Guide for Optimization

Main is a matlab-file that performs all operations. Use this for an overview of the optimization process.

# Programs

The following programs/add-ons are needed to perform the optimization/temperature transformation.

## Optimization

* Matlab (R2017a)
* Matlab add-on: MinGW64 (GGC version 4.9.2 by MathWorks Supported Compilers Team)
* Matlab add-on: Myslicer (version 1.1 by Anders Brun)
* Iso2mesh (Iso2mesh 2017 (v1.8), codenamed Deviled Egg)

<http://iso2mesh.sourceforge.net/cgi-bin/index.cgi/?Download>

## Temperature

### Windows

* Virtualbox (VirtualBox 5.1.20 platform packages, windows hosts)  
  <https://www.virtualbox.org/wiki/Downloads>
* Virtualbox: Ubuntu (give at least 15 MB space)  
  <https://www.youtube.com/watch?v=QkJmahizwO4>
* Ubuntu: FEniCS

Type following commands in Ubuntu terminal to install

sudo add-apt-repository ppa:fenics-packages/fenics  
 sudo apt-get update  
 sudo apt-get install --no-install-recommends fenics  
 sudo apt-get dist-upgrade

### Mac

* Anaconda (Anaconda 1.6.2)
  + Dolfin (Dolfin 2017.1.0) should come with Anaconda
* Python (Python 2.7.13)
* Anaconda Navigator: FEniCS  
  To activate FEniCS type following commands in normal mac terminal  
   conda create -n fenicsproject -c conda-forge fenics  
   source activate fenicsproject
* Install h5py  
  Type following command in terminal found in Anaconda Navigator > Environments > fenicsproject > Open Terminal:  
   pip install h5py

### Linux

We have not used Linux, but doing so should be easier since FEniCS is more compatible with the system.

