The Ambisonic Tool Kit

1. Introduction

The Ambisonic Tool Kit (ATK) is intended to bring together a number of tools and transforms for working with Ambisonic surround sound. Rather than focusing on the needs and concerns of the classical music sound recordist or the popular music mix-engineer/producer or the acoustician/engineer, use is targeted towards the composer of acousmatic music. The intention is for the toolset to be both ergonomic and comprehensive, providing algorithms to creatively manipulate and synthesize Ambisonic soundfields.

The tools are framed for the user to 'think Ambisonically'. By this, it is meant the ATK is not focused on the problem of auralization and/or room modelling. Auralization is a complex problem beyond the scope of the fundamental algorithms of the ATK. (It is worth noting, however, with the toolset provided, successful room modelling may be implemented.) Interestingly enough, many composers of acousmatic music often do not move beyond the problem of auralization or room modelling. The ATK, by addressing the holistic problem of creatively controlling a complete soundfield allows and encourages the composer to think beyond the placement of sounds in a sound-space and instead attend to the impression and image of a soundfield, therefore taking advantage of the model the Ambisonic technology presents.

The remainder of this document is divided into sections detailing the elements of the toolset. These are encoders, transforms, and decoders. [Please note, presently this document lists 1st-order B-format only.]

2. Encoders

2.1. Frequency Independent

2.1.1. AtoB

Transform an A-format signal to the B-format domain. Note: a coincident A-format input is expected; inputs are not equalized to generate coincidence from spaced microphone inputs.

2.1.1.1. Interface

Name: O (orientation)
Range: [flu, fld, flr, fud, fbd, fbu, flru, flrd]
Default: flu
Description: Orientation of the A-format channel tetrahedron:

front left up: FLU, FRD, BLD, BRU
front left down: FLD, FRU, BLU, BRD
front left-right: FL, FR, BU, BD
front up-down: FU, FD, BL, BR
front and back down: F, BD, BLU, BRU
front and back up: F, BU, BLD, BRD
front left-right up: FLU, FRU, FD, B
front left-right down: FLD, FRD, FU, B

Name: M (mode)
Range: [can, dec, uns]
Default: can
Description: The weighting of the scaling on W: 'can' gives canonical W scaling of 1/sqrt(2), 'dec' gives weighting appropriate for decorrelated soundfields of 1/sqrt(3), 'uns' gives a weight of 1 on W. 'dec' is the usual choice for use in reverberators.

2.1.1.2. Matrix

for $O = flu, M = can$:

$$AtoB(O,M) = \begin{bmatrix} \frac{1}{2} & \frac{1}{2} & \frac{1}{2} & \frac{1}{2} \\ \frac{1}{2} & \frac{1}{2} & -\frac{1}{2} & -\frac{1}{2} \\ \frac{1}{2} & -\frac{1}{2} & \frac{1}{2} & -\frac{1}{2} \\ \frac{1}{2} & -\frac{1}{2} & -\frac{1}{2} & \frac{1}{2} \end{bmatrix}$$

for $O = flu, M = dec$:

$$AtoB(O,M)=\begin{bmatrix} \sqrt{6}/4 & \sqrt{6}/4 & \sqrt{6}/4 & \sqrt{6}/4 \\ 1/2 & 1/2 & -1/2 & -1/2 \\ 1/2 & -1/2 & 1/2 & -1/2 \\ 1/2 & -1/2 & -1/2 & 1/2 \end{bmatrix}$$

for $O=flu, M=uns$:

$$AtoB(O,M)=\begin{bmatrix} \sqrt{2}/4 & \sqrt{2}/4 & \sqrt{2}/4 & \sqrt{2}/4 \\ 1/2 & 1/2 & -1/2 & -1/2 \\ 1/2 & -1/2 & 1/2 & -1/2 \\ 1/2 & -1/2 & -1/2 & 1/2 \end{bmatrix}$$

for $O=fld, M=can$:

$$AtoB(O,M)=\begin{bmatrix} 1/2 & 1/2 & 1/2 & 1/2 \\ 1/2 & 1/2 & -1/2 & -1/2 \\ 1/2 & -1/2 & 1/2 & -1/2 \\ -1/2 & 1/2 & 1/2 & -1/2 \end{bmatrix}$$

for $O=fld, M=dec$:

$$AtoB(O,M)=\begin{bmatrix} \sqrt{6}/4 & \sqrt{6}/4 & \sqrt{6}/4 & \sqrt{6}/4 \\ 1/2 & 1/2 & -1/2 & -1/2 \\ 1/2 & -1/2 & 1/2 & -1/2 \\ -1/2 & 1/2 & 1/2 & -1/2 \end{bmatrix}$$

for $O=fld, M=uns$:

$$AtoB(O,M)=\begin{bmatrix} \sqrt{2}/4 & \sqrt{2}/4 & \sqrt{2}/4 & \sqrt{2}/4 \\ 1/2 & 1/2 & -1/2 & -1/2 \\ 1/2 & -1/2 & 1/2 & -1/2 \\ -1/2 & 1/2 & 1/2 & -1/2 \end{bmatrix}$$

for $O=flr, M=can$:

$$AtoB(O,M)=\begin{bmatrix} 1/2 & 1/2 & 1/2 & 1/2 \\ 1/2 & 1/2 & -1/2 & -1/2 \\ 1/\sqrt{2} & -1/\sqrt{2} & 0 & 0 \\ 0 & 0 & 1/\sqrt{2} & -1/\sqrt{2} \end{bmatrix}$$

for $O=flr, M=dec$:

$$AtoB(O,M)=\begin{bmatrix} \frac{\sqrt{6}}{4} & \frac{\sqrt{6}}{4} & \frac{\sqrt{6}}{4} & \frac{\sqrt{6}}{4} \\ \frac{1}{2} & \frac{1}{2} & -\frac{1}{2} & -\frac{1}{2} \\ \frac{1}{\sqrt{2}} & -\frac{1}{\sqrt{2}} & 0 & 0 \\ 0 & 0 & \frac{1}{\sqrt{2}} & -\frac{1}{\sqrt{2}} \end{bmatrix}$$

for $O = flr, M = uns$:

$$AtoB(O,M)=\begin{bmatrix} \frac{\sqrt{2}}{4} & \frac{\sqrt{2}}{4} & \frac{\sqrt{2}}{4} & \frac{\sqrt{2}}{4} \\ \frac{1}{2} & \frac{1}{2} & -\frac{1}{2} & -\frac{1}{2} \\ \frac{1}{\sqrt{2}} & -\frac{1}{\sqrt{2}} & 0 & 0 \\ 0 & 0 & \frac{1}{\sqrt{2}} & -\frac{1}{\sqrt{2}} \end{bmatrix}$$

for $O = fud, M = can$:

$$AtoB(O,M)=\begin{bmatrix} \frac{1}{2} & \frac{1}{2} & \frac{1}{2} & \frac{1}{2} \\ \frac{1}{2} & \frac{1}{2} & -\frac{1}{2} & -\frac{1}{2} \\ 0 & 0 & \frac{1}{\sqrt{2}} & -\frac{1}{\sqrt{2}} \\ \frac{1}{\sqrt{2}} & -\frac{1}{\sqrt{2}} & 0 & 0 \end{bmatrix}$$

for $O = fud, M = dec$:

$$AtoB(O,M)=\begin{bmatrix} \frac{\sqrt{6}}{4} & \frac{\sqrt{6}}{4} & \frac{\sqrt{6}}{4} & \frac{\sqrt{6}}{4} \\ \frac{1}{2} & \frac{1}{2} & -\frac{1}{2} & -\frac{1}{2} \\ 0 & 0 & \frac{1}{\sqrt{2}} & -\frac{1}{\sqrt{2}} \\ \frac{1}{\sqrt{2}} & -\frac{1}{\sqrt{2}} & 0 & 0 \end{bmatrix}$$

for $O = fud, M = uns$:

$$AtoB(O,M)=\begin{bmatrix} \frac{\sqrt{2}}{4} & \frac{\sqrt{2}}{4} & \frac{\sqrt{2}}{4} & \frac{\sqrt{2}}{4} \\ \frac{1}{2} & \frac{1}{2} & -\frac{1}{2} & -\frac{1}{2} \\ 0 & 0 & \frac{1}{\sqrt{2}} & -\frac{1}{\sqrt{2}} \\ \frac{1}{\sqrt{2}} & -\frac{1}{\sqrt{2}} & 0 & 0 \end{bmatrix}$$

