Creating surrogate brains for Magnetoencephalographic (MEG) brain imaging

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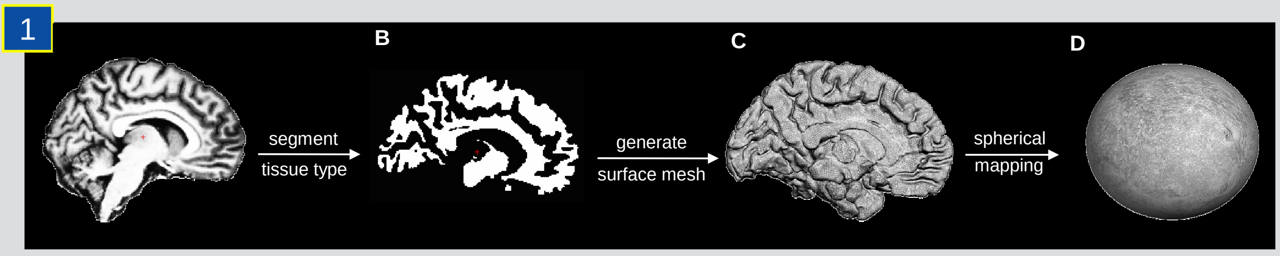
Introduction

The MEG inverse problem is theoretically non-unique, every set of magnetic field measurements having an infinite set of possible source configurations which explain it. Many inversion techniques exist, all using different a-priori assumptions in order to reduce the number of possible solutions. Recent work [1] has exploited the idea that a perfect reconstruction of the electrical current distribution should also follow the cortical grey matter anatomy. Specifically, MEG beamformer images compared with a spherical section of the true underlying anatomy, yielded more mutual information than when the same images were compared to rotated spherical sections of the same anatomy. The problem with this approach is that it can only be used to test the solution within a limited (spherical) volume. In this work we set out to develop a method which can robustly compute surrogate cortical surfaces using spherical harmonic decompositions. These surfaces should have two main properties- they should possess the same spatial statistics (curvature etc) as the original surfaces and they should occupy the same volume within the skull.

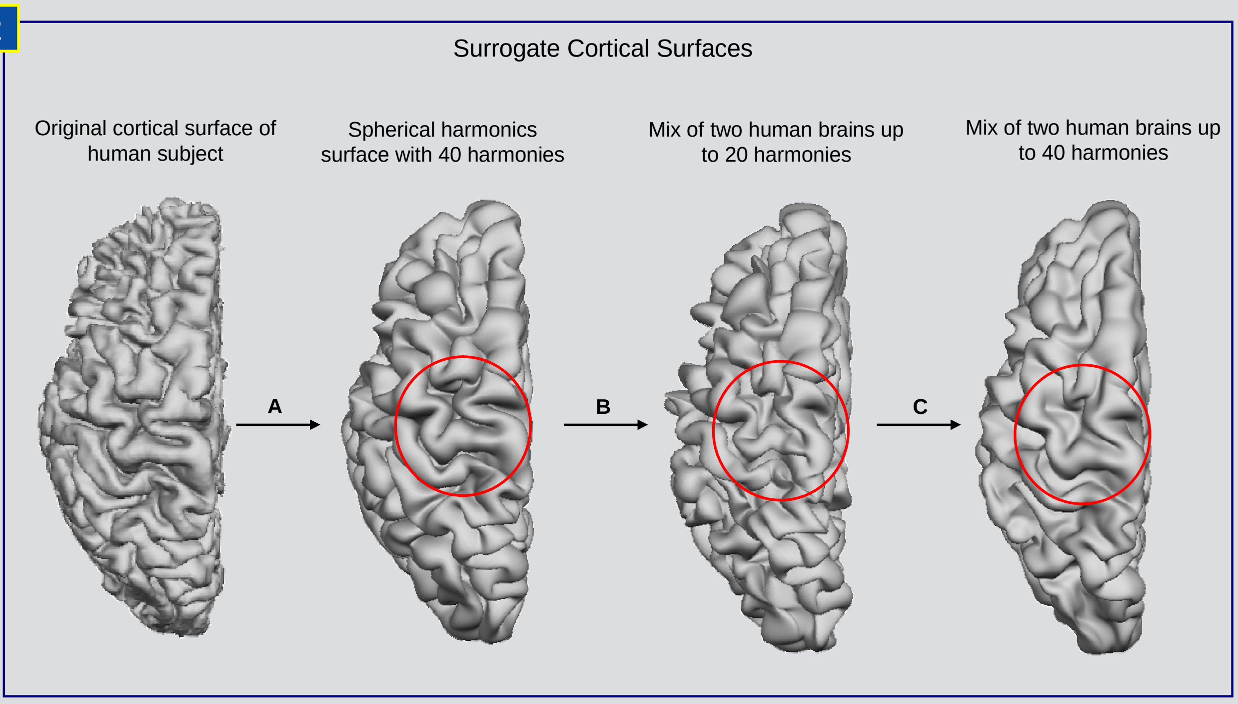
Surrogate Cortical Surfaces

1



Cortical surface reconstruction and spherical mapping. Step A orients and normalizes the MR image, step B segments the tissue types, step C generates a smooth triangular surface mesh and step D maps the vertex points to a spherical coordinate system.

