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 human cerebral cortex, whether tracing it through phylogeny or ontogeny, emerges through expansion and progressive differentiation into larger and more diverse areas. While current methodologies address this analytically by characterizing local cortical expansion in the form of surface area˜[1], several lines of research have proposed that the cortex in fact expands along trajectories from primordial anchor areas˜[2, 3], and furthermore, that the distance along the cortical surface is informative regarding cortical differentiation˜[4]. 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 from passing through nodes of non-cortical areas such as the 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 the cortex is approximated˜[5].

The second challenge, for which there was no prefabricated solution, was ensuring that the shortest path does not traverse non-cortical areas— most prominently, the medial wall. It was 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˜[6]. The pipeline is wrapped in a command-line interface and allows for straightforward distance calculations of entire FreeSurfer-preprocessed datasets. Group-level data are stored as CSV files for each requested mesh resolution, source label and hemisphere, facilitating further statistical analyses.

3 Results

The resultant package, SurfDist, achieves the aforementioned goals of faciliating the calculation of exact geodesic distance on the cortical surface. We present here the distance measures from the central sulcus label on the FreeSurfer native surfaces (Figure 1, *(*Top)). The zone analysis provides constructs a Voronoi diagram based on a set of individual nodes or sets of nodes, revealing patches of cortex closest to each set (Figure 1, *(*Bottom)).

Surface rendering of the results draws from plotting functions as implemented in Nilearn ˜[7] and exclusively relies on the common library matplotlib to minimize dependencies. The visualization applies sensible

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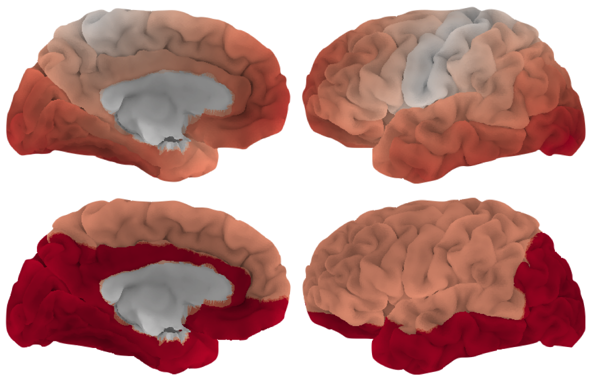

Figure 1 (Top) Exact geodesic distance from the central sulcus on an individual pial surface. (Bottom) Zones based on proximity to the central or calcarine sulcus.

defaults but can flexibly be adapted to different views, colormaps and thresholds as well as shadowing using a sulcal depth map.

4 Conclusions

The SurfDist package is designed to enable investigation of intrinisic geometric properties of the cerebral cortex based on geodesic distance measures. Towards the aim of enabling applications specific to neuroimaging-based research question, we have designed the package to facilitate analysis and visualization of geodesic distance metrics using standard cortical surface meshes.

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.

Competing interests

None

Author's contributions

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

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