

EZ-LCA

A New Ready-to-Use Algorithm for Lambda Chart Analysis

Version 1.06

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EZ-LCA is a new algorithm for Lambda Chart Analysis (LCA) based on Diffusion Tensor Analysis. LCA, allowing for a graphic representation of tissue diffusion characteristics, can effectively segregate isotropic and anisotropic components, and can be used for the noninvasive assessment of isotropic parenchymal components. It is written in MATLAB scripting language (MathWorks, Natick, MA, USA) and can be implemented on common operating systems, such as Microsoft Windows, UNIX, and LINUX. At present, EZ-LCA is available on Microsoft Windows, Red Hat LINUX, and Sun Solaris.

Update history:

2005/06/23 Released version 1.06.

Installation:

Download ezl106.zip from our website (http://coe.bri.niigata-u.ac.jp/), and unzip files into a directory of your choice. Execute MATLAB (version 5.3 or later) and add this directory to the MATLAB Path.
For deconvolution of trace function described below, MATLAB Curve Fitting Toolbox (version 1.1 or later) is required.

How to use:

1. Start EZ-LCA:
   Execute MATLAB and type "ezl" in MATLAB command prompt window followed by "return" and EZ-LCA control panel will appear.

2. Specify directory of full tensor diffusion weighted imaging files (hereinafter abbreviated DWI files):
   Push "Directory" button (available in MATLAB version 6.5 or later) or enter directory name in the text box.

3. Specify diffusion gradient b value and MPG vector set:
   Sum of diffusion gradient b value in each axis is 1000 sec/mm^2 by default. If needed, enter different value in the text box.
   Directional pattern of motion probing gradient (MPG) in diffusion weighted imaging sequence is defined by MPG vector set. The initial setting of MPG vector set is,

   none
   (1, 0, 1)
   (-1, 0, 1)
   (0, 1, 1)
   (0, 1, -1)
   (1, 1, 0)
   (-1, 1, 0),

   where (x, y, z) direction correspond to (read-out, phase, slice).

   To customize the directional pattern for MPG, create comma separated values (csv) file describing MPG vector set as a following example, and push "MPG vector..." button to select and load this file. See two samples in the unzipped files, "ezt_tensor_dat.txt" and "ezt_tensor_dat2.txt".

   (start of file)
   -0.754267366, 0.173499508, -0.633228759
   0.330321246, -0.372227441, 0.867372242

-0.533035489, -0.458931922, 0.710812675
-0.686807856, -0.708384154, -0.162747843
-0.321357402, 0.941504078, -0.101486408
0.617869469, 0.786068318, -0.018273425
0.019352413, 0.576222568, 0.817063667
0.311368579, -0.948900372, 0.05135847
-0.882505894, 0.313694805, 0.350398224
-0.038448968, -0.536051111, -0.843309482
0.184148321, 0.468947288, -0.863815858
0.936881687, 0.003852304, 0.349625321
0.813567705, -0.236010694, -0.531419365
(end of file)

Note: Each MPG vector in csv file does not have to be normalized.

4. Select and load DWI files into MATLAB workspace:

Supported file formats and how to arrange DWI files:
a) Analyze 7.5 format (http://www.mayo.edu/bir/PDF/ANALYZE75.pdf)
The files consist of image files (*.img) and corresponding header files (*.hdr). Each image file is 2D or 3D (multiple-slice) diffusion weighted image with one of MPG vectors defined in MPG vector set. The files must be sequentially numbered as follows,

(in case of 4 slice 2D files)
1st acquisition

image001.img(hdr)	:MPG none	:slice 1
image002.img(hdr)	:MPG none	:slice 2
image003.img(hdr)	:MPG none	:slice 3
image004.img(hdr)	:MPG none	:slice 4
image005.img(hdr)	:MPG vector (1, 0, 1)	:slice 1
image006.img(hdr)	:MPG vector (1, 0, 1)	:slice 2
image007.img(hdr)	:MPG vector (1, 0, 1)	:slice 3
image008.img(hdr)	:MPG vector (1, 0, 1)	:slice 4
image009.img(hdr)	:MPG vector (-1, 0, 1)	:slice 1
image010.img(hdr)	:MPG vector (-1, 0, 1)	:slice 2
image011.img(hdr)	:MPG vector (-1, 0, 1)	:slice 3

