

## **LEFA (Lineament Extraction Fracture Analysis) v. 1.0**

*Analytical GUI remote sensing software for Mathworks Matlab™ environment*

### **About LEFA Software**

Project LEFA (<http://lefa.geologov.net>) is GUI Matlab script package created for satellite image decomposition for Earth sciences implications. Fracture analysis is often being used for geological mapping, detecting natural hazards and prospecting of mineral resources. Achievements in computer image processing and digital mapping made possible human independent feature recognition.

LEFA contains free of charge set of Matlab scripts, which allows to:

- Extract lineament features on satellite image (Landsat 7 and 8, SRTM and some others are supported);
- Compute feature spatial distribution parameters (density and Minkowski Dimension);
- Create Rose diagram plot of lineaments direction;
- Export features into ESRI shape format to continue work in GIS software.

LEFA inherit single

### **Who we are**

LEFA software was written in Matlab by academic geologists of FEGI FEB RAS and Far East Federal University. This software is available publically without any charge.

Dr. Sergei L. Shevyrev is researcher and associate professor. Research interests include regional geology, geotectonics, remote sensing, modeling and computer programming.

### **System Requirements and Third party tools**

Running LEFA requires Matlab (2013b and higher) installed on you system along following toolboxes:

- Mapping Toolbox;
- Statistics toolbox;
- Image processing toolbox.

Absence of named Matlab toolboxes may affect program workflow.

**Recommended hardware properties:**

Computer must support Matlab 2013b+, also 4+ Gb RAM

**Third party tools:**

- Software uses Minkowski calculator script by Frederic Moisy ([link](#));
- [QantumGIS \(QGIS\)](#) software is recommended for *geotiff* and *shape* output stacking and projecting.

**User's obligations**

This software can be used for any purpose, disassembled, analyzed and reassembled. In any case reference and link to software website and author should be saved (look “How to cite” section. If you are opposed or disagree, please remove this software from your computer immediately.

**How to cite this software**

If you have used LEFA software in your research or study, please, put this link in your references:

*Sergei Shevyrev., 2018 LEFA: Lineament Extraction and Fracture Analysis.*  
<http://lefa.geologov.net>

**Disclaimer**

Being of free experimental software, LEFA comes with NO warranty for its output and productivity. You are using it AT YOUR OWN RISK. Author(s) are not responsible for any harm, loss of profit and inconvenience. If you are disagreeing with that, please, remove LEFA from your computer immediately.

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## 1. How to start

In order to start LEFA software, please, make sure that Matlab has been installed into your system, next [download](#) LEFA archive, and unzip it to the folder at your choice. In order to run LEFA pick *start.m* file by right mouse button than choose “run *start.m*” from the context menu or type run *start.m* in Command window. Program window should appear (fig. 1).

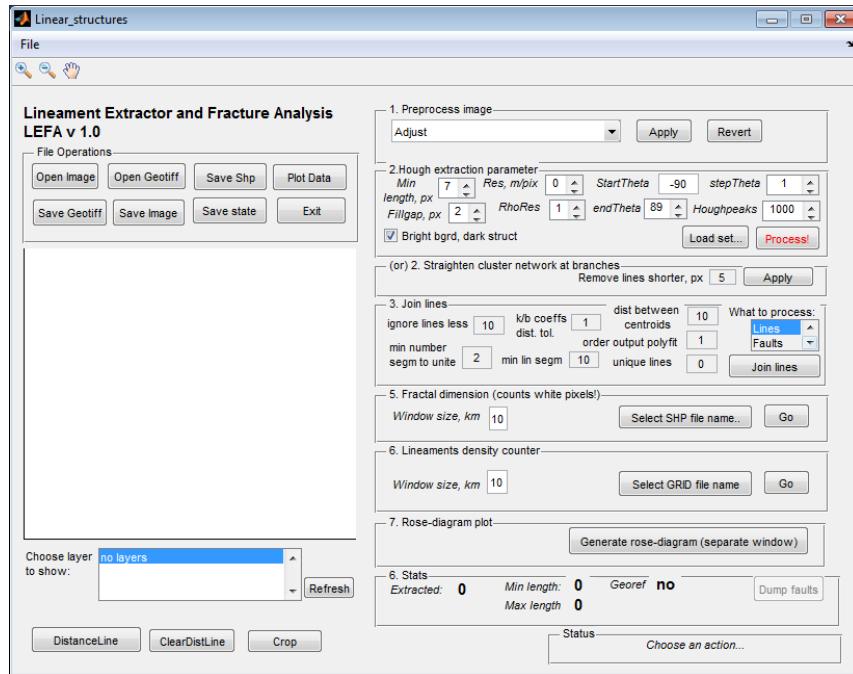


Fig. 1. LEFA program window.

