iBEAT V2.0 Cloud

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A new version of iBEAT (Infant Brain Extraction and Analysis Toolbox) is now available online as iBEAT V2.0 Cloud (http://www.ibeat.cloud/), which is developed with latest advanced techniques (including deep learning) at the University of North Carolina at Chapel Hill. iBEAT V2.0 Cloud can handle pediatric brain images from **multiple sites** with various scanners and protocols. Users can process brain structural images from birth through adolescence, including images during the first postnatal year, which typically exhibit low tissue contrast and dynamic appearance and size changes [1] as shown in **Fig. 1**, by simply uploading images (T1w images, or T2w images, or both) into iBEAT V2.0 Cloud. All uploaded data will be securely managed in the iBEAT V2.0 web server and will not be distributed to public. If you do not authorize, all data, including the intermediate results, will be permanently deleted once we finish processing.

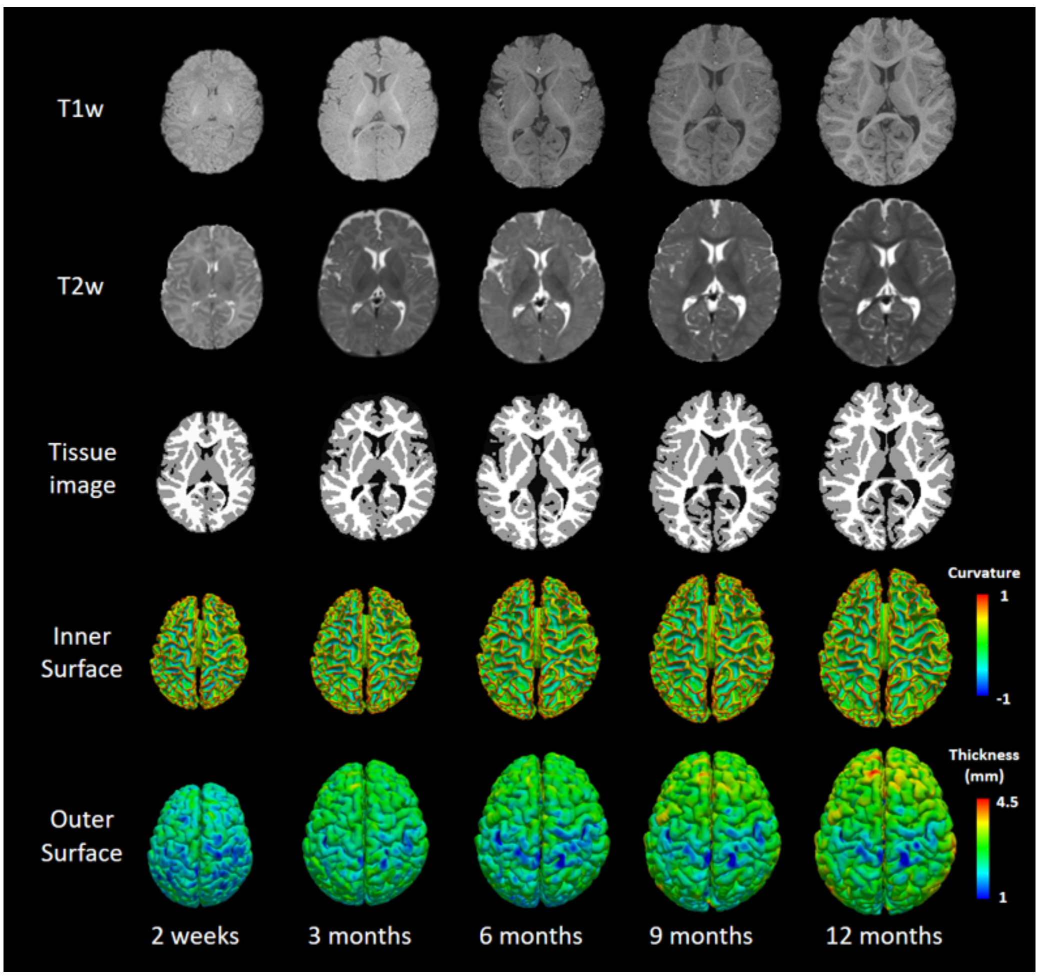


Fig. 1. T1w images, T2w images, and tissue segmentation results as well as the reconstructed inner and outer surfaces of a typically-developing infant, scanned longitudinally at 2 weeks, 3, 6, 9 and 12 months of age. Inner surfaces are color-coded with the maximum principal curvature, and outer surfaces are color-coded with cortical thickness. (This figure is from [1])

Key Functionality

The current functionality of iBEAT V2.0 Cloud includes:

(a) Inhomogeneity correction [2];

(b) Skull stripping [3];

(c) Tissue segmentation [4];

(d) Left/Right hemisphere separation;

(e) Topology correction [5];

(f) Cortical surface reconstruction [6, 7];

(g) Cortical surface measurement [8-10];

(h) Cortical surface parcellation [11-14].

