UNC Infant 0-1-2 Atlases

Infant Brain Atlases from Neonates to 1- and 2-year-olds

Updates

2012/02/20 Fixed label map coverage problem.

Files changed: infant-neo-aal.img, infant-1yr-aal.img, infant-2yr-aal.img

2011/11/08. We have updated our atlases by using (a) new segmentation results with surface constraints [1] and (b) new implemented groupwise-HAMMER tool [2].

[1] L. Wang, F. Shi, P.-T. Yap, W. Lin, J. H. Gilmore, and D. Shen, "Longitudinally Guided Level Sets for Consistent Tissue Segmentation of Neonates," Human Brain Mapping, p. In press, 2011.

[2] The groupwise-HAMMER tool is now available with name “GLIRT” at http://www.nitrc.org/projects/glirt/.

0. Where to Download

http://bric.unc.edu/ideagroup/free-softwares/unc-infant-0-1-2-atlases/

1. Data and MRI Acquisitions

We constructed 3 atlases dedicated for neonates, 1-year-olds, and 2-year-olds. Each atlas comprises a set of 3D images made up of the intensity model, tissue probability maps, and anatomical parcellation map. These atlases are constructed with the help of state-of-the-art infant MR segmentation and groupwise registration methods, on a set of longitudinal images acquired from 95 normal infants (56 males and 39 females) at neonate, 1-year-old, and 2-year-old (Table 1).

Table 1. Demographic information of the normal infants used in this study

Scan	N	Gender	Age at Birth (weeks)	Age at MRI (weeks)	Group
First	95	56 m/39 f	37.9±1.8 (33.4 – 42.1)	41.5±1.7 (38.7 – 46.4)	Neonate
Second				94.2±3.4 (87.9 – 109.1)	1-year-old
Third				146.2±4.9 (131.4 – 163.4)	2-year-old

Images were acquired on a Siemens head-only 3T scanner (Allegra, Siemens Medical System, Erlangen, Germany) with a circular polarized head coil. For T1-weighted images, 160 sagittal slices were obtained by using the three-dimensional magnetization-prepared rapid gradient echo (MPRAGE) sequence: TR=1900ms, TE=4.38ms, inversion time=1100ms, Flip Angle=7°, and resolution=1x1x1mm3. For T2-weighted images, 70 transverse slices were acquired with turbo spin-echo (TSE) sequences: TR=7380ms, TE=119ms, Flip Angle=150°, and resolution=1.25x1.25x1.95mm3. Data were collected longitudinally at 3 age groups: neonates, 1-year-olds, and 2-year-olds. Data with motion artifacts was discarded and a rescan was made when possible. Finally, complete 0-1-2 data of 95 normal infants was acquired.

2. Package Description

Images are distributed at ".hdr"+".img" format. Please use MRIcro/MRIcron/SPM to open.

'neo' refers to images at neonate, '1yr' refers to 1-year-old, and '2yr' refers to 2-year-old.

Below lists name convention for neonatal images.

infant-neo.hdr	Intensity model (mean image of all 95 registered intensity images)
infant-neo-withSkull.hdr	Intensity model with skull
infant-neo-withCerebellum.hdr	Intensity model with Cerebellum
infant-neo-seg.hdr	Segmentation model
infant-neo-seg-gm.hdr	Probability map for GM
infant-neo-seg-wm.hdr	Probability map for WM
infant-neo-seg-csf.hdr	Probability map for CSF
infant-neo-aal.hdr	Label map with 90 ROIs

Fig. 1 shows the above images at a typical axial slice.

