LeAFtool — Lesion Area Finding tool

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Research on plant diseases requires the acquisition of quantitative data to characterize and quantify the symptoms caused by different pathogens, especially lesions on leaves. The most relevant variables used to characterize disease impact are the number of lesions per unit of leaf area, the area and the shape of the lesions.

We developed LeAFtool (Lesion Area Finding tool), an R package aimed to automatically analyze visible lesions on an infected leaf. Automatic scoring of relevant variables increase precision and repeatability while avoiding experimenter biases.
LeAFtool has been encapsulated in a graphical, user-friendly interface (GUI), but can also be used in command line mode.

Methodology

Training

Traning step is based on supervised learning (pixel colors in RGB or HSV)

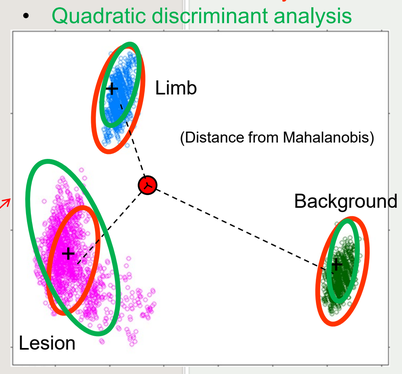
Matrix of pixels for training

group	red	green	blue
background	0.988235	0.972549	0.968627
background	0.788235	0.788235	0.780392
limb	0.235294	0.392157	0.164706
limb	0.215686	0.372549	0.137255
lesion/lesion1	0.749020	0.603922	0.396078
lesion/lesion1	0.760784	0.603922	0.400000
lesion/lesion2	0.980392	0.980392	0.392157
lesion/lesion2	0.992157	1.000000	0.419608

Discriminating axes (= parameters)

	LD1	LD2	LD3
red	-104	64	-4.37
green	66	-104	-16.86
blue	49	45	0.45

Different methods
- Linear discriminant analysis
- Quadratic discriminant analysis



Classification of the training set

group	red	green	blue	predict
background	0.988235	0.972549	0.968627	background
background	0.788235	0.788235	0.780392	background
limb	0.235294	0.392157	0.164706	limb
limb	0.215686	0.372549	0.137255	limb
lesion/lesion1	0.749020	0.603922	0.396078	lesion/lesion1
lesion/lesion1	0.760784	0.603922	0.400000	lesion/lesion1
lesion/lesion2	0.980392	0.980392	0.392157	lesion/lesion2
lesion/lesion2	0.992157	1.000000	0.419608	lesion/lesion2

class define \ class predict	background	limb	lesion/lesion1	lesion/lesion2
background	143774	0	0	0
limb	0	14364	0	0
lesion/lesion1	0	11	2827	50
lesion/lesion2	6	1	0	2902

Error rate: 0.04%

Confusion matrix

Three input folders are mandatory for training

Training phase (pixel sample)

- Definition of pixel classes
- Extracting of pixel samples from each class (training set)
- Discriminant analysis
- Parameter estimation
- Classification of the pixels
- Evaluation

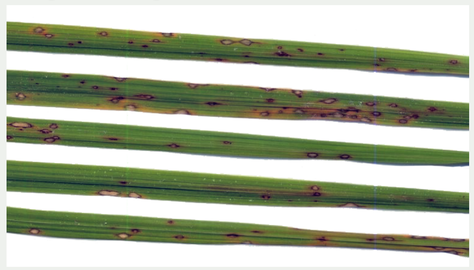
Parameters

Analysis phase (images)

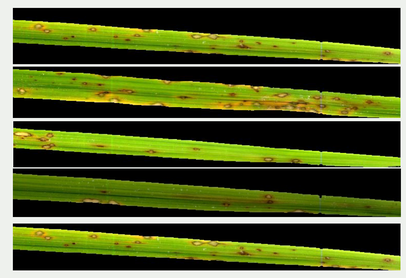
- Preliminary image processing (filtering, noise reduction ...)
- Pixel classification of images
- Morphological operations: dilation, erosion, removal of objects according to criteria
- Segmentation (separation of objects)
- Computation (counting, calculation of areas)

