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Magnetic Stimulation of the Human Brain with Low-Intensity Field

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Project overview

→ Motivation: WHO reports, under-researched area

→ Novelty: hand-held device, new ways of modeling

[1–4]

First stage: materials and methods

Objective: model → technical specification

Underlying theory

❶ E/M field

❷ FE-analysis

❸ Segmentation

Implementation

❶ TMS in COMSOL

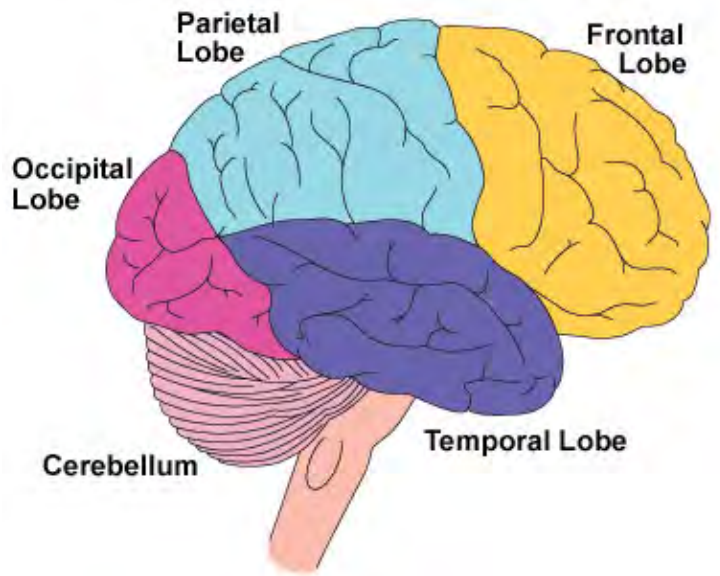
❷ LFMS in COMSOL

❸ Head in Simpleware

❹ Validation in phantom

Transcranial magnetic stimulation

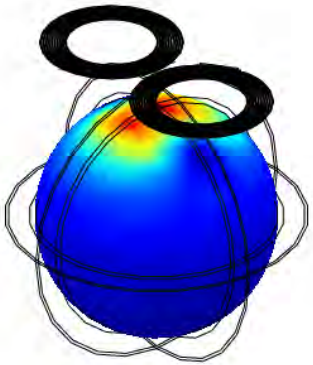
- Coils: circular, eight-shaped
- Sites: frontal and temporal lobes
- I_{peak} = 5–10 kA at 100 µs
- B_{coil} = 1–5 T
- E_{head} = 100 V/m average
- J_{brain} = up to 1 A/m^2

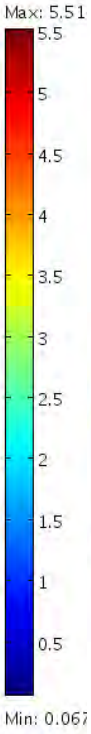


[5]

