NOMAD – Near-infrared Optode Montage Automated Designer

MathLab

Neuroscience and Mental Health Institute | University of Alberta
Brain Health and Injury Research

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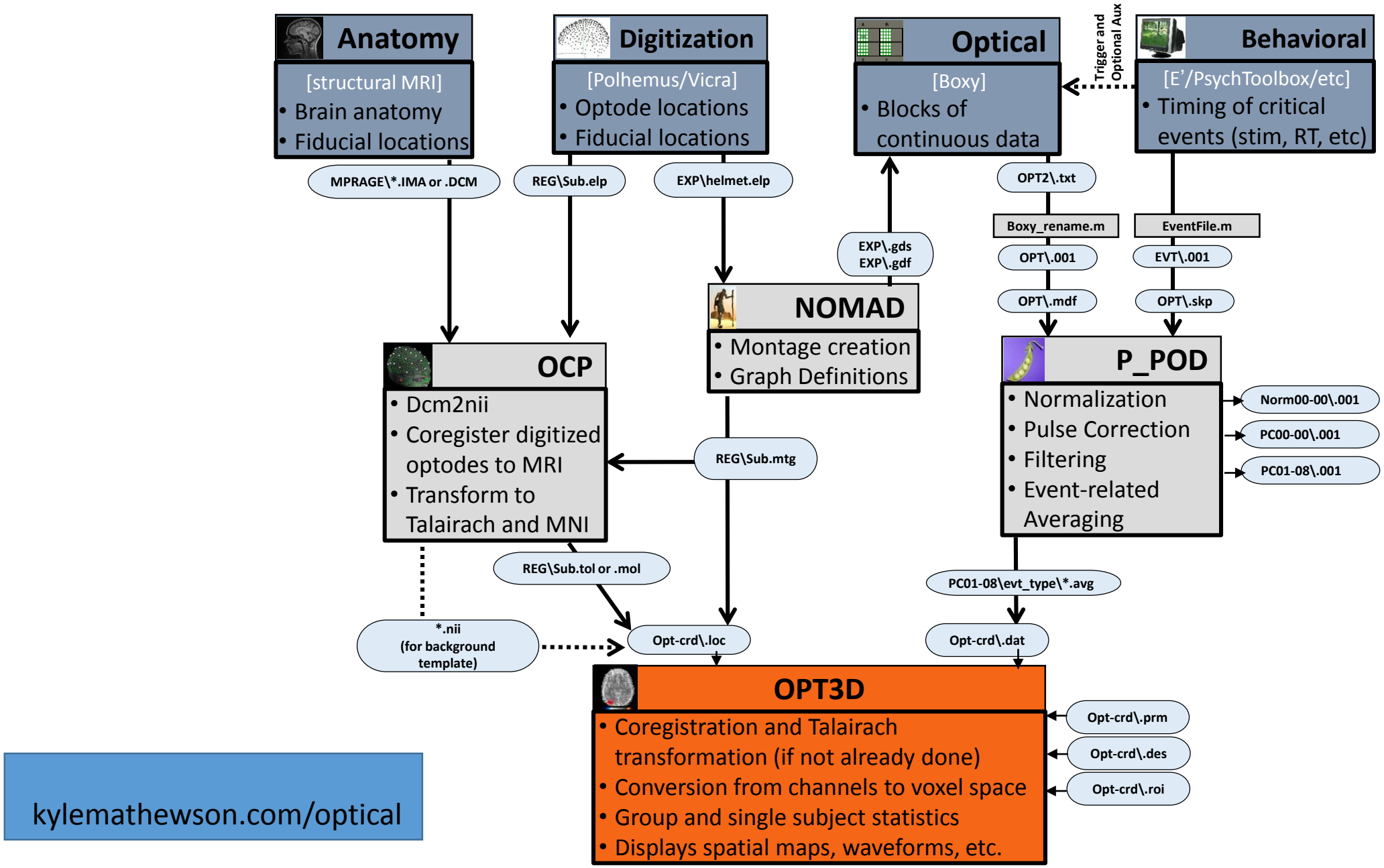
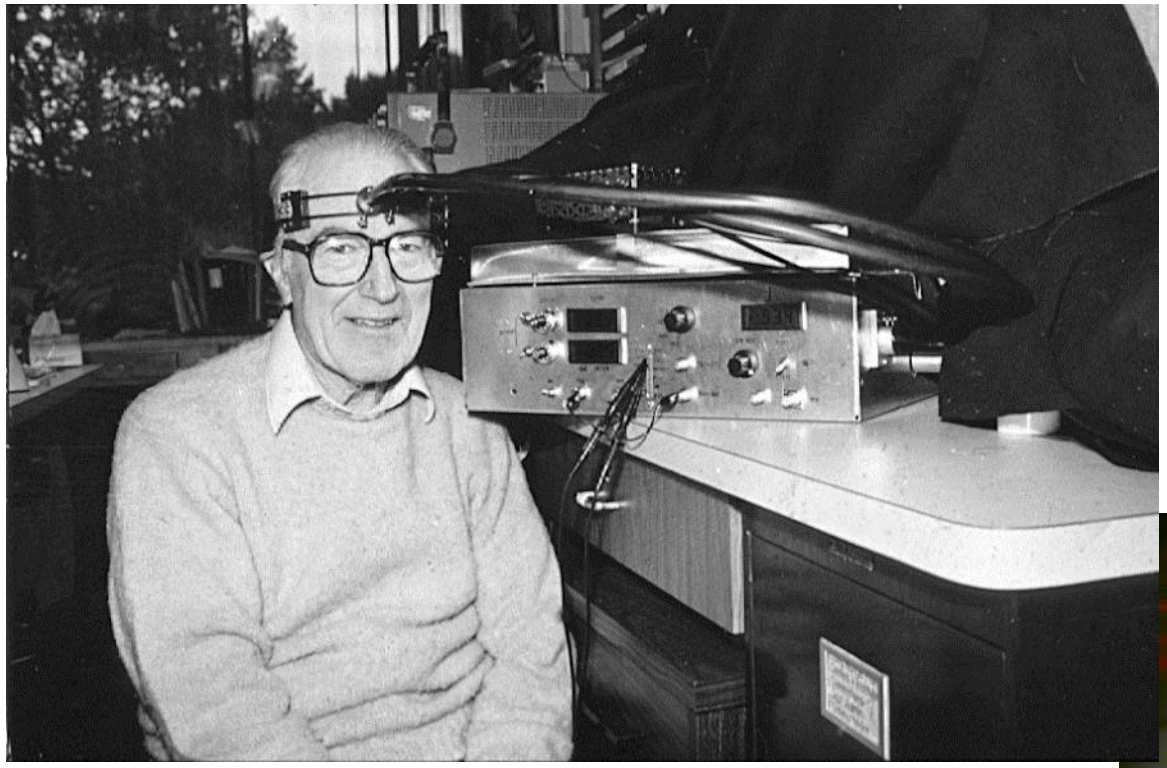
Faculty of Science, University of Alberta

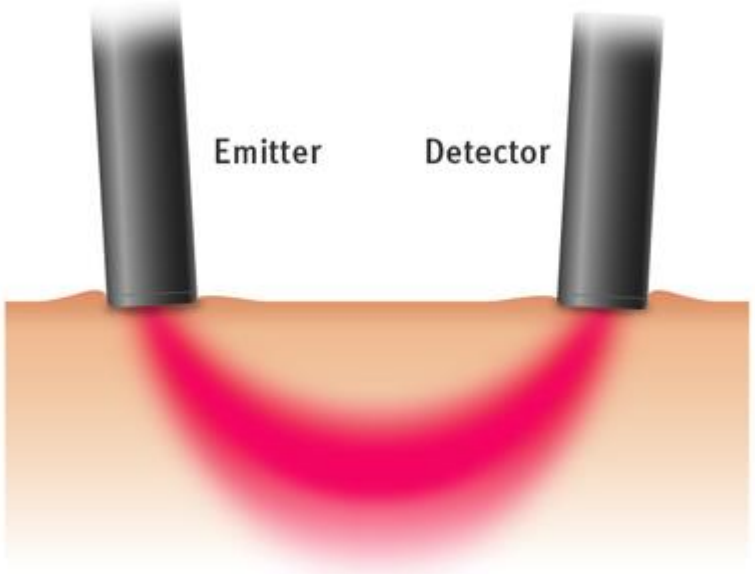
Optical Imaging Summer School, Beckman Institute, UIllinois – May 27, 2015



