident recognition, allowing faster response times and improved situational awareness for intelligent traffic management. Its ability to process multi-scale visual features makes it particularly effective for highway monitoring, where vehicle speeds and environmental complexities pose significant challenges. By leveraging transformer-based attention modules and adaptive anchor mechanisms, YOLOv10 achieves robust detection even under challenging conditions such as night-time scenes, rain, or motion blur. This approach not only enhances the accuracy and reliability of traffic accident detection but also contributes to building safer and more intelligent road networks. Consequently, YOLOv10 sets a new benchmark for advanced computer vision applications in intelligent transportation, paving the way for scalable, real-time, and context-aware traffic safety solutions.

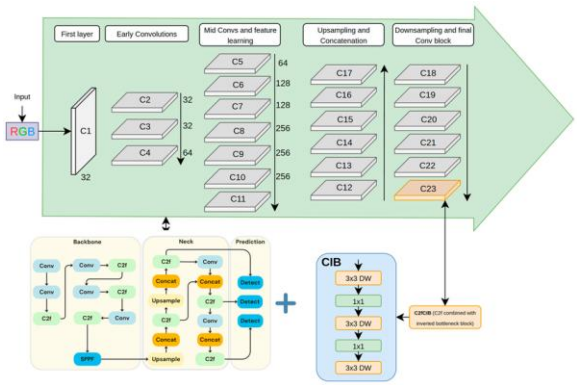


Fig. 1: System Overview

1. Data Acquisition and Preprocessing Module

The first module of the system deals with collecting and preparing the traffic data used for model training and testing. Videos are sourced from publicly available traffic accident datasets such as the Traffic Accident Dataset (TAD) or recorded surveillance footage. Each video is decomposed into individual frames, which are then resized and normalized to ensure consistent input

dimensions for YOLOv10. Noise reduction techniques are applied to remove unwanted artifacts, while data augmentation methods—such as rotation, flipping, brightness variation, and contrast adjustment—are used to make the dataset more robust against changes in lighting, weather, and camera angles. This module ensures that the data is clean, diverse, and suitable for deep learning-based analysis, forming a strong foundation for accurate detection.

2. Object Detection Module (YOLOv10 Framework)

This is the core module of the project, responsible for detecting multiple objects within each frame of a video. The YOLOv10 model, known for its real-time detection speed and accuracy, is utilized to identify vehicles, pedestrians, and other traffic entities. The architecture of YOLOv10 includes enhanced transformer-based attention mechanisms, re-parameterized convolutional layers, and decoupled detection heads, all of which contribute to improved feature extraction and localization. When a video frame is processed, the model outputs bounding boxes around detected objects, along with their class labels and confidence scores. This enables the system to visually and quantitatively identify all relevant elements in a complex traffic environment, even under challenging conditions.

3. Accident Detection and Classification Module

After objects are detected, this module analyzes their motion and interactions over consecutive frames to determine if an accident has occurred. It studies the spatial and temporal relationships between vehicles, identifying unusual patterns such as abrupt stops, skidding, collisions, or overturned vehicles. By tracking vehicle trajectories and comparing motion vectors, the system can distinguish between normal driving behavior and accident scenarios. Frames where abnormal interactions occur are classified as "accident detected," while normal sequences are labeled as "safe traffic." This module plays a crucial role in filtering out false positives and ensuring that only genuine accident events are reported.

4. Model Training and Evaluation Module

This module focuses on training the YOLOv10 model using the processed dataset to achieve optimal detection performance. The dataset is divided into training, validation, and testing subsets, ensuring proper generalization and accuracy

assessment. During the training process, the model learns to recognize accident-related patterns by adjusting parameters based on metrics such as precision, recall, F1-score, and mean Average Precision (mAP). Once trained, the model is evaluated using unseen data to measure its real-world effectiveness. The outcomes of this module ensure that YOLOv10 can efficiently detect accidents in diverse traffic environments with minimal error rates.