Analysis

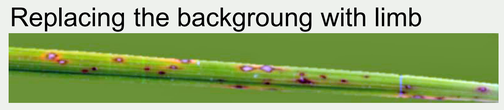
Original image



Separation of leaves

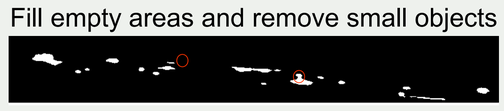


Replacing the backgroung with limb

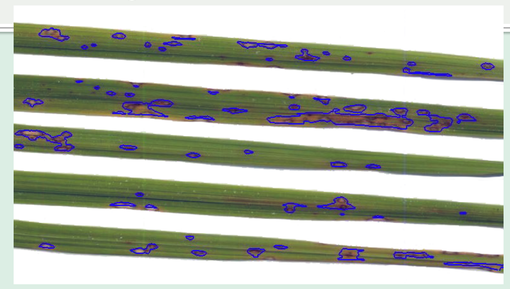


Classification: detection of lesions

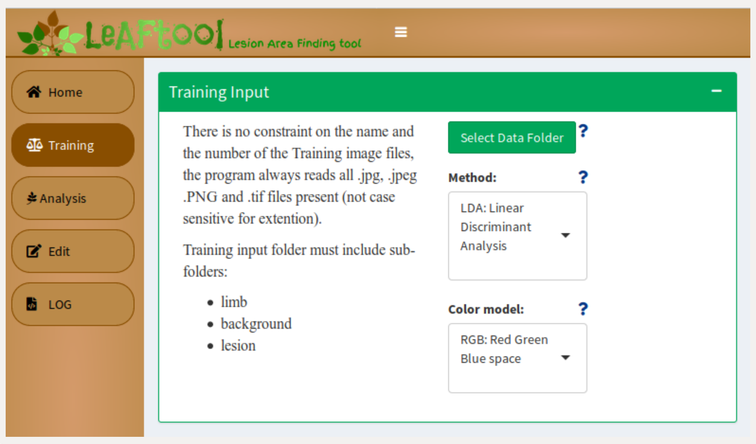
Fill empty areas and remove small objects

