fMRI/DTI analysis using Dynasuite
(revised 4/12/19)

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1 Logging in

Log-in to the Dynasuite workstation using your DHE username and password. There is a workstation in the DMP reading room and in the DMP MRI suite. There are 2 other workstations in offices (Petrella & Voyvodic).

Run the DynaSuite software by double clicking the "DynaSuite" icon on the desktop.

This will bring up InVivo's login window for Dynasuite.
   Leave the Workspace as "dynasuite"
   Generic login name: dynasuite
   Generic password: dynasuite
If successful this will start Dynasuite, which will fill your screen

2 Finding a patient session

Scan sessions are organized in Dynasuite by scanner manufacturer, or you can find any session by selecting "All Studies" in the navigation pane (upper left side of screen).
   Double-click the study you want to examine (loading may take a minute).

Studies are usually sorted by date (most recent first) – you can change/check the sort order by right-clicking in the navigation pane and selecting the Sorting option.
Once you enter a study you should see:

Left side of screen:
- Applications: Use "Smart fusion" for most fMRI/DTI analysis
- Other Images: Original images imported to Dynasuite (e.g. from scanners)
- Reports: Text documents (e.g. from Neuroquant)
- Results: User-generated DICOM image results made in Dynasuite

Middle of screen:
Image viewing region: In "Smart Fusion" this has 3 planes plus a 3D recon window.
By default this window will show the 3DT1 reference data set.
- You can change the base image by dragging another data set to lower-left corner of any of the 3-plane views and replacing the current view
- You can overlay other images onto the base image by dragging a data set to the lower-left corner and adding it as another view
- Select which view is active by clicking the arrow in the lower-left corner of the window and then selecting a view

Right side of screen:
- Top: Dynasuite processed images
  - Anatomical
    - Original images recognized as suitable for processing
    - The most important of these is "3DT1" – it is the reference for all others
  - Diffusion
    - Map results of DTI analysis (processed "DTI" images in Anatomical list)
  - fMRI
    - Map results of fMRI analysis (recognized tasks from Anatomical list)

Right side, bottom of screen:
The lower right portion of screen changes depending on which Image data set is currently active.
If you are running the "Smart Fusion" application:
The upper part of this region is series-dependent, changing each time you select a different image set (by clicking on it). This panel will have adjustment icons to let you check or change image properties. The icons will change depending on what type of image series is currently selected.

The lower part of the region displays ROI's drawn for this patient and lets you generate and manipulate fiber-tracking results.
Processing fMRI/DTI scans

Analyzing fMRI scan sessions has several steps:
1. Align all other images to the high-resolution T1 images (SPGR/MPRAGE)
2. Overlay fMRI maps on T1 anatomical images
3. Adjust fMRI activation threshold levels
4. Save overlaid images as DICOMs and send to PACS
5. Send Neuronavigation images and overlays to Temp filesystem for making montages
6. Send Neuronavigation images and overlays to PACS (for Brainlab/Synaptive)
7. Overlay fMRI maps on FLAIR images
8. Overlay DTI color FA map on T1 or FLAIR
9. Do DTI fiber-tracking if needed
10. Make multi-slice montage images (not in Dynasuite software)

The following instructions go over most of these steps in detail.
But before that there are some general tips for manipulating the Dynasuite user interface.
Note: These instructions assume you are using the Smart Fusion application, but the basic interactive features are similar for other applications.

Viewing and adjusting images

Within each orthogonal viewing pane you can manipulate the slice location in the other panes by dragging the crosshair.

Right-clicking the mouse will bring up a control wheel.
Around the edge of the wheel are display control options; these let you select what the left mouse button controls (e.g. brightness, position, zoom, rotation, etc).
Inside each display control there is an arrow; these give you more control options.
The arrow at the top of the wheel allows you to change various display settings.
The camera icon in the upper-left part of the wheel lets you save a snapshot of the current image, or if you choose its arrow you can save a whole series of images for that pane.