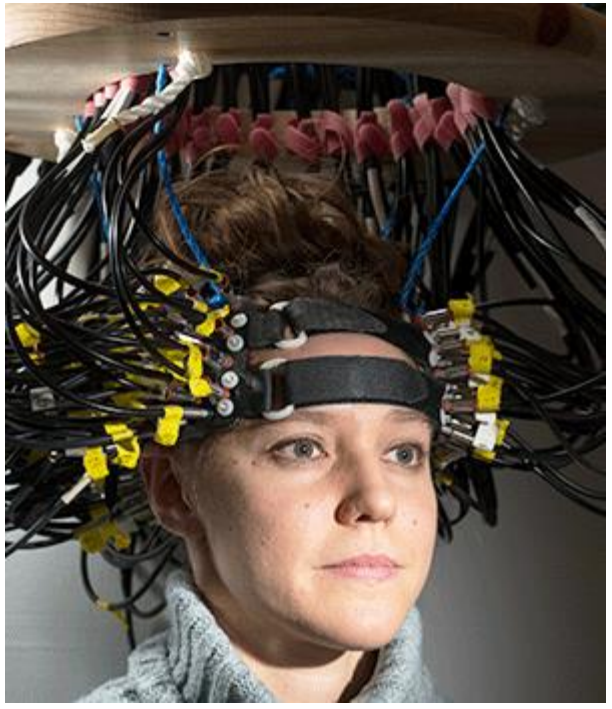
kylemathewson.com/optical

Optical Brain Imaging

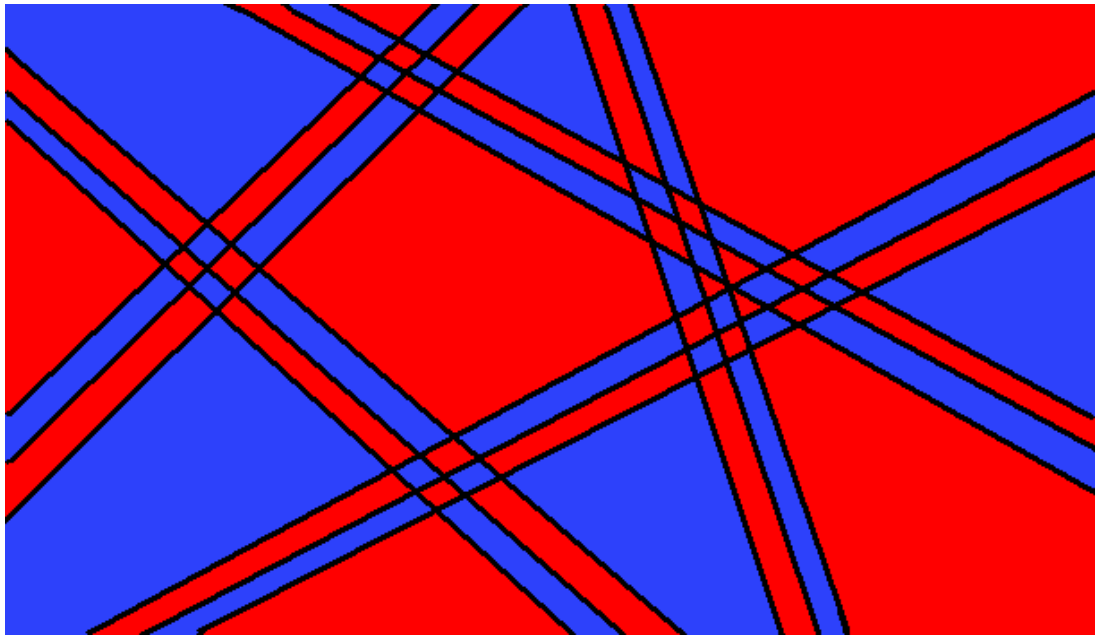


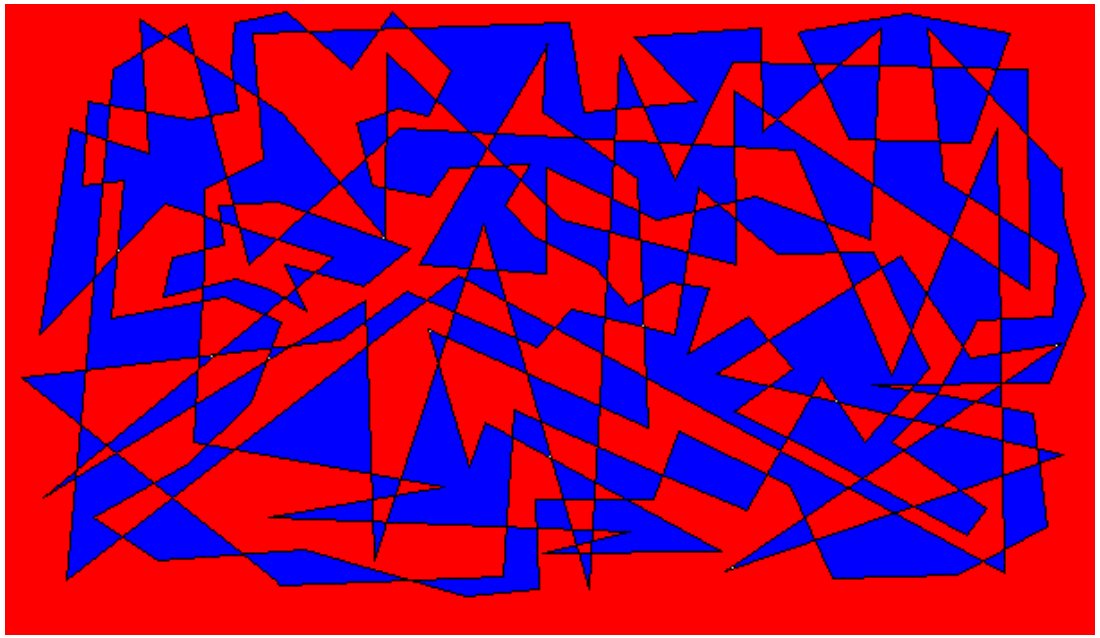


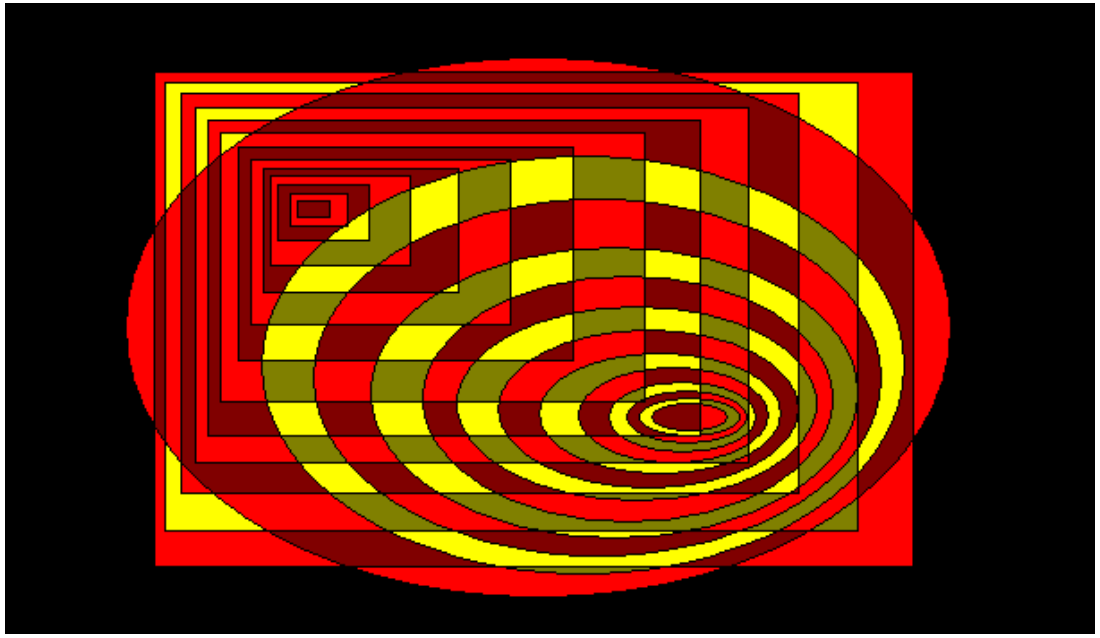
Headgear, Patches, and Montages

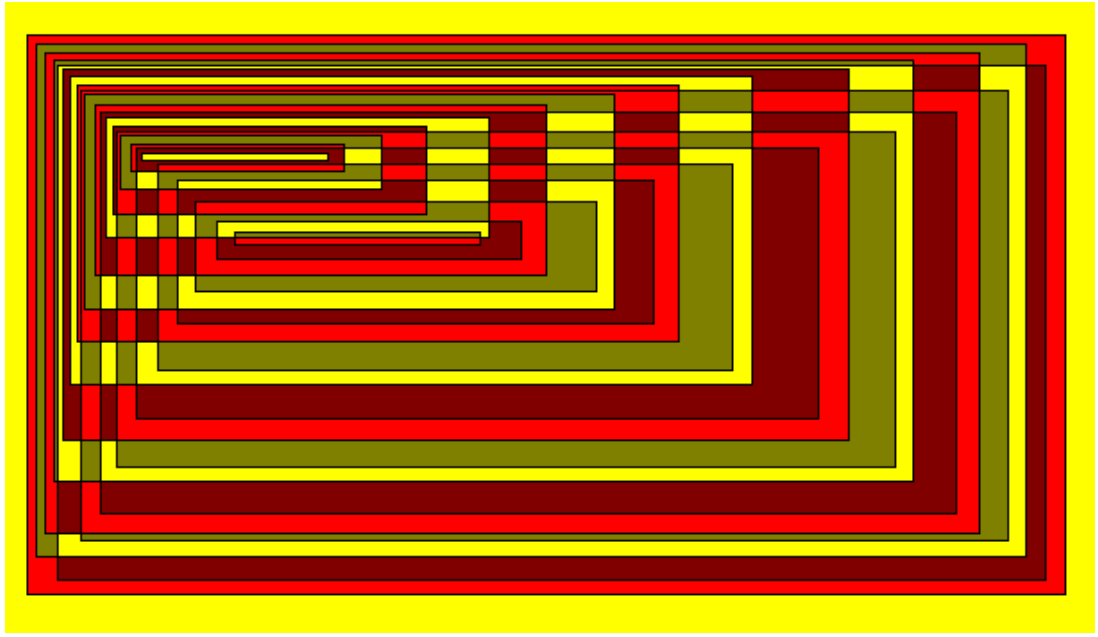


Drawing







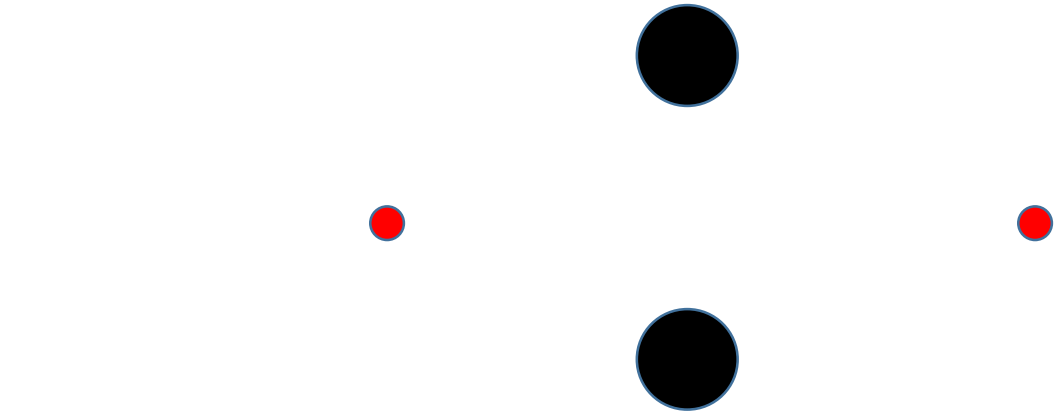


Map Colouring

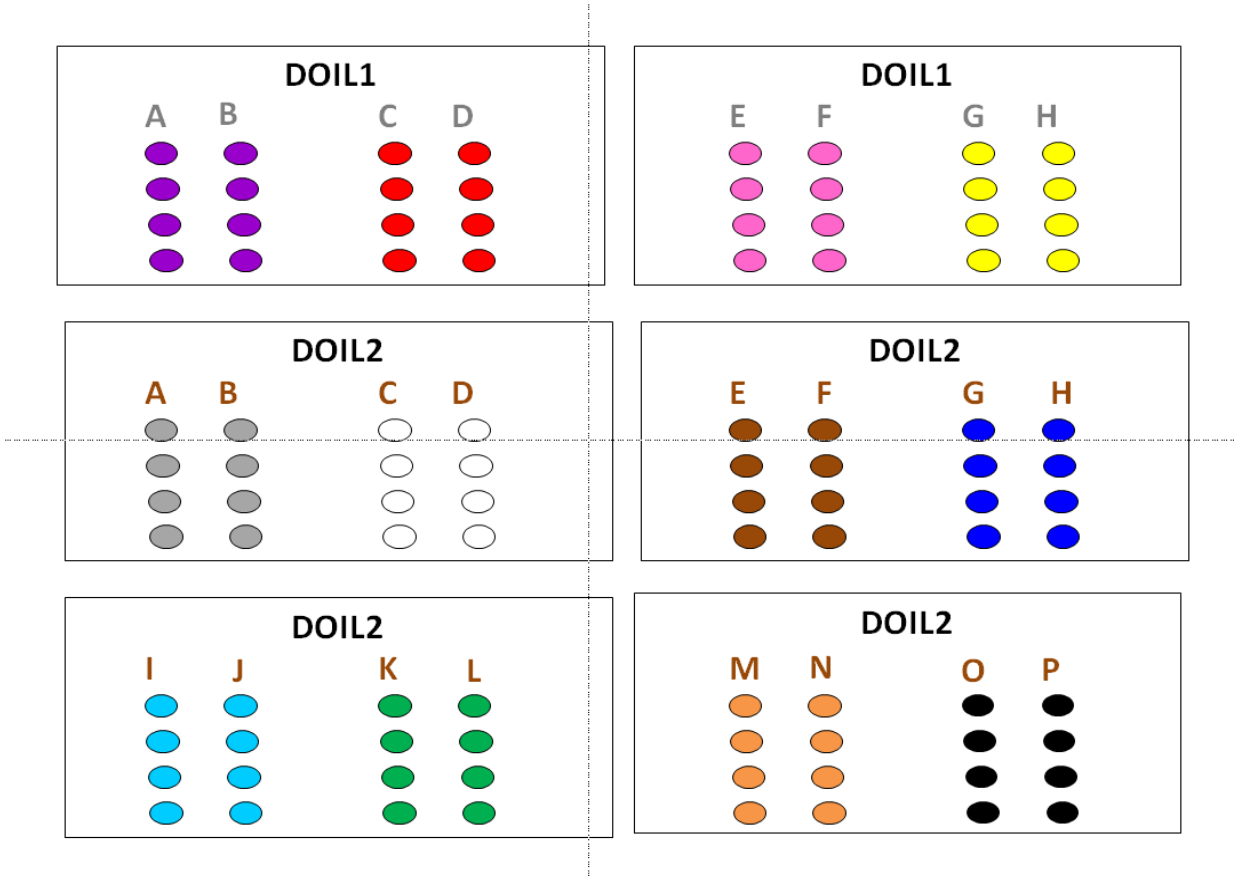
Multiplexing and Crosstalk

Crosstalk

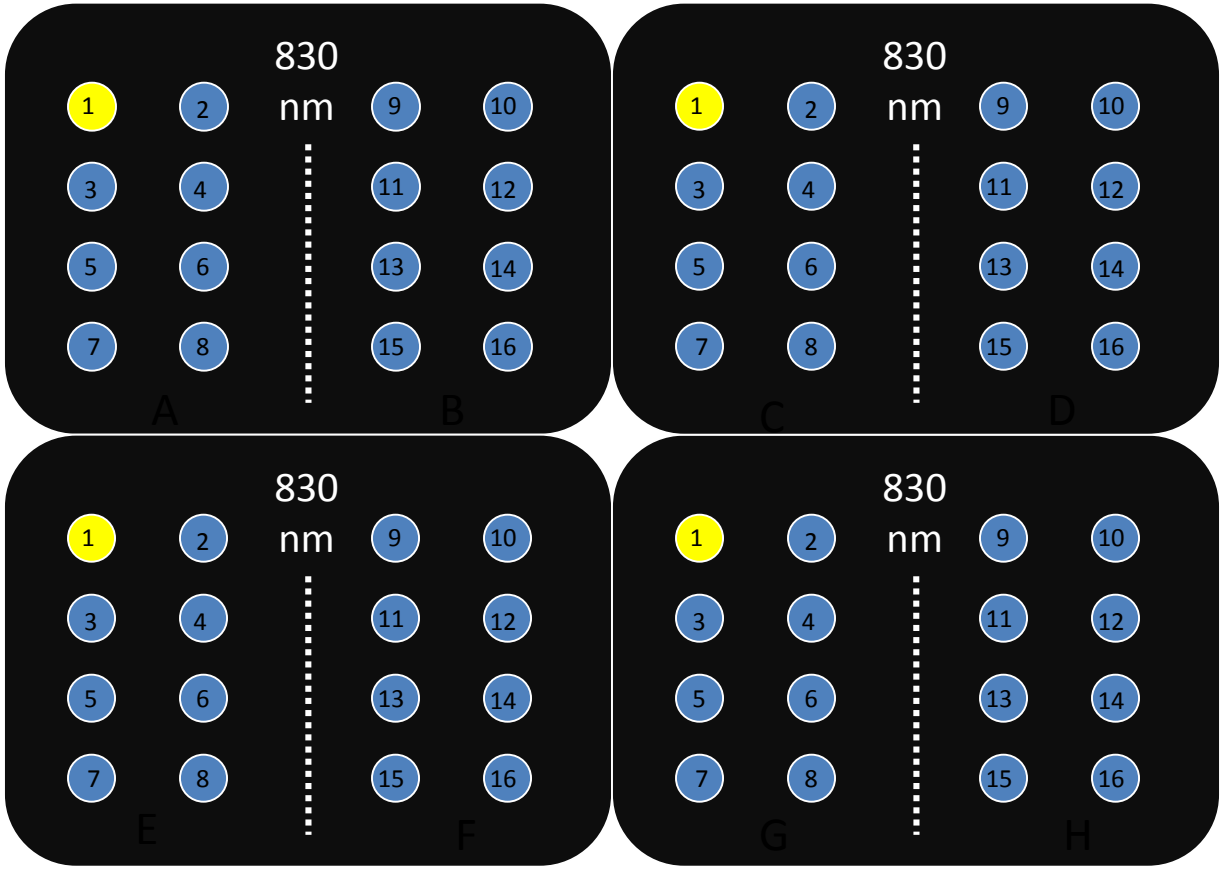
Spatial Multiplexing
Temporal Multiplexing
Frequency Multiplexing



