SEAM PROJECT - SUSTAINED STEREOPHONY

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ABSTRACT

After decades of sound and music technology development, the everyday practice reveals one of the first walking dead: the stereophony. In less than a hundred years from its birth, the stereophony is not only at the end of its comprehension but also at the end of its necessity. The electroacoustic literature has constant focus, through history, to the listening. Listening as a starting point of thinking, as a background of composing, as a long-distance perspective. Actually today we know better than Blumlein how people listen, how ears and brain do what they do. What we lose versus Blumlein, is the necessity of listening, of reproduction, of listening of reproduction.

When the words no longer point themselves we lose, with the meaning, also the reality we used to refer, using them. The transition from the age of mechanical reproduction of reality, through the history of attempts to reproduce it up to the virtual reality, must pass through, preserving and sustaining, that concepts which have defined the necessity of reproduction. Sustaining the electroacoustic literature, the repertoire, means to sustain the necessity of some concepts, like stereophony, and their related consolidated practice, to the perspective of development or, at least, the surviving of comprehension.

1. INTRODUCTION

Sustained Electro-Acoustic Music is a project inspired by Alvise Vidolin and Nicola Bernardini's article [1] on *live electroacoustic music sustainability*.

The main ambition of this project is to grow the interpretation and the electroacoustic musical practice with the consciousness of the electronic and informatics problems that had made arduous to approach this music and prevented the growth of interpretative thinking. It is possible, with a community structure, to determine, build and stratify interpretation of musical core, the repertoire, concealing the environment-related technological issues. They are instruments, not the music itself, after all.

These are the SEAM organisation coordinates:

- `http://s-e-a-m.github.io`
- `http://seam-world.slack.com`

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2. PROBLEMS

Why a project about sustained electroacoustic music must focus on stereophony issues? The literature and the repertoire survive thanks to the community activities. Most of those activities require education, strong education about sound and musical matters, layered, from roots to top floor of knowledge.

Especially the roots, the elementary concepts, the etymology of the basic lexis, is the most fragile and most violated place of knowledge, a place where stereophony, one of the keywords of the sound realm, just before to lose its meaning still losing its necessity.

Speaking about stereophonic sound in music classes, at each level of learning, should be a keynote, a moment in which by simple words, simple by different level of learning, people can understand how they listen to something, perhaps the music, they also understand the sound reproduction meaning, with reproduction significance of something real, where per real we focus at least on what we perceive and able to describe, like about sound. So, in music, speaking of listening and, after, stereophony, must be a grade zero of comprehension and, after, knowledge. How it could happen if the explanations about sounds, reproduction of sounds and stereophonic sounds are the following?

> È bene chiarire subito la differenza fra il concetto di "mono" e quello di "stereo". Mono è un termine che deriva dal greco e vuol dire ≪solo≫, ≪formato da uno solo≫. Nel campo audio si definisce mono un segnale che viaggia su un solo canale; esso è costituito da un'unica onda. Si definisce Stereo una coppia di segnali audio aventi delle differenze anche minime fra loro, che viaggia su due canali indipendenti: il canale sinistro e il canale destro; il segnale stereo è pertanto costituito da due onde [1] . [2]

. . . and many greetings to Blumlein.

Which electroacoustic realm could be based on these explanations? The one we internationally have now. The one that totally ignores the loss of the necessity of listening with both ears. The most music, audible during electroacoustic concerts and live interactive performances, in

[1] It is good to immediately clarify the difference between the concept of "mono" and that of "stereo". Mono is a term that derives from the Greek and means "solo", "made up of just one". In the audio field, a signal that travels on a single channel is defined as mono; it consists of connected wave. Stereo is defined as a pair of audio signals having even minimal differences between them, which travels on two independent channels: the left channel and the right channel; the stereo signal consists of two waves. (The Book here cited is the most adopted by Italian Musical High School)

particular the one made with high technology sensors and interactive features, easily does not focus at all on how people will listen to the performance. At the question "which is your music staging plan?" the most diffused worst answer is "stereo". Worst, because it is untrue, because they do not know what are saying and doing.

The first consequence of missing two-ears-attitude in the electroacoustic domain is the persistence of works that not have the necessity of audience, of auditorium neither. We do not even know who is the chicken or the egg, we only can underline the bond of them.