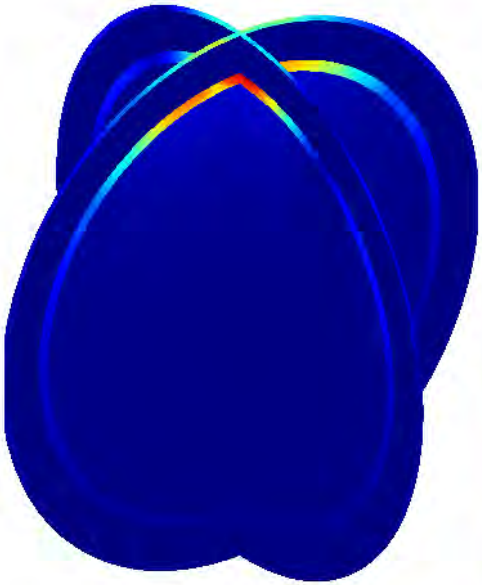
TMS model

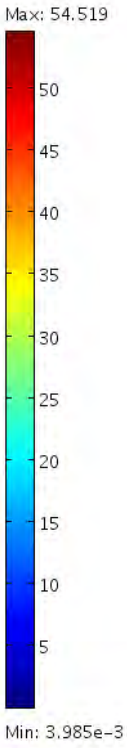
130μs: |J| in brain, A/m²

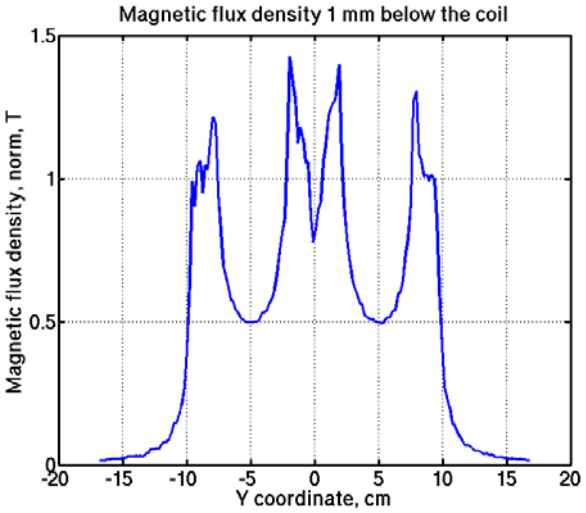




130μs: |J| in head, A/m²







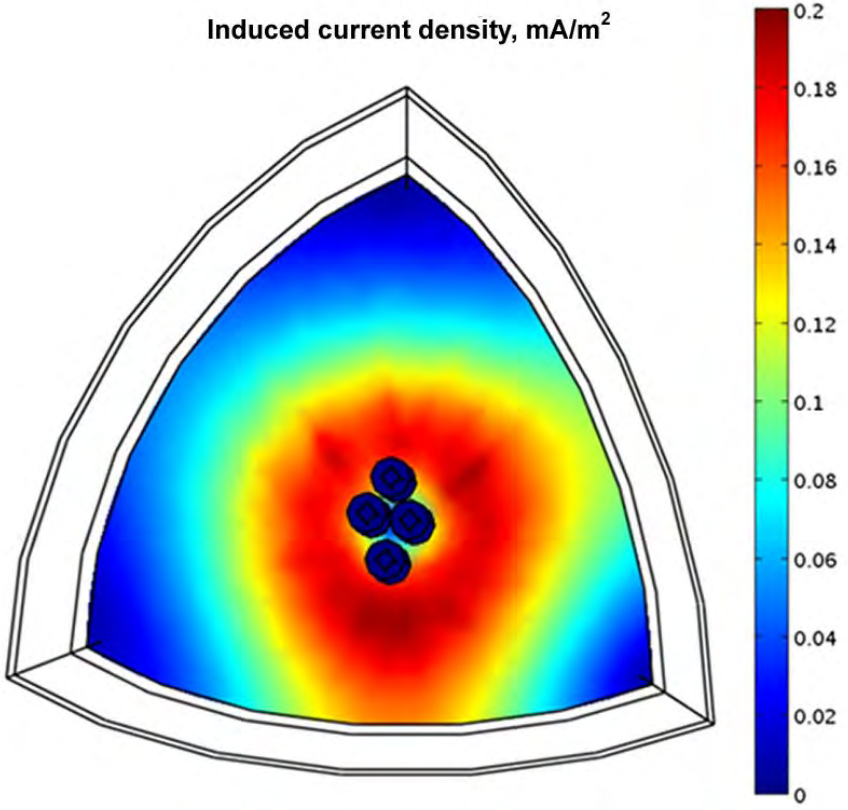
Server farm, 9 Gb RAM, ~2m linear mesh, >2m DOFs, 8 hours

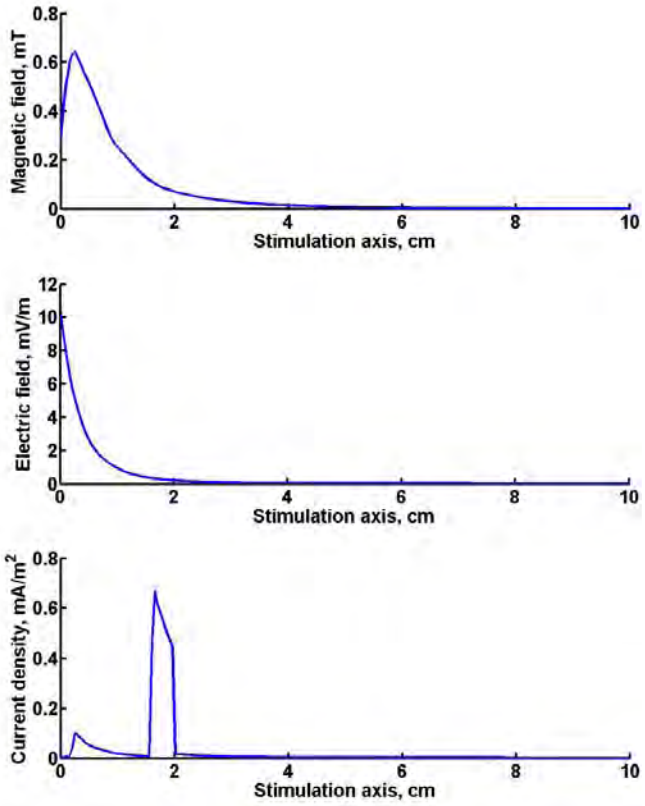
Low-field magnetic stimulation

- Several small coils
- Frontal and temporal lobes
- I_{peak} = 1–10 A at 1 kHz
- B_{coil} = 1–5 mT
- E_{head} =100 mV/m average
- J_{brain} = up to 1 mA/m^2

