Creating SSP operators for the Vectorview and Neuromag systems

Pre-requisites:

- Vectorview or Neuromag Systems hardware
- Neuromag software release 3.2.1 or later

These instructions can be followed also to update the SSP operator in a previously recorded data file; steps 3 ... 7 are valid for this purpose, however, all references to the directory `/neuro/ssp` should be replaced by the directory containing the raw data. The utility `copy_proj_fiff` can be used to replace the SSP vectors in a FIFF file.

Procedure:

1. Tune all the channels. Make a note of extremely noisy or nonfunctional channels.
2. Do "empty room" measurements both in upright and supine positions. Use 600 Hz sampling, 200 Hz low-pass, and 0.1 Hz high-pass. Record raw data for about two minutes in both positions. Save the raw data files with names like `empty_room_upright.fif` and `empty_room_supine.fif`.
3. Start the Signal processor (*Graph*) program. Load or create a Graph setup, which includes at least the ssp and pca packages in addition to the basic setup. These additional modules can be loaded by the lisp commands

   ```
   (require "pca")
   (require "ssp")
   (require "std-selections")
   ```

   Create and connect the widgets as follows (the *type* of the widget is in parenthesis and the name you should give to the widget is before the parenthesis):

   file(*diskfile*) **->** buffer(*ringbuffer*) **->** meg(*pick*) **->**

   ssp(*suppressor*) **->** pick(*pick*) **->** display(*plotter*)

   Change the buffer size of ssp widget by double-clicking its icon: Enter 20000 (the default is 2000, which is too low). Increase also the buffer size of the buffer widget to 1000000 to speed up the processing.
4. To calculate the SSP operator for gradiometers, change the 'names' resource of the meg widget to `MEG*` and 'ignore' to `MEG*1`. This retains the original order of the gradiometer channels in the data file. For magnetometers, change the 'names' resource to `MEG*1`.

   Add the bad channels found at step 1, if any, as 'ignore'd channels so that they won't spread the noise to the good channels via the SSP.

   Open the raw data file. Use 'Selections' menu to display and browse through the channel sets of interest. You may want to enable the 'superpose' function of the 'display' widget for a better view.

   Enter the lisp command

   ```
   (pca-on-widget 'meg 0 120)
   ```

to calculate the principal components for the timespan 0 .. 120 seconds since the beginning of the file.

Once the PCA calculation is complete, open the 'SSP dialog' from the 'Commands' menu. Select 'Add PCA fields' from the 'Actions' menu, then select '8 vectors'. You should get an entry like PCA[204,8] in the vector pool. Select it by clicking it and do 'Explode' from the 'Edit' menu. Now you can apply the vectors one at a time by first selecting the vector (start from PCA-v1 as it is the one corresponding to the largest singular value) and then clicking the right arrow, which copies the vector to the SSP vector panel. The suppressor automatically turns on once there is at least one vector assigned for it. You should see a decreasing noise level on the display as you keep on adding vectors.

Once you have decided how many and which vectors you need, delete the rest ALSO from the vector pool! Then click File/Save and give a file name like

```
/neuro/ssp/grad_ssp_upright.fif
```

or

```
/neuro/ssp/grad_ssp_supine.fif
```

depending on whether the loaded file was the supine (bed) or upright (chair).

Generally, 5 vectors for magnetometers seem to be enough in most cases, and 0 ... 3 vectors for gradiometers. Using more vectors, of course, make the raw data look better but they unnecessarily attenuate brain signals as well and complicate analysis. So, do not use more vectors than necessary.

Select a short timespan (less than one second) of raw data on the display with the right mouse button. Select 'Make evoked file' in the File menu of the Graph window. Give a file name like

```
/neuro/ssp/grad_names.fif
```

5. Open a terminal window. Do

```
cd /neuro/ssp
/neuro/bin/util/add_proj_namelist -f grad_names.fif
        grad_ssp_upright.fif
```

This operation adds the channel names to the SSP vectors.

6. You may now repeat steps 4. and 5. for magnetometers. Of course, delete the previous SSP vectors both from the pool and SSP panels and set 'names' resource of the meg widget to MEG*1 before doing the PCA for the magnetometers. Save the results to files like

```
/neuro/ssp/mag_ssp_upright.fif

/neuro/ssp/mag_names.fif
```

7. Combine the gradiometer and magnetometer SSP operators in the Source modelling program (XFit).

Open an evoked response file which has data from all channels (both magnetometers and gradiometers if you are going to do the operator for both types of sensors.) Open the 'Projection' window and use File/Load to load your newly created

`/neuro/ssp/grad_ssp_upright.fif`

and

`/neuro/ssp/mag_ssp_upright.fif`

Check the "Allow measurement ID mismatch" before loading the above files.

Select all the SSP vectors in the projection list. Click File/Save and give a file name like

`/neuro/ssp/online_upright.fif`

8. Check the file permissions and create a symbolic link

```
cd /neuro/ssp
chmod 644 online_upright.fif
ln -s online_upright.fif online.fif
```

9. Test the new SSP operator by starting the acquisition and checking the signals on the raw data display with the "Apply SSP" button in the 'Scales' window on and off. If the button is insensitive (i.e., you cannot click it on or off), the file `/neuro/ssp/online.fif` (or the file it points to) does not contain valid SSP vectors or is unreadable.
10. Repeat the steps 4. through 8. with the raw data from the supine position. Remember to replace the word 'upright' by 'supine' in the file names.
11. When both `online_upright.fif` and `online_supine.fif` are present, the GantryPositionSelect utility (in the Neuromag/Maintenance toolbox) can be used for switching between these two SSP operators. The newly selected operator is activated at the next acquisition start ('GO' button press).