image012.img(hdr) :MPG vector (-1, 0, 1) :slice 4
image013.img(hdr) :MPG vector (0, 1, 1) :slice 1
image014.img(hdr) :MPG vector (0, 1, 1) :slice 2
image015.img(hdr) :MPG vector (0, 1, 1) :slice 3
image016.img(hdr) :MPG vector (0, 1, 1) :slice 4
image017.img(hdr) :MPG vector (0, 1, -1) :slice 1
image018.img(hdr) :MPG vector (0, 1, -1) :slice 2
image019.img(hdr) :MPG vector (0, 1, -1) :slice 3
image020.img(hdr) :MPG vector (0, 1, -1) :slice 4
image021.img(hdr) :MPG vector (1, 1, 0) :slice 1
image022.img(hdr) :MPG vector (1, 1, 0) :slice 2
image023.img(hdr) :MPG vector (1, 1, 0) :slice 3
image024.img(hdr) :MPG vector (1, 1, 0) :slice 4
image025.img(hdr) :MPG vector (-1, 1, 0) :slice 1
image026.img(hdr) :MPG vector (-1, 1, 0) :slice 2
image027.img(hdr) :MPG vector (-1, 1, 0) :slice 3
image028.img(hdr) :MPG vector (-1, 1, 0) :slice 4
2nd acquisition
..., and so forth.

(in case of 3D files)
1st acquisition
image01.img(hdr) : MPG none
image02.img(hdr) : MPG vector (1, 0, 1)
image03.img(hdr) : MPG vector (-1, 0, 1)
image04.img(hdr) : MPG vector (0, 1, 1)
image05.img(hdr) : MPG vector (0, 1, -1)
image06.img(hdr) : MPG vector (1, 1, 0)
image07.img(hdr) : MPG vector (-1, 1, 0)
2nd acquisition
image08.img(hdr) : MPG none
image09.img(hdr) : MPG vector (1, 0, 1)
image10.img(hdr) : MPG vector (-1, 0, 1)
image11.img(hdr) : MPG vector (0, 1, 1)
image12.img(hdr) : MPG vector (0, 1, -1)
image13.img(hdr) : MPG vector (1, 1, 0)

image14.img(hdr) : MPG vector (-1, 1, 0)
..., and so forth.

b) DICOM format (http://www.psychology.nottingham.ac.uk/staff/cr1/dicom.html)
The files (*.dcm) must be sequentially numbered as a following example of 4 slices,

1st acquisition

image001.dcm	:MPG none	:slice 1
image002.dcm	:MPG none	:slice 2
image003.dcm	:MPG none	:slice 3
image004.dcm	:MPG none	:slice 4
image005.dcm	:MPG vector (1, 0, 1)	:slice 1
image006.dcm	:MPG vector (1, 0, 1)	:slice 2
image007.dcm	:MPG vector (1, 0, 1)	:slice 3
image008.dcm	:MPG vector (1, 0, 1)	:slice 4
image009.dcm	:MPG vector (-1, 0, 1)	:slice 1
image010.dcm	:MPG vector (-1, 0, 1)	:slice 2
image011.dcm	:MPG vector (-1, 0, 1)	:slice 3
image012.dcm	:MPG vector (-1, 0, 1)	:slice 4
image013.dcm	:MPG vector (0, 1, 1)	:slice 1
image014.dcm	:MPG vector (0, 1, 1)	:slice 2
image015.dcm	:MPG vector (0, 1, 1)	:slice 3
image016.dcm	:MPG vector (0, 1, 1)	:slice 4
image017.dcm	:MPG vector (0, 1, -1)	:slice 1
image018.dcm	:MPG vector (0, 1, -1)	:slice 2
image019.dcm	:MPG vector (0, 1, -1)	:slice 3
image020.dcm	:MPG vector (0, 1, -1)	:slice 4
image021.dcm	:MPG vector (1, 1, 0)	:slice 1
image022.dcm	:MPG vector (1, 1, 0)	:slice 2
image023.dcm	:MPG vector (1, 1, 0)	:slice 3
image024.dcm	:MPG vector (1, 1, 0)	:slice 4
image025.dcm	:MPG vector (-1, 1, 0)	:slice 1
image026.dcm	:MPG vector (-1, 1, 0)	:slice 2
image027.dcm	:MPG vector (-1, 1, 0)	:slice 3
image028.dcm	:MPG vector (-1, 1, 0)	:slice 4

2nd acquisition
..., and so forth.