[6]

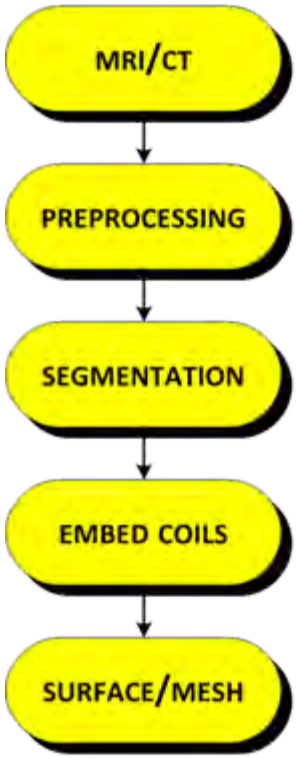
LFMS model

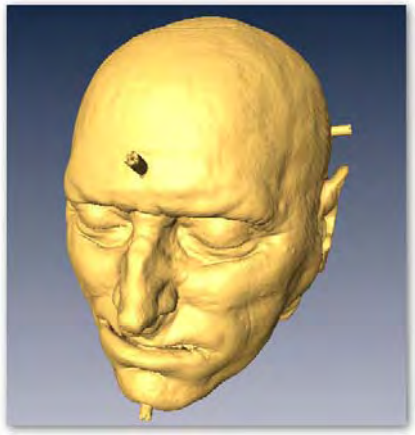


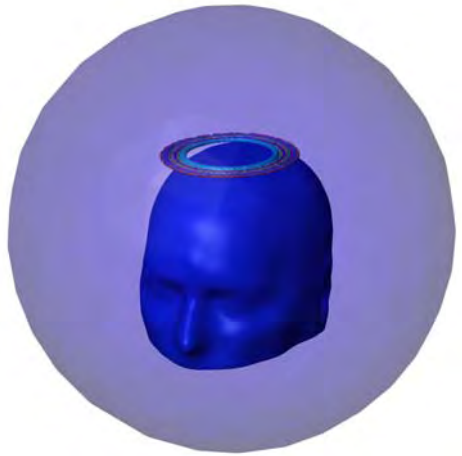


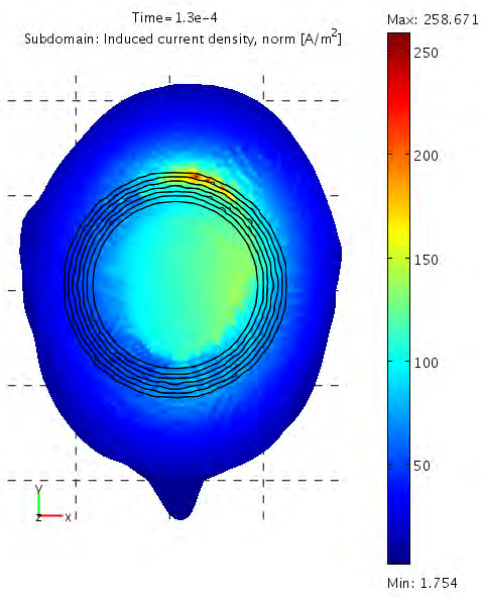
Server farm, 26 Gb RAM, ~50k quadratic mesh, ~400k DOFs, 19.5 hours

