BIOSENSOR DESIGN: INTRACRANIAL TUMOR TREATING FIELDS

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REU

PRESENTATION AGENDA

- ASU Training
- Problem Statement
- Proposed Solution
- Results
- Future Research
- Reflection

ASU TRAINING

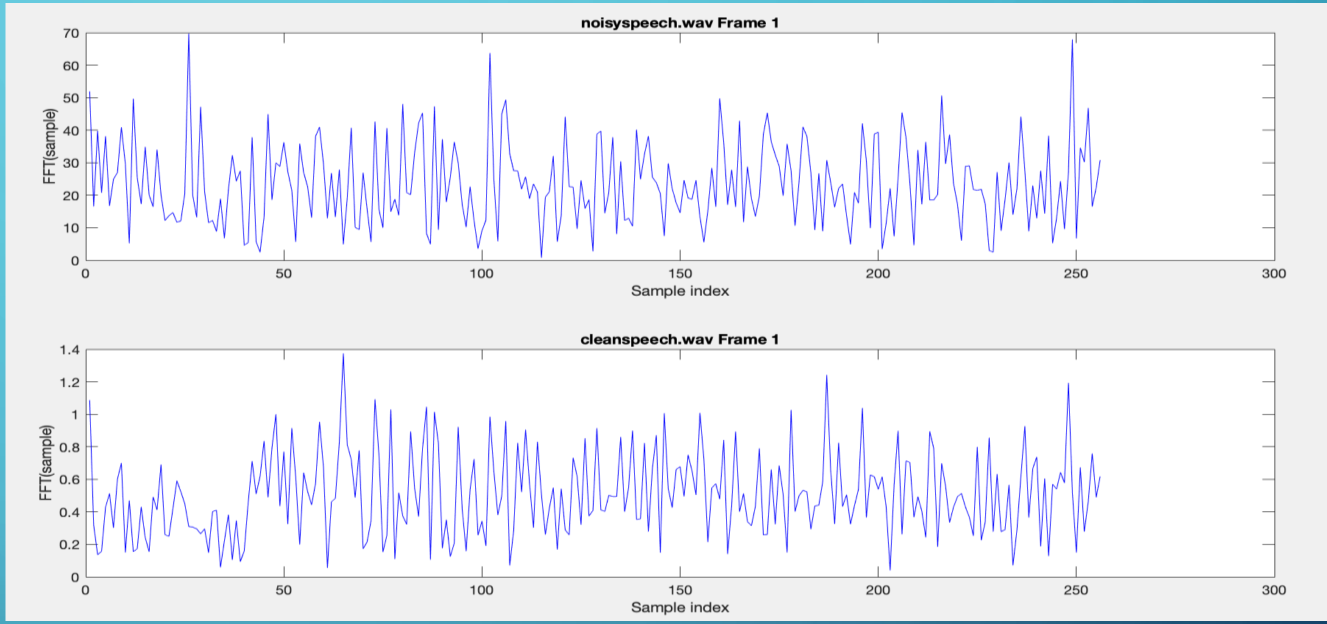
ex13.m | ex14.m | ex15.m | adaptiveNoiceCancel.m

```
new = abs(fft(s1));
new1 = abs(fft(s2));

for k = 1:K
    % Compute indices for current frame

    n = (1:N)+(N*(k-1));

%     % Signal 1
%     subplot(211);
%     plot(n,s1(n),'b',n,e(n),'r');
%     msg=sprintf('%s Frame %d',infile1,k);
%     title(msg);
%     ylabel('Normalized Amplitude');
%     xlabel('Sample index');
%
%     % Signal 2
%     subplot(212);
%     plot(n,s2(n),'b',n,e(n),'r');
%     msg=sprintf('%s Frame %d',infile2,k);
%     title(msg);
%     ylabel('Normalized Amplitude');
%     xlabel('Sample index');
%
%     % Pause between frames, waiting for keypress
%     pause
```