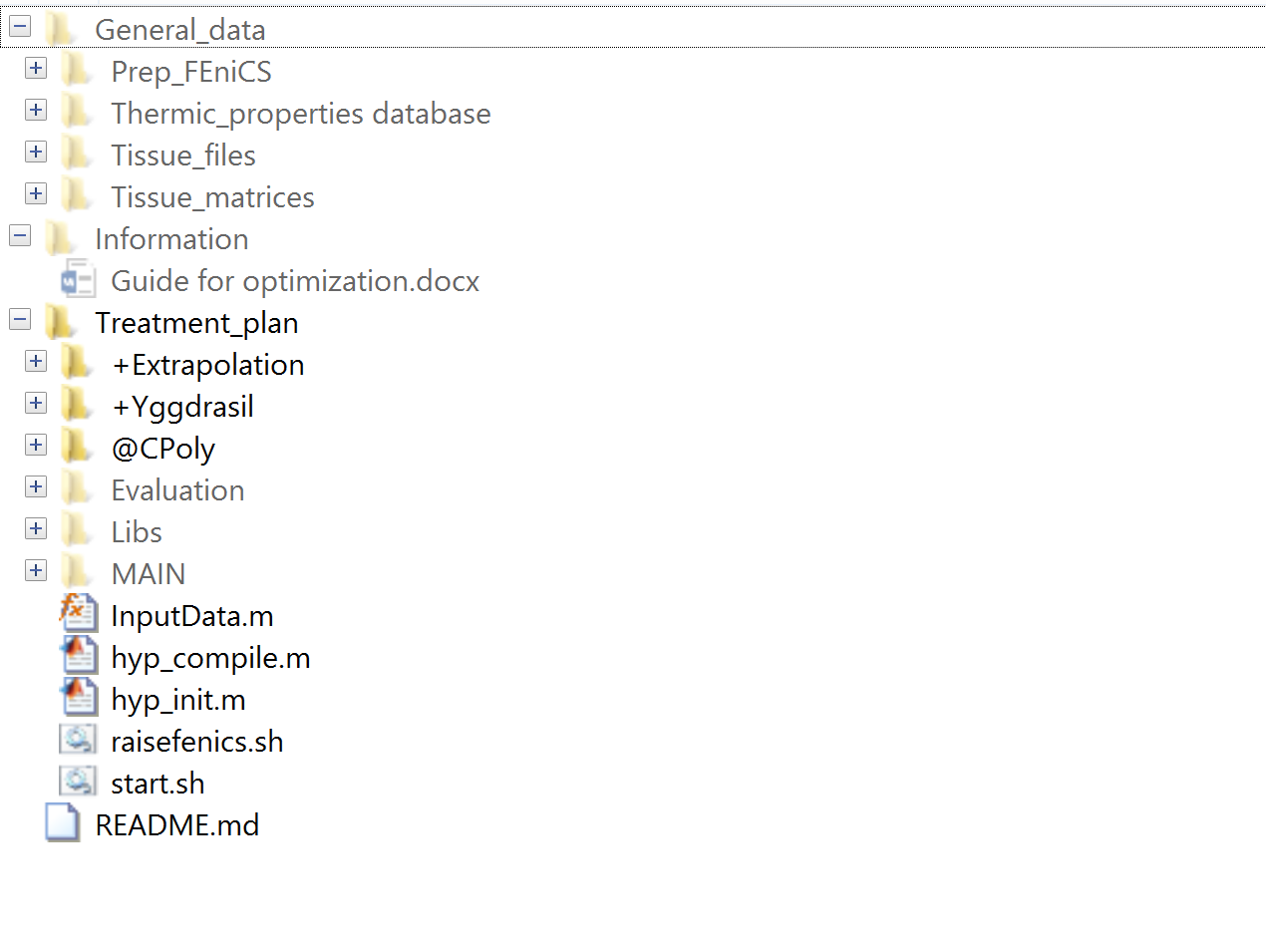
# E-fields and Octrees

The program CST microwave studios (2014) is used to simulate the E-fields, that are then exported to matlab using the function ExportEfieldsFFT that can be found on NewHopa. These Efields are then converted to Octrees (to save space) in the optimization. When they have been converted to Octrees, the original Efields are no longer needed for the optimization.

# Folder System

The folder system used for the hyperthermia treatment planning process is explained in this section.

The first folder encountered is the project folder *Hyperthermia\_Treatment\_Plan*. This folder contains the subfolders *General\_data*, *Information* and *Treatment\_plan, see image below*.



## General\_data

General data is the library used to store the different data for all models. The data is stored in descriptive folders. The data needed to perform a treatment plan is collected here and moved to the data folder used by Main, see *Treatment\_plan* below.

This folder currently contains files used for temperature conversion in FEniCS, a database (excel-file) for generating new thermic properties in preparation for temperature conversions, tissue files for different models, as well as tissue matrices.

## Information

This folder contains information about how to use the Treatment planning system and the different programs that are needed to do so.

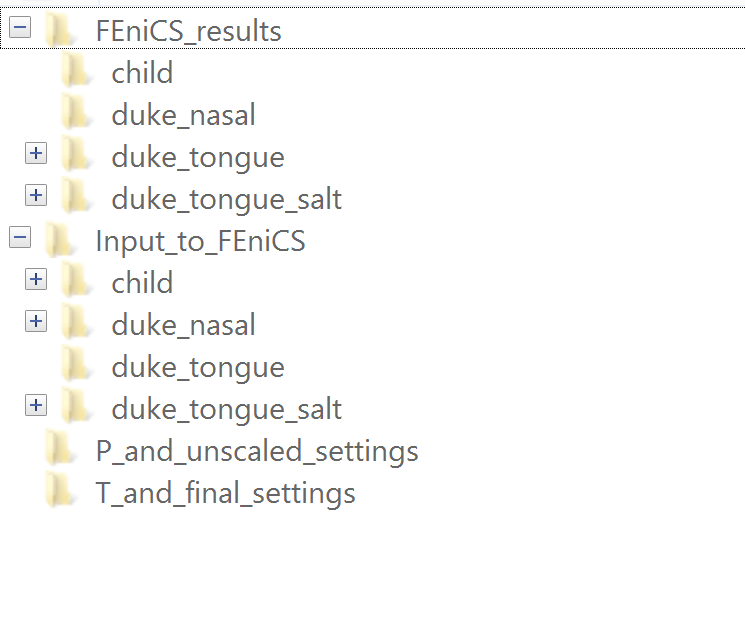
## Treatment\_plan

This is the folder used to perform the treatment planning. The subfolders *+Extrapolation, +Yggdrasil, @CPoly* contain different functions that are needed for creating octrees, octree operations, polynomial calculations and functions for loading files. *Evaluation* contains scripts used to evaluate the treatment plan after and during optimization and to compare different results. It has the subfolders *quality\_indicators* and *visualize* that contain different scripts that calculate HTQ, TC, or visualize different values in histograms/graphs. *Libs* contains *iso2mesh* and *myslicer.* Iso2mesh is vital for creating a mesh that is used in the temperature conversion and myslicer is used to plot the results in matlab. It also contains *histnorm.*