for $O = fbd, M = can$:

$$AtoB(O,M)=\begin{bmatrix} \frac{1}{2} & \frac{1}{2} & \frac{1}{2} & \frac{1}{2} \\ \frac{\sqrt{3}}{2} & -\frac{\sqrt{3}}{6} & -\frac{\sqrt{3}}{6} & -\frac{\sqrt{3}}{6} \\ 0 & 0 & \frac{1}{\sqrt{2}} & -\frac{1}{\sqrt{2}} \\ 0 & -\frac{\sqrt{6}}{3} & \frac{1}{\sqrt{6}} & \frac{1}{\sqrt{6}} \end{bmatrix}$$

for $O = fbd, M = dec$:

$$AtoB(O,M) = \begin{bmatrix} \sqrt{6}/4 & \sqrt{6}/4 & \sqrt{6}/4 & \sqrt{6}/4 \\ \sqrt{3}/2 & -\sqrt{3}/6 & -\sqrt{3}/6 & -\sqrt{3}/6 \\ 0 & 0 & 1/\sqrt{2} & -1/\sqrt{2} \\ 0 & -\sqrt{6}/3 & 1/\sqrt{6} & 1/\sqrt{6} \end{bmatrix}$$

for $O = fbd, M = uns$:

$$AtoB(O,M) = \begin{bmatrix} \sqrt{2}/4 & \sqrt{2}/4 & \sqrt{2}/4 & \sqrt{2}/4 \\ \sqrt{3}/2 & -\sqrt{3}/6 & -\sqrt{3}/6 & -\sqrt{3}/6 \\ 0 & 0 & 1/\sqrt{2} & -1/\sqrt{2} \\ 0 & -\sqrt{6}/3 & 1/\sqrt{6} & 1/\sqrt{6} \end{bmatrix}$$

for $O = fbu, M = can$:

$$AtoB(O,M) = \begin{bmatrix} 1/2 & 1/2 & 1/2 & 1/2 \\ \sqrt{3}/2 & -\sqrt{3}/6 & -\sqrt{3}/6 & -\sqrt{3}/6 \\ 0 & 0 & 1/\sqrt{2} & -1/\sqrt{2} \\ 0 & \sqrt{6}/3 & -1/\sqrt{6} & -1/\sqrt{6} \end{bmatrix}$$

for $O = fbu, M = dec$:

$$AtoB(O,M) = \begin{bmatrix} \sqrt{6}/4 & \sqrt{6}/4 & \sqrt{6}/4 & \sqrt{6}/4 \\ \sqrt{3}/2 & -\sqrt{3}/6 & -\sqrt{3}/6 & -\sqrt{3}/6 \\ 0 & 0 & 1/\sqrt{2} & -1/\sqrt{2} \\ 0 & \sqrt{6}/3 & -1/\sqrt{6} & -1/\sqrt{6} \end{bmatrix}$$

for $O = fbu, M = uns$:

$$AtoB(O,M) = \begin{bmatrix} \sqrt{2}/4 & \sqrt{2}/4 & \sqrt{2}/4 & \sqrt{2}/4 \\ \sqrt{3}/2 & -\sqrt{3}/6 & -\sqrt{3}/6 & -\sqrt{3}/6 \\ 0 & 0 & 1/\sqrt{2} & -1/\sqrt{2} \\ 0 & \sqrt{6}/3 & -1/\sqrt{6} & -1/\sqrt{6} \end{bmatrix}$$

for $O = flru, M = can$:

$$AtoB(O,M)=\begin{bmatrix} \frac{1}{2} & \frac{1}{2} & \frac{1}{2} & \frac{1}{2} \\ \frac{\sqrt{3}}{6} & \frac{\sqrt{3}}{6} & \frac{\sqrt{3}}{6} & -\frac{\sqrt{3}}{2} \\ \frac{1}{\sqrt{2}} & -\frac{1}{\sqrt{2}} & 0 & 0 \\ \frac{1}{\sqrt{6}} & \frac{1}{\sqrt{6}} & -\frac{\sqrt{6}}{3} & 0 \end{bmatrix}$$

for $O = flru, M = dec$:

$$AtoB(O,M)=\begin{bmatrix} \frac{\sqrt{6}}{4} & \frac{\sqrt{6}}{4} & \frac{\sqrt{6}}{4} & \frac{\sqrt{6}}{4} \\ \frac{\sqrt{3}}{6} & \frac{\sqrt{3}}{6} & \frac{\sqrt{3}}{6} & -\frac{\sqrt{3}}{2} \\ \frac{1}{\sqrt{2}} & -\frac{1}{\sqrt{2}} & 0 & 0 \\ \frac{1}{\sqrt{6}} & \frac{1}{\sqrt{6}} & -\frac{\sqrt{6}}{3} & 0 \end{bmatrix}$$

for $O = flru, M = uns$:

$$AtoB(O,M)=\begin{bmatrix} \frac{\sqrt{2}}{4} & \frac{\sqrt{2}}{4} & \frac{\sqrt{2}}{4} & \frac{\sqrt{2}}{4} \\ \frac{\sqrt{3}}{6} & \frac{\sqrt{3}}{6} & \frac{\sqrt{3}}{6} & -\frac{\sqrt{3}}{2} \\ \frac{1}{\sqrt{2}} & -\frac{1}{\sqrt{2}} & 0 & 0 \\ \frac{1}{\sqrt{6}} & \frac{1}{\sqrt{6}} & -\frac{\sqrt{6}}{3} & 0 \end{bmatrix}$$

for $O = flrd, M = can$:

$$BtoA(O,M)=\begin{bmatrix} \frac{1}{2} & \frac{1}{2} & \frac{1}{2} & \frac{1}{2} \\ \frac{\sqrt{3}}{6} & \frac{\sqrt{3}}{6} & \frac{\sqrt{3}}{6} & -\frac{\sqrt{3}}{2} \\ \frac{1}{\sqrt{2}} & -\frac{1}{\sqrt{2}} & 0 & 0 \\ -\frac{1}{\sqrt{6}} & -\frac{1}{\sqrt{6}} & \frac{\sqrt{6}}{3} & 0 \end{bmatrix}$$

for $O = flrd, M = dec$:

$$BtoA(O,M)=\begin{bmatrix} \frac{\sqrt{6}}{4} & \frac{\sqrt{6}}{4} & \frac{\sqrt{6}}{4} & \frac{\sqrt{6}}{4} \\ \frac{\sqrt{3}}{6} & \frac{\sqrt{3}}{6} & \frac{\sqrt{3}}{6} & -\frac{\sqrt{3}}{2} \\ \frac{1}{\sqrt{2}} & -\frac{1}{\sqrt{2}} & 0 & 0 \\ -\frac{1}{\sqrt{6}} & -\frac{1}{\sqrt{6}} & \frac{\sqrt{6}}{3} & 0 \end{bmatrix}$$

for $O = flrd, M = uns$:

$$BtoA(O,M) = \begin{bmatrix} \sqrt{2}/4 & \sqrt{2}/4 & \sqrt{2}/4 & \sqrt{2}/4 \\ \sqrt{3}/6 & \sqrt{3}/6 & \sqrt{3}/6 & -\sqrt{3}/2 \\ 1/\sqrt{2} & -1/\sqrt{2} & 0 & 0 \\ -1/\sqrt{6} & -1/\sqrt{6} & \sqrt{6}/3 & 0 \end{bmatrix}$$

3. Transforms

3.1. Frequency Independent

3.1.1. Direct

Adjust directivity of an ambisonic B-format sound field.

3.1.1.1. Interface

Name: theta
Range: -pi to pi
Default: pi/2
Description: the angle of distortion in radians, from -pi to pi. 0 reduces the directivity to the w component only, bringing everything to the middle of the image. Values greater than pi/2 increase the gain of x, y, z while reducing w; this range of values can be used to exaggerate the directional impression. Values between pi/2 and -pi/2 bring the image from unchanged, through the center, to inverted directional components. The default, pi/2, results in no change.

