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OPTIMIZING OBJECT DETECTORS WITH KNOWLEDGE DISTILLATION FOR ON-BOARD EARTH OBSERVATION

Abstract

In the last decade, Big Data-driven Earth Observation (EO) technologies have thrived with an increase in satellite launches and readily available satellite data. Onboard real-time data processing technologies attracted significant attention as the high cost of downlinking unprocessed data to ground stations. Remote sensing (RS) object detection, which involves identifying specific objects from satellite images, is a vital task in EO, with numerous applications such as emergency rescue and disaster warning that require real-time detection. However, due to size and power consumption limitations, high-powered processors like those on the ground cannot be used in satellites. Therefore, lightweight optimization of the model and deployment of detectors on embedded hardware platforms are necessary for applying RS detectors to satellites. In this paper, we propose a feature pyramid network-based distillation approach to guide lightweight student models to learn features extracted from different complex teacher models for optimizing detectors for onboard real-time EO, leading to efficiency object detection. Additionally, embedded deployment of lightweight detectors is implemented using TensorRT, a high-performance deep learning inference engine, to meet the requirements of onboard real-time detection. Extensive experiments validate the effectiveness of our approach. We evaluate approach performance on a large RS dataset DIOR, which contains 23,463 images and 192,472 annotated instances of 20 objects object categories, including airplanes, airports, baseball fields, basketball courts, etc. Experimental results on different network models show significant improvements in speed, memory consumption, and accuracy for all lightweight detectors without increasing the network parameters. By using the proposed approach, the mean Average Precision (mAP) of ResNet18-based detector improves from 68.4% to 71.1%, and ResNet50-based detector improves from 70.6% to 73.2% mAP, which surpasses even the more complex teacher network (73.0%). Finally, experiments conducted in Jetson TX2 verify the detection performance on the embedded platform, showing that the inference optimization of the model improves the inference time by a factor of 4.5 and increases the speed from 6 frames per second (FPS) to 27 FPS, enabling real-time deployment of the detector on the embedded platform. In summary, this approach enables lightweight optimization of the detector to meet the requirements for real-time satellite detection and lays the foundation for onboard intelligent processing of EO.