
DAT096

Ultrasonic Sound Localization using Microphone Arrays

Contribution Report Group M3

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Contents

1	Ashwin Kumar Balakrishnan	3
1.1	General contribution	3
1.2	Project specific contribution	3
1.3	Report work	4
2	Hezhe Xiao	5
2.1	General project contribution	5
2.2	Specific tasks	5
2.3	Contribution in Report	6
3	John Croft	7
3.1	General Project Contribution	7
3.2	Specific Tasks	7
3.3	Contribution in Report	8
4	Prema Manickavasagam	9
4.1	General Project Contribution	9
4.2	Specific Tasks	9
4.3	Contribution in Report	10

1 Ashwin Kumar Balakrishnan

1.1 General contribution

- As a scrum master, I organized team meetings to discuss the progress and results achieved. Reminded the group of unfinished tasks and deadlines.
- Set up Trello boards to manage tasks and strongly recommended everybody in the team to use it.(Was not that successful with anyone except myself). Although we used it a lot for the final report work.
- Set up a sprint retrospective which i feel helped us work faster for sprint 2 and understand and learn from our mistakes the previous sprint.
- Attended all the scrum master meetings and tried to incorporate suggestions and techniques from Lena and other scrum masters.
- Prepared the slides for Half time presentation and presented the project with Prema.
- Participated in the lectures and all other team bonding activities(both online and offline).
- Setup meetings with Bhavishya whenever required and informed the team about that(both online and offline).

1.2 Project specific contribution

- Worked in error correction in the MATLAB scripts for delay values and Beamforming.
- Mapped all the microphones to their respective pins on the breakout board and fpga connector with Prema.
- Reasearch on CIC and FIR filters multi-channel mode
- Designed and verified the Time multiplexer thus enabling multiple microhpones to work properly.
- Designed the De-multiplexer along with Hezhe and helped in error correction.
- Re-wrote the code for delay calculations but we didnt use it in practice.
- Participated in testing and debugging of the design after the delay and sum part with the team.

1.3 Report work

I wrote the following sections/chapters in the report.

- abstract.
- Introduction.
- Reorganized the implementation chapter and corrected all the errors and added explanation about new design changes after half-time reviews.
- first part of the Experiments chapter.
- Conclusion.

2 Hezhe Xiao

2.1 General project contribution

- As scrum master for the sprint 2 and attend master meetings
- Take part in the teaming meetings to set up sprint plans for sprints
- Half report writing and give feedback to Ashwin and Prema
- Send emails to ask Bhavishya to ask the help for technical questions
- Final report writing

2.2 Specific tasks

- Study how the Beam Pattern can be used to calculate the sensitivity of a microphone array for signals from a directional acoustic sound
- Study FPGA reference design that takes input from one microphone
- Expand the refence design to simultaneously take input from multiple microphones, start from two microphones and four microphones
- Test multiple microphones to record the human voice sound with the sampling PDM frequency of 1.4112 Mhz
- Research on the PDM sampling rate, PCM sampling rate and clocking in the design to meet the requirement of the ultrasonic mode for the microphone which is activated for PDM clock frequency larger than 3.072 Mhz per microphone and change the PDM sampling rate to 3.2 Mhz and 4.608 Mhz to test dog whistle
- Research on PDM to PCM conversion and CIC filter multichannel mode to improve the design of Mux block based on Ashwin's code
- Writing code for Demux block to separate one channel to four channels
- Research on how to use finite state machine to control the microphones are propagated out of the shift registers by the delay values saved in ROMs and writing the scanning block code
- Transfer the delay clock cycles to Hexadecimal data, save it as .coe file and upload it to ROMs
- Design the energy calculation block with sum and multiplication together and compare the squared signals to get the maximum value
- Read the energy data in Matlab to analyze and try to get the location direction from sound sauce

2.3 Contribution in Report

- Chapter 4 of Implementation(4.1, 4.2, 4.3, 4.5, 4.6 , 4.9)
- Chapter 5 of Experiment(5.2, 5.3, 5.4, 5.5)
- Adding some points of Results in Chapter
- Correcting some error in future work part

3 John Croft

3.1 General Project Contribution

- Was SCRUM-master for the last two sprints (Sprints 4 & 5).
- Helped write and gave feedback on mid-term presentation (but did not present).
- Report writing and final presentation.
- Set up versioning-control system, GIT, and strongly recommended team to use it. Was not particularly successful in using it effectively as a team.