At the lower-left of each viewing pane there is an arrow and legend. Clicking a legend icon selects that portion of the display (i.e. base image or overlay); for example, if an overlay is active then the display adjustments will be applied to the overlay.
Clicking the arrow in the lower-left corner shows what is currently being displayed in that pane. You can turn on and off different components by clicking the 'eye' icon for each.

To change the image series being displayed, drag the new series you want to see from the Image list on the right of the screen and drop it on the current base image in the image legend (e.g. 3DT1). Only one image series will be shown in full gray-scale at a time.

To add another image series as a color overlay on top of the base images, drag that series from the Image list and hover over the legend; you will then be able to either
drop it on top of an existing series name (replacing that series), or drop it in an empty
legend slot to add it as another overlay.

In the 3D reconstruction pane, the lower-left arrow also lets you manipulate transparency
of different components of the 3D scene, and it allows you to select different cutting
planes for looking within the reconstructed brain.

Step-by-step instructions

1. **Align all other images to the high-resolution T1 images (SPGR/MPRAGE)**

Dynasuite uses a whole-brain T1 scan (3DT1) as its reference for all other processing. If it does not recognize a scan as 3DT1 (T1-weighted with more than 50 slices) it will not do any automated processing.

All other Images listed on the right side of the screen are automatically registered to the brain based on a mask generated by automated segmentation of the 3DT1 data set. The segmentation is also used to create the 3D brain reconstruction views.

To check/modify the T1 segmentation:
   Select the 3DT1 image set by clicking on it in the Anatomical Images list (upper right)
   Click on the "3D check" option in the 3DT1 panel in the lower right of the screen
   This should change the middle windows to display the segmentation mask overlaid on the 3DT1 images
   Move through the display by dragging the crosshair in any view
   To remove non-brain regions from the mask click on that region
      (this will usually remove a portion of the mask)
   To add brain regions not included in the mask, click on that region
   This should (eventually) let you get a reasonable segmented brain
      (it doesn't need to be perfect)
   Click "Save" in the lower right corner if you have made changes.
   Click "Done" (lower right corner) when finished.

Checking image registration

You should verify that the other image sets are all properly registered to the 3DT1 images. This should be done for the FLAIR images, the DTI raw image series, and each EPI functional series.

To check registration of a series:
   1. Select the series from the “Anatomical” section of the Images list (upper right).
   2. Click the “Registration Check” option in the series-dependent panel (middle right).
   3. This should result in a blue overlay of that image series on top of the 3DT1 images.
   4. Adjust intensity of the 3DT1 and blue overlays to have contrast in both (see below)
      You can either adjust blue intensities to see gyri (left) or whole brain outline (right)
   5. Move through the display by dragging the crosshair in any view.
   6. If necessary, translate the overlay images to improve registration.
   7. You may also need to adjust rotation (especially in the sagittal view).
8. Repeat steps 5-7 until you get good registration (especially near lesion)
9. Click “Save” in the lower right corner if you have made changes.
10. Click "Done" (lower right corner) when finished.

Each series needs to be registered independently. Once you register the Anatomical image series, the changes you made will be automatically applied to the associated Diffusion and fMRI result images as well.

Image registration is tiresome but essential.

2. Overlay fMRI maps on T1 anatomical images

To add an activation map, select the result from the “fMRI” Image list (right panel), and drag it to the legend in the lower left corner of any pane in the central viewing region. Depending on where you drop the cursor, you can add an overlay, replace an overlay, or replace the underlay image.

Overlays are color-coded and thresholded according to the parameter settings in the series-dependent section of the right panel.

If multiple fMRI maps are overlaid at the same time each will appear as a different color. The colors and series names appear in the display legend in the lower left of each view.
Note: positive activation signals (BOLD signal increased with task) are assigned bright colors with each task result displayed in a different color, whereas negative activations (BOLD increased during rest) are all overlaid as gray. Dynasuite does not allow you to set different thresholds for positive and negative activations. Gray overlays should in general be ignored as their meaning is not well defined.

Combine activation maps, adjusting colors as necessary to produce optimal presentation of results.

