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Interpretation of Modified YOLOv7 for Predicting Two-lane Highway Passing Zones: Preliminary Study

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Extended Abstract

Research on the application of cutting-edge AI, including computer vision and edge AI devices, in transportation is gaining prominence to enhance safety and efficiency. The authors have developed an Autonomous Passing Zone Distance Detection (APZDD) device, consisting of a camera interfaced with an edge AI device, for the Department of Transportation (DoT) to ensure safe driving on two-lane state highways [1, 2, & 3]. The APZDD process involves two DoT vehicles (leader and follower), each equipped with a APZDD device, driving at highway speeds, maintaining a constant separation distance, with the follower vehicle capturing the images of the back of the leader vehicle at a constant sampling rate and storing each captured frame stamped with the GPS coordinates in real-time. The captured frames are processed offline by the modified YOLOv7 [4] machine learning (ML) model to predict safe passing zones of a highway. The modified YOLOv7 model performs object detection on the leader vehicle in each captured frame and identifies the start and end frames of the leader vehicle's presence. Using the GPS coordinates of the start and end frames, the safe passing zone of the highway is predicted for DoT operators to paint passing zone lines, ensuring safe passing by consumer vehicles. The DoT operators, after using the APZDD device for a year, identified the lack of interpretation by the model, in particular, of false positive passing zones predicted, i.e., safe pass zones of a highway section predicted by the model, are clearly no-passing zones determined manually by examining the captured video of the leader vehicle. The false positive without any interpretation is concerning to DoT operators due to safety and liability issues. This lack of interpretation resulted in a lack of confidence in the passing zones predicted by the model.

Since the modified YOLOv7 model is a deep learning approach, it is inherently a black-box system, which does not permit any interpretation of the relationship between input and output variables, resulting in a lack of trust in the model. To address this issue, we propose using post-hoc interpretation techniques on the trained model to interpret and provide explanations for the predicted safe passing zones [5]. The modified YOLOv7 model [3] first classifies images based on the presence or absence of the leader vehicle and then determines the location (bounding box with probability values) of the leading vehicle within an image through segmentation.

Several intuitive post-hoc interpretation techniques, such as Grad-CAM [6] and Saliency Maps [7], both of which are gradient-based interpretation methods, and Occlusion [8], a perturbation method, are investigated. The Grad-CAM and Saliency Maps techniques were chosen to utilize the gradient of the modified YOLOv7 output with respect to the input features, specifically pixels, to determine which parts of the image are most influential in the classification. The occlusion technique was selected to identify which areas of the image, beyond the leader vehicle's pixels, contributed to the false positive classification. All three techniques were applied to several cases of false positives.

The Grad-CAM interpretation of false positives revealed that the model was influenced by geometric shapes, such as trash cans, roadside signposts, and the fronts of vehicles in the opposite lane of the highway, when determining the location of the back of the leader vehicle. The saliency map and occlusion interpretation of false positives did not provide any insights, as these two techniques indicated that the influence of pixels representing vegetation and sky was significant in detecting the back of the leader vehicle. An in-depth study is necessary to provide a comprehensive understanding of the interpretations offered by these three techniques.

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