The folder *MAIN* is the folder that will be actively used during the optimization and temperature conversion. This is also where the *Main* script can be found. The Main script is the script that calls on all functions necessary to perform the optimization, preparation for FEniCS and matrix conversion after temperature calculations. Run this script to input your variables! *MAIN* has the subfolders *Data, Scripts* and *Results.* Data is the folder where the data needed to run the current calculations is added. The data needed for a complete run is:

* E-fields or octrees for frequency(ies) of interest
* Tissue-matrix
* Tissue-file
* Boundary condition
* Temperature
* Thermal compilation or thermal\_db\_index\_to\_mat\_index

More specific information about these files are in a README in the data folder. *Scripts* contains scripts that are used for different parts of the planning, split into descriptive folders. *Results* is the folder where all generated results are saved, see image below.



*P\_and\_unscaled\_settings* is where P-matrices and settings with unscaled amplitudes are saved. *Input\_to\_FEniCS* (with subfolders named after the models)is where files that need to be input to FEniCS are saved and FEniCS\_results is where the user inputs the results after temperature conversions in FEniCS. The files *temperature.h5* and *scaledAmplitudes.txt* should be here, placed in a subfolder named after the model. *T\_and\_final\_settings* contains the temperature matrix created from the *temperature.h5* and the settings with scaled amplitudes. These amplitudes are the ones that should be used for the treatment.

*Treatment\_plan* also contains *hyp\_compile, hyp\_init, InputData, raisefenics* and *start.* The first three scripts compiles the c-code, adds paths and opens the input-data dialogue when running *Main*. *raisefenics* and *start* can be used if the user uses eg. Docker to run FEniCS, and in that case help to open and run FEniCS automatically. These files have not been used in combination with Ubuntu but are saved for future use.

# Optimization

## EF\_optmization

Single and double, what they do

## Goal Function

Different options and what they mean

## Particle Swarm

Kort om alternativ för den

Create boundaries – ändra settings för PS

# Temperature Conversion

This is performed in FEniCS. This can be done in different ways depending on what system you are using. The files in Scripts > FEniCS and Results > Input\_to\_FEniCS need to be accessible for the program. Everything in this document should be downloaded and available on NewHopa. To open ubuntu on NewHopa; open virtualbox, start Ubuntu and log in using the password “hej!1234”. Open gnome control center to log in to your drive-account (for guide on this, see link “howtogeek” below).

## Windows (using Ubuntu)

Ubuntu and FEniCS need to be installed. It is also very helpful to install google drive on Ubuntu since it facilitates the copying of data between Ubuntu and Windows. For instructions on how to do this, see <https://www.howtogeek.com/196635/an-official-google-drive-for-linux-is-here-sort-of-maybe-this-is-all-well-ever-get/>.

We used the folders: Input\_to\_FEniCS, FEniCS and FEniCS\_results in Downloads on Ubuntu. The first time a PLD (P-matrix) is to be converted to temperature, we did:

1. Widows: copy the three folders (FEniCS\_results is empty) from Windows to a shared folder in google drive
2. Ubuntu: copy the folders from google drive on Ubuntu to Downloads
3. Ubuntu: rename P-matrix to only P.mat
4. Ubuntu: open the terminal och enter ”ls” to view current directory, then step into Downloads>Input\_to\_FEniCS using “cd”
5. Ubuntu: type ”python pennes.py” in the terminal to start the conversion
6. Ubuntu: copy the created files in Downloads>FEniCS\_results to google drive

Move the files to the results folder Results > FEniCS\_results in windows and keep running Main to plot the result using myslicer and to convert the .h5 file to a .mat. It is also possible to use paraview to view the temperature, but then the code that creates the .pvd and .vtu files needs to be not-commented in pennes.py.

After the process has been performed once and a model and a different frequency is to be used, only the P-matrix, amplitudes.txt (and ampLimit.txt if this has changed) need to be switched for new versions since the remaining files will be the same.

## Other Systems

Open the terminal used to run FEniCS and initiate the FEniCS project. Find the correct folder and make sure all the files you need to run pennes.py are there. The PLD-matrix should only be named P.mat. To run the script, enter “ python pennes.py “.