3.1.1.2. Matrix

$$Direct(\theta) = \begin{bmatrix} \sqrt{2}\cos\frac{\theta}{2} & 0 & 0 & 0 \\ 0 & \sqrt{2}\sin\frac{\theta}{2} & 0 & 0 \\ 0 & 0 & \sqrt{2}\sin\frac{\theta}{2} & 0 \\ 0 & 0 & 0 & \sqrt{2}\sin\frac{\theta}{2} \end{bmatrix}$$

3.1.2. Squishes

3.1.2.1. Squish

Squish, direct-able to azimuth, elevation

3.1.2.2. SquishX

Squish an ambisonic B-format sound field on the x-axis.

3.1.2.2.1. Interface

Name: theta
Range: -pi to pi
Default: pi/2
Description: the angle of distortion in radians. 0 squishes the x-axis to the center, bringing what was at front center and back center to the middle of the image, squishing the image to the y-z plane. Values greater than pi/2 increase the gain of x while reducing w, y, z; this range of values can be used to exaggerate the front/back depth of the image. Values between pi/2 and -pi/2 squish the image from unchanged, through the y-z plane, to front/back reversed. The default, pi/2, results in no change.

3.1.2.2.2. Matrix

$$SquishX(\theta) = \begin{bmatrix} \sqrt{2}\cos\frac{\theta}{2} & 0 & 0 & 0 \\ 0 & \sqrt{2}\sin\frac{\theta}{2} & 0 & 0 \\ 0 & 0 & \sqrt{2}\cos\frac{\theta}{2} & 0 \\ 0 & 0 & 0 & \sqrt{2}\cos\frac{\theta}{2} \end{bmatrix}$$

3.1.2.3. SquishY

Squish an ambisonic B-format sound field on the x-axis.

3.1.2.3.1. Interface

Name: theta
Range: -pi to pi
Default: pi/2
Description: the angle of distortion in radians, from -pi to pi. 0 squishes the y-axis to the center, bringing what was at hard left and hard right to the middle of the image, squishing the image to the x-z plane. Values greater than pi/2 increase the gain of y while reducing w, x, z; this range of values can be used to exaggerate the left/right width of the image. Values between pi/2 and -pi/2 squish the image from unchanged, through the x-z plane, to left/right reversed. The default, pi/2, results in no change.

3.1.2.3.2. Matrix

$$SquishY(\theta) = \begin{bmatrix} \sqrt{2}\cos\frac{\theta}{2} & 0 & 0 & 0 \\ 0 & \sqrt{2}\cos\frac{\theta}{2} & 0 & 0 \\ 0 & 0 & \sqrt{2}\sin\frac{\theta}{2} & 0 \\ 0 & 0 & 0 & \sqrt{2}\cos\frac{\theta}{2} \end{bmatrix}$$

3.1.2.4. SquishZ

Squish an ambisonic B-format sound field on the x-axis.

3.1.2.4.1. Interface

Name: theta
Range: -pi to pi
Default: pi/2
Description: the angle of distortion in radians, from -pi to pi. 0 squishes the z-axis to the center, bringing what was at up and down to the middle of the image, squishing the image to the x-y plane. Values greater than pi/2 increase the gain of z while reducing w, x, y; this range of values can be used to exaggerate the height of the image. Values between pi/2 and -pi/2 squish the image from unchanged, through the x-y plane, to up/down inverted. The default, pi/2, results in no change.

3.1.2.4.2. Matrix

$$SquishZ(\theta) = \begin{bmatrix} \sqrt{2}\cos\frac{\theta}{2} & 0 & 0 & 0 \\ 0 & \sqrt{2}\cos\frac{\theta}{2} & 0 & 0 \\ 0 & 0 & \sqrt{2}\cos\frac{\theta}{2} & 0 \\ 0 & 0 & 0 & \sqrt{2}\sin\frac{\theta}{2} \end{bmatrix}$$

3.1.3. Rotations

3.1.3.1. Turn

Rotation, direct-able to axis at azimuth, elevation

3.1.3.2. Rotate

Rotate an ambisonic B-format sound field counter-clockwise around the z-axis. (Rotation around z-axis)

3.1.3.2.1. Interface

Name: theta
Range: -pi to pi
Default: 0
Description: the angle of rotation in radian. pi/2 rotates what was front center to hard left and -pi/2 rotates to hard right. Both pi and -pi will rotate what was front center to back center. The default, 0, results in no change.

3.1.3.2.2. Matrix

$$Rotate(\theta) = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos\theta & -\sin\theta & 0 \\ 0 & \sin\theta & \cos\theta & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

3.1.3.3. Tilt

Tilt an ambisonic B-format sound field clockwise around the x-axis. (Rotation around x-axis)

3.1.3.3.1. Interface

Name: theta
Range: -pi to pi
Default: 0
Description: the angle of rotation in radians. pi/2 rotates what was hard left to up and -pi/2 rotates to down. Both pi and -pi will rotate what was hard left to hard right, also resulting in a vertically inverted image. The default, 0, results in no change.

3.1.3.3.2. Matrix

$$Tilt(\theta) = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & \cos\theta & -\sin\theta \\ 0 & 0 & \sin\theta & \cos\theta \end{bmatrix}$$

3.1.3.4. Tumble

Tumble an ambisonic B-format sound field ‘upwards’ around the y-axis. (Rotation around y-axis)

3.1.3.4.1. Interface

Name: theta
Range: -pi to pi
Default: 0
Description: the angle of rotation in radians. pi/2 rotates what was hard left to up and -pi/2 rotates to down. Both pi and -pi will rotate what was hard left to hard right, also resulting in a vertically inverted image. The default, 0, results in no change.

3.1.3.4.2. Matrix

$$Tumble(\theta) = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos\theta & 0 & -\sin\theta \\ 0 & 0 & 1 & 0 \\ 0 & \sin\theta & 0 & \cos\theta \end{bmatrix}$$

3.1.4. Dominance

3.1.4.1. Dominate

Dominance, direct-able to azimuth, elevation

3.1.4.2. DominateX

Apply dominance on the x-axis to an ambisonic B-format sound field.

3.1.4.2.1. Interface

Name: gain
Range: -∞ to ∞
Default: 0
Description: the dominance gain, in dB, applied on the x-axis. Positive values increase the gain at front center to +gain, while decreasing the gain at back center to -gain, simultaneously distorting the image towards front center. Negative values of gain invert this distortion, distorting the image towards back center. The default, 0, results in no change.

3.1.4.2.2. Matrix

$$\lambda = 10^{gain/20}$$

$$Do\min ateX(\lambda) = \begin{bmatrix} \frac{1}{2}\left(\lambda + \frac{1}{\lambda}\right) & \frac{1}{\sqrt{8}}\left(\lambda - \frac{1}{\lambda}\right) & 0 & 0 \\ \frac{1}{\sqrt{2}}\left(\lambda - \frac{1}{\lambda}\right) & \frac{1}{2}\left(\lambda + \frac{1}{\lambda}\right) & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

3.1.4.3. DominateY

Apply dominance on the y-axis to an ambisonic B-format sound field.

3.1.4.3.1. Interface

Name: gain
Range: -∞ to ∞
Default: 0
Description: the dominance gain, in dB, applied on the y-axis. Positive values increase the gain at hard left to +gain, while decreasing the gain at hard right to -gain, simultaneously distorting the image towards hard left. Negative values of gain invert this distortion, distorting the image towards hard right. The default, 0, results in no change.

3.1.4.3.2. Matrix

$$\lambda = 10^{gain/20}$$

$$Dominate Y(\lambda) = \begin{bmatrix} \frac{1}{2}\left(\lambda + \frac{1}{\lambda}\right) & 0 & \frac{1}{\sqrt{8}}\left(\lambda - \frac{1}{\lambda}\right) & 0 \\ 0 & 1 & 0 & 0 \\ \frac{1}{\sqrt{2}}\left(\lambda - \frac{1}{\lambda}\right) & 0 & \frac{1}{2}\left(\lambda + \frac{1}{\lambda}\right) & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

3.1.4.4. DominateZ

Apply dominance on the z-axis to an ambisonic B-format sound field.

3.1.4.4.1. Interface

Name: gain
Range: -∞ to ∞
Default: 0
Description: the dominance gain, in dB, applied on the z-axis. Positive values increase the gain at up to +gain, while decreasing the gain at down to -gain, simultaneously distorting the image towards up. Negative values of gain invert this distortion, distorting the image towards down. The default, 0, results in no change.