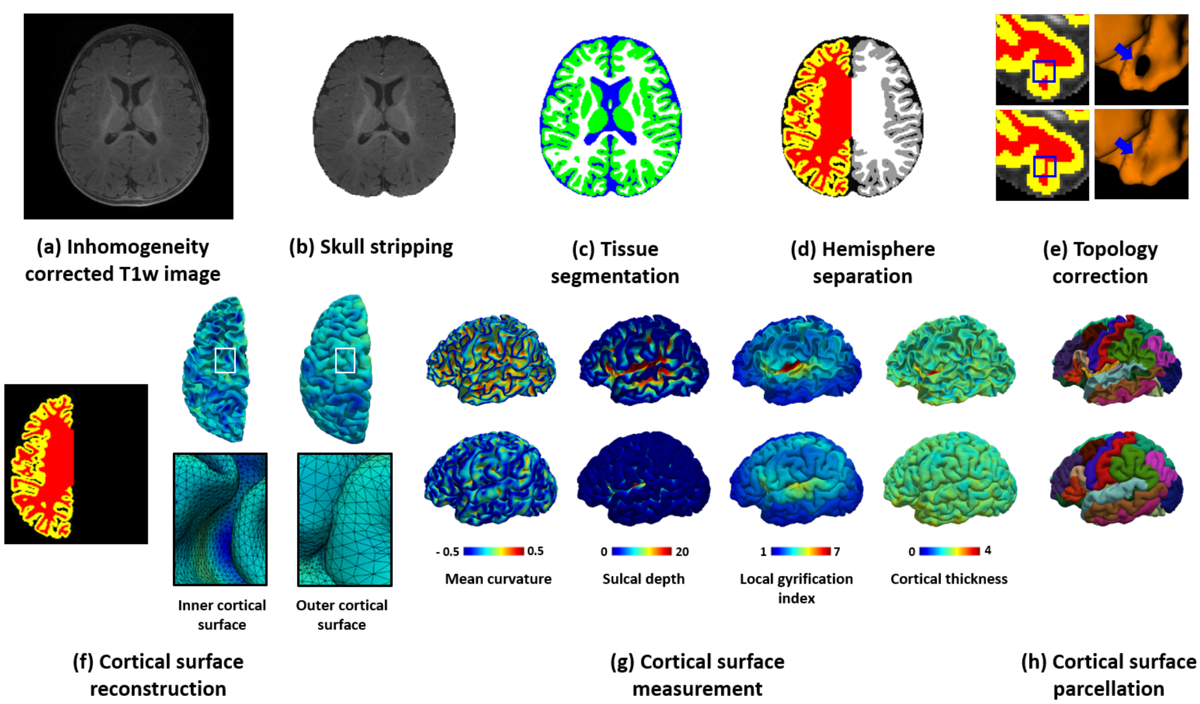


Fig. 2. Illustration of the key functionality included in the iBEAT V2.0 Cloud.

Feedbacks

So far, we have successfully processed **3000+** infant brain images from multiple sites (51 institutions) with various scanners and protocols, as shown in **Table 1**. Here are some feedbacks from users:

- **Stanford University:**
  - ❖ *“The preliminary version of the tools has helped us process 30+ infant subjects at 6 months of age. I am impressed with the outstanding performance of the tools.”*
  - ❖ *"We are very impressed with the results. Thank you so much for making this available!"*
- **Emory University:**
  - ❖ *"We went through these images and were very impressed by the results! Thank you!"*
- **Tokyo Metropolitan University:**
  - ❖ *"The result of iBeat Cloud segmentation looks great."*
- **Arkansas Children’s Research Institute:**
  - ❖ *“I am very impressed by the segmentation results achieved by your algorithms.”*
- **New York State Psychiatric Institute:**
  - ❖ *“We found out iBEAT performs better than other tools in neonatal segmentation.”*
- **The University of Tokyo:**
  - ❖ *“Your computational tools proved very useful in analyzing MRI data in order to build our brain models.”*
- **South China Normal University:**
  - ❖ *“We really appreciate your endeavour to provide such kind of free service! We are happy to find the results of tissue segmentation of 6-month old infants quite good!”*
- **Yale University:**
  - ❖ *"Wow! I am truly impressed! These results are remarkable: we have never seen grey/white matter segmentation this good! Even when we provided you only the T1w images these results are sufficient for our use case!"*
  - ❖ *"I have finished my analyses of the first two participants with the surfaces you provided (they look great!)"*
- **Loma Linda University:**

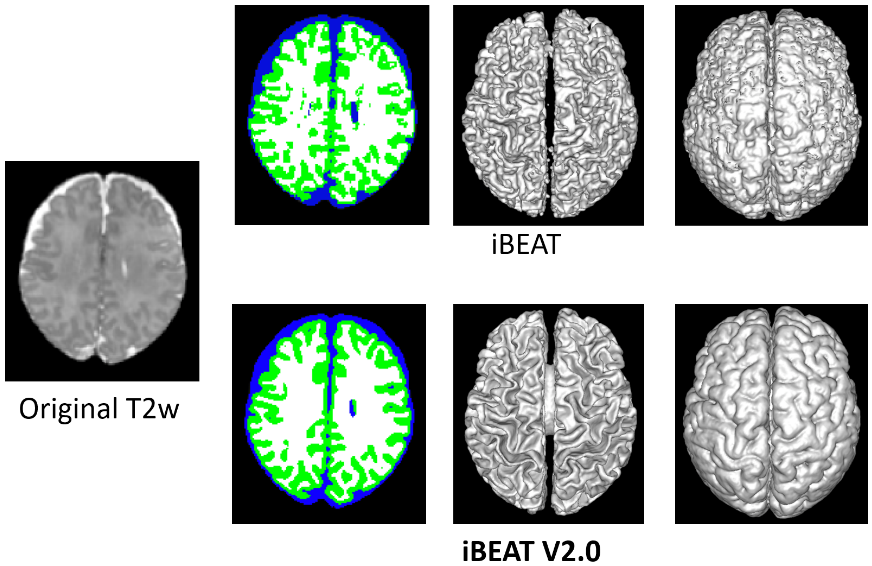
Table 1. Successfully processed infant images from multiple sites with various protocols and scanners.

