Brainstorming on optical imaging experiment analyses

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Seminar F
Nov 2007
Talk Overview

- Aim of experiment and motivation
- Optical Imaging signals
- Details of experiment in Debrecen (Z. Kisvarday)
- Some first analyses
Previous studies: Temporal dynamics and fusion of information

- Nicolič, Häusler, Singer & Maass, 2006
Analyzes of temporal dynamics of information: Results

- When is **information about preceding input** available for a neuron within the circuit?
  - At each time $t$ we **trained a linear classifier** from the readout spike response to classify the stimulus class
- Simulation approximates qualitatively experiments in cat area 17

![Graph showing performance over time for different simulations in cat area 17. The x-axis represents time in milliseconds (0 to 700), and the y-axis represents performance in percent correct. The graph includes three curves: one black, one blue, and one green. The black curve represents the simulation for a neuron in layer 2/3, the blue curve for a neuron in layer 5, and the green curve for the readout spike response. The time intervals are marked as 0, 100, 200, 300, 400, 500, 600, and 700 ms. The performance ranges from 0 to 100%.](image)
Motivation

- How is the dynamic of information about spatial stimuli?
- How does lateral connectivity play a role?

When and how well can a neuron with this RF distinguish the stimulus A and B?
**Experimental setup**

- Experiments on an anaesthetized cat
- Area 17 and 18 (primary visual area)
- Optical imaging (BOLD related signal)

(Up to) 6x8 mm region of interest
Setup

[Diagram showing a setup with labeled components: Computer, Digital Camera Controller, Light Guide Illuminator, CCD Camera, Image Display, Visual Stimulator, Video-projector, and a projection screen with an image of a brain.]
Intrinsic signal (BOLD related)
Possible noise sources

less than **6% signal change** relative to intensity at 605 nm

- CO level change due to respiration
- brain pulsation because of relatively large cranial window
- light scatter
- slow changes in blood oxygenation
  - on time scale of several minutes/hours
  - oscillation of oxygenation at about 0.15Hz (not related to heart beat)
Experiment in Debrecen on 10/8/2007 -10/12/2007

- What was done:
  - Mapping of retina/fovea to stimulus screen
  - (Cross hemisphere activation map)
  - Extracellular reference electrode measurement with receptive field characterization
  - 3 sets of “complex” stimuli presentation
  - More extracellular recordings to get RF structure and tracer filling
  - Intracellular recordings
  - Cortex slice preparation for microscopy
  - 3D neuron reconstruction (+ button density map) of biocytin tracer labeling
Data to analyse

- 3 experiments with a selection of “complex stimuli”
  - 15 trials and twice 75 trials
  - 2 experiments with additional full-field gratings
  - Monitor setting somewhat changed between experiments
  - Monitor aligned to reference electrode measurement (where RF is known)
  - However, it seems that 5 trials are averaged in one block without recording the data for single trials
“complex” stimuli: 3 regions + 3 orientations (back and forth movement)

Exp 12: a smaller selection of stimuli + 4 full-field gratings

Exp 13: as in Exp12 but 75 trials instead of 15

Exp 14: all stimuli + orientations same in upper and lower half
Stimulus presentation time line

- Data acq. (4.8 sec)
- Stim 1 (4.8 sec)
- Blank (10 sec)
- Data acquisition
- Stim 2

Time

Reference Frame
2560 msec/frame

Data Frame

2560 msec/frame

Stimulus DAQ Period
4800 msec/stimulus

Video Frame
40.00 msec/frame

480.00 msec/frame
Data examples

Blank. Mean over trials an frames. Normalized intensity.
Single 5-trial (i.e avg. over 5 trials)

Stimulus: Each frame averaged over ca. 500 ms
Trial average (75 trials)

Stimulus:

frame 1

frame 2

frame 3

frame 4

frame 5

frame 6

frame 7

frame 8

frame 9

frame 10

Rel. intensity [AU]

-400 200 0 200 400
Analyses

- Online maps:
RF might be partly inferred from data. Zoltan has also some reference information about that.
Analysis
Computing orientation maps over time
Analysis
Computing orientation maps over time

Masked with locking strength ("strength of preference")
Analysis
Computing orientation maps over time

Different normalization? Overall intensity of each stimulus type substracted:

frame 1  frame 2  frame 3  frame 4
frame 5  frame 6  frame 7  frame 8
frame 9  frame 10

Preferred orientation
\[\text{preferred orientation}\]
Analysis
Information between classes

Class 1

Class 2

Class 3
Info about lower versus upper region
Analysis
Information between classes

Info about upper versus triangle region

upper vs. triangle regions (regardless of orientation)

frame 1  frame 2  frame 3  frame 4

frame 5  frame 6  frame 7  frame 8

frame 9  frame 10

Information about stm [bit]

0.2  0.4
Analysis
Information between classes

Info about lower versus triangle region

lower vs. triangle regions (regardless of orientation)
Analysis
Information between classes

regions (regardless of orientation)

frame 1
frame 2
frame 3
frame 4
frame 5
frame 6
frame 7
frame 8
frame 9
frame 10

max info across frames

upper vs. lower
upper vs. triangle
lower vs. triangle

(scale: 1.75; mxinfo = 0.400)
Analysis
Information between classes

ori (regardless of region)

frame 1
frame 2
frame 3
frame 4
frame 5
frame 6
frame 7
frame 8
frame 9
frame 10

max info across frames

|| vs. ==
|| vs. \|\|
== vs. \|

(scale: 1.75; mxinfo = 0.198)
Analysis
Information between classes

orientation in lower half

frame 1
frame 2
frame 3
frame 4
frame 5
frame 6
frame 7
frame 8
frame 9
frame 10

max info across frames

(scale: 1.75; mxinfo = 0.191)
Further analyses

● Temporal and spatial evolution of information

● Relate information dynamics to lateral connectivity (and link it to anatomical data)

● What normalizing scheme is best to get most signal?

● What is noise, what is signal? What should be correct?
  - Compare orientation map (or something else) for all three experiments
  - Compare different kind of stimuli in some clever way

● Any ideas?
Further reading on experiment