Nevertheless, the authors [2] of the text above cited, in the preface they claim the necessity of a didactic book, a text to take on during the early stage of music technology learning. They are full of interpretations to allow oneself to follow the unstoppable urge of writing books for young students, instead give them The Gift, the best instruction to be passed to people who caress the roots: how to search the meaning of things on literature and, especially, the encyclopedia [2] .

So, to argue our point, why focus on greek etymology of *mono*, *alone*, and not of *stereo*, from greek *Stereos*, *solid*. Maybe because it means not a number, not a configuration, only an adjective. Again, *solid*, *firm and stable in shape*, *having three dimensions*. *Solid*, from Latin root of *Solidus*, *Sollus*, *entire*.

We also prefer to underline that *mono* is the nickname for *monophonic*, with the bond between *monos* and *phonē*, *one voice*, *alone*. The same word used in a Gregorian chant description, later evolved in polyphony (from Greek *poluphōnia*, from *polu*, *many* and *phonē*). So the dichotomy, if must be one, between monophony and stereophony simply does not exist. The extension of monophony concept is the polyphony. Stereophony is simply another concept.

With the word Stereophony, we should describe a condition by which a *Phonē*, voice, sound, arrival solid to the listener, whole, firm and stable in their multidimensional sound shape, even in its electroacoustic reproduction, with any necessary number of channels.

3. ROOTS

The healthy mental attitude to sharing knowledge forecast the roots knowledge and sharing, even without interpretations, they could be afforded later.

> An observer in the room is listening with two ears, so that echoes reach him with the directional significance which he associates with the music performed in such room. He therefore discount these echoes and psychologically focuses his attention on the source of the sound. When the music is reproduced through a single channel the echoes arrive from the same direction as the direct sound so that confusion results. [...] Human ability to determine the direction from which sound arrives is due to binaural hearing, the brain being able to detect differences between sound received by the two ears from the same source and thus to determine angular directions from which various sounds arrive. [3]

With those words, Blumlein [3] described simultaneously the fundamentals of at least two huge arguments: how we perceive acoustic sounds, how we had reproduced sounds until that moment to be listened to and perceived.

Is a single human voice speaking, a monophonic voice inside a small room, an acceptable stereophonic condition? In agreement with Blumlein, Yes! This is the first firm point.

The binaural-ity of the human listening as the first statement of Blumlein conception: "*an observer in the room is listening with two ears*".

approfondire... in realtà qui ci starebbe bene il discorso di Gerzon sulla percezione MS.

[2] The Italian Treccani encyclopedia at `http://www.treccani.it/enciclopedia/stereofonia/` explain with universally-simple words what humanity, without allowing to personal interpretations, should refer with stereophony words. It is free knowledge, for Italian speaking people, not overwritten-able. We ironically even must sustain the use of the encyclopedia.

4. BRANCHES

With the deep knowledge of time meaning between us and Blumlein, we can expose loudspeaker significance better than him. For the Blumlein era, the loudspeaker was the future instrument for a better present time. The reproduced sound, at its young age, was pure magic. Today we know well how unsatisfied we are of loudspeaker reproduction. When the first iPhone was the only one smart-thing on the planet, it was awesome an awesome object of crafting. Today with the same object we would not take even a picture. Listening to a violin solo reproduced by the best loudspeaker on the market is not the same experience of the real performance. It is not related to stereophony and technique ability, it is integral to the reproduction limit of the technology we are able to craft.

Replacing the human voice speaking with a loudspeaker speaking the just now recorded human voice we lose, as Blumlein described, the capacity of ears-brain deciphers the sound-environment relationship. It is not more a stereophonic listening.