3.1.4.4.2. Matrix

$$\lambda = 10^{gain/20}$$

$$Dominate Z(\lambda) = \begin{bmatrix} \frac{1}{2}\left(\lambda + \frac{1}{\lambda}\right) & 0 & 0 & \frac{1}{\sqrt{8}}\left(\lambda - \frac{1}{\lambda}\right) \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ \frac{1}{\sqrt{2}}\left(\lambda - \frac{1}{\lambda}\right) & 0 & 0 & \frac{1}{2}\left(\lambda + \frac{1}{\lambda}\right) \end{bmatrix}$$

3.2. Zoom

Dominance, in terms of angular distortion rather than gain

3.2.1. Zoom

Dominance, direct-able to azimuth, elevation.

3.2.2. ZoomX

Apply dominance, in terms of distortion angle, on the x-axis to an ambisonic B-format sound field.

3.2.2.1.1. Interface

Name: theta
Range: -pi/2 to pi/2
Default: 0
Description: the angle of distortion in radians, from -pi/2 to pi/2. Positive values increase gain in the front center of the image, reducing the gain at back center. Negative values do the inverse. The default, 0, results in no change. Note, +/-pi/2 generate infinite gain, so the usable range is between these values.

3.2.2.1.2. Matrix

$$ZoomX(\theta) = \begin{bmatrix} \frac{1}{\cos\theta} & \frac{1}{\sqrt{2}}\tan\theta & 0 & 0 \\ \sqrt{2}\tan\theta & \frac{1}{\cos\theta} & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

3.2.3. ZoomY

Apply dominance, in terms of distortion angle, on the y-axis to an ambisonic B-format sound field.

3.2.3.1.1. Interface

Name: theta
Range: -pi/2 to pi/2
Default: 0
Description: the angle of distortion in radians, from -pi/2 to pi/2. Positive values increase gain at the hard left of the image, reducing the gain at hard right. Negative values do the inverse. The default, 0, results in no change. Note, +/-pi/2 generate infinite gain, so the usable range is between these values.

3.2.3.1.2. Matrix

$$ZoomY(\theta) = \begin{bmatrix} \frac{1}{\cos\theta} & 0 & \frac{1}{\sqrt{2}}\tan\theta & 0 \\ 0 & 1 & 0 & 0 \\ \sqrt{2}\tan\theta & 0 & \frac{1}{\cos\theta} & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

3.2.4. ZoomZ

Apply dominance, in terms of distortion angle, on the z-axis to an ambisonic B-format sound field.

3.2.4.1.1. Interface

Name: theta
Range: -pi/2 to pi/2
Default: 0
Description: the angle of distortion in radians, from -pi/2 to pi/2. Positive values increase gain at up of the image, reducing the gain at down. Negative values do the inverse. The default, 0, results in no change. Note, +/-pi/2 generate infinite gain, so the usable range is between these values.

3.2.4.1.2. Matrix

$$ZoomX(\theta) = \begin{bmatrix} \frac{1}{\cos\theta} & 0 & 0 & \frac{1}{\sqrt{2}}\tan\theta \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ \sqrt{2}\tan\theta & 0 & 0 & \frac{1}{\cos\theta} \end{bmatrix}$$

3.2.5. Focus

***Note: focus algorithms require two matricies, one for + distortions and another for -.

3.2.5.1. Focus

Focus, direct-able to azimuth, elevation

3.2.5.2. FocusX

Apply focus on the x-axis to an ambisonic B-format sound field.

3.2.5.2.1. Interface

Name: theta
Range: -pi/2 to pi/2
Default: 0
Description: the angle of distortion in radians. Positive values focus on the front center of the image, and at pi/2 collapse the soundfield to mono, reducing the gain at back center to -inf dB. Negative values focus on back center. The default, 0, results in no change.

3.2.5.2.2. Matrix

for $\theta \geq 0$:

$$FocusX(\theta) = \begin{bmatrix} \dfrac{1}{1+\sin\theta} & \dfrac{1}{\sqrt{2}}\left(\dfrac{\sin\theta}{1+\sin\theta}\right) & 0 & 0 \\ \sqrt{2}\left(\dfrac{\sin\theta}{1+\sin\theta}\right) & \dfrac{1}{1+\sin\theta} & 0 & 0 \\ 0 & 0 & \sqrt{\dfrac{1-\sin\theta}{1+\sin\theta}} & 0 \\ 0 & 0 & 0 & \sqrt{\dfrac{1-\sin\theta}{1+\sin\theta}} \end{bmatrix}$$

for $\theta < 0$:

$$FocusX(\theta) = \begin{bmatrix} \dfrac{1}{1-\sin\theta} & \dfrac{1}{\sqrt{2}}\left(\dfrac{\sin\theta}{1-\sin\theta}\right) & 0 & 0 \\ \sqrt{2}\left(\dfrac{\sin\theta}{1-\sin\theta}\right) & \dfrac{1}{1-\sin\theta} & 0 & 0 \\ 0 & 0 & \sqrt{\dfrac{1+\sin\theta}{1-\sin\theta}} & 0 \\ 0 & 0 & 0 & \sqrt{\dfrac{1+\sin\theta}{1-\sin\theta}} \end{bmatrix}$$

3.2.5.3. FocusY

Apply focus on the y-axis to an ambisonic B-format sound field.

3.2.5.3.1. Interface

Name: theta
Range: -pi/2 to pi/2
Default: 0
Description: the angle of distortion in radians, from -pi/2 to pi/2. Positive values focus on the hard left of the image, and at pi/2 collapse the soundfield to mono, reducing the gain at hard right to -inf dB. Negative values focus on hard left. The default, 0, results in no change.

3.2.5.3.2. Matrix

for $\theta \geq 0$:

$$FocusY(\theta) = \begin{bmatrix} \dfrac{1}{1+\sin\theta} & 0 & \dfrac{1}{\sqrt{2}}\left(\dfrac{\sin\theta}{1+\sin\theta}\right) & 0 \\ 0 & \sqrt{\dfrac{1-\sin\theta}{1+\sin\theta}} & 0 & 0 \\ \sqrt{2}\left(\dfrac{\sin\theta}{1+\sin\theta}\right) & 0 & \dfrac{1}{1+\sin\theta} & 0 \\ 0 & 0 & 0 & \sqrt{\dfrac{1-\sin\theta}{1+\sin\theta}} \end{bmatrix}$$

for $\theta < 0$:

$$FocusY(\theta) = \begin{bmatrix} \frac{1}{1-\sin\theta} & 0 & \frac{1}{\sqrt{2}}\left(\frac{\sin\theta}{1-\sin\theta}\right) & 0 \\ 0 & \sqrt{\frac{1+\sin\theta}{1-\sin\theta}} & 0 & 0 \\ \sqrt{2}\left(\frac{\sin\theta}{1-\sin\theta}\right) & 0 & \frac{1}{1-\sin\theta} & 0 \\ 0 & 0 & 0 & \sqrt{\frac{1+\sin\theta}{1-\sin\theta}} \end{bmatrix}$$

3.2.5.4. FocusZ

Apply focus on the z-axis to an ambisonic B-format sound field.

3.2.5.4.1. Interface

Name: theta
Range: -pi/2 to pi/2
Default: 0
Description: the angle of distortion in radians, from -pi/2 to pi/2. Positive values focus on up of the image, and at pi/2 collapse the soundfield to mono, reducing the gain at down to -inf dB. Negative values focus on down. The default, 0, results in no change.

3.2.5.4.2. Matrix

for $\theta \geq 0$:

$$FocusZ(\theta) = \begin{bmatrix} \frac{1}{1+\sin\theta} & 0 & 0 & \frac{1}{\sqrt{2}}\left(\frac{\sin\theta}{1+\sin\theta}\right) \\ 0 & \sqrt{\frac{1-\sin\theta}{1+\sin\theta}} & 0 & 0 \\ 0 & 0 & \sqrt{\frac{1-\sin\theta}{1+\sin\theta}} & 0 \\ \sqrt{2}\left(\frac{\sin\theta}{1+\sin\theta}\right) & 0 & 0 & \frac{1}{1+\sin\theta} \end{bmatrix}$$

for $\theta < 0$:

$$FocusZ(\theta) = \begin{bmatrix} \frac{1}{1-\sin\theta} & 0 & 0 & \frac{1}{\sqrt{2}}\left(\frac{\sin\theta}{1-\sin\theta}\right) \\ 0 & \sqrt{\frac{1+\sin\theta}{1-\sin\theta}} & 0 & 0 \\ 0 & 0 & \sqrt{\frac{1+\sin\theta}{1-\sin\theta}} & 0 \\ \sqrt{2}\left(\frac{\sin\theta}{1-\sin\theta}\right) & 0 & 0 & \frac{1}{1-\sin\theta} \end{bmatrix}$$

3.2.6. Push

***Note: push algorithms require two matricies, one for + distortions and another for -.

3.2.6.1.