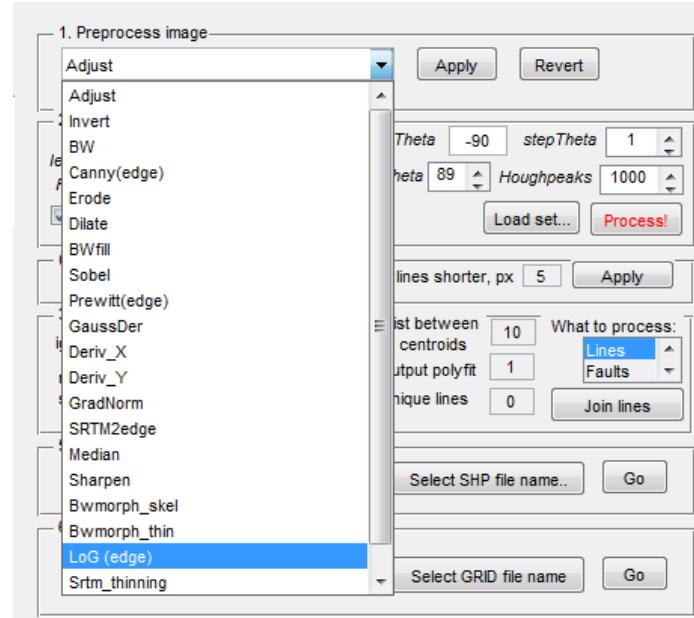
## 2. Open georeferenced tiff (GeoTiff)

Press button “Open GeoTiff” on panel board (fig. 2). Wait until picture loads. Please, mind that unprocessed image often appears too dark, so it’s better to equalize it for preview purposes. Further steps are outlined onto analysis board (right side of program window).

## 3. Preprocess image

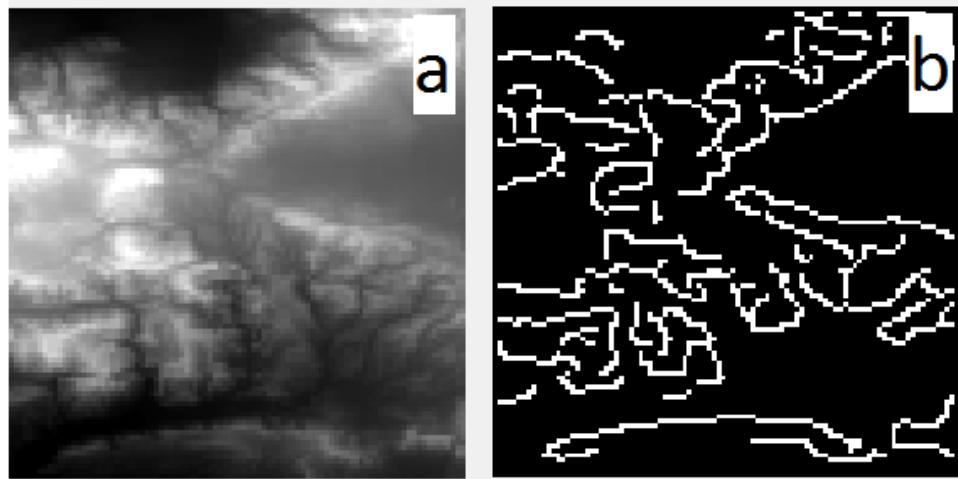
Select filters repeatedly from the list, than press button “apply” . If result appears to be inappropriate, press “revert” button to start it all over. Filters are available from the list (fig. 2).

Be noted that line detecting requires pre-made edge detecting. The simplest ready-to-go solution is Canny algorithm, which allows outlining contrast edges. Anyway, image should be binarized prior to line extracting.



*Fig. 2. Image preprocessing prior to line detecting*

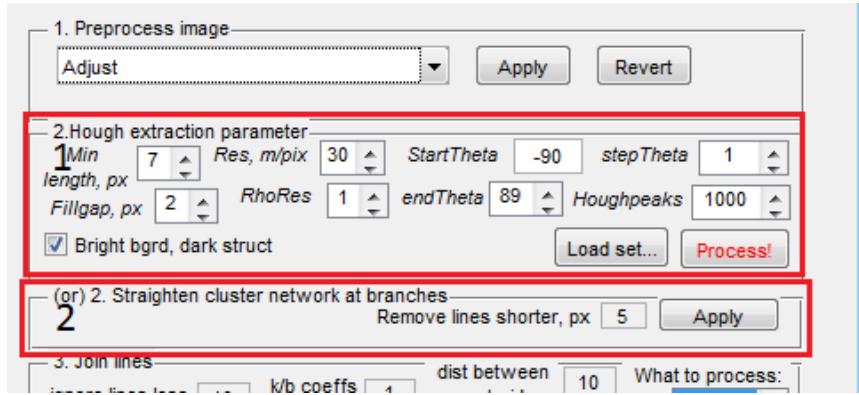
Result of edge detecting with Canny algorithm applied to SRTM is shown (fig. 3).



