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WORKSHEETS

1 | Background

1.1 Standard MRI pre-processing

There are multiple ways to preprocess fMRI images, some depending on the apparent application. However, there is a standard set of methods that is mostly usually used across all applications. The following section seek to elucidate some of the most commonly used correction methods including the ones considered for the standard preprocessing method used in this project.

1.1.1 Techniques for quality control

Conducting a continues appropriate quality control is highly recommended to do across all applications, as the example on figure **??**age 35 shows. Various scanner artifacts can occur while acquiring an MRI series. Spike artifacts are seen as a regular pattern of change in brightness across the entire image. This problem can occur due to instability inside the scanner derivering e.g. from electrical discharges. The artifact called ghosting can occur mainly due to two reasons. One being an offset in phase between different lines in K-space and the other due to periodic motion as in heartbeat and respiration. Ghosting can be seen as light copies of the object appearing to either side of the object. Both types of artifacts can corrupt the information contained in the images. However, artifacts of this kind rarely present themselves in newer scanners, nevertheless it is still recommended to control the quality of the scan. [**Handbook**]

1.1.2 Distortion correction

Some fMRI acquisition methods, including the most widely used method of gradient-echo echo planar imaging, suffers from artifacts at regions air and tissue meet. This could be the areas of ear canal and sinuses. Inhomogeneity in the magnetic field in these areas can cause two types of artifacts, dropout and geometric distortion. A dropout will result in a reduced signal intensity in region close to the air to tissue passage. When a dropout during an acquisition occurs the lost signal cannot be restored and the damage is permanent. Therefore it is wise to consider the appropriate acquisition method taking the area of interest into addition. Air to tissue passages can also be subject to spatial distortion due to inhomogeneity created in the magnetic field. This will lead to structures not being located correctly in the captured image. This distortion makes is difficult to align two different scan, as done when aligning fMRI images with structural images. The spatial distortion can partially be corrected by employing field maps. In order to do a field map, the pulse sequences from the scan are needed. The process involved acquiring images at two different echo times. This result in images with two different phases which can be used to compute the field inhomogeneity. Thereby it becomes possible to calculate the relative distance each voxel has shifted. This makes up a map for the distance shift for each voxel, and by inverting the map the original image can be restored.

1.1.3 Slice timing correction

Acquiring fMRI scans is nearly always done in two-dimensions, where the slices are taken one by one. This can either be in an ascending, descending or interleaved order. Interleaved order is sequentially skipping every either odd or even slice and then afterwards do to skipped slices. Regardless of which order the slices are acquired, a difference in effect in each slice to the same hemodynamic response will be present due to the time difference in the slices. The difference in time between slices can range up to a couple of seconds depending on the acquisition protocol. The difference in slice timing constitutes a problem when analyzing the data. The data is formed into statistical model, but since this model assumes that all slices are acquired at the same time point, the actual signal and the model creates a mismatch. To counter this problem slice timing correction was introduced. The common approach in this method is to choose a reference slice, usually the slice acquired at T/2, and use this slice to interpolate the others. Linear interpolation can be used for simplicity, but most often sinc interpolation is used as it imposes less smoothing to the signal.

1.1.4 Motion correction

Having to deal with motion artifacts when doing MRI is inevitable, since even the best subjects will not be able to hold still. Even subtle movements as swallowing will be visible in the raw acquired image.

Multiple internal and external factors can cause a subject to move. Internal factors are physiologic motion. The heartbeat causes a pulsating movement which makes the brain move. Additionally motion created during respiration can cause small changes in the magnetic field around the head. External factors like imposed stimulus might cause the subject to make sudden movements. Often when doing fMRI the brain activation is measured while the subject is subjected to some kind stimulus. The stimulus would make the patient move, while the brain center would be active, therefore it is easy to mistake brain activation with stimulus correlated movement when analysing the data, resulting in a weaker/false statistical analysis.

Motion during image acquisition can result in two primary effects, being Bulk motion and Spin history. Bulk motion refers to the movement of the head as a whole and requires standard correction methods, e.g. the images throughout the series to be realigned to a reference image. The effect of Bulk motion can be visual in the entire image of the brain, but the effect will be most predominant at the edges of the brain. Here the artifact will be noticeable as either a drop or increase in intensity as a voxel would switch from containing brain tissue to suddenly not, during head motion. Spin history is associated head movement interfering with MRI signal. The interference occur during acquisition when a voxel of excited protons are moved in to a neighbouring slice. The scanner will thereby receive a different signal than expected which is not correctly represent the actual tissue properties. This results in an image where the intensities change in a striped pattern, visible when acquiring slices in interleaved order. The standard motion correction methods cannot cope with this type of artifact, but Independent Component Analysis (ICA) might be to correct for this artifact.

Motion correction techniques on monday

1.1.5 Spatial smoothing

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