# Notes on Audio Processing

As of March 19, 2019

*signal* $\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \mathbb{R} \to \mathbb{C}$

$i^2 = -1$

$\text{correlate}\,(a,\ b)_t = a_t \cdot \overline{b_t}$

$\text{fourier}\,(\text{out}\ \textit{(signal)},\ \text{in}\ \textit{(signal)},\ \text{frequency} \in \mathbb{R},\ \text{bandwidth} \in \mathbb{R})\ \{$

Let $a = \text{in}$

Let $b_t = e^{i \cdot \omega \cdot t}$ with $\omega = 2\pi \cdot \text{frequency}$ $\forall\ t \in \text{range}$

$\text{out} \leftarrow \text{correlate}(a, b)$

$\text{out} \leftarrow \text{lowPass}(\text{out}, \text{bandwidth})$

$\text{out} \leftarrow \text{lowPass'}(\text{out}, \text{bandwidth})$

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The beauty of that definition lies within its simplicity:
It only consists of building blocks that are simple to implement and cheap in run-time cost.
The 'lowPass' and 'correlate' procedures need only make a single pass over the signal data, thus run in $\mathcal{O}(n)$ time.
$e^{i \cdot \omega \cdot t}$ too can be implemented to run very quickly.

So far for the well-known oscillation physics...

To express my thoughts, I need to introduce you to the concept of a "standing wave": In my mental model, it's an oscillation that, while in constant movement, conserves a special property. An example would be the swinging of a pendulum that conserves its energy: The energy contained within the movement is constant, in contrast to the oscillating properties (position, velocity). This conserved constant is a characteristic of the oscillation and describes its "3. axis". While we can imagine oscillation like circular movement, we can imagine the conserved constant as an axis: Combine it and you get a "Helix".

This is what the following is about. When we hear a sound, we don't exactely register the periodic movement of the air pressure, but rather the "preserved property" (which is the sound with its specific frequency/intensity per se). When we use a language to express something, we construct words with constant meaning out of a stream of varying values (a *signal*). Language is all about signals: We don't focus on the volatile atoms, but rather at the "direction at which we're going": The 3. Axis.