5. MID-SIDE

```
nsum = 0.5*(_+_);
ndif = 0.5*(_-_);
sdmx = _,_ <: nsum, ndif;
\label{ls:sdmx}
```

> . . . it is fairly well established that the main factor having effect are phase differences and intensity differences between the sounds reaching the two ears, the influence with each of these has depending upon the frequency of the sounds emitted. For low frequency sound waves there is little or non difference in intensity at the two ears but there is a marked phase difference. For a give obliquity of sound the phase difference is approximately proportional to frequency, representing a fixed time delay between sound arriving at the two ears, by noting which there is a phase difference of pi radians or more between sound arriving at the two ears from a source located on the line joining them: but above such frequency if phase difference were the sole feature relied upon for directional location there would be ambiguity in the apparent position of the source. At the stage however the head begins to became effective as a baffle and causes noticeable intensity difference between the sounds reaching the two ears, and it is by noting such intensity difference that brain determines direction of sounds at higher frequencies.
>
> . . . the frequency at which the brain changes over from phase- to intensity-discrimination occurs at about 700cps. . . . inn any case the transference is not sudden or discontinuous but there is considerable overlap of the two phenomena so that over a considerable frequency range differences of both phase and intensity will to some extent have an effect ion determine the sense of direction experienced.
>
> The invention also consists in a system of sound transmission wherein the sound is receive by two or more microphones, wherein at low frequencies difference in the phase of sound pressure at the microphone is reproduced as difference in volume at the loud speaker.

6. MID-SIDE PANNER

During the lessons in Rome Conservatory in which *SEAM* was born and its related problems were shared with classes to sensitize students to community work, the core software used to explode issues was *Faust* [3] . This wasn't a restriction, it was a preference. Text-based DSP offers the deepest learning experience and great expressivity and readability. *Faust* code could be written to educate a musician at the same time with computation versatility and efficiency. The *Faust libraries* concept is useful to focus on write once, and read forever, code. We think *Faust* itself represents a rather concept of electroacoustic sustainability. Thinking, for example, at the *filters.lib* and at the names that contributed the enrichment of speculation around each object, make us wish to a musical interest capable to do community more than with the adoption of other software.

Instruments carved by musical ideas on readable text (code) becomes a sub-literature in which each brick maintain the power of the source code, the clarity of an equation, the efficiency of the continuous development, the reusability of a word in different contexts.

The *SEAM library* local importing points to other libraries catalogued by arguments, like in *Standard Faust Libraries* [4] .

```
import("stdfaust.lib");
import("seam.lib");
```

The following passages will lead step-by-step to the Mid-Side panner developing. First of all, it is necessary to understand the polar pattern significance of a signal. An alone signal, in its amplitude variance around zero, could be derived by any kind of microphone without a particular meaning. It could be electrically generated by a microphone or other synthetic source without specific relevance. The polar provenience, the shape of the signal phase, becomes relevant to the comparison between signals.

From the Blumlein description of *Mid-Side*, we have a *Mid* frontal channel commonly described by a cardioid microphone. The first-order cardioid microphone could be described as a balanced sum of non-directional pressure (*ndp*) variations

$$ndp = 1 \tag{1}$$

and bidirectional pressure gradient.

$$bpg = \cos\theta \tag{2}$$

The first relevant difference between a non-directional polar pattern equation (1) and directional one (3) is the presence of the angular coefficient. The theta angle in the equation (3) describes the pointing direction of the bidirectional microphone expressed in radians.

The cardioid (*cpg*) microphone we attempt to synthesize must point to the front-central position that is the zero radians reference.

$$cpg = 0.5(x) + 0.5(\cos\theta x) \tag{3}$$

[3] https://faust.grame.fr

[4] https://github.com/grame-cncm/faustlibraries

Cardioid and other first order most common patterns are produced with the following balancing between non-directional pressure and bidirectional pressure gradient.

Polar Pattern	Equation
Omnidirectional	$1(x)$
Subcardioid	$0.75(x) + 0.25(\cos\theta x)$
Cardioid	$0.5(x) + 0.5(\cos\theta x)$
Supercardioid	$0.37(x) + 0.63(\cos\theta x)$
Hypercardioid	$0.25(x) + 0.75(\cos\theta x)$
Bidirectional	$\cos\theta x$

Table 1. *non-directional pressure* coefficient and *bidirectional pressure gradient* coefficient balancing to first order polar patterns description.

So by balancing the primitive first-order polar patterns, non-directional and bidirectional, we could derive, progressively, each shade of shape between them, angular pointing everywhere around 2pi radians.

Finally, the Mid component of the Mid-Side panner could be exressed by the formula

$$m(x, p, \Theta) = (p * x) + ((1 - p) * (\cos\Theta x) \tag{4}$$

Where x is the input signal, the p is the balancing coefficient, 0.5 for cardioid purpose, the θ is the angular impact direction expressed in radians.