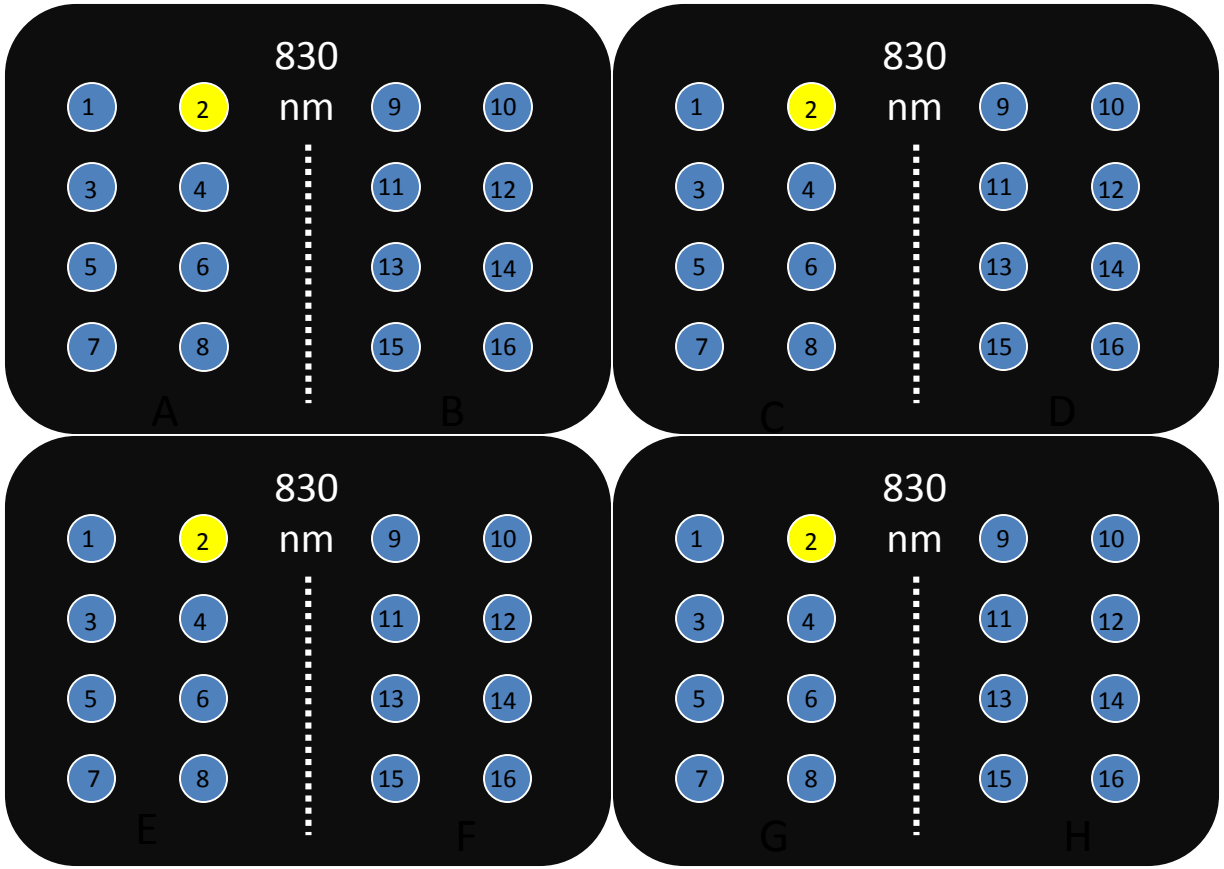
Multiplexing and Crosstalk



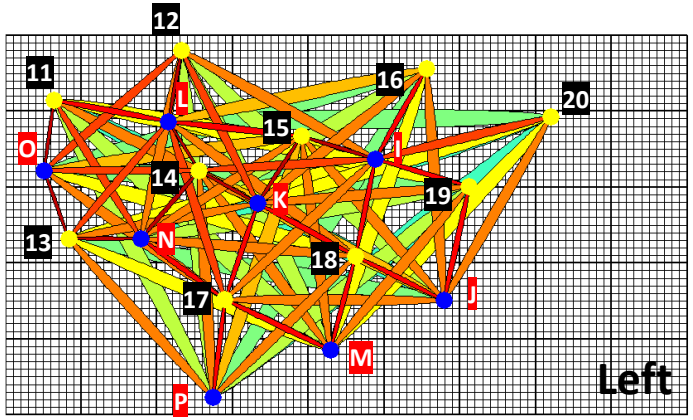
Time Division Multiplexing of Sources

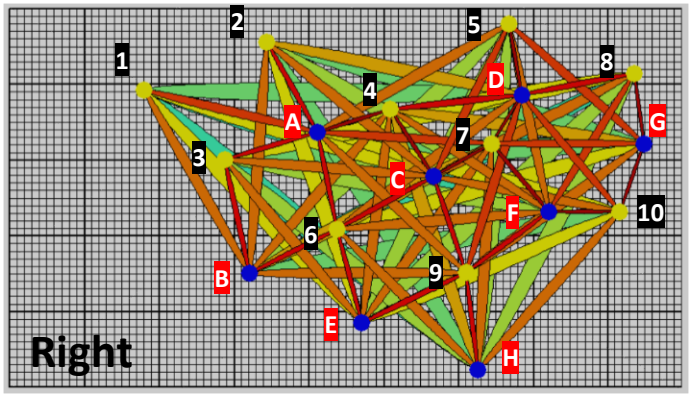


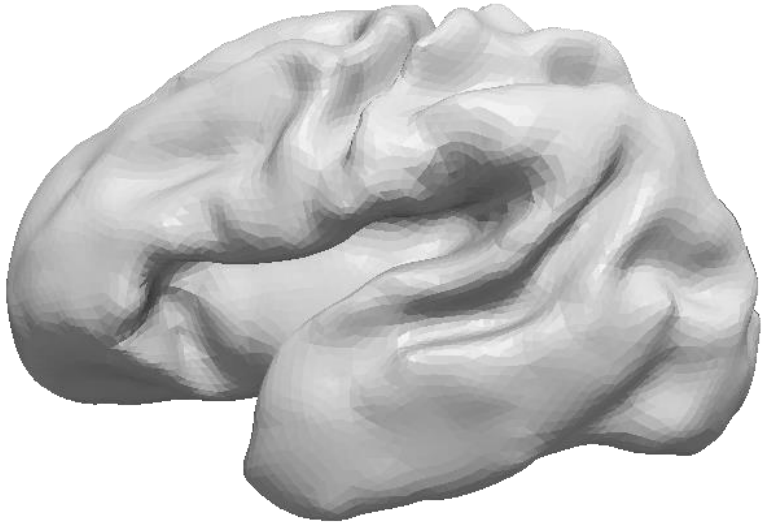
Time Division Multiplexing of Sources

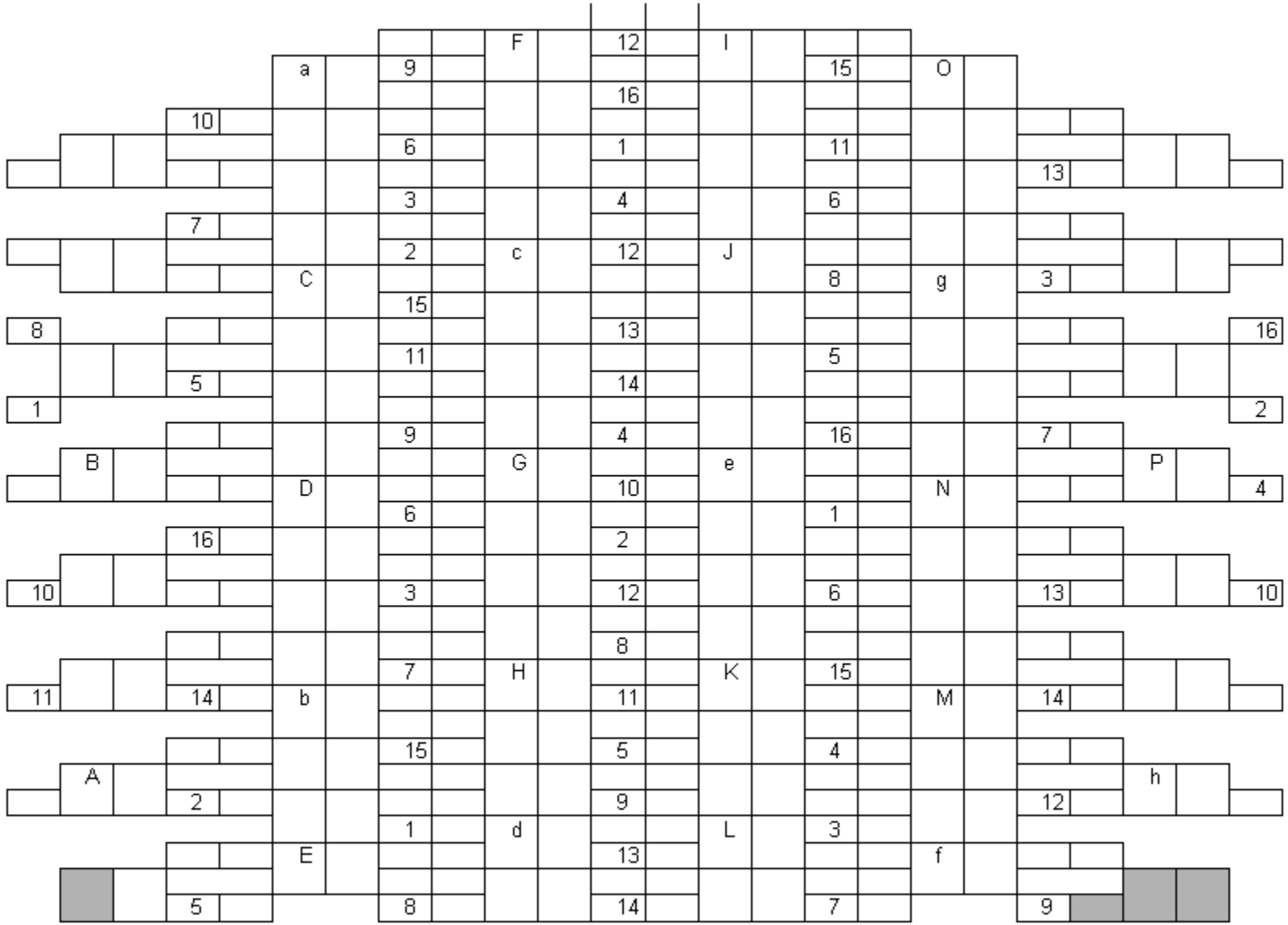


Source and Detector labels used for setup








F
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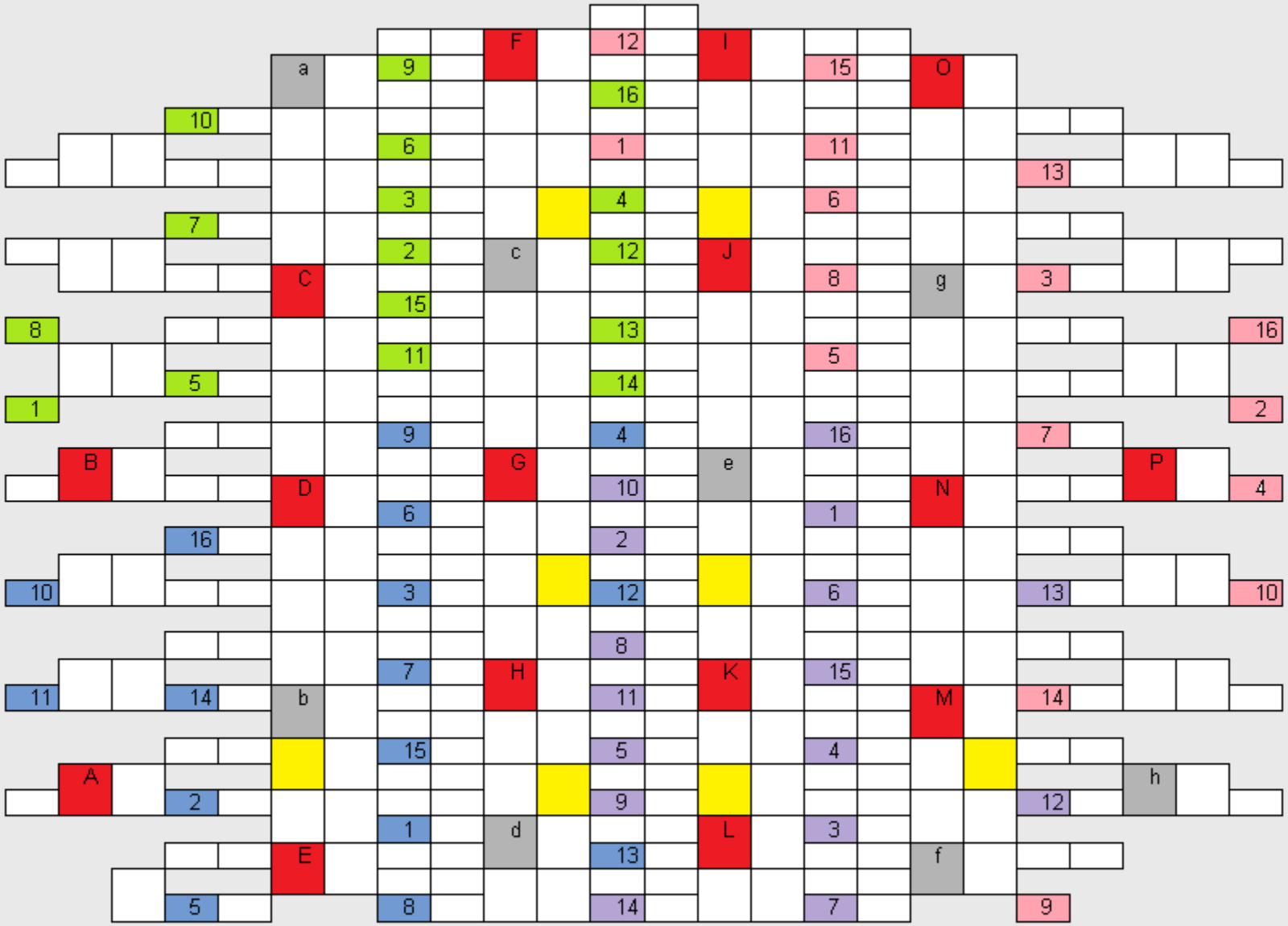
F
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f
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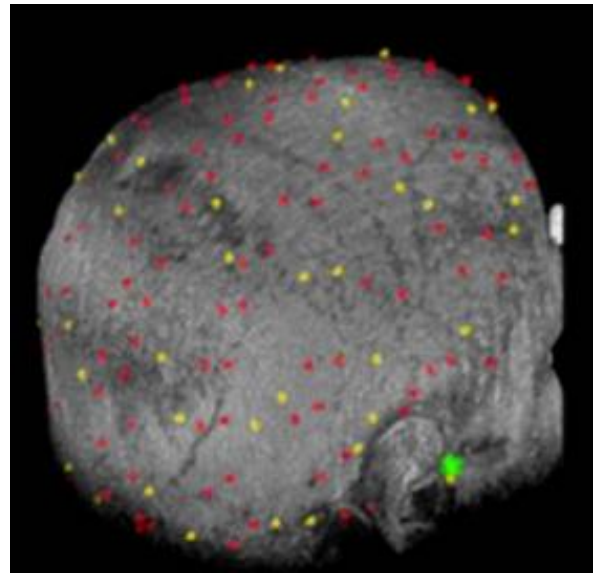
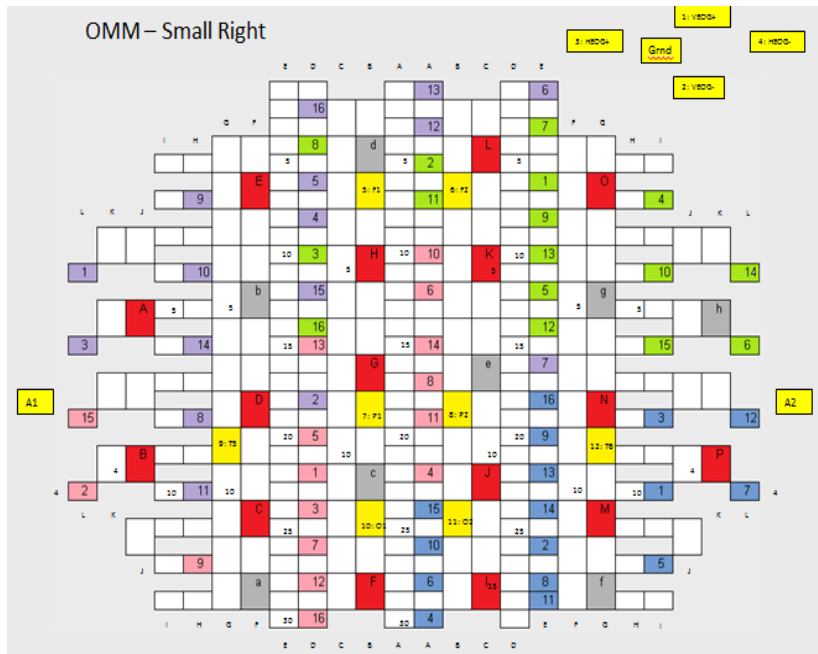
14
7
9

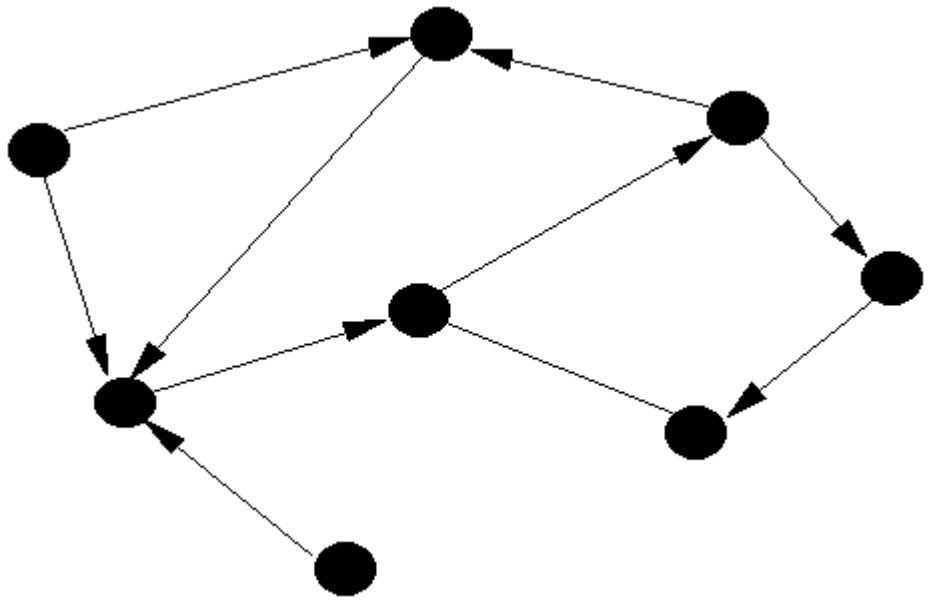
```
3    2
//Probe file
//Minor revision number
1
//ProbeName
%N    Name
//Probe type, number of sensors
1     413
//Position of fiducials X+, Y+, Y- on the subject
%F    9.000000E-002   0.000000E+000   0.000000E+000
%F    6.000000E-003   7.000000E-002   0.000000E+000
%F    -6.000000E-003  -7.000000E-002  0.000000E+000
//Sensor type
%S    400
//Sensor name and data for sensor #   1
%N    LA01
9.496068E-002   2.542426E-004   3.771265E-002
//Sensor type
%S    400
//Sensor name and data for sensor #   2
%N    LA02
9.474291E-002   -1.652279E-004  5.051081E-002
//Sensor type
%S    400
//Sensor name and data for sensor #   3
%N    LA03
9.331623E-002   -1.682153E-004  6.079303E-002
//Sensor type
%S    400
//Sensor name and data for sensor #   4
%N    LA04
9.017427E-002   6.393264E-004   7.171076E-002
//Sensor type
%S    400
//Sensor name and data for sensor #   5
%N    LA05
8.711883E-002   1.622036E-004   8.015445E-002
//Sensor type
%S    400
//Sensor name and data for sensor #   6
%N    LA06
8.265424E-002   3.672390E-005   8.826668E-002
//Sensor type
%S    400
//Sensor name and data for sensor #   7
%N    LA07
7.660089E-002   2.702118E-004   9.611061E-002
```

