Remote Monitoring of Coral Reef Underwater Sounds

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Introduction

Background

- **Coral Reefs as Natural Resources**: Hawai'i's coral reefs are critical ecosystems, providing essential ecological, cultural, and economic benefits to the public and government agencies.
- **Acoustic Indicators of Reef Health**: The diversity and abundance of underwater sounds, such as fish calls and invertebrate activity, reflect the biological vitality of coral reefs.
- **Ecosystem Monitoring**: Continuous audio monitoring offers a non-invasive method to assess reef health, detect changes in biodiversity, and support conservation efforts.

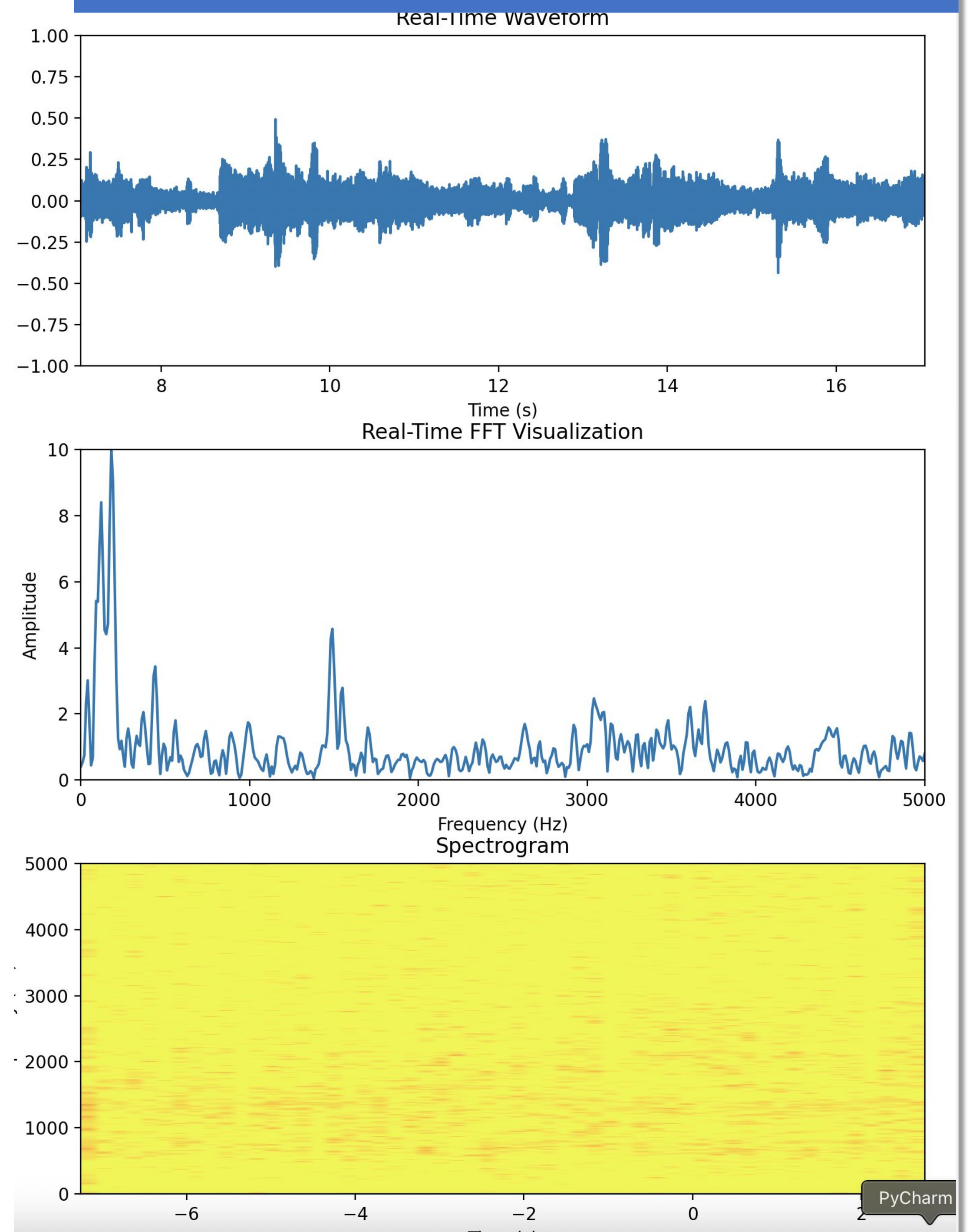
The Problem

- **Manual Retrieval**: Relies on divers or vessels, significantly increasing operational costs and risks.
- **Data Gaps**: Retrieval interrupts real-time monitoring, causing loss of valuable insights.
- **Resource Constraints**: High hardware and operational costs limit scalability and accessibility.
- **Monitoring Limitations**: Traditional methods do not enable continuous, remote observation.

Requirements

- **Real-time monitoring** of underwater audio for continuous observation.
- **Reliable long-term data collection** with reduced interruptions.
- **Automated and cost-effective approach** to replace manual retrieval methods.