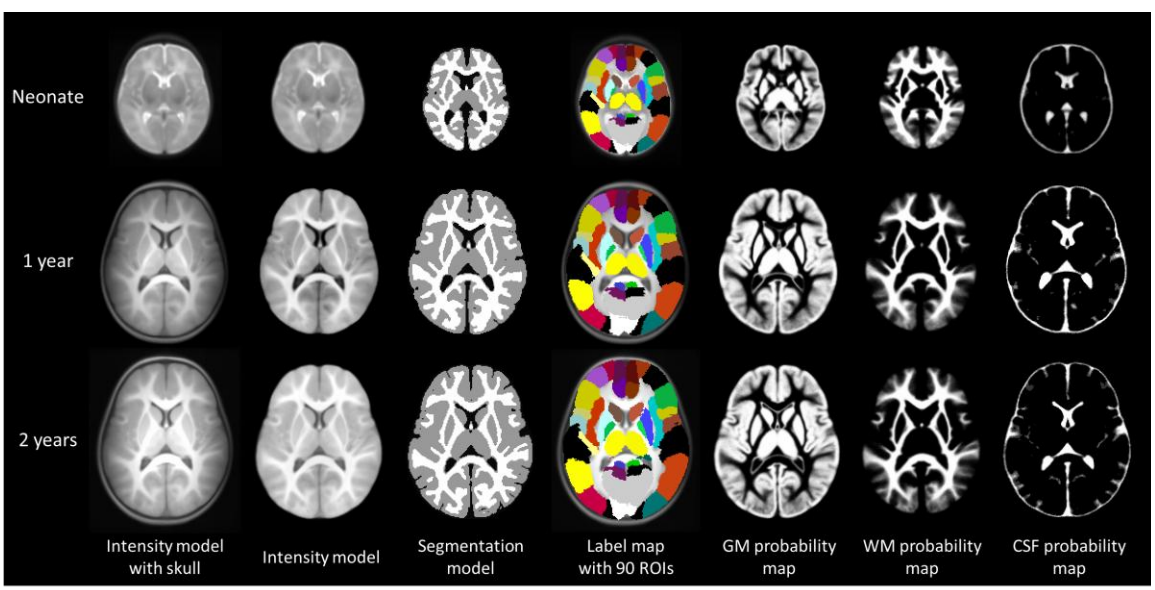

Figure 1. Atlas components for neonates, 1-year-olds, and 2-year-olds.

Intensity/Segmentation models are used to align with individual images, so that the label map can be transferred to individual images.

The anatomical description of regions in "infant-neo-aal.hdr" image is detailed in Table 2. The definition is originally from N. Tzourio-Mazoyer et al, Neuroimage, 15: 273-289, 2002, but now it is warped into infant spaces.

Table 2. Regions of interest (ROI) defined in the infant-AAL template.

Index	Region	Abbreviation	Index	Region	Abbreviation
1	Precentral gyrus left	PreCG-L	46	Cuneus right	CUN-R
2	Precentral gyrus right	PreCG-R	47	Lingual gyrus left	LING-L
3	Superior frontal gyrus (dorsal) left	SFGdor-L	48	Lingual gyrus right	LING-R
4	Superior frontal gyrus (dorsal) right	SFGdor-R	49	Superior occipital gyrus left	SOG-L
5	Orbitofrontal cortex (superior) left	ORBsupb-L	50	Superior occipital gyrus right	SOG-R
6	Orbitofrontal cortex (superior) right	ORBsupb-R	51	Middle occipital gyrus left	MOG-L
7	Middle frontal gyrus left	MFG-L	52	Middle occipital gyrus right	MOG-R
8	Middle frontal gyrus right	MFG-R	53	Inferior occipital gyrus left	IOG-L
9	Orbitofrontal cortex (middle) left	ORBmid-L	54	Inferior occipital gyrus right	IOG-R
10	Orbitofrontal cortex (middle) right	ORBmid-R	55	Fusiform gyrus left	FFG-L
11	Inferior frontal gyrus (opercular) left	IFGoperc-L	56	Fusiform gyrus right	FFG-R
12	Inferior frontal gyrus (opercular) right	IFGoperc-R	57	Postcentral gyrus left	PoCG-L
13	Inferior frontal gyrus (triangular) left	IFGtriang-L	58	Postcentral gyrus right	PoCG-R
14	Inferior frontal gyrus (triangular) right	IFGtriang-R	59	Superior parietal gyrus left	SPG-L
15	Orbitofrontal cortex (inferior) left	ORBinf-L	60	Superior parietal gyrus right	SPG-R
16	Orbitofrontal cortex (inferior) right	ORBinf-R	61	Inferior parietal lobule left	IPL-L
17	Rolandic operculum left	ROL-L	62	Inferior parietal lobule right	IPL-R
18	Rolandic operculum right	ROL-R	63	Supramarginal gyrus left	SMG-L
19	Supplementary motor area left	SMA-L	64	Supramarginal gyrus right	SMG-R
20	Supplementary motor area right	SMA-R	65	Angular gyrus left	ANG-L
21	Olfactory left	OLF-L	66	Angular gyrus right	ANG-R
22	Olfactory right	OLF-R	67	Precuneus left	PCUN-L
23	Superior frontal gyrus (medial) left	SFGmed-L	68	Precuneus right	PCUN-R
24	Superior frontal gyrus (medial) right	SFGmed-R	69	Paracentral lobule left	PCL-L
25	Orbitofrontal cortex (medial) left	ORBmed-L	70	Paracentral lobule right	PCL-R
26	Orbitofrontal cortex (medial) right	ORBmed-R	71	Caudate left	CAU-L
27	Rectus gyrus left	REC-L	72	Caudate right	CAU-R
28	Rectus gyrus right	REC-R	73	Putamen left	PUT-L
29	Insula left	INS-L	74	Putamen right	PUT-R
30	Insula right	INS-R	75	Pallidum left	PAL-L
31	Anterior cingulate gyrus left	ACG-L	76	Pallidum right	PAL-R
32	Anterior cingulate gyrus right	ACG-R	77	Thalamus left	THA-L
33	Middle cingulate gyrus left	MCG-L	78	Thalamus right	THA-R
34	Middle cingulate gyrus right	MCG-R	79	Heschl gyrus left	HES-L
35	Posterior cingulate gyrus left	PCG-L	80	Heschl gyrus right	HES-R
36	Posterior cingulate gyrus right	PCG-R	81	Superior temporal gyrus left	STG-L
37	Hippocampus left	HIP-L	82	Superior temporal gyrus right	STG-R
38	Hippocampus right	HIP-R	83	Temporal pole (superior) left	TPOsup-L
39	ParaHippocampal gyrus left	PHG-L	84	Temporal pole (superior) right	TPOsup-R
40	ParaHippocampal gyrus right	PHG-R	85	Middle temporal gyrus left	MTG-L
41	Amygdala left	AMYG-L	86	Middle temporal gyrus right	MTG-R
42	Amygdala right	AMYG-R	87	Temporal pole (middle) left	TPOmid-L
43	Calcarine cortex left	CAL-L	88	Temporal pole (middle) right	TPOmid-R
44	Calcarine cortex right	CAL-R	89	Inferior temporal gyrus left	ITG-L
45	Cuneus left	CUN-L	90	Inferior temporal gyrus right	ITG-R