Signal Reconstruction Analytically for ω_s=2B

$$h(t) * x_s(t) \leftrightarrow H(\omega) X_s(\omega)$$

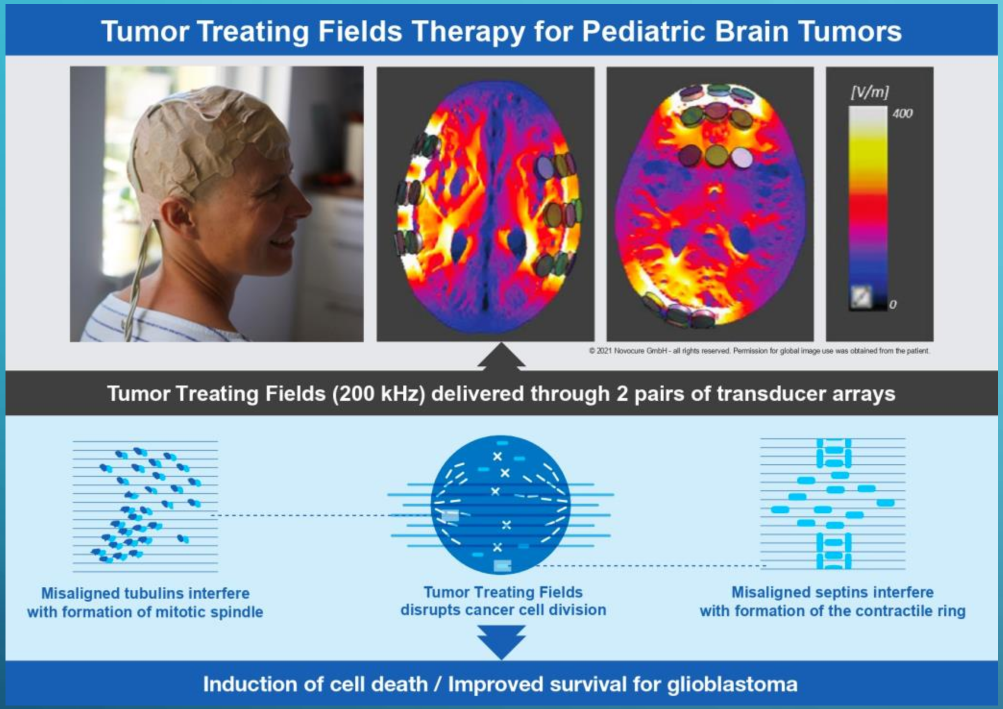
$$h(t) = \frac{1}{2\pi} \int_{-\infty}^{\infty} H(\omega) e^{j\omega t} d\omega = \text{sinc}(Bt)$$

$$x(t) = \text{sinc}(Bt) * \left\{ \sum_{n=-\infty}^{\infty} x(nT)\delta(t - nT) \right\}$$

$$\Rightarrow x(t) = \sum_{n=-\infty}^{\infty} x(nT)\,\text{sinc}(B(t - nT))$$

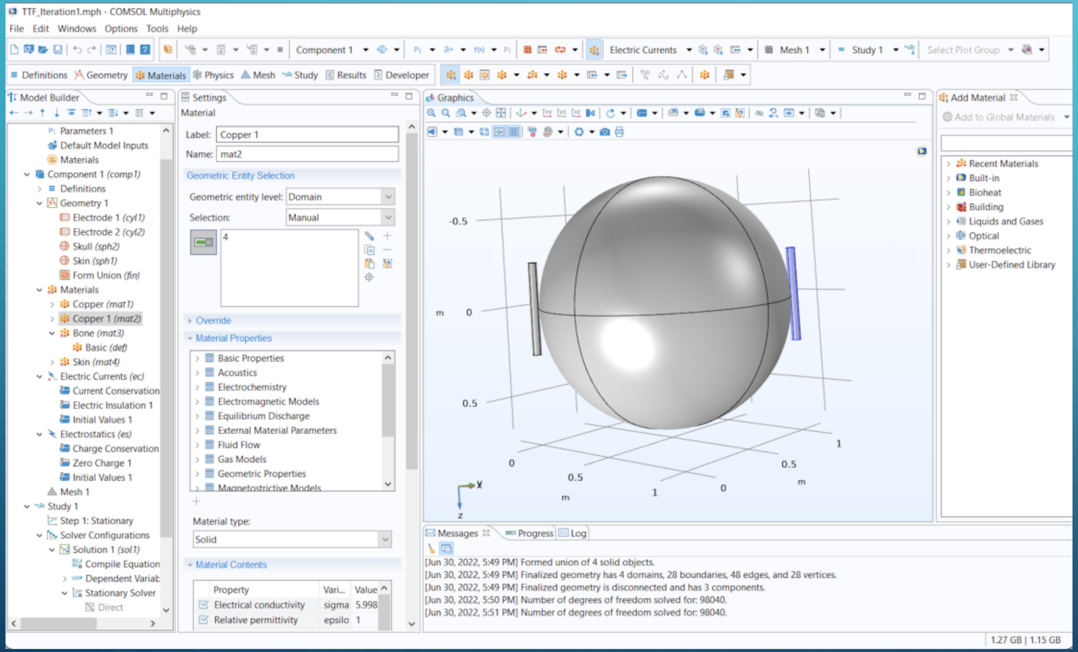
Remark: Note that the reconstruction filter *interpolates* between the samples with sinc functions - hence the name interpolation filter.