Push, direct-able to azimuth, elevation

Well behaved for x, -x. Doesn't keep constant gain for y (down by -3db @ pi/4

3.2.6.2. PushX

Apply push on the x-axis to an ambisonic B-format sound field.

3.2.6.2.1. Interface

Name: theta
Range: -pi/2 to pi/2
Default: 0
Description: the angle of distortion in radians, from -pi/2 to pi/2. Positive values push to the front center of the image, and at pi/2 collapse the soundfield to mono. Negative values push to back center. The default, 0, results in no change.

3.2.6.3. Matrix

for $\theta \geq 0$:

$$PushX(\theta) = \begin{bmatrix} 1 & 0 & 0 & 0 \\ \sqrt{2}\sin^2\theta & \cos^2\theta & 0 & 0 \\ 0 & 0 & \cos^2\theta & 0 \\ 0 & 0 & 0 & \cos^2\theta \end{bmatrix}$$

for $\theta < 0$:

$$PushX(\theta) = \begin{bmatrix} 1 & 0 & 0 & 0 \\ -\sqrt{2}\sin^2\theta & \cos^2\theta & 0 & 0 \\ 0 & 0 & \cos^2\theta & 0 \\ 0 & 0 & 0 & \cos^2\theta \end{bmatrix}$$

3.2.6.4. PushY

Apply push on the y-axis to an ambisonic B-format sound field.

3.2.6.4.1. Interface

Name: theta
Range: -pi/2 to pi/2
Default: 0
Description: the angle of distortion in radians, from -pi/2 to pi/2. Positive values push to hard left of the image, and at pi/2 collapse the soundfield to mono. Negative values push to hard left. The default, 0, results in no change.

3.2.6.4.2. Matrix

for $\theta \geq 0$:

$$PushY(\theta) = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos^2\theta & 0 & 0 \\ \sqrt{2}\sin^2\theta & 0 & \cos^2\theta & 0 \\ 0 & 0 & 0 & \cos^2\theta \end{bmatrix}$$

for $\theta < 0$:

$$PushY(\theta) = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos^2\theta & 0 & 0 \\ -\sqrt{2}\sin^2\theta & 0 & \cos^2\theta & 0 \\ 0 & 0 & 0 & \cos^2\theta \end{bmatrix}$$

3.2.6.5. PushZ

Apply push on the z-axis to an ambisonic B-format sound field.

3.2.6.5.1. Interface

Name: theta
Range: -pi/2 to pi/2
Default: 0
Description: the angle of distortion in radians, from -pi/2 to pi/2. Positive values push to up of the

image, and at pi/2 collapse the soundfield to mono. Negative values push to down. The default, 0, results in no change.

3.2.6.5.2. Matrix

for $\theta \geq 0$:

$$PushZ(\theta) = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos^2\theta & 0 & 0 \\ 0 & 0 & \cos^2\theta & 0 \\ \sqrt{2}\sin^2\theta & 0 & 0 & \cos^2\theta \end{bmatrix}$$

for $\theta < 0$:

$$PushZ(\theta) = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos^2\theta & 0 & 0 \\ 0 & 0 & \cos^2\theta & 0 \\ -\sqrt{2}\sin^2\theta & 0 & 0 & \cos^2\theta \end{bmatrix}$$

3.2.7. Press

Maintains y on the surface of the sphere.

3.2.8. Doesn't keep constant gain for x.

*This press algorithm uses squish [(1+sin) (1-sin) (1+sin) (1+sin)] followed by focus.
***Note: push algorithms require two matricies, one for + distortions and another for -.

3.2.9.

3.2.9.1. Press

Press, direct-able to azimuth, elevation

3.2.9.2. PressX

Apply press on the x-axis to an ambisonic B-format sound field.

3.2.9.2.1. Interface

Name: theta
Range: -pi/2 to pi/2
Default: 0
Description: the angle of distortion in radians, from -pi/2 to pi/2. Positive values press to the front center of the image, and at pi/2 collapse the soundfield to mono. Negative values press to back center. The default, 0, results in no change.

3.2.9.2.2. Matrix

for $\theta \geq 0$:

$$\mathrm{Pr}essX(\theta) = \begin{bmatrix} 1 & \frac{1}{\sqrt{2}}\sin\theta\left(\frac{1-\sin\theta}{1+\sin\theta}\right) & 0 & 0 \\ \sqrt{2}\sin\theta & \frac{1-\sin\theta}{1+\sin\theta} & 0 & 0 \\ 0 & 0 & \cos\theta & 0 \\ 0 & 0 & 0 & \cos\theta \end{bmatrix}$$

for $\theta < 0$:

$$\Pr essX(\theta) = \begin{bmatrix} 1 & \frac{1}{\sqrt{2}}\sin\theta\left(\frac{1+\sin\theta}{1-\sin\theta}\right) & 0 & 0 \\ \sqrt{2}\sin\theta & \frac{1+\sin\theta}{1-\sin\theta} & 0 & 0 \\ 0 & 0 & \cos\theta & 0 \\ 0 & 0 & 0 & \cos\theta \end{bmatrix}$$

3.2.9.3. PressY

Apply press on the y-axis to an ambisonic B-format sound field.

3.2.9.3.1. Interface

Name: theta
Range: -pi/2 to pi/2
Default: 0
Description: the angle of distortion in radians, from -pi/2 to pi/2. Positive values press to hard left of the image, and at pi/2 collapse the soundfield to mono. Negative values press to hard left. The default, 0, results in no change.

3.2.9.3.2. Matrix

for $\theta \geq 0$:

$$\Pr essY(\theta) = \begin{bmatrix} 1 & 0 & \frac{1}{\sqrt{2}}\sin\theta\left(\frac{1-\sin\theta}{1+\sin\theta}\right) & 0 \\ 0 & \cos\theta & 0 & 0 \\ \sqrt{2}\sin\theta & 0 & \frac{1-\sin\theta}{1+\sin\theta} & 0 \\ 0 & 0 & 0 & \cos\theta \end{bmatrix}$$

for $\theta < 0$:

$$\Pr essY(\theta) = \begin{bmatrix} 1 & 0 & \frac{1}{\sqrt{2}}\sin\theta\left(\frac{1+\sin\theta}{1-\sin\theta}\right) & 0 \\ 0 & \cos\theta & 0 & 0 \\ \sqrt{2}\sin\theta & 0 & \frac{1+\sin\theta}{1-\sin\theta} & 0 \\ 0 & 0 & 0 & \cos\theta \end{bmatrix}$$

3.2.9.4. PressZ

Apply press on the z-axis to an ambisonic B-format sound field.

3.2.9.4.1. Interface

Name: theta
Range: -pi/2 to pi/2
Default: 0
Description: the angle of distortion in radians, from -pi/2 to pi/2. Positive values press to up of the image, and at pi/2 collapse the soundfield to mono. Negative values press to down. The default, 0, results in no change.

3.2.9.4.2. Matrix

for $\theta \geq 0$:

$$\Pr essZ(\theta) = \begin{bmatrix} 1 & 0 & 0 & \frac{1}{\sqrt{2}}\sin\theta\left(\frac{1-\sin\theta}{1+\sin\theta}\right) \\ 0 & \cos\theta & 0 & 0 \\ 0 & 0 & \cos\theta & 0 \\ \sqrt{2}\sin\theta & 0 & 0 & \frac{1-\sin\theta}{1+\sin\theta} \end{bmatrix}$$

for $\theta < 0$:

$$\Pr essZ(\theta) = \begin{bmatrix} 1 & 0 & 0 & \frac{1}{\sqrt{2}}\sin\theta\left(\frac{1+\sin\theta}{1-\sin\theta}\right) \\ 0 & \cos\theta & 0 & 0 \\ 0 & 0 & \cos\theta & 0 \\ \sqrt{2}\sin\theta & 0 & 0 & \frac{1+\sin\theta}{1-\sin\theta} \end{bmatrix}$$

3.2.9.5. AtoA

Reorient an A-format soundfield.

