



Report from 2015 Brainhack Americas (MX)

A cortical surface-based geodesic distance package for Python

Project URL: <http://github.com/margulies/surfdist>

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1 Introduction

The emergence of the human cerebral cortex, whether tracing it through phylogeny or ontogeny, tracks its expansion and progressive differentiation into larger and more diverse areas. While several previous methodologies have addressed this analytically by characterizing local cortical expansion, several lines of research have proposed that the cortex in fact expands along trajectories from primordial anchor areas [1, 2], and furthermore, that the distance along the cortical surface is informative regarding cortical differentiation [3]. We sought to investigate the geometric relationships that arise in the cortex based on expansion from such origin points. Towards this aim, we developed a python package for measuring the geodesic distance along the cortical surface that restricts shortest paths through the non-cortical medial wall.

2 Approach

The calculation of geodesic distance along a mesh surface is based in the cumulative distance of the shortest path between two points. The first challenge that arises is the sensitivity of the calculation to the resolution of the mesh: the corser the mesh, the longer the shortest path may be, as the distance becomes progressively less direct. This problem has been previously addressed and subsequently implemented in the python package *gdist*, which calculates the exact geodesic distance along a mesh by subdividing the shortest path until a straight line along is approximated [4].

The second challenge, for which there was no prefabricated solution, is ensuring that the shortest path does

not tranverse non-cortical areas— most prominently, the medial wall. It is therefore necessary to remove mesh nodes prior to calculating the exact geodesic, which requires reconstructing the mesh and assigning the respective new node indices for any seed regions-of-interest.

Finally, to facilitate applications to neuroscience research questions, we enabled the loading and visualization of data from commonly used formats such as FreeSurfer and the Human Connectome Project (HCP). A Nipype pipeline for group-level batch processing has also been made available.

3 Results

The resultant package, *SurfDist*, achieves the aforementioned goals of facilitating the calculation of exact geodesic distance on the cortical surface. We present here the distance measures from the central sulcus label on the FreeSurfer fsaverage template and the HCP 32k_LR template (Figure 1).

The zone analysis provides a means to construct a Voronoi diagram based on a set of individual nodes or sets of nodes.

Figures can be embedded directly in an IPython Notebook [Link], and requirements are limited to common packages such as matplotlib.

4 Conclusions

The *SurfDist* package is designed to enable investigation of intrinsic geometric properties of the cerebral cortex.

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Availability of Supporting Data

More information about this project can be found at:

<http://github.com/margulies/surfdist>. Further data and files supporting this project are hosted in the *GigaScience* repository REFXXX.

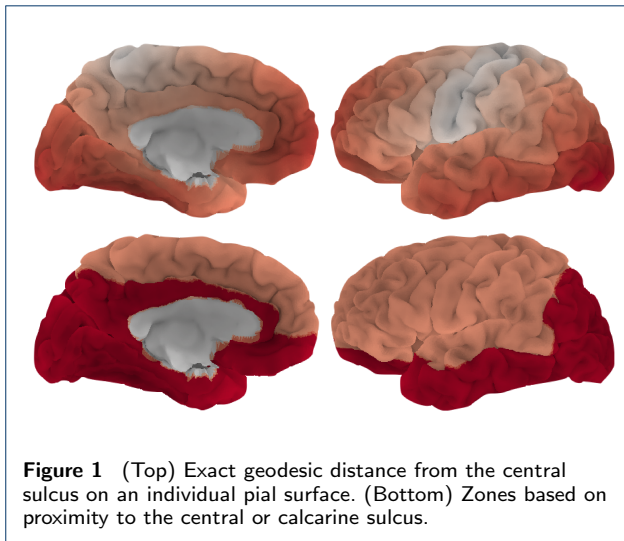


Figure 1 (Top) Exact geodesic distance from the central sulcus on an individual pial surface. (Bottom) Zones based on proximity to the central or calcarine sulcus.

Competing interests

None

Author's contributions

DSM, MF, and JH wrote the software and report.

Acknowledgements

The authors would like to thank the organizers and attendees of Brainhack MX.

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