PROBLEM STATEMENT



- Tumor treating fields are alternating electric fields that are a relatively new way to treat cancer (glioblastoma)
- When properly applied, these fields disrupt macromolecular protein structures thought to possess large dipole moments
- Higher frequency/field strength is better, but the skull gets in the way (pain/heat)
- Problem: How to design a TTF system that allows for a stronger field?

PROPOSED SOLUTION



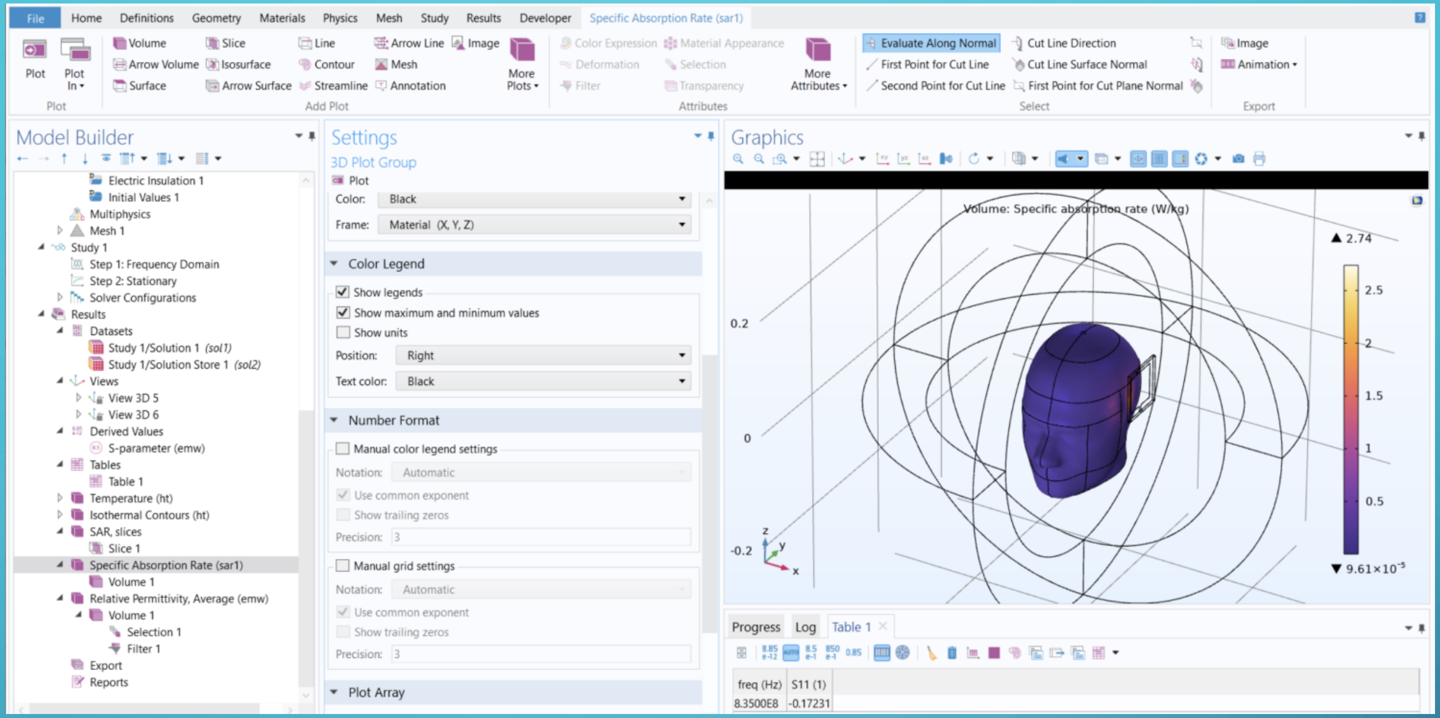
Metrics:

