An Application Specific Processor for CNN-Based Massive MIMO Positioning

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Abstract

This work sets out to create an implementation for fingerprint-based positioning using massive multiple-input multiple-output (MIMO) technology, by means of deep convolutional neural networks (CNN), and utilizing the wireless channel state information (CSI). Due to the sheer volume of computational requirements imposed by CNN processing, an accelerator-assisted design is well-suited to the task at hand. Consequently, an application specific instruction set processor (ASIP) is designed to combine flexibility with implementation efficiency. The scalar core, which forms the backbone of the processor, adheres to the reduced instruction set computer (RISC) principles, but integrates custom instructions to speed up computations. Furthermore, to eliminate branch overhead, it employs a hardware zero-overhead loop mechanism, that can handle up to three nested static-bound loops. This is augmented with a loop buffer, that stores the instructions locally, on-the-fly, to forgo repeated accesses to the program memory, thereby saving on instruction fetch power. This ASIP is equipped with vector processing capabilities employing a single instruction multiple data (SIMD) scheme, and additionally has a very large instruction word (VLIW) architecture to further exploit instruction-level parallelism. A configurable 2D array of processing engines (PE) is integrated into the processor, in a tightly coupled manner, to accelerate the CNN operation. Synthesis results will be demonstrated using the GF-22 nm FD-SOI technology with a clock frequency of 555 MHz. The system can achieve a throughput of 271 positionings/s, with an average positioning error of 3.5 λ (40 cm) at a carrier frequency of 2.6 GHz. [1]

Index Terms

5G, massive MIMO, communications processor, baseband processor, positioning, computer architecture, programmable processor, accelerator architecture, vector processor, matrix processor, VLIW, SIMD, ASIP, CNN

REFERENCES

[1] M. Attari, J. R. Sánchez, L. Liu, and S. Malkowsky, "An application specific vector processor for cnn-based massive mimo positioning," in *2021 IEEE International Symposium on Circuits and Systems (ISCAS)*, 2021, pp. 1–5.