3.2.9.5.1. Interface

Name: I (in orientation)
Range: [flu, fld, flr, fud, fbd, fbu, flru, flrd]
Default: flu
Description: Orientation of the input A-format channel tetrahedron:

front left up: FLU, FRD, BLD, BRU
front left down: FLD, FRU, BLU, BRD
front left-right: FL, FR, BU, BD
front up-down: FU, FD, BL, BR
front and back down: F, BD, BLU, BRU
front and back up: F, BU, BLD, BRD
front left-right up: FLU, FRU, FD, B
front left-right down: FLD, FRD, FU, B

Name: O (out orientation)
Range: [flu, fld, flr, fud, fbd, fbu, flru, flrd]
Default: flu
Description: Orientation of the input A-format channel tetrahedron:

front left up: FLU, FRD, BLD, BRU
front left down: FLD, FRU, BLU, BRD
front left-right: FL, FR, BU, BD
front up-down: FU, FD, BL, BR
front and back down: F, BD, BLU, BRU
front and back up: F, BU, BLD, BRD
front left-right up: FLU, FRU, FD, B
front left-right down: FLD, FRD, FU, B

3.2.9.5.2. Matrix

Due to the large number of matrices, these are not listed. Instead, it is advised the algorithm be implemented as a wrapper in the following manner:

AtoB(I, can)–>BtoA(O, can)

Note: weighting on W is transparent for this transform, the resulting output A-format will have the same weight on W as the input A-format.

3.3. Frequency Dependent

3.3.1. Distance

3.3.2. Proximity

3.3.3. Spread

4. Decoders

4.1. Frequency Independent

4.1.1. BtoA

Transform a B-format signal to the A-format domain.

4.1.1.1. Interface

Name: O (orientation)
Range: [flu, fld, flr, fud, fbd, fbu, flru, flrd]
Default: flu
Description: Orientation of the A-format channel tetrahedron:

front left up: FLU, FRD, BLD, BRU
front left down: FLD, FRU, BLU, BRD
front left-right: FL, FR, BU, BD
front up-down: FU, FD, BL, BR
front and back down: F, BD, BLU, BRU
front and back up: F, BU, BLD, BRD
front left-right up: FLU, FRU, FD, B
front left-right down: FLD, FRD, FU, B

Name: M (mode)
Range: [can, dec, uns]
Default: can
Description: The weighting of the scaling on W: ‘can’ gives canonical W scaling of 1/sqrt(2), ‘dec’ gives weighting appropriate for decorrelated soundfields of 1/sqrt(3), ‘uns’ gives a weight of 1 on W. ‘dec’ is the usual choice for use in reverberators.

4.1.1.2. Matrix

for $O = flu, M = can$:

$$BtoA(O,M) = \begin{bmatrix} \frac{1}{2} & \frac{1}{2} & \frac{1}{2} & \frac{1}{2} \\ \frac{1}{2} & \frac{1}{2} & -\frac{1}{2} & -\frac{1}{2} \\ \frac{1}{2} & -\frac{1}{2} & \frac{1}{2} & -\frac{1}{2} \\ \frac{1}{2} & -\frac{1}{2} & -\frac{1}{2} & \frac{1}{2} \end{bmatrix}$$

for $O = flu, M = dec$:

$$BtoA(O,M) = \begin{bmatrix} \frac{1}{\sqrt{6}} & \frac{1}{2} & \frac{1}{2} & \frac{1}{2} \\ \frac{1}{\sqrt{6}} & \frac{1}{2} & -\frac{1}{2} & -\frac{1}{2} \\ \frac{1}{\sqrt{6}} & -\frac{1}{2} & \frac{1}{2} & -\frac{1}{2} \\ \frac{1}{\sqrt{6}} & -\frac{1}{2} & -\frac{1}{2} & \frac{1}{2} \end{bmatrix}$$

for $O = flu, M = uns$:

$$BtoA(O,M)=\begin{bmatrix} \frac{1}{\sqrt{2}} & \frac{1}{2} & \frac{1}{2} & \frac{1}{2} \\ \frac{1}{\sqrt{2}} & \frac{1}{2} & -\frac{1}{2} & -\frac{1}{2} \\ \frac{1}{\sqrt{2}} & -\frac{1}{2} & \frac{1}{2} & -\frac{1}{2} \\ \frac{1}{\sqrt{2}} & -\frac{1}{2} & -\frac{1}{2} & \frac{1}{2} \end{bmatrix}$$

for $O = fld, M = can$:

$$BtoA(O,M)=\begin{bmatrix} \frac{1}{2} & \frac{1}{2} & \frac{1}{2} & -\frac{1}{2} \\ \frac{1}{2} & \frac{1}{2} & -\frac{1}{2} & \frac{1}{2} \\ \frac{1}{2} & -\frac{1}{2} & \frac{1}{2} & \frac{1}{2} \\ \frac{1}{2} & -\frac{1}{2} & -\frac{1}{2} & -\frac{1}{2} \end{bmatrix}$$

for $O = fld, M = dec$:

$$BtoA(O,M)=\begin{bmatrix} \frac{1}{\sqrt{6}} & \frac{1}{2} & \frac{1}{2} & -\frac{1}{2} \\ \frac{1}{\sqrt{6}} & \frac{1}{2} & -\frac{1}{2} & \frac{1}{2} \\ \frac{1}{\sqrt{6}} & -\frac{1}{2} & \frac{1}{2} & \frac{1}{2} \\ \frac{1}{\sqrt{6}} & -\frac{1}{2} & -\frac{1}{2} & -\frac{1}{2} \end{bmatrix}$$

for $O = fld, M = uns$:

$$BtoA(O,M)=\begin{bmatrix} \frac{1}{\sqrt{2}} & \frac{1}{2} & \frac{1}{2} & -\frac{1}{2} \\ \frac{1}{\sqrt{2}} & \frac{1}{2} & -\frac{1}{2} & \frac{1}{2} \\ \frac{1}{\sqrt{2}} & -\frac{1}{2} & \frac{1}{2} & \frac{1}{2} \\ \frac{1}{\sqrt{2}} & -\frac{1}{2} & -\frac{1}{2} & -\frac{1}{2} \end{bmatrix}$$

for $O = flr, M = can$:

$$BtoA(O,M)=\begin{bmatrix} \frac{1}{2} & \frac{1}{2} & \frac{1}{\sqrt{2}} & 0 \\ \frac{1}{2} & \frac{1}{2} & -\frac{1}{\sqrt{2}} & 0 \\ \frac{1}{2} & -\frac{1}{2} & 0 & \frac{1}{\sqrt{2}} \\ \frac{1}{2} & -\frac{1}{2} & 0 & -\frac{1}{\sqrt{2}} \end{bmatrix}$$

for $O = flr, M = dec$:

$$BtoA(O,M)=\begin{bmatrix} \frac{1}{\sqrt{6}} & \frac{1}{2} & \frac{1}{\sqrt{2}} & 0 \\ \frac{1}{\sqrt{6}} & \frac{1}{2} & -\frac{1}{\sqrt{2}} & 0 \\ \frac{1}{\sqrt{6}} & -\frac{1}{2} & 0 & \frac{1}{\sqrt{2}} \\ \frac{1}{\sqrt{6}} & -\frac{1}{2} & 0 & -\frac{1}{\sqrt{2}} \end{bmatrix}$$

for $O = flr, M = uns$:

$$BtoA(O,M) = \begin{bmatrix} \frac{1}{\sqrt{2}} & \frac{1}{2} & \frac{1}{\sqrt{2}} & 0 \\ \frac{1}{\sqrt{2}} & \frac{1}{2} & -\frac{1}{\sqrt{2}} & 0 \\ \frac{1}{\sqrt{2}} & -\frac{1}{2} & 0 & \frac{1}{\sqrt{2}} \\ \frac{1}{\sqrt{2}} & -\frac{1}{2} & 0 & -\frac{1}{\sqrt{2}} \end{bmatrix}$$

for $O = fud, M = can$:

$$BtoA(O,M) = \begin{bmatrix} \frac{1}{2} & \frac{1}{2} & 0 & \frac{1}{\sqrt{2}} \\ \frac{1}{2} & \frac{1}{2} & 0 & -\frac{1}{\sqrt{2}} \\ \frac{1}{2} & -\frac{1}{2} & \frac{1}{\sqrt{2}} & 0 \\ \frac{1}{2} & -\frac{1}{2} & -\frac{1}{\sqrt{2}} & 0 \end{bmatrix}$$

for $O = fud, M = dec$:

$$BtoA(O,M) = \begin{bmatrix} \frac{1}{\sqrt{6}} & \frac{1}{2} & 0 & \frac{1}{\sqrt{2}} \\ \frac{1}{\sqrt{6}} & \frac{1}{2} & 0 & -\frac{1}{\sqrt{2}} \\ \frac{1}{\sqrt{6}} & -\frac{1}{2} & \frac{1}{\sqrt{2}} & 0 \\ \frac{1}{\sqrt{6}} & -\frac{1}{2} & -\frac{1}{\sqrt{2}} & 0 \end{bmatrix}$$

for $O = fud, M = uns$:

$$BtoA(O,M) = \begin{bmatrix} \frac{1}{\sqrt{2}} & \frac{1}{2} & 0 & \frac{1}{\sqrt{2}} \\ \frac{1}{\sqrt{2}} & \frac{1}{2} & 0 & -\frac{1}{\sqrt{2}} \\ \frac{1}{\sqrt{2}} & -\frac{1}{2} & \frac{1}{\sqrt{2}} & 0 \\ \frac{1}{\sqrt{2}} & -\frac{1}{2} & -\frac{1}{\sqrt{2}} & 0 \end{bmatrix}$$

for $O = fbd, M = can$:

$$BtoA(O,M) = \begin{bmatrix} \frac{1}{2} & \frac{\sqrt{3}}{2} & 0 & 0 \\ \frac{1}{2} & -\frac{\sqrt{3}}{6} & 0 & -\frac{\sqrt{6}}{3} \\ \frac{1}{2} & -\frac{\sqrt{3}}{6} & \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{6}} \\ \frac{1}{2} & -\frac{\sqrt{3}}{6} & -\frac{1}{\sqrt{2}} & \frac{1}{\sqrt{6}} \end{bmatrix}$$

for $O = fbd, M = dec$:

$$BtoA(O,M)=\begin{bmatrix} 1/\sqrt{6} & \sqrt{3}/2 & 0 & 0 \\ 1/\sqrt{6} & -\sqrt{3}/6 & 0 & -\sqrt{6}/3 \\ 1/\sqrt{6} & -\sqrt{3}/6 & 1/\sqrt{2} & 1/\sqrt{6} \\ 1/\sqrt{6} & -\sqrt{3}/6 & -1/\sqrt{2} & 1/\sqrt{6} \end{bmatrix}$$

for $O = fbd, M = uns$:

$$BtoA(O,M)=\begin{bmatrix} 1/\sqrt{2} & \sqrt{3}/2 & 0 & 0 \\ 1/\sqrt{2} & -\sqrt{3}/6 & 0 & -\sqrt{6}/3 \\ 1/\sqrt{2} & -\sqrt{3}/6 & 1/\sqrt{2} & 1/\sqrt{6} \\ 1/\sqrt{2} & -\sqrt{3}/6 & -1/\sqrt{2} & 1/\sqrt{6} \end{bmatrix}$$

for $O = fbu, M = can$:

$$BtoA(O,M)=\begin{bmatrix} 1/2 & \sqrt{3}/2 & 0 & 0 \\ 1/2 & -\sqrt{3}/6 & 0 & \sqrt{6}/3 \\ 1/2 & -\sqrt{3}/6 & 1/\sqrt{2} & -1/\sqrt{6} \\ 1/2 & -\sqrt{3}/6 & -1/\sqrt{2} & -1/\sqrt{6} \end{bmatrix}$$

for $O = fbu, M = dec$:

$$BtoA(O,M)=\begin{bmatrix} 1/\sqrt{6} & \sqrt{3}/2 & 0 & 0 \\ 1/\sqrt{6} & -\sqrt{3}/6 & 0 & \sqrt{6}/3 \\ 1/\sqrt{6} & -\sqrt{3}/6 & 1/\sqrt{2} & -1/\sqrt{6} \\ 1/\sqrt{6} & -\sqrt{3}/6 & -1/\sqrt{2} & -1/\sqrt{6} \end{bmatrix}$$

for $O = fbu, M = uns$:

$$BtoA(O,M)=\begin{bmatrix} 1/\sqrt{2} & \sqrt{3}/2 & 0 & 0 \\ 1/\sqrt{2} & -\sqrt{3}/6 & 0 & \sqrt{6}/3 \\ 1/\sqrt{2} & -\sqrt{3}/6 & 1/\sqrt{2} & -1/\sqrt{6} \\ 1/\sqrt{2} & -\sqrt{3}/6 & -1/\sqrt{2} & -1/\sqrt{6} \end{bmatrix}$$

for $O = flru, M = can$:

$$BtoA(O,M) = \begin{bmatrix} 1/2 & \sqrt{3}/6 & 1/\sqrt{2} & 1/\sqrt{6} \\ 1/2 & \sqrt{3}/6 & -1/\sqrt{2} & 1/\sqrt{6} \\ 1/2 & \sqrt{3}/6 & 0 & -\sqrt{6}/3 \\ 1/2 & -\sqrt{3}/2 & 0 & 0 \end{bmatrix}$$

for $O = flru, M = dec$:

$$BtoA(O,M) = \begin{bmatrix} 1/\sqrt{6} & \sqrt{3}/6 & 1/\sqrt{2} & 1/\sqrt{6} \\ 1/\sqrt{6} & \sqrt{3}/6 & -1/\sqrt{2} & 1/\sqrt{6} \\ 1/\sqrt{6} & \sqrt{3}/6 & 0 & -\sqrt{6}/3 \\ 1/\sqrt{6} & -\sqrt{3}/2 & 0 & 0 \end{bmatrix}$$

for $O = flru, M = uns$:

$$BtoA(O,M) = \begin{bmatrix} 1/\sqrt{2} & \sqrt{3}/6 & 1/\sqrt{2} & 1/\sqrt{6} \\ 1/\sqrt{2} & \sqrt{3}/6 & -1/\sqrt{2} & 1/\sqrt{6} \\ 1/\sqrt{2} & \sqrt{3}/6 & 0 & -\sqrt{6}/3 \\ 1/\sqrt{2} & -\sqrt{3}/2 & 0 & 0 \end{bmatrix}$$

for $O = flrd, M = can$:

$$BtoA(O,M) = \begin{bmatrix} 1/2 & \sqrt{3}/6 & 1/\sqrt{2} & -1/\sqrt{6} \\ 1/2 & \sqrt{3}/6 & -1/\sqrt{2} & -1/\sqrt{6} \\ 1/2 & \sqrt{3}/6 & 0 & \sqrt{6}/3 \\ 1/2 & -\sqrt{3}/2 & 0 & 0 \end{bmatrix}$$

for $O = flrd, M = dec$:

$$BtoA(O,M) = \begin{bmatrix} 1/\sqrt{6} & \sqrt{3}/6 & 1/\sqrt{2} & -1/\sqrt{6} \\ 1/\sqrt{6} & \sqrt{3}/6 & -1/\sqrt{2} & -1/\sqrt{6} \\ 1/\sqrt{6} & \sqrt{3}/6 & 0 & \sqrt{6}/3 \\ 1/\sqrt{6} & -\sqrt{3}/2 & 0 & 0 \end{bmatrix}$$

for $O = flrd, M = uns$:

$$BtoA(O,M) = \begin{bmatrix} \frac{1}{\sqrt{2}} & \frac{\sqrt{3}}{6} & \frac{1}{\sqrt{2}} & -\frac{1}{\sqrt{6}} \\ \frac{1}{\sqrt{2}} & \frac{\sqrt{3}}{6} & -\frac{1}{\sqrt{2}} & -\frac{1}{\sqrt{6}} \\ \frac{1}{\sqrt{2}} & \frac{\sqrt{3}}{6} & 0 & \frac{\sqrt{6}}{3} \\ \frac{1}{\sqrt{2}} & -\frac{\sqrt{3}}{2} & 0 & 0 \end{bmatrix}$$

4.1.2. PantoF

Decode a two dimensional ambisonic B-format signal to a farfield set of speakers in a regular, horizontal polygon. The "farfield" decode is preferred for large scale and concert hall decoding. The outputs will be in counter-clockwise order. The position of the first speaker is either center or left of center.