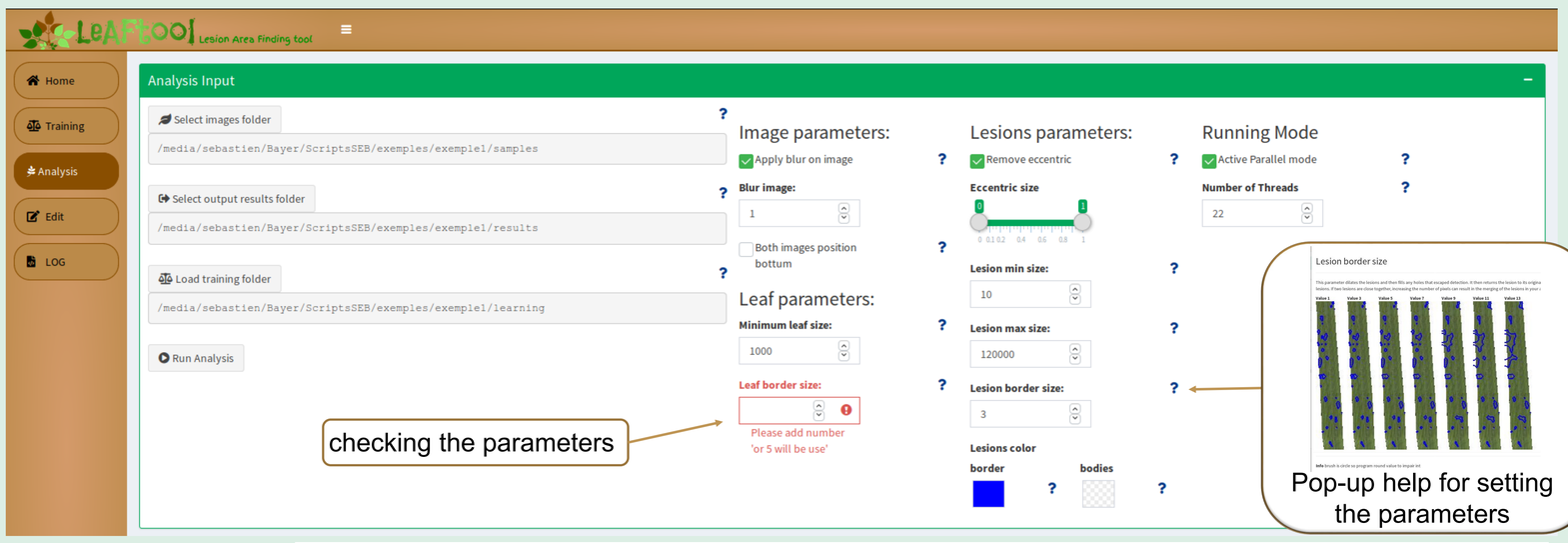


Final image with lesions

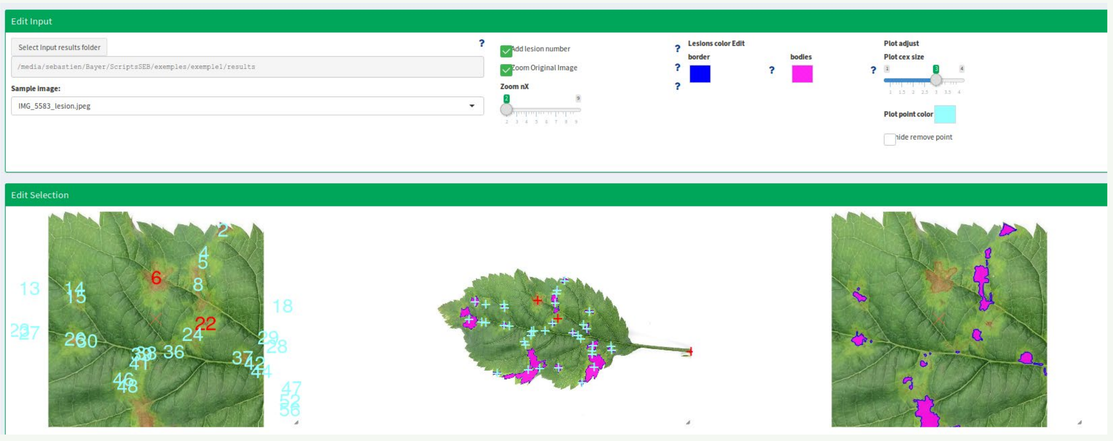


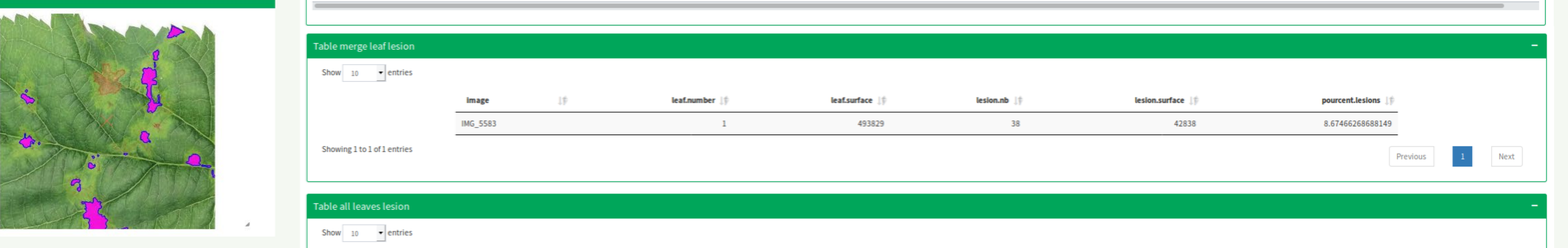
GUI





Edit

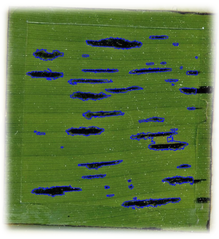




The interface allows the editing of lesions (deletion of false lesion), and the filtering of information according to parameters (surface area, shape,...)

Exemples

Magnaporthe oryzae / rice

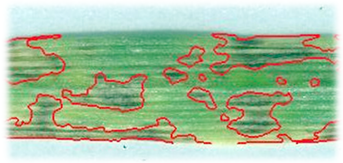


Pseudocercospora fijiensis / banana plant

Microcyclus ulei / hevea

Venturia inaequalis / apple tree

Puccinia triticina / wheat



Parastagonospora nodorum / wheat

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https://github.com/sravel/LeAFtool