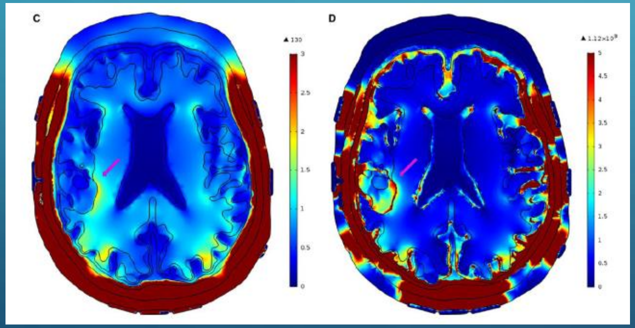
Electric field strength

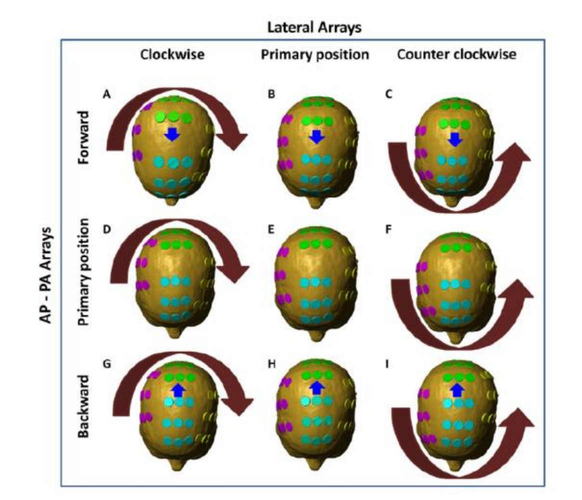
Electric field directionality

Thermal Effects

Material properties


File
Home
Definitions
Geometry
Materials
Physics
Mesh
Study
Results
Developer
Specific Absorption Rate (sar1)
Model Builder
Settings
3D Plot Group
Graphics
Volume: Specific absorption rate (W/kg)
Color Legend
Show legends
Show maximum and minimum values
Show units
Number Format
Plot Array
Electric Insulation 1
Initial Values 1
Multiphysics
Mesh 1
Study 1
Step 1: Frequency Domain
Step 2: Stationary
Solver Configurations
Results
Datasets
Views
Derived Values
Tables
Temperature (ht)
Isothermal Contours (ht)
SAR, slices
Specific Absorption Rate (sar1)
Relative Permittivity, Average (emw)
Export
Reports
freq (Hz)
S11 (1)
8.3500E8
-0.17231


C
D


Lateral Arrays
Clockwise
Primary position
Counter clockwise
AP - PA Arrays
Forward
Primary position
Backward
A
B
C
D
E
F
G
H
I

RESULTS

Metric	SR Remodeling	COMSOL	Analysis
Electric Field Strength (V/M)	1-3 V/m	3 V/m	Achieved using EM module – run current through
Electric Field Directionality	MRI based array location	Fields Visible	- Need fields to change; location - Scan integration
Thermal Effects	Skin Rash	Unclear – SAR	- Encouraging results - Anatomical accuracy