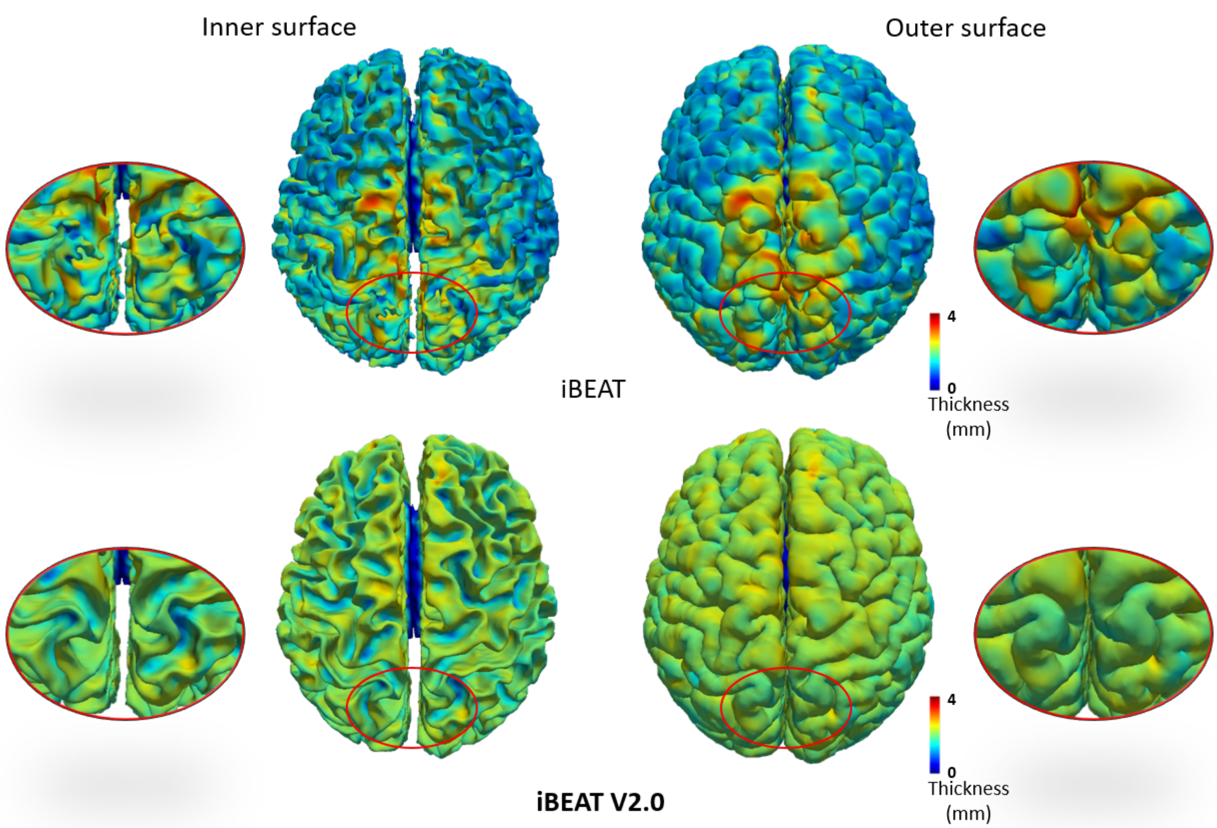
	Scanner	Modality	TR (ms)	TE (ms)	Resolution (mm³)
BCP (UNC/UMN)	SIEMENS	T1w	2400	2.24	0.8×0.8×0.8
		T2w	3200	564	0.8×0.8×0.8
Stanford University	GE	T1w	7.6	2.90	0.9×0.9×0.8
		T2w	2502	91.4	1.0×1.0×0.8
Emory University	SIEMENS	T1w	2400	2.19	1.0×1.0×1.0
		T2w	3200	561	1.0×1.0×1.0
University of California	SIEMENS	T1w	2400	2.22	0.8×0.8×0.8
		T2w	3200	563	0.8×0.8×0.8
Yale University	SIEMENS	T1w	2250	0.07	0.9×0.9×0.9
		T2w	3200	563	1.0×1.0×1.0
Stanford University	GE	T1w	-	-	
		T2w	3650	123.5	0.8×0.8×0.8
The University of Texas	SIEMENS	T1w	2170	3.6	1.0×1.0×1.0
		T2w	3200	410	1.0×1.0×1.0
Columbia University	SIEMENS	T1w	-	-	
		T2w	7380	119	0.6×0.6×0.6
Southeast University	SIEMENS	T1w	600	20	0.9×0.9×1.0
		T2w	2500	100	0.6×0.6×6.0
dHCP (Oxford University, Imperial College London, Kings College London)	PHILIPS	T1w	4795	8.7	0.5×0.5×0.5
		T2w	12000	156	0.5×0.5×0.5
University of Maryland	SIEMENS	T1w	1900	2.43	0.3×0.3×0.8
		T2w	3200	480	0.7×0.7×0.8
University of California, Irvine	SIEMENS	T1w	2400	3.16	1.0×1.0×1.0
		T2w	3200	255	1.0×1.0×1.0
Loma Linda University	SIEMENS	T1w	1800	2.27	0.9×0.9×1.0
		T2w	3000	408	0.9×0.9×1.0
University of Denver	SIEMENS	T1w	2500	2.03	1.0×1.0×1.0
		T2w	3200	564	1.0×1.0×1.0

  - *"The segmentation looks really good!"*
- **UT Health Science Center at Houston:**
  - *"The results of your new segmentation (and brain extraction) look great! I'm very impressed because we've struggled a lot with getting these images processed. iBEAT had been the software that was working the best for us, but the results you sent back are even better than what I was able to get out of the older version of iBEAT. "*
  - *"I finally got a chance to show the results of iBEAT cloud to my collaborators. They are all very impressed, and we plan to upload some more subjects to you in the near future. Thank you for all your hard work on this new version of iBEAT! It is very impressive."*
- **University of Cadiz**
  - *"Thank you very much for the processing. The segmentation is fantastic. I am quite happy with the segmentation."*
- **Boston Children's Hospital/ Harvard Medical School**
  - *"What I've seen so far look far more accurate than the infant pipelines I tried previously."*
- **University of Houston**
  - *"Thank you so much for running our brains through your segmentation pipeline. Your pipeline did a fantastic job segmenting our brains."*
- **Biomedical Research and Innovation institute of Cadiz**
  - *"I have to say that my impression about the performance of the software is, by far, better than expected. Actually, I thought it was not going to be possible for the last patients. I am quite happy with the results. Just for make it clear, results are perfect for me and are even better that the dHCP-derived results which is optimized for neonates."*

