

Long Project with Audiogaming

Additive Synthesis with Inverse Fourier Transform for Non-Stationary Signals

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Introduction

The company



- Localization: Toulouse, Paris
- Activity: Audio plug-in (VSTs and RTAS)
- Main customers: Film and Video Game Industry (Sony, Ubisoft)
- 10 employees

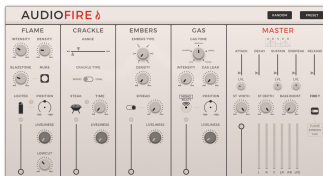


Figure: Audiofire: audio plug-in that recreates fire sound

Introduction

Objective

- We are continuing the Audiogaming long project from 2015 (Emilie Abia, Lili Zheng, Quentin Biache)

Objective : Synthesizing sounds from their spectrum with a FFT^{-1}

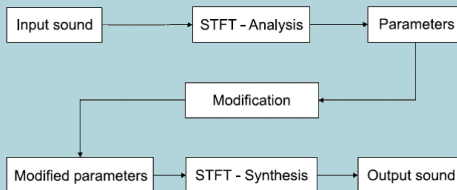


Figure: General approach for modifying a sound in the spectral domain

- We have to implement a new method of additive synthesis \Rightarrow computationally very fast

Introduction

Context of the Project

- 6 weeks only \Rightarrow Focus on the synthesis method only.

Given codes in Python and Matlab from the 2015 project :

- Python : Analysis estimator of sinus parameters and sinus generation with those parameters (only stationary)
 - Matlab : Some reasearch on the Non-stationary synthesis with the LUT of lobes
-
- We made our own Object Oriented Programmation tree structure in Python
 - We remade all the codes to be coherent with the OOP tree structure

Introduction

Work Environment



Figure: *PyCharm* as Python IDE , *Slack* to communicate, *GitHub* to stock the codes and have a versionning, *Freedcamp* to plan the project events

Introduction

Project Management : Gantt Chart (expected event)



Introduction

Project Management : Gantt Chart now



Additive Synthesis

Time Domain

The sound signal is represented as a sum of N sinusoids:

$$x(t) = \sum_{n=1}^N a_n \sin(2\pi f_n t + \phi_n)$$

- Very costly to implement
- Impossible to compute in real-time

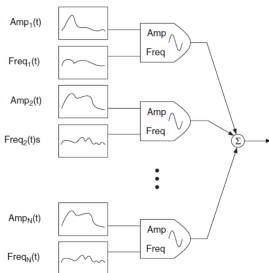


Figure: *The additive synthesis*

Method Overview : Windowing

Analysis

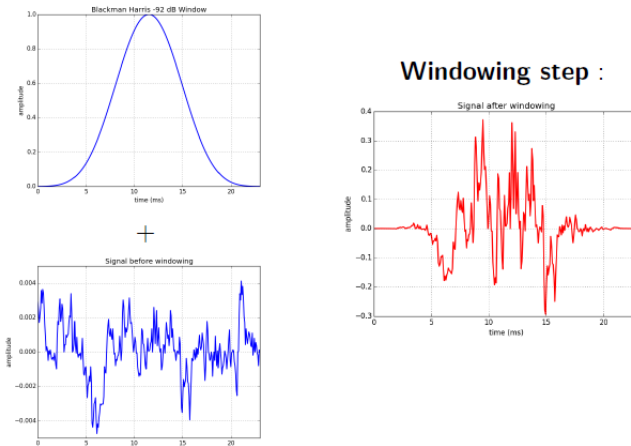


Figure: Windowing step

Method Overview : Peak detection in Frequency Domain

Analysis

Peak detection and extraction of parameters by STPT (particular Short Time Fourier Transform):