3.2 Specific Tasks

- Wrote MATLAB scripts for parameterized beampattern and delay-value generation.
- Wrote HDL model for the primary system (excluding implementation-specific infrastructure), used for simulation and functional verification.
- Wrote testbench for HDL model to test the effects of different system parameters, such as sampling rates, buffer sizes, phase-shift between input signals etc.
- Investigated how signal energy could be computed using various practical implementations.
- Investigated how DAS beamforming could be realized using addressable shift-registers. Confirmed this in HDL simulations.
- Investigated how various parameters (frequency, distance and number of sensors) affect the filter-response of a DAS beamformer. Using this, an ideal configuration was selected and used in subsequent models.
- Investigated how to parametrically generate FIR taps in MATLAB.
- Traced signals from sensors to FPGA package using schematics.
- Changed constraints file to map all 24 sensor pins. This was challenging as several sensor pins conflicted with other pin-mappings in the base design.
- Implemented and verified ultrasonic support in the system, using filter-coefficients computed by Prema and the ultrasonic audio-source provided to us.
- Set up report documents.

3.3 Contribution in Report

The report was iterated upon, and often several team members contributed to a certain part. I will mention parts in which I wrote (or rewrote) a significant amount.

- Acknowledgement.
- §1-Introduction, excluding first section.
- §2-Background, excluding §2.2-Beamforming Techniques.
- §3-Hardware Design.
- §4-Implementation, only introduction.
- Several sections in §5-Experiments, especially §5.6-emulating System Functionality in Questasim.
- Majority of §6.1-Discussion & Analysis.
- Several future experiment descriptions in §7-Conclusion & Future Work.
- General editing for style and language.
- Latex template used for both mid-term and final reports.

4 Prema Manickavasagam

4.1 General Project Contribution

- Attended the scrum master meetings(sprint 3),inform the team about the suggestions discussed and reminded the group of deadlines.
- Took part in the lectures, group activities ,sprint retrospective (and discussed about where the team is lagging and came up with ideas to overcome them).
- Participated in team meetings to discuss about the progress and provided possible solutions to problems.
- Took individual tasks in trello and managed to finish it on time and update the team about it.
- Prepared the slides with Ashwin and presented the half time presentation.

4.2 Specific Tasks

- Research on the overall system design and tested the beamforming plot with different parameters to study it's behaviour.
- Studied the design of the CIC filter multiple channels and worked with Ashwin in the first phase of designing the time multiplexer.
- Debugging and testing of multiple microphones with the team, studied the FFT of the audio source to verify functionality.
- Documented pin mapping with Ashwin using the schematics and breakout board and changed the constraints file according to it.
- Studied the behaviour of CIC filter for different number of stages using MATLAB (5 stages initially for source in audio range, ended up using the same since our source was not that high).
- Created MATLAB script to generate coefficient files to tune the filter to sample ultrasonic frequencies (ended up not using them, because couldn't set all the parameters using the inbuilt function).
- Generated coefficient files using the MATLAB filter designer for the half-band and low pass filter and studied its spectrum to verify.
- Finalized the final clock rate and sampling rate based on the product guide and input frequency.
- Research on energy calculation. Wrote code for multiplier and started some work on the accumulator(didn't continue because we decided not to use it).

4.3 Contribution in Report

- Beamforming techniques
- Hardware design (apart from ultrasonic sound source).
- RAM based shift register and block memory generator.
- Energy calculation and source location.
- Wrote some part in future work.
- Added acronyms.
- Rewrote experiments and made some changes to implementation.
- Proofread the entire report and corrected some formatting errors (citation, spelling mistakes, figure captions etc).