Sound Data Visualization



Custom Visualization Prompt

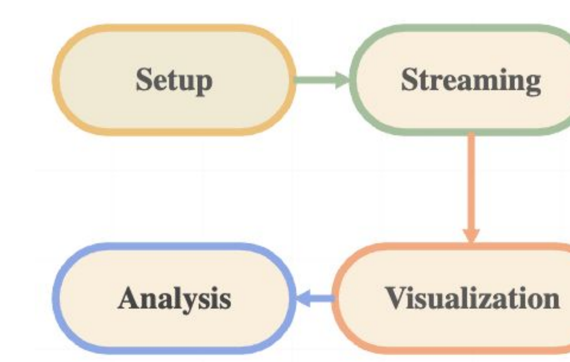
```
Choose audio source:
1. Live audio from microphone
2. SRT audio stream via FFmpeg
Enter '1' for live audio or '2' for SRT stream: 1
Selected live audio stream from microphone.
Choose visualizations to display:
Show waveform? (y/n): y
Show FFT? (y/n): y
Show spectrogram? (y/n): y
Please select the frequency range for visualization (Spectrogram and FFT):
1. 0-20,000 Hz (default)
2. 0-5,000 Hz
3. 0-2,000 Hz
4. 0-1,000 Hz
5. 0-500 Hz
Enter the number of your choice: 2
Frequency range set to 0-5000 Hz.
Select the time window (in seconds) for visualization:
1. 3 seconds
2. 5 seconds
3. 7 seconds
4. 9 seconds
Enter your choice (1-4): 2
Time window set to 5 seconds.
Starting live audio stream...
Detected sample rate: 48000 Hz
```

Tech Stack

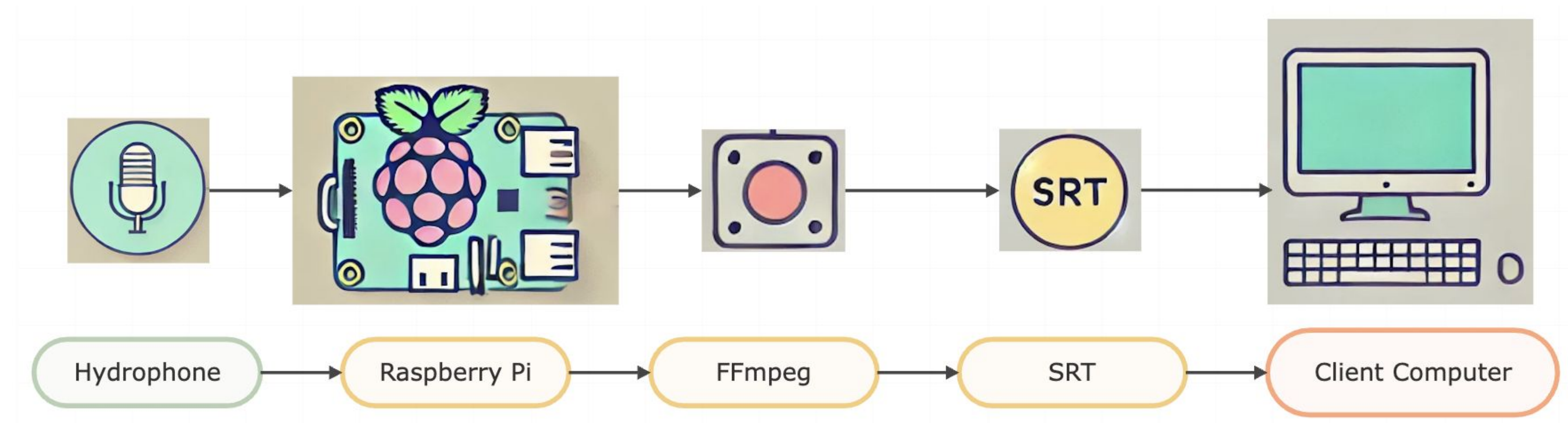
Raspberry Pi OS

SRT SECURE RELIABLE TRANSPORT

FFMPEG



Diagram



Solution

Tasks Accomplished

- Configured a **Raspberry Pi** with **FFMPEG** and **SRT** to digitize and stream audio from a connected hydrophone.
- Established a real-time audio stream connection between the Raspberry Pi server and a client receiver using **SRT protocol**.
- Developed a visualization system for live spectrogram, FFT (Fast Fourier Transform), and waveform displays to analyze audio signals.
- Successfully integrated a solution that streams audio while simultaneously saving the data for future analysis.
- Designed the system for portability and long-term deployment in underwater environments.

Challenges

- **Network Latency**: Configuring SRT for consistent real-time audio streaming.
- **Hardware Limitations**: Ensuring Raspberry Pi performance was sufficient for continuous streaming and data saving.
- **Power Management**: Mitigating the short battery life by incorporating power-efficient configurations.
- **Environmental Factors**: Ensuring equipment resilience to underwater conditions like pressure and saltwater exposure.

Learnings

- **Effective Use of SRT and FFMPEG:** Enabled efficient real-time audio streaming and robust file handling.
- **System Optimization:** Balanced hardware constraints and resource-intensive tasks for improved performance.
- **Modular Design:** Developed a scalable and adaptable system to meet evolving requirements.
- **Audio Data Visualization:** Enhanced analysis through spectrograms, waveforms, and FFT representations.

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