

# INM6 retreat 2016: Sessions

## Slot 1: Techniques and Tools I

Monday, June 6th, 14:00–15:30

### 1. Transfer of methods from modern theoretical physics to neuroscience

**Chair:** David (Moritz)

**Focus of interest of:** David, Lukas, Dima, Tobias, Jannis

**Proposed participants:** David, Claudia, Michael D, Tobias, Lukas, Hannah, Markus, Dima, Moritz

#### **Schedule:**

We divide the session into 3 parts, the first discussing past/published projects, the second ongoing projects and the third one future projects. The format will be that each session will have one person who presents a collection of slides (2-3 slides per project) on all corresponding projects in that category (past, ongoing, future). The presentation should not take longer than 15 minutes. Afterwards we will have 5 minutes for immediate questions. At the end of the session, we will then have 30 minutes for in-depth discussion.

Slides:

Please prepare 2-3 slides on each of your projects with the main idea, relation to experiments and a sketch of the methods/tools involved. Unfortunately, there won't be time to go into depth for the methods. We should rather get an overview which methods are/were already employed at our institute in order to see where we can find cross-links or further methods for future projects. In addition to the content of future projects, we will also discuss their organization.

### 2. Bayesian statistics

**Chair:** Luca (Emiliano)

**Focus of interest of:** Vahid, Luca, Nicole, Emiliano, Alper, Sven, Junji

**Proposed participants:** Pietro, Daniel B, Sepehr, Sacha, Julia, Jakob, Junji, Nicole, Robin, Luca, Jenia, Sven, Emiliano, Jyotika, Tammo

#### **Schedule:**

- Bayesian-logic tutorial: The Monty Hall problem (15–20 min)
- discussion/questions on the main points of Bayesian logic (15–20 min)
- brief presentation of an open inference problem from neuroscience by Sacha (5–10 min)
- hands-on: group work and discussion (possibly dividing into small groups) on the Bayesian analysis and setup of the presented neuroscientific inference problem (according to the guidelines of the tutorial) (remaining time, c. 40 min)
- round-up and literature suggestions (last 5–10 min)

### 3. Machine learning and data mining

**Chair:** Vahid (Alper)

**Focus of interest of:** Vahid, Alper, Abigail, Jeyathevy, Robin

**Proposed participants:** Tom, Alper, Simone, Renato, Daniel M, Steffen, Jeyashree, Michael B, Max, Philipp, Johanna, Rembrandt, Abigail, Fred

#### **Schedule:**

- short introduction into Bayesian statistics (Luca/Max; up to 15 mins)
- interfacing ML and Bayes (Alper, Sepehr; 15mins)

- (Bayesian) Linear Regression
- MLE/MAP
- state-space analysis (Renato, 15mins)
- clustering analysis (Alper, Daniel, 15mins)
  - k-means
  - DBSCAN
  - Expectation Maximization
- open discussion, e.g. how to use ML on our problems or in general, problems and solutions regarding our work, in depth discussion

#### 4. Interpretation of spike rates

**Chair:** Robin (Jakob)

**Focus of interest of:** Robin, Vahid, Luca, Jakob

**Proposed participants:** Inga, Espen, Jannis, Sonja, Carlos, Marcel, Lyuba, Jeyathevy

**Schedule:**

Paper presentations (10-15min each):

- Barlow H. The neuron doctrine in perception. In Gazzaniga M, editor, The Cognitive Neurosciences. Boston: MIT Press, 1994 (Jakob)
- Quiroga, R. Q., Reddy, L., Kreiman, G., Koch, C., & Fried, I. (2005). Invariant visual representation by single neurons in the human brain. Nature, 435(7045), 1102-1107 (Carlos)
- Romain Brette, (2015), Philosophy of the Spike: Rate-Based vs. Spike-Based Theories of the Brain (Robin)

## Slot 2: Techniques and Tools II

Tuesday, June 7th, 9:00–10:30

#### 5. Good programming practices, design of extendable software & documentation

**Chair:** Julia (Steffen)

**Focus of interest of:** Julia, Steffen

**Proposed participants:** Daniel B, Sacha, Julia, Claudia, Jakob, Inga, Junji, Tobias, Steffen, Jeyashree, Jenia, Espen, Jannis, Max, Lukas, Markus, Abigail, Tammo

**Schedule:**

- Introduction to PEP8 standard [Julia, 15']
- Aspects of clean code (based on 'Clean Code: A Handbook of Agile Software Craftsmanship' by Robert C. Martin) [Julia, 15']
- Good Programming Practices - An Overview and Introduction in NEST [Tammo, 30']
- Code Quality Assurance and Problems in Elephant [Junji, 15']
- Discussion Time [everybody, 15']

