6.111 Project Presentation

Auditory Localization

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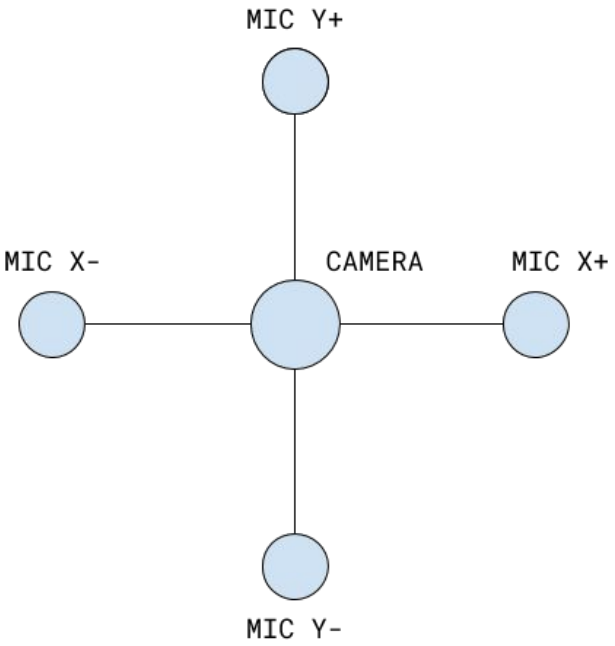
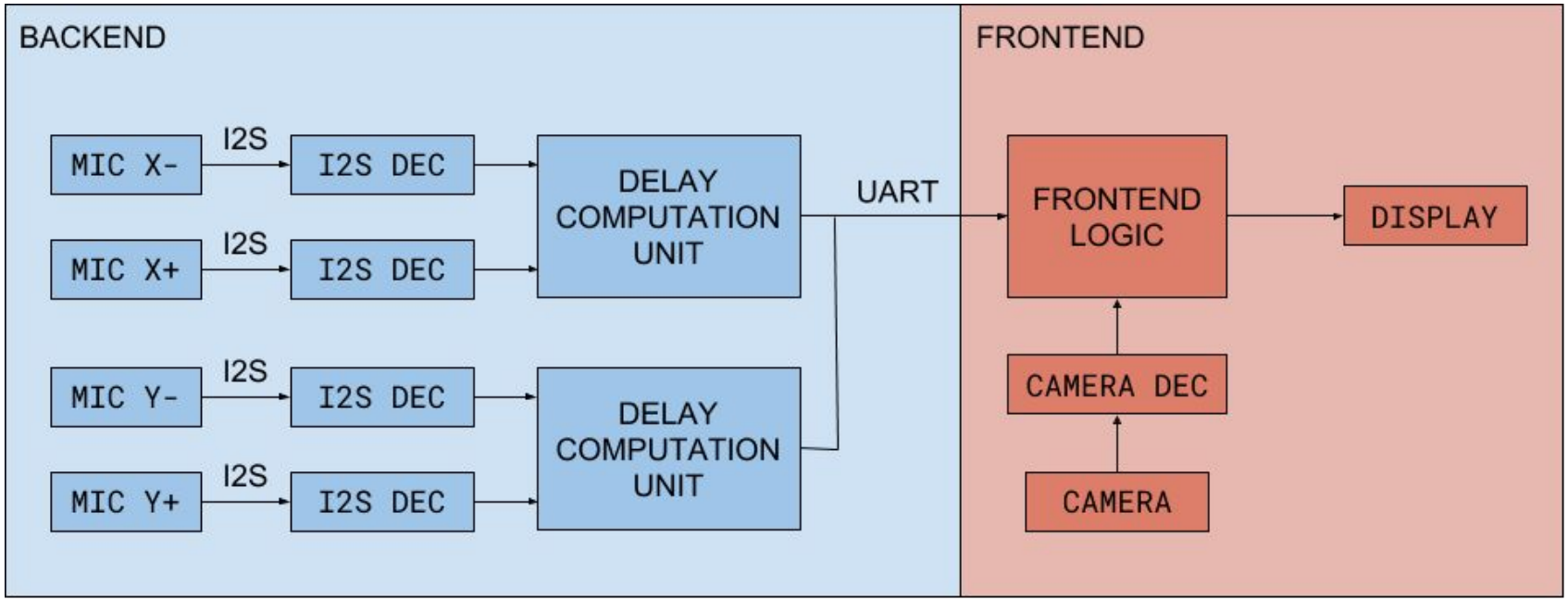
Overview

