WE 207
Evaluation of Three Cortical Surface Flattening Methods

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Intoduction

FreeSurfer (FS) [1], a popular software package for cortical surface flattening, explicitly minimizes metric distortion of the flattened surface. In contrast, LSCM [3] and CirclePack (CP) [2] are quasi-conformal flattening methods that preserve angles locally; however, spherical maps generated by these methods can be normalized by a Moebius transformation that minimizes metric distortion among the auomorphism group. All three methods can flatten user-defined patches as well as an entire cortical surface.

Methods

Topologically-correct triangulated surfaces of the left hemisphere were extracted from two high-resolution T1 MRI brain volumes (MNI, PENN) that had been parcellated by an expert neuroanatomist; parcellation of the extracted cortical sheet was guided by the volume parcellation using in-house software (ParcelMan [4]). For each brain, the left hemispheral cortex (equivalent to a topological sphere) and four lobar cortical patches (equivalent to topological discs) were flattened using FS, LSCM, and CP to create the corresponding spherical or planar maps. Measurements of angular and metric distortion of the flattened surfaces [3], which are invariant under the similarity transformations were used to describe the quality of resulting maps.

Results and Conclusions

Measurements of angular and metric distortion for the three methods, two brains, and five surfaces (the left hemispheral cortex and four lobar patches) are presented in Table 1, and frequency histograms of angular and metric distortion for the MNI left hemispheral cortex are illustrated in Figure 1. For the lobar patches FS clearly outperforms both conformal methods with regard to the preservation of metric information; however, for the MNI left hemispheral cortex FS and LSCM produce similar results for mean metric distortion: 31.72% and 36.07%, respectively. For all five surfaces LSCM is superior to the other methods with regard to the preservation of angular information, and CP and LSCM perform similarly with regard to metric distortion. Thus, by preserving angular (shape) information and adequately preserving metric information, LSCM may offer advantages to methods such as FS, which preserve only metric information, for flattening hemispheral cortical surfaces.

References

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Table 1. Angular (degrees) and metric (%) distortion of flat maps generated by FS, LSCM and CP.

		MNI surface					PENN Surface				
Flat Maps		S	F	O	P	T	S	F	O	P	T
FS	MAD	18.76	11.38	11.82	7.27	27.49	18.99	15.12	14.02	13.32	23.14
	MMD	31.72	18.14	18.81	15.24	25.79	24.47	22.60	22.29	20.73	30.46
LSCM	MAD	4.65	1.80	2.06	1.57	2.35	7.21	3.02	3.25	2.55	2.70
	MMD	36.07	34.94	32.38	29.14	36.19	40.70	36.10	36.59	39.45	41.93
CP	MAD	16.39	11.27	11.25	11.28	11.17	15.73	11.93	10.67	10.95	11.29
	MMD	40.18	31.51	31.69	24.23	39.98	41.42	32.81	35.32	30.74	45.20

MAD, mean angular distortion; MMD, mean metric distortion; S, spherical map of the left hemispheral cortex; F,O,P,T, planar maps of frontal, occipital, parietal and temporal patches, respectively.

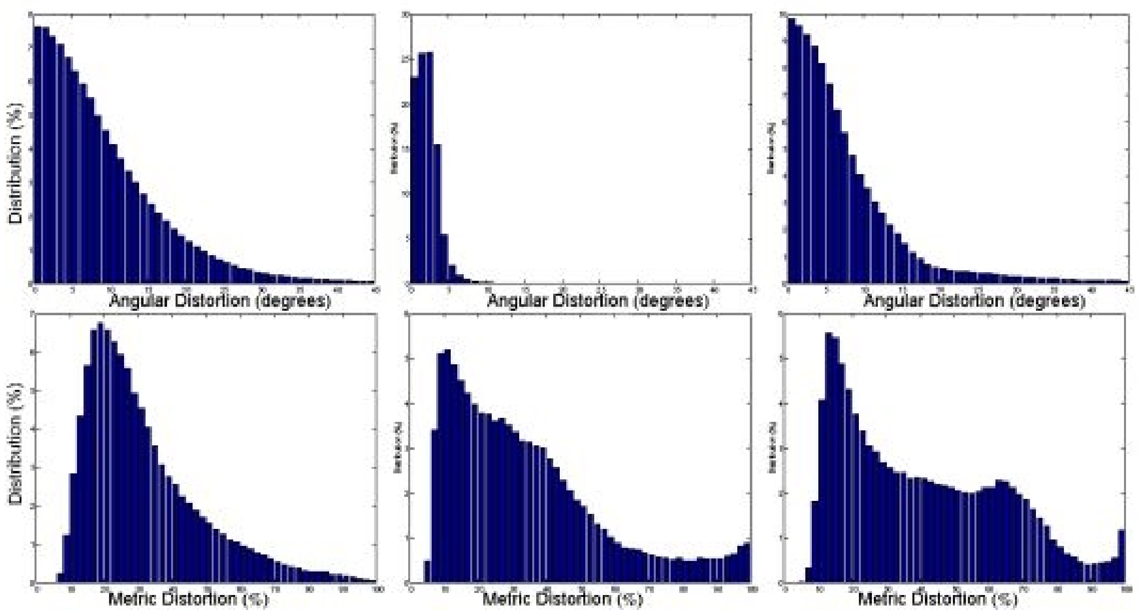

Figure 1. Frequency histograms illustrating the angular and metric distortion of spherical maps of the MNI left hemispheral cortex generated by FS (left), LSCM (middle) and CP(right). Top row, angular distortion; bottom row, metric distortion.