

Hands on MEG Analyses

06.05.16, Christoph Braun, Somatosensory System



MEG

- Measures mass neuromagnetic activity of
 - Apical dendrites of
 - Pyramidal cells
 - Summed activity of 10.000s of neurons
- MEG records activity at ~300 sensors across the head
- MEG has a high temporal resolution: 1 ms
- Spatial resolution depends on the complexity of the activity: from millimeter to centimeter
- Analysis of
 - Evoked responses
 - Oscillatory Activity
 - Functional connectivity (phase relationships)
- Source Localization: inverse problem (ill-posed, solveable with additional constraints).
 - Equivalent dipole model, minimum-norm model, beamformer model
- Less sensitive to secondary volume currents
- Only sensitive to tangential sources and blind for radial sources





Content

- Analysis of MEG-data
- Focus on the matlab toolbox Fieldtrip
- Addressing general principles of data analysis
- Hands-on training of own data

Goals

- You should be able to access your data and do basic steps of analyses
- You should know where to get information from to analyse your data
- You should have acquired strategies of data analyses



What you cannot expect

- A demonstration of all Fieldtrip functions with all features
- A complete analysis of your data
- Ready answers for complex questions

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Program

Course	Date	Time	Topic
1	04.05.2016	9:00	Trigger, Segmentation, Filtering
2	05.05.2016	14:00	Artifact rejection, Timel locked analysis
3	06.05.2016	14:00	Time frequency analysis
4	11.05.2016	9:00	Functional connectivity
5	12.05.2016	14:00	Preparation of source localization
6	13.05.2016	14:00	Source localization, review

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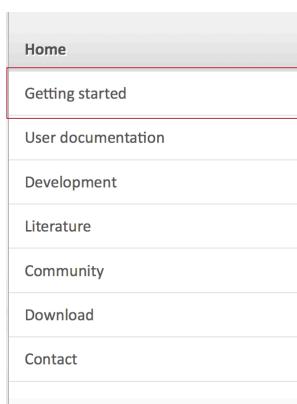
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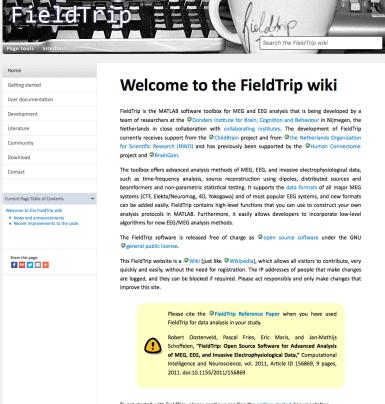
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Sources of Information

- Fieldtrip Webpage: <http://www.fieldtriptoolbox.org>



The screenshot shows the left sidebar of the Fieldtrip website. The sidebar includes links for Home, Getting started (which is highlighted with a red border), User documentation, Development, Literature, Community, Download, and Contact.



The screenshot shows the main page of the Fieldtrip wiki. It features a search bar at the top right, a banner with the Fieldtrip logo, and a "Welcome to the FieldTrip wiki" message. Below this, there is a brief introduction about the Fieldtrip toolbox and its development team. A sidebar on the left lists "Current Page Table of Contents" and "Recent changes to the code".

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Sources of Information

- Fieldtrip Webpage: http://www.fieldtriptoolbox.org/getting_started

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Sources of Information

- Fieldtrip Webpage: <http://www.fieldtriptoolbox.org/documentation>

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Sources of Information

- Fieldtrip Webpage: <http://www.fieldtriptoolbox.org/tutorial>

http://fbcbraininformatics.org/fieldtrip/tutorials. You can log in with someone's username and use your email address as password.' A small 'Edit' link is located at the bottom right." data-bbox="238 240 780 444"/>

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Sources of Information

- Fieldtrip Webpage: <http://www.fieldtriptoolbox.org/walkthrough>

http://fbcbraininformatics.org/fieldtrip/tutorials. You can log in with someone's username and use your email address as password.' A small 'Edit' link is located at the bottom right." data-bbox="238 610 780 814"/>

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Sources of Information

- Fieldtrip Webpage: <http://www.fieldtriptoolbox.org/video>

Getting started

User documentation

Tutorial documentation

Walkthrough

Video lectures

Workshop material

Importing your data

Frequently asked questions

Reference documentation

Template models and data

Example matlab scripts

Video lectures and tutorials

This page lists the video documentation that is publicly available online. Please note that we are no experts in video editing, so the quality of the video material may vary. We are doing our best to make this video material as good as we can and to make it available, but be considerate that it sometimes is not as polished as we would like it to be.

