

Article

A Tree Crown Segmentation Approach for Unmanned Aerial Vehicle Remote Sensing Images on Field Programmable Gate Array (FPGA) Neural Network Accelerator

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Abstract: Tree crown detection of high-resolution UAV forest remote sensing images using computer technology has been widely performed in the last ten years. In forest resource inventory management based on remote sensing data, crown detection is the most important and essential part. Deep learning technology has achieved good results in tree crown segmentation and species classification, but relying on high-performance computing platforms, edge calculation, and real-time processing cannot be realized. In this thesis, the UAV images of coniferous *Pinus tabuliformis* and broad-leaved *Salix matsudana* collected by Jingyue Ecological Forest Farm in Changping District, Beijing, are used as datasets, and a lightweight neural network U-Net-Light based on U-Net and VGG16 is designed and trained. At the same time, the IP core and SoC architecture of the neural network accelerator are designed and implemented on the Xilinx ZYNQ 7100 SoC platform. The results show that U-Net-light only uses 1.56 MB parameters to classify and segment the crown images of double tree species, and the accuracy rate reaches 85%. The designed SoC architecture and accelerator IP core achieved 31 times the speedup of the ZYNQ hard core, and 1.3 times the speedup compared with the high-end CPU (Intel Core™ i9-10900K). The hardware resource overhead is less than 20% of the total deployment platform, and the total on-chip power consumption is 2.127 W. Shorter prediction time and higher energy consumption ratio prove the effectiveness and rationality of architecture design and IP development. This work departs from conventional canopy segmentation methods that rely heavily on ground-based high-performance computing. Instead, it proposes a lightweight neural network model deployed on FPGA for real-time inference on unmanned aerial vehicles (UAVs), thereby significantly lowering both latency and system resource consumption. The proposed approach demonstrates a certain degree of innovation and provides meaningful references for the automation and intelligent development of forest resource monitoring and precision agriculture.

Keywords: tree crown segmentation; neural network accelerator; SoC design



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1. Introduction

The application of automatic tree crown detection in high-resolution forest remote sensing images has been a topic attracting extensive attention over the last ten years [1–4]. Tree crown detection is the utmost and essential part of almost all methods of forest resource inventory and management based on remote sensing data [5,6]. A lot of work on forest

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