fFIRST APPROACH TO THE ASSESSMENT

AIM: get the spatial correlation and the level difference having output signals and encoding mic matrix.

Encoding matrix: [ SH x mic]

1. **Get IR matrix**

* Convolve each signal from signal matrix with the inverse of the sweep: get IRs
* Cut the IRs around the peak: length=3501 samples
* Build IR\_matrix\_fft (in frequency)

[24 x 64 x 3501]= [#l.s. x #mics x bins]

* The IR are cut al the same samples, not align one to the other.

1. **Get A’ matrix**

* Extract each single filter from the filter matrix, fft performed using: fft(encoding\_filter, IR\_length) so that the compatibility is granted.
* Multiply in frequency=convolution

Per ogni armonico sferico

IR\_matrix\_fft(sp,mic,:) .\* proper\_filter(sh, mic,: )

for sp=1:n\_sp %for each speaker

for sh=1:n\_sh %for each spherical harmonic

for mic=1:n\_mic %for each microphone

current\_harmonic=

squeeze(IR\_matrix\_fft(sp, mic, :)) .\*encoding\_filter\_fft\_cut;

* Sum on each microphone:



H mappa da segnale mic a SH mic

A’ mappa direttività SH speakers

A\_effective(sp, sh, :)= A\_effective(sp, sh, :)+ifft(current\_harmonic)

where ifft(current\_harmonic) is calculated for each mic

* Then perform the fft of A\_effective and get:

A’= [24 x 49 x 3501] =[ #l.s. x #sh x # samples]

1. **Get ideal A matrix**

* Use T-design function to get the azimuth and elevation values of a t-design discretization that returns 24 points of a sphere.

Used function:

<https://github.com/polarch/Spherical-Harmonic-Transform/blob/master/getTdesign.m>

t=6 to get 24 points

* add a 25th point for the north-pole
* order the points following location similarities with the one on the virtual room
* Get A using:

<https://github.com/polarch/Spherical-Harmonic-Transform/blob/master/getSH.m>

that follows:

A black rectangular with black lines and numbers

Description automatically generated with medium confidence

* A=[25 x 49] = [ directions\_virtual\_sources x #sh] frequency independent

1. **Spatial correlation**

* As guaranteed from the re-order of the points of discretization, the two matrices can be easily compared.

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D are the directions of the loudspeakers

* Then, the average of the components leading to the same ambisonic order to obtain a matrix

[6 x 3501]

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Summing on the ‘v’ spherical harmonic:

For each frequency bin:

for n=0:order

center=n+1; %center sh

for v=last+center-n:last+center+n

13/12

The ideal A matrix is obtained from the actual discretization of the space present in the virtual room, not a T-design, in order to better compare the spherical harmonics and not the space discretization.

Therefore azimuth and elevation of each speaker is given.

The result is still very poor

ALIASING FREQUENCY

Fmax= 343/4\*l

L is 2.5 cm= 0.025 m

Complex SH

Y\_{nm}(\theta,\phi) =

(-1)^m \sqrt{\frac{2n+1}{4\pi}\frac{(n-m)!}{(n+m)!}} P\_l^m(\cos\theta) e^{im\phi}

Real SH

R\_{nm}(\theta,\phi) =

\sqrt{\frac{2n+1}{4\pi}\frac{(n-|m|)!}{(n+|m|)!}} P\_l^{|m|}(\cos\theta) N\_m(\phi)

N\_m(\phi) = \sqrt{2} cos(m\phi}, m>0

N\_m(\phi) = 1, m>0

N\_m(\phi) = \sqrt{2} sin(|m|\phi}, m<0

<http://research.spa.aalto.fi/projects/sht-lib/sht.html>

**The level difference is performed using Y\_N real:**

%quadrato del modulo di un numero complesso è sempre reale

* Being x a complex number, x \* conj(x) = abs(x)^2, therefore at the numerator we use the real value of Y or the absolute valueof Y complex???

Real Y used complex Y and abs(Y used)

A graph of different colored lines

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La "level difference" è tipicamente calcolata confrontando la potenza effettiva con la potenza ideale.

Quindi, il modulo al quadrato non è real(A)^, ma è real(A)^2+imag(A)^2 o, equivalentemente, abs(A)^2. La funzione abs in MATLAB restituisce il modulo di un numero complesso, che è la radice quadrata della somma dei quadrati delle sue parti reale e immaginaria.

QUINDI Y complex 🡪 abs(Y)

A close up of a number

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A red square root of a square root of a square root of a square root of a square root of a square root of a square root of a square root of a square root of a square

Description automatically generatedz complex, x real part, y imag part

Osservazion:

Se passo solo Y^2 al numeratore il risultato è quasi uguale

A graph of colored lines

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To do:

Finish the filters

Check SC and LD with the Equalization

Note:

The spatial correlation implemented is the same as the one implemented in ita toolbox but the ita toolbox is already summed in all the directions.

IDEAS

Check the locatization quality **by plotting a 3d plot of the perceived pressure**.