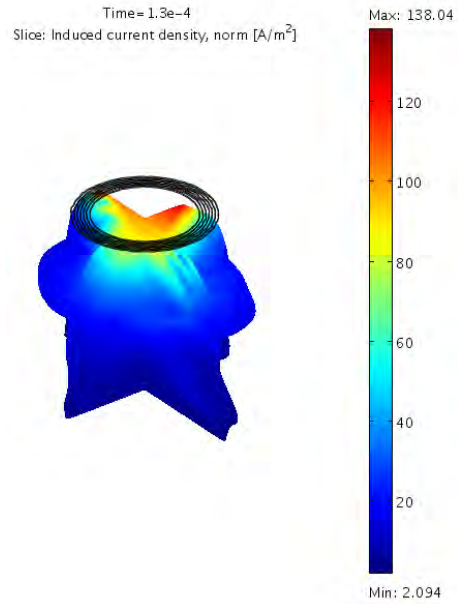
Head model





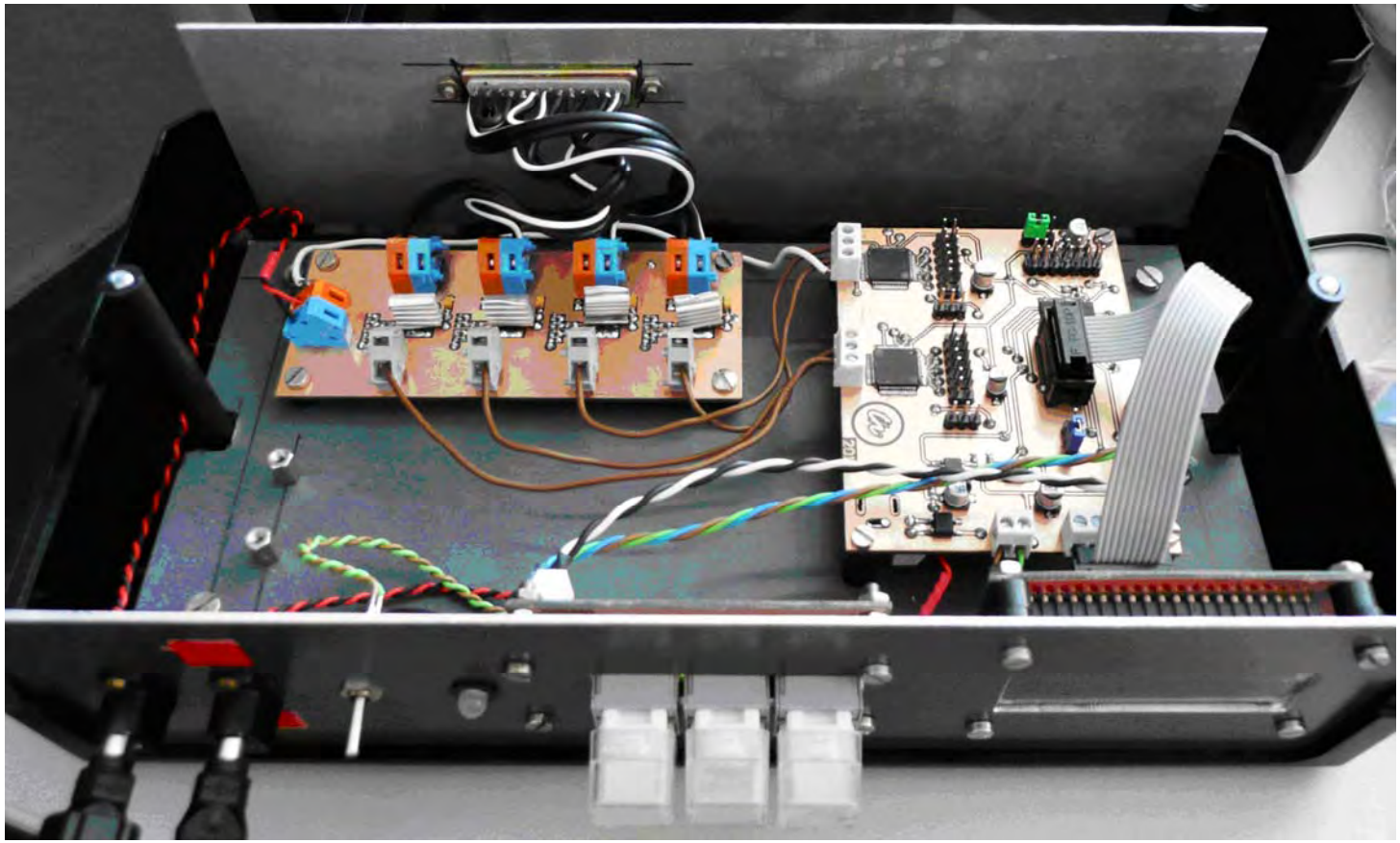






8x2.4GHz CPU, 15Gb RAM, 2mm³ voxel, ~7m linear mesh, >8m DOFs

Stimulator prototype



The work of Daniel Laqua [7]

Conclusion

- **Literature review:** no models of LFMS, worth it
- **Obtained results:** TMS and LFMS models
- **Work in progress:** human head model
- **Contributions:** technical specification draft
- **Future plans:** inverse study and validation


Thank you for your attention!
Photo by Dominic Kamp

References

[1] Sabate E. Depression in young people and the elderly. *The World Health Organization*. 2004.

[2] Adair RK. Constraints on biological effects of weak extremely-low frequency electromagnetic fields. *Phys Rev A*. 1991;**43**(2):1039–48.

[3] Kirschvink JL. Comment on constraints on biological effects of weak extremely-low-frequency electromagnetic fields. *Phys Rev A*. 1992;**46**(4):2178–84.

[4] Berg H. Problems of weak electromagnetic field effects in cell biology. *Bioelectrochem Bioenerg*. 1999;**48**(2):355–60.

[5] Jalinous R. The guide to magnetic stimulation. *The Magstim Company Limited*. 2006.

[6] Rohan M, et al. Low-field magnetic stimulation in bipolar depression using an MRI-based stimulator. *Am J Psychiatry*. 2004;**161**:93–8.

[7] Lazutkin D, Laqua D, Husar P. Modeling of low-field magnetic stimulation of the human brain. *55th International Scientific Colloquium*. 2010;497–500.