Similarly, in customized directional pattern for MPG, DWI files in both file formats must be sequentially numbered in the same order as those of corresponding MPG vectors described in csv file, as a following example of 3D Analyze format,

1st acquisition
image01.img(hdr) : MPG none
image02.img(hdr) : MPG vector in 1st line in the csv file
image03.img(hdr) : MPG vector in 2nd line in the csv file
image04.img(hdr) : MPG vector in 3rd line in the csv file
image05.img(hdr) : MPG vector in 4th line in the csv file
image06.img(hdr) : MPG vector in 5th line in the csv file
image07.img(hdr) : MPG vector in 6th line in the csv file
image08.img(hdr) : MPG vector in 7th line in the csv file
image09.img(hdr) : MPG vector in 8th line in the csv file
image10.img(hdr) : MPG vector in 9th line in the csv file
..., and so forth.

To select and load Analyze or DICOM files arranged as above, push "Analyze files...", or "DICOM files..." button. Change number of acquisitions in the text box in need. The figures of loaded images will appear. When another slice level of interest is selected using the pop list, the corresponding images will come up. The image parameters such as matrix size, FOV, and slice thickness (with spacing) are read from the header of the files and displayed in the control panel.

Note:

i) Please make sure of the specified directory before pushing "Analyze files..." or "DICOM files..." button. In addition, DWI files must be named with extension, ".img" and ".hdr" in Analyze format, and ".dcm" in DICOM format, respectively. Pushing these buttons will only list files with these extensions in the directory.

ii) In EZ-LCA, the slice is supposed to be ordered from superior to inferior. If DWI files are numbered in the opposite order, click on "reverse slice" checkbox in the main control panel before pushing "Analyze files..." or "DICOM files..." button.

iii) In loading 2D Analyze or DICOM files, number of slices is decided from three parameters: number of directional patterns for MPG, number of selected files, and number of acquisitions.

One must confirm these parameters correctly before pushing "Analyze files..." or "DICOM files..." button.

iv) In selecting Analyze or DICOM files in the list box, one cannot select the files in an arbitrary order. Selected files will be loaded in alphabetical order.

5. Trimming images (optional):

Push "trimming" button and the diffusion weighted image without MPG in the selected slice level will appear in another figure for determining a trimming rectangle. To specify a trimming rectangle, drag mouse pointer from one of the corners of a rectangle and a green rectangle will appear when the pointer rests. This rectangle can be moved by another mouse dragging or can be resized by dragging each corner of the rectangle. To determine trimming rectangle finally, push any key with keyboard. This trimming rectangle will apply to all of the loaded diffusion weighted and base images in all of the slice levels, and the figures will be updated with the trimmed images.

6. Create Lambda Chart:

Push "lambda chart" button, and the Lambda Chart will appear in another figure.

7. Remove anisotropic area:

Specify values for "lower limit of anisotropic angle (deg)" and "Upper limit of anisotropic angle (deg)". Default values are 45 degrees and 55 degrees respectively. To determine anisotropic area for removal, push "Yes" and the trace function will appear.

8. Deconvolution of trace function and re-mapping of segregated pixel groups (required MATLAB Curve Fitting Toolbox):

Push "deconvolution" button, and the menu of options for deconvolution will appear:

i) Execute curve fitting toolbox GUI tool: Pushing this button executes Curve Fitting Tool originally included in MATLAB Curve Fitting Toolbox with the trace function loaded. At first, a weighting vector of fitting condition must be specified. One can select an example of a vector in the displayed menu, or determine a vector by editing the arguments of "cftool" function in the script "ezl_deconv_ui.m". See MATLAB help for details of Curve Fitting Toolbox . With Curve Fitting Tool, one can edit options for deconvolution, such as fitting functions and range of parameters. After confirming all of the options, push "re-mapping" button. The deconvoluted trace function and re-mapping of segregated groups will appear.

ii) Automatic deconvolution: In this selection, fitting process will be performed using MATLAB

Curve Fitting Toolbox built-in function, "fit". Fitting options such as a weighting vector of fitting condition, fitting functions and range of parameters must be specified by editing the arguments of "fit" function in the script "ezl_deconv_auto.m". See MATLAB help for details of Curve Fitting Toolbox. An example of a weighting vector can be selected in the displayed menu. In the automatic deconvolution, the next re-mapping process will proceed without pushing "re-mapping" button.

9. To reset current data in MATLAB workspace, push "reset" button.

10. To exit EZ-LCA, push "exit" button.

For details of this algorithm, see our article,
Matsuzawa H, Nakayama N, Kwee IL, Nakada T. Isotropic component trace analysis. J Neuroimaging. 2005 Jul;15(3):233-9.

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