Please use the menu to the left of this page to get an overview and to navigate through the workshop material. Note that some of the earlier material has been presented and recorded multiple times. In general, we recommend you start with the most recent version.

Welcome message

Welcome to our FieldTrip !

Robert Oostenveld

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Sources of Information

Introduction to EEG MEG and introduction to the FieldTrip toolbox.mp4
https://www.youtube.com/watch?v=eUVL_twWNdk

NatMEG lecture: Introducing FieldTrip by Robert Oostenveld
<https://www.youtube.com/watch?v=zOxCqcYmlfA>

NatMEG lecture: FieldTrip introduction by Robert Oostenveld
<https://www.youtube.com/watch?v=l1lQumrWFkS>

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Sources of Information

- Fieldtrip Webpage: <http://www.fieldtriptoolbox.org/workshop>

The screenshot shows the left sidebar with categories like "Getting started", "User documentation", "Tutorial documentation", "Walkthrough", "Video lectures", "Workshop material", "Importing your data", "Frequently asked questions", and "Reference documentation". The "Reference documentation" section is highlighted with a red box. The main content area displays a workshop registration form with fields for name, email, and location, along with a list of previous workshops held in various countries.

Same as: help function

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Sources of Information

- Fieldtrip Webpage: <http://www.fieldtriptoolbox.org/reference>

The screenshot shows the left sidebar with categories like "Tutorial documentation", "Walkthrough", "Video lectures", "Workshop material", "Importing your data", "Frequently asked questions", "Reference documentation", "Template models and data", and "Example matlab scripts". The "Reference documentation" section is highlighted with a red box. The main content area displays a detailed list of data structures used in Fieldtrip, such as "t_datablock", "t_datablock_h5stack", "t_datablock_h5", "t_datablock_cortex", "t_datablock_sourse", "t_datablock_volume", "t_datablock_dipole", "t_datablock_segregation", "t_datablock_zplane", "t_datablock_poles", and "t_datablock_headmodel".

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Sources of Information

- Fieldtrip Webpage: <http://www.fieldtriptoolbox.org/example>

Video lectures
Workshop material
Importing your data
Frequently asked questions
Reference documentation
Template models and data
Example matlab scripts
Development
Literature
Community

FieldTrip

Example MATLAB SCRIPTS

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Sources of Information: Wiki University of Trento

- <https://wiki.cimec.unitn.it/tiki-index.php?page=MEGHomePage>

Welcome to the MEG Lab at the Center for Mind/ Brain Sciences CiMeC

General Remarks
Accessing the Lab
Running Studies
Data Analysis & Tutorial
Using the OBO Cluster
Code Development
CiMeC MEG community And FAQ
Scripts for the teaching session May 2015

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Sources of Information: Wiki University of Trento

- <https://wiki.cimec.unitn.it/tiki-index.php?page=DataAnalysisMain>

Neuro Imaging Laboratories

Tutorial Beta

Data Analysis

- LNIF Home Page
- MRI General
- MRI lab
- MEG lab
- TMS lab
- Software
- PHD Documents

