ETH zürich

IEEE IUS 2025 International Ultrasonics Symposium
September 15 - 18, 2025 || Utrecht, Netherlands

Poster number 2330

Real-Time Histogram-Based Automated Signal Exposure Correction on FPGA for Optoacoustic Imaging

Viturin Schuhmacher[1], Federico Villani[1], Giusy Spacone[1], Xiang Liu[1,2], Andrea Cossettini[1], Daniel Razansky[1,2], Luca Benini[1,3]

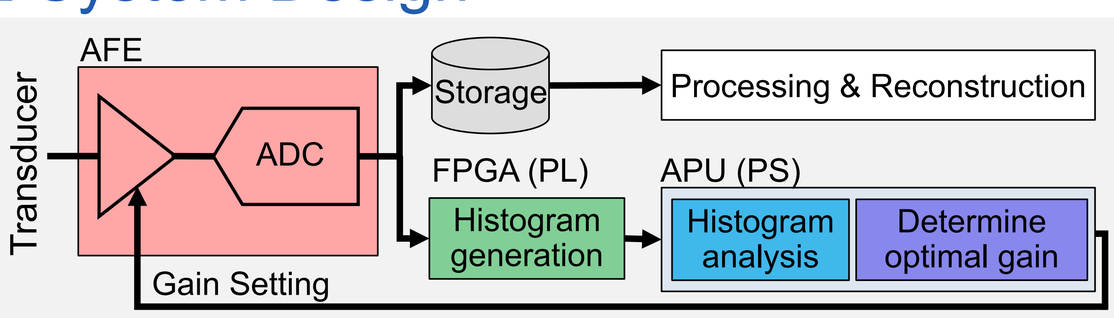
[1]*Department of Information Technology and Electrical Engineering, ETH Zurich, Switzerland*
[2]*Institute for Biomedical Engineering and Institute of Pharmacology and Toxicology, University of Zurich and ETH Zurich, Switzerland*
[3]*University of Bologna, Bologna, Italy*

1 Introduction

The adoption of optoacoustic imaging relies on compact, user-friendly systems that don't require expert tuning. Manual optimization of **Analog Frontend (AFE) gain** is time-consuming, non-scalable, and prone to errors that affect image quality, especially at high frame rates.

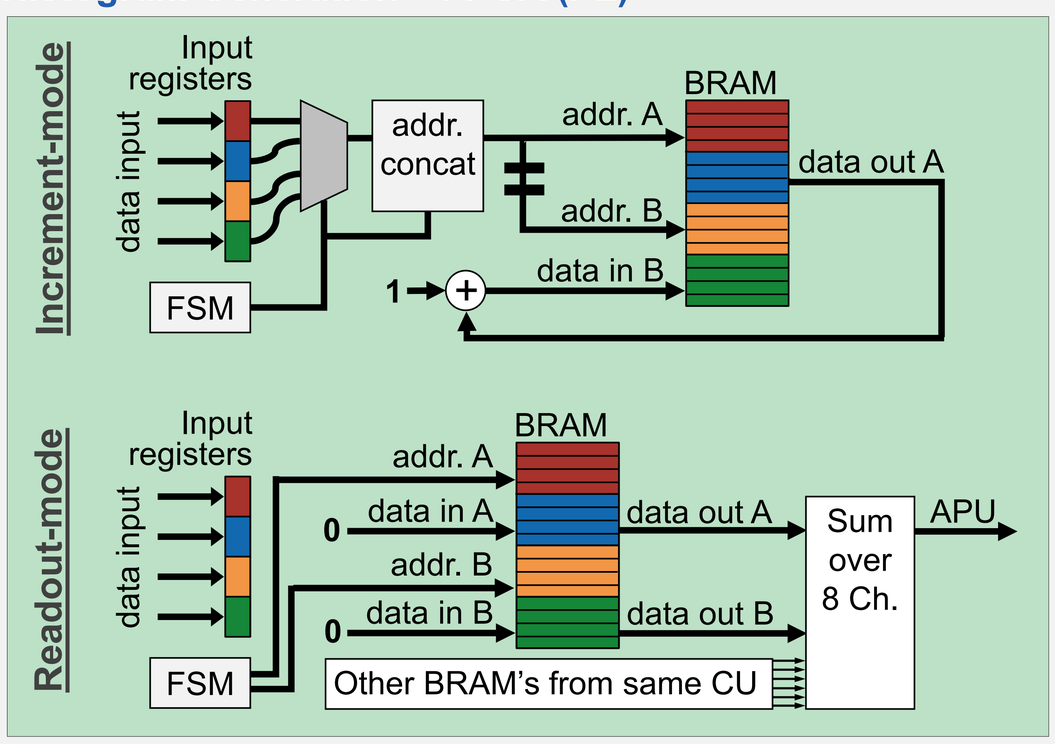
This work proposes an FPGA-based **Automated Gain Control (AGC)** method that uses histogram analysis of raw ultrasound data. AGC provides near instantaneous adjustments, as no image reconstruction is needed, and effectively prevents over- or underexposure, consistently setting an optimal gain level.

