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VISION AND SENSORS

Multi-scale Small Target Detection for Indoor Mobile Rescue Vehicles Based on Improved YOLOv5

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Abstract
To solve the problems that the YOLOv5 object detection network has low detection accuracy, false detection, and missed detection of small objects for trapped people and medical rescue supplies when there is interference in the light background during indoor rescue, this paper proposes a multi-scale small object detection network multi-scale small YOLOv5s (MS-YOLOv5s). A CAC3 module that integrates the attention mechanism is proposed to capture object feature information in both channel and spatial directions; the neck BiFPN feature pyramid network is improved to improve the model's ability to fuse features of different scales, and the activation function of the convolution module is replaced by SiLU, to improve the adaptive ability of the model for small object detection. The model is deployed on the mobile rescue detection platform. The experimental results show that the mAP @ 0.5 of MS-YOLOV5s is 7.8% and 24.9% higher than that of YOLOv5s at different scales and different postures of trapped people, and the FPS reaches about 12, which can meet the needs of indoor mobile detection, proving the effectiveness of the method proposed in this paper and the robustness of the network model.

Keywords Indoor rescue vehicle · CA attention · Multi-scale fusion · Small target detection · Model deployment

1 Introduction

Modern buildings have the characteristics of complex structure, concentrated electrical appliances, and difficult post-disaster rescue. In recent years, with the frequent occurrence of indoor accidents caused by climate change and improper human operation, it has posed a great threat to the safety of people's lives and property. Many people lost their lives after the disaster, because they were not rescued in time (Jia et al., 2019). Therefore, there is an urgent need to use rescue vehicles to enter indoor disaster scenes, collect important information, search for trapped people, and provide urgently needed medical relief supplies. This is of great significance for improving rescue efficiency, reducing mortality, ensuring the safety of rescuers, and carrying out follow-up rescue work.

The indoor environment after the disaster is complex, the indoor light is too bright or too dark, and the presence of dust and obstacles will also interfere with the detection of trapped people. This paper conducts autonomous search and detection for static trapped persons. During the search, the rescue target is a long-distance small target or a short-distance large target. Disinfectant alcohol and gauze are selected for medical rescue supplies. As a specific research object, it has weak texture features and is easily disturbed by background light. In optical images, objects whose size is less than 10% of the original image size are usually identified as small objects (NIU et al., 2022). Compared with larger objects in the image, small objects have lower resolution and fewer semantic features, fuzzy details, and lack of important color information. It is difficult to detect objects in complex light scenes. He et al. (2021), Zhao et al. (2021), and Chen et al. (2014) propose to use of infrared technology to detect small targets in complex light scenes, but the detection accuracy is low and the robustness is poor. In recent years, object detection based on deep learning technology has been developed rapidly, which has the advantages of high detection accuracy and fast speed. Related applications include two-stage object detection algorithms and variants, such as Faster R-CNN (Ren et al., 2017. Song et al., 2023). Single-stage object detection algorithms such as YOLO series (Bochkovskiy et al., 2020; Redmon & Farhadi, 2018;

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