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Collaborative Misbehaviour Response System for Improving Road Safety

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***Abstract*—Wrong-way driving (WWD), Driver Monitoring System (DMS), and parking violations pose significant threats to road safety. To address these challenges, we propose a collaborative misbehavior response system (MBR) that generates real-time, context-aware navigation recommendations to the nearest available parking spot. The MBR integrates individual misbehavior detection systems(MBDs) for a holistic approach to road safety and leverages Kafka and Avro for efficient communication under the 5GMETA Platform.**

I. Introduction and Background

Traffic misbehaviour events like wrong-way driving, inattentive parking, and distracted driving pose critical risks to road safety. Traditional methods including sensor-based systems and centralized traffic management [11], [12], along with Parking Lot Detection [2]–[4], [7] and Wrong-Way Driving Detection [5], [9], [14], are challenged by latency issues and lack real-time inter-vehicle collaboration. Addressing these multifaceted issues, the proposed MBR system integrates real-time collaborative responses using 5GMETA's advanced 5G technology and edge computing. This system enhances detection and processing of traffic events and extends its capabilities to driver condition monitoring with a sophisticated DMS, employing face detection and recognition to assess driver alertness and attentiveness in real-time. The unified MBR system exemplify a significant leap over traditional approaches, providing a cohesive, immediate solution to road safety hazards.

II. System Architecture

A. Overview

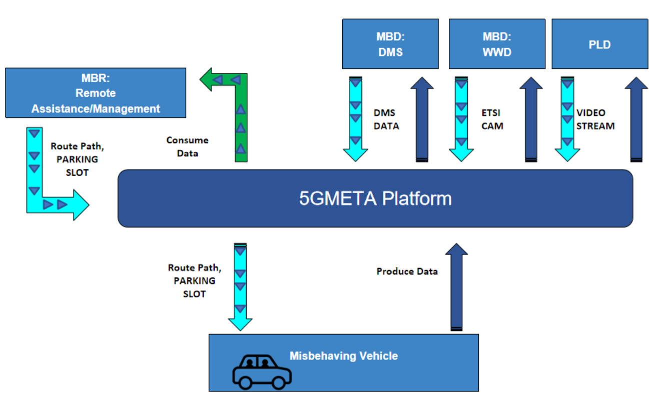

Fig. 1. MBR and MBD Services

The proposed system is a synergy of Misbehavior Detection Systems (MBDs), a Collaborative Misbehavior Response (MBR) System, and the OSRM Engine. It leverages the interplay between real-time data collection through sensors and cameras, efficient route optimization to available parking spaces, and rapid dissemination of misbehavior alerts exploiting the power of 5GMETA platform for real-time data sharing as illustrated in Figure 1. This comprehensive framework utilizes advanced machine learning algorithms and high-performance routing based on up-to-date traffic information.

B. Misbehavior Detection Systems (MBDs)

The integrated suite of MBDs is pivotal for real-time detection and response to traffic misbehaviors, utilizing state-of-the-art algorithms and data fusion techniques.

1) Wrong-way Driving (WWD) Detection System: The WWD Detection System harnesses the power of deep learning and computer vision to accurately detect and track vehicles. Using the YOLO architecture [6] and ByteTrack [15], the system captures dynamic vehicle movements. KMEANS clustering [8] is applied to the trajectories to discern lane direction and identify WWD instances. This real-time analysis is crucial for immediate response to such critical events.

2) Driver Monitoring System (DMS): The DMS is designed to ensure the driver's attention and well-being through a multi-component neural network approach. It features a robust face detection mechanism based on the Ultra-Light-Fast-Generic Face-Detector-1MB, complemented by a facial recognition module utilizing MobileFaceNet for accurate identification. The DMS's core analyzes these inputs to determine the driver's state (e.g., attentive, drowsy, or distracted), thereby enhancing road safety by real-time monitoring of driver behavior.

3) Parking Lot Detector (PLD): To tackle the ubiquitous challenge of parking, the PLD employs a combination of YOLOv5 and DeepSORT [1], [10], [13] algorithms for vehicle detection and tracking. The inclusion of a Static Object Detection algorithm enables the differentiation between occupied and available parking spaces. An image classification system processes the parking occupancy status in real-time, with effective data communication facilitated by the 5GMETA platform.

These MBDs, through their collaborative operation, enable the MBR system to execute a comprehensive and instantaneous response to various traffic-related misbehaviors, ensuring a safer and more efficient driving environment.

C. MBR System

The MBR system is the core of the collaborative misbehavior response system. It receives misbehavior events from the MBDs and generates optimized routes to the nearest available parking spot.

1) Monitoring and Route Generation: When the MBR receives a misbehavior event, it checks the message content to determine the type of misbehavior and the location of the vehicle. The MBR then generates a route to the nearest available parking spot using the OSRM Engine. The MBR considers factors such as traffic conditions, road closures, and the availability of parking spaces when generating routes.

2) Parking Occupancy Updates: The MBR receives parking lot data from the PLD every 10 seconds. This data includes the occupancy status of each parking space. The MBR updates its parking occupancy database with this information, which ensures that drivers have accurate information about available parking spaces.

3) Deployment: The MBR can be deployed in two different setups:

On the 5GMETA Platform as a third-party application: This deployment provides a suitable latency of approximately 1.2 seconds, making it ideal for non-critical applications.

On 5GMETA MEC (Multi-Access Edge Computing) for low latency: This deployment reduces latency to a stable 40 milliseconds, ensuring near-instantaneous responses for critical situations.

III. Results and Evaluation

MBR System demonstrated the ability to integrate MBDs and Routing generation with efficiency and seamlessly levraging the power of 5GMETA for enhanced communication between the MBR and MBDs showcasing great results in Figure 2. The MBR was evaluated in two different deployment levels: on the 5GMETA Platform and on 5GMETA MEC. The results showed that the MBR can effectively generate optimized routes to the nearest available parking spot in response to detected misbehaviors. We demonstrated that the MBR can provide near-instantaneous responses in critical situations when deployed on 5GMETA MEC.

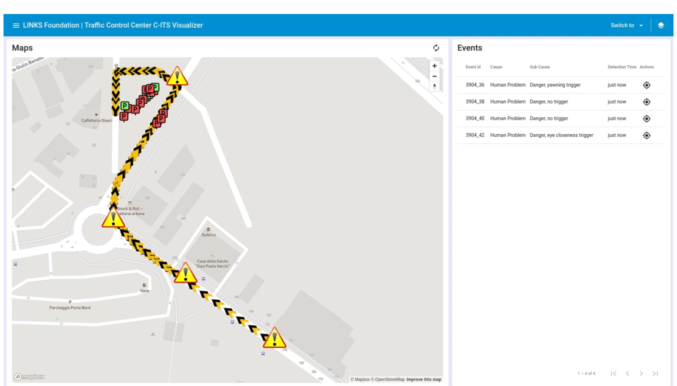

Fig. 2. The Collaborative Misbehavior Response System in action

IV. Conclusion

The MBR enhances road safety by providing real-time, context-aware navigation recommendations in response to detected misbehaviors. It offers a comprehensive solution that integrates individual misbehavior detection systems, enabling a more coordinated and effective approach to road safety. The MBR's ability to generate optimized routes and provide near-instantaneous responses makes it a valuable tool for improving traffic safety and efficiency.

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