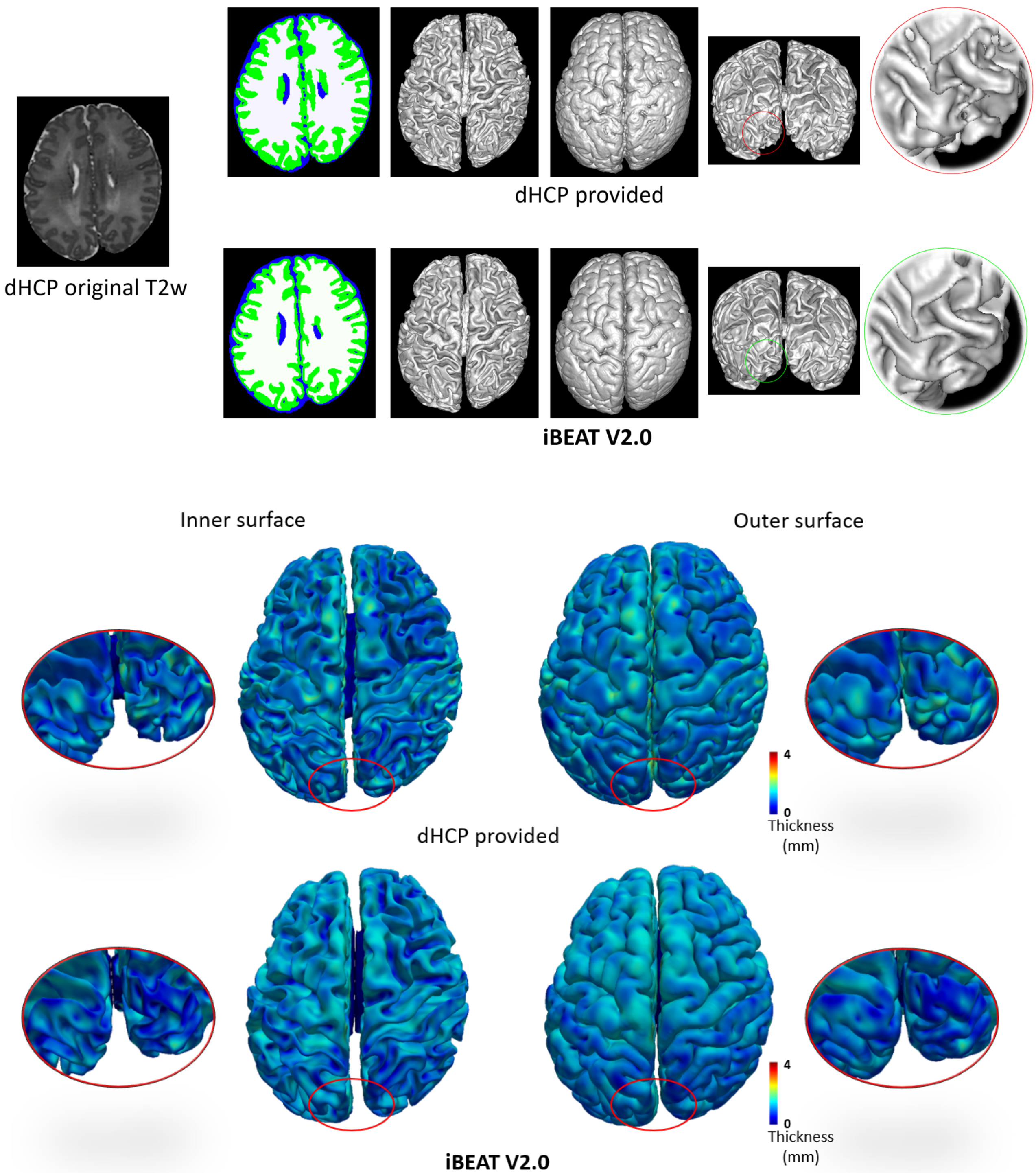
Demos

Comparison between iBEAT and iBEAT V2.0

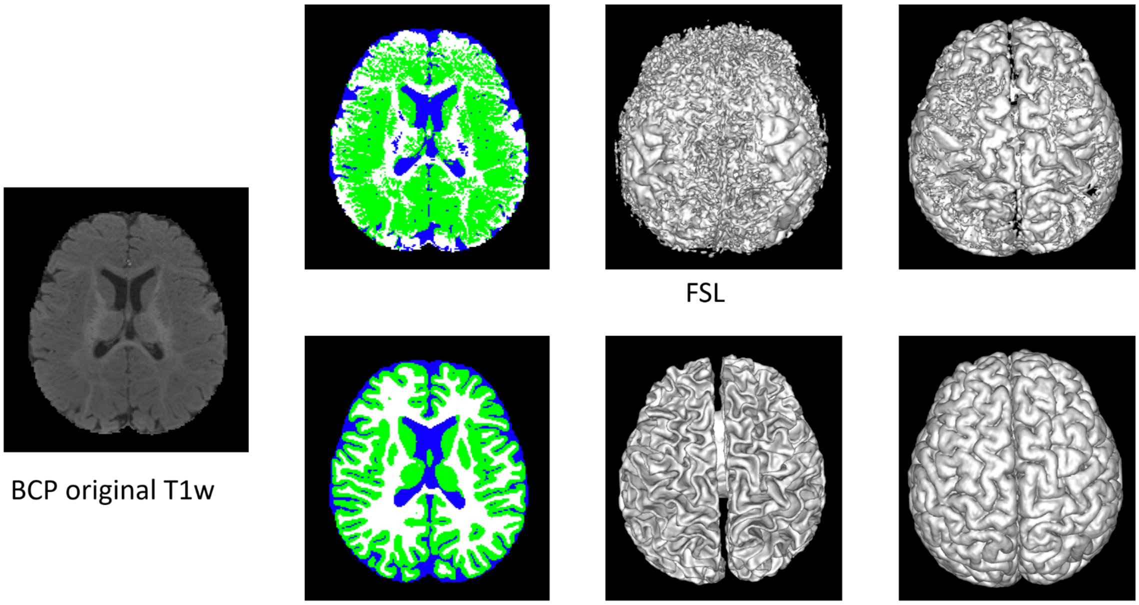