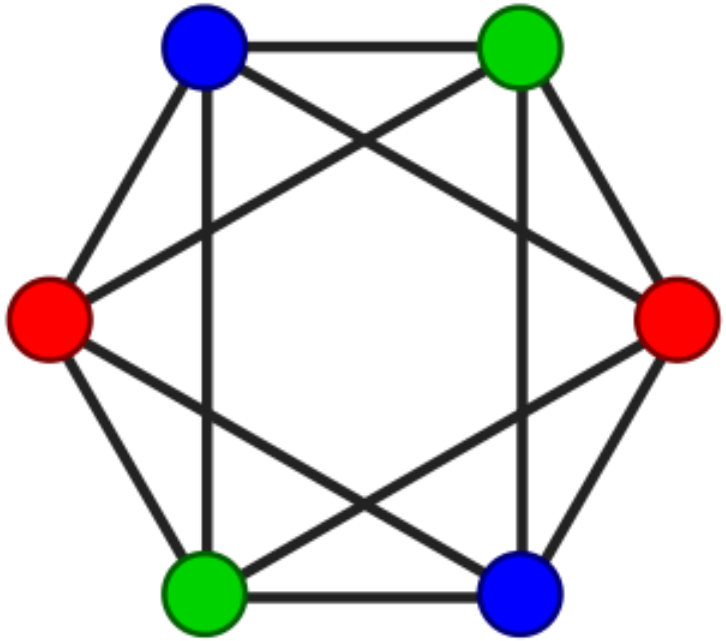




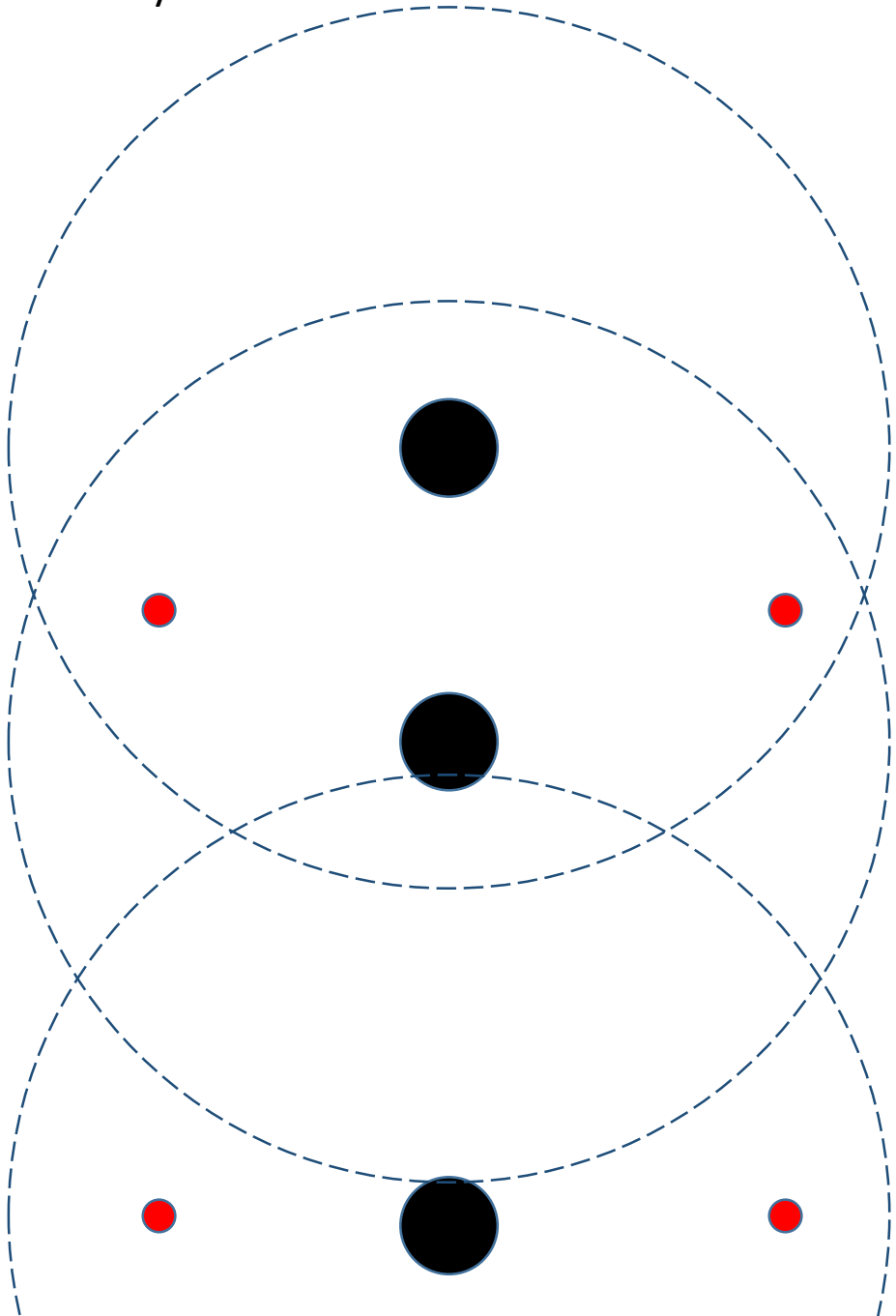

```
NEW
128 256 128 256
1       1       RE09  RJ01  830   110
2       2       RH05  RJ01  830   110
3       3       RL02  RJ01  830   110
4       4       RD09  RJ01  830   110
5       5       RL03  RJ01  830   110
6       6       RH08  RJ01  830   110
7       7       RH12  RJ01  830   110
8       8       RH03  RJ01  830   110
9       9       RL04  RJ01  830   110
10      10      RL01  RJ01  830   110
11      11      RD13  RJ01  830   110
12      12      RH04  RJ01  830   110
13      13      RH06  RJ01  830   110
14      14      RL05  RJ01  830   110
15      15      RE10  RJ01  830   110
16      16      RH02  RJ01  830   110
17      17      RE09  RJ02  830   110
18      18      RH05  RJ02  830   110
19      19      RL02  RJ02  830   110
20      20      RD09  RJ02  830   110
21      21      RL03  RJ02  830   110
22      22      RH08  RJ02  830   110
23      23      RH12  RJ02  830   110
24      24      RH03  RJ02  830   110
25      25      RL04  RJ02  830   110
26      26      RL01  RJ02  830   110
27      27      RD13  RJ02  830   110
28      28      RH04  RJ02  830   110
29      29      RH06  RJ02  830   110
30      30      RL05  RJ02  830   110
31      31      RE10  RJ02  830   110
32      32      RH02  RJ02  830   110
33      33      RE09  RJ03  830   110
34      34      RH05  RJ03  830   110
35      35      RL02  RJ03  830   110
36      36      RD20  RJ03  830   110
37      37      RL03  RJ03  830   110
38      38      RH08  RJ03  830   110
39      39      RH12  RJ03  830   110
40      40      RH03  RJ03  830   110
41      41      RL04  RJ03  830   110
42      42      RL01  RJ03  830   110
43      43      RH13  RJ03  830   110
```

