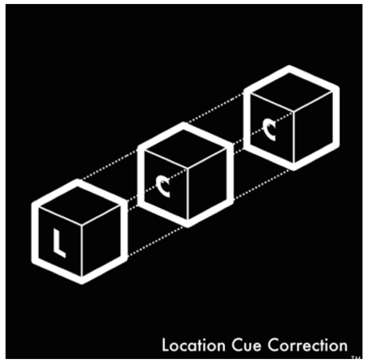
Localization Cue Correction (LCC) Algorithm

How the *Computationally Recurrent Correction Sample Exchange Protocol* works



A technology developed at
L&L Innovation Labs

In normal binaural hearing, a side sound source produces a 750µs delay between the ears. If the microphones used to record such a sound source at the far side have a TD of 750µs, then that is what LCC can deliver to the ears unchanged. Normal stereo will change the 750µs aspect on the recording to an irrational sequence where the first ITD is 220µs followed by one at 750µs[1] followed by one at 220µs but reversed as to which ear is leading.

In order to prevent a signal from the left speaker reaching the right ear requires that the right speaker emit a delayed and lower level inverse of the left signal to the right ear. Of course, this is also audible at the left ear after a short delay and a drop in level; thus, you need to now emit a signal from the left speaker in the original polarity and with the proper delay and level to correct for the inverted signal that came from the right speaker.

This process continues iteratively, with each sample declining in loudness and increasing in delay until infinity, i.e., 0dB.

Thus, LCC eliminates any inadvertent changes in ITD and ILD cues by carrying out this process until even small errors in ITD and ILD are eliminated.

LCC allows speakers to be placed more conveniently closer together at narrower angles, thus simultaneously producing an immersive sound stage no matter the head size or head attitude of a listener and correcting a major pinna direction finding error for central audio content information.

[1] The 750µs delays will not be reproduced with speakers are at 60-degrees, spaced apart, and without LCC. The reduction occurs because the early signal is reaching both ears including the wrong ear after 220µs.

(*The following equation is for 2.0 channels, and it can be extended for multiple channels and driver arrays*)
Where L = Left channel (input), R = Right channel (input)
Alpha = decay per reiteration, d = forward interval delay per reiteration, L' = Left channel (output), R' = Right channel (output), and beta = midpoint scaling, LCC is given by the expression:

$$L'(t) = \sum_{i=0}^{\infty} (\alpha^{2i} L(t - 2di) - \alpha^{2i+1} R(t - 2di - d)) + \beta(L(t) + R(t))$$

$$R'(t) = \sum_{i=0}^{\infty} (\alpha^{2i} R(t - 2di) - \alpha^{2i+1} L(t - 2di - d)) + \beta(L(t) + R(t))$$