The Side component is figure-8 straight formula pointing on left.

$$s(x, \Theta) = x * (sin(-\theta)) \tag{5}$$

The Faust code for a Mid-Side panner is truly self-explained: the straight equations to describe both cardioid and figure-8 are the two components at the out of panning.

```
mspan(x,p,rad) = m,s
  with{
    m = (p*x)+((1-p)*(x*cos(rad)));
    s = x*(sin(-rad));
};
\label{ls:mspan}
```

```
mspan_lr(x,p,rad) = mspan(x,p,rad) : sdmx;
\label{ls:mspanlr}
```

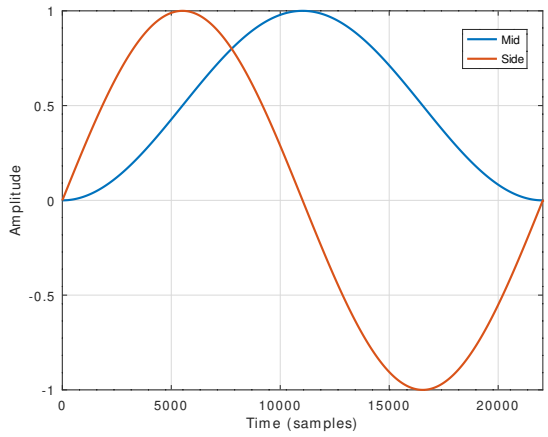

Figure 1. Mid-Side panner, 360 degrees sweep from left to right. The Side (red) line shows the bipolarity of the signal related to angular information. The Mid (blue) line has only positive energy in relation to angular information. It is evident the zero meaning at both edges of -180 and 180 degrees, where cardioid and figure-8 are hear-less.

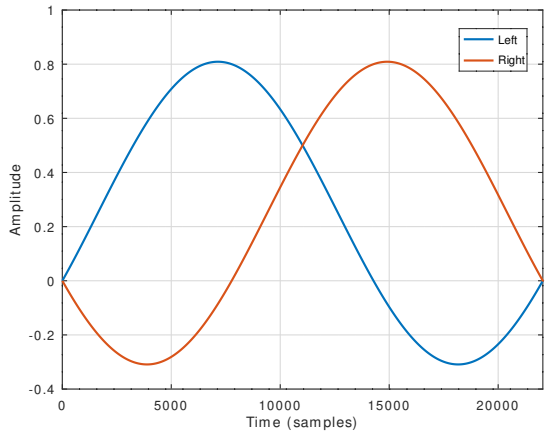

Figure 2. Mid-Side panner to Left Right amplitude matrix. 360 degrees sweep from left to right.

7. MS-PAN. LIVE USAGE

One of the most useful considerations of choosing panning techniques is usability in multiple circumstances. There are people who think quadratic panner is better than linear only because of its most recent introduction. They do not analyse the manual usage of one in place of the other. They do not analyse the mixer market and the role of panning in mass-culture music. Without analysing these practical issues, it is not really understandable why the worst panning technique ever is the most hardware implemented.

We have explained the path to Mid-Side panning, starting from the roots. Now it is the moment to understand what possible usages are, what are the peculiarities of a Mid-Side panner instead of amplitude panners.

The matrixed signal has its complexity as a disadvantage. To understand a signal as the significance of matrix combination requires a bit of tricky work more than straight signals.

As musicians, even when plots and formulas are pretty clear, at the end of judgment, are the ears and the musical usability to determine the best, personal, choice. So, for us, for example, the phase modulation strength of the Mid-Side panner suggested, even before a practical test, better stability on live usages. It is pretty simple to demonstrate. A microphone is routed into a channel, with a mid-lateral pointed panner, and fed to the loudspeakers. With a quadratic panner, both left and right channels have the same phase. The feedback of signal inside the microphone has in-phase different energies. The feedback will increase quadratically. On the other hand, in the same feedback situation, with the same angular panning to the microphone signal, the Mid-Side panning will produce different phase and different energy for both loudspeakers. The differences, in air, will produce a more resistive feedback pattern. In other words, the Mid-Side panner act ”naturally” as anti-Larsen.

To have an idea of live usability differences conditions, we plot the result of the same infinite loop for the Left Right quadratic panner.

```
1 lrpanq(x,p) = l,r
2   with{
3     l = sqrt(1-p)*x;
4     r = sqrt(p)*x;
5 };
```

8. CONCLUSIONS

9. REFERENCES

[1] N. Bernardini and A. Vidolin, "The title of the journal paper," in *Sound and Music Computing*, 2005.

