

# Tecnologías Multimedia - Study Guide -

## Milestone 6: Inter-channel decorrelation in stereo audio signals

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September 30, 2020

# 1. Description

**Correlation** is the term used in statistics for referring to the interdependency between **random variables**. It can be measured by the **correlation coefficient** [1].

In the case of InterCom, the random variables are the two channels (left  $L$  and right  $R$ ) of the **stereo signal**. In most cases, both channels are going to be **highly correlated** (especially if the microphone is mono), which means that we can represent one of them (for example, the  $R$  channel) with respect to the other (the  $L$  channel). From a mathematical point of view, this process can be seen as a **decorrelation** [2] process.

To perform this inter-channel decorrelation, we use an orthogonal transform

$$y = Kx = \frac{1}{2} \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix} x, \quad (1)$$

where  $x$  represents a frame (a tuple of  $L$  and  $R$  samples,  $x[0]$  and  $x[1]$ ),  $K$  is the  $2 \times 2$  KLT (**Karhunen-Loève Transform**) matrix multiplied by  $1/\sqrt{2}$  (which is closely related with the **Haar transform** [4]), and  $y$  represents the transform coefficients (in our case, a couple of coefficients  $y[0]$  and

$y[1]$ ). Notice that this transform is not orthonormal (energy preserving in the transform domain) because

$$\sum y[i]^2 = \frac{1}{\sqrt{2}} \sum x[i]^2, \quad (2)$$

although both subbands  $y[0]$  and  $y[1]$  have the same gain ( $1/\sqrt{2}$ ). This will simplify the **quantization** of  $y$ .

This transform can be implemented *in-place* using the following algo-

rithm:

**Algorithm 1.1:** INTER-CHANNEL\_DECORRELATION( )

**procedure** ANALYZE(frame)

$$\begin{cases} \text{frame}[0] - = \text{frame}[1] \\ \text{frame}[1] + = (\text{frame}[0] \gg 1) \\ \text{frame}[0] \gg = 1 \end{cases}$$

**procedure** SYNTHESIZE(frame)

$$\begin{cases} \text{frame}[0] \ll = 1 \\ \text{frame}[1] - = (\text{frame}[0] \gg 1) \\ \text{frame}[0] + = \text{frame}[1] \end{cases}$$

where  $a - = b$  is a shorter representation of the operation  $a = a - b$ , and  $\gg$  and  $\ll$  represent the bit-wise left and right shift operations, respectively. Notice that this type of in-place computations are commonly used in the implementation of DWTs (Discrete Wavelet Transforms) using

the Lifting Scheme [3].

## 2. What you have to do?

1. Inherit the class `Intercom_minimal` and override the method `record_io_and_play()`. Do this in a module named `intercom_intra-channel_decorrelation.py`.
2. Implement in this method the procedures `Analyze()` and `Synthesize()`.  
**Vectorized operations** should be used.

### 3. Timming

You should reach this milestone at most in two weeks.

## 4. Deliverables

The module `intercom_intra-channel_decorrelation.py`. Store it at the **root directory** of your `intercom`'s repo.



## 5. Resources

- [1] Allen B. Downey. *Think Stats Probability and Statistics for Programmers*. O'Reilly, 2011.
- [2] Khalid Sayood. *Introduction to data compression*. Morgan Kaufmann, 2017.
- [3] Wim Sweldens. *The Lifting Scheme: A Custom-Desing Constuction of Biorthogonal Wavelets*. *Applied and Computational Harmonic Analysis*, 3(2):186–200, 1996.
- [4] Martin Vetterli and Jelena Kovacevic. *Wavelets and Subband Coding*. Prentice-hall, 1995.