VEHICLE RECOGNITION IN REGIONS OF INTEREST WITHIN SURVEILLANCE CAMERA SYSTEMS

ABSTRACT

Today, with the rapid pace of urbanization, traffic monitoring and automated parking management have become an urgent need. However, traditional methods are often costly and difficult to maintain. Current object recognition models are primarily based on rectangular bounding boxes, leading to significant errors when vehicles are parked diagonally or when there is overlap within the area of interest (ROI). This study proposes a new vehicle recognition system by transforming the object recognition problem into pose estimation to accurately determine the vehicle's position based on its four wheels.

The system uses Deep Learning models (YOLOv8-Pose and YOLOv11-Pose) combined with a Polygon Intersection geometry algorithm to calculate the degree of vehicle overlap relative to the ROI. The experiment was conducted on a dataset of 900 images from parking lots in South Korea in 2024, including various harsh weather conditions such as rain, snow, and different lighting conditions.

The experimental results showed that both YOLOv8 and YOLOv11 architectures achieved near-perfect mAP50 Box recognition accuracy at 99.5%. For the feature point recognition (Pose) task, YOLOv8-Pose achieved an mAP50 of 55.4%, slightly better than YOLOv11-Pose (52.7%). Notably, the developed logic algorithm is capable of recovering obscured points based on geometric properties, ensuring stable system operation even when vehicles are partially obscured or parked off-line.

Despite limitations in inference speed (~96.3ms/image), the study demonstrated the superior effectiveness of using Keypoints compared to traditional bounding box methods in smart parking space management. The next steps in the project include optimizing speed using TensorRT and deploying it on Edge devices.

Keywords: *Vehicle Recognition, YOLOv8-Pose, Region of Interest (ROI), Keypoint Annotation, Polygon Intersection, Smart Parking.*