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### ABSTRACT

We present the freesurferformats and fsbrain R packages, which enable the reading and writing of MRI neuroimaging data and results from different standard neuroimaging software packages, with a focus on FreeSurfer. The fsbrain package offers a powerful high-level visualization interface for neuroimaging data in R.

### INTRODUCTION

FreeSurfer (<http://freesurfer.net>, [1]) is a neuroimaging software suite which enables the analysis of magnetic resonance imaging files on volume and surface level. It uses various file formats to store raw data and results, including multi-dimensional images, surfaces, segmentation and parcellation results, and related data.

GNU R (<https://r-project.org>) is a statistical computation language that offers a wide array of modern statistical methods through a package system. However, there currently exist no packages for R that provide a user-friendly interface to read, write and visualize FreeSurfer neuroimaging data. The availability of such packages would enable a complete and reproducible analysis of neuroimaging data in GNU R.

Here we present the freesurferformats and fsbrain packages, which enable seamless access to neuroimaging data in R as well as visualization of raw data and results.

### RESULTS & AVAILABILITY

Both packages are free software, and available to the community under the very permissive MIT license. They can be installed directly from the Comprehensive R Archive Network (CRAN, <https://cran.r-project.org>) or from Github:

- freesurferformats: <https://github.com/dfsp-spirit/freesurferformats>
- fsbrain: <https://github.com/dfsp-spirit/fsbrain>

### METHODS & SOFTWARE

We have implemented two R packages that provide access to neuroimaging data in various formats and support visualization of raw and intermediate data and results.

The freesurferformats package implements low-level access to neuroimaging data, including:

- Volume images in MGH, MGZ and NIFTI [2] formats (including header data). This includes segmentations, masks, and other data stored in these formats.
- Brain surface meshes in VTK, GIFTI, FreeSurfer surface (binary and ASCII) and other formats. Export to standard 3D modelling software formats (PLY, OBJ, OFF) available.
- Morphometry data in MGH, MGZ, GIFTI [3], and curv formats.
- Brain surface parcellations based on atlases (annot format).
- FreeSurfer patches, labels, and weight files.

The fsbrain package adds:

- Access to data for groups of subjects (FreeSurfer SUBJECTS\_DIR).
- Aggregation on the level of atlas regions and hemispheres.
- Data and result visualization for volumes and surfaces.
- Hardware-accelerated mesh rendering using OpenGL via rgl [4].