*Fig. 3. Implication of Canny edge detecting algorithm. Before (a) and after (b).*

#### 4. Line's detecting

Line detecting can be achieved by application of Hough algorithm (4.1) or cluster centerline extracting (4.2). Their admissibility can be determined by researchers' experience (fig. 4).



*Fig. 4. Line extraction's alternative actions. Selections: 1 – Hough transform; 2 – cluster straightening*

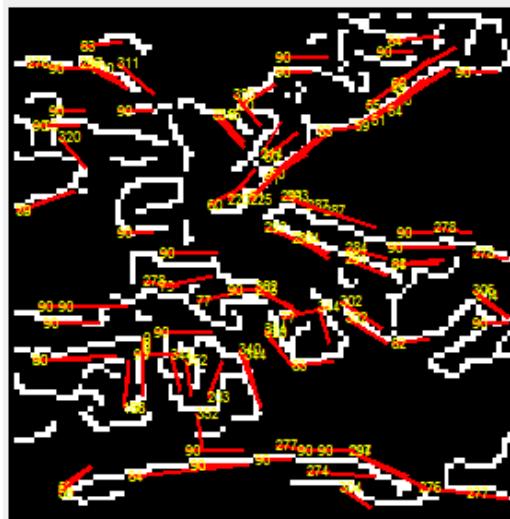
#### 4.1. Hough algorithm description

Hough algorithm relies on transformation of binary images to the Hough polar coordinates from Cartesian. The brief description of Hough transform is available from OpenCV documentation (see. *Reference*).

Variance of parameters of Hough detection (fig. 3, outline 1) changes tolerance in gap and Hough coordinates shifting. For instance, increasing in gap resulting growth of linear features population, but precision of analysis relatively lowers.

The parameters of transform are available to change. So, number of Hough peaks controls number of output objects.

Output of Hough algorithm produces linear object following over image. Each line (red) is marked by azimuth (fig. 5).



*Fig. 5. Result of Hough algorithm application to binary image*

## 4.2 Cluster centerline extraction

Cluster centerline extraction is the way of extraction of linear features as the longest axis of ellipse outline of point clusters. In order to produce such array of elements, binary edge framework must be disconnected at the branch points. In some cases this approach creates more reliable tectonic fracturing pattern. Also it can be used for analysis of clusters. Sequence of “Image adjust” → “LoG (edge)” → “Straighten cluster network...” produced following output (fig. 6).

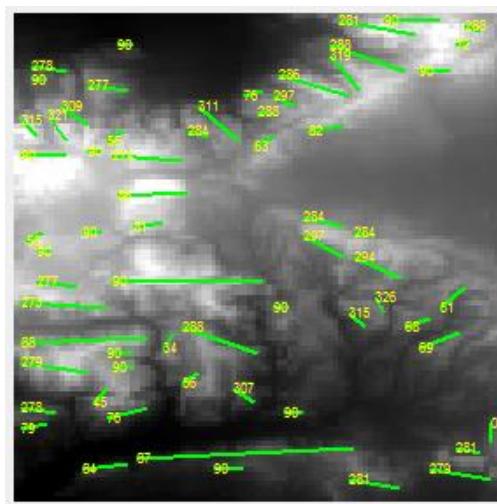


Fig. 6. Result of Cluster shortening algorithm

## 5. Lineaments processing and faults detecting

Extracted linear features no matter algorithm of their detecting could be joined into greater order features respectively their distance to one another and collinearity. Features could be considered as collinear when their k/b relationship differences less than given in appropriate field (fig. 7).

3. Join lines									
ignore lines less	2	k/b coeffs	2	dist between	30	What to process:			
dist. tol.				centroids		Lines	<input type="checkbox"/>	<input checked="" type="checkbox"/>	
min number	5	order output polyfit	1	unique lines	0	Faults	<input type="checkbox"/>	<input checked="" type="checkbox"/>	
segm to unite	5	min lin segm	3			Join lines	<input type="button"/>		

Fig. 7. Parameters of line joining applied to Hough lines

The quality of lines and faults detecting process could be examined by expert than claimed as appropriate. Parameters, which are shown above produce following joined lines (or “faults”) (fig. 8).

