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Implementation and Evaluation of Audio Based Methods for Robust Inter-Robot Communication

Project Thesis – Introductory Talk

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June 15, 2016

- Introduction
- Chirp Based Communication
- The NAO Robotic Platform
- Status Quo of Implementation
- Current Problems and Outlook
- References

Introduction

Motivation

- Aerial acoustic transmission over a large distance (25m)
- Robust transmission in noisy environments

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- Designed for single payload transmission with server based backend

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Method introduced by Lee et al. [3]

Chirp Based Communication

Working Principle – Symbol Space

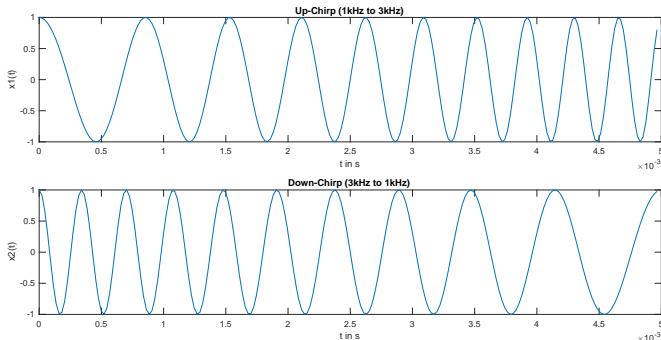


Figure: Time domain plots for up- and down-chirp.

Chirp Based Communication

Working Principle – Symbol Correlation

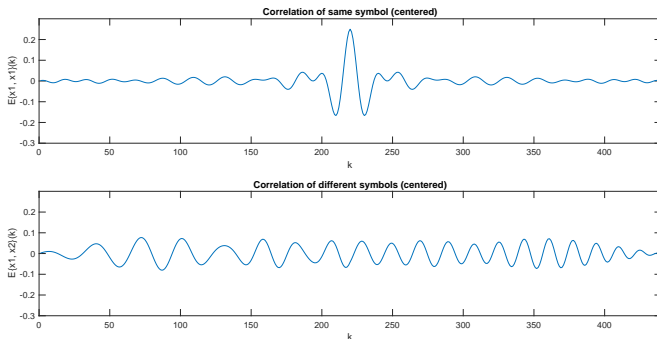


Figure: Correlation of up-chirp with (1) up-chirp and (2) down-chirp

Chirp Based Communication

Working Principle – Symbol Mapping

Definition

For every 0-bit, transmit a down-chirp. For every 1-bit, transmit an up-chirp.

Definition

Data is transmitted in **packages**, each package containing 16bits

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- each package is announced by a **preamble**

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Data is transmitted in **packages**, each package containing 16bits

- each package is announced by a **preamble**
- every two symbols are spaced by a **guard interval**

Chirp Based Communication

Working Principle – Receiver Synchronization

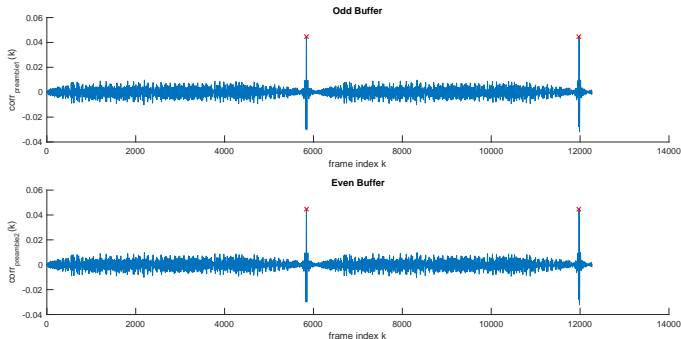


Figure: Correlation with the preamble yields significant peaks at beginning of each package.

Chirp Based Communication

Working Principle – Symbol Detection

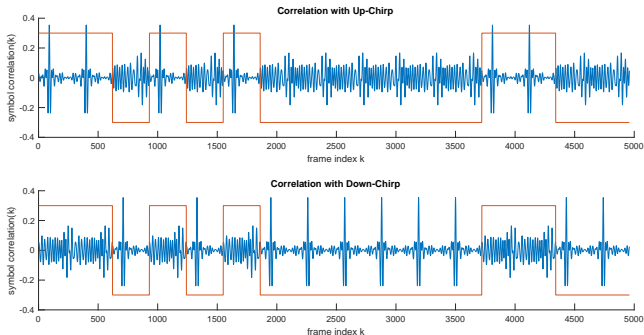


Figure: Matched Filter Symbol Detection. The detected bits are marked orange.

The NAO Robot System

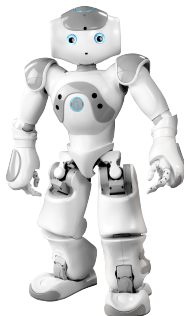


Figure: NAO Robot standing upright.