### EXAMPLES: SURFACE VISUALIZATION

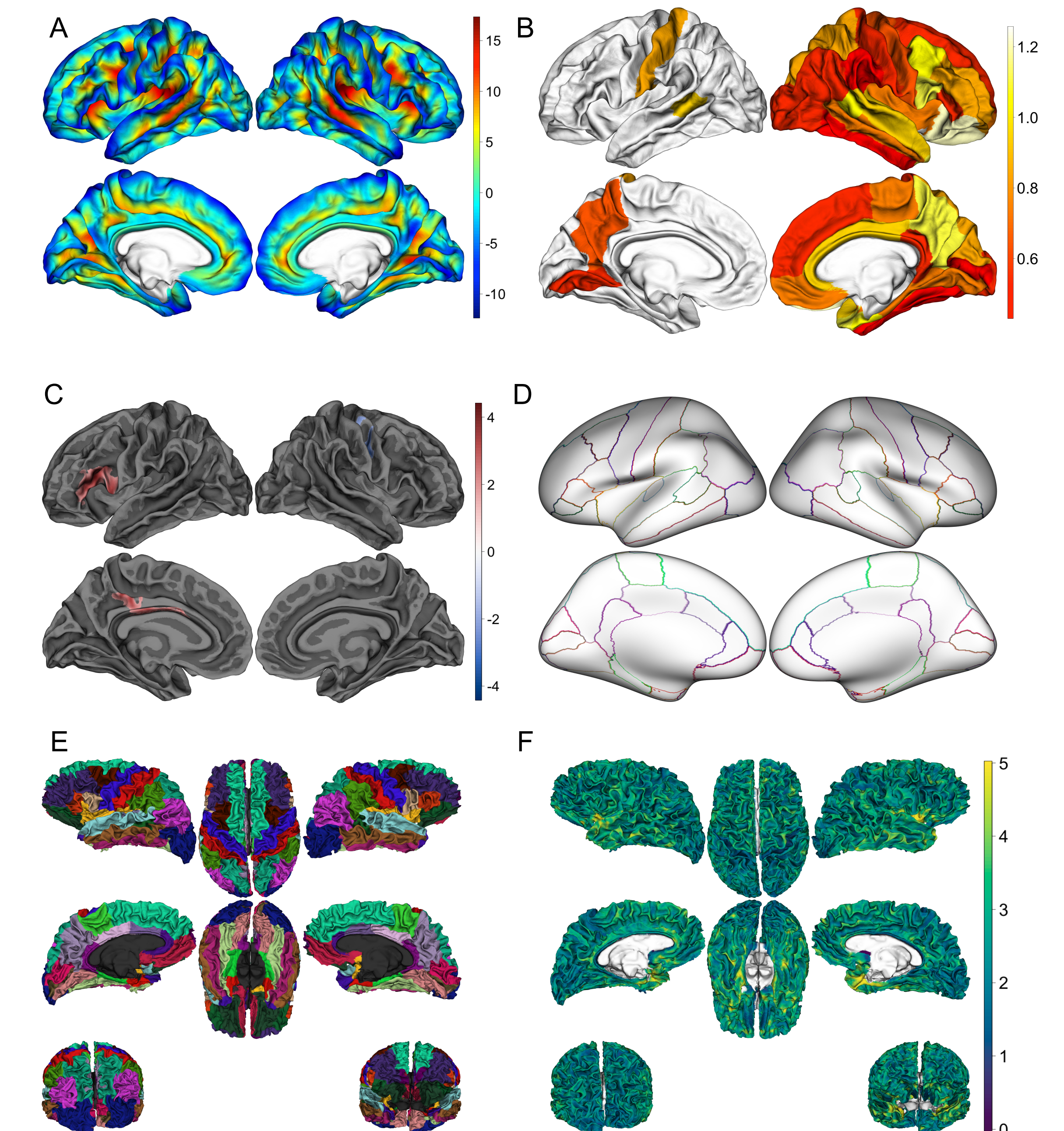


Fig. 2: Surface visualizations. **A** Standard space morphometry data: sulcal depth, mm. **B** Region-based results, using the Desikan atlas. **C** Clusters on the fsaverage surface using a diverging colormap, with a background generated from thresholded mean curvature. **D** Outlines of Desikan atlas [5] regions on the inflated fsaverage surface. **E** Brain parcellation, visualized on an individual example subject in native space. **F** Native space morphometry data: cortical thickness, mm.

