Pyramic: Full Stack Open Microphone Array Architecture and Dataset

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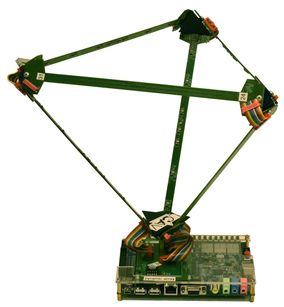
Full-stack microphone array design

Abstract – We present **Pyramic**[1], a *full-stack open* microphone array design. Full-stack open means that every step of the array design from the hardware up to data collection and algorithms is open and documented. The result is a collection of templates under **permissive licenses** covering the whole design process and that can be reused as needed.

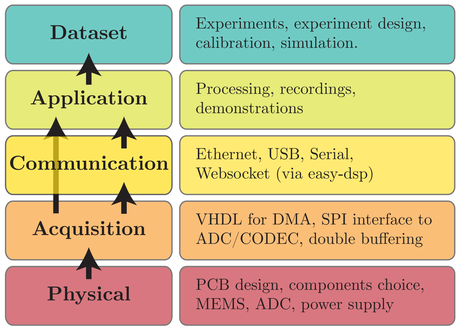
Targets – Compact arrays, embedded arrays, robotics, IoT, wearables

The Pyramic array



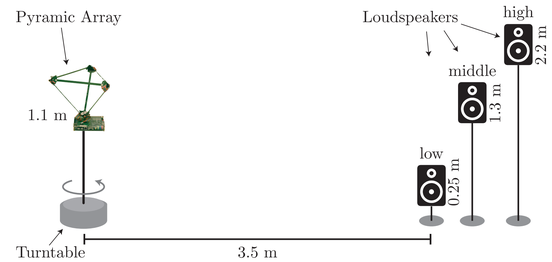
- **48 microphones** distributed on 6 edges
- 2 output channels
- Sampling frequency @ 48 kHz
- Bit depth of 16 bits per channel
- FPGA reads samples into shared memory
- Dual-core ARM CPU @ 800 MHz

Full-stack design



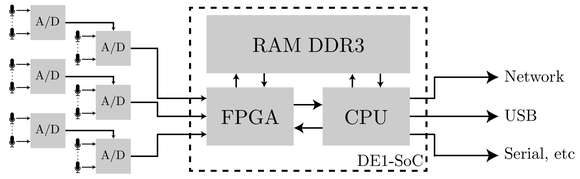
Dataset layer: Anechoic recordings[2]

- Recordings done in anechoic chamber
- Array fully rotated in increments of **2 degrees**
- Three loudspeaker heights
- Total of 540 positions
- 8 samples per position (2x sweeps, 1x noise, 5x speech)



Communication/Application layer

- System-On-Chip with FPGA/ARM, 1GB RAM
- Linux system
- Ethernet connection to the network
- USB/Serial communication
- Easy-DSP[3]: Browser based processing interface



Physical layer: PCB design[1]

- Each sub-array is 27 cm long
- **Microphones**: Analog INMP5404 MEMS
- **Analog to Digital converter (ADC)**: AD7606

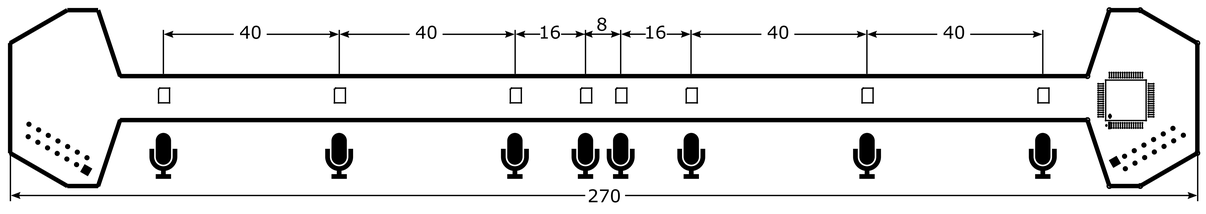


Figure 1: In a single PCB, six microphones form a uniform linear array, with the remaining two closely spaced at the center to avoid spatial aliasing. Distances are in millimeters.

Calibration and Code Samples

- Manual calibration improved with self-localization [Thrun 2006]
- Dataset wrapper and code samples provided in Python[2]

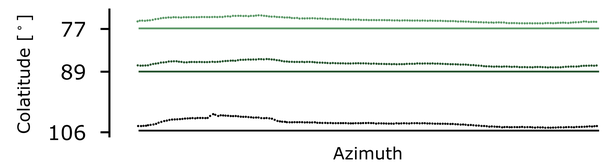
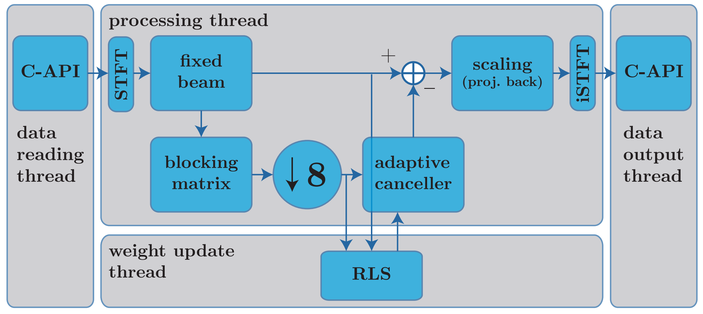


Figure 2: Difference of manual (solid line) and optimized (dotted line) calibrations.

Tonight: Demo! Real-Time Beamforming[4]

Demo session at 19:30

- Fixed 48-channel beamformer computed during calibration step
- Number of channels reduced to 6 in the adaptive branch
- Recursive least squares (RLS) computes the adaptive weights
- Multi-threaded implementation



Publications using the Pyramic array

H. Pan, R. Scheibler, E. Bezzam et al., *FRIDA: FRI-based DOA Estimation with Arbitrary Array Layout*, ICASSP, 2017

E. Bezzam, R. Scheibler, J. Azcarreta, H. Pan et al., *Hardware And Software For Reproducible Research In Audio Array Signal Processing* , ICASSP, 2017

R. Scheibler, D. Horiike, N. Ono, *Blinkies: Sound-to-light conversion sensors and their application to speech enhancement and sound source localization*, APSIPA, 2018

Get it all!

Free, as in *free speech*, and as in *free beer*!!
[1]Pyramic hardware and software: `https://github.com/LCAV/Pyramic`
[2]Dataset: `https://zenodo.org/record/1209563#.W5qOkkxuKUk`
[3]Easy-DSP: `https://github.com/LCAV/easy-dsp`
[4]Demo software: `https://github.com/fakufaku/pyramic-demo`

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