**THE PATCH FORWARD SOLUTION**

The bulk of detectable visual evoked potentials are generated by groups of pyramidal neurons located at the midpoint between the outer surfaces of the gray and the white matter and the orientations of these neurons are aligned perpendicular to the cortical surfaces. Given the above generalization, the forward solutions in our boundary element models are produced as follows. First, based on the individual MRI scans, 3-layer segmentation is generated defined by the surfaces of the scalp, gray, and white matter. The initial segmentation results in approximately 150,000 triangulated mesh points per hemisphere at nearly uniform density. Typically, this number is sufficient for producing accurate and smooth cortical representation. Each mesh point is defined by 3 sets of parameters: 1) a position vector with an arbitrary origin located at the center of the brain **(P)** and 2) an orientation vector that denotes the normal to the cortical surface at the mesh position **(M)** 3) a scalar value denoting the area associated with the point **(a)**. Note that if the discrete sampling of the cortical surfaces were done at exactly uniform density, then every area value would be identical.

While the exact values of conductivities are variable between individual subjects, we have assumed the conductivities values of (XX, YY, ZZ) for the scalp, gray, and white matter segmentations as described in (XYZ, 1990) for all subjects. Ideally, we calculate the lead fields in the x-, y-, and z- directions for each anatomical mesh points available in the segmentation using the method described in (Nunez, 1990). The calculation of the lead field is computationally taxing, however, particularly for analyses involving multiple subjects. In an effort to balance the accuracies of forward solutions and the required computation time, we initially generate the lead fields only on a subset of the anatomical mesh points (10,242 points out of the 150,000 points per hemisphere per subject).

To give a measure of mesh densities in physical dimensions, a 1 cm by 1 cm patch on the cortex is represented by approximately 170 mesh points. With the subsampling, approximately 12 of these will contain their own calculated lead fields. The lead field values are then interpolated to all of the remaining mesh points. For simplicity, the interpolation is done with a routine that assumes the value of the nearest neighbor with a lead field value. Due to the smoothness of the lead fields in the 3 cardinal directions, we believe this is a relatively accurate and fast interpolation scheme. As a result we have interpolated forward solution on all anatomical mesh points which is accompanied by accurate surface normal definitions.

To simulate the experimental data, we use the ‘patch forward solution.’ In conventional simulation and source estimation studies, the M/EEG data is generated by simulating an equivalent dipole at a discrete location occupying zero physical area. In reality, a stimulus shown as a patch in visual field, such as multifocal dartboard, activates a measurable area on the visual cortex. The cortical patch representing the stimulus resides on a high convoluted surface and the changes in orientation within its boundaries are complex and variable. The complexity and variability of these folding patterns must be taken into consideration when discussing the utility of source estimation methods. We suspect that simulating a dataset based on the activation of the entire cortical patch instead of the simplified equivalent dipole provides a more realistic method for simulating experimental data.

The increased realism of the forward model comes with a small computation cost since the calculation of patch forward solution is simple. It is merely the weighted sum of all individual forward solutions contained by the cortical patch. As an example, suppose a cortical patch representing a visual stimulus contains 170 mesh points. Thus there are *n* associated individual lead fields L1, L2, …, Ln, orientation vectors M1, M2, … Mn, and area scalars a1, a2, … an . The forward solution per mesh point is the inner products between the normal vector and the lead field scaled by the area values.

**SIMULATION OF EXPERIMENTAL DATA**

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| --- | --- |
| Source response (time course) | Ales et al., 2009 |
| Source locations | Ales et al., 2010 |
| Conductivities | XXX |

THE STIMULUS

We simulate the EEG data in response to a check reversing 96-patch multifocal stimulus composed of 24 spokes and 4 rings (Figure. XYZ). Typically, each patch contains 2 by 4 checks in tangential and radial directions. Except for their respective spatial locations, every patch is assumed to be qualitatively identical and is expected to produce identical time course. We have divided the 20 subjects into 2 groups consisting of 10 subjects each. The first group was presented with a stimulus with inner angle of 1.5 degrees and outer angle of 4 degrees. The latter was presented with 1.5 and 7 degrees inner and outer radius, respectively.

The goal of the simulation study was to examine the validity of using principal component analysis for accurately predicting the V1 responses in realistic experimental settings. Therefore, the incorporation of experimental data and parameters from prior experiments should bolster the realism. In particular, we suspect that there are two factors that are crucial when determining the success and failure of PCA – 1) the size and the geometry of the cortical activation and 2) the orthogonality of the time course. The determination of the physiological geometry of cortical activation is performed with retinotopic f/MRI experiment (Ales et al. 2009) as described in the f/MRI section. The f/MRI retinotopy is accurate to 2 mm of true activation, and should provide the simulation with ample realism.

The choice for defining the temporal characteristics of the activated visual sources is less certain as there are no ways of non-invasively measuring temporal activation of visual sources in human subjects.