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VISION AND SENSORS

Lightweight YOLOv8 Networks for Driver Profile Face Drowsiness Detection

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Abstract
Vision-based driver monitoring, a non-invasive method designed to identify potentially dangerous operations, has attracted increasing attention in recent years. In this study, a head pitch angle detection method was established to evaluate the driver's drowsiness. Rather than employing the front facial landmarks to estimate head pitch angle, the proposed method measure this angel directly from driver's profile face. To meet the requirement of real-time detection, the method applies the YOLOv8 network of single-stage detection and utilizes MobileNetV3 and FasterNet for lightweight improvement. The detector is trained with re-labeled CFP datasets, and real-time speed tests have been performed. Results demonstrate that the non-improved detector can achieve an mAP50 of 97.3% of the keypoints in a single frame, meanwhile realizing the frame rate of 30.41 FPS. After improvement, parameters of the model have been reduced by 21.3% and 40.9% respectively, while the frame rate can be increased to 37.13 FPS and 52.70 FPS, and the mAP50 of keypoints is increased by 0.41% and 0.51%. The results during the in-car experiment have proved that the developed detection method can effectively evaluate the head pitch angle, thus detect the driver's drowsiness. We provide open-access to the annotated data and pre-trained models in this study.

Keywords Drowsiness detection · Facial landmarks · Keypoint detection · YOLOv8 · MobileNetV3 · FasterNet

1 Introduction

Traffic accidents can result from various factors, with drowsy driving emerging as a significant contributor. Research indicates that 16.5% of fatal and 12.5% of injury-causing traffic accidents in the US are attributed to drowsy driving (Tefft, 2010). Moreover, it is estimated that nearly 90% of such accidents could be prevented with timely driver warning systems (Kang, 2013). Consequently, there is a pressing need for research into drowsy driving detection (Sikander & Anwar, 2019).

Presently, technologies employed for identifying driver drowsiness can be categorized into three main groups: physiology based, vehicle parameter based, and behavior based (Nam et al., 2022; Saleem et al., 2022; Sar et al., 2023; Wang et al., 2019). Physiology-based techniques typically involve the use of precise medical equipment, which can be invasive and impractical for real-world application in vehicles, as they require additional devices to gather driver data (Houshmand et al., 2021; Hu, 2017; Scarpelli et al., 2021).

Detection methods based on vehicle parameters often rely on identifying patterns such as lane departure, abnormal vehicle distance, and yaw rate anomalies. However, these methods may face challenges in detecting drowsiness early due to inherent delays (Hu et al., 2020; Pomerleau, 1995). These issues can be addressed through behavior-based detection methods.

Computer vision technology is frequently utilized to capture various driver's behavior features, including head movements, eye states, and facial expressions. Our proposed work focuses on capturing the driver's head movement, with specific emphasis on head pitch angle characteristics, as abnormal head pitch angles often indicate driver's drowsiness during driving. Accurately and real-time extracting the pitch angle feature of the head has become a crucial task for this study.

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