4.1.2.1. Interface

Name: N
Range: 1 to 24 (? There is no need to have a max. 4-8 is typical)
Default: 4
Description: number of loudspeakers.

Name: O (orientation)
Range: “f” OR “l” (the letter “ell”)
Default: “l”
Description: Should be "f" if the front is a vertex of the polygon. The first speaker will be directly in front. Should be "l" (the letter ell) if the front bisects a side of the polygon. Then the first speaker will be the one left of center. Default is "l".

Name: D (directivity)
Range: -1 to +1
Default: +1
Description: The weighting of the ambisonic decoding equations. Varies between -1 for idealized, strict soundfield decoding to +1 for controlled opposites, in-phase decoding. A value of 0 will give optimized energy decoding. Controlled opposites is the option preferred for acoustically live spaces.

4.1.2.2. Matrix

$$G_0 = 1$$

$$G_1 = 2^{-D/2}$$

$$PantoF(N,O="l",D) = \begin{bmatrix} G_0 & G_1\cos(\frac{1+2*0}{N}\pi) & G_1\sin(\frac{1+2*0}{N}\pi) & 0 \\ G_0 & G_1\cos(\frac{1+2*1}{N}\pi) & G_1\sin(\frac{1+2*1}{N}\pi) & 0 \\ \vdots & \vdots & \vdots & \vdots \\ G_0 & G_1\cos(\frac{1+2(N-1)}{N}\pi) & G_1\sin(\frac{1+2(N-1)}{N}\pi) & 0 \end{bmatrix}$$

$$PantoF(N,O="f",D) = \begin{bmatrix} G_0 & G_1\cos(\frac{0}{N}2\pi) & G_1\sin(\frac{0}{N}2\pi) & 0 \\ G_0 & G_1\cos(\frac{1}{N}2\pi) & G_1\sin(\frac{1}{N}2\pi) & 0 \\ \vdots & \vdots & \vdots & \vdots \\ G_0 & G_1\cos(\frac{N-1}{N}2\pi) & G_1\sin(\frac{N-1}{N}2\pi) & 0 \end{bmatrix}$$

4.1.3. PeriF

[Work needs to be done on the weighting and also the elevation scaling!!!]
Decode a three dimensional ambisonic B-format signal to a set of speakers in a set of two regular polygons, the first elevated above the second. The "farfield" decode is preferred for large scale and concert hall decoding. outputs will be in counter-clockwise order. The position of the first speaker is either center up or left of center up. The first half of the output is the upper polygon and the second half is the lower polygon.

4.1.3.1. Interface

Name: N
Range: 1 to 24 (? There is no need to have a max. 4-8 is typical)
Default: 4
Description: number of loudspeakers.

Name: O (orientation)
Range: “f” OR “l” (the letter “ell”)
Default: “l”
Description: Should be "f" if the front is a vertex of the polygon. The first speaker will be directly in front. Should be "l" (the letter ell) if the front bisects a side of the polygon. Then the first speaker will be the one left of center. Default is "l".

Name: ϕ (elevation)
Range: pi/3 to pi/8?? [Need to look more in detail at this!!!]
Default: 0.6155, arctan(1/sqrt(2))
Description: Adjusts the angle of elevation for the height of the decoding array.

Name: D (directivity)
Range: -1 to +1
Default: +1
Description: The weighting of the ambisonic decoding equations. Varies between -1 for idealized, strict soundfield decoding to +1 for controlled opposites, in-phase decoding. A value of 0 will give optimized energy decoding. Controlled opposites is the option preferred for acoustically live spaces.

4.1.3.2. Matrix

$$G_0 = 1$$

$$G_1 = \sqrt{2}\big/2$$ ****[Weighting is incorrect!!!!]

$$PantoF_{Up}(N, O = "l", \phi, D) = \begin{bmatrix} G_0 & G_1\cos(\frac{1+2*0}{N}\pi) & G_1\sin(\frac{1+2*0}{N}\pi) & 0 \\ G_0 & G_1\cos(\frac{1+2*1}{N}\pi) & G_1\sin(\frac{1+2*1}{N}\pi) & 0 \\ \vdots & \vdots & \vdots & \vdots \\ G_0 & G_1\cos(\frac{1+2(N-1)}{N}\pi) & G_1\sin(\frac{1+2(N-1)}{N}\pi) & 0 \end{bmatrix}$$

$$PantoF_{Down}(N, O = "l", \phi, D) = \begin{bmatrix} G_0 & G_1\cos(\frac{1+2*0}{N}\pi) & G_1\sin(\frac{1+2*0}{N}\pi) & 0 \\ G_0 & G_1\cos(\frac{1+2*1}{N}\pi) & G_1\sin(\frac{1+2*1}{N}\pi) & 0 \\ \vdots & \vdots & \vdots & \vdots \\ G_0 & G_1\cos(\frac{1+2(N-1)}{N}\pi) & G_1\sin(\frac{1+2(N-1)}{N}\pi) & 0 \end{bmatrix}$$

$$PantoF_{Up}(N,O="f",\phi,D)=\begin{bmatrix} G_0 & G_1\cos(\frac{0}{N}2\pi) & G_1\sin(\frac{0}{N}2\pi) & 0 \\ G_0 & G_1\cos(\frac{1}{N}2\pi) & G_1\sin(\frac{1}{N}2\pi) & 0 \\ \vdots & \vdots & \vdots & \vdots \\ G_0 & G_1\cos(\frac{N-1}{N}2\pi) & G_1\sin(\frac{N-1}{N}2\pi) & 0 \end{bmatrix}$$

$$PantoF_{Down}(N,O="f",\phi,D)=\begin{bmatrix} G_0 & G_1\cos(\frac{0}{N}2\pi) & G_1\sin(\frac{0}{N}2\pi) & 0 \\ G_0 & G_1\cos(\frac{1}{N}2\pi) & G_1\sin(\frac{1}{N}2\pi) & 0 \\ \vdots & \vdots & \vdots & \vdots \\ G_0 & G_1\cos(\frac{N-1}{N}2\pi) & G_1\sin(\frac{N-1}{N}2\pi) & 0 \end{bmatrix}$$

4.2. Frequency Dependent

4.2.1. PantoN

4.2.2. PeriN

5. Further Algorithms

5.1. Squish variant

Used with press

5.1.1. Matrix

$$SquishX(\theta)=\begin{bmatrix} 1+\sin\theta & 0 & 0 & 0 \\ 0 & 1-\sin\theta & 0 & 0 \\ 0 & 0 & 1+\sin\theta & 0 \\ 0 & 0 & 0 & 1+\sin\theta \end{bmatrix}$$

6. Depricated

6.1. Push

This push algorithm has been used in ATK-VST version 0.1.

6.1.1. PushX

Push on x-axis

$$PushX(\theta)=\begin{bmatrix} 1 & 0 & 0 & 0 \\ \sqrt{2}\sin\theta & 1-\sin\theta & 0 & 0 \\ 0 & 0 & \sqrt{\frac{1-\sin\theta}{1+\sin\theta}} & 0 \\ 0 & 0 & 0 & \sqrt{\frac{1-\sin\theta}{1+\sin\theta}} \end{bmatrix}$$

6.1.2. PushY

Push on y-axis

$$PushY(\theta) = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \sqrt{\frac{1-\sin\theta}{1+\sin\theta}} & 0 & 0 \\ \sqrt{2}\sin\theta & 0 & 1-\sin\theta & 0 \\ 0 & 0 & 0 & \sqrt{\frac{1-\sin\theta}{1+\sin\theta}} \end{bmatrix}$$

6.1.3. PushZ

Push on z-axis

$$PushZ(\theta) = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \sqrt{\frac{1-\sin\theta}{1+\sin\theta}} & 0 & 0 \\ 0 & 0 & \sqrt{\frac{1-\sin\theta}{1+\sin\theta}} & 0 \\ \sqrt{2}\sin\theta & 0 & 0 & 1-\sin\theta \end{bmatrix}$$