FUTURE

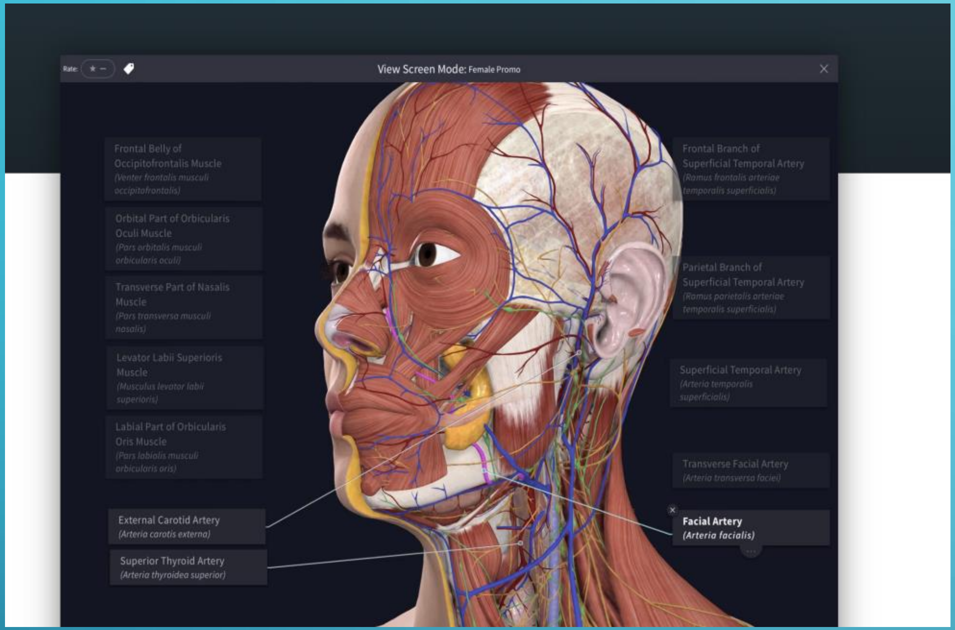


Table 1. Physical parameters required as inputs for computer modeling.

Tissue structure	Volume (cc)	Electric conductivity σ (S/m)	Relative permittivity ε_r
Gross tumor volume (GTV)	5.813874	2.50E-01	1.00E+04
Necrotic core	2.421458	1.00E+02	1.00E+00
Scalp	524.5453	1.05E-03	1.10E+03
Skull	463.5451	2.11E-02	2.04E+02
Dura	216.8171	5.02E-01	2.90E+02
Cerebrospinal fluid	238.8805	2.00E+00	1.09E+02
White matter	593.1396	8.68E-02	1.29E+03
Gray matter	261.5665	1.41E-01	2.01E+03
Bilateral ventricle	51.38429	2.00E+00	1.09E+02
Brainstem	28.7721	1.61E-01	2.30E+03
Orbits	12.89734	1.50E+00	9.66E+01
Cerebellum	44.55224	1.61E-01	2.30E+03
Unspecified tissue/muscle	133.3064	3.84E-01	6.38E+03
Electrodes	N/A	1.00E-05	1.10E+04
Titanium wires	N/A	1.28E+06	5.00E+01

The volume, electric conductivity and relative permittivity values for GTV, necrotic core, scalp, skull, dura, cerebrospinal fluid, white matter, gray matter, bilateral ventricles, brainstem, orbits, cerebellum, unspecified tissue/muscle, electrodes, and titanium wires that were used in the analysis.

MPh

Pythonic scripting interface for Comsol Multiphysics

Comsol is a commercial software application that is widely used in science and industry for research and development. It excels at modeling almost any (multi-)physics problem by solving the governing set of partial differential equations via the finite-element method. It comes with a modern graphical user interface to set up simulation models and can be scripted from Matlab or its native Java API.

MPh brings the dearly missing power of Python to the world of Comsol. It leverages the Java bridge provided by JPype to access the Comsol API and wraps it in a layer of pythonic ease-of-use. The Python wrapper covers common scripting tasks, such as loading a model from a file, modifying parameters, importing data, to then run the simulation, evaluate the results, and export them.

REFLECTION

- First, thank you to the faculty that made this experience possible!
- Special thank you to Daniel Gulick and Professor Christen
- Experienced doing research in an academic setting
- Learned about an interesting method to develop biocompatible systems
- Increased my familiarity with the application of ML to sensor data problems

REFERENCES

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