### EXAMPLES: VOLUME VISUALIZATION

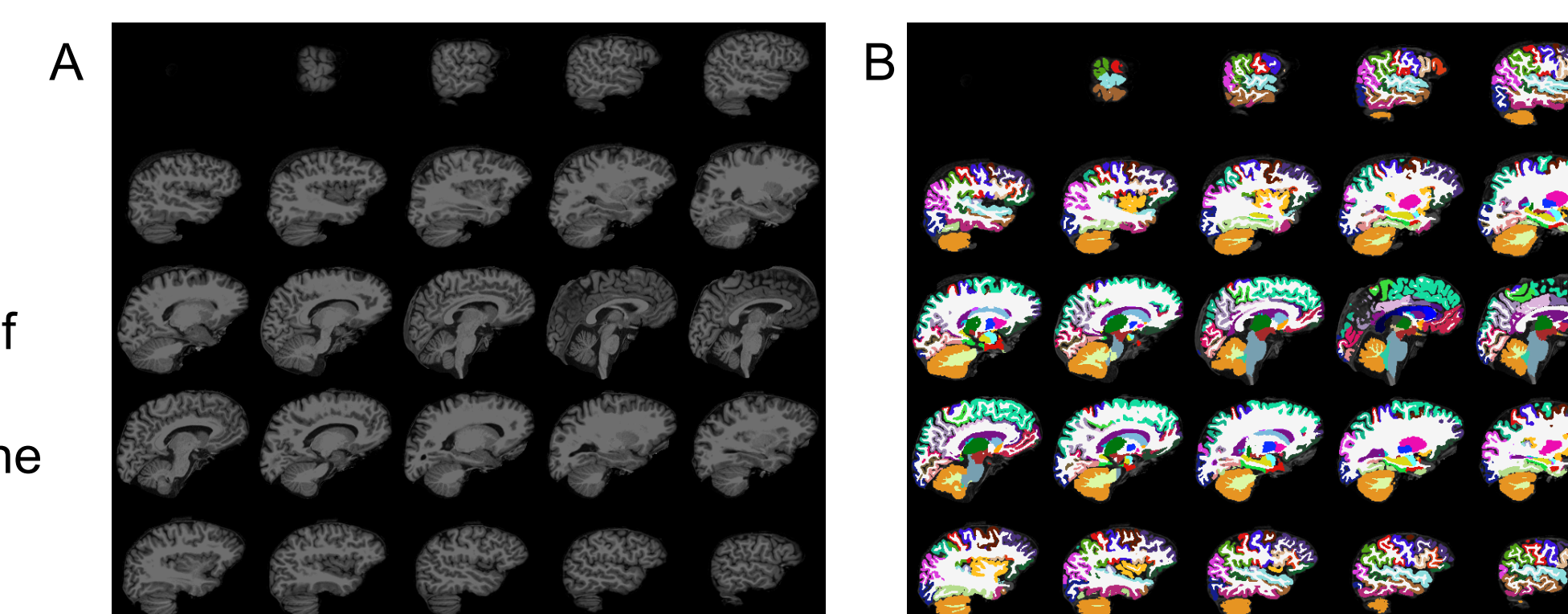


Fig. 1: Lightbox views of volumes. **A** Intensity-corrected T1 scan. **B** The respective FreeSurfer segmentation.

### GETTING STARTED

The documentation is included and [available online](#). An example notebook in markdown format can be found at <http://tiny.cc/fsbex>.

### CONCLUSION AND OUTLOOK

- The freesurferformats and fsbrain packages provide access to FreeSurfer data in GNU R on different abstraction levels.
- We hope that their availability will enable researchers to leverage the wide array of statistical methods available in R for neuroimaging research.
- The ability to visualize data and results directly in R and integrate them into notebooks, papers or presentations generated in R is an important step towards reproducible research.
- In combination with the large array of state-of-the-art statistical methods available in R, the packages enable the complete workflow of neuroimaging data analysis in R.

### REFERENCES

- [1] Dale, A.M., Fischl, B., Sereno, M.I., 1999. Cortical surface-based analysis. I. Segmentation and surface reconstruction. *Neuroimage* 9, 179-194. [2] Whitcher, B., Schmid, V.J., Thornton, A. (2011). Working with the DICOM and NIFTI Data Standards in R. *Journal of Statistical Software*, 44(6), 1-28. [3] Muschelli, J. (2019). gifti: Reads in 'Neuroimaging' 'GIFTI' Files with Geometry Information. R package version 0.7.5.9001 [4] Adler, D., Murdoch, D., and others (2020). rgl: 3D Visualization Using OpenGL. R package version 0.100.54. [5] Desikan, R.S., Ségonne, F., Fischl, B.,... & Albert, M.S. (2006). An automated labeling system for subdividing the human cerebral cortex on MRI scans into gyral based regions of interest. *Neuroimage*, 31(3), 968-980.