Machine Learning to digest CookieBox Data

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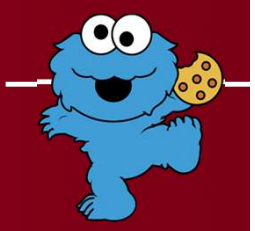
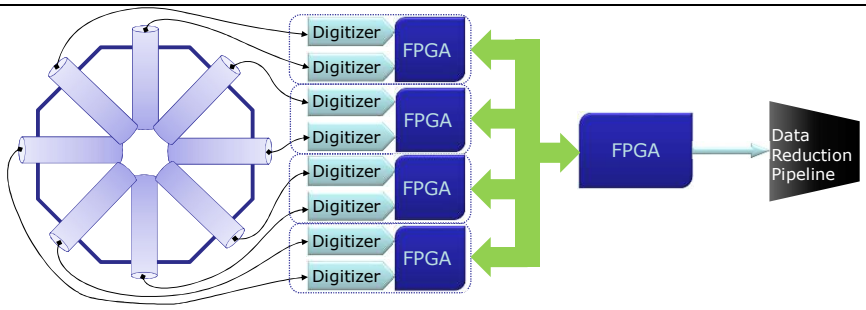


Introduction

The CookieBox aims to provide LCLS-II with a diagnostic tool capable of quantifying the multi-color, multi-pulse and multi-polarization of x-ray pulses. The data from the detectors must be combined and analyzed in real-time to provide information to downstream detectors. Machine learning inference implemented on ultrascale FPGAs will be used to extract pertinent information with minimal latency.

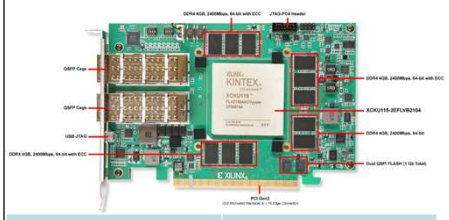
Data Flow



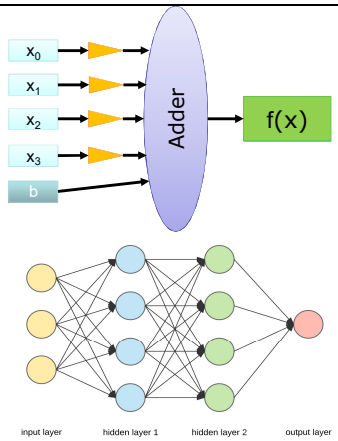
Analog signal → Digital signal → Compressed signal →Extracted information

Only half of the detectors (8 shown, 16 total) are included for clarity.

Machine Learning in FPGA



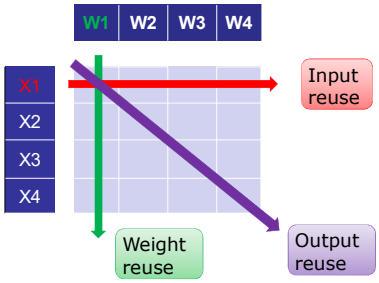
Feature	Value
FPGA	XCKU115-2FLVB2104E
System Logic Cell	1,451K
DSP Slices	5,520
RAM	75.9 Mb internal block 16 Gb external DDR4
Transceivers	64 x 16.3Gb/s - 8 fibers - PCIe Gen3
I/O Pins	832



We can map the virtual ML layers to independent hardware implementations and pipeline the algorithm or create efficient reusable large matrix multipliers.

FPGA optimization:

- Pruning
- Integer implementation
- Low bit precision
- Lookup tables for f(x)
- Minimal external memory access



FPGA Advantages

- Fit the hardware to the algorithm
- Highly parallel
- Dedicated computing blocks
- Reconfigurable
- High Speed data transfer
  - Optic fiber transceivers
- Somewhat high power consumption
- Low frequency
- Specialized training
- Limited by development board

Conclusions

The implementation of machine learning on FPGA would let us provide critical information in time for downstream decisions. Several hardware architectures are available for the FPGA implementation and each provide distinct advantages for certain applications. We still need to explore the design space of the KCU1500 card to select the best architecture candidate for the CookieBox.

References

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