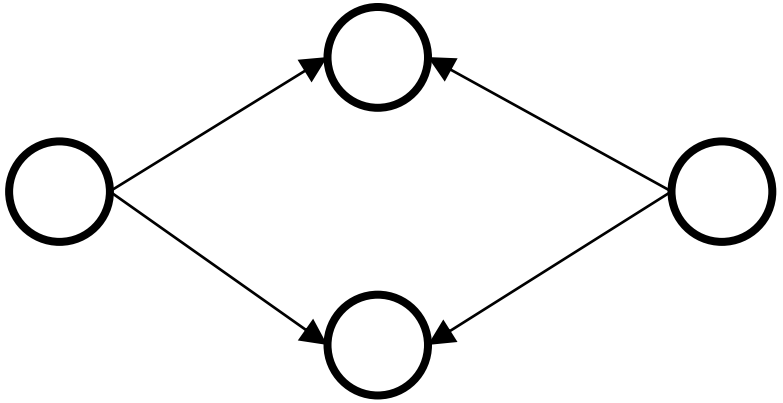
Graph Theory

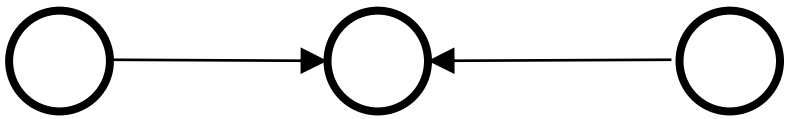




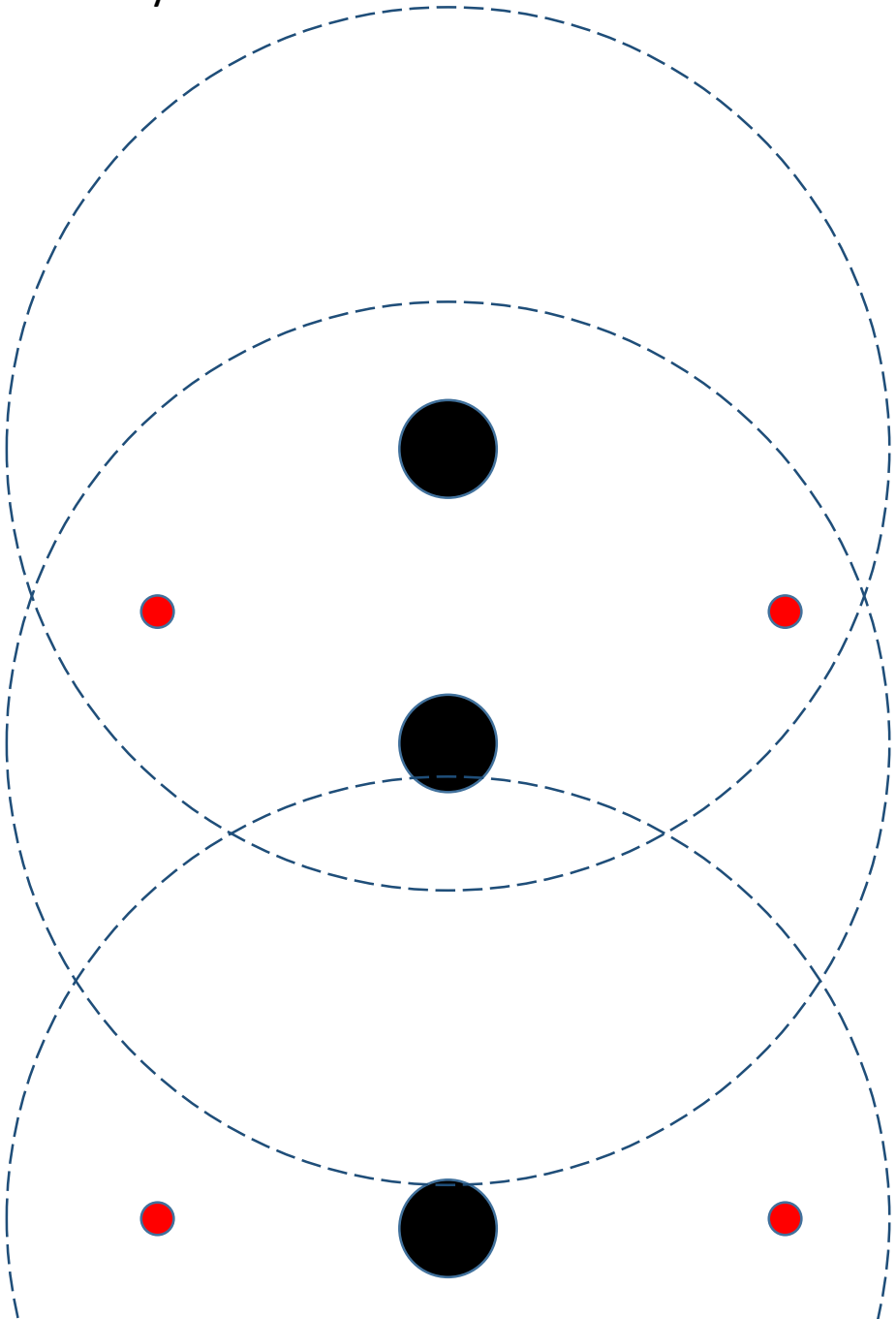
Graph Theory

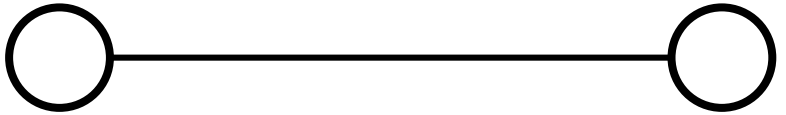


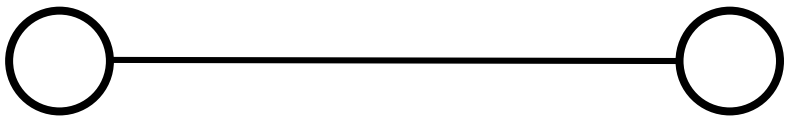




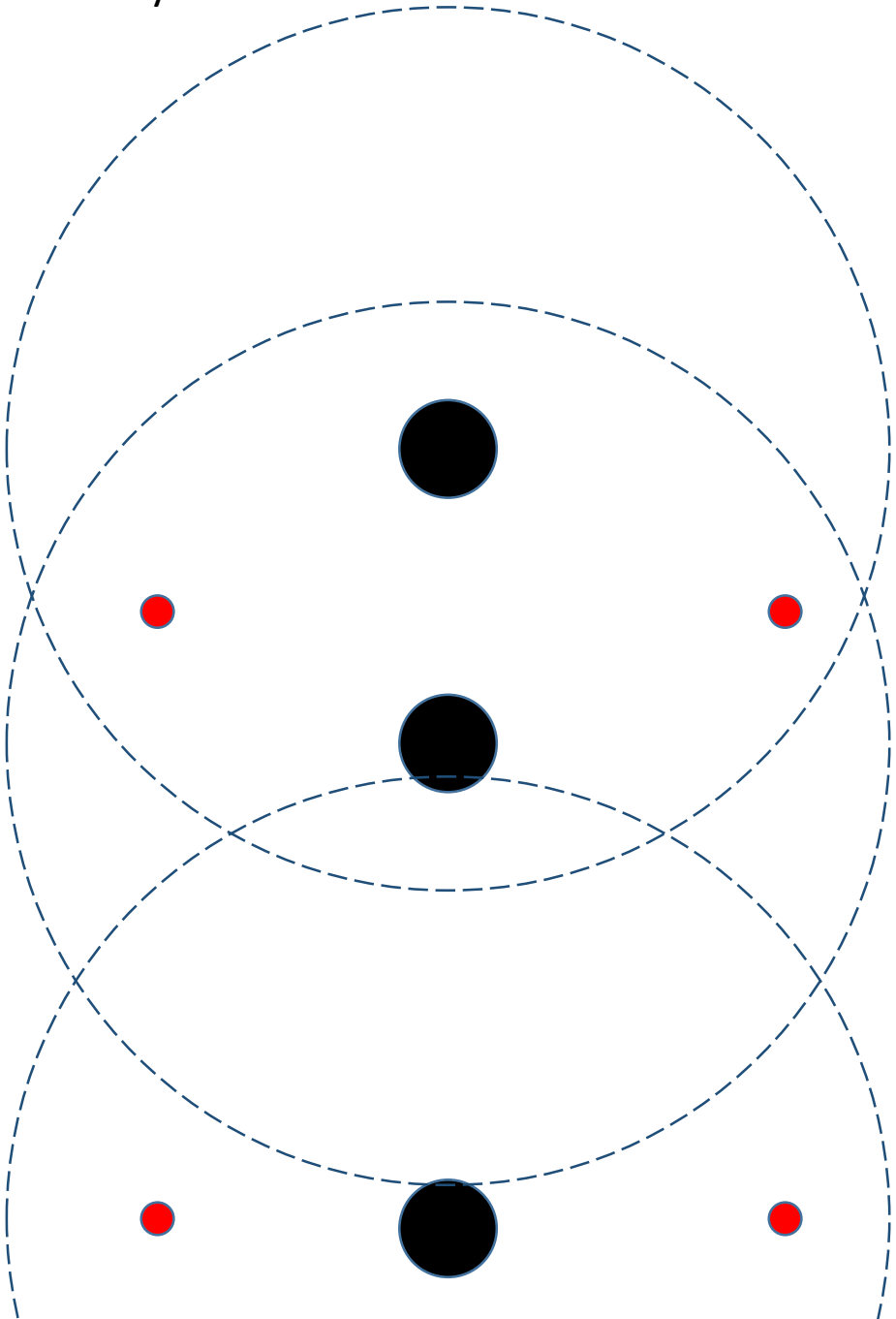
Graph Theory

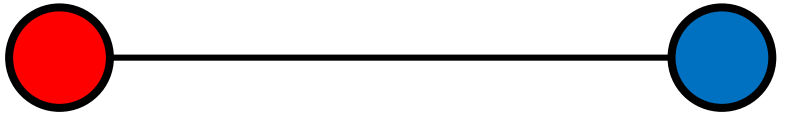


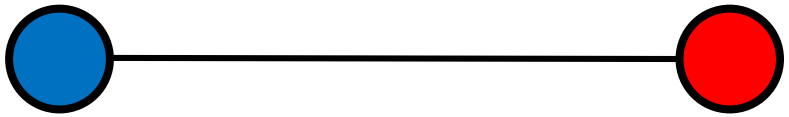




Graph Theory







NOMAD – Near-infrared Optode Montage Automated Design

Main Algorithm

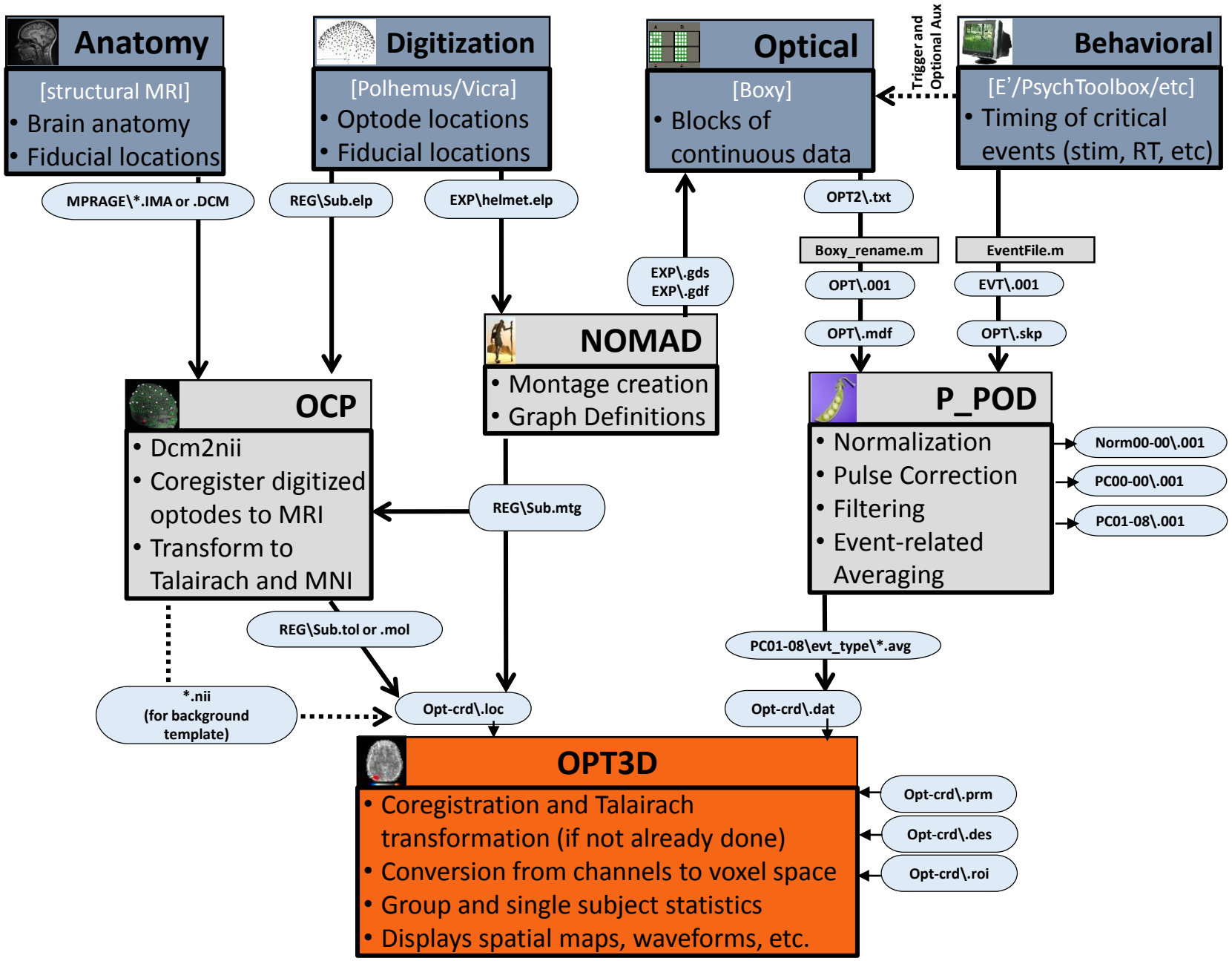
```
function [mux_numbers, mux_list] = monte_carlo_clqmux

clq_swapper = 1:n_clqs;
clq_swapper = clq_swapper(randperm(n_clqs));

mux_list = repmat(1:n_muxs,1,n_banks);
mux_list = mux_list(randperm(length(mux_list)));

mux_numbers = zeros(mtg.n_srcs,1);

for current_clq = clq_swapper
    for i_src = 1:n_srcs
        if src_dist(current_clq,i_src) <= max_dist  && mux_numbers(i_src) == 0
            for i_mux_list = 1:length(mux_list)
                if isempty(find(mux_numbers(E_mat(i_src,:) == 1) == mux_list(i_mux_list),1)) && mux_numbers(i_src) == 0
                    mux_numbers(i_src) = mux_list(i_mux_list);
                    mux_list(i_mux_list) = [];
                    break
                end
            end
        end
    end
end
```


Anatomy
[structural MRI]
• Brain anatomy
• Fiducial locations
Digitization
[Polhemus/Vicra]
• Optode locations
• Fiducial locations
Optical
[Boxy]
• Blocks of continuous data
Trigger and Optional Aux
Behavioral
[E'/PsychToolbox/etc]
• Timing of critical events (stim, RT, etc)
MPRAGE*.IMA or .DCM
REG\Sub.elp
EXP\helmet.elp
EXP\.gds
EXP\.gdf
OPT2\.txt
Boxy_rename.m
OPT\.001
OPT\.mdf
EventFile.m
EVT\.001
OPT\.skp
NOMAD
• Montage creation
• Graph Definitions
OCP
• Dcm2nii
• Coregister digitized optodes to MRI
• Transform to Talairach and MNI
P_POD
• Normalization
• Pulse Correction
• Filtering
• Event-related Averaging
Norm00-00\.001
PC00-00\.001
PC01-08\.001
REG\Sub.mtg
REG\Sub.tol or .mol
PC01-08\evt_type*.avg
*.nii
(for background template)
Opt-crd\.loc
Opt-crd\.dat
OPT3D
• Coregistration and Talairach transformation (if not already done)
• Conversion from channels to voxel space
• Group and single subject statistics
• Displays spatial maps, waveforms, etc.
Opt-crd\.prm
Opt-crd\.des
Opt-crd\.roi

Created by Kyle Mathewson
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Cognitive Neuroimaging Lab
Beckman Institute
University of Illinois

nomad.m

1 SettingGUI.m

2 SchemGUI.m

3 AssignMuxGUI.m

4 OutputGUI.m

nomad.jpg

helmet_schem_maker.m

make_the_montage.m

helm_draw_schem.m
helm_mouse_ixy.m
ginputax.m

mtg_head_plot.m
channel_stat_plot.m

helm_draw_mtg.m

assign_the_mux.m

assign_mux.m
assign_mux_parallel.m

MathewsonMuxCheck.m

nomad.jpg
export_fig.m

a) helm_draw_mtg_out.m
b) output_mtg_combined.m
c) GDF_TextFileGenerator_KM.m
make_colormap.m
get_BoxyColorcode.m