- How to get and setup the officially supported Fieldtrip version
- General comments on planning data analysis in Fieldtrip
 - The tutorial pipeline
 - Reading the data with fieldtrip
 - Virtual artifact rejection of bad trials/channels
 - Evoked potentials and sensor space timelock analysis
 - Time - frequency analysis
 - Co registration of MRI
 - Head models and forward calculation
 - Source space analysis
 - More advanced fieldtrip usages
 - Creating your own trial-functions
 - Using the photodiode to correct for delay and jitter of visual stimuli
 - Virtual Channel analysis
 - ICA Data Cleaning
 - Benefits of single trials
 - Graph Mapping
 - Finding grid points within anatomically defined ROI
 - Fieldtrip support
 - (Python-based data analysis (supported by NI group))
 - Nitime: spectral analysis and filtering of time series
 - MEG data visualization
 - How to import your data into CARET for producing surface plots
 - How to get your data into MRICroGL for producing surface plots and looking in deeper effects
 - Visualizing data with mrizon
 - 3Dish plots in MRICroX
- Set up the connection to the analysis server
- Important general remarks
- Data analysis
- Hands-on Fieldtrip analysis pipeline
- Other snippets / general / intermediate
 - Making FTFs on histograms
 - A better way for cluster statistics in source space
 - Some realtime MEG snippets
- Commercial products / Matlab toolboxes:
 - Biosemi
 - Field Trip
 - EEG Lab
 - Brainstorm
 - SPM
- Data analysis developments, still not ready for the general use public
- Signal processing tutorials:
 - ICA
 - MEG general
 - Fourier Analysis
- Useful links:
 - 田中一郎 TVC
 - Neurosynth
- Using the Cluster
 - executing Matlab functions from outside Matlab
- Where to get sMRIs?
 - Where to get a sMRI for source reconstruction
 - How to share a sMRI to others if you are the project manager

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Sources of Information: Wiki University of Trento

- <https://wiki.cimec.unitn.it/tiki-index.php?page=SupportedFieltrip>

CIMeC LNIF Wiki page

Log in through Shibboleth

Neuro Imaging Laboratories

How to access and use the official fieldtrip version and custom analysis functions

After almost two years of experiences supporting data analysis for people and groups with very different research backgrounds and experience, it became obvious that it is impossible to offer good and fast support if the toolboxes and workflows used are different in every user and group. We thus decided to offer an official distribution of Fieldtrip, the supported analysis toolbox. We enhanced the Fieldtrip version according to needs at the CIMeC and added some convenient functions on top.

The result is the "cimec_owntf" distribution. This article will tell you how to use it on the analysis server, the lnif-cluster and on your laptop/workstation. Of course, we constantly update the Fieldtrip version within the distribution. (At least once a week)

I do my analysis on the MEG analysis server and/or the cluster

In this case, it is very easy. The official distribution lies on the `ser1` storage of Nathan. So, all you have to do, is add the folder to your path and run `"cimec_init_ft"`:

```
addpath('/mnt/storage/tier1/natwei/Shared/cimec_owntf/');
```

`cimec_init_ft;`

Running of all your analysis scripts. It does not hurt behavior because messed up Matlab paths are the R calling "cimec_init_ft!"

help cimec_init_ft

to find out about it.

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Sources of Information: Wiki University of Trento

- <https://wiki.cimec.unitn.it/tiki-index.php?page=SupportedFieltrip>

I do my analysis on my workstation or laptop and I do NOT have a constant network connection to the UNITN

In this case, you have two possibilities.

1. You can simply download the current version from http://192.168.185.69/cimec_ownft.zip. Whenever we change something, this zip file is automatically updated.
2. Clone the repository via git. If you know how to handle git, this is going to be much better for you because you can update easier and do not have to redownload everything again.



Prerequisites

- Matlab installed
- Fieldtrip installed
- Example files
 - Fieldtrip toolbox: <ftp://ftp.fieldtriptoolbox.org/pub/fieldtrip/>
 - CTF-Dataset:
 - Elekta-dataset:

Conventions

Task:

Code:
t=[0:0.001:2]
f=[20:0.5:120]
a=1./((f-mean(f)).^2+25);

Tasks to do are in boxes of sandy color

Snippets of code are in blue

Programming

- Fieldtrip is a set of matlab-functions



```
[b,a]=butter(4,[.02 .1],‘bandpass’)
```

- Input(s) and output(s) can be all data types:

- single values: numbers, letters: a=5; b='c'
- vectors/matrices: data of same type
`a=[5 8 -1]; b=['abc', 'def'; 'ghi', 'jkl']`
- cells
`a={'christoph', 'braun', 11,07,1957; 'mario', 'rosso', 21,03,1981}`
- Structures
`a.first_name='christoph'; a.name='braun'; birthdasy=[11, 07, 1957]`

