

CSEE W4840 Project Proposal

Team Members

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Introduction

Our project aims to harness the power of audio input processing using Fast Fourier Transform (FFT) to extract valuable information such as frequency and amplitude from USB microphone input. This proposal outlines the development of three innovative applications leveraging this technology. We are unsure which one will be the most feasible one for future work.

Firstly, we will utilize the audio data to generate visually captivating images, where the frequency and amplitude information will drive the creation of intricate patterns and designs. Secondly, we propose a novel approach to dynamic wallpaper generation, where audio input and user interaction through mouse will dynamically alter wallpaper features based on the detected sound frequencies, offering an interactive and immersive experience. Lastly, we envision an engaging audio input game that utilizes real-time audio data to control in-game elements, offering players an immersive and dynamic gameplay experience.

The scope of our work involves capturing audio input through USB microphones and processing it using FFT algorithms to extract frequency and amplitude data. Each application will employ unique methodologies to interpret this data and deliver meaningful outputs. The development process will adhere to a structured timeline, encompassing phases of design, implementation, and testing to ensure the functionality and usability of each application.

Design Question

Signal Processing Complexity: Implementing FFT algorithms on the DE1-SoC board might strain its limited processing capabilities, particularly when dealing with real-time audio data. Optimizing the algorithms for efficient execution on the board's FPGA fabric or ARM processor cores while maintaining accuracy could present a significant technical challenge.

Memory Constraints: The DE1-SoC board's 64MB SDRAM on FPGA and 1GB DDR3 SDRAM on HPS memory resources may limit the size of audio input buffers or the storage capacity for processed data. Managing memory allocation efficiently to accommodate the processing requirements of the FFT algorithms and application modules while minimizing latency and resource contention will be critical.

Integration Complexity: Integrating the various software and hardware components involved in audio input processing on the DE1-SoC board may encounter challenges related to data synchronization, communication protocols, and resource sharing. Coordinating the functionalities of the USB microphone, FFT processing modules, and application logic while minimizing latency and data loss will require meticulous planning and testing.

Real-time Processing Requirements: Meeting the stringent timing constraints for real-time audio processing on the DE1-SoC board could prove challenging, particularly if the applications demand low-latency response times or high throughput. Ensuring timely data acquisition, processing, and output generation while maintaining accuracy and stability will necessitate careful optimization and validation.

Major Tasks

Hardware Setup and Configuration:

- Set up the DE1-SoC board and ensure compatibility with the chosen USB microphone.
- Configure hardware interfaces and drivers necessary for capturing audio input.

Software Development:

- Develop software for interfacing with the USB microphone and capturing audio input.
- Implement FFT algorithms for transforming audio data into frequency and amplitude information.
- Design and develop algorithms for each proposed application (image generation, map modification, audio input game).

Integration and Testing:

- Integrate software components with the DE1-SoC board's hardware interfaces.
- Conduct unit testing to verify the functionality and accuracy of audio processing algorithms.
- Test each application module individually to ensure proper operation and performance.

Real-time Processing Optimization:

- Optimize FFT algorithms and application logic for real-time processing on the DE1-SoC board.
- Fine-tune parameters and settings to minimize latency and maximize throughput.

User Interface Design:

- Design user interfaces for each application, considering usability and aesthetic appeal.
- Implement user interaction features and controls to enhance the user experience.

Advanced Features and Ideas:

- Interactive visuals: make the visual output interactive by allowing users to adjust parameters like sensitivity or color schemes in real time.
- Audio effects: Allow users to apply audio effects like filters and reverb, and visually represent these effects.

Milestone 1: Setup and Development Kickoff

Tasks:

- Set up the DE1-SoC board and configure hardware interfaces.

- Research and select a suitable USB microphone, ensuring compatibility with the board.
- Develop software for capturing audio input and interfacing with the microphone.
- Begin implementing FFT algorithms for audio signal processing.

Deliverables:

- DE1-SoC board configured and ready for audio input processing.
- Software prototype for capturing and processing audio input.
- Initial implementation of FFT algorithms.

Milestone 2: Application Development and Testing

Tasks:

- Develop algorithms for selected application (image generation/ wallpaper engine / audio input game).
- Integrate application modules with the audio processing software and DE1-SoC hardware.
- Conduct unit testing to verify the functionality and performance of each application.
- Optimize real-time processing algorithms for latency and throughput.

Deliverables:

- Fully functional applications for image generation, map modification, and audio input game.
- Tested and optimized algorithms for real-time audio processing.
- Initial documentation outlining the development process and key findings.

Milestone 3: Final Testing, Feedback Collection, and Reporting

Tasks:

- Conduct comprehensive testing of the applications under various conditions.
- Collect feedback from users and stakeholders on usability and performance.

- Iterate on the design and functionality based on feedback received.
- Finalize documentation, including user manuals and technical reports.

Deliverables:

- Fully tested and refined applications ready for deployment.
- Comprehensive documentation covering software architecture, algorithms, and user guides.
- Presentation materials summarizing project outcomes and lessons learned.