Custom Import

/elp/

helmet_name.elp

Load Struct

Save Struct

/Examples/

XXX_large.mat

GDF Folder Dist Map

/GDF
/DOIL1_Large
/Session A|B
/DC|AC|PH/

Large_SeshA_DOIL1_DetA_DC.txt

/reg/

XXX_large_Dist.bmp

.mtg file

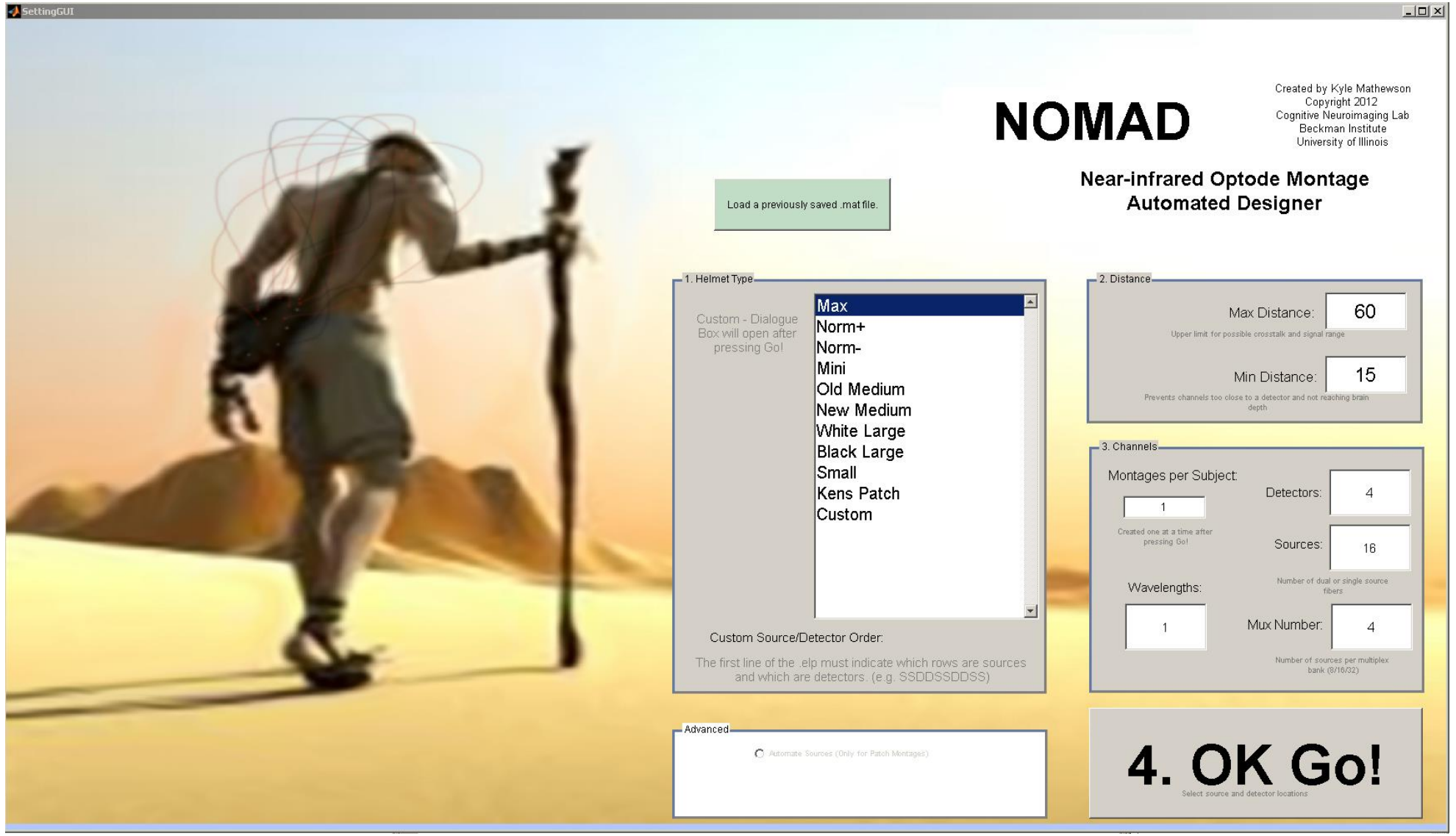
/reg/

XXX_large.mtg

Schematics

/reg/

XXX_large_A.bmp
XXX_large_B.bmp


SettingGUI
NOMAD
Created by Kyle Mathewson
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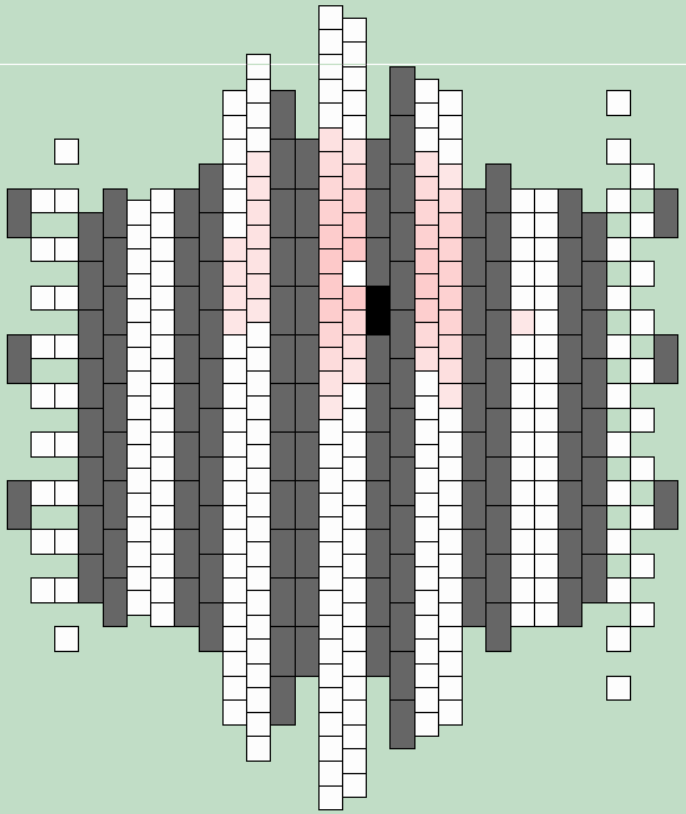
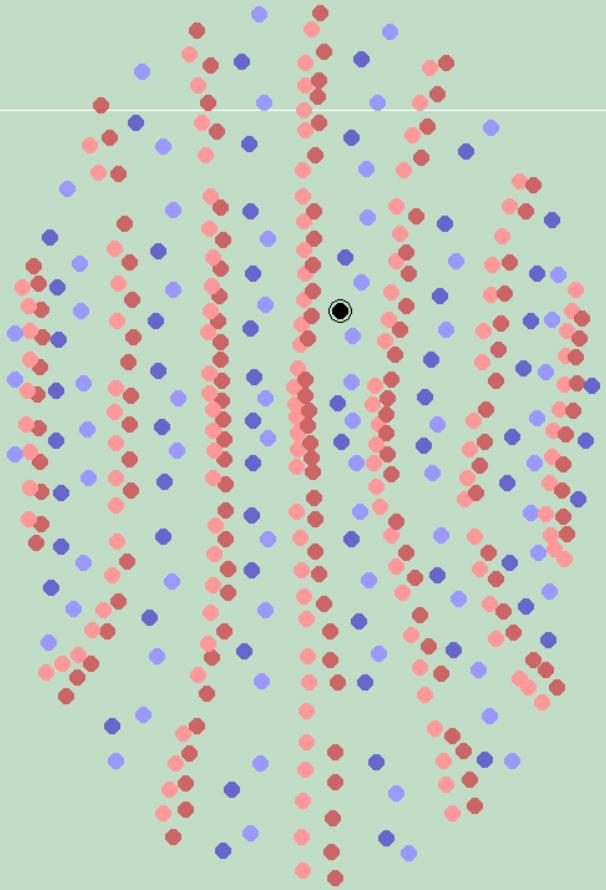
Cognitive Neuroimaging Lab
Beckman Institute
University of Illinois
Near-infrared Optode Montage
Automated Designer
Load a previously saved .mat file.
1. Helmet Type
Custom - Dialogue Box will open after pressing Go!
Max
Norm+
Norm-
Mini
Old Medium
New Medium
White Large
Black Large
Small
Kens Patch
Custom
Custom Source/Detector Order:
The first line of the .elp must indicate which rows are sources and which are detectors. (e.g. SSDDSSDDSS)
2. Distance
Max Distance:
60
Upper limit for possible crosstalk and signal range
Min Distance:
15
Prevents channels too close to a detector and not reaching brain depth
3. Channels
Montages per Subject:
1
Created one at a time after pressing Go!
Detectors:
4
Sources:
16
Number of dual or single source fibers
Wavelengths:
1
Mux Number:
4
Number of sources per multiplex bank (8/16/32)
Advanced
Automate Sources (Only for Patch Montages)
4. OK Go!
Select source and detector locations

SchemGUI

Montage Design

There are 3 detectors remaining.





Restart

--First click either plot to select detector locations (black), right click to remove a location.
--Red areas represent areas within the optimal range of detectors.
--Next click to select from the red locations each source location (Blue).
--White areas are either too far from a detector or too close to a detector.
--Grey areas within range of detectors that already have too many sources.
--Right click (with caution) to remove a source. Or just Restart.
----Press Done when complete to assign mux numbers

Use these to adjust the spaceing of the sources and detectors and refresh the window.

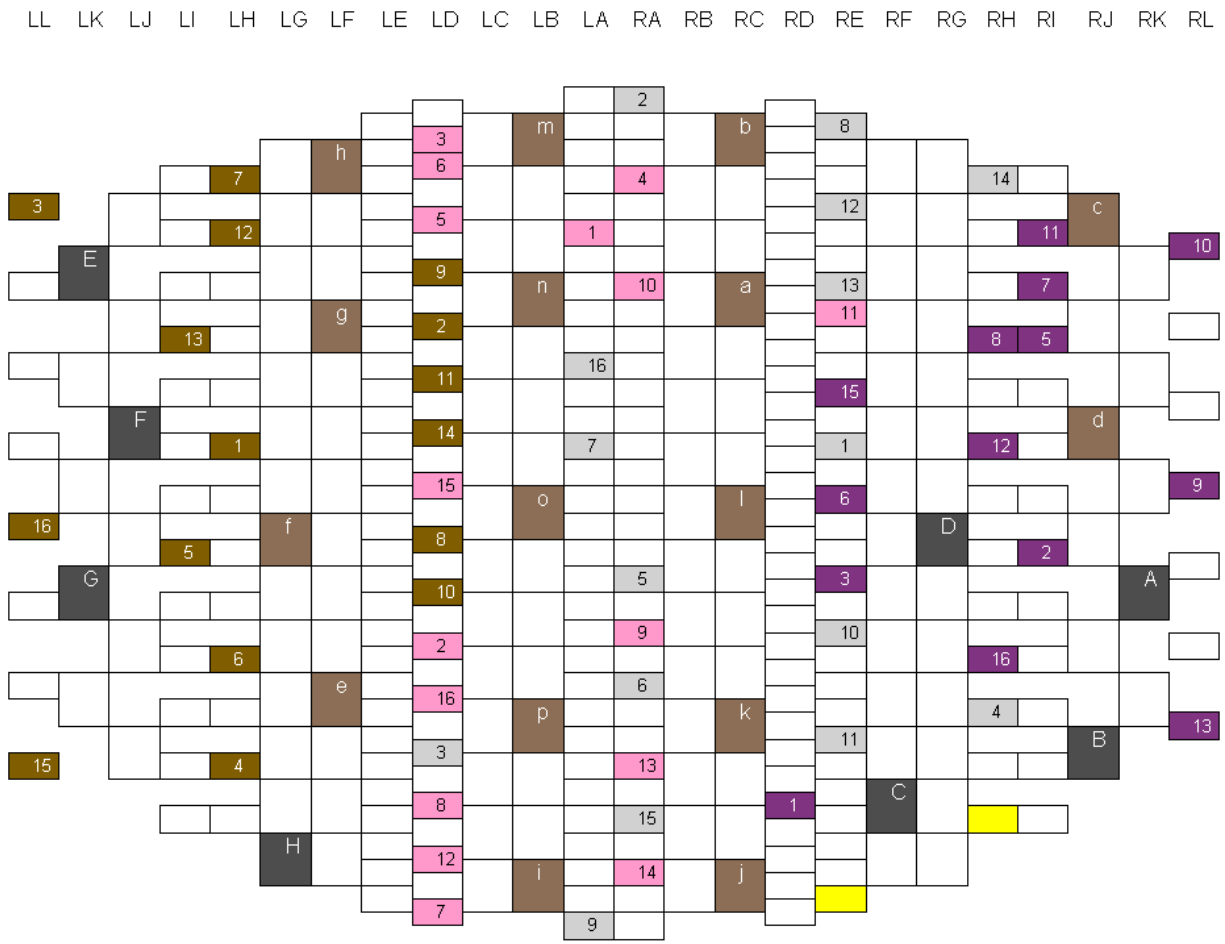
Space Det | Space Src

Squeeze Det | Squeeze Src

Done

Back

AssignMuxGUI



NOMAD

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Automated Multiplex (MUX) Assignment

1. Plot Bananas

These are combined accross both montages

2. Channel Stats

3. Select Current Montage

Montage Number

1

Show

Remember to colour each montage by selecting here!