#### 6. How to use git and backup technologies

**Chair:** Michael B (Jakob)

**Proposed participants:** David, Tom, Simone, Renato, Nicole, Robin, Luca, Marcel, Dima

**Schedule:** **TBA**

#### 7. Visualization techniques, visual analytics

**Chair:** Maximilian

**Proposed participants:** Alper, Sepehr, Daniel M, Michael D, Sven, Jyotika, Philipp, Johanna, Hannah, Moritz

**Schedule:**

- VisNEST [Maximilian, 10']
- Correlation Analyzer [Pietro, 10']
- VIOLA (4x4 Visualizer) [Johanna, 10']
- Visiphant and NEST-Elephant Multiview [Michael, 10']
- Generation and visualization of graphs with python-igraph [Maximilian, 10']
- pyQT [Alper, 10']
- maya-vi [Michael]
- Discussion
  - Scripts and command-line tools vs. GUI
  - Bring your plots - favorite or problematic plots

Notes:

- see books recommended by Benni W

## 8. Research-data management

**Chair:** Carlos (Lyuba)

**Focus of interest of:** Carlos, Lyuba, Frederic

**Proposed participants:** Pietro, Michael B, Emiliano, Sonja, Carlos, Rembrandt, Fred, Lyuba, Jeyathevy

**Schedule:** **TBA**

Notes:

- data sharing and access to databases (e.g. rodent-brain data through web clients)
- metadata annotation
- digitization of the research process (workflows)

## Slot 3: Data-analysis applications

Tuesday, June 7th, 11:00–12:30

### 9. Spatio-temporal patterns

**Chair:** Michael D (Emiliano)

**Focus of interest of:** Emiliano, Carlos, Michael D, Alper, Pietro, Vahid, (Max), (Karolina)

**Proposed participants:** Pietro, Sepehr, Renato, Daniel M, Jakob, Junji, Luca, Jenia, Espen, Philipp, Johanna, Marcel, Lyuba, Nicole, Jeyathevy

**Schedule:** **TBA**

Notes:

- correlation structure in artificial neural networks
- analyzing spiking activity in multi-area model
- detection of spatio-temporal patterns in deep networks
- correlation structure in macaque motor cortex

### 10. Graph theory: applications and toolboxes

**Chair:** Abigail (Jyotika)

**Focus of interest of:** Abigail, Robin, Jyotika, Jeyashree, Max

**Proposed participants:** Daniel B, David, Alper, Simone, Claudia, Michael D, Tobias, Steffen, Jeyashree, Sven, Max, Jyotika, Sonja, Abigail, Dima, Moritz, Tammo

**Schedule:** **TBA**

Notes:

- graph-theoretical analysis of biological neural networks

- graph-theoretical analysis of artificial neural networks
- graph-theoretical analysis of neural data
- How can anatomical or functional data benefit from graph-theoretical analysis?

## 11. Brain maps and connectomics

**Chair:** Rembrandt (Sacha)

**Focus of interest of:** Rembrandt, Sacha, (Renato)

**Proposed participants:** Sacha, Julia, Lukas, Hannah, Rembrandt, Markus, Fred, (Nicole)

**Schedule:** TBA

Notes:

- folding patterns of ferret cortex in developing brains
- features of new connectivity matrix of macaque visual cortex

## 12. Applying our insights and methods to networks/data outside neuroscience (knowledge export)

**Chair:** Johanna (Max)

**Focus of interest of:** Johanna, Max

**Proposed participants:** Inga, Robin, Michael B, Emiliano, Jannis, Carlos, Tom, Jakob, Luca, Jeyashree

**Schedule:**

The idea is to study concrete examples where techniques from our work can be applied to other fields (and what we can learn from other related fields). The main focus should be on networks of spiking neurons, i.e., how to construct and how to analyze them. The session will be composed of short presentations of examples from literature/experience, discussions and the development of concrete ideas.

- Introduction
- Tom on Chapuis2014 "The variability of tidewater-glacier calving: origin of event-size and interval distributions"
- Carlos on Cheng2014 "Can cascades be predicted?" and on Cheng2016 "Do cascades recur?"
- Max on time series forecasting (tba)
- Johanna on Lymperopoulos2015 "Online social contagion modeling through the dynamics of Integrate-and-Fire neurons"
- Brainstorming/Collection and discussion of other ideas (e.g., Max on train system, finance, weather)
- Wrap-up/Conclusions

## Slot 4: Dynamics of neural systems

Wednesday, June 8th, 9:00–10:30

## 13. Dynamical-system analysis of neural networks

**Chair:** Jannis (Sven)

**Focus of interest of:** Sven, Jannis, Tom

**Proposed participants:** David, Tom, Alper, Claudia, Michael D, Inga, Junji, Jeyashree, Sven, Emiliano, Max, Jyotika, Philipp, Lukas, Moritz

**Schedule:**

- Short introduction to Lyapunov exponents (characterizing chaos) in spiking systems, for example based [http://wwwold.fi.isc.cnr.it/users/alessandro.torcini/ARTICOLI/agt\\_pre2015.pdf](http://wwwold.fi.isc.cnr.it/users/alessandro.torcini/ARTICOLI/agt_pre2015.pdf)

- The participants form small groups to try out the presented ideas directly in spiking simulations with NEST.