The NAO Robot System

Audio Hardware

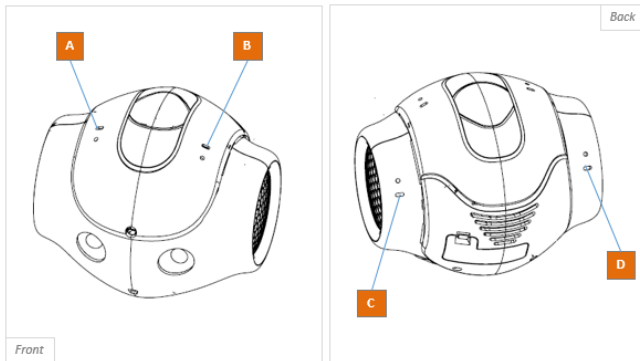


Figure: Positioning of NAO's microphones [4].

The NAO Robot System

Audio Hardware

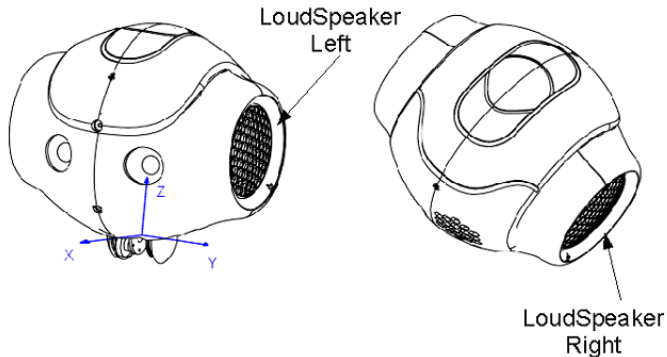


Figure: Positioning of NAO's speakers [4].

Status Quo of Implementation

C++ Framework

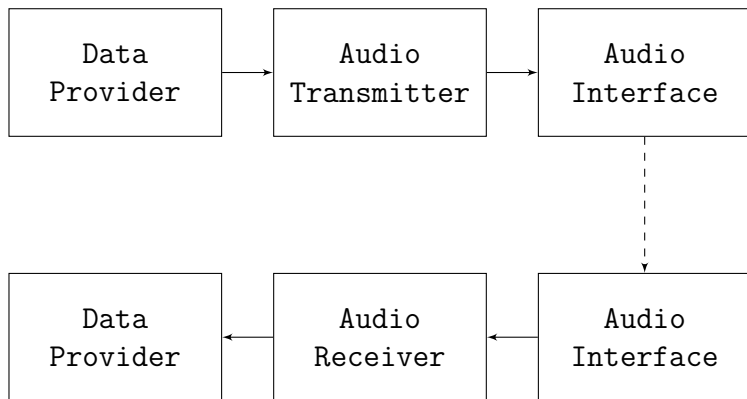


Figure: Data Flow inside the C++ Application

FFTW

A very fast implementation of the Fast Fourier Transform (FFT), also used by MATLAB [2].

PortAudio

Free, cross-platform, open-source, audio I/O library [1].

Problems and Outlook

Pulse Shaping and Band Limiting

- Sharp edges in chirp pulses lead to higher bandwidth than needed.

Problems and Outlook

Pulse Shaping and Band Limiting

- Sharp edges in chirp pulses lead to higher bandwidth than needed.
- Solution: Use a pulse shaping filter for each symbol.

Problems and Outlook

Envelope Detection for High Frequency Chirps



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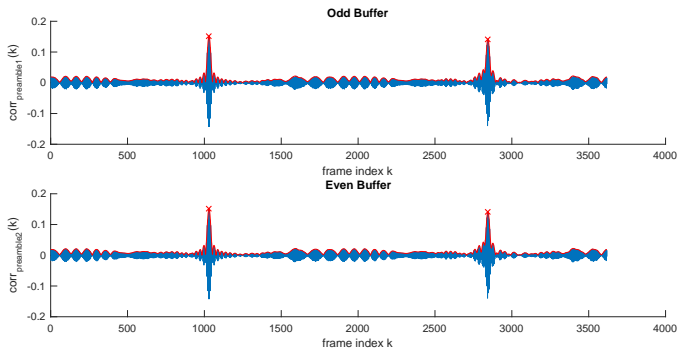


Figure: The Envelope Detection yields more distinctive peaks.



Problems and Outlook

Larger Symbol Space for Higher Data Rate

Idea:

Use multiple Chirps in different frequency areas to utilize more of the available spectrum.

Discussion



Ross Bencina and Phil Burk.

Portaudio—an open source cross platform audio api.

In Proc. 2001 Intl. Computer Music Conf.(ICMC-01), 2001.



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Massachusetts Institute of Technology, 1999.



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In Computer Communications (INFOCOM), 2015 IEEE Conference on, pages 2407–2415. IEEE, 2015.



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