Press to assign mux numbers

4. Colour!

Monte Carlo Trys: 10

Schematic Style

Colouring: DOIL

Color of the labels on the fibers and imagent. Custom will bring up a prompt later.

Advanced Assignment

Parallel Toggle

Mux Assignment Algorithm:

Monte Carlo

Mux Number:

16

Increase trys for difficult solutions. Parallel to engage multiple cores. Monte Carlo works best and fastest generally. Try to lower Mux number if no solution found.

5. Crosstalk Check

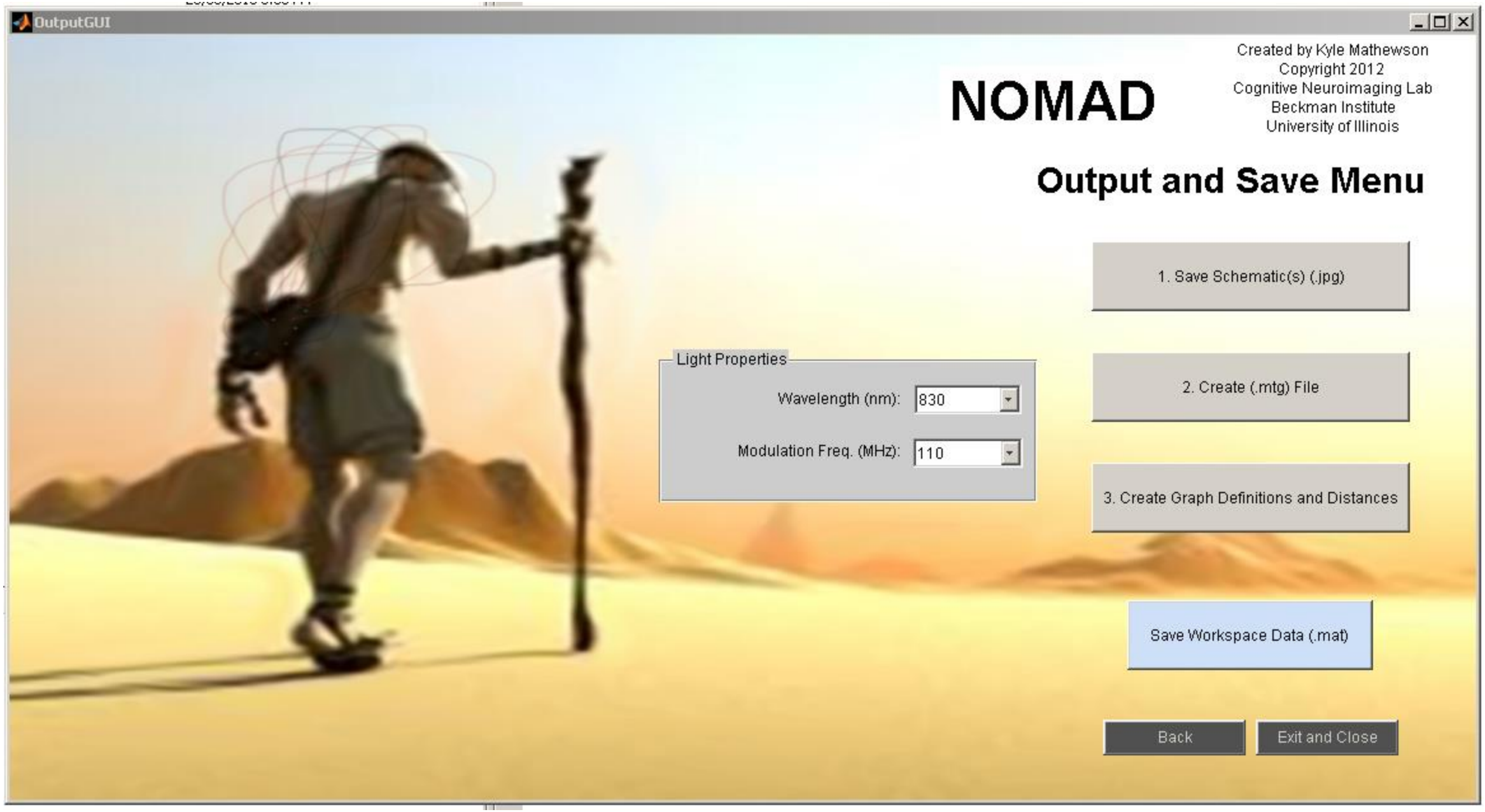
Safeguard to validate colouring

Back to Reset Positions

Remember to colour all montages

6. Done all Montages!

Create output files and save


OutputGUI
NOMAD
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Output and Save Menu
1. Save Schematic(s) (.jpg)
Light Properties
Wavelength (nm):
830
Modulation Freq. (MHz):
110
2. Create (.mtg) File
3. Create Graph Definitions and Distances
Save Workspace Data (.mat)
Back
Exit and Close

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nomad.m

1 SettingGUI.m

2 SchemGUI.m

3 AssignMuxGUI.m

4 OutputGUI.m

nomad.jpg

helmet_schem_maker.m

make_the_montage.m

helm_draw_schem.m
helm_mouse_ixy.m
ginputax.m

mtg_head_plot.m
channel_stat_plot.m

helm_draw_mtg.m

assign_the_mux.m

assign_mux.m
assign_mux_parallel.m

MathewsonMuxCheck.m

nomad.jpg
export_fig.m

a) helm_draw_mtg_out.m
b) output_mtg_combined.m
c) GDF_TextFileGenerator_KM.m
make_colormap.m
get_BoxyColorcode.m

Custom Import

/elp/

helmet_name.elp

Load Struct

Save Struct

/Examples/

XXX_large.mat

GDF Folder Dist Map

/GDF
/DOIL1_Large
/Session A|B
/DC|AC|PH/

Large_SeshA_DOIL1_DetA_DC.txt

/reg/

XXX_large_Dist.bmp

.mtg file

/reg/

XXX_large.mtg

Schematics

/reg/

XXX_large_A.bmp
XXX_large_B.bmp

Tutorial

Limitations

-it works, but don't know when to stop for very hard graphs

-takes a while, because its stupid

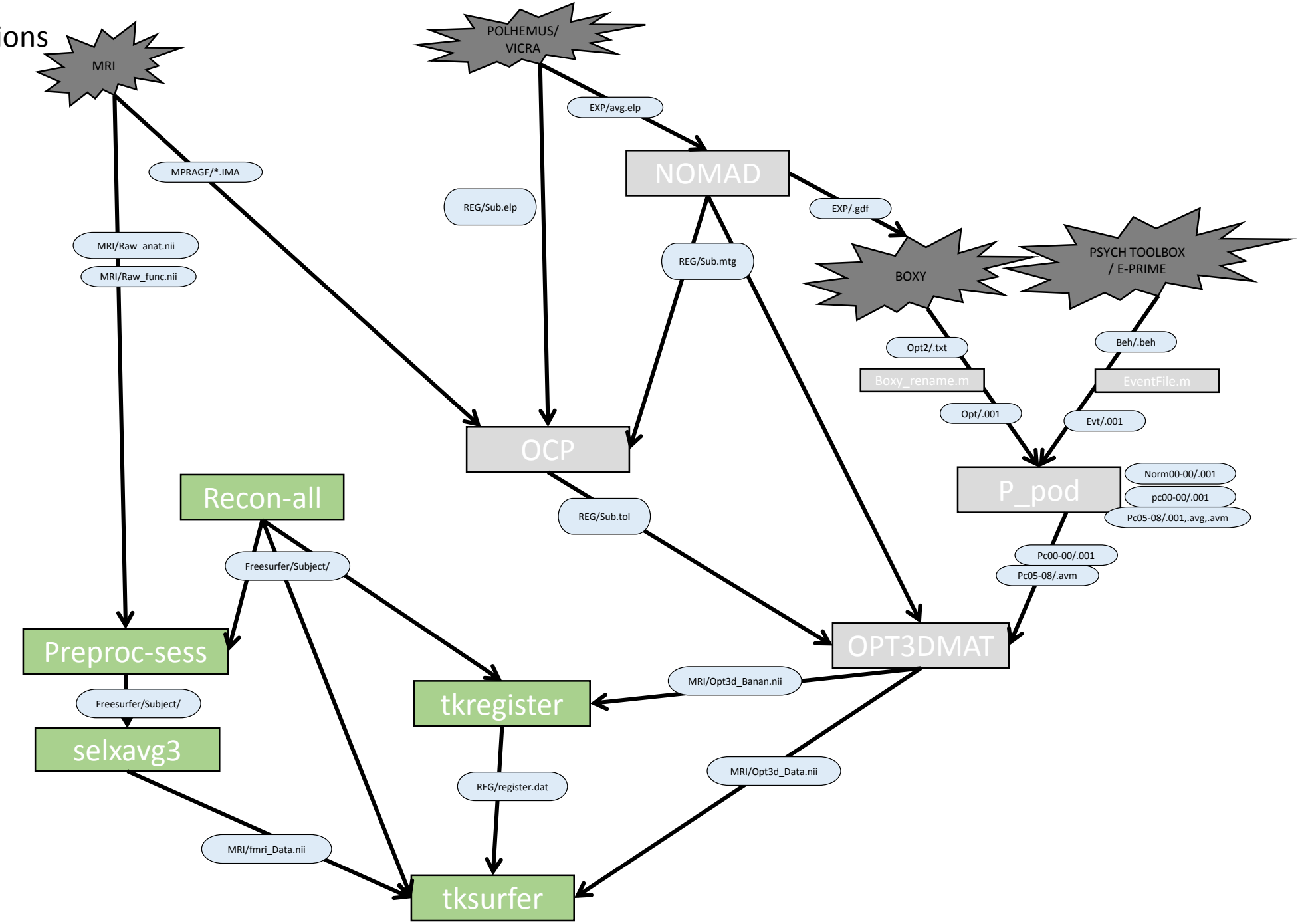
-the chance of finding a solution in iteration n is unrelated to chance in n-1

-can't be sure you are on the absolute minima

Mathewson, K. E., Beck, D. M., Ro, T., Maclin, E. L., Low, K. A., Fabiani, M., & Gratton, G. (2014). Dynamics of alpha control: preparatory suppression of posterior alpha oscillations by frontal modulators revealed with combined EEG and event-related optical signal. *Journal of cognitive neuroscience*,*26*(10), 2400-2415.

Mathewson, K. E., Low, K., Maclin, E. L., Owens, G., Fabiani, M., & Gratton, G. (in preparation). A graph coloring solution for the assignment of temporal multiplexing location in diffuse optical imaging.

Future Directions



Future Directions