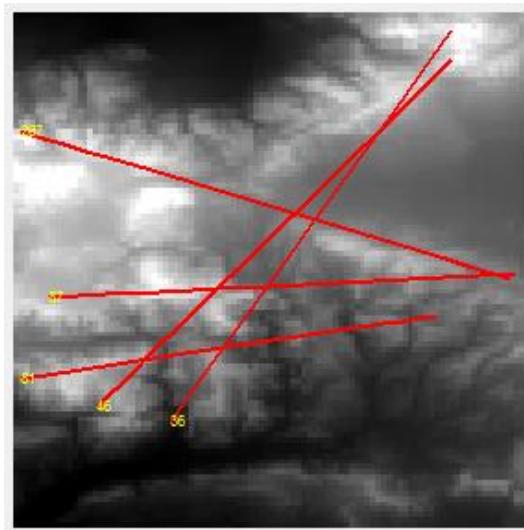


Fig. 8. “Faults” or joined lines

## 6. Shape file exporting

Lines and faults when detected and properly assessed, could be exported into georeferenced shape file(s). This files could be opened, edited and compared with other data in GIS software. This feature is remarkable in LEFA.

In order to complete shape file output, one should press button “Save Shp” in program window. This will call file save dialogue for two feature groups consequently. Shape files could be combined with other data in QGis or other supporting software.

## 7. Line density calculator

This feature is available when line array was extracted from image. For selected width of averaging window it generates GeoTiff surface of lines density (sum of lines length per window square) in km/km<sup>2</sup>. Resulting GeoTiff output will inherit projection of original input data and doesn’t require user’s attention.

## 8. Minkowski fractal dimension.

This feature is available for binary image (effective when edge filter has been applied). It takes value from 0 to 2 on a plane. This feature can be applied alternatively to line density. Computing result is being exported as tile of georeferenced square polygons of given width in km. In order to perform that kind of analysis one should press “Select SHP file name” and “Go” button in according section repeatedly (fig. 9).

5. Fractal dimension (counts white pixels!)

Window size, km

Fig. 9. Fractal dimension section of the program window

## 9. Rose diagram output

Detected lines could be visualized in according window by pressing button “Generate rose-diagram (separate window)”  in rose-diagram plot section (fig. 10).

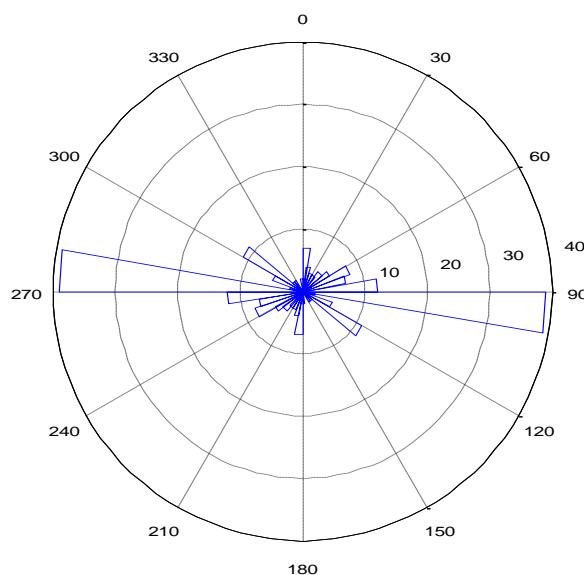


Fig. 10. Rose-diagram plot of detected lines over srtm\_la\_sample2.tif image.

## Representing results

Finally, computing results can be composed in GIS software (qgis.org project is recommended) (fig. 11).

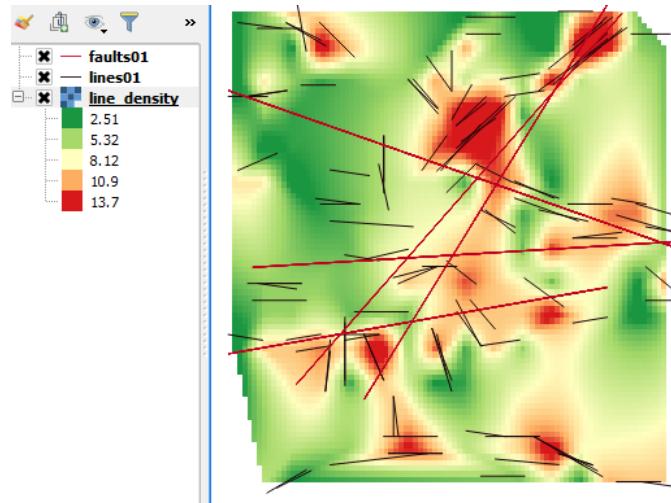


Fig. 11. Output of layer overlay in QGis software (Layer panel is shown on the right side of the image).

## Reference

1. Hough Transform. OpenCV documentation. URL:  
[https://docs.opencv.org/3.4/d9/db0/tutorial\\_hough\\_lines.html](https://docs.opencv.org/3.4/d9/db0/tutorial_hough_lines.html)