#### 14. Synaptic and structural plasticity and homeostasis

**Chair:** Renato (Phillip)

**Focus of interest of:** Phillip, Renato, Claudia, Sepehr, Dima

**Proposed participants:** Pietro, Daniel B, Sepehr, Robin, Jenia, Jannis, Abigail, Dima

**Schedule:** **TBA**

Notes:

- features of synapses that allow system to learn and adapt (incl. homeostasis)
- interaction of plasticity and activity on different time scales
- homeostasis and robustness of networks
- similar output despite different system properties

#### 15. Brain-activity features: functional relevance or byproduct?

**Chair:** Junji (Hannah)

**Focus of interest of:** Hannah, Junji

**Proposed participants:** Julia, Jakob, Steffen, Hannah, Rembrandt, Fred, Marcel, Lyuba

**Schedule:**

- Interactive perspective presentation "Relations between neuronal noise and signal (or ongoing and response activities)" by Junji (45 min)
- Interactive perspective presentation "Oscillation as filtered noise" by Hannah (30 min)
- Open discussion (15 min)

#### 16. Forward models & biophysically realistic multi-scale activity

**Chair:** Espen (Daniel M)

**Focus of interest of:** Espen, Daniel M

**Proposed participants:** Simone, Sacha, Renato, Daniel M, Tobias, Luca, Espen, Michael B, Sonja, Carlos, Johanna, Markus, Tammo, Nicole, Jeyathevy

**Schedule:**

- 00-10 min: Espen: Introduction, Forward modeling of extracellular potentials
- 10-20 min: Sonja: spike-LFP and spike synchrony - LFP relation
- 20-30 min: Carlos: Interpretation and biophysics underlying the fMRI signal (dead salmon fMRI controversy?)
- 30-40 min: Markus: Mass signal-prediction in macroscopic neuronal network models
- 40-50 min: Sacha: Why do certain features in electrophysiological data emerge on a specific scale (e.g., alpha-band activity in EEG spectra)?
- 50-60 min: Daniel: Origin of low frequencies in multi-area models
- 60-70 min: Espen: Forward modeling schemes for ECoG, EEG and MEG signals
- 70-90 min: Discussion + misc.

### Slot 5: Function of neural systems

Wednesday, June 8th, 11:00–12:30

#### 17. Coding and information transfer in biological neural networks

**Chair:** Sepehr (Daniel M)

**Focus of interest of:** Sepehr, Daniel M, Jeyathevy

**Proposed participants:** Pietro, David, Sacha, Julia, Renato, Daniel M, Michael D, Tobias, Robin, Luca, Espen, Sven, Emiliano, Jyotika, Philipp, Sonja, Carlos, Lukas, Hannah, Rembrandt, Marcel, Lyuba, Jeyathevy

**Schedule:**

- Background and overview (10 min)
- Mutual info, Granger Causality, and transfer entropy and their shortcomings (10 min)
- New metrics (10 mins)
- When to use which metric (5 min)
- Discussion (10 mins)
- Break (10 mins)
- Summary (5 mins)
- Hands-on session (30 mins)

## 18. Bayesian computing in biological neural networks

**Chair:** Jakob (Luca)

**Focus of interest of:** Jakob, Luca, Daniel M, Jenia, Tom

**Proposed participants:** Daniel B, Jakob, Inga, Junji, Nicole, Max, Moritz

**Schedule:**

- introduction (20min, Jakob)
- hands on: Boltzmann learning; adapting internal representation to match target distribution; probabilistic inference (50min; Vahid, Jakob)
- discussion (20min)

## 19. Measures of computational capability of neural networks

**Chair:** Tom (Sven)

**Focus of interest of:** Tom, Sven, Daniel B

**Proposed participants:** Tom, Simone, Claudia, Jannis, Johanna, Markus, Dima

**Schedule:**

- Types of computation (tasks) (Tom)
  - brief overview of different types of tasks (e.g. memory, classification, inference, sequence generation, prediction of dynamical systems, ...)
  - examples from neuroscience-literature where these tasks are implemented by neural networks
  - measures of task complexity (e.g. dimensionality)
- Discussion: What tasks can you think of? What tasks does the (biological) brain perform? Can we classify tasks?
- Computational capability of neural networks
 

Which measure are used/common in neuro-literature (short presentations by session participants, 1-2 slides/measure)?
- Discussion
  - How do the individual measures relate to specific tasks? What measure is reasonable for what task?
  - Which measures are task specific? Which measures are not (or less) task specific?
  - What aspects of the task do the different measures account for?

## 20. Deep learning

**Chair:** Jenia (Jakob)

**Focus of interest of:** Jenia, Jakob

**Proposed participants:** Alper, Steffen, Jeyashree, Jenia, Michael B, Abigail, Fred, Tammo

**Schedule:** **TBA**

**Notes:**

- multi-modal learning in very deep recurrent neural networks
- deep denoising autoencoders