2 System Design

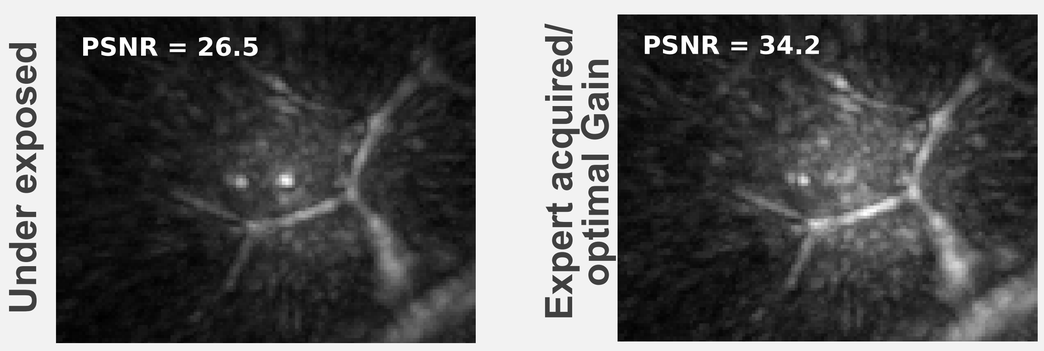


- 256 Channel Input stream at 100MHz with 16 bit resolution
- Grouped into Compute Units (CU) of 16 Channels

Histogram Generation – FPGA (PL)



- A histogram is generated for each channel
- Multiple channels are summed together during readout
- Application processor determines if the image is under- or overexposed and changes the acquisition gain



Gain Control – APU (PS)

3 Results

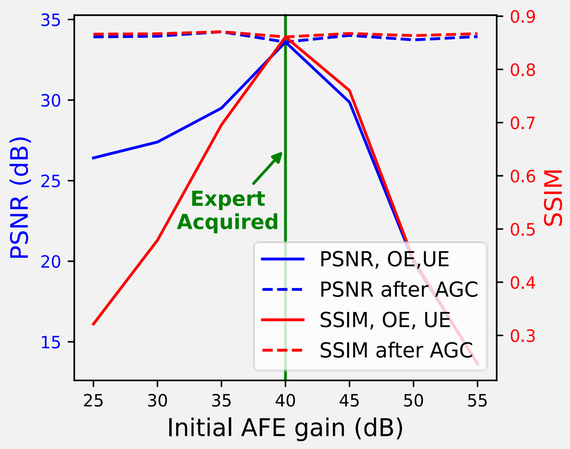
Image Quality:

- AGC sets **optimal gain** over a dynamic range of 65dB
- Achieves SSIM: > 0.96 to expert acquired image (almost identical).

Hardware:

- Low resource implementation on Xilinx Kria K26 (more than 300 channels possible on small FPGAs)

Utilization per CU	
# Channels	16
Sampling frequency	100 MHz
FPGA frequency	400 MHz
# LUT	256 (0.22%)
# FF	299 (0.13%)
# 18kb BRAM	4 (2.8%)



4 Conclusion

- **Histogram-based over- or underexposure detection directly from the AFE data stream**
- **Fully autonomous, real-time AFE gain correction**
- **Optimal image quality achieved with minimal FPGA resource usage**

villanif@iis.ee.ethz.ch
vschuhmacher@ethz.ch

IEEE IUS 2025 International Ultrasonics Symposium
September 15 - 18, 2025 || Utrecht, Netherlands