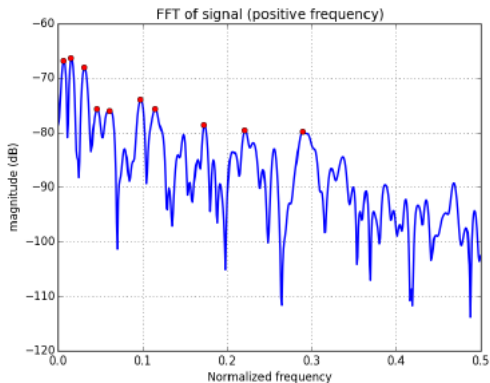


Figure: *Peak detection*

Method Overview : Result (FFT^{-1})

Synthesis

Additive synthesis with FFT^{-1} according to the parameters from the analysis:

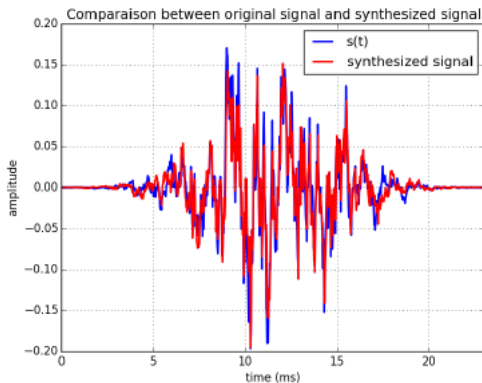


Figure: Synthesized frame vs Original frame

Stationary Case

Stationary sinusoidal model

Mathematical model :

$$s(t) = a_0 \exp[j(2\pi f_0 t + \phi_0)] \quad (1)$$

- 3 parameters: a_0 (amplitude), f_0 (frequency) and ϕ_0 (phase).
- Simplest model but useful for certain kinds of signals.
- Each spectral bin represents a stationary sinusoid.

Stationary Case

Lobe generation

We generate the sinusoids in frequency domain in order to reduce the computation time :

- Window the signal to maximize the energy in the main lobe
- We only keep the main lobe for each sine (11 points)
- We assume that the parameters (amplitude, frequency, phase) are already given by the analysis

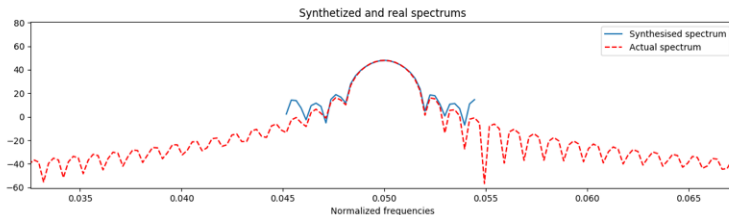


Figure: *Windowed sine lobe*

Stationary Case

Frames separation

The sound signal is a frame-by-frame signal:

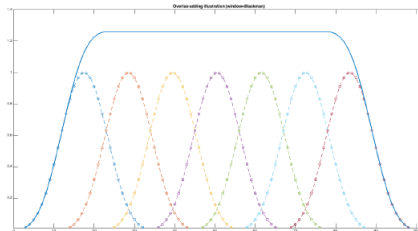


Figure: Sum of small size Hanning windows

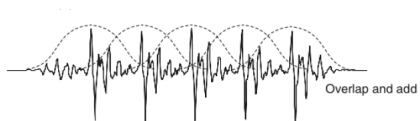


Figure: Overlap and add

Stationary Case

Phase coherence

Phase coherence ???

Casi-Stationary Case

What is changing

Non-Stationary Case

Very different approach

Non-Stationary Case

Look up table

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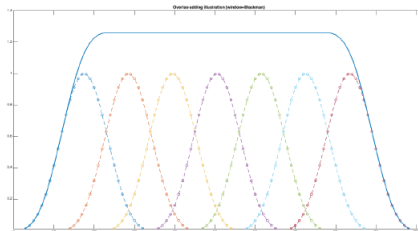


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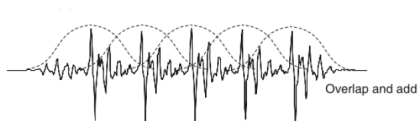


Figure: Overlap and add

Stationary Case

Sine waves

Stationary Case

Triangular waves

The additive synthesis

Changed Sine waves

The additive synthesis

Chirps

Conclusion

References