To change activation colors, click on the map and then in the adjustment window (lower right of screen), click the "More" option. This will bring up the color adjuster:

![Color Adjuster](image)

To change color from red to green you first click the bright red region of the color selector, then select bright green when the color palette appears, and save. Then click the dark red part of the color selector, and then select dark green from the color palette.

Note: Dynasuite provides a separate fMRI application ( ) to enable closer inspection of fMRI results than is provided using the Smart Fusion application. The fMRI application allows viewing time series plots for signal fluctuations for individual active regions. Its usefulness is limited, however, because the software does not provide tools for coping with irregularities in the time series if they are present, other than adjusting the statistical threshold.

3. Adjust fMRI activation threshold levels

Adjusting the threshold for fMRI activations can be rather subjective. At Duke, we use the AMPLE approach which involves setting the threshold at half the maximum signal value for the activation region of interest. This works well for strong activations (i.e., peaks over t-value of 10); for weak signals the threshold should probably not go below 3.5 as that results in lots of false-positive blobs.

So, for each fMRI map, center your crosshair on the region you are most interested in (e.g. motor area ipsilateral to the lesion, or expressive/receptive language areas) and raise the threshold slider until all that activation just disappears. Note that maximum t-value, then move the slider down to half that value.

Activations adjusted using the AMPLE threshold approach have been shown to be reproducible and to correspond to expected functional anatomical areas.
4. Save overlaid images as DICOMs and send to PACS

Save a series of overlaid images
To save a whole series of images of different slices, you should first decide how many slices you want to save, and then identify which is the middle slice of that series. Step through slices until that middle slice is on the screen. Then right-click on the image, select the arrow under the camera icon, and select “Save Result Series”.

In the dialog window, choose “Around current slice”, then enter the number of slices, give the series a descriptive name (eg “fMRI_axT1”), and select “Forward to default PACS”. That will create a whole series of images and send them directly to PACS.

I usually create DICOM images overlaid on T1 images only in the axial view (120 slices). I create DICOM overlays on FLAIR images in axial (120 slices), coronal (130 slices), and sagittal (140 slices) views.

Creating a Results folder
Before creating result images you should make sure you are saving into a new Results folder. If there are already saved Results, new images will be added to the same folder by default. If the previous images have already been sent to PACS, adding more images to the same folder may cause problems when you try to send them to PACS because PACS does not like receiving the same image series more than once (all images in a folder get sent as the same series). So if there are already images in Results, it is good practice to create a new Results folder before creating any new images.

To create a new Results folder, right-click the “Results” section header and select “create new folder”.


Turning off the whole-screen crosshair
Before saving screenshots you may want to turn off the large crosshair. To do so, right click in any slice image, select the top arrow, and then “Displayed Information”, then the “Show/hide Cutlines” option.

Saving single screenshots
To generate a screenshot of any viewing pane you can right-click on that pane and select the camera icon. That will save a single image.
To send that image to PACS you will need to export it explicitly, either by right clicking that single Result image, or by right-clicking the folder title and exporting the whole folder. (Do not export a whole folder if some of its images have already been sent to PACS.)

5. Send Neuronavigation images and overlays to Temp files for making montages
To make 2-D multislice montage images (neurosurgeons’ preferred format), you should send copies of the fMRI overlay images to the local filesystem,
To do so, right click in the axial view image, then click the arrow under the camera icon, then select “export to neuronavigation system” from the option list.
When the export window appears, select the “File” option (see image) and then “OK”.

Whole brain series of all images and overlays will be sent to the LocalData/Temp folder. This is done in the background so you don’t need to wait for it.

6. Send Neuronavigation images and overlays to PACS (for Brainlab/Synaptive)
We routinely also send a copy of the fMRI activation maps to PACS so the neurosurgeons can import them into the surgical navigation system.
To do so, repeat step 5, except instead of selecting “File” as the target you should select “DICOM SCP”, which goes to PACS.
7. **Overlay fMRI maps on FLAIR images**

After saving fMRI maps on T1 images, you should replace the T1 images with FLAIR images.