Programming

- Fieldtrip is a set of matlab-functions



```
data_processed=ft_preprocessing(cfg,data)
```

- Input(s):

- configuration structure:
`cfg.dataset='subject01.ds'
cfg.hpfILTER='yes'`

...
remark: the structure doesn't need to be called 'cfg' any name is possible

- data structure:

data

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Programming

- Inputs and outputs: see help *function* or doc *function*

[MATLAB File Help: ft_preprocessing](#)

[View code for ft_preprocessing](#)

ft_preprocessing

```
ft_preprocessing reads MEG and/or EEG data according to user-specified trials
and applies several user-specified preprocessing steps to the signals.
```

Use as

```
[data] = ft_preprocessing(cfg)
or [data] = ft_preprocessing(cfg, data)
```

The first input argument "cfg" is the configuration structure, which contains all details for the dataset filenames, trials and the preprocessing options. You can only do preprocessing after defining the segments of data to be read from the file (i.e. the trials), which is for example done based on the occurrence of a trigger in the data.

If you are calling **ft_preprocessing** with only the configuration as first input argument and the data still has to be read from file, you should specify

```
cfg.dataset = string with the filename
cfg.trl = Nx3 matrix with the trial definition, see FT_DEFINETRIAL
cfg.padding = length to which the trials are padded for filtering (default = 0)
cfg.pdftype = string, type of padding (default: 'data' padding or
               'mirror', depending on feasibility)
cfg.continuous = 'yes' or 'no' whether the file contains continuous data
               (default is determined automatic)
```

Instead of specifying name and path to the dataset file, you can also specify the file containing the cfg structure below apply.

If you are calling **ft_preprocessing** with only the configuration as first

input argument and the data still has to be read from file, you should

specify

The channels that will

be used for analysis

If you are calling **ft_preprocessing** with only the configuration as first

input argument and the data still has to be read from file, you should

specify

The preprocessing options

cfg.lpfilter = string with the filter name

cfg.hpfiler = string with the filter name

cfg.dttfilter = string with the filter name

cfg.medfilter = string with the filter name

cfg.hpfreq = float, the highpass frequency

cfg.bpfreq = float, the bandpass frequency

cfg.dpffreq = float, the decimation frequency

cfg.dpffilt = string with the filter name

The first input argument "cfg" is the configuration structure, which contains all details for the dataset filenames, trials and the preprocessing options. You can only do preprocessing after defining the segments of data to be read from the file (i.e. the trials), which is for example done based on the occurrence of a trigger in the data.

If you are calling **ft_preprocessing** with only the configuration as first input argument and the data still has to be read from file, you should

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               'mirror', depending on feasibility)
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               (default is determined automatic)
```

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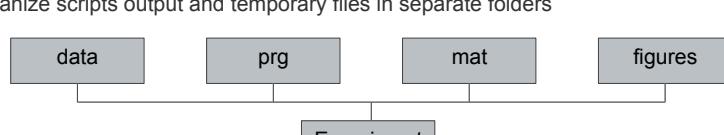


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How to Program

- Use scripts and not only analyses on the command line
 - Helps to keep track what you have done
 - Analysis can be redone easily or applied to other subjects
- Comment your scripts and functions in order to understand what you have done
- Save intermediate steps in order to avoid memory overflow
- Organize interactive and automatic parts in separate blocks
- Don't save any redundant information, because your disk will overflow
- Group steps of analyses and put them even in function in order to get a modular structure
- Organize scripts output and temporary files in separate folders



```
graph TD; data --> Experiment; prg --> Experiment; mat --> Experiment; figures --> Experiment;
```

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Open Datafile

Command: *ft_databrowser*

Task:

- Read data of subject01 using the databrowser (<ftp://ftp.fieldtriptoolbox.org/pub/fieldtrip/tutorial/Subject01.zip>)
- Select different channel groups: Trigger, MEG channels, EOG channel, describe what you see.
- Scroll through trials, and look whether you find untypical activity.
- Isolate bad MEG-channels