Results on dHCP data



<u>Results on BCP data</u>



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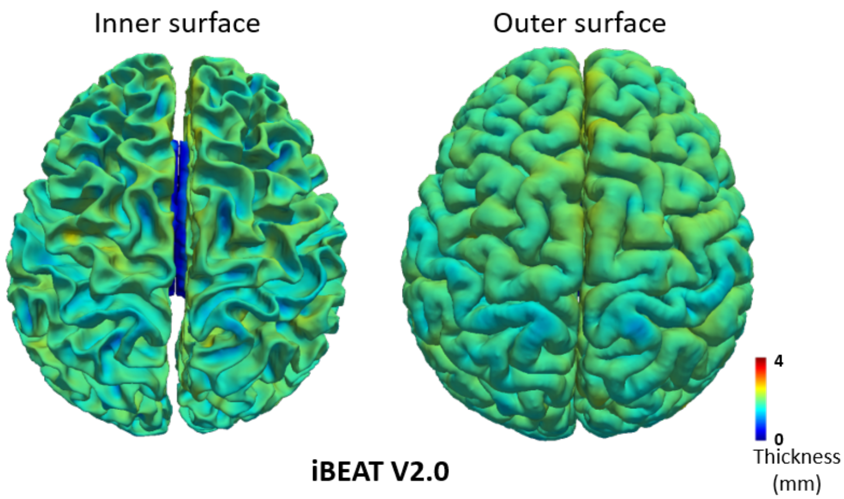