Drag the FLAIR images from the upper right box and drop them on top of the T1 image name. Note you want to replace the T1 underlay images with the FLAIRs; if the FLAIRs appear as a colored overlay on top of the T1s, right-click on the FLAIR in the images overlay list and “delete”. Then drag and drop on the T1 again.

With FLAIR as the underlay images you should repeat steps 4 and 5 above, to send images to PACS and the local Temp filesystem. Note: when sending FLAIRs to Temp you should uncheck the overlay boxes at the top to avoid sending duplicate copies of all the activation maps (may be confusing in step 10 later). Unchecking those boxes will cause a warning message to appear when you click OK, but just say OK again.

8. **Overlay DTI color FA map (usually on FLAIR)**

To create color DTI overlay images replace the fMRI activation map overlays by selecting the color FA map from the list of Diffusion images in the upper right corner of the screen, and dragging that map to the overlay box in the lower left corner of any brain image view.

You should also delete (by right-clicking the overlay name) or hide the fMRI maps.

Adjust the intensity/contrast of the FA map colors a bit (generally I just raise the intensity slightly), then save “Result series” in all 3 view windows (axial, coronal, and sagittal) as you did in step 4.

9. **DTI fiber-tracking (if needed)**

Fiber-tracking is not described in this manual. Consult experienced neuroradiologists for how that is done.

**Logging off Dynasuite**

To close a patient study, click the check mark icon near the upper left corner of the screen. This will then ask you whether you want to “Defer” or “Complete” the study. Always select “Defer” – this allows someone else to return to that study later.

Dynasuite sometimes crashes while closing a study – just accept it and continue.

To log off, click the “X” in the upper right corner to close the Dynasuite display. This will then ask you if you want to log out of Dynasuite – say yes.
10. Make multi-slice montage images (not in Dynasuite software)

If you sent images to the local Temp filesystem you can use “fScan Montage” to create multi-slice mosaic JPEG images.

If you do not see the “fScan Montage” icon on the Windows desktop you should do this one-time procedure:
- Open the Windows File explorer (click folder icon on Windows taskbar).
- Navigate to the D: disk drive
- Click on “LocalData”
- Right-click the “fScan Montage” shortcut and drag to copy it to your desktop
- Right-click the “JPEGs” folder and drag to put a shortcut to it on your desktop

Making JPEG montages involves 2 steps:
1) Double-click the “fScan Montage” shortcut
   - This runs the fScan program with the “montage” script.
   - Note: you may need to keep wiggling the mouse while this script runs. There is a bug that causes it to wait for any kind of user interaction
   - A list of patient folders (in Temp) should appear. Choose any folder with your patient’s name. Then Okay
   - Keep wiggling the mouse while it sorts out the image data
   - When that’s done it will say you need to close fScan and restart. Click Okay
2) Run “fScan Montage” again
   a. This time when the patient list appears, click the short form of your patient’s name
   b. All of the images you sent to Temp should appear
   c. A “Montage” taskbar should also appear; it provides all your interactive options (its ‘?’ icon provides a help window)
   d. Click “Init” to initialize the montage.
   e. Check the colors of the overlay activation maps. You can change colors by clicking the map and then clicking a color in the taskbar. If you can’t see any activation in the fMRI map window click that window then click “Auto Z Max” to jump to the slice with most signal.
   f. Select which anatomical image to use as background, click in that window, then click “Set Anat”
   g. Adjust brightness/contrast of the anat images (light icons or up/down arrow keys)
h. Click “Merge Olays”. That takes several seconds to merge overlays and background.
i. Click the image plane you want (axial, coronal, L/R sagittal icons).
j. Images will start small because small images adjust faster; zoom up if you want.
k. Adjust slices by clicking in the Merged window and using PageUp/PageDown keys.
l. When you have the slices you want, zoom to the full size you want.
m. Click in the Merged window to get the text legend to appear.
n. Click the camera icon in the Taskbar to create a JPEG image of that window.
o. Repeat steps i-n for other views if you want.
p. Repeat steps f-n for other background images (e.g. FLAIR) if you want

All JPEG images are stored in the JPEGs folder
D:/LocalData/JPEGs