- Auditory localization through an array of four microphones
- The inferred direction of the sound source will be overlaid on a video feed of the surroundings
- Hope to implement a bug squashing game



- Adafruit I2S MEMS Microphone
  - 18 bit 64 kHz digital microphone
- NTSC Camera

Top level block diagram



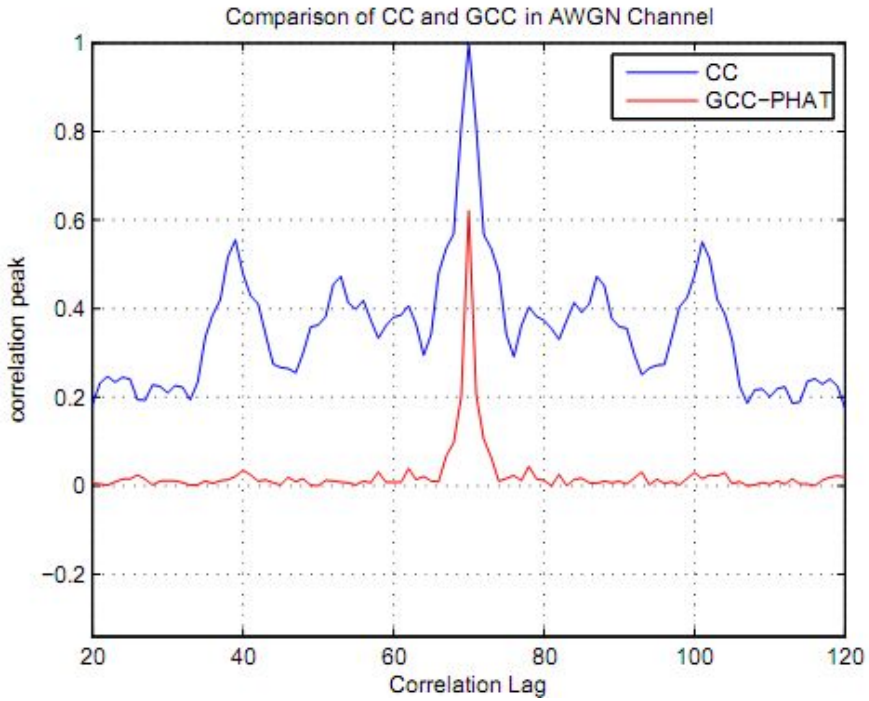
Artix-7 (Nexys 4)

Virtex-2 (Labkit)

Time delay extraction algorithm

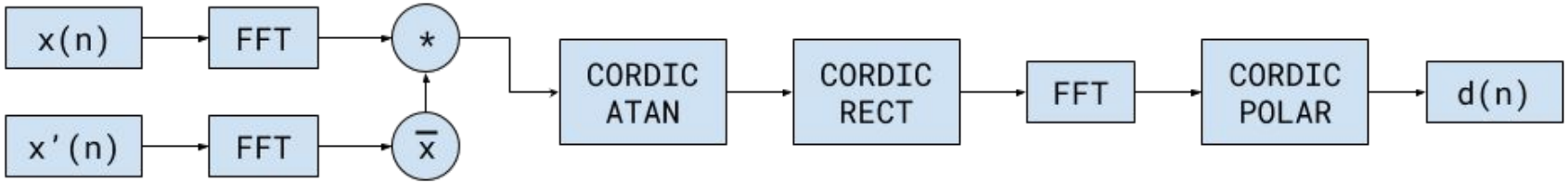
- Generalized Cross-correlation Phase Transform Algorithm (GCC-PHAT)
  - High noise immunity compared to standard cross-correlation algorithm
  - Three fourier transforms per pair of input signals