3. How to Use

Typical applications of the infant atlases are the spatial normalization, brain parcellation, and atlas-based segmentation.

Spatial normalization: Use registration algorithm to register all your infant subjects to their age-matched atlas (the intensity model).

For registration algorithm, you can choose:

SPM (http://www.fil.ion.ucl.ac.uk/spm/),
HAMMER (http://www.nitrc.org/projects/hammerwml/),
Demons (http://www.insight-journal.org/browse/publication/154).

Brain parcellation: Use registration algorithm to register the age-matched atlas to your infant subjects. Then use the generated deformation field to transform the relative AAL map from atlas space to subject space.

Atlas-based segmentation:

Using iBEAT. iBEAT (Infant Brain Extraction and Analysis Toolbox) is a MATLAB toolbox we recently developed with modules for state-of-the-art infant brain segmentation and registration. It is available at http://www.nitrc.org/projects/ibeat.

Using SPM. Open the SPM in MATLAB environment, click the "Segment" in main menu, click "Data" to choose the to-be-segmented image. For use the infant atlas, Click "Custom", "Tissue probability maps", replace the three tissue priors with the age-matched priors, with sequence from "pbmap_1", "pbmap_2", to "pbmap_0". Note that the atlas should be previously well-aligned with the to-be-segmented image.

Hint: Use "Check Reg" function in SPM to preview your to-be-segmented image and the infant atlases, make sure their orientations are similar, so that segmentation can be correctly carried out.

4. How It Constructed

In particular, based on the observation that the images acquired at 2-year-olds can be segmented with relative ease and higher accuracy, we use their segmentation results to guide segmentation of images from earlier age groups, i.e., neonates and 1-year-olds. At the same time, longitudinal correspondences across three age groups are also established. With the 2-year-old images as the bridge, the anatomical parcellation, i.e., Automated Anatomical Labeling (AAL) map, is propagated to images of neonates and 1-year-olds. Finally, images at each individual age group are registered cross-sectionally with a groupwise algorithm to form a respective atlas. The obtained infant atlases can be used as references for spatial normalization of a group of infant images, as tissue priors for atlas-based tissue segmentation, and as templates for structural labeling. The effectiveness of our atlases, in comparison with other 3 widely used atlases, is evaluated with typical atlas-based applications. Results indicate that our atlases yield the highest spatial-temporal consistency in spatial normalization and structural labeling of individual infant brain images. Additionally, our atlases give the best performance in atlas-based segmentation of neonatal images.

5. Citation

Please cite our below paper for using the atlas:

Feng Shi, Pew-Thian Yap, Guorong Wu, Hongjun Jia, John H. Gilmore, WeiliLin, Dinggang Shen, "Infant Brain Atlases from Neonates to 1- and 2-year-olds", PLoS ONE, 6(4): e18746, Apr. 2011. doi:10.1371/journal.pone.0018746.

6. Contact

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