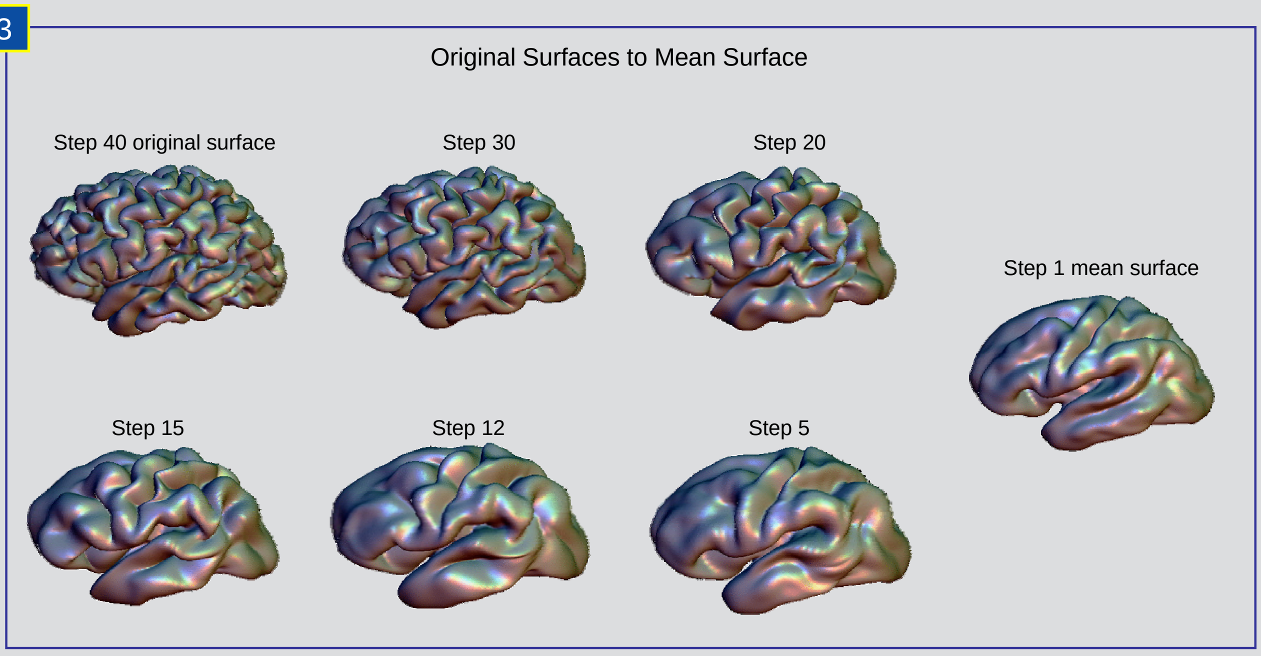
2



Then the surface mesh is decomposed into a series of spherical harmonic (SPH) basis functions [2]. This allows to keep any detail in the fine cortical structure but also generates a multi-resolution description from coarse to fine folding patterns [3].

A normalization procedure aligns each cortical surface to a common coordinate system. The alignment is based on the transformation to the SPH series and matches the surfaces in their low frequencies coefficients only, effectively aligning their coarse shape. With this procedure scaling, rotational and translational difference in the population have been completely removed. The mean shape between individual subjects can now produce surrogate cortical surfaces by mixing the spherical harmonic coefficients.

3



Transforming the original cortical surfaces (top left) to a mean cortical surface (middle right) using spherical harmonic decomposition. SPH Coefficients in the original surface are replaced step by step with the coefficients from the mean surface.

Conclusion

Based on the spherical harmonic decomposition surrogate cortical surfaces can be computed. Figure 2 shows the original surface, its SPH decomposition and two surrogate surfaces. By mixing two or more brains (Fig. 2B, 2C) new anatomical configurations can be computed. This work may provide a direct method by which any MEG inversion can be directly assessed on a subject by subject basis.

REFERENCES
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