EPSSNet: 
A Lightweight Network With Edge Processing and Semantic Segmentation for Mobile Robotics

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ABSTRACT

Fast and accurate segmentation is important for robot judgement, e.g. robot detection, segmentation, and control. Most researchers have focused on deploying lightweight semantic segmentation models into robot services. The problem is that the critical interaction between semantic segmentation and boundaries is ignored. In this chapter, the authors propose a lightweight parallel execution model (EPSSNet) based on semantic flow branch (SFB), edge flow branch (EFB) and self-adapting weighting fusion (SAWF) for mobile robot service projects. The semantic flow branching module is used to obtain accurate object shape features. The boundary constraint module uses multiple convolution and upsampling to distinguish boundary features from semantic features. In order to adaptively fuse boundary features with semantic segmentation features, the SAWF is proposed. It adaptively fuses semantic and boundary features by learning boundary and semantic feature fusion weights. Detailed experimental results on Cityscapes, Pascal VOC 2012 and ADE20k datasets demonstrate the superior performance of our approach.

KEYWORDS

Boundary, Constraint, EFB, EPSSNet, Robotic Service, SFB, SAWF

INTRODUCTION

In recent years, rapid advancements in machine learning and deep learning have found extensive applications across various domains. For instance, supervised classification leveraging machine learning techniques has been explored (Salhi et al., 2021). Text analysis has notably benefited from deep learning methodologies (Singh & Sachan, 2021; Ismail et al., 2022; Gu et al., 2022), alongside sentiment analysis (Mohammed et al., 2022), industrial applications (Sharma et al., 2022), medical diagnostics (Xu et al., 2021), disease safety detection (Nguyen et al., 2021), and image enhancement tasks like defogging (Liu et al., 2022). The metaverse (Deveci et al., 2022) emerges as a groundbreaking platform for experimenting with autonomous driving, heavily reliant on deep learning for its core technology. Image segmentation and boundary detection are crucial in the field of computer vision,
serving various fields such as autonomous driving assistance (Teichmann et al., 2018), simultaneous localization and mapping (SLAM) (Chen et al., 2021), point cloud segmentation (Wang et al., 2022), and medical imaging (Liu et al., 2022). Semantic segmentation involves assigning specific labels to individual pixels within objects, while boundary detection focuses on delineating object edges. However, prevalent neural network architectures like FCN (Long et al., 2015), ODE (Zhou et al., 2014), and UERF (Luo et al., 2016) face challenges in effectively capturing extensive pixel relationships as network depth increases, impeding accurate pixel classification. Moreover, deeper networks introduce noise and interference, further complicating the precise classification of minimal pixel clusters and leading to resolution loss and blurring during feature extraction downsampling. As network depth increases, external factors increasingly interfere with end-to-end segmentation. Predicted image outputs often contain unknown pixel classes, significantly impacting subject boundary segmentation quality.

Accurate recognition of subject boundary pixels is crucial, especially for mobile robots operating in various environments. The main focus of boundary detection in the study aims to precisely locate subject boundary pixels, even in scenarios involving multiple object classes, where edge pixels belonging to different classes can lead to inadequate environmental understanding by mobile robots.

To overcome this problem, JSBD (Zhen et al., 2020) proposed that the appearance of the subject often comes with a boundary, and the appearance of the boundary contour also refines the subject, so both advantages can be utilized to guide each other’s learning. Ada-detector (Sun et al., 2022) proposed the RRT boundary detection algorithm, which enhances the speed of boundary detection by restricting the region detected by RRT to the vicinity of the boundary point. HFDS (Xu et al., 2021) uses global exploration and local exploration trees, which ensures that the robot detects the unknown region, reduces the repeated detection of the robot, and improves efficiency. In addition, the subject boundary can localize the object’s relative pose and position, and the semantic subject

Figure 1. EPSSNet is compared with other lightweight models
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