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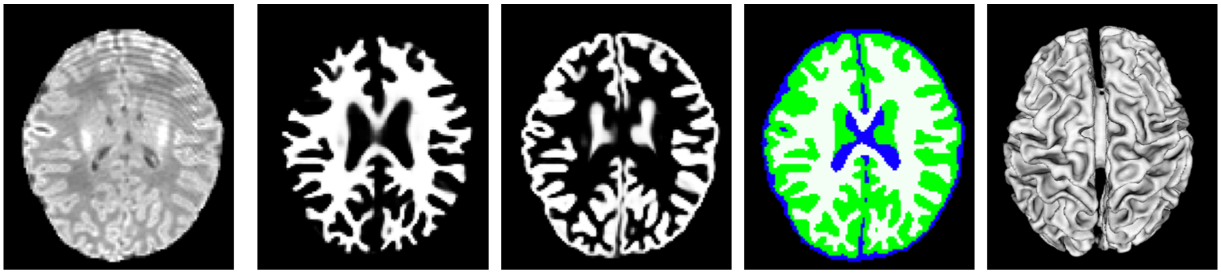
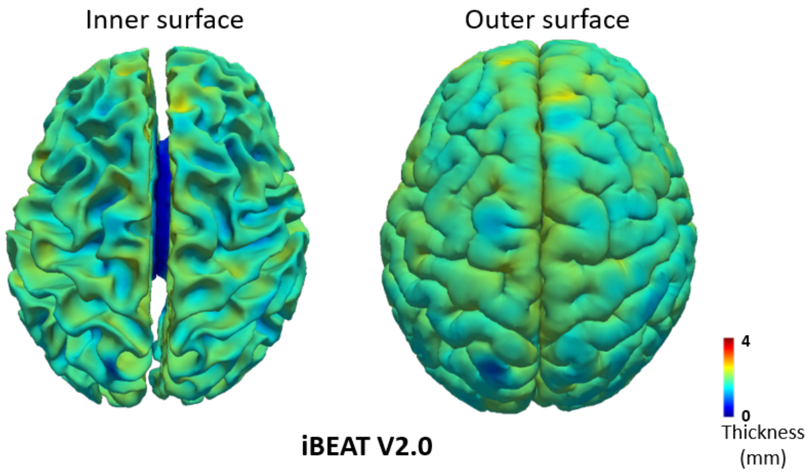
Results on images with artifacts



iBEAT V2.0



iBEAT V2.0

About Us

The iBEAT V2.0 Cloud is developed by the IDEA group at the University of North Carolina at Chapel Hill, directed by Dr. Dinggang Shen (dgshen@med.unc.edu).

- Volume-based analysis was designed by Dr. Li Wang (li_wang@med.unc.edu).
- Surface-based analysis was designed by Dr. Gang Li (gang_li@med.unc.edu).

Citations

Please cite the following papers if you use the results provided by iBEAT V2.0 Cloud.

- Wang et al., Volume-based analysis of 6-month-old infant brain MRI for autism biomarker identification and early diagnosis. MICCAI 2018, 1072: 411-419, 2018.
- Li et al., Measuring the dynamic longitudinal cortex development in infants by reconstruction of temporally consistent cortical surfaces. NeuroImage, 90: 266-279, 2014.
- Li et al., Construction of 4D high-definition cortical surface atlases of infants: Methods and applications. Medical Image Analysis, 25: 22-36, 2015.
- Li et al., Computational neuroanatomy of baby brains: A review. NeuroImage 185: 906-925, 2019

References

[1] G. Li, L. Wang, P.-T. Yap, F. Wang, Z. Wu, Y. Meng*, et al.*, "Computational neuroanatomy of baby brains: A review," *NeuroImage,* vol. 185, pp. 906-925, 2018.

[2] J. G. Sled, A. P. Zijdenbos, and A. C. Evans, "A nonparametric method for automatic correction of intensity nonuniformity in MRI data," *IEEE transactions on medical imaging,* vol. 17, pp. 87-97, 1998.

[3] Q. Zhang, L. Wang, X. Zong, W. Lin, G. Li, and D. Shen, "Frnet: Flattened Residual Network for Infant MRI Skull Stripping," in *2019 IEEE 16th International Symposium on Biomedical Imaging (ISBI 2019)*, 2019, pp. 999-1002.

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[10] G. Li, J. Nie, L. Wang, F. Shi, A. E. Lyall, W. Lin*, et al.*, "Mapping longitudinal hemispheric structural asymmetries of the human cerebral cortex from birth to 2 years of age," *Cerebral Cortex,* vol. 24, pp. 1289-1300, 2013.

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[13] F. Zhao, S. Xia, Z. Wu, D. Duan, L. Wang, W. Lin*, et al.*, "Spherical U-Net on cortical surfaces: methods and applications," in *International Conference on Information Processing in Medical Imaging*, 2019, pp. 855-866.

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