$$\hat{G}_{PHAT}(f) = \frac{X_i(f)[X_j(f)]^*}{|X_i(f)[X_j(f)]^*|}$$



Backend Implementation

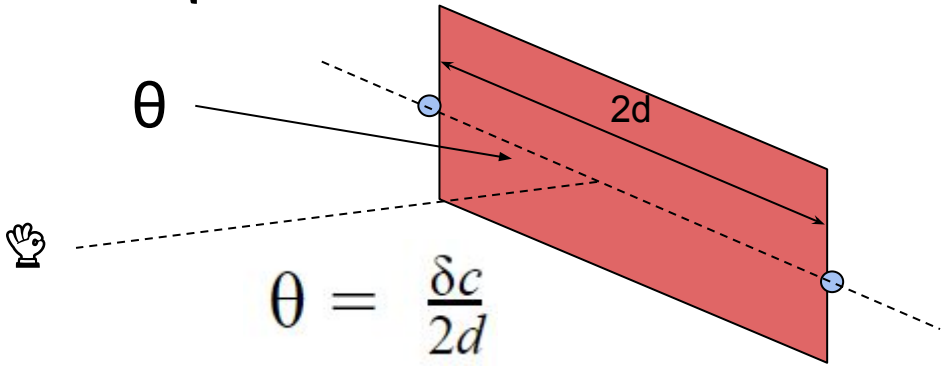
- Makes use of the FFT and CORDIC IP Cores
  - Vivado block design to implement DSP pathway
- State machines on both ends to packetize and feed the data
  - Must interface with the AXI4-Stream protocol
- Precise bus widths and packet sizes will be determined after resource utilization considerations
  - FFT modules are very resource intensive
  - Tentatively 1024 samples of 12 bits per packet



Frontend-Backend Interface

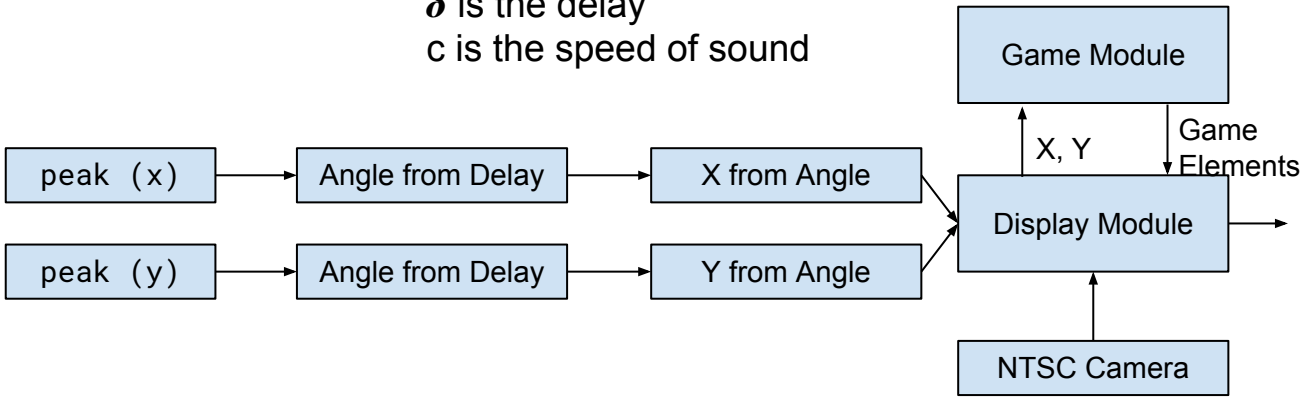
- UART interface
- 1 million baud
- 512 bytes transferred once processing complete
- First 256 bytes -> X Axis Delay Data, Final 256 bytes -> Y Axis Delay Delta
- Each block of 256 bytes contains delay data from -δ to +δ
- δ needs to be measured

Frontend Block Implementation



$$\theta = \frac{\delta c}{2d}$$

δ is the delay
c is the speed of sound



User Interface

- Simple user interface: Mirror of video feed from camera, red spot overlay indicating predicted location
- Bug Squashing Game: bugs crawling on the screen, get killed when you snap your fingers over one

Expected Challenges

- Hooking up the DSP pathway and the AXI4-Stream IO
- Dealing with resource utilization of the FFT modules
- Distinguishing global maximum from local maxima caused by noise
- Clapping might be too rapid for pickup
- Echos might mess up measurement

Proposed Timeline

- 11/11 - Test Component IO (Camera, Mics, etc)
- 11/18 - Test DSP Chain
- 11/25 - Simple Overlay on Camera Feed
- 12/2 - Final Tweaks / Bug Squashing Game
- 12/9 - Complete Report