TAILOR-MADE NOTCHED MUSIC TRAINING

A THERAPY OF CHRONIC TINNITUS

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Conclusion: The solution to tinnitus



- 1. Introduction and medical background
- 2. Tailored Notch filtering
- 3. Therapy potential analysis
- 4. Outlook: Potential of software assisted tinnitus therapy
- 5. Conclusions

INTRODUCTION AND MEDICAL BACK-GROUND

10–15% of the general adult population is affected by tinnitus.[4]



How does tinnitus sound like?

How does tinnitus sound like?

The tinnitus frequency is individual [6]



5 / 37

sample 1 at 200 HZ

sample 2 at 11.500 HZ



⁰http://www.hearing.nihr.ac.uk/public/auditory-examples-sounds-of-tinnitus

Tinnitus is associated with depression, angst, and inablity to concentrate [2]



A selection of therapy options

Invasive "Cochlear Implants".



A selection of therapy options

Drug Therapy.



Listen to your favorite music which is only slightly modified.



Idea: Chronic tinnitus (may be) caused by hyperactivity in the brain and not by a physical malfunction of the ear.[13]



Neural plasticity of the auditoral cortex is proven via Magnetoencephalography.[9]





Rebalance the brain by listening to individually "modified" music (based on the patient's unique tinnitus frequency).[11, 8]



TAILORED NOTCH FILTERING

Music notching is a filtering problem: Remove frequencies around the patient's tinnitus frequency.



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How does it sound like?

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Sample: Humoresken Nr. 7 in Gb Op. 101/7 by Antonín Dvořák.



Kind of like this:

Sample: Humoresken Nr. 7 in Gb Op. 101/7 by Antonín Dvořák notched at 1200 HZ.



You want a very narrow Band-stop (Notch) filter.



The fitting filter type for this notching is a high order Butterworth filter. [11, 7]

Butterworth filter (low pass)

$$H(j\omega)| = \frac{1}{\sqrt{1 + (\frac{\omega}{\omega_c})^{2n}}}$$

- $\bigcirc \omega$ is the input frequency, ω_c cutoff frequency
- \bigcirc *H* is the filter response
- \bigcirc *n* is the filter order



So we are using an equalizer and that's it?



Yes, but optimization is possible because of lossy compression





All music equally suited?



THERAPY POTENTIAL ANALYSIS

Not all music is **equally suited** for notched music therapy. [11]



Let us compare.





Energy is centered at the low frequency level



Brighter color = more energy

Energy is distributed evenly



Brighter color = more energy

The therapy potential analysis is fundamentally a spectral analysis problem.



After applying the therapy, Dvorák looks like this:



OUTLOOK: POTENTIAL OF SOFT-WARE ASSISTED TINNITUS THERAPY

Going to the doctor (usually) is very inconvenient for the patient.

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What benefits come from app-assisted self-therapy?

- eHealth solutions improve therapy compliance [12]
- Data collection and statistics
- \bigcirc transparency over therapy status



CONCLUSIONS

Music Notching



Music Notching



Frequency spectrum analysis



Music Notching



Frequency spectrum analysis



App assisted therapy, statistics



• Only applicable if tinnitus is chronic and within a frequency range [11]

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 Max study group size n=100 [10]

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- Isolated therapy is not recommended, combined approaches of electrical stimulation and TNMT show promise. [5, 1].

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- Max study group size n=100 [10]
- Isolated therapy is not recommended, combined approaches of electrical stimulation and TNMT show promise. [5, 1].
- Commercialization of the therapy tends to "overstate" therapy success to make money.[5]

Tinnitracks

Bills paid by three health insurance companies in Germany [3]

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Online site with thousands of users worldwide [6]

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More to come once eHealth acceptance increases.[12]

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Appendix: Notched Music therapy



Based on the average frequency selectivity of a person, and is two equivalent rectangular bandwidths (ERB). The ERB is dependent on frequency, so if your tinnitus frequency is 10,000 Hz (10 kHz), the ERB is about 1000 Hz, which means you'd have to get within a 1000Hz of your true tinnitus frequency (ERB = 107.94*f +24.7 = 107.94*10 + 24.7 = 1104 Hz).

the-definitive-guide-to-detecting-your-tinnitus-frequeny

⁰http://www.audionotch.com/blog/tinnitus/

OGG compression optimization