[2] G. Cappellani, M. D'Agostino, L. D. Siena, G. Paolozzi, and S. Mudanò, *Laboratorio di Tecnologie Musicali Vol. I*. Contemponet, 2014.

[3] A. D. Blumlein, "British patent specification 394,325," *JAES, vol. 6, no. 2, p.91*, 1958.

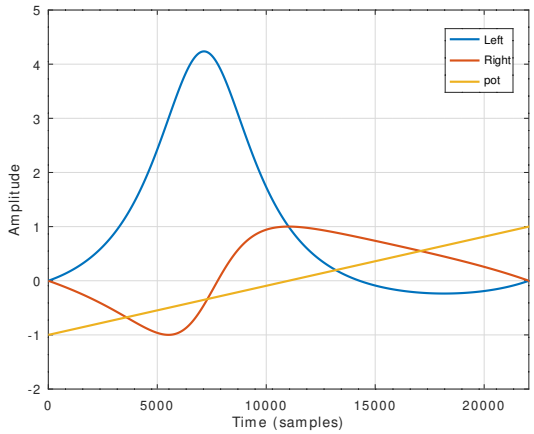

Figure 3. Mid-Side to Left-Right panner. The plot describes the feedback response with a pan movement through the entire panorama, from -180 to 180 degrees (yellow line, normalized to -1 and 1). The energy multiplies up to four times for the left channel in infinite feedback (blue line). The top of feedback encreasing is at 45 degrees position in direction of the channel in feedback.

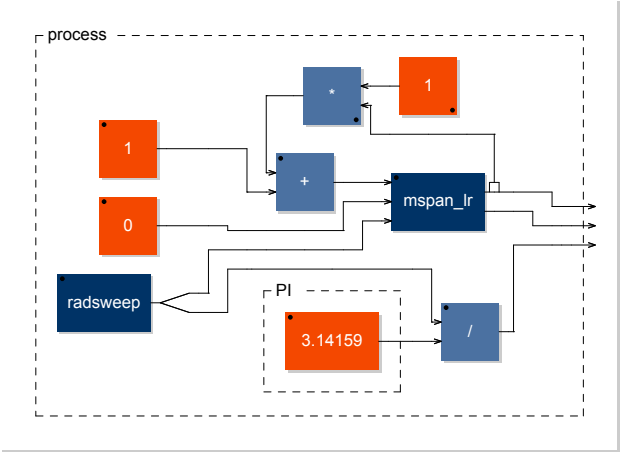

Figure 4. block diagram of the infinite feedback condition simulation.

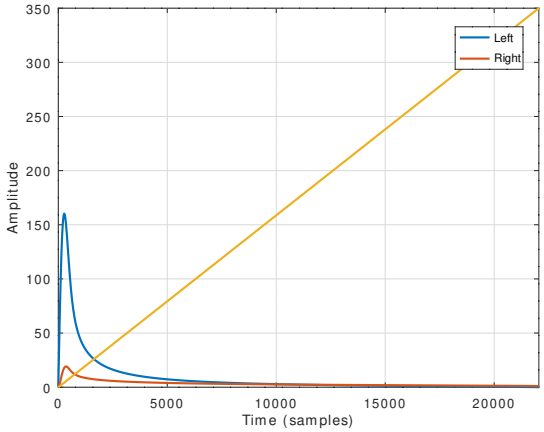

Figure 5. Mid-Side panner to Left Right amplitude matrix. 360 degrees sweep from left to right.

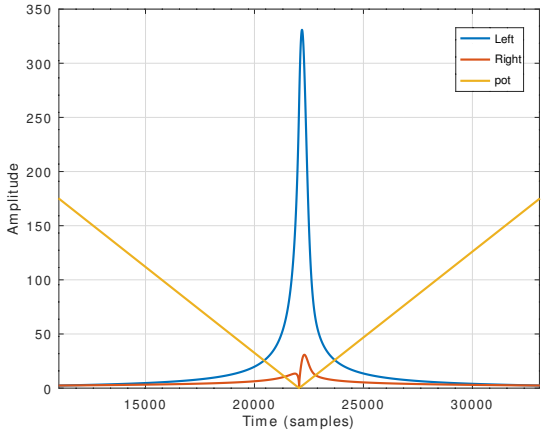

Figure 6. Mid-Side panner to Left Right amplitude matrix. 360 degrees sweep from left to right.