All the capsule for one signal, compare the peak of the intensity with the actual coordinates of the virtual source.

plot SH phyton and link

<https://www.cond-mat.de/teaching/QM/JSim/spherharm.html>

<https://github.com/DalInar/schrodingers-snake/blob/master/SphericalHarmonicsVisualization/SphericalHarmonicsVisualization.ipynb>

**SPARTA | Array2SH**

Decoder containing a plug in for the computation of level difference and spatial correlation, code in c++ on git hub

PLOT

<https://github.com/DalInar/schrodingers-snake/blob/master/SphericalHarmonicsVisualization/SphericalHarmonicsVisualization.ipynb>

* Normalizzazione: utilizzare normalize, “norm”
* Meshgrid di valori del valore assoluto delle armoniche sferiche normalizzate in base a azimuth e elevation, angoli espressi sempre in radianti
* Se uso ‘norm’ ‘inf’ i valori sono molto diversi, quindi non la uso

IDEAL (same thing for the A’ but using A\_effective\_cut\_fft, normalizing it in the same way)

1. Get coordinates

dirs(:, 1)=deg2rad(azimuth);

dirs(:, 2)=pi/2-deg2rad(elevation); %converti all’inclinazione necessaria in getSH

1. Get SH throught the proper function

Y=getSH(5, dirs, 'complex');

Y=normalize(Y, "norm",Inf);

1. Calculate cartesian coordinates where abs(Y(:,v))) gives the distance radius

[X, Y, Z]=sph2cart(theta=dirs(:, 1), phi=pi/2+dirs(:, 2), abs(Y(:,v)));

scatter3(X, Y, Z)

19.12.2023 sono state effettuate correzioni sui plot, ora forse definitivi

Ultimi dubbi:

corretto orientamento delle immagini e delle coordinate quando si esegue sph2cart. 

%Polar diagrams of the shperical harmonics:

% In each direction (ϑ,φ) we plot a point at distance r=|Yl,m(ϑ,φ)|

% from the origin.

Da fare:

% We color this point with the phase of Yl,m(ϑ,φ).

% (Connecting these colored points gives the surfaces that are shown.)

% Observe that all spherical harmonics are rotationally symmetric about the z axis,

% with the phase given by eimφ.

Riflettere sul da farsi… SC e LD sono giusti

From Farina, church in Parma

This decoder, developed by F. Adriaensen, gives the

capability of a different decoding of medium-bass and medium-high frequencies, the use of

near-field filters, gains and delays if the layout is not regular (Figure 7). Before the

installation of the system some simulations were made with the aim of finding the best

coefficients for a 1st and 2nd Ambisonic order decoder, optimizing the velocity vector for the

bass frequencies and the energy vector for the high frequencies.

A first prototype of this system was implemented in the laboratory of Casa della Musica

(Parma) with the aim of testing the decoder, the right placement, the tracks.

Suggestions:

try with current phase shift and actual tuning

Try with the new tuning and phase corrections

Try lower volume

DOMANDE

In :

|  |
| --- |
| EVALUATION OF AMBISONICS DECODING METHODS WITH EXPERIMENTAL MEASUREMENTS |

come ottengono il valore di target field??

Errori da calcolare:

Sound pressure error

Sound intensity error

Phase error

Comparison of reconstructed versus original sound field through the norm of the energy vector Ra(Gerzon, M. A., “General Metatheory of Auditory Localisation).

This metric quantifies, on the playback side, the amount of energy coming from the expected direction and indicates the directivity of the reproduced sound field.

For ideal Re=M/(M+1).

M\_eff= Re/(1-Re)

L'approccio di Gerzon all'ottimizzazione della decodifica è dedicato all'ascoltatore al centro del sistema.

. Per caratterizzare e ottimizzare la riproduzione in questa posizione privilegiata, Gerzon introduce due grandezze matematiche destinate a riflettere l'effetto della localizzazione nei domini delle basse e delle alte frequenze. Metatheory

rispettivamente

Vettore velocità V A black text on a white background

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Vettore dell’energia A black and white math equation

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Al fine di valutare la qualità dell'approssimazione (o della ricostruzione) dell'onda piana, vengono utilizzate due misure di errore proposte in [BV95] e [Pol96a]: la media ¯εpM del valore assoluto dell'errore, calcolata mediante integrazione su un perimetro circolare di raggio kr intorno all'origine 􀀀r 0, e il suo massimo εpM su questo stesso perimetro:

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dove

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pp 168 moreau tesi

from

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| **EVALUATION OF AMBISONICS DECODING METHODS WITH EXPERIMENTAL MEASUREMENTS** |

ERROR METRICS (USED TO ASSESS DECODERS PERFORMANCE)

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where p\_m is the measured pressure, p\_t is the target pressure

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Description automatically generated

A math problem with numbers and symbols

Description automatically generated with medium confidence

ESTRAZIONI DI I

Valutazione

A math equations and formulas

Description automatically generated with medium confidence HA CALCOLATO MISURATO IN DIVERSI PUNTI

Extensive work has been made to evaluate the performance of Ambisonics by means of perceptual or physical approaches. These assessments are commonly based on numerical simula-tions [4, 6, 8] or by listening test [9-11]. However, results ob-tained from experimental measurements of the acoustic pressure or the acoustic intensity field generated by HOA systems are less frequent in the scientific literature.