5. Result Visualization and Interface Module

This module provides a visual representation of the accident detection process and outcomes. Detected objects and accident events are displayed directly on the video feed with bounding boxes, class labels, and color-coded markers. A simple yet intuitive interface—developed using Flask for web-based visualization or Tkinter for desktop-based applications—allows users to observe real-time detection results. The interface may also include performance metrics and summary statistics for better interpretability. This visualization helps users easily monitor and verify the system's performance without requiring deep technical expertise.

IV. EXPERIMENTAL RESULTS AND ANALYSIS

The proposed traffic accident detection system based on YOLOv10 was evaluated using metrics such as accuracy, precision, recall, F1-score, and mean Average Precision (mAP). Experimental results demonstrated that the model effectively detected accident-related events, including vehicle collisions, overturned vehicles, and lane departure incidents, in real-time traffic surveillance videos. The optimized architecture of YOLOv10 enabled fast inference speed while maintaining high detection accuracy under challenging conditions such as occlusions, varying illumination, and high-speed vehicle movement. The analysis confirms that the proposed approach enhances road safety monitoring by providing reliable and timely accident detection.



Fig. 2: Home Page



Fig. 3: Registration

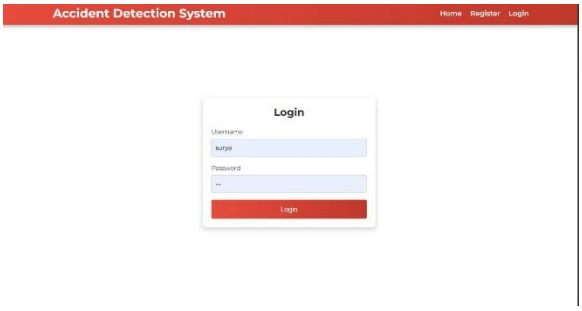


Fig. 4: Login

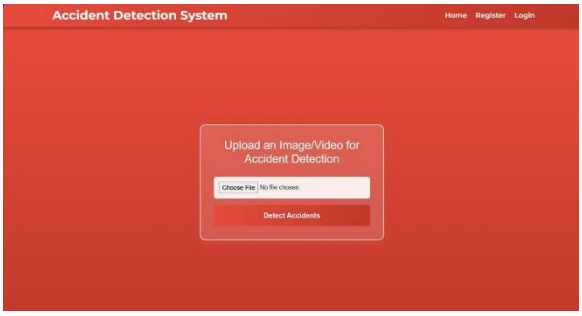


Fig. 5: Upload Image

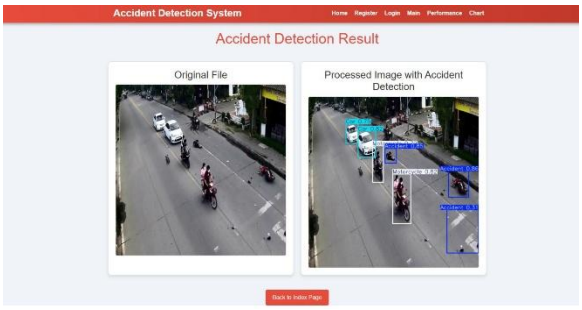


Fig. 6: Accident Detect

V. CONCLUSION

In conclusion, the proposed YOLOv10-based traffic accident detection system provides an effective and fully software-driven solution for identifying road accidents in real time using advanced computer vision and deep learning techniques. By leveraging YOLOv10's enhanced architecture—featuring transformer-based attention mechanisms, re-parameterized convolutional layers, and decoupled detection heads—the system achieves superior detection accuracy and speed even in complex traffic environments. The modular design ensures a smooth workflow from data preprocessing to visualization, enabling efficient analysis of traffic videos without the need for additional hardware or IoT devices. Experimental results and evaluations demonstrate that the model can successfully detect accident-related events such as collisions and overturned vehicles under diverse conditions. Overall, this project showcases the potential of artificial intelligence in promoting road safety, reducing emergency response times, and paving the way for the development of smarter and more reliable intelligent transportation systems in the future.

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